



*This manual is to be given  
to the end user*

## UNIDRIVE

# Universal variable speed drive

### User guide

## General Information

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

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

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## Drive software version

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

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 LEROY-SOMER.

## Environmental statement

LEROY-SOMER 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.

The electronic variable-speed drives manufactured by LEROY-SOMER 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. LEROY-SOMER' 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: b (12)

Software: 01.15.00 onwards

# How to use this guide

This user guide provides complete information for installing and operating the drive from start to finish.

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

## NOTE

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

This map of the user guide helps to find the right sections for the task you wish to complete, but for specific information, refer to *Contents* on page 4:

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# 1 Safety Information

## 1.1 Warnings, Cautions and Notes



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

**WARNING**



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

**CAUTION**

### NOTE

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

## 1.2 Electrical safety - general warning

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

Specific warnings are given at the relevant places in this User 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/start-up and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this User Guide carefully.

The STOP and SAFE TORQUE OFF (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.

**With the sole exception of the SAFE TORQUE OFF (SECURE DISABLE) function, none of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.**

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.

The SAFE TORQUE OFF (SECURE DISABLE) function has been approved<sup>1</sup> as meeting the requirements of EN954-1 category 3 for the prevention of unexpected starting of the drive. It may be used in a safety-related application. **The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.**

<sup>1</sup>Independent approval by BGIA has been given.

## 1.4 Environmental limits

Instructions in this User 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 User 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 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

Standard squirrel cage induction motors are designed for single speed operation. If it is intended to use the capability of the drive to run a motor at speeds above its designed maximum, it is strongly recommended that the manufacturer is consulted first.

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

The values of the motor parameters set in the drive affect the protection of the motor. The default values in the drive should not be relied upon.

It is essential that the correct value is entered in parameter **0.46** motor rated current. This affects the thermal protection of the motor.

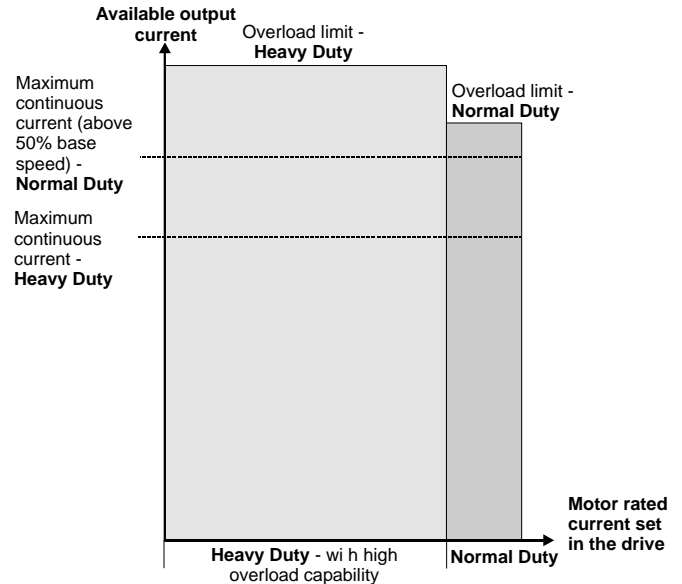
## 1.7 Adjusting parameters

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 Product Information

### 2.1 Ratings

The Unidrive SP is dual rated.  
 The setting of the motor rated current determines which rating applies - Heavy Duty or Normal Duty.  
 The two ratings are compatible with motors designed to IEC60034.  
 The graph aside illustrates the difference between Normal Duty and Heavy Duty with respect to continuous current rating and short term overload limits.



#### Normal Duty

For applications which use Self ventilated (TENV/TEFC) induction motors and require a low overload capability, and full torque at low speeds is not required (e.g. fans, pumps).  
 Self ventilated (TENV/TEFC) induction motors require increased protection against overload due to the reduced cooling effect of the fan at low speed. To provide the correct level of protection the I<sup>2</sup>t software operates at a level which is speed dependent. This is illustrated in the graph below.

#### NOTE

The speed at which the low speed protection takes effect can be changed by the setting of Pr 4.25. The protection starts when the motor speed is below 15% of base speed when Pr 4.25 = 0 (default) and below 50% when Pr 4.25 = 1.

#### Heavy Duty (default)

For constant torque applications or applications which require a high overload capability, or full torque is required at low speeds (e.g. winders, hoists).  
 The thermal protection is set to protect force ventilated induction motors and permanent magnet servo motors by default.

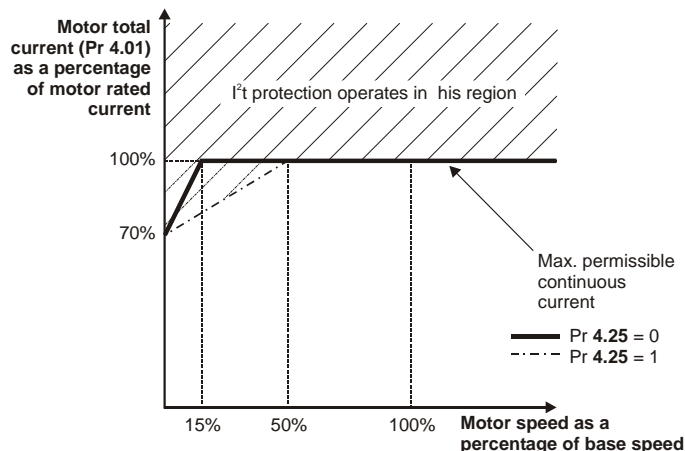
#### NOTE

If the application uses a self ventilated (TENV/TEFC) induction motor and increased thermal protection is required for speeds below 50% base speed, then this can be enabled by setting Pr 4.25 = 1.

#### Operation of motor I<sup>2</sup>t protection (I<sub>t</sub> AC trip)

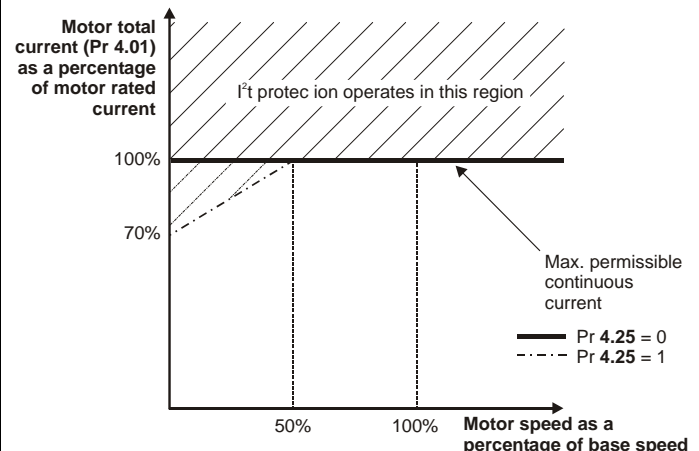
Motor I<sup>2</sup>t protection is fixed as shown below and is compatible with:

- Self ventilated (TENV/TEFC) induction motors









Motor I<sup>2</sup>t protection defaults to be compatible with:

- Forced ventilation induction motors
- Permanent magnet servo motors



The continuous current ratings given are for maximum 40 C (104 F), 1000m altitude 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 section 12.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 242.








**Table 2-1 200V drive ratings (200V to 240V ±10%)**

Model			Normal Duty				Heavy Duty				
	LS	CT	Maximum continuous output current	Nominal power at 220V	Motor power at 230V	Peak current	Maximum continuous output current	Open loop peak current	Closed loop peak current	Nominal power at 220V	Motor power at 230V
			A	kW	hp	A	A	A	A	kW	hp
	1M/TL	0201					2.2	3.3	3.8 (3.3)*	0.37	0.5
	1.2M/TL	0202					3.1	4.6	5.4 (4.6)*	0.55	0.75
	1.5M/TL	0203					4.0	6.0	7.0 (6.0)*	0.75	1.0
	2M/TL	0204					5.7	8.5	9.9 (8.5)*	1.1	1.5
	2.5M/TL	0205					7.5	11.2	13.1 (11.2)*	1.5	2.0
	1.5TL	1201	5.2	1.1	1.5	5.7	4.3	6.4	7.5	0.75	1.0
	2TL	1202	6.8	1.5	2.0	7.4	5.8	8.7	10.1	1.1	1.5
	2.5TL	1203	9.6	2.2	3.0	10.5	7.5	11.2	13.1	1.5	2.0
	3.5TL	1204	11	3.0	3.0	12.1	10.6	15.9	18.5	2.2	3.0
	4.5TL	2201	15.5	4.0	5.0	17.0	12.6	18.9	22	3.0	3.0
	5.5TL	2202	22	5.5	7.5	24.2	17	25.5	29.7	4.0	5.0
	8TL	2203	28	7.5	10	30.8	25	37.5	43.7	5.5	7.5
	11TL	3201	42	11	15	46	31	46.5	54.2	7.5	10
	16TL	3202	54	15	20	59	42	63	73.5	11	15
	22TL	4201	68	18.5	25	74	56	84	98	15	20
	27TL	4202	80	22	30	88	68	102	119	18.5	25
	33TL	4203	104	30	40	114	80	120	140	22	30
	40TL	5201	130	37	50	143	105	157	183	30	40
	50TL	5202	154	45	60	169	130	195	227	37	50

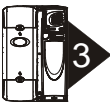
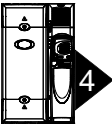
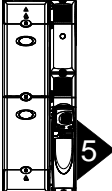
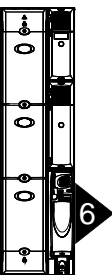
\*The closed loop peak current is based on 175% of the maximum continuous output current when the drive is used on a 3 phase supply. The value in brackets is the peak current based on 150% of the maximum continuous output current when the drive is used on a 1 phase supply.



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

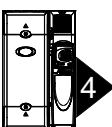
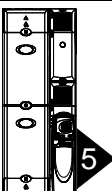
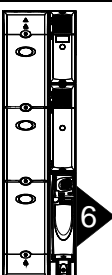
Model	Normal Duty						Heavy Duty				
	LS	CT	Maximum continuous output current	Nominal power at 400V	Motor power at 460V	Peak current	Maximum continuous output current	Open loop peak current	Closed loop peak current	Nominal power at 400V	Motor power at 460V
			A	kW	hp	A	A	A	A	kW	hp
	1T	0401					1.3	1.9	2.2	0.37	0.5
	1.2T	0402					1.7	2.5	2.9	0.55	0.75
	1.5T	0403					2.1	3.1	3.6	0.75	1.0
	2T	0404					3.0	4.5	5.2	1.1	1.5
	2.5T	0405					4.2	6.3	7.3	1.5	2.0
	1.5T	1401	2.8	1.1	1.5	3.0	2.1	3.1	3.6	0.75	1.0
	2T	1402	3.8	1.5	2.0	4.1	3.0	4.5	5.2	1.1	2.0
	2.5T	1403	5.0	2.2	3.0	5.5	4.2	6.3	7.3	1.5	3.0
	3.5T	1404	6.9	3.0	5.0	7.5	5.8	8.7	10.1	2.2	3.0
	4.5T	1405	8.8	4.0	5.0	9.6	7.6	11.4	13.3	3.0	5.0
	5.5T	1406	11	5.5	7.5	12.1	9.5	14.2	16.6	4.0	5.0
	8T	2401	15.3	7.5	10	16.8	13	19.5	22.7	5.5	10
	11T	2402	21	11	15	23	16.5	24.7	28.8	7.5	10
	16T	2403	29	15	20	31	25	34.5	40.2	11	20
	20T	2404					29	43.5	50.7	15	20
	22T	3401	35	18.5	25	38	32	48	56	15	25
	27T	3402	43	22	30	47	40	60	70	18.5	30
	33T	3403	56	30	40	61	46	69	80.5	22	30
	40T	4401	68	37	50	74	60	90	105	30	50
	50T	4402	83	45	60	91	74	111	129.5	37	60
	60T	4403	104	55	75	114	96	144	168	45	75
	75T	5401	138	75	100	151	124	186	217	55	100
	100T	5402	168	90	125	184	156	234	273	75	125
	120T	6401	205	110	150	225	180	231	269	90	150
	150T	6402	236	132	200	259	210	270	315	110	150

**Table 2-3 575V drive ratings (500V to 575V ±10%)**

Model			Normal Duty				Heavy Duty				
	LS	CT	Maximum continuous output current	Nominal power at 575V	Motor power at 575V	Peak current	Maximum continuous output current	Open loop peak current	Closed loop peak current	Nominal power at 575V	Motor power at 575V
			A	kW	hp	A	A	A	A	kW	hp
				3.5TM 3501	3501	5.4	3.0	3.0	5.9	4.1	6.1
	4.5TM 3502	3502	6.1	4.0	5.0	6.7	5.4	8.1	9.4	3.0	3.0
	5.5TM 3503	3503	8.4	5.5	7.5	9.2	6.1	9.1	10.6	4.0	5.0
	8TM 3504	3504	11	7.5	10	12.1	9.5	14.2	16.6	5.5	7.5
	11TM 3505	3505	16	11	15	17.6	12	18	21	7.5	10
	16TM 3506	3506	22	15	20	24.2	18	27	31.5	11	15
	22TM 3507	3507	27	18.5	25	29.7	22	33	38.5	15	20
	33TH 4603	4603	36	22	30	39.6	27	40.5	47.2	18.5	25
	40TH 4604	4604	43	30	40	47.3	36	54	63	22	30
	50TH 4605	4605	52	37	50	57.2	43	64.5	75.2	30	40
	60TH 4606	4606	62	45	60	68	52	78	91	37	50
	75TH 5601	5601	84	55	75	92	63	93	108.5	45	60
	100TH 5602	5602	99	75	100	108	85	126	147	55	75
	120TH 6601	6601	125	90	125	137	100	128	149	75	100
	150TH 6602	6602	144	110	150	158	125	160	187	90	125

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

**Table 2-4 690V drive ratings (500V to 690V ±10%)**

Model			Normal Duty				Heavy Duty				
	LS	CT	Maximum continuous output current	Nominal power at 690V	Motor power at 690V	Peak current	Maximum continuous output current	Open loop peak current	Closed loop peak current	Nominal power at 690V	Motor power at 690V
			A	kW	hp	A	A	A	A	kW	hp
				22TH 4601	4601	22	18.5	25	24.2	19	27
	27TH 4602	4602	27	22	30	29.7	22	33	38.5	18.5	25
	33TH 4603	4603	36	30	40	39.6	27	40.5	47.2	22	30
	40TH 4604	4604	43	37	50	47.3	36	54	63	30	40
	50TH 4605	4605	52	45	60	57.2	43	64.5	75.2	37	50
	60TH 4606	4606	62	55	75	68.2	52	78	91	45	60
	75TH 5601	5601	84	75	100	92	63	93	108.5	55	75
	100TH 5602	5602	99	90	125	108	85	126	147	75	100
	120TH 6601	6601	125	110	150	137	100	128	149	90	125
	150TH 6602	6602	144	132	175	158	125	160	187	110	150

### 2.1.1 Typical short term overload limits

The maximum percentage overload limit changes depending on the selected motor. Variations in motor rated current, motor power factor and motor leakage inductance all result in changes in the maximum possible overload. The exact value for a specific motor can be calculated using the equations detailed in Menu 4 in the *Advanced User Guide*.

Typical values are shown in the table below for closed loop vector RFC mode (VT) and open loop (OL) modes:

**Table 2-5 Typical overload limits for SPz and size 1 to 5**

Operating mode	Closed loop from cold	Closed loop from 100%	Open loop from cold	Open loop from 100%
Normal Duty overload with motor rated current = drive rated current	110% for 165s	110% for 9s	110% for 165s	110% for 9s
Heavy Duty overload with motor rated current = drive rated current	175% for 40s	175% for 5s	150% for 60s	150% for 8s
Heavy Duty overload with a typical 4 pole motor	200% for 28s	200% for 3s	175% for 40s	175% for 5s

**Table 2-6 Typical overload limits for size 6**

Operating mode	Closed loop from cold	Closed loop from 100%	Open loop from cold	Open loop from 100%
Normal Duty overload with motor rated current = drive rated current	110% for 165s	110% for 9s	110% for 165s	110% for 9s
Heavy Duty overload with motor rated current = drive rated current	150% for 60s	150% for 8s	129% for 97s	129% for 15s

Generally the drive rated current is higher than the matching motor rated current allowing a higher level of overload than the default setting as illustrated by the example of a typical 4 pole motor.

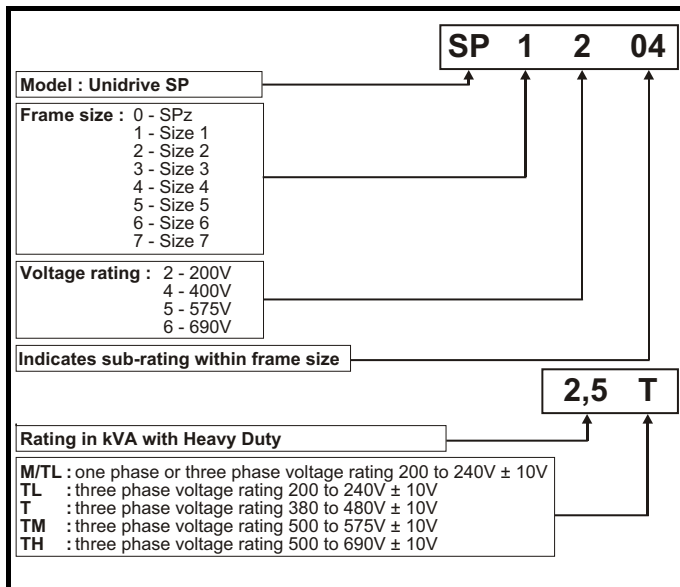
The time allowed in the overload region is proportionally reduced at very low output frequency on some drive ratings.

**NOTE**

The maximum overload level which can be attained is independent of the speed.

## 2.2 Model number

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



## 2.3 Operating modes

The Unidrive SP is designed to operate in any of the following modes:

- Open loop mode
  - Open loop vector mode
  - Fixed V/F mode (V/Hz)
  - Quadratic V/F mode (V/Hz)
- RFC mode
- Closed loop vector
- Servo
- Regen

### 2.3.1 Open loop mode

The drive applies power to the motor at frequencies varied by the user. The motor speed is a result of the output frequency of the drive and slip due to the mechanical load. The drive can improve the speed control of the motor by applying slip compensation. The performance at low speed depends on whether V/F mode or open loop vector mode is selected.

For further details refer to section 8.1.1 *Open loop motor control* on page 126.

### Open loop vector mode

The voltage applied to the motor is directly proportional to the frequency except at low speed where the drive uses motor parameters to apply the correct voltage to keep the flux constant under varying load conditions.

Typically 100% torque is available down to 1Hz for a 50Hz motor.

### Fixed V/F mode

The voltage applied to the motor is directly proportional to the frequency except at low speed where a voltage boost is provided which is set by the user. This mode can be used for multi-motor applications.

Typically 100% torque is available down to 4Hz for a 50Hz motor.

### Quadratic V/F mode

The voltage applied to the motor is directly proportional to the square of the frequency except at low speed where a voltage boost is provided which is set by the user. This mode can be used for running fan or pump applications with quadratic load characteristics or for multi-motor applications. This mode is not suitable for applications requiring a high starting torque.

### 2.3.2 RFC mode

Rotor flux control provides closed loop control without the need for position feedback by using current, voltages and key motor parameters to estimate the motor speed. It can eliminate instability traditionally associated with open loop control such as operating large motors with light loads at low frequencies.

For further details, refer to section 8.1.2 *RFC mode* on page 128.

### 2.3.3 Closed loop vector mode

For use with induction motors with a feedback device installed.

The drive directly controls the speed of the motor using the feedback device to ensure the rotor speed is exactly as demanded. Motor flux is accurately controlled at all times to provide full torque all the way down to zero speed.

### 2.3.4 Servo

For use with permanent magnet brushless motors with a feedback device installed.

The drive directly controls the speed of the motor using the feedback device to ensure the rotor speed is exactly as demanded. Flux control is not required because the motor is self excited by the permanent magnets which form part of the rotor.

Absolute position information is required from the feedback device to ensure the output voltage is accurately matched to the back EMF of the motor. Full torque is available all the way down to zero speed.

### 2.3.5 Regen

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 SCR/thyristor front end.

## 2.4 Compatible encoders

Table 2-7 Encoders compatible with Unidrive SP

Encoder type	Pr 3.38 setting
Quadrature incremental encoders with or without marker pulse	Ab (0)
Quadrature incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	Ab.SErvo (3)
Forward / reverse incremental encoders with or without marker pulse	Fr (2)
Forward / reverse incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	Fr.SErvo (5)
Frequency and direction incremental encoders with or without marker pulse	Fd (1)
Frequency and direction incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	Fd.SErvo (4)
Sincos incremental encoders	SC (6)
Heidenhain sincos encoders with Endat comms for absolute position	SC.EndAt (9)
Stegmann sincos encoders with Hiperface comms for absolute position	SC.HiPEr (7)
Sincos encoders with SSI comms for absolute position	SC.SSI (11)
SSI encoders (Gray code or binary)	SSI (10)
Endat comms only encoders	EndAt (8)
UVW commutation only encoders*	Ab.SErvo (3)

\* This feedback device provides very low resolution feedback and should not be used for applications requiring a high level of performance

## 2.5 Drive features

Figure 2-1 Features of the SPz drive

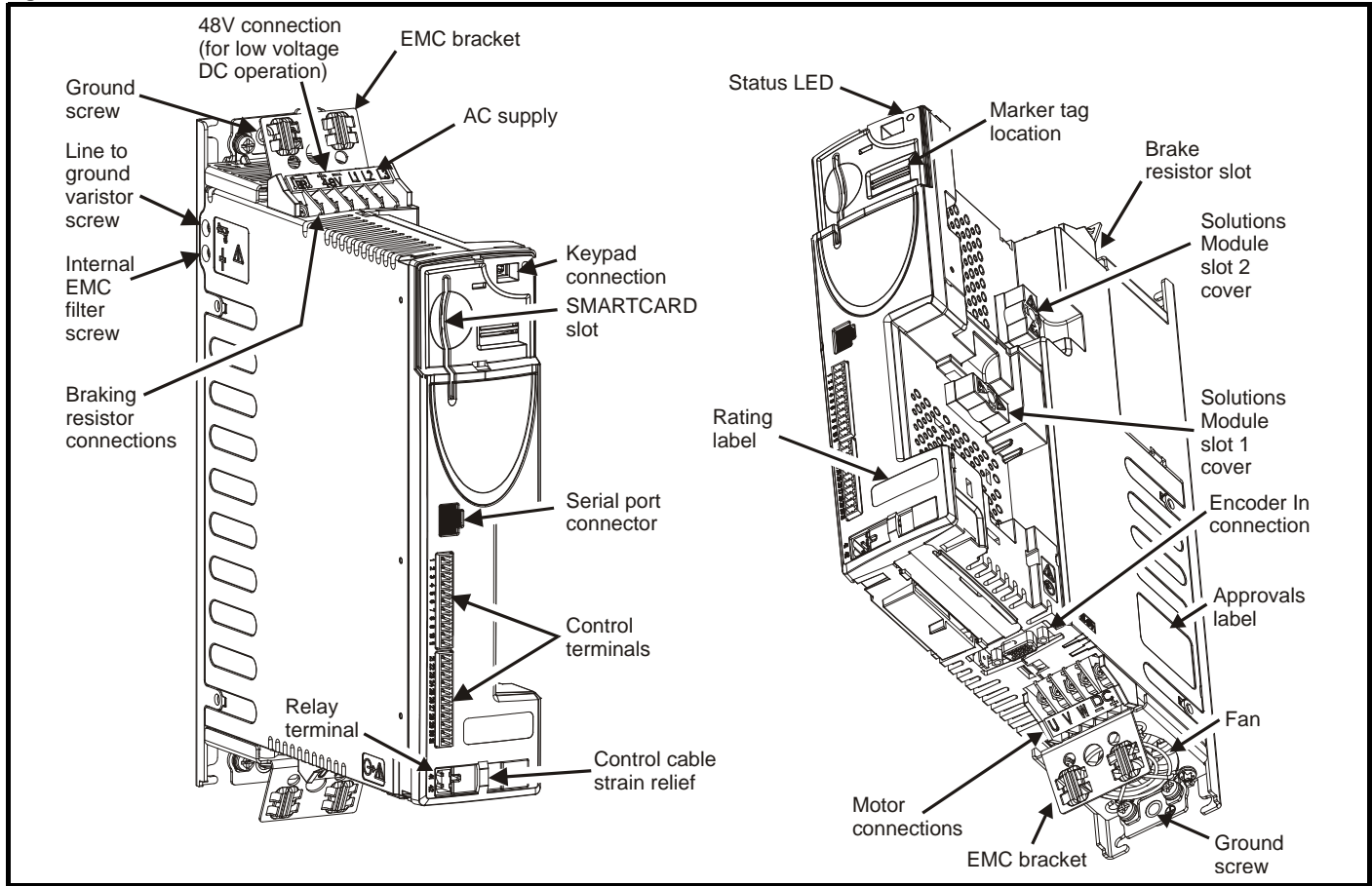
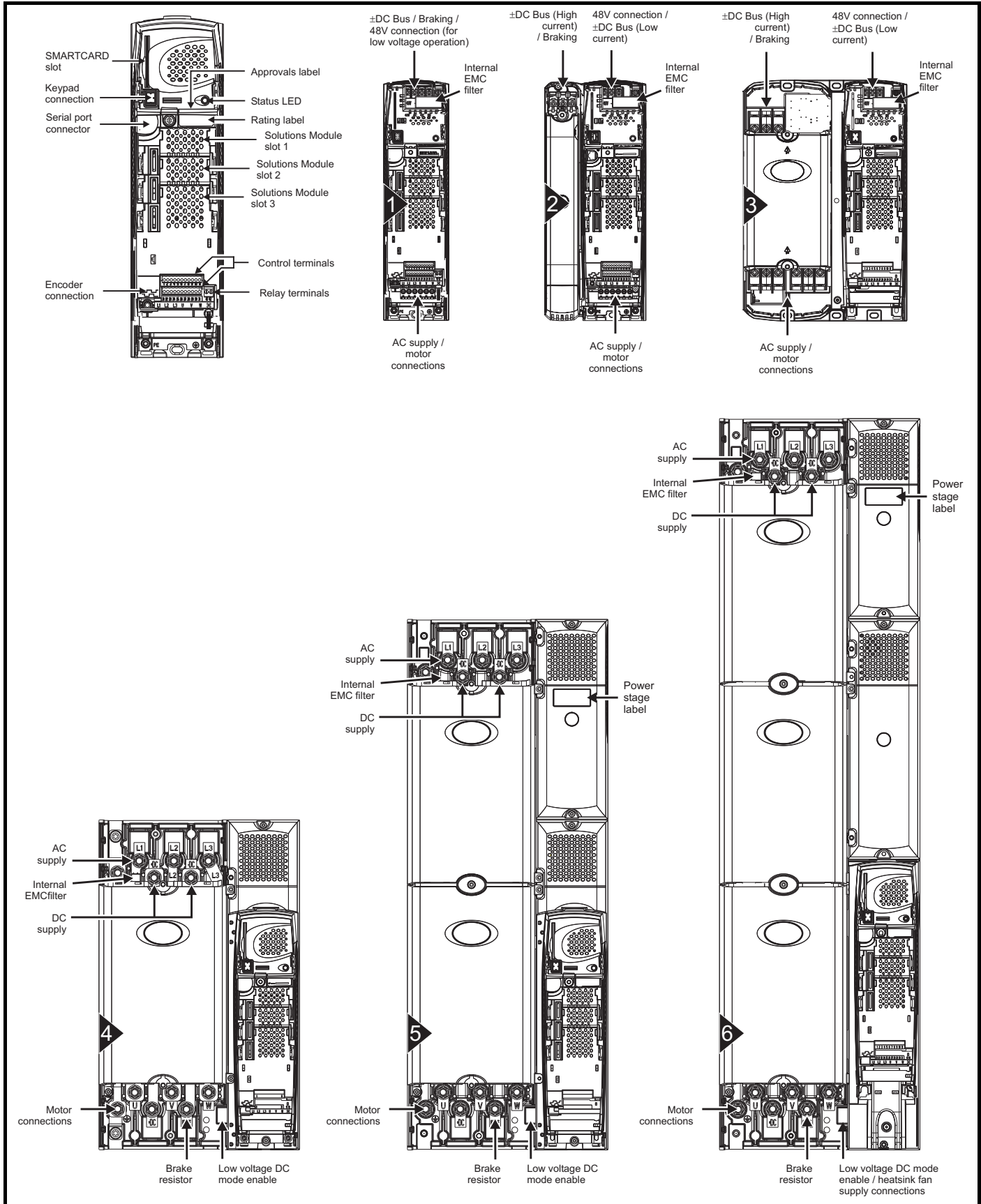


Figure 2-2 Features of the size 1 to 6 drive



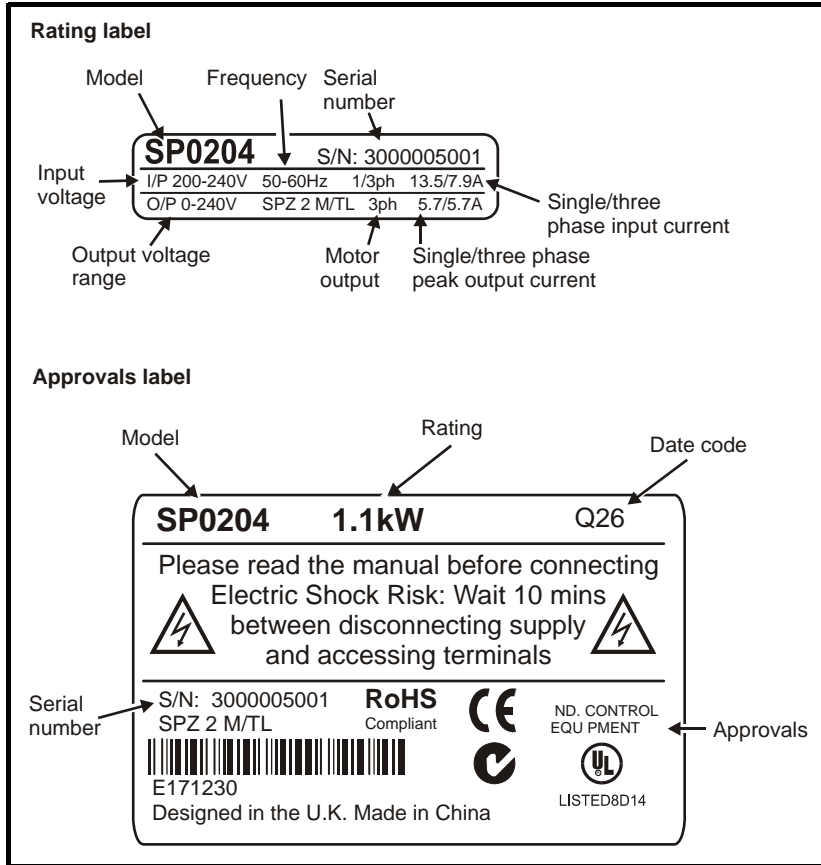
**NOTE**

The size 6 drive requires a 24V supply for the heatsink fan.

## 2.6 Nameplate description

See Figure 2-1 and Figure 2-2 for location of rating labels.

**Figure 2-3 Typical drive rating labels for SPz**



**Figure 2-4 Typical drive rating labels for size 1 to 6 drives**

### Rating label (size 1 to 6)

Input voltage rating: I/P 200-240V  
 Input frequency: 50-60Hz  
 No. of phases: 3ph  
 Typical input current for Normal Duty rating: 7.1A  
 Model: **SP1201**  
 S.No: **3000005001**  
 Output voltage range: O/P 0-240V  
 Heavy Duty / Normal Duty rating output current: SP 1,5 TL, 4.3 / 5 2A  
 Serial number: 3000005001

### Approvals label (Size 1 to 6)

Model: **SP1201**  
 Heavy Duty / Normal Duty power rating: **0.75 / 1.1kW**  
 Please read manual before connecting.  
 Electric Shock Risk: Wait 10 min between disconnecting supply & removing covers  
 SP 1,5 TL  
 Ser No: 3000005001  
 Made In U.K.  
 Customer and date code: **STDL25**  
 Approvals: UL, CE, N1652

### Key to approvals

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

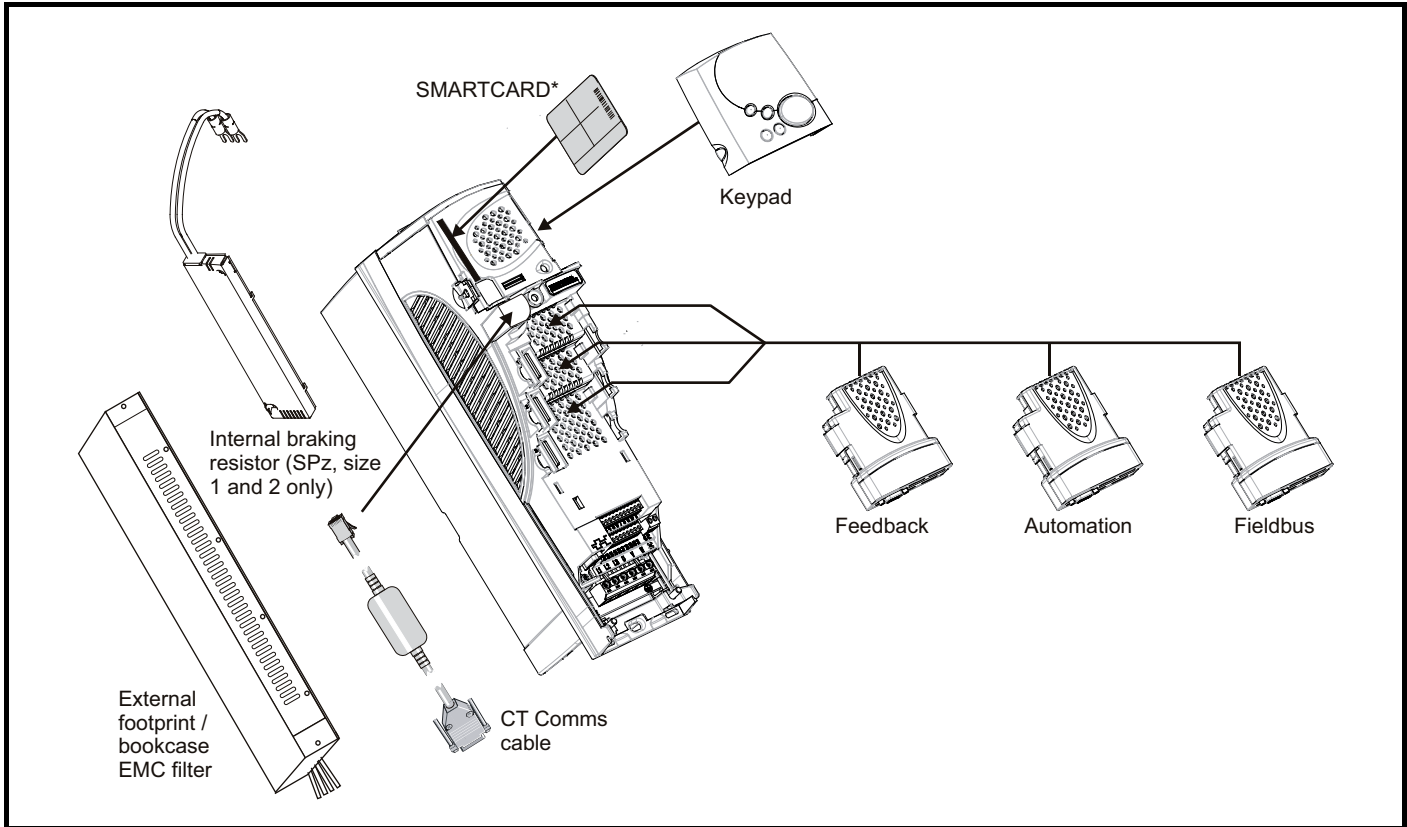
### Power stage label (Size 5 and 6 only)

Model: **SP5402**  
 Heavy Duty / Normal Duty power rating: **75 / 90kW**  
 Customer and date code: **STDN39**  
 Please read manual before connecting.  
 Electric Shock Risk: Wait 10 min between disconnecting supply & removing covers  
 Input voltage: I/P 380-480V  
 Output voltage: O/P 0-480V  
 Input frequency: 50-60Hz  
 Heavy Duty / Normal Duty rating output current: 3ph 152.0A  
 No. of phases & Typical input current for Normal Duty rating: 156 / 168A  
 Serial number: Ser No: 3000005001  
 Made In U.K.  
 Approvals: UL, CE, N1652  
 SP 100 T  
 E171230



## 2.7 Options







Figure 2-5 Options available with Unidrive SP











\* A SMARTCARD is provided as standard. For further information, refer to Chapter 9 SMARTCARD operation on page 139.

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









Table 2-8 Solutions Module identification

Type	Solutions Module	Color	Name	Further Details
Feedback		Light Green	SM-Universal Encoder Plus	<b>Universal Feedback interface</b> Feedback interface for the following devices: <b>Inputs</b> <ul style="list-style-type: none"> <li>Incremental encoders</li> <li>SinCos encoders</li> <li>SSI encoders</li> <li>EnDat encoders</li> </ul> <b>Outputs</b> <ul style="list-style-type: none"> <li>Quadrature</li> <li>Frequency and direction</li> <li>SSI simulated outputs</li> </ul>
		Light Blue	SM-Resolver	<b>Resolver interface</b> Feedback interface for resolvers. Simulated quadrature encoder outputs
		Brown	SM-Encoder Plus	<b>Incremental encoder interface</b> Feedback interface for incremental encoders without commutation signals. No simulated encoder outputs available
		Dark Brown	SM-Encoder Output Plus	<b>Incremental encoder interface</b> Feedback interface for incremental encoders without commutation signals. Simulated encoder output for quadrature, frequency and direction signals
		N/A	15-way D-type converter	<b>Drive encoder input converter</b> Provides screw terminal interface for encoder wiring and spade terminal for shield
		N/A	Single ended encoder interface (15V or 24V)	<b>Single ended encoder interface</b> Provides an interface for single ended ABZ or UVW encoder signals, such as those from hall effect sensors. 15V and 24V versions are available.




**Table 2-8 Solutions Module identification**

Type	Solutions Module	Color	Name	Further Details
Automation (I/O Expansion)		Yellow	SM-I/O Plus	<b>Extended I/O interface</b> Increases the I/O capability by adding the following to the existing I/O in the drive: <ul style="list-style-type: none"> <li>• Digital inputs x 3</li> <li>• Digital I/O x 3</li> <li>• Analog inputs (voltage) x 2</li> <li>• Analog output (voltage) x 1</li> <li>• Relay x 2</li> </ul>
		Yellow	SM-I/O 32	<b>Extended I/O interface</b> Increase the I/O capability by adding the following to the existing I/O in the drive: <ul style="list-style-type: none"> <li>• High speed digital I/O x 32</li> <li>• +24V output</li> </ul>
		Dark Yellow	SM-I/O Lite	<b>Additional I/O</b> 1 x Analog input ( $\pm 10V$ bi-polar or current modes) 1 x Analog output (0-10V or current modes) 3 x Digital input and 1 x Relay
		Dark Red	SM-I/O Timer	<b>Additional I/O with real time clock</b> As per SM-I/O Lite but with the addition of a Real Time Clock for scheduling drive running
Automation (Applications)		Dark Green	SM-Applications	<b>Applications Processor (with CTNet)</b> 2 <sup>nd</sup> processor for running pre-defined and /or customer created application software with CTNet support
		White	SM-Applications Lite	<b>Applications Processor</b> 2 <sup>nd</sup> processor for running pre-defined and /or customer created application software
		Moss Green	SM-Applications Plus	<b>Applications Processor (with CTNet)</b> 2 <sup>nd</sup> processor for running pre-defined and /or customer created application software with CTNet support. Enhanced performance over SM-Applications
		White	SM-Applications Lite V2	<b>Applications Processor</b> 2 <sup>nd</sup> processor for running pre-defined and /or customer created application software. Enhanced performance over SM-Applications Lite

**Table 2-8 Solutions Module identification**

Type	Solutions Module	Color	Name	Further Details
Fieldbus		Purple	SM-PROFIBUS-DP	<b>Profibus option</b> PROFIBUS DP adapter for communications with the drive
		Medium Grey	SM-DeviceNet	<b>DeviceNet option</b> Devicenet adapter for communications with the drive
		Dark Grey	SM-INTERBUS	<b>Interbus option</b> Interbus adapter for communications with the drive
		Light Grey	SM-CANopen	<b>CANopen option</b> CANopen adapter for communications with the drive
		Red	SM-SERCOS	<b>SERCOS option</b> Class B compliant. Torque velocity and position control modes supported with data rates (bit/s): 2MB, 4MB, 8MB and 16MB. Minimum 250µs network cycle time. Two digital high speed probe inputs 1µs for position capture
		Beige	SM-Ethernet	<b>Ethernet option</b> 10 base-T / 100 base-T; Supports web pages, SMTP mail and multiple protocols: DHCP IP addressing; Standard RJ45 connection
		Brown Red	SM-EtherCAT	<b>EtherCAT option</b> EtherCAT adapter for communications with the drive
		Pale Green	SM-LON	<b>LonWorks option</b> LonWorks adapter for communications with the drive

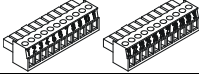


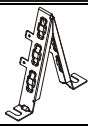
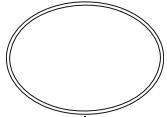
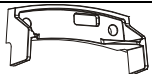
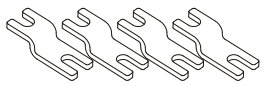
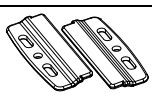
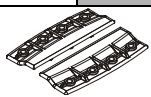
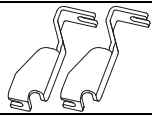




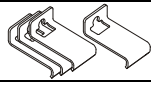

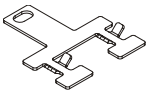
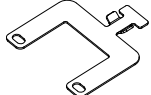
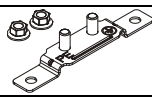

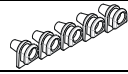







**Table 2-9 Keypad identification**

Type	Keypad	Name	Further Details
Keypad		SPz Keypad	<b>LED keypad option</b> Keypad with a LED display for SPz
		SM-Keypad	<b>LED keypad option</b> Keypad with a LED display for size 1 to 9
		SM-Keypad Plus	<b>LCD keypad option</b> Keypad with an alpha-numeric LCD display with Help function

## 2.8 Items supplied with the drive

The drive is supplied with a printed manual, a SMARTCARD, a safety information booklet, the Certificate of Quality, an accessory kit box including the items shown in Table 2-10, and a CD ROM containing all related product documentation and software tools.

**Table 2-10 Parts supplied with the drive**

Description	SPz	Size 1	Size 2	Size 3	Size 4	Size 5	Size 6
Control connectors							
Relay connector							
UL warning label							
Grounding bracket							
Through panel mounting gasket							
Through panel mounting bracket							
Surface mounting brackets							
Top surface mounting brackets							
Nylon washers							
Sealing clips							
Mounting screws							
Grounding clamp							
Ground cable bridge and M5 nuts							
DC terminal cover grommets							
Ferrite ring							
Supply and motor connector							
Ground mounting screws							
Fan supply connector							
IP54 gasket							
IP54 insert							

## 3 Mechanical Installation

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

- Through-hole mounting
- IP54 as standard or through-panel mounting
- Enclosure sizing and layout
- Solutions Module fitting
- Terminal location and torque settings

### 3.1 Safety information



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



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



**Many of the drives in this product range weigh in excess of 15kg (33lb). Use appropriate safeguards when lifting these models.**  
A full list of drive weights can be found in section 12.1.19 *Weights* on page 250.



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

### 3.2 Planning the installation

The following considerations must be made when planning the installation:

#### 3.2.1 Access

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

The IP (Ingress Protection) rating of the drive is installation dependent. For further information, please refer to section 3.9 *Enclosing standard drive for high environmental protection* on page 40.

#### 3.2.2 Environmental protection

The drive must be protected from:

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

#### NOTE

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

#### 3.2.3 Cooling

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

For further information, refer to section 3.6.2 *Enclosure sizing* on page 38.

#### 3.2.4 Electrical safety

The installation must be safe under normal and fault conditions. Electrical installation instructions are given in Chapter 4 *Electrical Installation* on page 57.

#### 3.2.5 Fire protection

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

#### 3.2.6 Electromagnetic compatibility

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

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

If it is necessary to meet strict emission limits, or if it is known that electromagnetically sensitive equipment is located nearby, then full precautions must be observed. In-built into the drive, is an internal EMC filter, which reduces emissions under certain conditions. If these conditions are exceeded, then the use of an external EMC filter may be required at the drive inputs, which must be located very close to the drives. Space must be made available for the filters and allowance made for carefully segregated wiring. Both levels of precautions are covered in section 4.11 *EMC (Electromagnetic compatibility)* on page 71.

#### 3.2.7 Hazardous areas

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

### 3.3 Terminal cover removal



#### Isolation device

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



#### Stored charge

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

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

#### 3.3.1 Removing the terminal covers

SPz is not fitted with any terminal covers.

Size 1 is fitted with two terminal covers: Control and DC terminal covers.

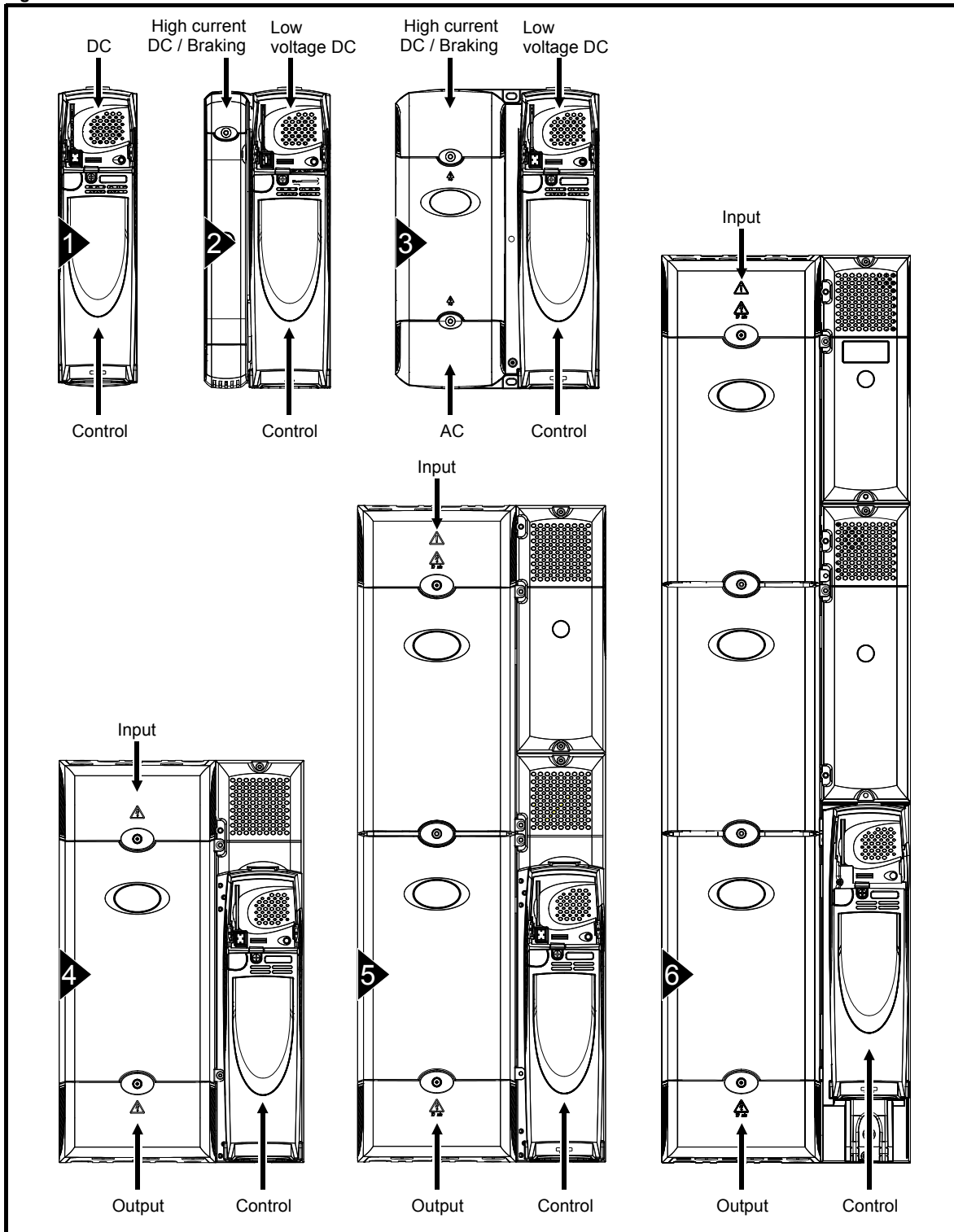
Size 2 is fitted with three terminal covers: Control, High current DC / Braking and low voltage DC terminal covers.

Size 3 is fitted with four terminal covers: Control, High current DC / Braking, low voltage DC and AC terminal covers.

Size 4, 5 and 6 are fitted with three terminal covers: Control, input and output terminal covers.

In order to provide access to the mounting holes when a size 1, 2 or 3 drive is through-panel mounted, the control terminal cover must be removed. For size 3 the high current DC / Braking and AC terminal covers must also be removed. Once the drive has been mounted, the terminal covers can be replaced.

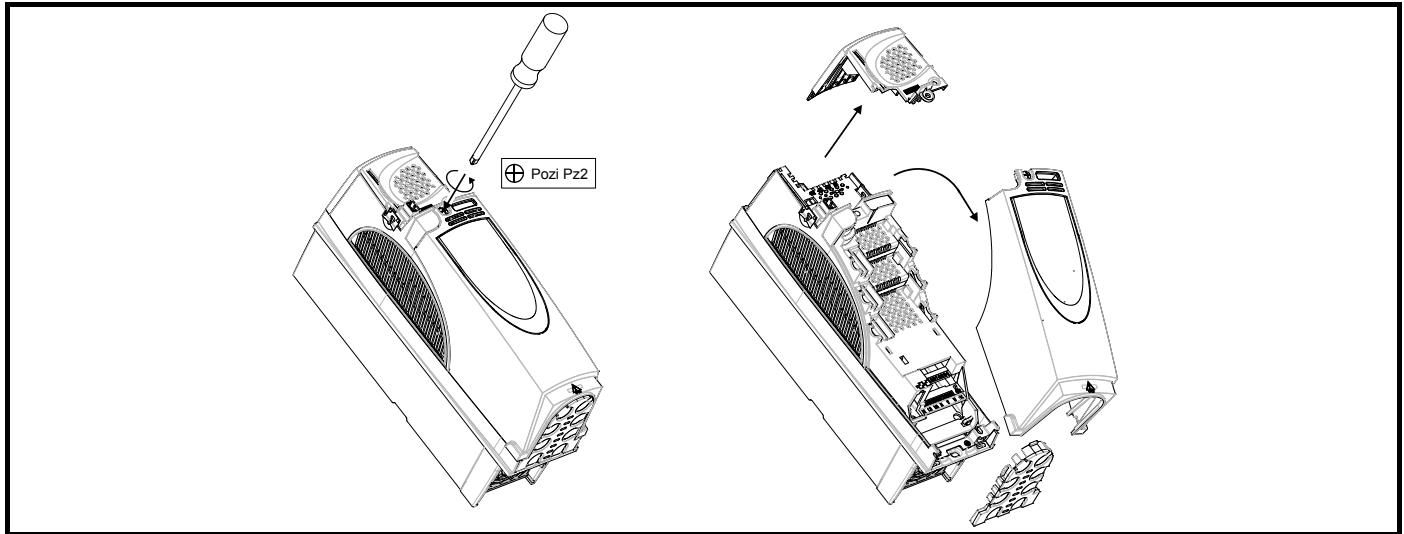
**Figure 3-1 Location and identification of terminal covers**



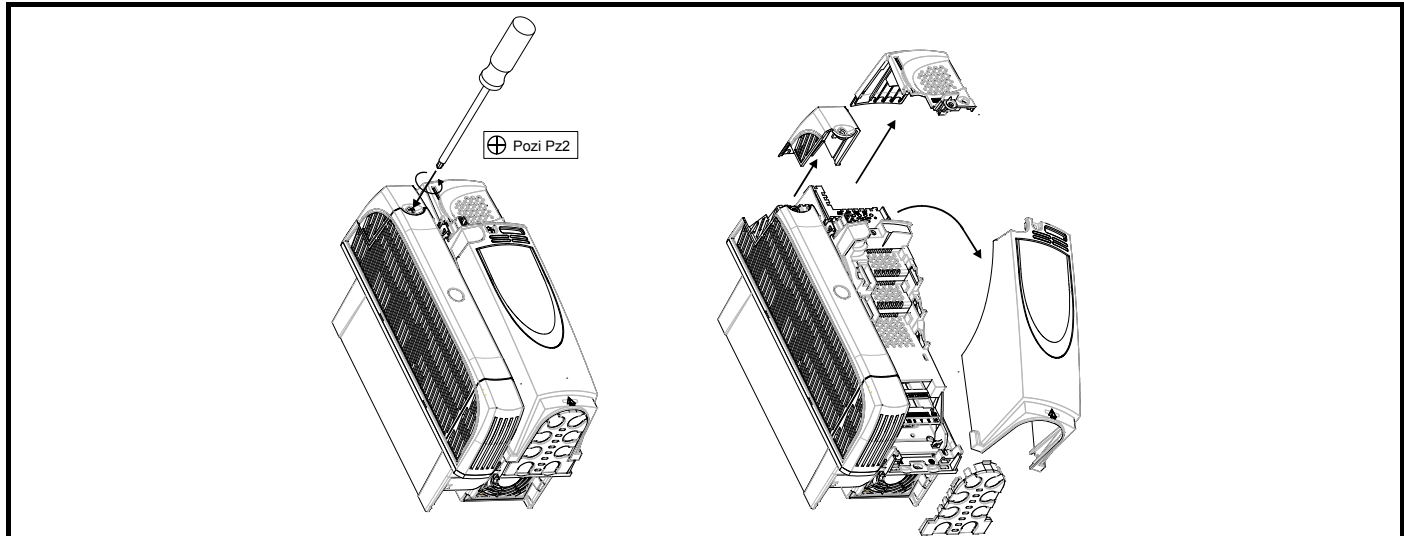
To remove a terminal cover, undo the screw and lift the terminal cover off as shown. The control terminal cover must be removed first before the DC (size 1) / low voltage DC (sizes 2 and 3) terminal cover can be removed.

When replacing the terminal covers the screws should be tightened with a maximum torque of 1 N m (0.7 b ft).

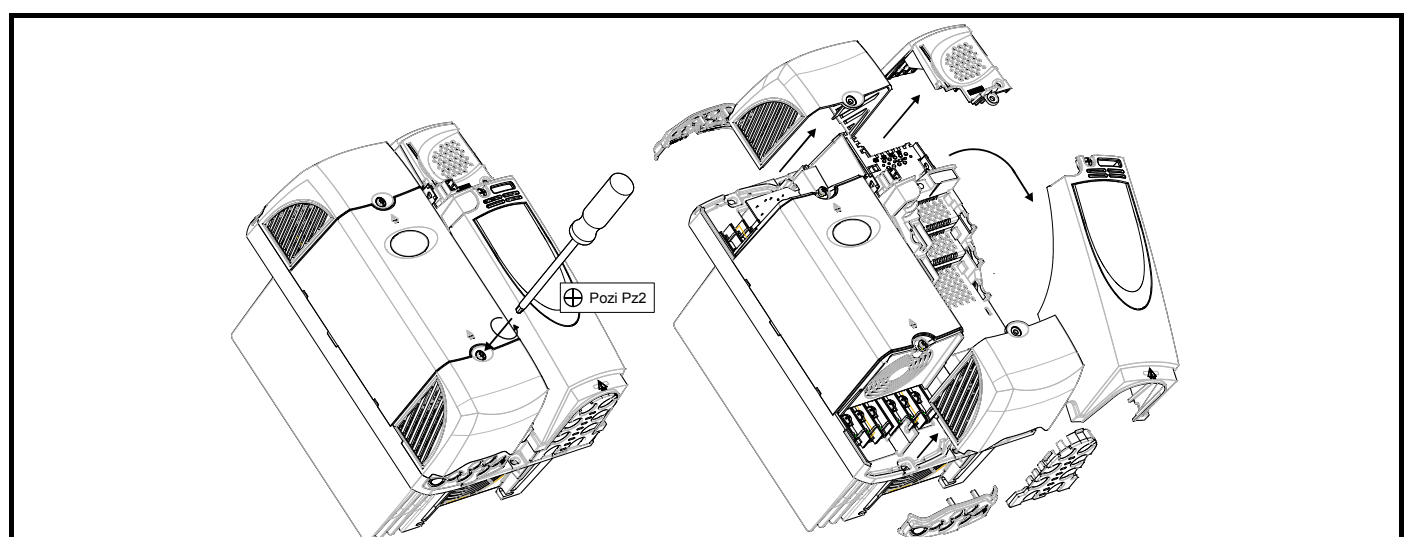
**Figure 3-2 Removing the size 1 terminal covers**



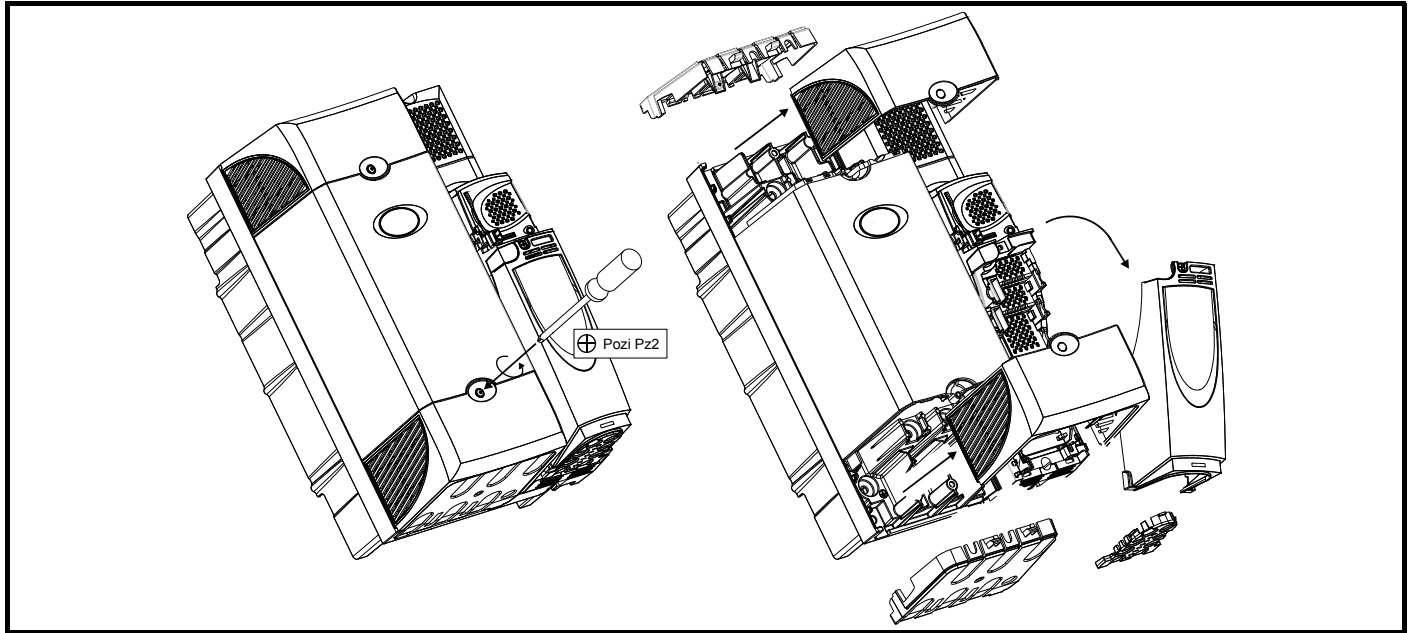
**Figure 3-3 Removing the size 2 terminal covers**



**Figure 3-4 Removing the size 3 terminal covers**

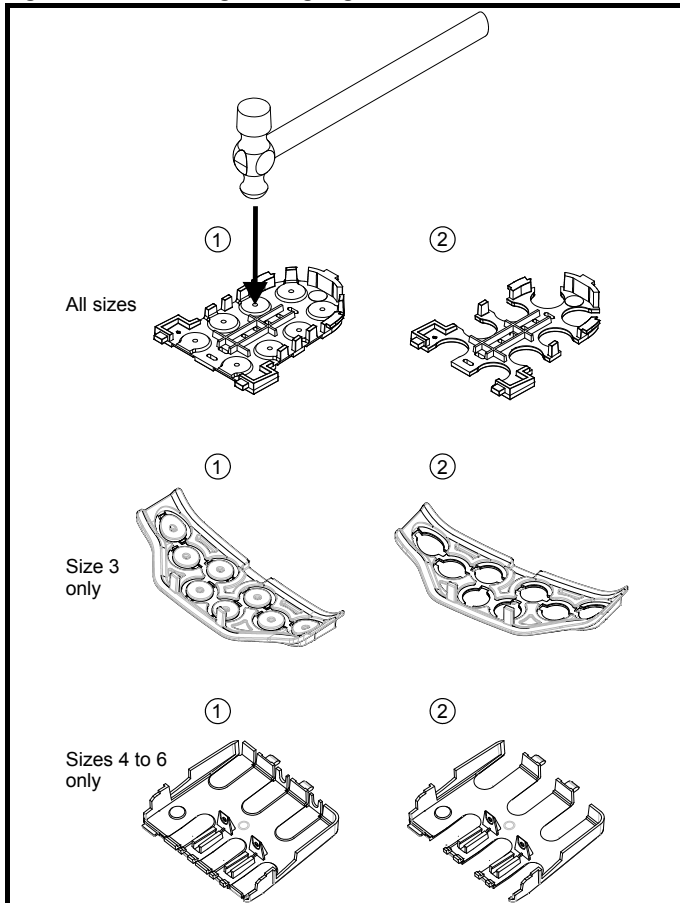


**Figure 3-5 Removing the size 4, 5 and 6 terminal covers (size 4 illustrated)**



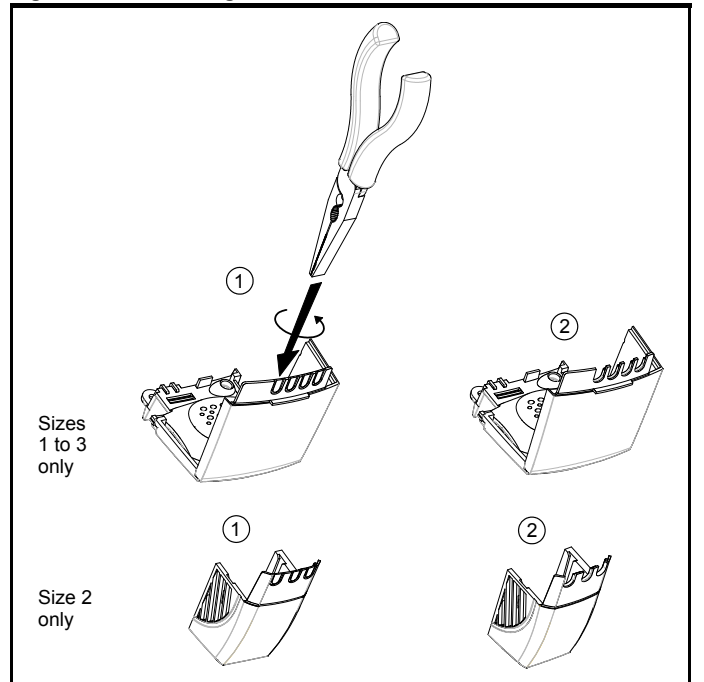
### 3.3.2 Removing the finger-guard and DC terminal cover break-outs

**Figure 3-6 Removing the finger-guard break-outs**



Place finger-guard on a flat solid surface and hit relevant break-outs with hammer as shown (1). Continue until all required break-outs are removed (2). Remove any flash / sharp edges once the break-outs are removed.

**Figure 3-7 Removing the DC terminal cover break-outs**



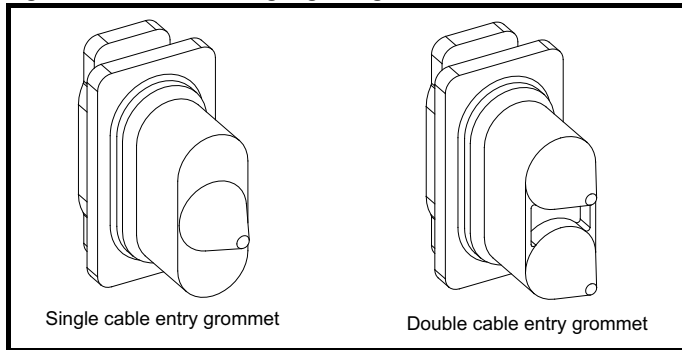
Grasp the DC terminal cover break-outs with pliers as shown (1) and twist to remove. Continue until all required break-outs are removed (2).

Remove any flash / sharp edges once the break-outs are removed. Use the DC terminal cover grommets supplied in the accessory box (Table 2-10 on page 20) to maintain the seal at the top of the drive.

Grommets are available for the size 4 to 6 finger-guards. Two versions are available allowing for either single or double cable entries. These are not required if the optional conduit box is installed.



**Figure 3-8 Size 4 to 6 finger-guard grommets**




The grommets are available as a kit of four grommets under the following part numbers:

9500-0074 Kit of four single entry grommets

9500-0075 Kit of four double entry grommets

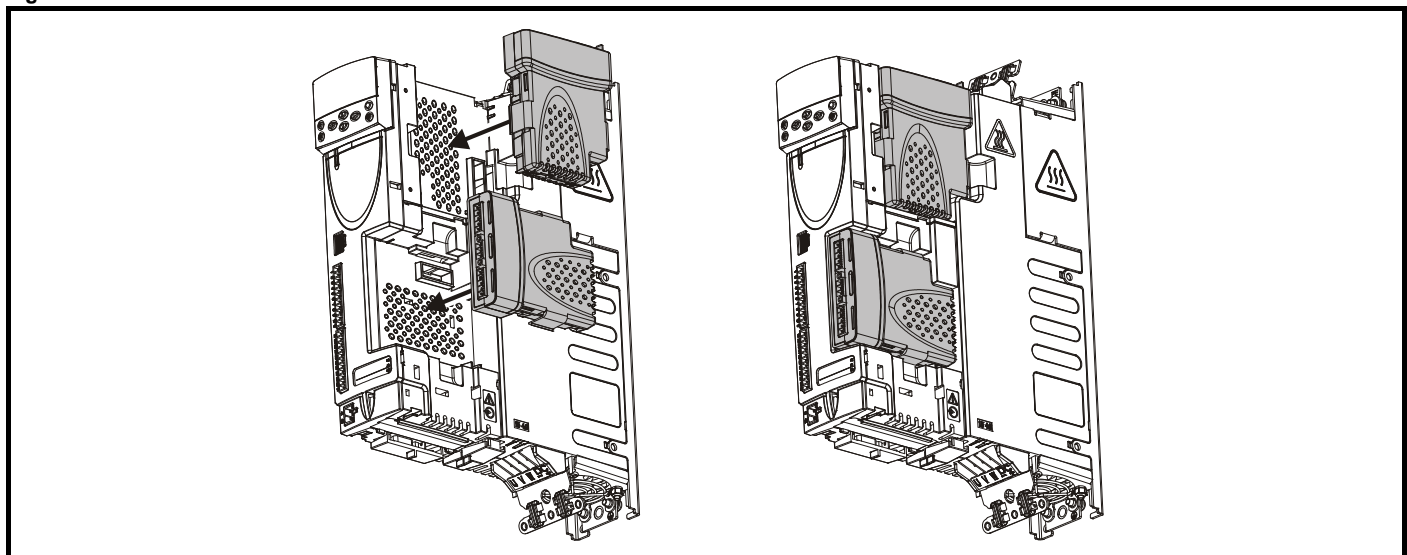
### 3.4 Solutions Module / keypad installation / removal



Power down the drive before installing / removing the Solutions Module. Failure to do so may result in damage to the product.

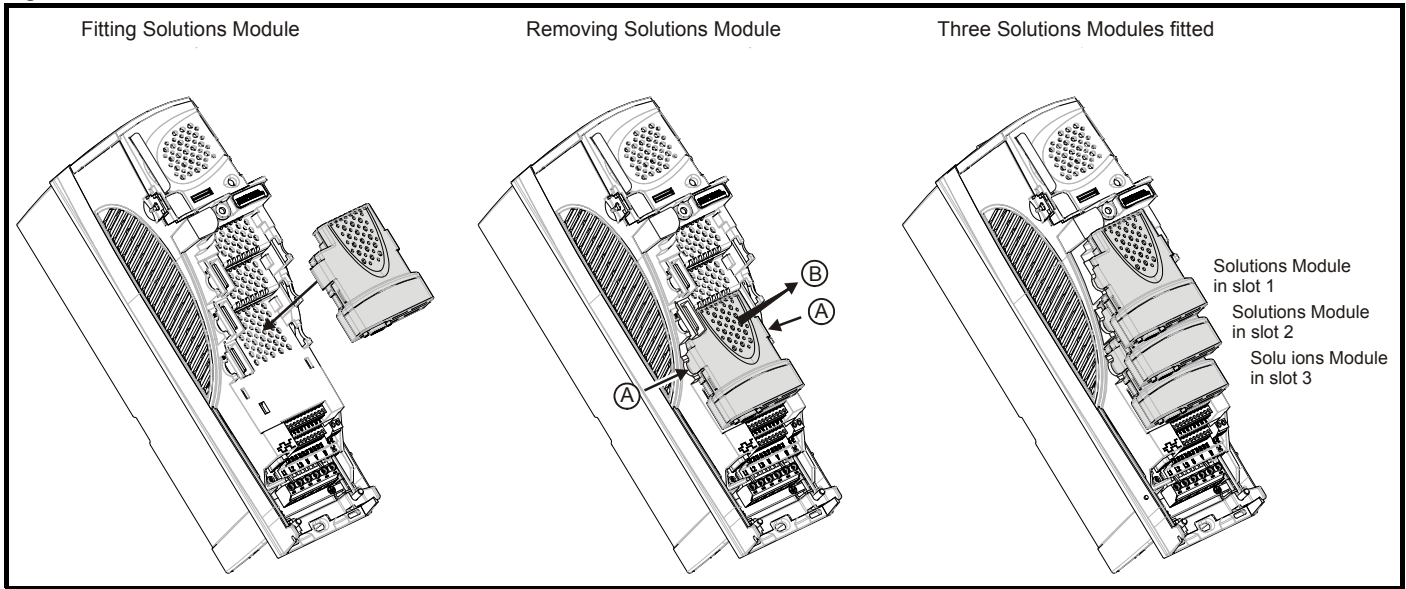
**CAUTION**

**Figure 3-9 Installation of a Solutions Module on SPz**



**NOTE**  
On SPz the protective tab from the Solutions Module slot must be removed before attempting to fit a Solutions Module.

**Figure 3-10 Installation and removal of a Solutions Module on size 1 to 6**



To install the Solutions Module, press down in the direction shown above until it clicks into place.

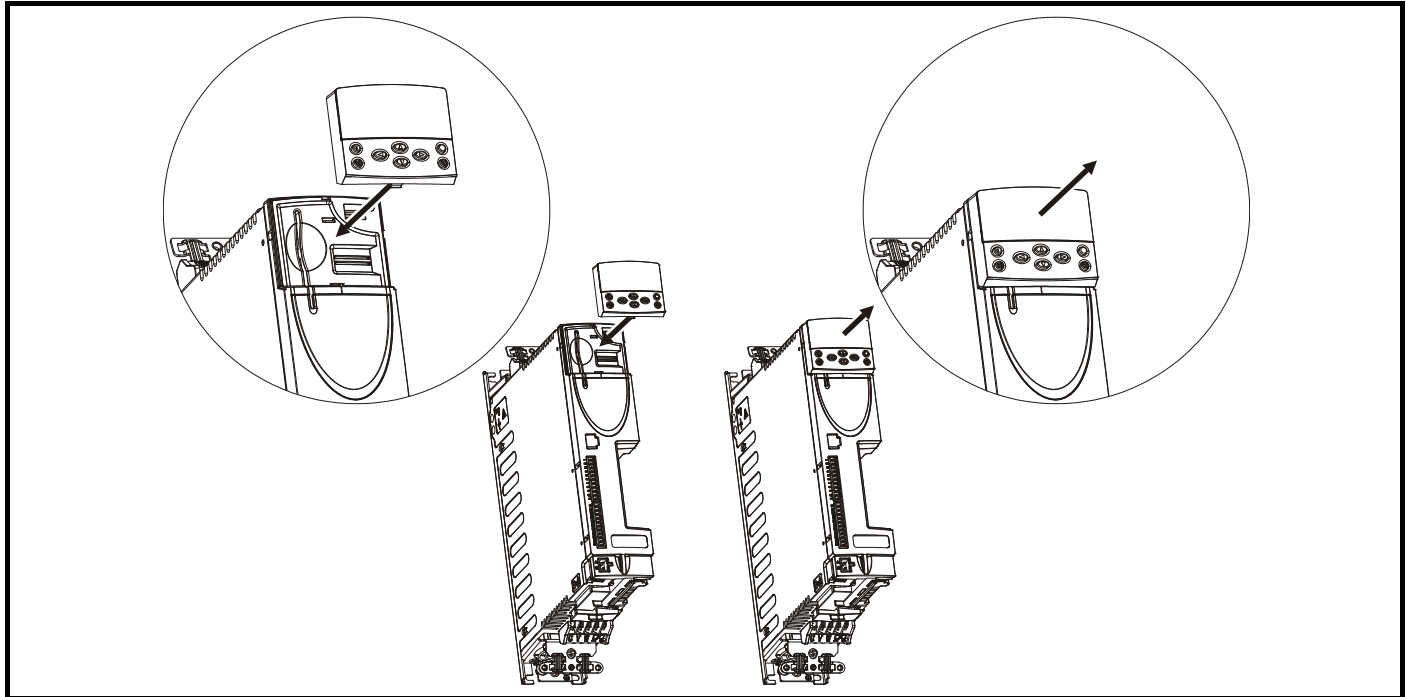
To remove the Solutions Module, press inwards at the points shown (A) and pull in the direction shown (B).

The drive has the facility for all three Solutions Module slots to be used at the same time, as illustrated.

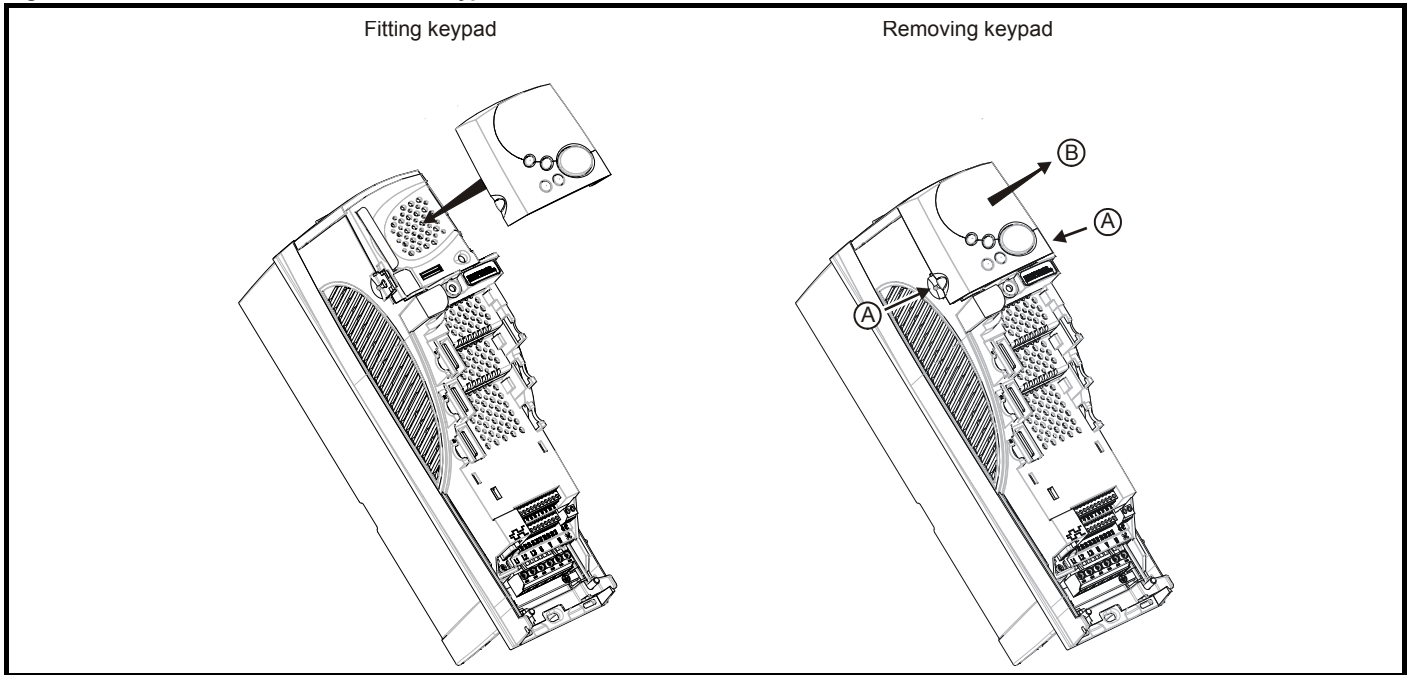
**NOTE**

It is recommended that the Solutions Module slots are used in the following order: slot 3, slot 2 and slot 1.

**Figure 3-11 Installation of a keypad on SPz**



**Figure 3-12 Installation and removal of a keypad on size 1 to 6**



To install, align the keypad and press gently in the direction shown until it clicks into position.

To remove, while pressing the tabs inwards (A), gently lift the keypad in the direction indicated (B).

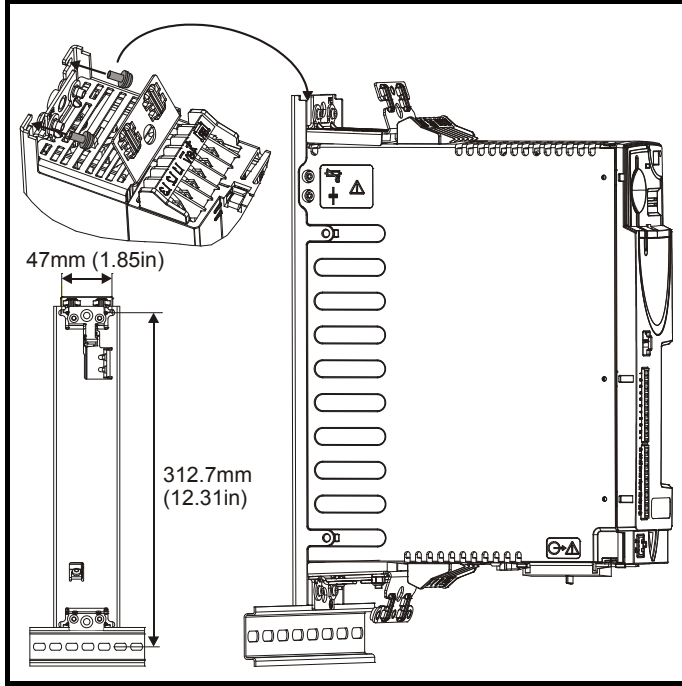
**NOTE**

The keypad can be installed / removed while the drive is powered up and running a motor, providing that the drive is not operating in keypad mode.

### 3.5 Mounting methods

SPz can be mounted using a DIN rail, either fixed at the top or the bottom of the drive (as illustrated in Figure 3-13). Two screws are required to fix the drive to the backplate at the opposite end to the DIN rail.

**Figure 3-13 Mounting the SPz using a DIN rail**



Unidrive SP size 1 to 6 units can be either surface or through-panel mounted using the appropriate brackets. SPz can only be surface mounted.

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



If the drive has been used at high load levels for a period of time, the heatsink can reach temperatures in excess of 70°C (158°F). Human contact with the heatsink should be prevented.

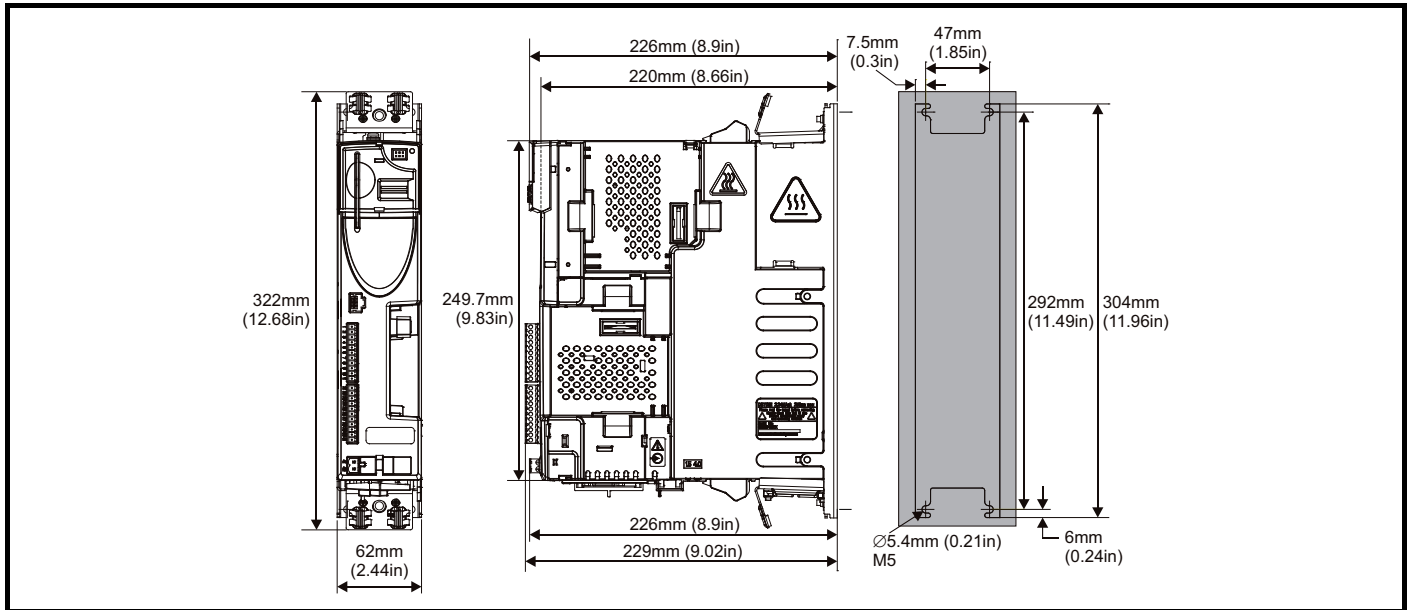


Many of the drives in this product range weigh in excess of 15kg (33lb). Use appropriate safeguards when lifting these models.

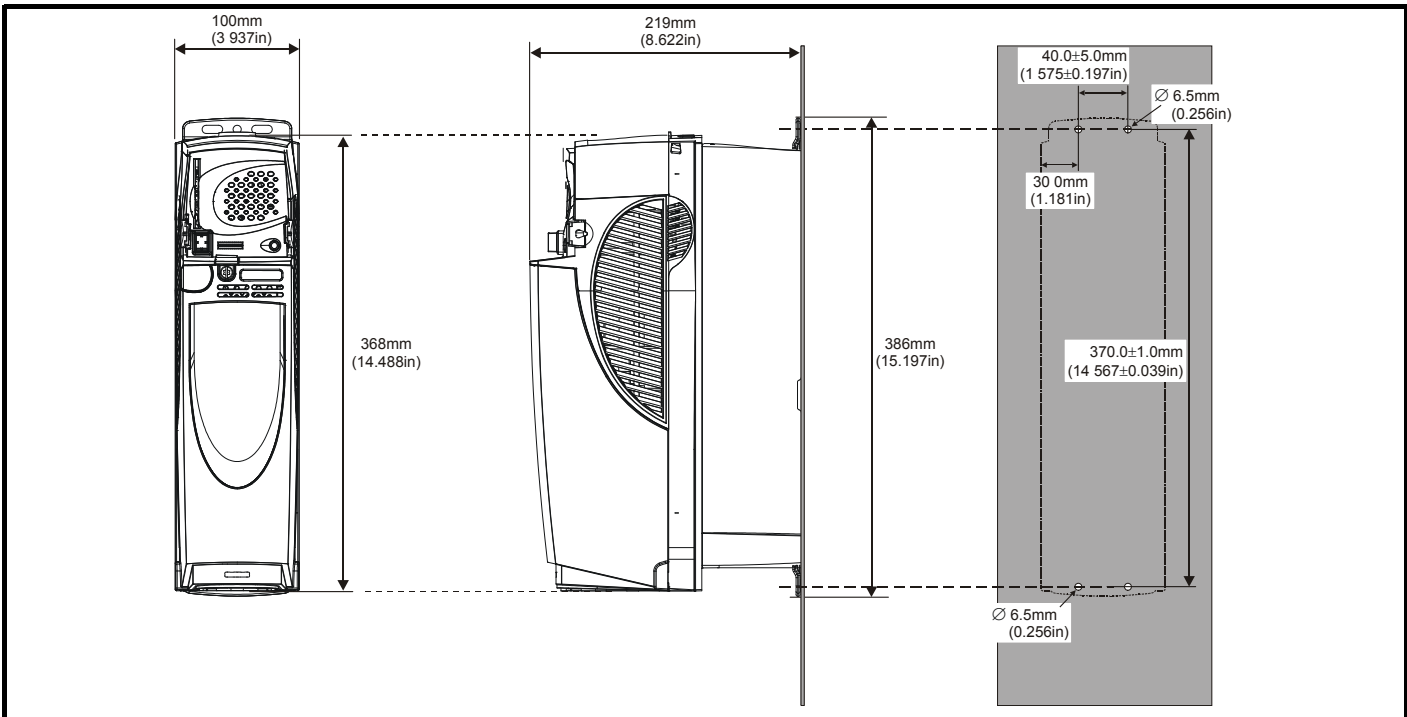
A full list of drive weights can be found in section 12.1.19 *Weights* on page 250.

#### 3.5.1 Surface mounting

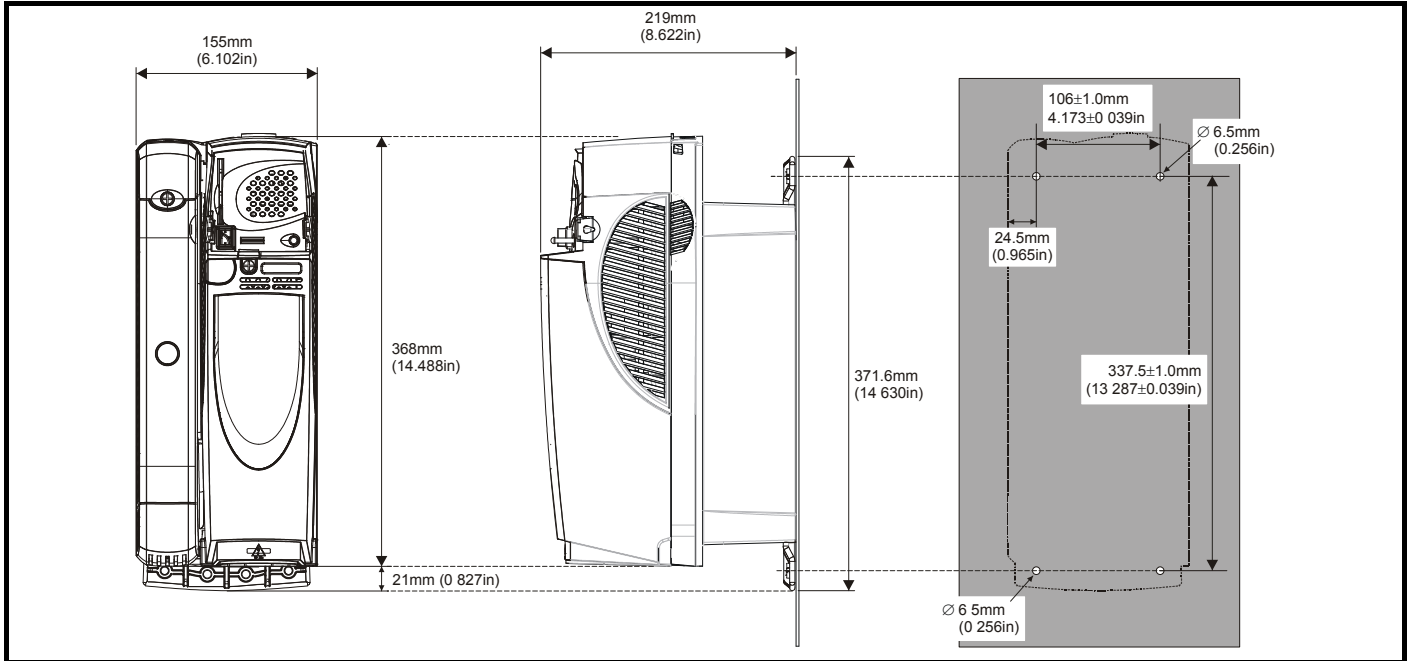
**Figure 3-14 Surface mounting the SPz drive**



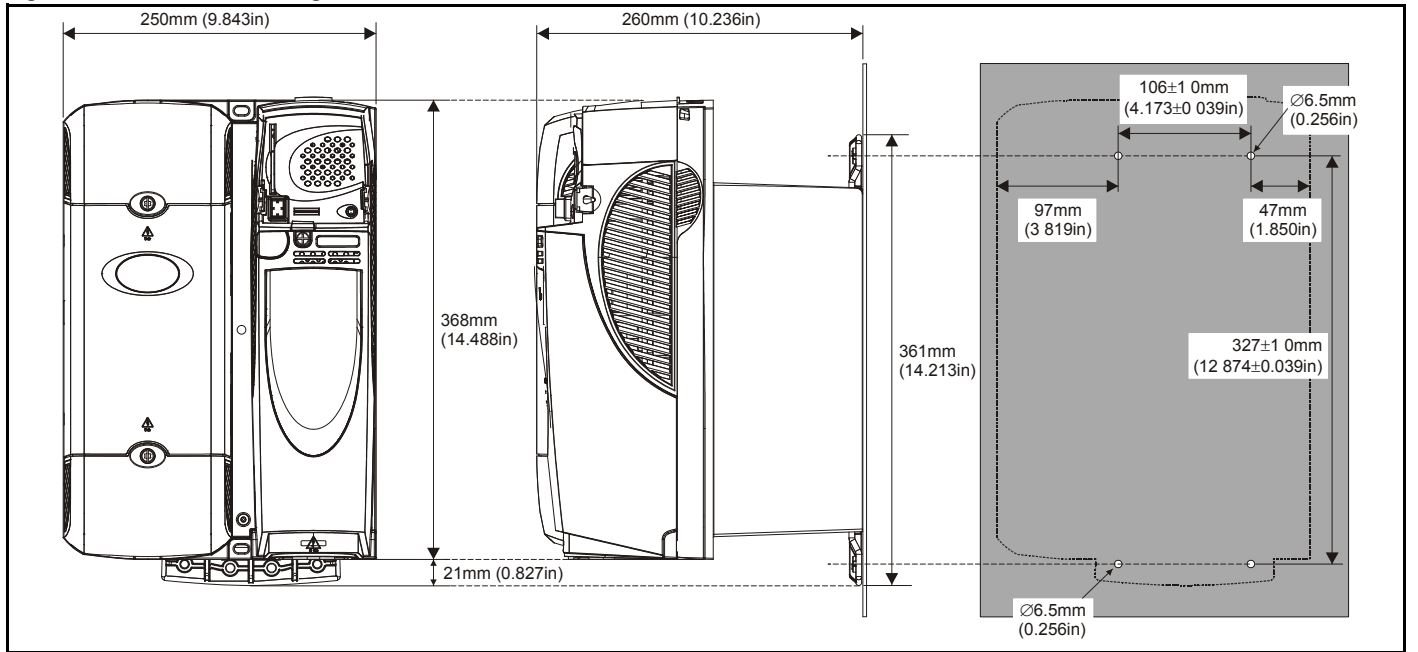
**Figure 3-15 Surface mounting the size 1 drive**



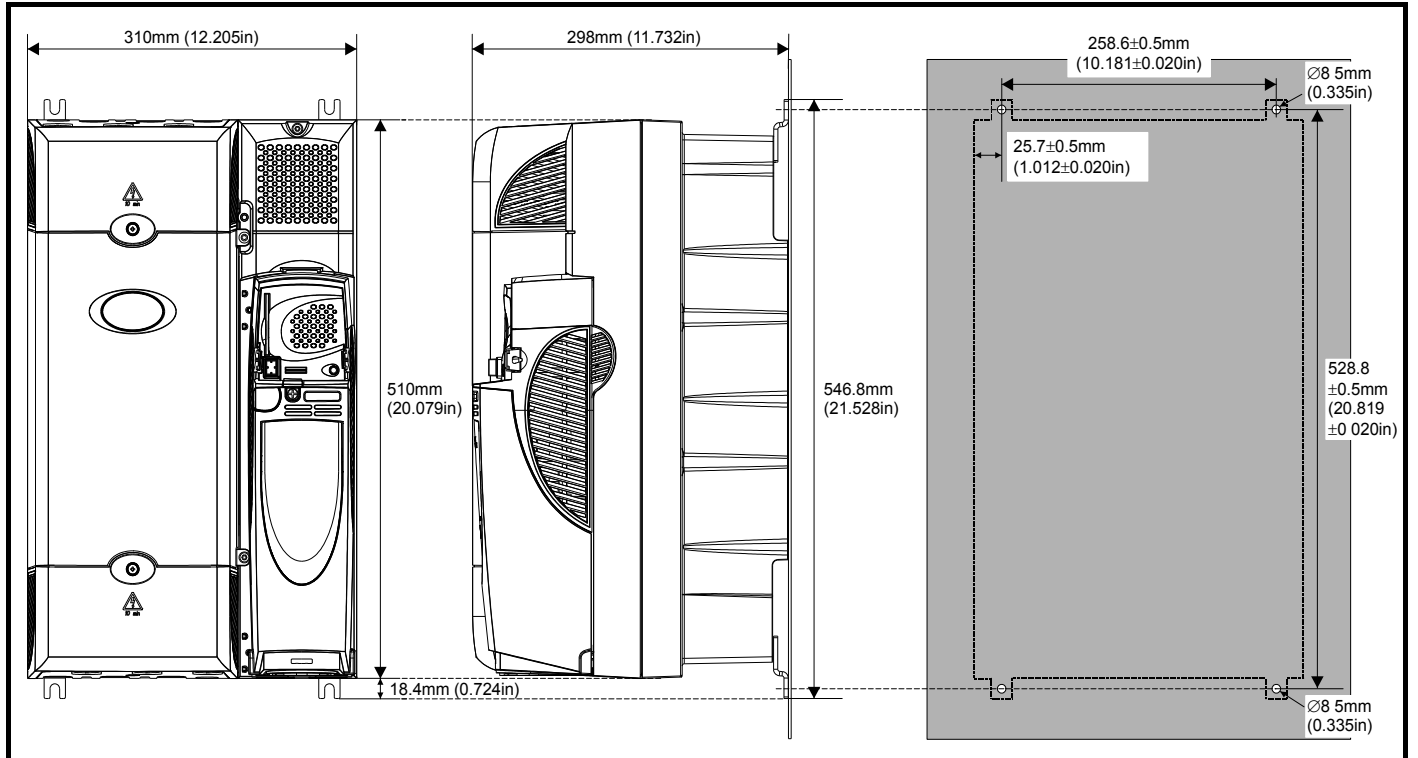
**Figure 3-16 Surface mounting the size 2 drive**



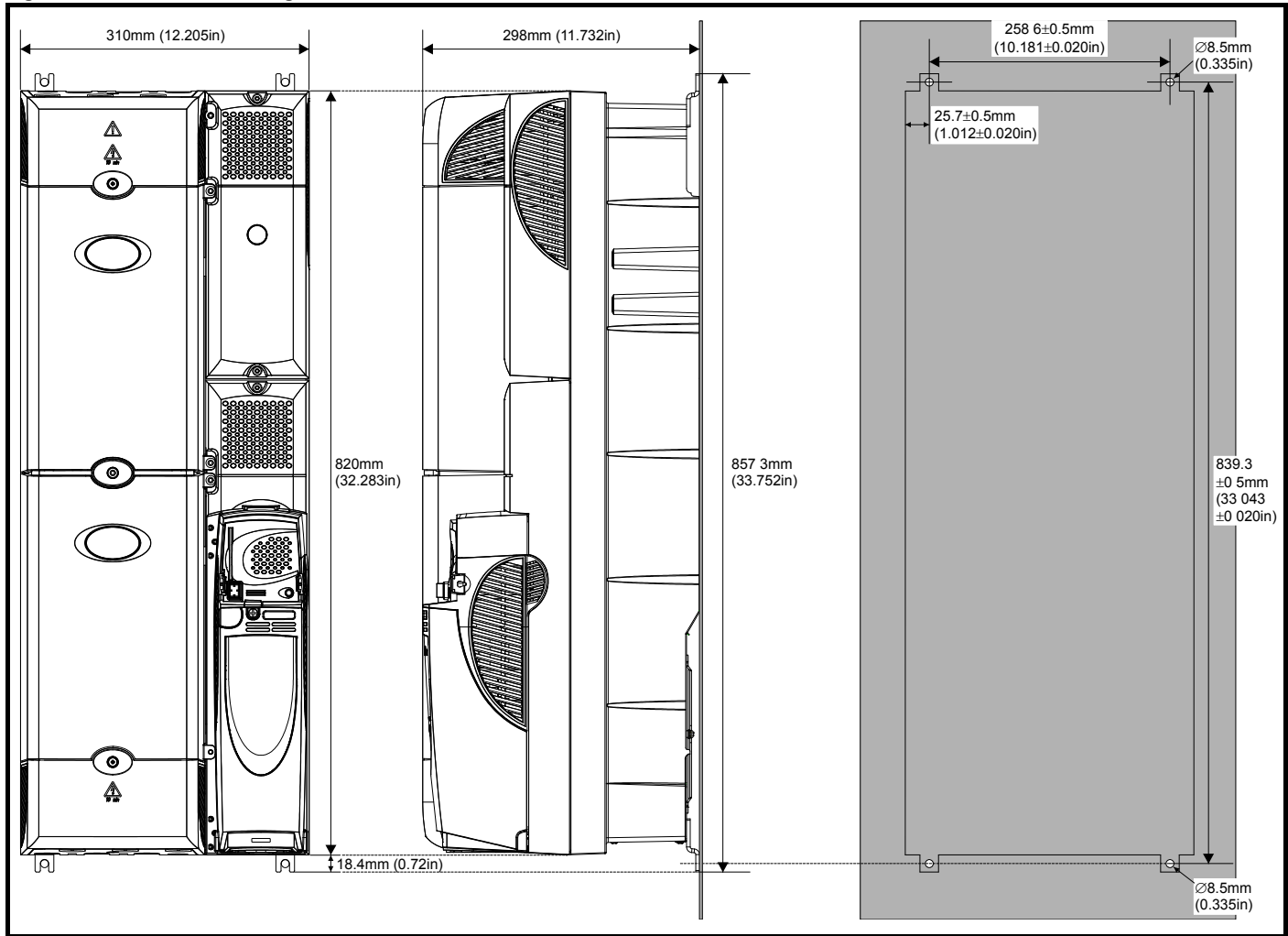
**Figure 3-17 Surface mounting the size 3 drive**



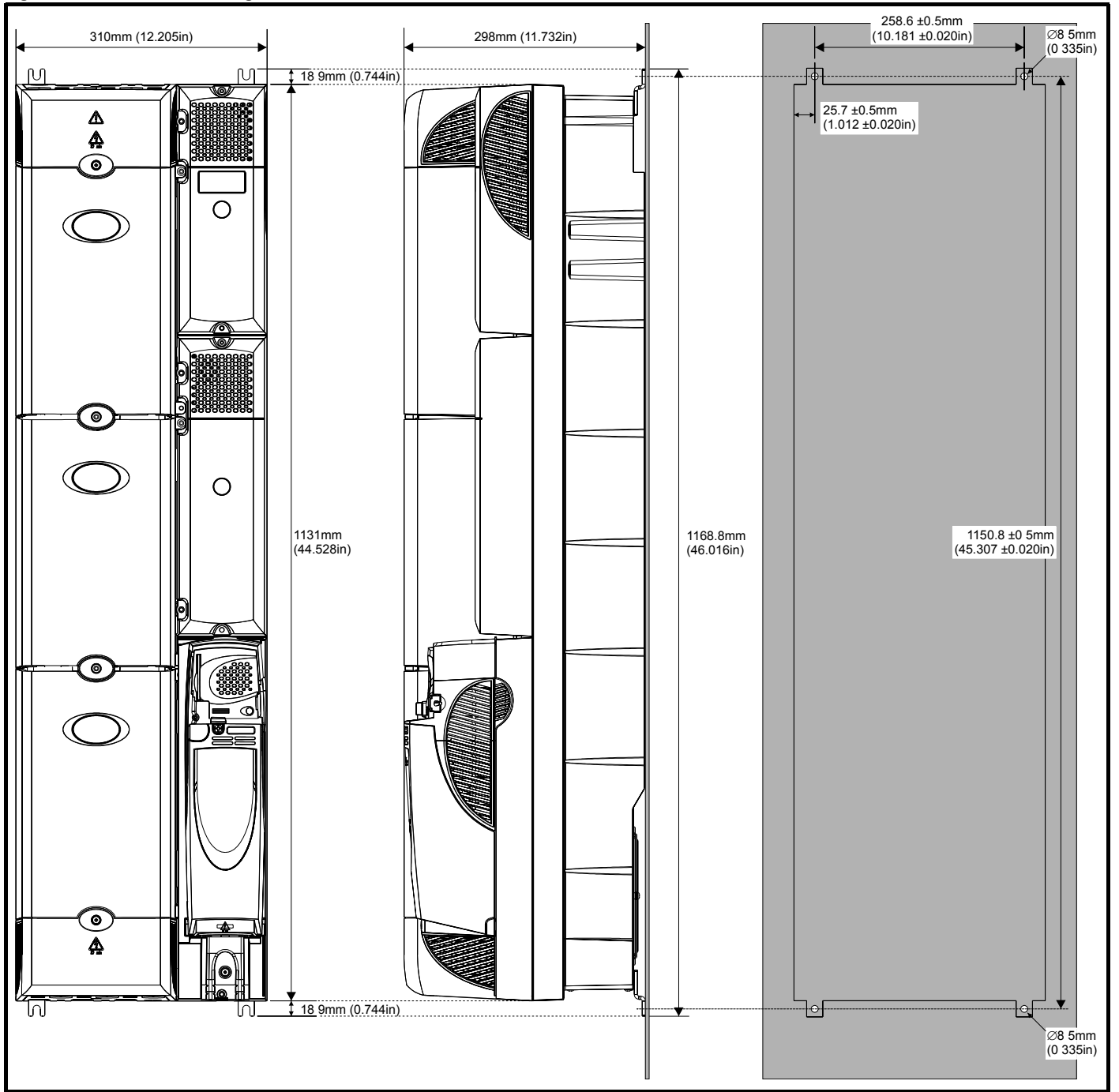
**Figure 3-18 Surface mounting the size 4 drive**



**Figure 3-19 Surface mounting the size 5 drive**



**Figure 3-20 Surface mounting the size 6 drive**

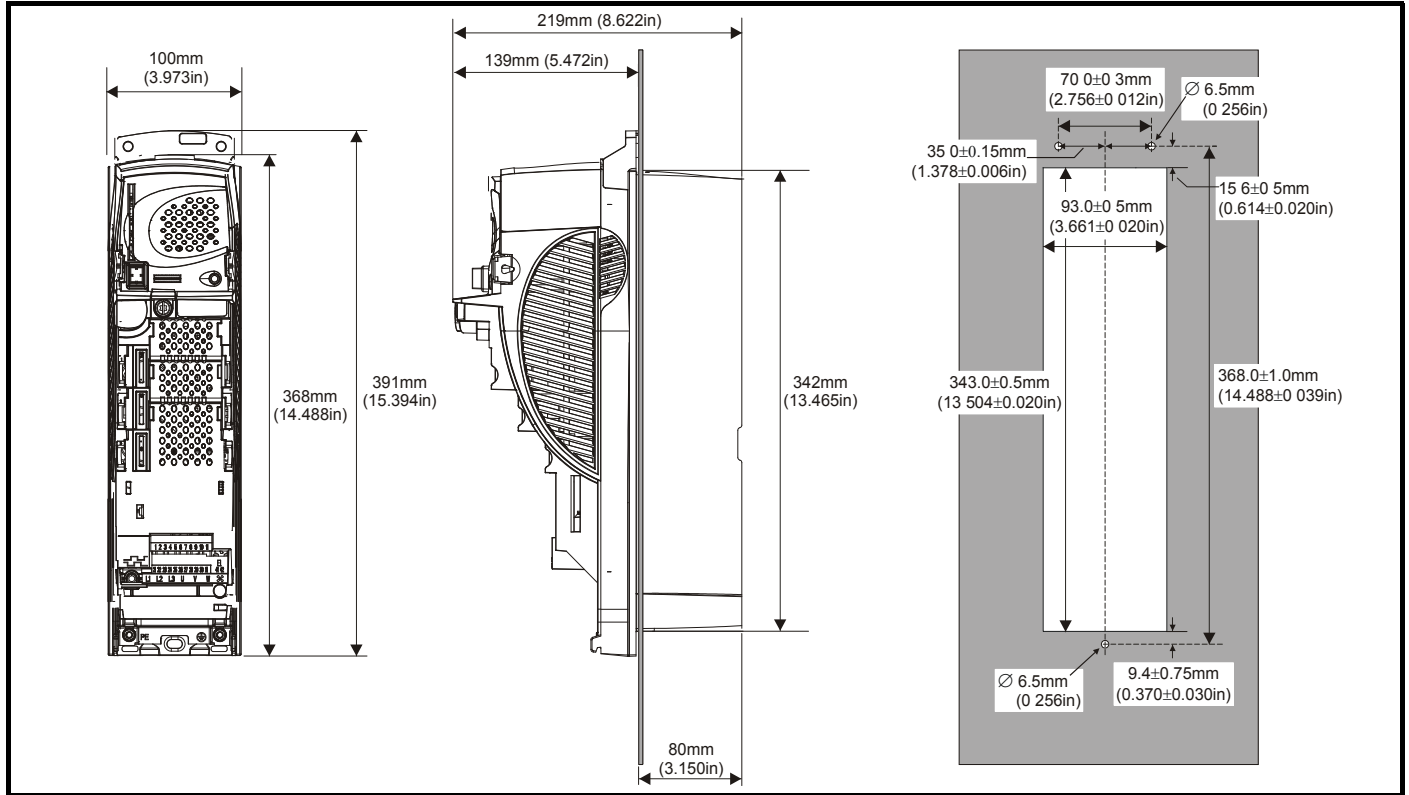




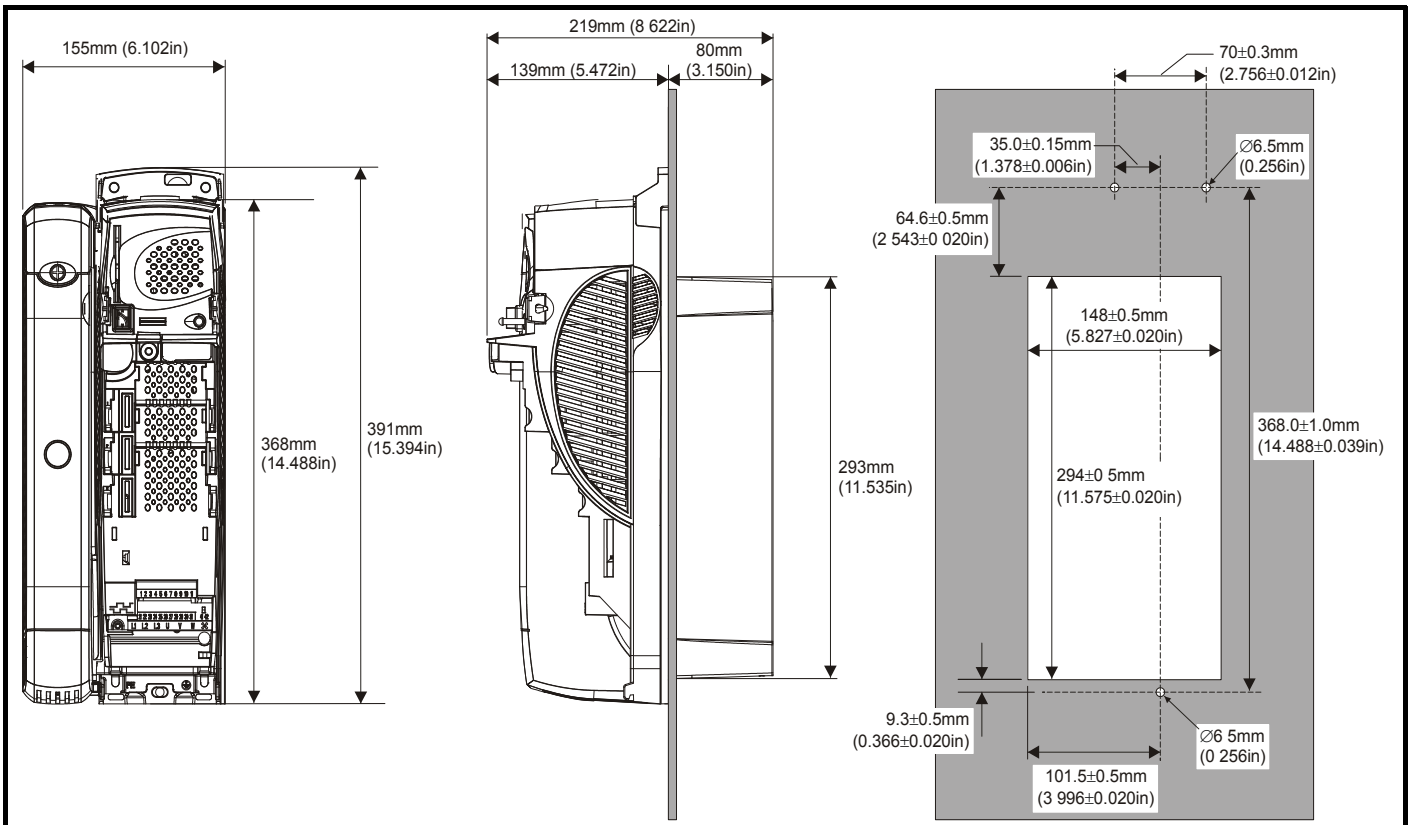
### 3.5.2 Through-panel mounting

When the drive is through-panel mounted, the main terminal cover(s) must be removed in order to provide access to the mounting holes. Once the drive has been mounted, the terminal cover(s) can be replaced.

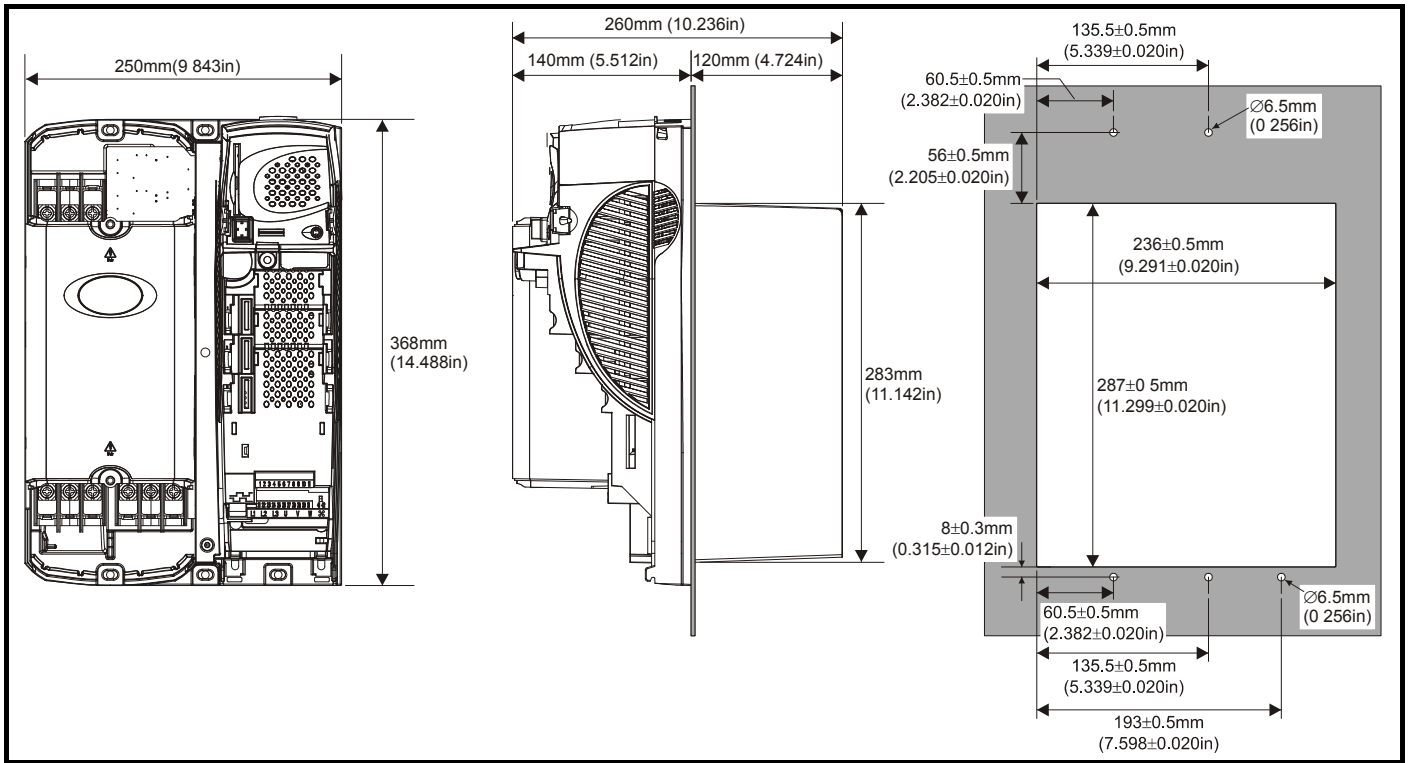
**Figure 3-21 Through-panel mounting the size 1 drive**



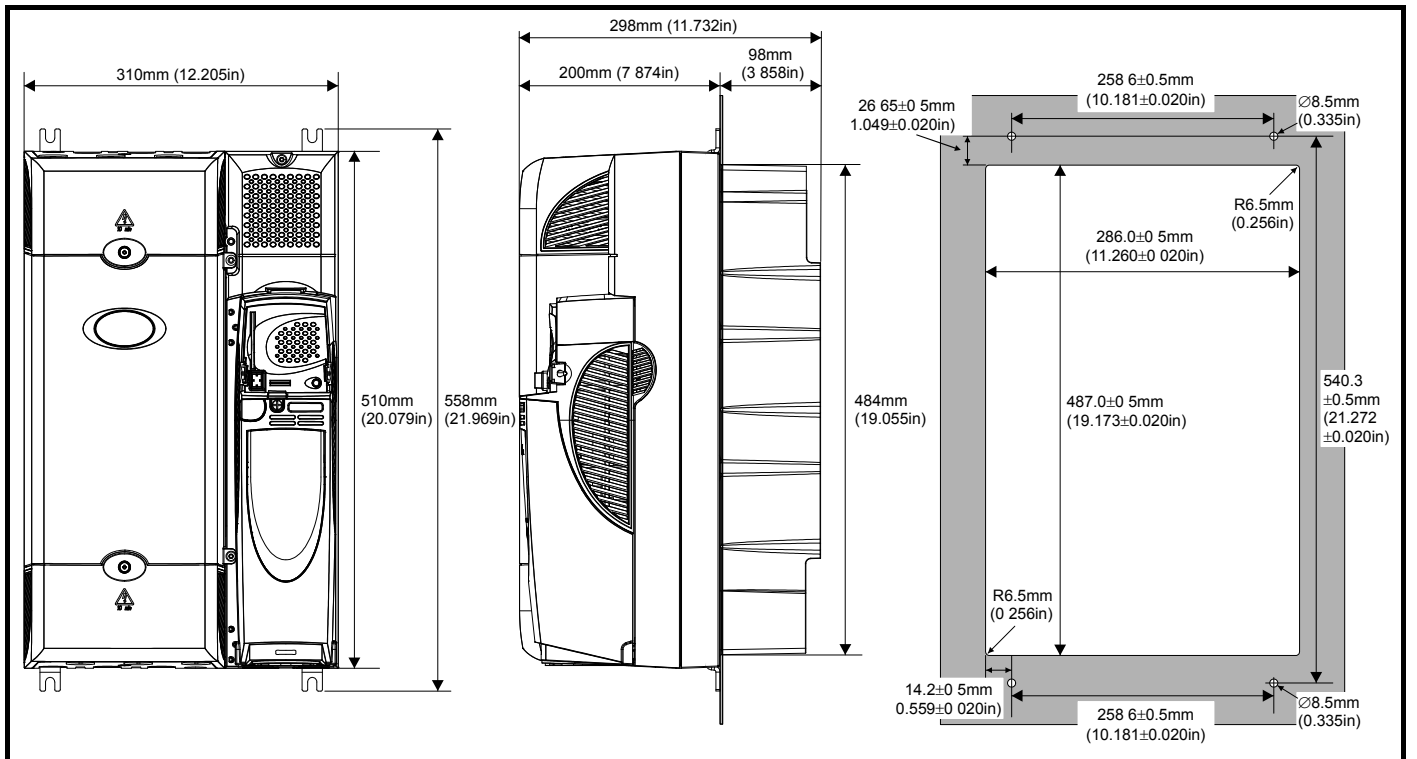
**Figure 3-22 Through-panel mounting the size 2 drive**



**Figure 3-23 Through-panel mounting the size 3 drive**

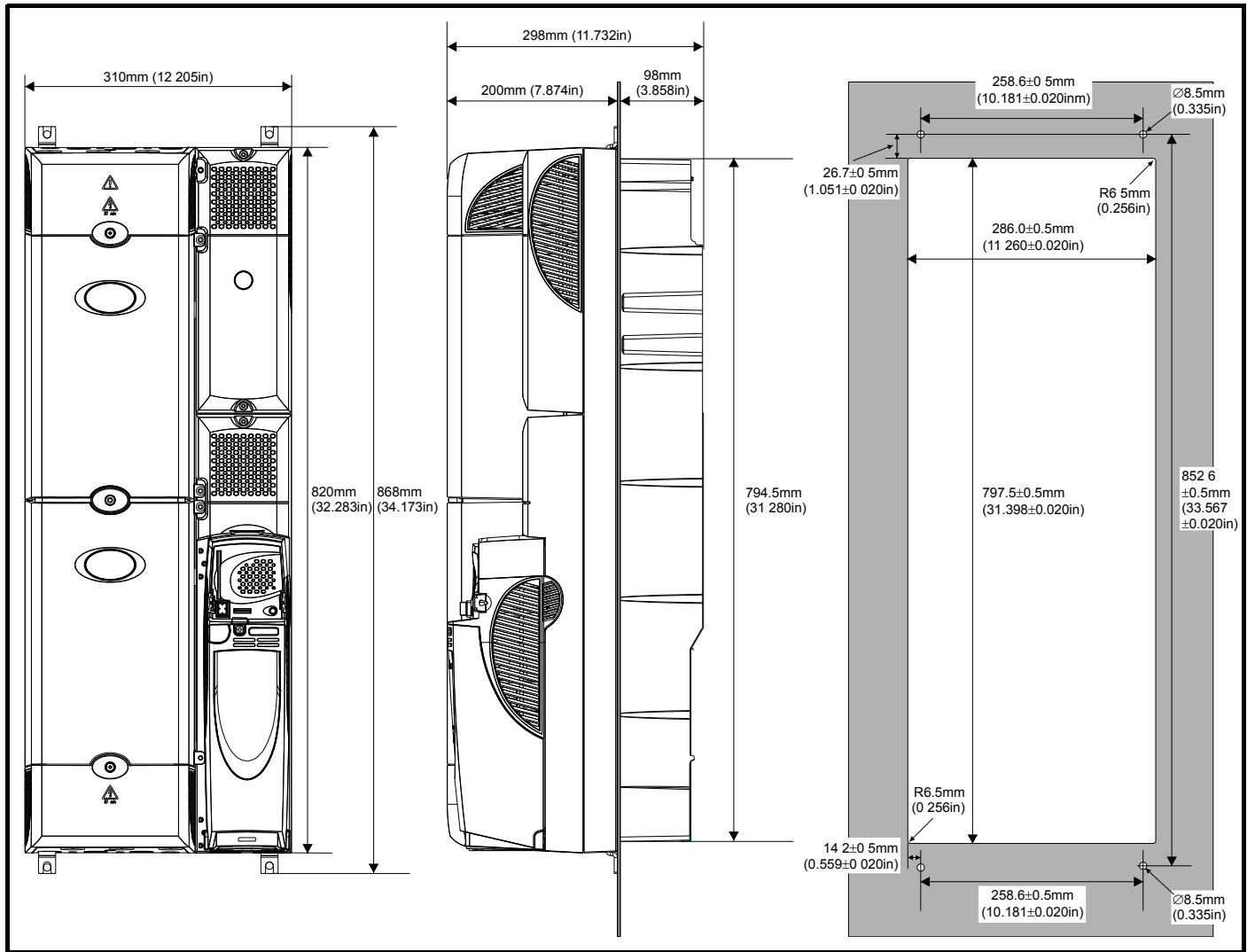


**Figure 3-24 Through-panel mounting the size 4 drive**



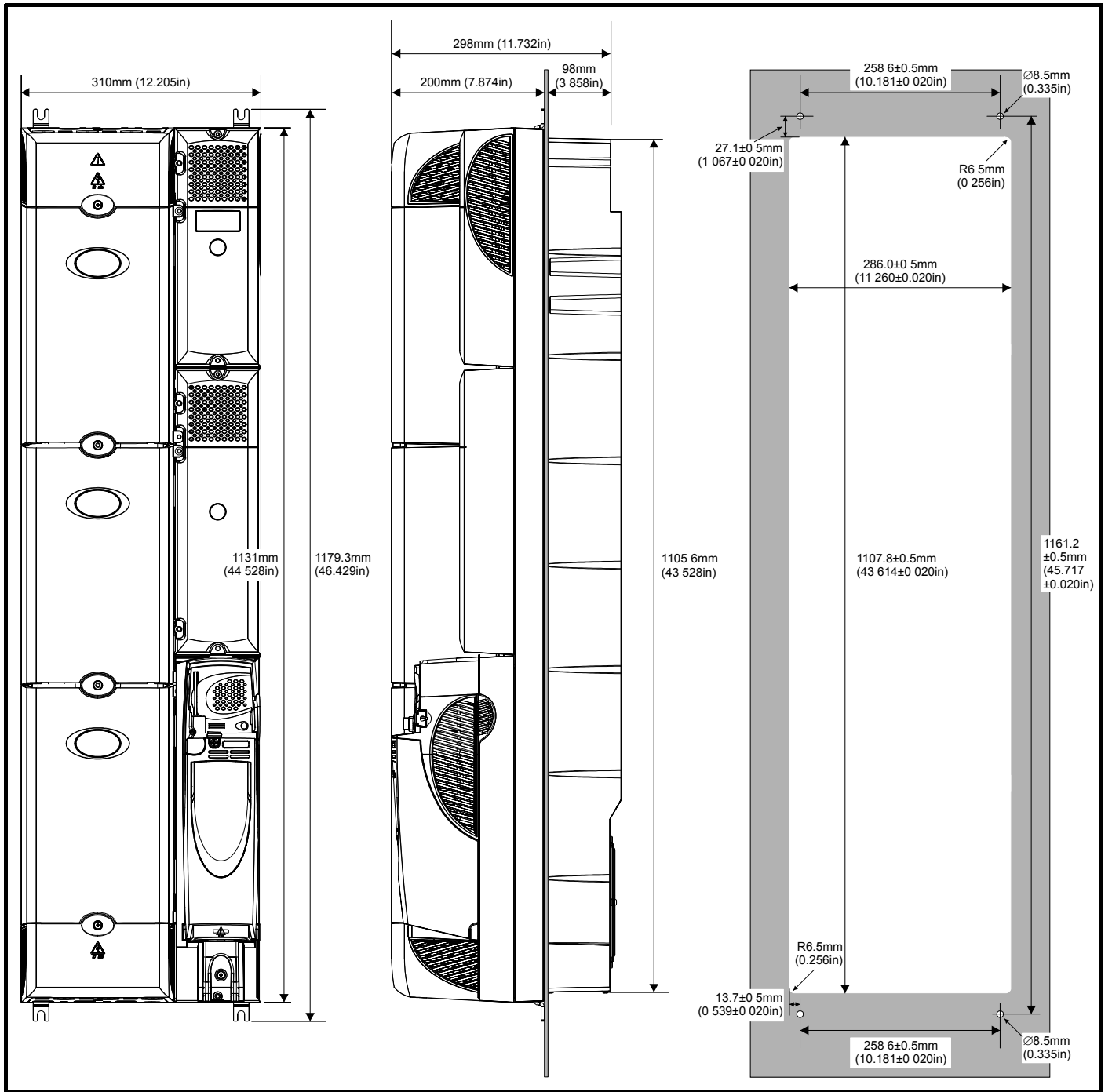
When a size 4 is through-panel mounted, the grounding link bracket must be folded upwards. This is required to provide a grounding point for the grounding bracket. See section 4.11.1 *Grounding hardware* on page 71 for more information.

**Figure 3-25 Through-panel mounting the size 5 drive**



When a size 5 is through-panel mounted, the grounding link bracket must be folded upwards. This is required to provide a grounding point for the grounding bracket. See section 4.11.1 *Grounding hardware* on page 71 for more information.



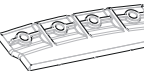

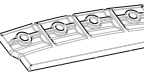



**Figure 3-26 Through-panel mounting the size 6 drive**



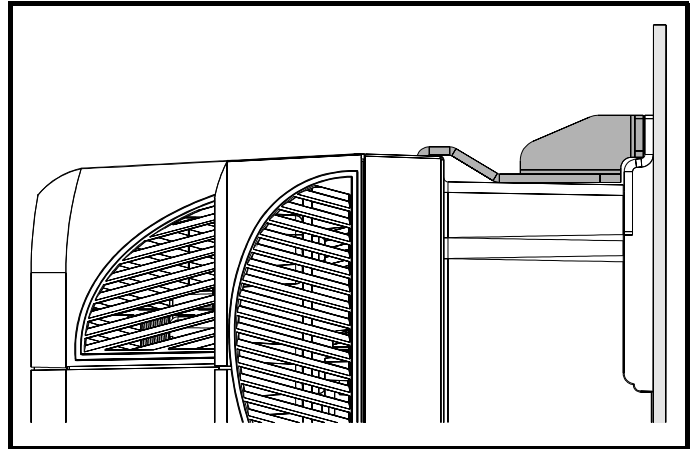
**NOTE**

In order to achieve IP54 rating (NEMA 12) for through-panel mounting, an IP54 insert must be installed (size 1 and 2) and the heatsink fan should be replaced with an IP54 rated fan (sizes 1 to 4). Additionally, the gasket provided should be installed between the drive and the backplate to ensure a good seal for the enclosure. If the heatsink mounted braking resistor is to be used with the drive through-panel mounted, refer to section 3.11 *Internal/heatsink mounted braking resistor* on page 50 prior to mounting the drive. For further information refer to section 3.9 *Enclosing standard drive for high environmental protection* on page 40.

**Table 3-1 Mounting brackets**

Model size	Surface	Through-panel	Hole size
1	 x2	 x1	6.5mm (0.256in)
2	 x2	 x1	
3	 x2		
4	 x4		8.5mm (0.335in)
5 & 6	 x4		
	 x2		

**Figure 3-29 Location of top surface mounting brackets for size 5 and 6**



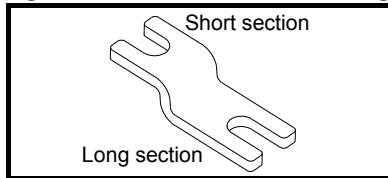
To avoid damaging the through-panel mounting bracket when through-panel mounting a size 1 or size 2, the through-panel mounting bracket should be used to mount the top of the drive to the back plate before the bottom of the drive is mounted to the back plate. The tightening torque should be 4 N m (2.9 lb ft).

### 3.5.3 Installation of the mounting bracket on size 4, 5 and 6

Size 4, 5 and 6 use the same mounting brackets for surface and through-panel mounting.

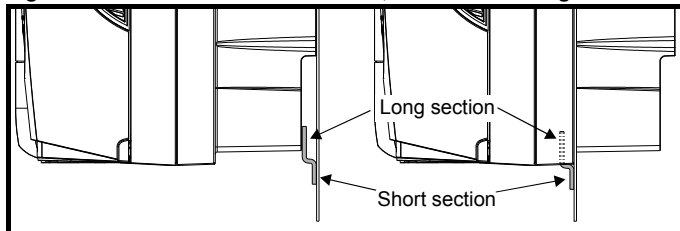
The mounting bracket has a long section and a short section.

**Figure 3-27 Size 4, 5 and 6 mounting bracket**



The mounting bracket must be installed in the correct orientation with the long section inserted into or attached to the drive and the short section is attached to the back plate. Figure 3-28 shows the orientation of the mounting bracket when the drive is surface and through-panel mounted.

**Figure 3-28 Orientation of the size 4, 5 and 6 mounting bracket**



When through-panel mounted, the mounting brackets on the left hand side of the drive can be secured using the screws already located there. On the right hand side, the mounting brackets are just inserted into the slots in the chassis of the drive; no fixing screws are present here.

Size 5 and 6 also require two top mounting brackets when the drive is surface mounted. The two brackets should be installed to the top of the drive as shown in Figure 3-29.

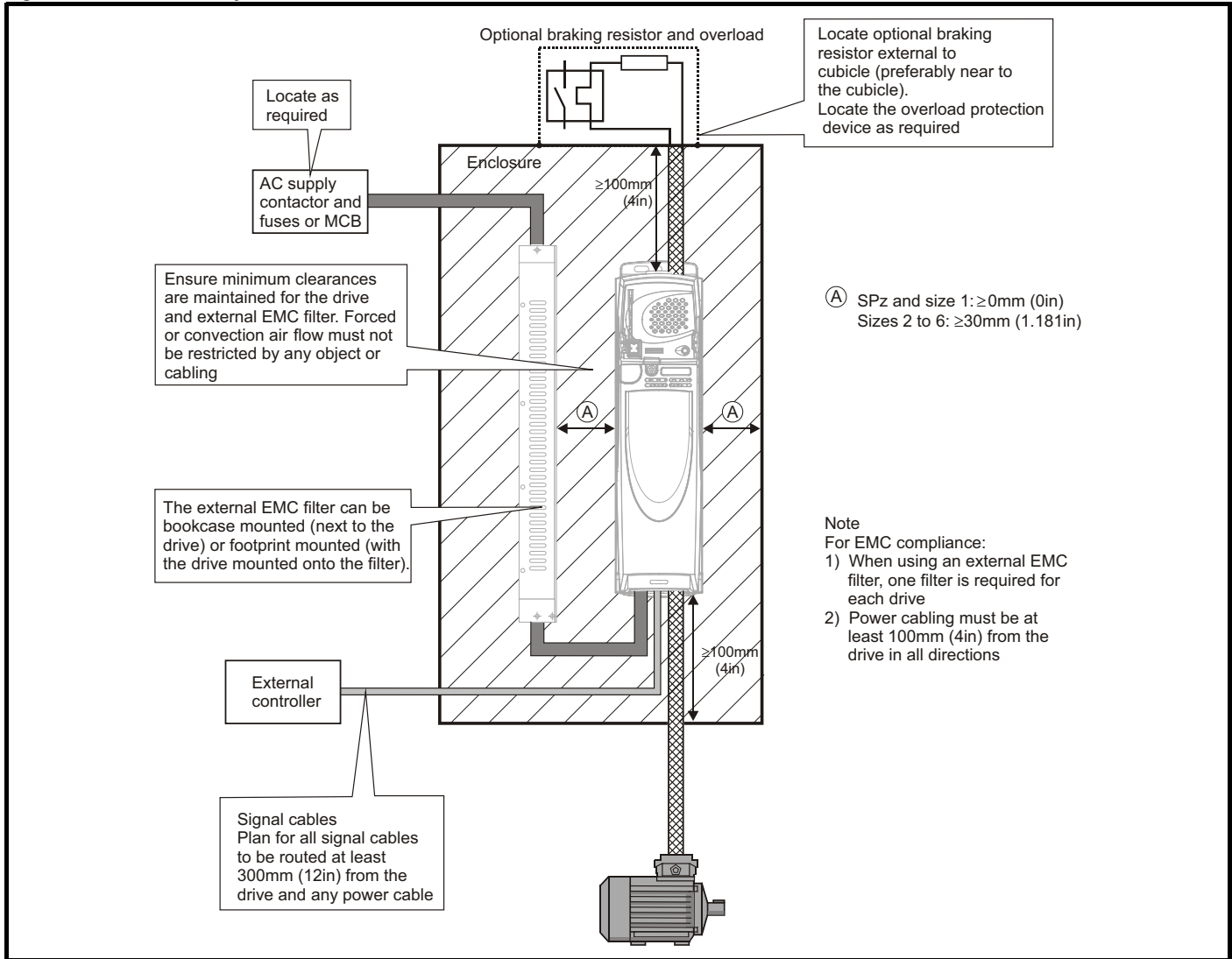
The maximum torque setting for the screws into the drive chassis is 10 N m (7.4 lb. ft).

### 3.6 Enclosure for standard drives

#### 3.6.1 Enclosure layout

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

**Figure 3-30 Enclosure layout**



#### 3.6.2 Enclosure sizing

1. Add the dissipation figures from section 12.1.2 *Power dissipation* on page 245 for each drive that is to be installed in the enclosure.
2. If an external EMC filter is to be used with each drive, add the dissipation figures from section 12.2.1 *EMC filter ratings* on page 257 for each external EMC filter that is to be installed in the enclosure.
3. If the braking resistor is to be mounted inside the enclosure, add the average power figures from for each braking resistor that is to be installed in the enclosure.
4. Calculate the total heat dissipation (in Watts) of any other equipment to be installed in the enclosure.
5. Add the heat dissipation figures obtained above. This gives a figure in Watts for the total heat that will be dissipated inside the enclosure.

#### Calculating the size of a sealed enclosure

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

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

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

Where:

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

#### Example

To calculate the size of an enclosure for the following:

- Two SP1406 models operating at the Normal Duty rating
- Each drive to operate at 6kHz PWM switching frequency
- Schaffner 16 A (FS6008-16-07) external EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40 C
- Maximum ambient temperature outside the enclosure: 30 C

Dissipation of each drive: 187 W (see Table 12-4 *Losses @ 40°C (104°F) ambient* on page 245)

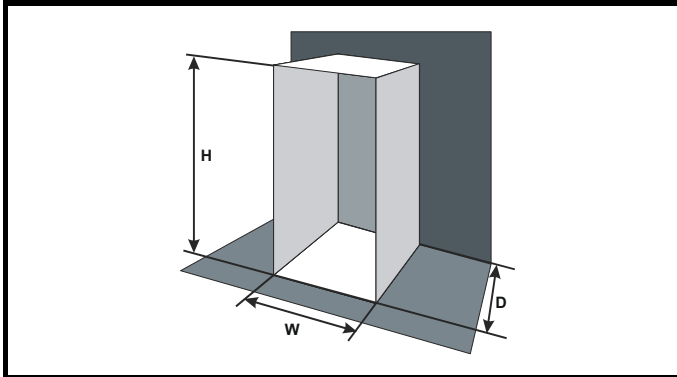
Dissipation of each external EMC filter: 9.2 W (max) (see section 12.2.1 *EMC filter ratings* on page 257)

Total dissipation: 2 x (187 + 9.2) = 392.4 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<sup>2</sup>/°C. Only the top, front, and two sides of the enclosure are free to dissipate heat.

The value of 5.5 W/m<sup>2</sup>/°C can generally be used with a sheet steel enclosure (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 3-31 Enclosure having front, sides and top panels free to dissipate heat**



Insert the following values:

T <sub>int</sub>	40 C
T <sub>ext</sub>	30 C
k	5.5
P	392.4 W

The minimum required heat conducting area is then:

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

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

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

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

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

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

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

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

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

### Calculating the air-flow in a ventilated enclosure

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

Calculate the minimum required volume of ventilating air from:

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

Where:

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

Where:

P <sub>0</sub>	is the air pressure at sea level
P <sub>1</sub>	is the air pressure at the installation

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

### Example

To calculate the size of an enclosure for the following:

- Three SP1403 models operating at the Normal Duty rating
- Each drive to operate at 6kHz PWM switching frequency
- Schaffner 10A (FS6008-10-07) external EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40 C
- Maximum ambient temperature outside the enclosure: 30 C

Dissipation of each drive: 101 W

Dissipation of each external EMC filter: 6.9 W (max)

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

Insert the following values:

T <sub>int</sub>	40 C
T <sub>ext</sub>	30 C
k	1.3
P	323.7 W

Then:

$$V = \frac{3 \times 1,3 \times 323,7}{40 - 30}$$

$$= 126.2 \text{ m}^3/\text{hr (74.5 ft}^3/\text{min)} \quad (1 \text{ m}^3/\text{hr} = 0.59 \text{ ft}^3/\text{min)}$$

## 3.7 Enclosure design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures. Totally enclosing or through panel mounting the drive in either a sealed cabinet (no airflow) or in a well ventilated cabinet makes a significant difference on drive cooling.

The chosen method affects the ambient temperature value (T<sub>rate</sub>) 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<sub>rate</sub> = T<sub>int</sub> + 5°C
2. Totally enclosed with air flow (>2 m/s) over the drive  
T<sub>rate</sub> = T<sub>int</sub>
3. Through panel mounted with no airflow (<2 m/s) over the drive  
T<sub>rate</sub> = the greater of T<sub>ext</sub> +5°C, or T<sub>int</sub>
4. Through panel mounted with air flow (>2 m/s) over the drive  
T<sub>rate</sub> = the greater of T<sub>ext</sub> or T<sub>int</sub>

Where:

T <sub>ext</sub>	= Temperature outside the cabinet
T <sub>int</sub>	= Temperature inside the cabinet
T <sub>rate</sub>	= Temperature used to select current rating from tables in Chapter 12 <i>Technical Data</i> .

### 3.8 Heatsink fan operation

The drive is ventilated by an internal heatsink mounted fan. The fan housing forms a baffle plate, channelling the air through the heatsink chamber. Thus, regardless of mounting method (surface mounting or through-panel mounting), the fitting of additional baffle plates is not required.

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

The heatsink fan on SPz and size 1 and 2 is a dual speed fan and on size 3 to 6 it is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. The size 3 to 6 is also fitted with a variable speed fan to ventilate the capacitor bank.

The heatsink fan on SPz and size 1 to 5 is supplied internally by the drive. The heatsink fan on size 6 requires an external 24Vdc supply. See section 4.4 *Heatsink fan supply* on page 62 for more information.

### 3.9 Enclosing standard drive for high environmental protection

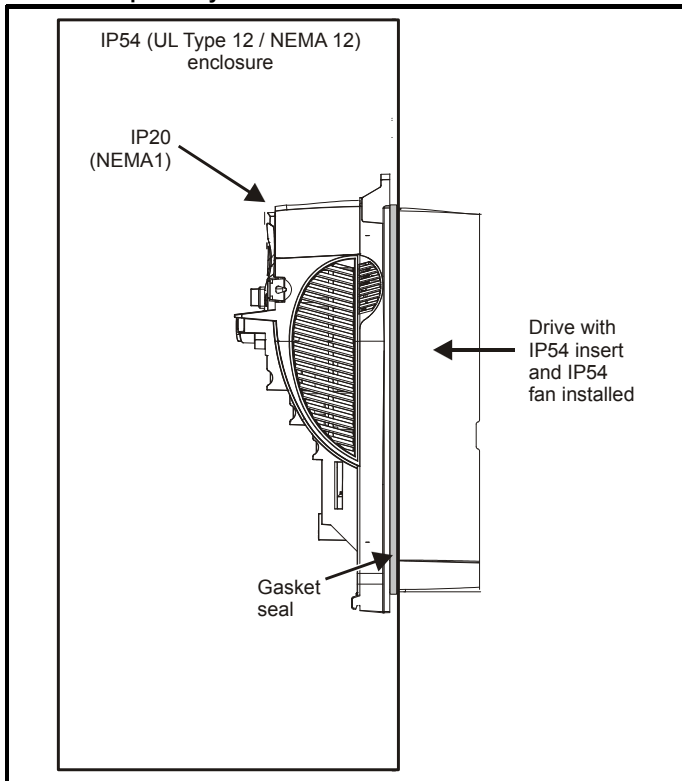
An explanation of environmental protection rating is provided in section 12.1.9 *IP / UL Rating* on page 248.

The standard drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP54 rating (UL Type 12 / NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required for size 1 and 2). Refer to Table 12-2.

This allows the front of the drive, along with various switchgear, to be housed in an IP54 (UL Type 12 / NEMA 12) enclosure with the heatsink protruding through the panel to the external environment. Thus, the majority of the heat generated by the drive is dissipated outside the enclosure maintaining a reduced temperature inside the enclosure. This also relies on a good seal being made between the heatsink and the rear of the enclosure using the gaskets provided.

**For Type 12 the drive must be mounted on a flat surface of a Type 12 enclosure.**

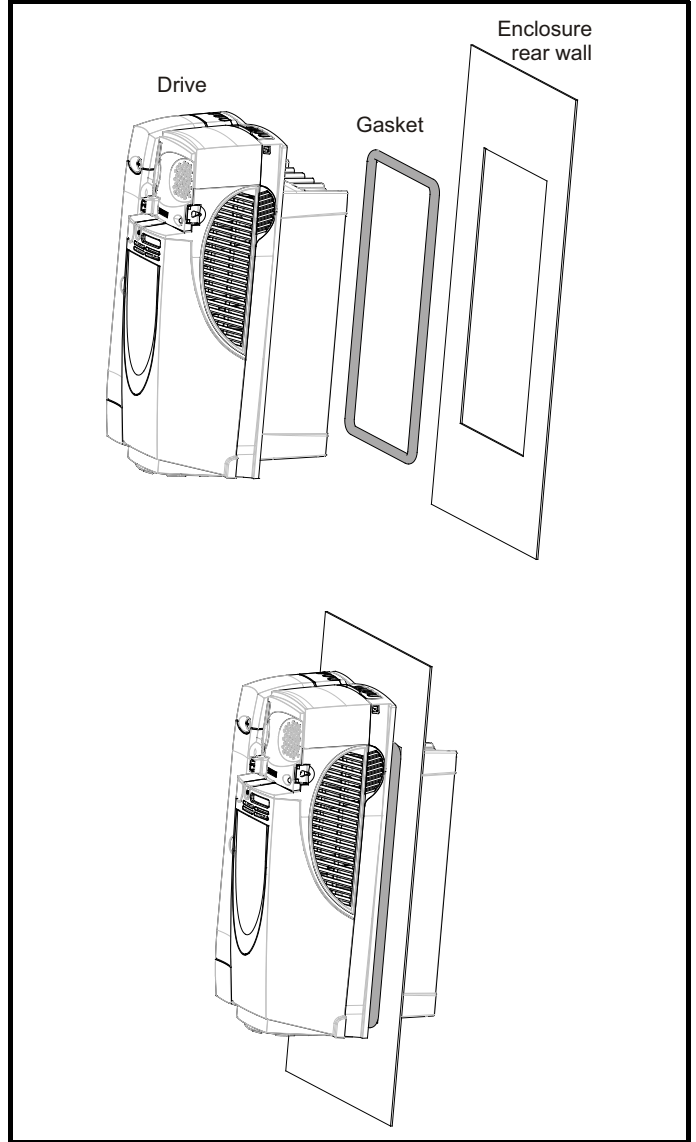
**Figure 3-32 Example of IP54 (UL Type 12 / NEMA 12) through-panel layout**



The main gasket should be installed as shown in Figure 3-33. Any screws / bolts that are used for mounting should be installed with the nylon washers provided in the kit box to maintain a seal around the screw hole. See Figure 3-36.

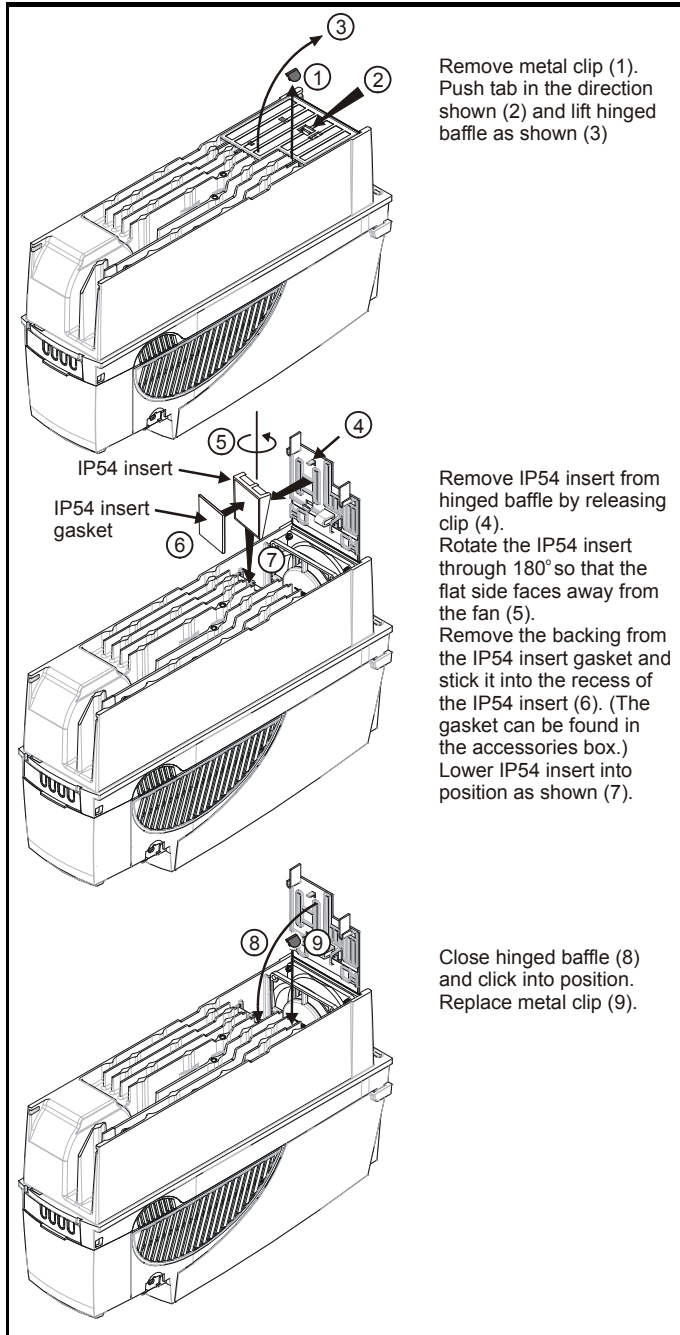
In order to achieve the high IP rating at the rear of the heatsink with size 1 and 2, it is necessary to seal a heatsink vent by installing the IP54 insert as shown in Figure 3-34 and Figure 3-35.

**Figure 3-33 Installing the gasket**





**Figure 3-34 Installation of IP54 insert for size 1**



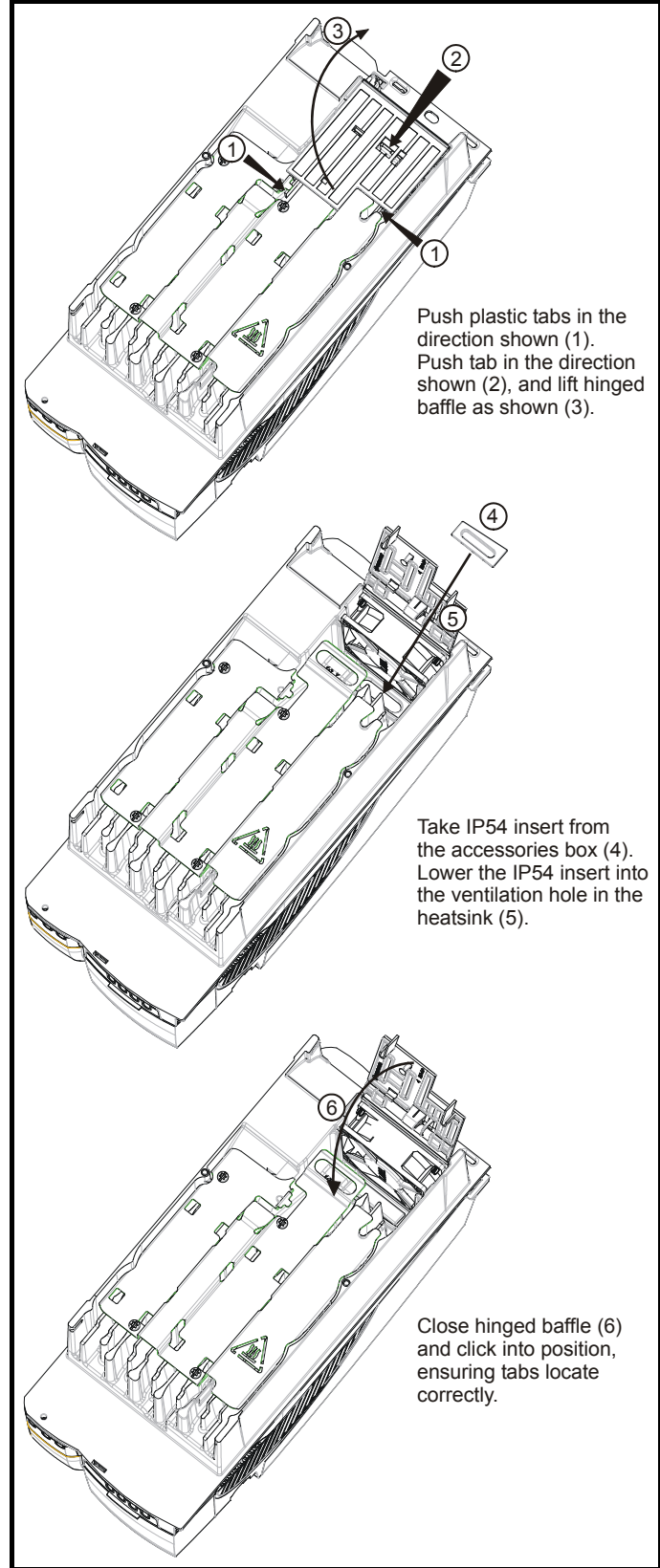
Remove metal clip (1). Push tab in the direction shown (2) and lift hinged baffle as shown (3)

Remove IP54 insert from hinged baffle by releasing clip (4). Rotate the IP54 insert through 180° so that the flat side faces away from the fan (5). Remove the backing from the IP54 insert gasket and stick it into the recess of the IP54 insert (6). (The gasket can be found in the accessories box.) Lower IP54 insert into position as shown (7).

Close hinged baffle (8) and click into position. Replace metal clip (9).

In order to remove the IP54 insert, repeat steps (1), (2) and (3), reverse steps (7), (6), (5) and (4) and repeat steps (8) and (9).

**Figure 3-35 Installation of IP54 insert for size 2**



Push plastic tabs in the direction shown (1). Push tab in the direction shown (2), and lift hinged baffle as shown (3).

Take IP54 insert from the accessories box (4). Lower the IP54 insert into the ventilation hole in the heatsink (5).

Close hinged baffle (6) and click into position, ensuring tabs locate correctly.

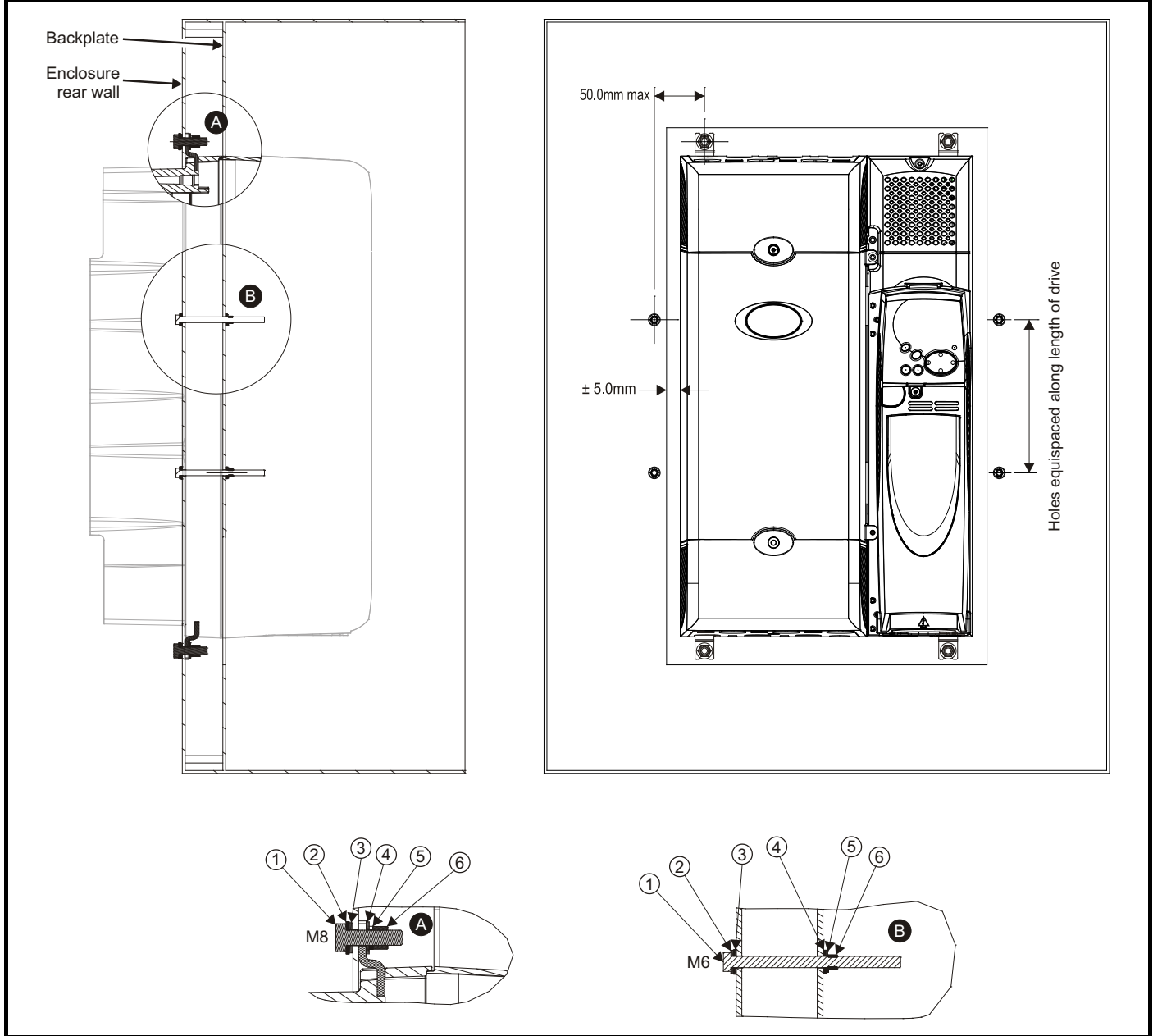
In order to remove the IP54 insert, repeat steps (1) (2) and (3), reverse steps (5) and (4) and repeat step (6).

For sizes 4 to 6 it may be necessary to improve the rigidity of the through panel mounting surface due to the larger distance between the top and bottom mounting brackets and the need to maintain compression on the gasket.

When the drive is mounted, if the gap between the drive flange (which the gasket rests on) and the rear wall of the enclosure is  $\geq 6\text{mm}$  at any point around the drive then the following methods can be used to compress the gasket further:

1. Use a thicker panel for the mounting wall of the enclosure through which the drive is mounted.
2. Use an internal backplate to pull the rear wall of the enclosure up to the drive gasket. See Figure 3-36 for details. (Nylon washers are supplied in the standard drive kit for sealing off any nut and bolt fixings that exit through the rear wall of the panel).
3. If an internal backplate is not available a separate clamp can be used to simulate option 2. See Figure 3-37. 4 off sealing clamps are supplied in the drive kit box.

**Figure 3-36 Option 2 for achieving IP54 (UL type 12 / NEMA 12) through-panel mounting**



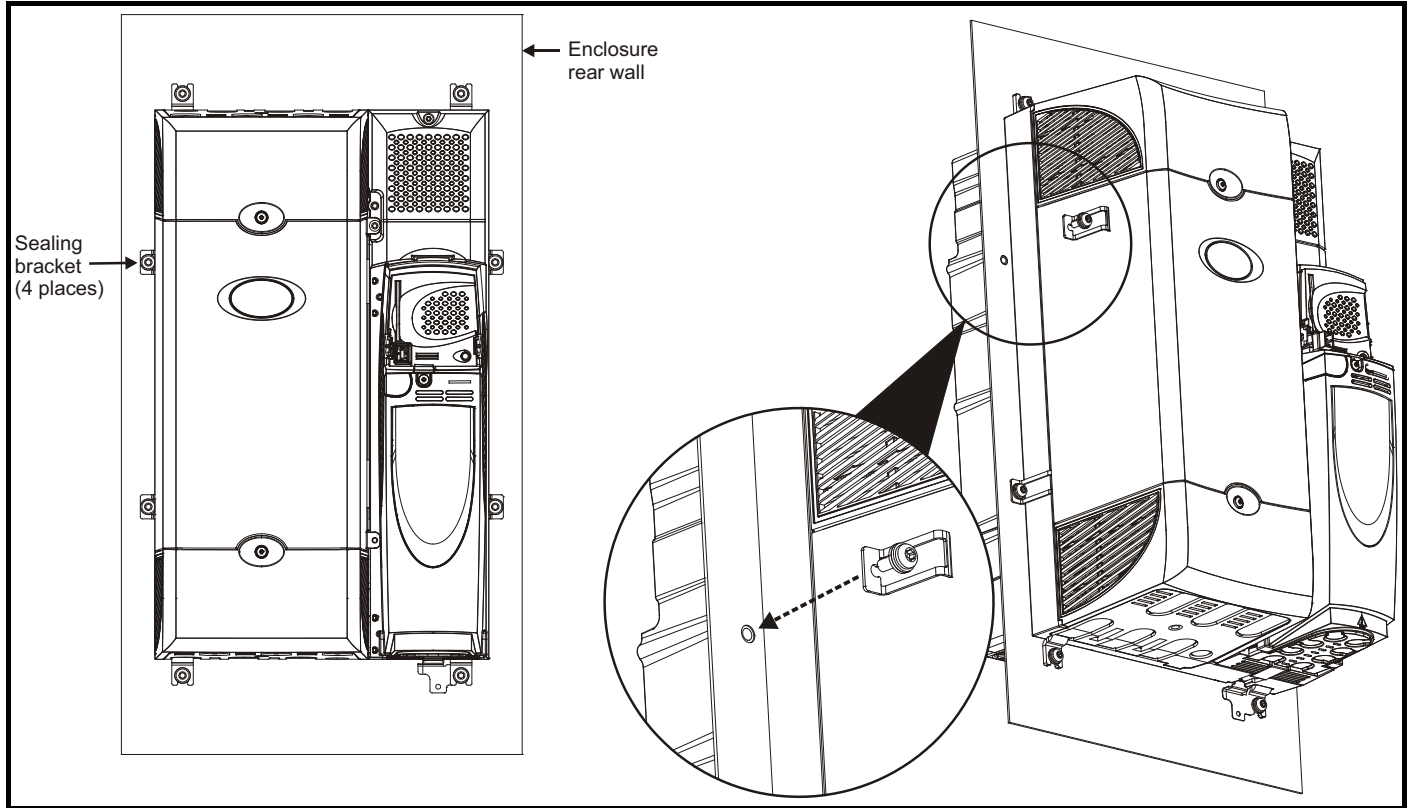
**Table 3-2 Description of fixings**

Item	Description
1	Bolt
2	Flat washer
3	Nylon washer (from kitbox)
4	Flat washer
5	Spring washer
6	Nut

**Table 3-3 Quantity of nylon washers supplied with the drive**

Size	Quantity of M8 (A)	Quantity of M6 (B)
1	0	3
2	0	3
3	0	4
4	4	4
5	4	4
6	4	4

**Figure 3-37 Option 3 for achieving IP54 (UL Type 12 / NEMA 12) through panel mounting**



For increased fan lifetime in a dirty environment the heatsink fan must be replaced with an IP54 rated fan. Contact the supplier of the drive for details. If the standard fan is used in a dirty/dusty environment, reduced fan lifetime will result. Regular cleaning of the fan and heatsink is recommended in this environment. The heatsink fan installed in sizes 5 and 6 are IP54 rated as standard.

The guidelines in Table 3-4 should be followed.

**Table 3-4 Environment considerations**

Environment	IP54 Insert	Fan	Comments
Clean	Not installed	Standard	
Dry, dusty (non-conductive)	Installed	Standard	Regular cleaning recommended. Fan lifetime may be reduced.
Dry, dusty (conductive)	Installed	Standard / IP54	Regular cleaning recommended. Fan lifetime may be reduced.
IP54 compliance	Installed	IP54	Regular cleaning recommended.

**NOTE**

A current derating must be applied to the size 1 and 2 if the IP54 insert and/or IP54 rated fan are installed. Derating information is provided in section 12.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 242.

Failure to do so may result in nuisance tripping.

**NOTE**

When designing an IP54 (NEMA 12) enclosure (Figure 3-32), consideration should be made to the dissipation from the front of the drive.

**Table 3-5 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

### 3.10 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.

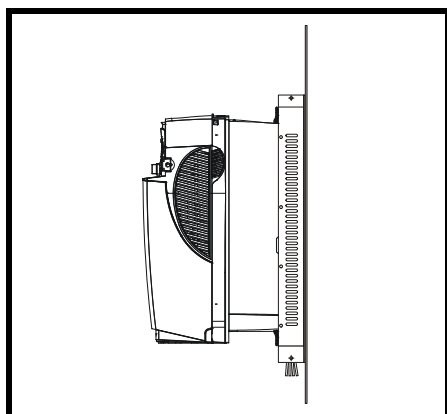
**Table 3-6 Drive EMC filter details (SPz and size 1 to 6)**

Drive		Schaffner		Epcos	
LS	CT	Reference	Weight	Reference	Weight
<b>1 phase</b>					
SPz 1M/TL to 2.5M/TL	SP0201 to SP0205	FS23072-19-07	1.2 kg (2.64 lb)		
<b>3 phase</b>					
SPz 1M/TL to 2.5M/TL	SP0201 to SP0205	FS23073-17-07	1.2 kg (2.64 lb)		
SPz 1T to 2.5T	SP0401 to SP0405	FS23074-11-07	1.2 kg (2.64 lb)		
1.5TL & 2TL	SP1201 & SP1202	FS6008-10-07	1.4 kg (3.1 lb)	B84143-A10-R207	2.1 kg (4.6 lb)
2.5TL & 3.5TL	SP1203 & SP1204	FS6008-16-07		B84143-A16-R207	
1.5T to 3.5T	SP1401 to SP1404	FS6008-10-07	1.4 kg (3.1 lb)	B84143-A10-R207	2.1 kg (4.6 lb)
4.5T & 5.5T	SP1405 & SP1406	FS6008-16-07		B84143-A16-R207	
4.5TL to 8TL	SP2201 to SP2203	FS6008-32-07	2.0 kg (4.4 lb)	B84143-A32-R207	3.3 kg (7.3 lb)
8T to 20T	SP2401 to SP2404	FS6008-32-07	2.0 kg (4.4 lb)	B84143-A32-R207	3.3 kg (7.3 lb)
11TL to 16TL	SP3201 & SP3202	FS6008-75-07	3.5 kg (7.7 lb)	B84143-A75-R207	5.1 kg (11.2 lb)
22TL to 33TL	SP4201 to SP4203	FS6008-101-35	4.0 kg (8.8 lb)	B84143-A101-R207	7.8 kg (17.2 lb)
40TL & 50TL	SP5201 & SP5202	FS6008-164-40	6.8 kg (15.0 lb)	B84143-A165-R207	12.0 kg (26.5 lb)
22T to 33T	SP3401 to SP3403	FS6008-62-07	3.5 kg (7.7 lb)	B84143-A75-R207	5.1 kg (11.2 lb)
3.5TM to 22TM	SP3501 to SP3507	FS6008-30-07		B84143-A30-R207	
40T to 60T	SP4401 to SP4403	FS6008-101-35	4.0 kg (8.8 lb)	B84143-A101-R207	7.8 kg (17.2 lb)
22TH to 60TH	SP4601 to SP4606	FS6008-58-53	3.8 kg (8.4 lb)	B84143-A58-R207	8.0 kg (17.6 lb)
75T & 100T	SP5401 & SP5402	FS6008-164-40	6.8 kg (15.0 lb)	B84143-A165-R207	12.0 kg (26.5 lb)
75TH & 100TH	SP5601 & SP5602	FS6008-95-35	4.4 kg (9.7 lb)	B84143-A95-R207	10.0 kg (22.0 lb)
120T & 150T	SP6401 & SP6402	FS6008-260-99	5.25 kg (11.6 lb)	B84143-A260-S207	8.6 kg (19.0 lb)
120TH & 150TH	SP6601 & SP6602	FS6008-160-99		B84143-A0160-S207	

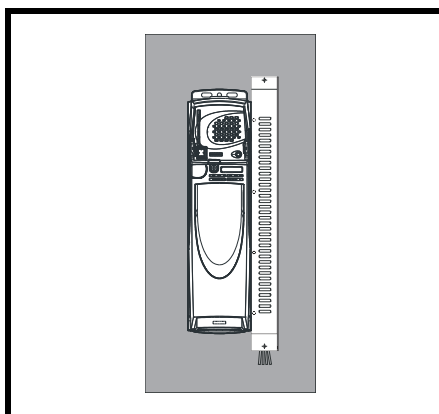
The external EMC filters for SPz and size 1 to 3 can be footprint or bookcase mounted, see Figure 3-38 and Figure 3-39. The external EMC filters for sizes 4 to 6 are designed to be mounted above the drive, as shown in Figure 3-40.

Mount the external EMC filter following the guidelines in section 4.11.5 *Compliance with generic emission standards* on page 77.

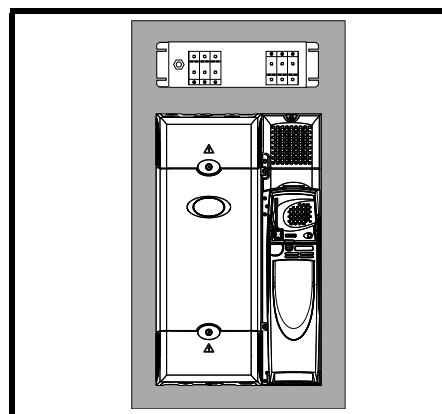
**Figure 3-38 Footprint mounting the EMC filter**



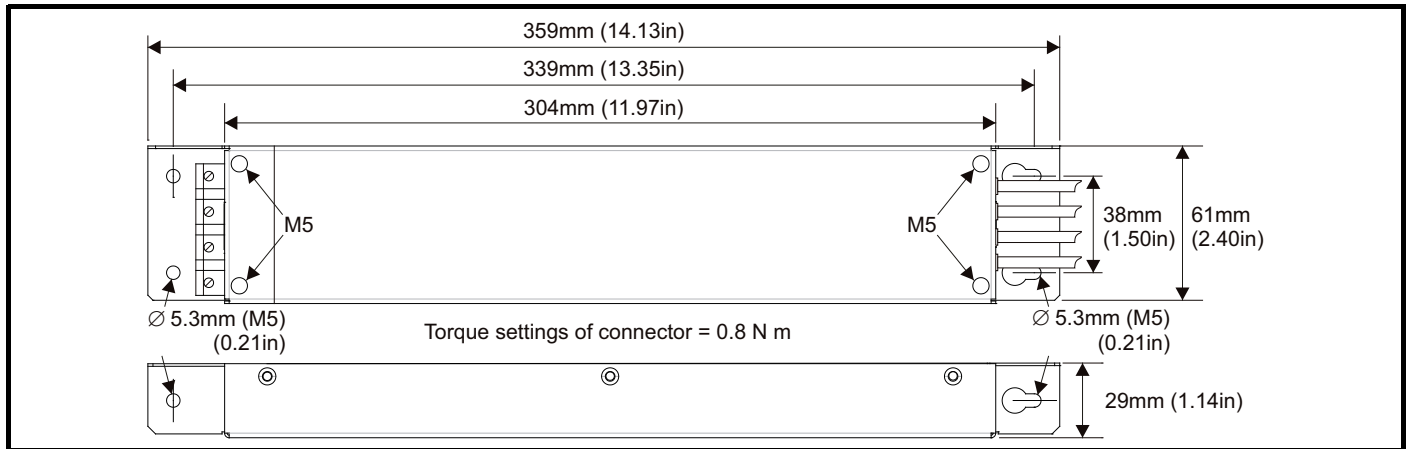
**Figure 3-39 Bookcase mounting the EMC filter**



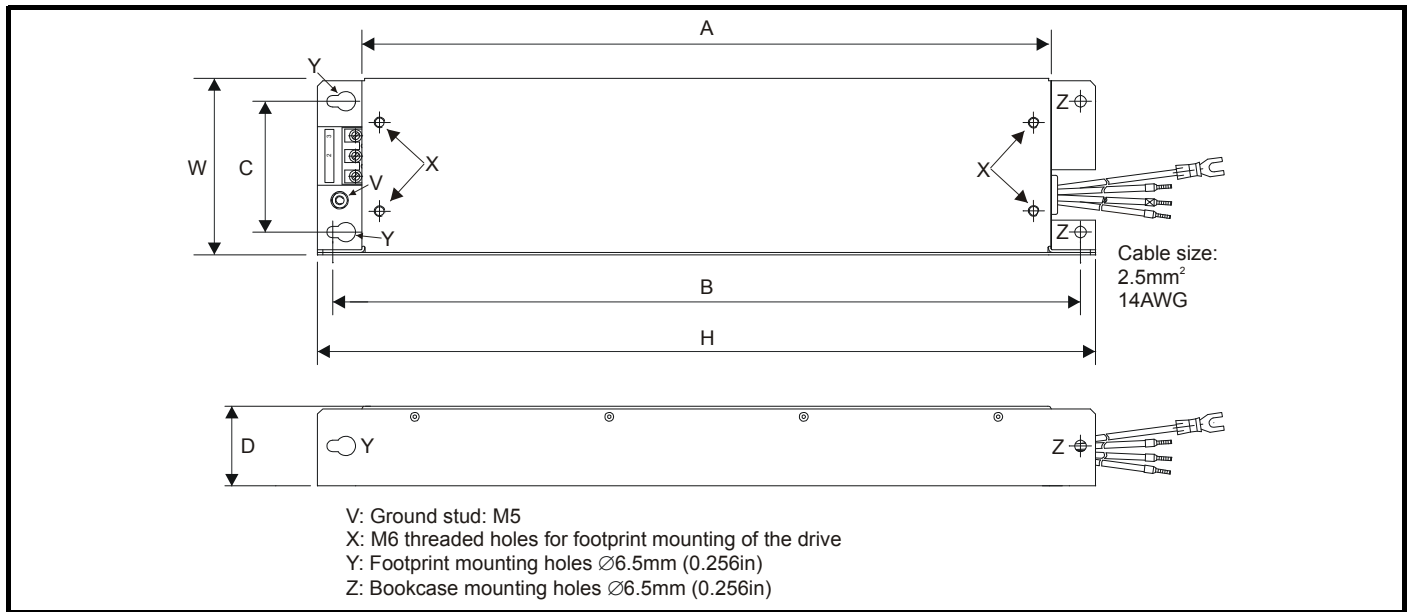
**Figure 3-40 Size 4 to 6 mounting of EMC filter**



**Figure 3-41 SPz external EMC filter**



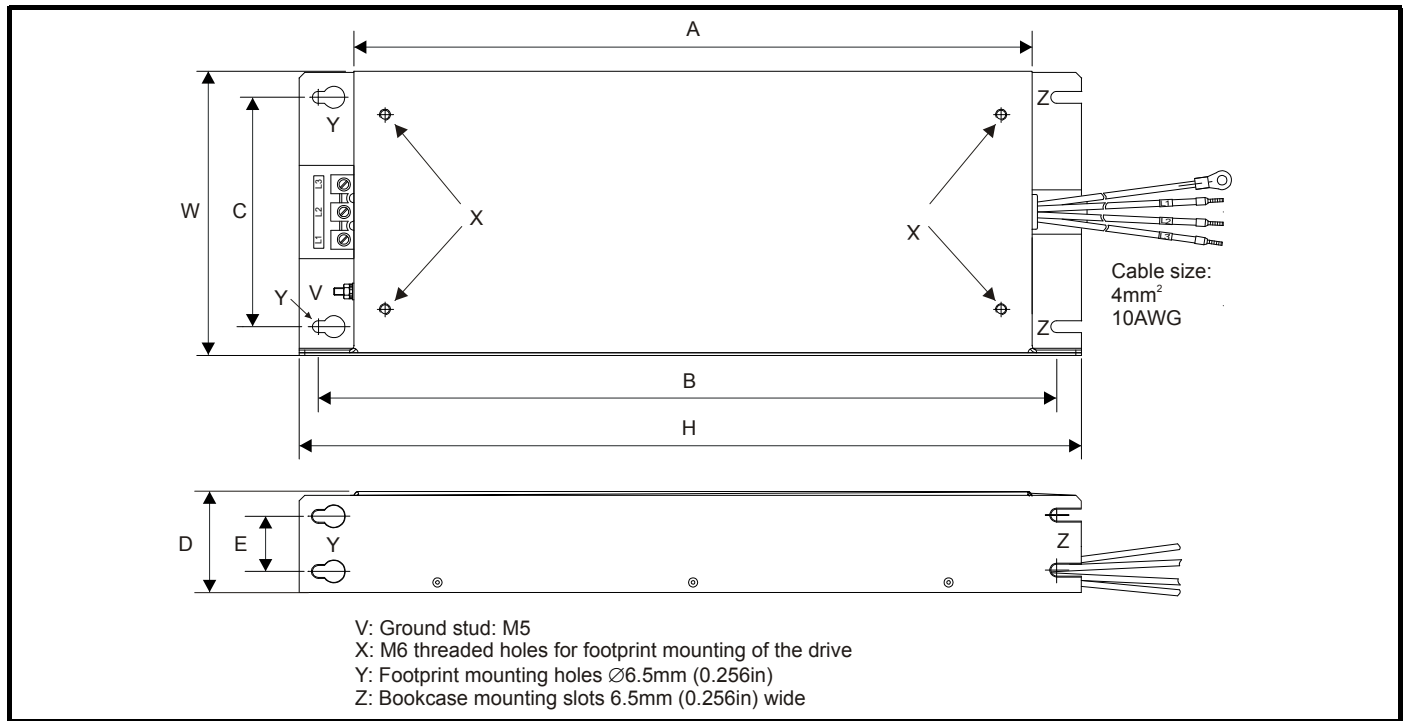
**Figure 3-42 Size 1 external EMC filter**



All filter mounting holes are suitable for M6 fasteners.

Reference	Manufacturer	A	B	C	D	H	W
FS6008-10-07	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)
FS6008-16-07						450 mm (17.717 in)	
B84143-A10-R207	Epcos	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)
B84143-A16-R207						450 mm (17.717 in)	

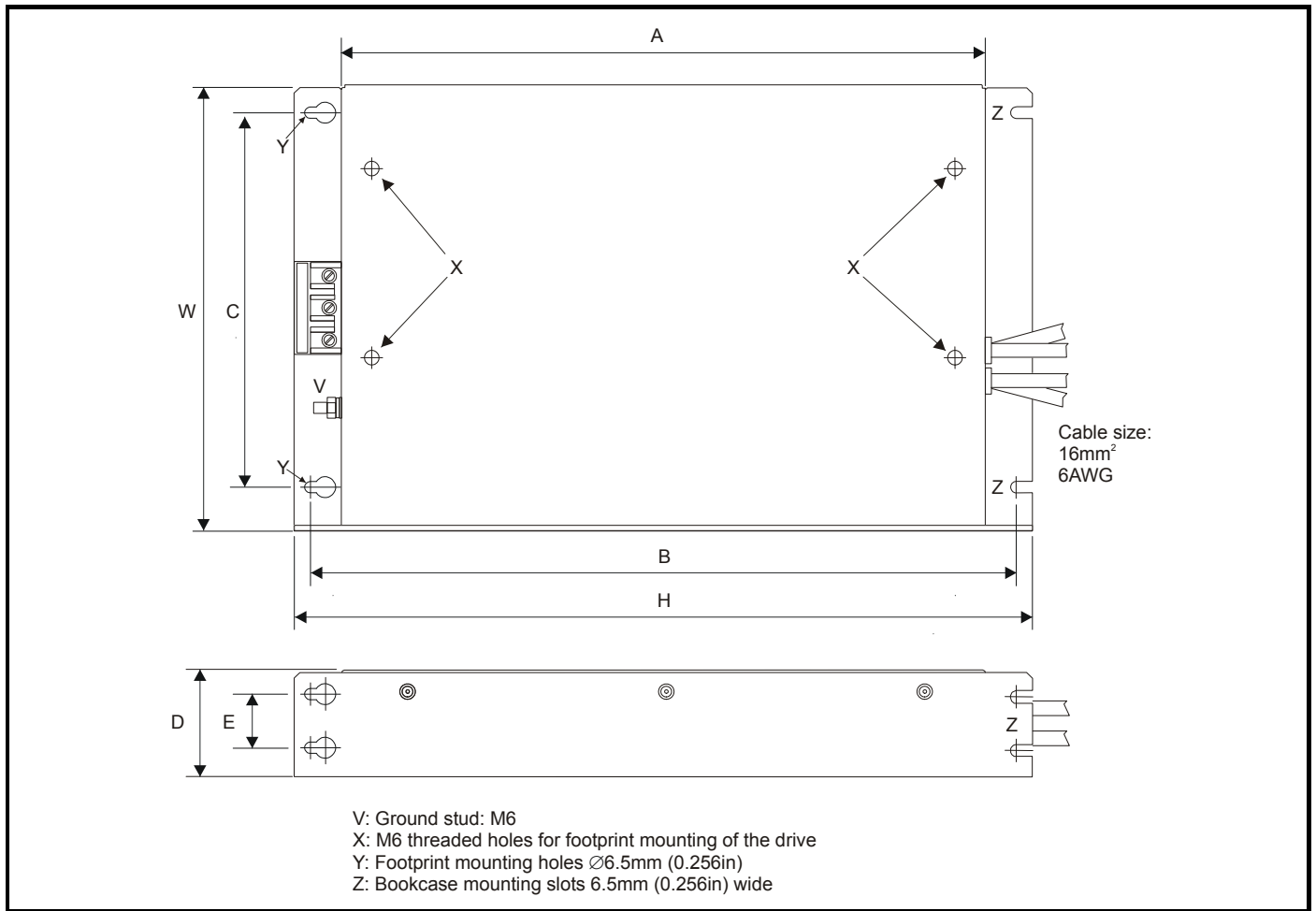
**Figure 3-43 Size 2 external EMC filter**



All filter mounting holes are suitable for M6 fasteners.

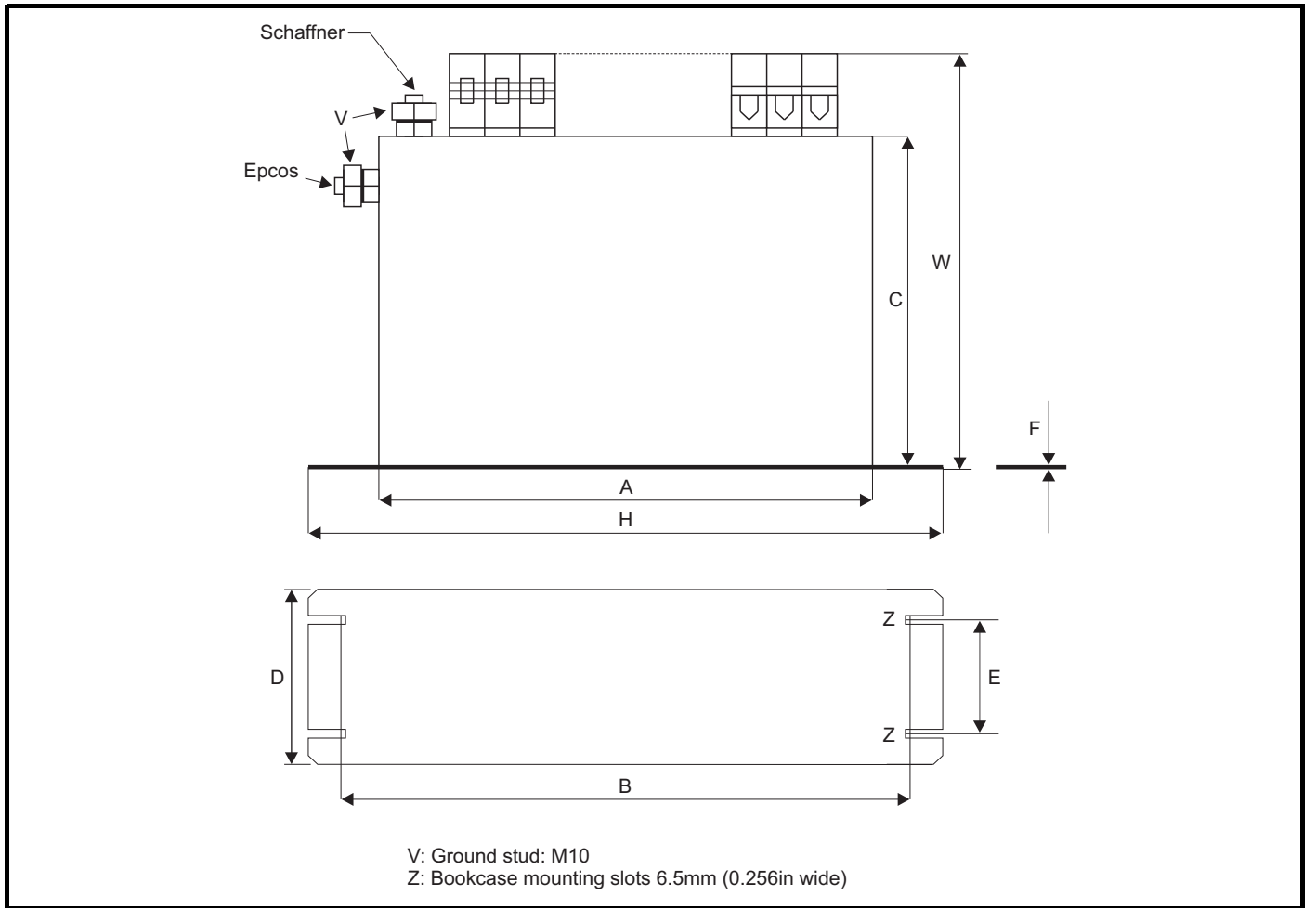
Reference	Manufacturer	A	B	C	D	E	H	W
FS6008-32-07	Schaffner	371.5 mm (14.626 in)	404.5 mm (15.925 in)	125 mm (4.921 in)	55 mm (2.165 in)	30 mm (1.181 in)	428.5 mm (16.870 in)	155 mm (6.102 in)
B84143-A32-R207	Epcos						431.5 mm (16.988 in)	

**Figure 3-44 Size 3 external EMC filter**



Reference	Manufacturer	A	B	C	D	E	H	W
FS6008-62-07	Schaffner	361 mm	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)
FS6008-75-07		(14.213 in)						
FS6008-30-07								
B84143-A75-R207	Epcos	365 mm	396 mm (15.591 in)	210 mm (8.268 in)	60 mm (2.362 in)	30 mm (1.181 in)	425 mm (16.732 in)	250 mm (9.843 in)
B84143-A30-R207		(14.370 in)						

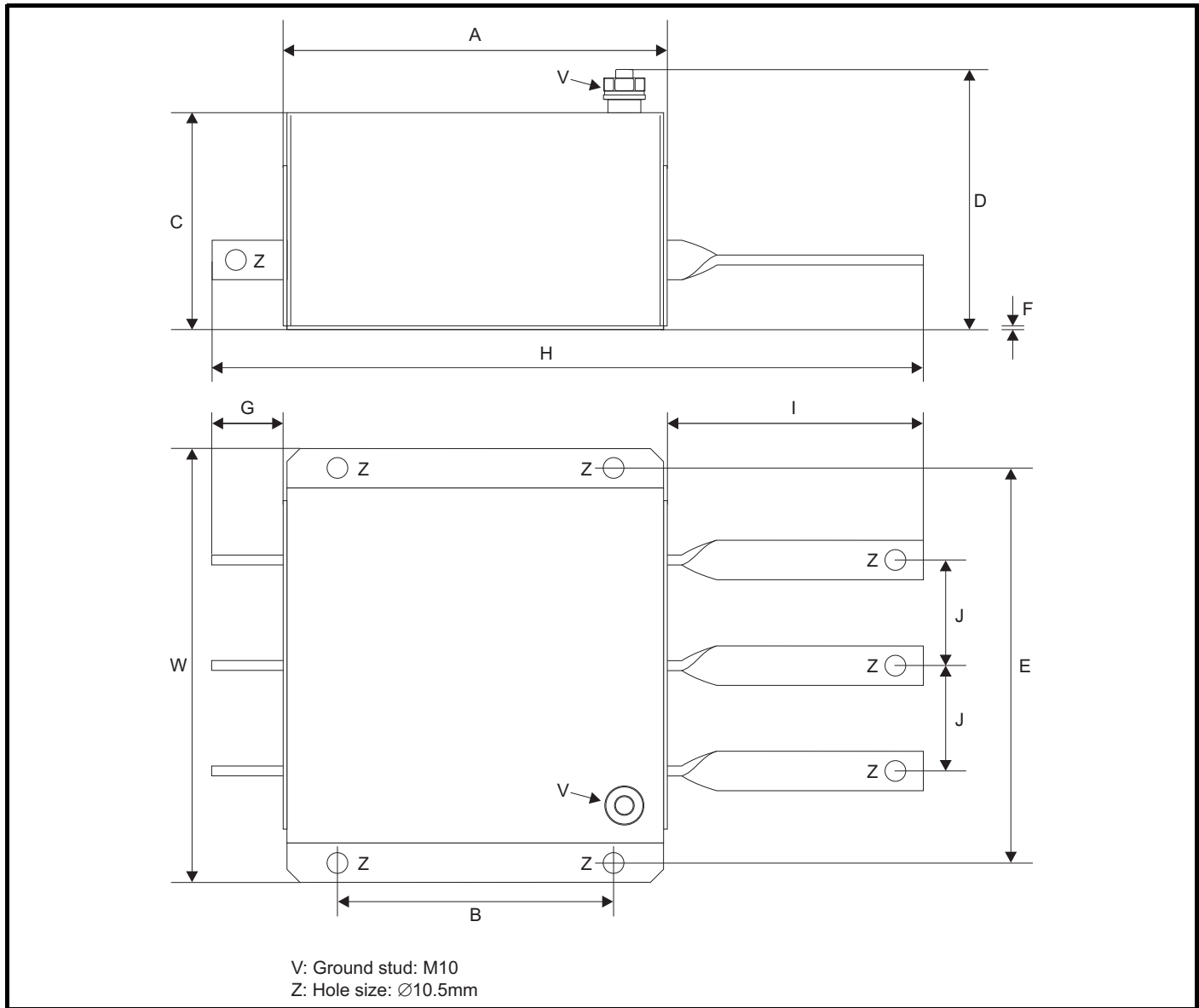
**Figure 3-45 Size 4 and 5 external EMC filter**



Reference	Manufacturer	A	B	C	D	E	F	H	W	
FS6008-101-35	Schaffner	260 mm (10.236 in)	275 mm (10.827 in)	170 mm (6.693 in)	100 mm (3.937 in)	65 mm (2.559 in)	1.5 mm (0.059 in)	300 mm (11.811 in)	225 mm (8.858 in)	
FS6008-58-53					120 mm (4.724 in)	85 mm (3.346 in)			208 mm (8.189 in)	
FS6008-164-40					100 mm (3.937 in)	65 mm (2.559 in)			249 mm (9.803 in)	
FS6008-95-35					150 mm (5.906 in)	90 mm (3.543 in)			65 mm (2.559 in)	207 mm (8.150 in)
B84143-A101-R207	Epcos	260 mm (10.236 in)	275 mm (10.827 in)	170 mm (6.693 in)	90 mm (3.543 in)	65 mm (2.559 in)	2 mm (0.079 in)	300 mm (11.811 in)	205 mm (8.071 in)	
B84143-A58-R207					120 mm (4.724 in)	85 mm (3.346 in)			249 mm (9.803 in)	
B84143-A165-R207					120 mm (4.724 in)	85 mm (3.346 in)			1 mm (0.039 in)	205 mm (8.071 in)
B84143-A95-R207					120 mm (4.724 in)	85 mm (3.346 in)			1 mm (0.039 in)	249 mm (9.803 in)



**Figure 3-46 Size 6 external EMC filter**



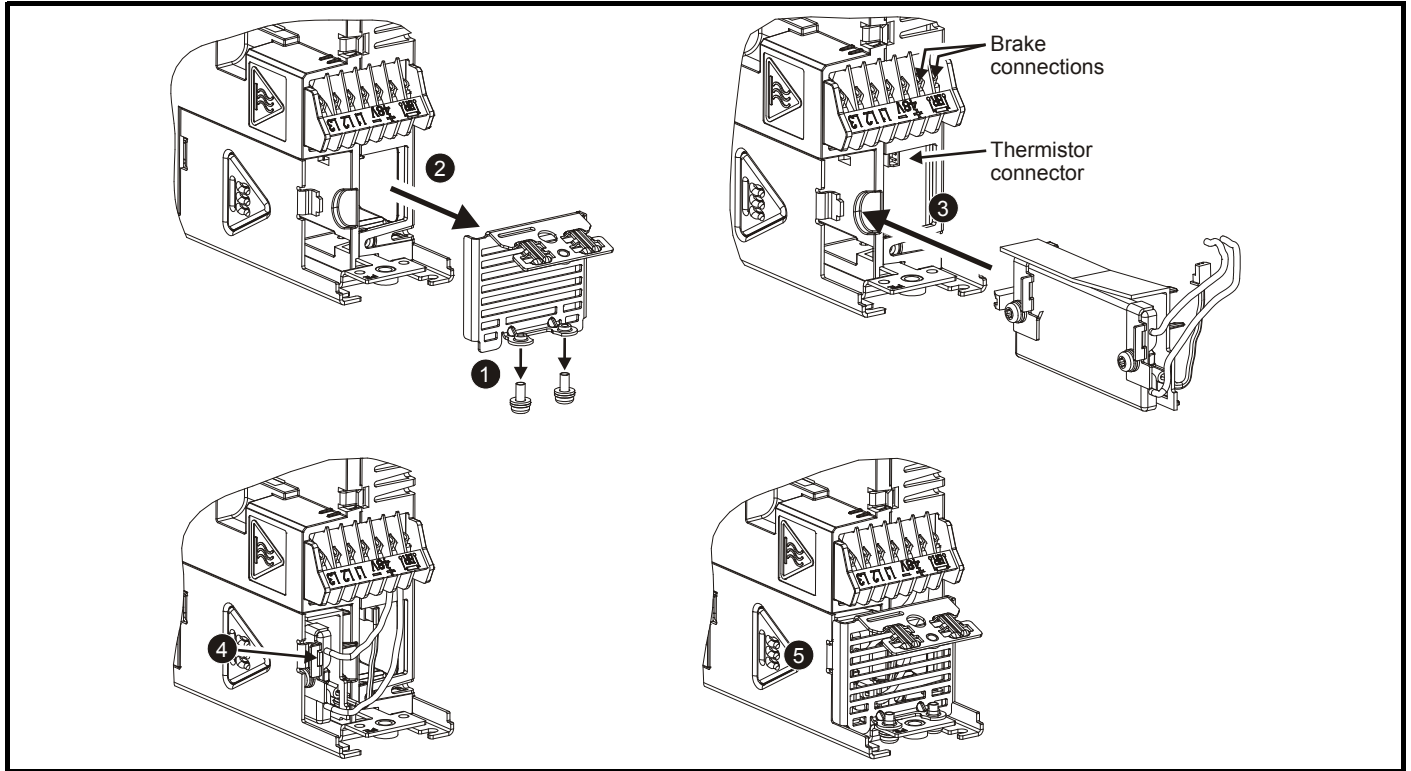
CT part no.	Manufacturer	A	B	C	D	E	F	G	H	I	J	W
FS6008-260-99	Schaffner	191 mm (7.717 in)	140 mm (5.512 in)	110 mm (4.331 in)	136 mm (5.354 in)	210 mm (8.268 in)	2 mm (0.079 in)	38 mm (1.496 in)	295 mm (11.614 in)	66 mm (2.958 in)	53.5 mm (2.106 in)	230 mm (9.055 in)
FS6008-160-99				108 mm (4.252 in)	147 mm (5.787 in)				357 mm (14.055 in)			
B84143-A260-S207	Epcos	200 mm (7.874 in)	140 mm (5.512 in)	108 mm (4.252 in)	147 mm (5.787 in)	210 mm (8.268 in)	2 mm (0.079 in)	36.5 mm (1.437 in)	364 mm (14.331 in)	127 mm (5.000 in)	53.5 mm (2.106 in)	230 mm (9.055 in)
B84143-A0160-S207				108 mm (4.252 in)	147 mm (5.787 in)				364 mm (14.331 in)			

## 3.11 Internal/heatsink mounted braking resistor

### 3.11.1 SPz internal braking resistor

The SPz has been designed to accommodate an optional internal resistor. When the internal resistor is used, an external thermal protection device is not required as the resistor is designed such that it will fail safely under fault conditions. The in-built software overload protection is set up at default to protect the resistor.

**Figure 3-47 Fitting an optional internal braking resistor (top view of drive)**



1. Remove screws
2. Remove grill
3. Fit the optional internal braking resistor in the slot provided and electrically connect the braking resistor (connections shown in Figure 4-1 on page 57). Ensure that the braking resistor thermistor is connected to the drive
4. Locate the braking resistor onto the drive tab
5. Refit the grill and mounting screws by reversing the procedure in points 1 and 2

### 3.11.2 Size 1 and 2 heatsink mounted braking resistor



If the drive has been used at high load levels for a period of time, the heatsink and heatsink mounted braking resistor can reach temperatures in excess of 70°C (158°F). Human contact with the heatsink and heatsink mounted braking resistor should be prevented.

**WARNING**



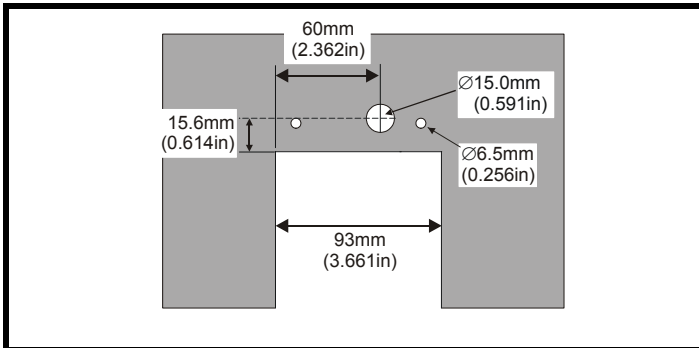
To avoid the risk of fire when the drive is surface mounted with the braking resistor installed, the back plate should be a non-flammable material.

**WARNING**

The size 1 and 2 have been designed with an optional space-saving heatsink mounted resistor. The resistor can be installed within the heatsink fins of the drive. When the heatsink mounted resistor is used, an external thermal protection device is not required as the resistor is designed such that it will fail safely under fault conditions. The in-built software overload protection is set up at default to protect the resistor. The resistor is rated to IP54 (NEMA12).

If the drive is to be through-panel mounted with the heatsink mounted brake resistor installed, then the aperture in the panel through which the drive is mounted must be modified as shown in Figure 3-48 and Figure 3-49. This is in order to allow for the braking resistor cables and grommets.

**Figure 3-48 Through-panel mounting cut-out details for size 1**

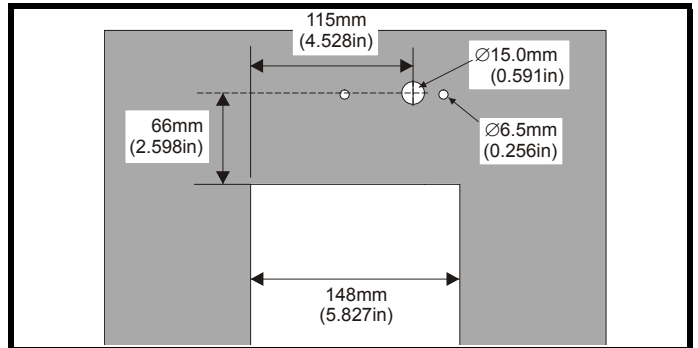


The part numbers for the resistor kits are as follows:

Size 1: 1220-2756-01

Size 2: 1220-2758-01

**Figure 3-49 Through-panel mounting cut-out details for size 2**

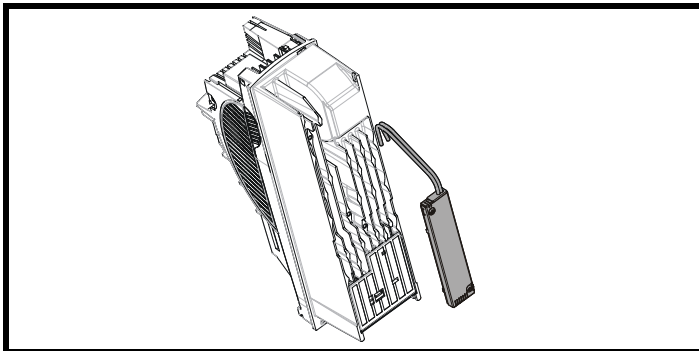


Each kit contains the following:

- A braking resistor assembly
- A through-panel grommet
- An installation sheet
- A wire clip (Size 2 only)

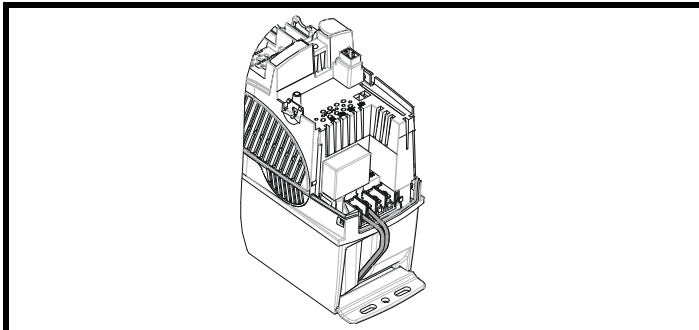
### 3.11.3 Size 1 braking resistor fitting instructions

**Figure 3-50 Fitting the heatsink mounted braking resistor on size 1**



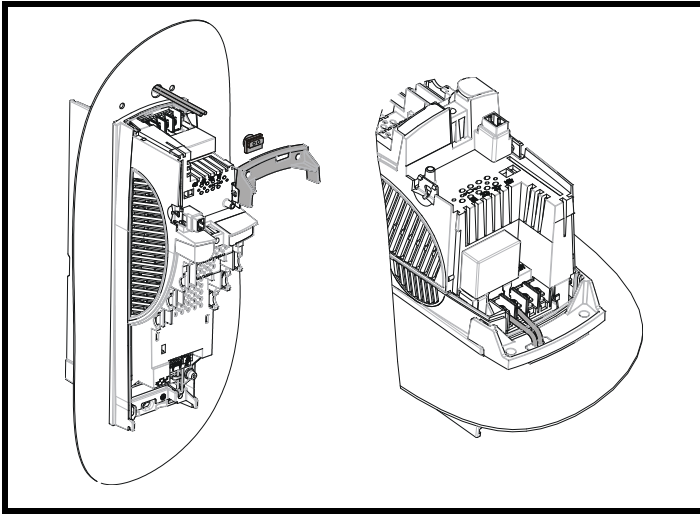
- Remove both terminal covers as detailed in section 3.3.1 *Removing the terminal covers* on page 21.
- Remove the two break-outs that line-up with the BR and +DC terminal connections as detailed in section 3.3.2 *Removing the finger-guard and DC terminal cover break-outs* on page 24.
- Install the braking resistor to the heatsink as shown in Figure 3-50. The resistor is installed with captive screws.
- The screws should be tightened to a maximum torque of 2 N m (1.5 lb ft).
- Ensure the cables are routed between the fins of the heatsink, and that the cables are not trapped between heatsink fins and the resistor.

**Figure 3-51 Connecting the brake resistor on a surface mounted size 1**



- Install the DC terminal cover grommets supplied in the accessory box with the drive, to the cables. To ensure a good seal, the grommets are a tight fit. Lubrication may be required to help install the grommets to the cables.
- Terminate the cables with suitable crimps and connect to the BR and +DC terminals. Tighten the screw terminals to a maximum torque of 1.5 Nm (1.1 lb ft).
- Replace both terminal covers.

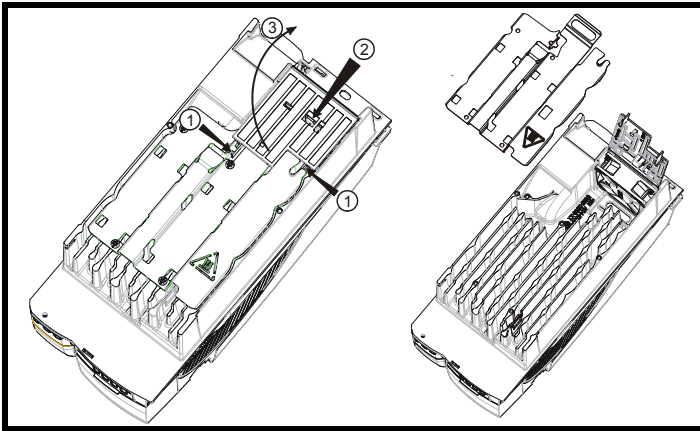
**Figure 3-52 Connecting the brake resistor on a through-panel mounted size 1**



- See Figure 3-48 for through-panel mounting cut-out details.
- Pass the cables through the hole in the panel and install the through-panel grommet.
- Install the through-panel mounting bracket.
- Install the DC terminal cover grommets supplied in the accessory box with the drive, to the cables. To ensure a good seal, the grommets are a tight fit. Lubrication may be required to help install the grommets to the cables.
- Terminate the cables with suitable crimps and connect to the BR and +DC terminals. Tighten the screw terminals to a maximum torque of 1.5 Nm (1.1 lb ft).
- Replace both terminal covers.

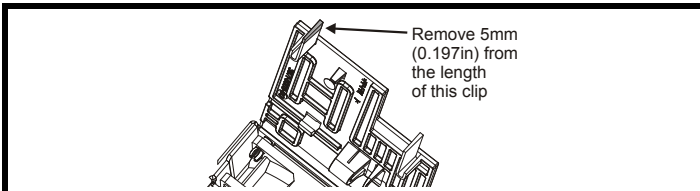
### 3.11.4 Size 2 braking resistor fitting instructions

**Figure 3-53 Removing the baffle plate on a size 2**



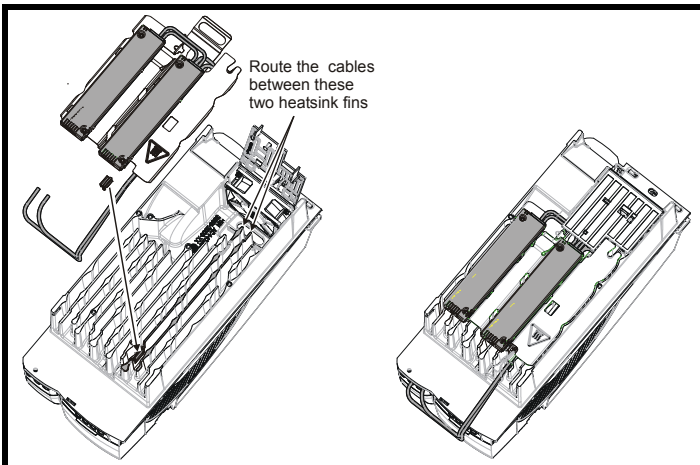
- Remove the DC cover as detailed in section 3.3.1 *Removing the terminal covers* on page 21.
- Remove the two break-outs that line-up with the BR and +DC terminal connections as detailed in section 3.3.2 *Removing the finger-guard and DC terminal cover break-outs* on page 24.
- Lift the hinged fan baffle by pushing plastic tabs in the direction shown (1). Push tab in the direction shown (2), and lift the baffle as shown (3).
- Remove the metal heatsink baffle plate by removing the two screws. These two screws are no longer required.

**Figure 3-54 Modifying the fan baffle on a size 2**



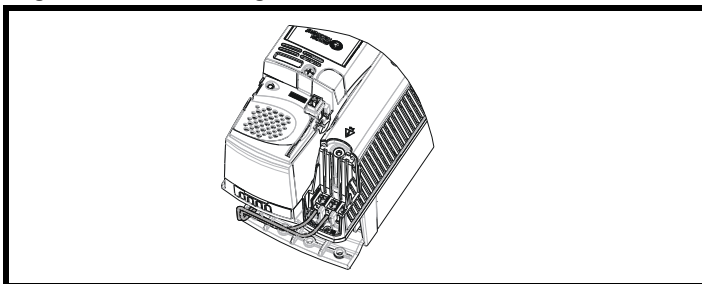
- Remove 5mm (0.197in) from the length of the clip on the plastic fan baffle.

**Figure 3-55 Fitting the heatsink mounted braking resistor on a size 2**



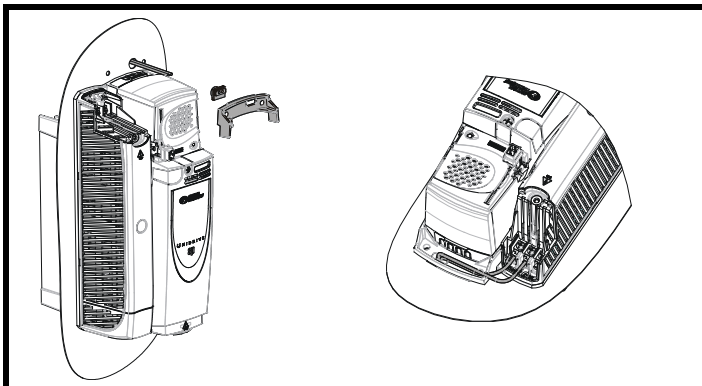
- Install clip to heatsink in the position shown in diagram opposite. Route the long cables of the resistor assembly between the fins of the heatsink as shown in Figure 3-55.
- Install the heatsink baffle plate in place with the cables routed underneath. Ensure the cables are not trapped between a heatsink fin and the baffle plate.
- Install the braking resistors to the heatsink. The resistors are installed with captive screws.
- The screws should be tightened to a maximum torque of 2.0 N m (1.5 lb ft).
- Close the hinged fan baffle.
- Install cables to heatsink clip.

**Figure 3-56 Connecting the brake resistor on a surface mounted size 2**



- Install the DC terminal cover grommets supplied in the accessory box with the drive, to the cables. To ensure a good seal, the grommets are a tight fit. Lubrication may be required to help install the grommets to the cables.
- Terminate the cables with suitable crimps and connect to the BR and DC2 terminals.
- Replace the terminal cover.

**Figure 3-57 Connecting the brake resistor on a through-panel mounted size 2**



- See Figure 3-49 for through-panel mounting cut-out details.
- Pass the cables through the hole in the panel and install the hole grommet.
- Install the mounting bracket.
- Install the DC terminal cover grommets supplied in the accessory box with the drive, to the cables. To ensure a good seal, the grommets are a tight fit. Lubrication may be required to help install the grommets to the cables.
- Terminate the cables with suitable crimps and connect to the BR and DC2 terminals.
- Replace the terminal cover.



### 3.11.5 Braking resistor overload protection parameter settings

#### Failure to observe the following information may damage the resistor.

The drive's software contains an overload protection function for a braking resistor. On size 1 and 2 this function is enabled at default to protect the heatsink mounted resistor. Below are the parameter settings.

Parameter		200V drive	400V drive
Full power braking time	Pr 10.30	0.04	0.02
Full power braking period	Pr 10.31	3.3	

Parameter		SPz		Size 1 and 2	
		200V drive	400V drive	200V drive	400V drive
Full power braking time	Pr 10.30	0.06	0.01	0.04	0.02
Full power braking period	Pr 10.31	2.6	1.7	3.3	

For more information on the braking resistor software overload protection, see the *Advanced User Guide*.

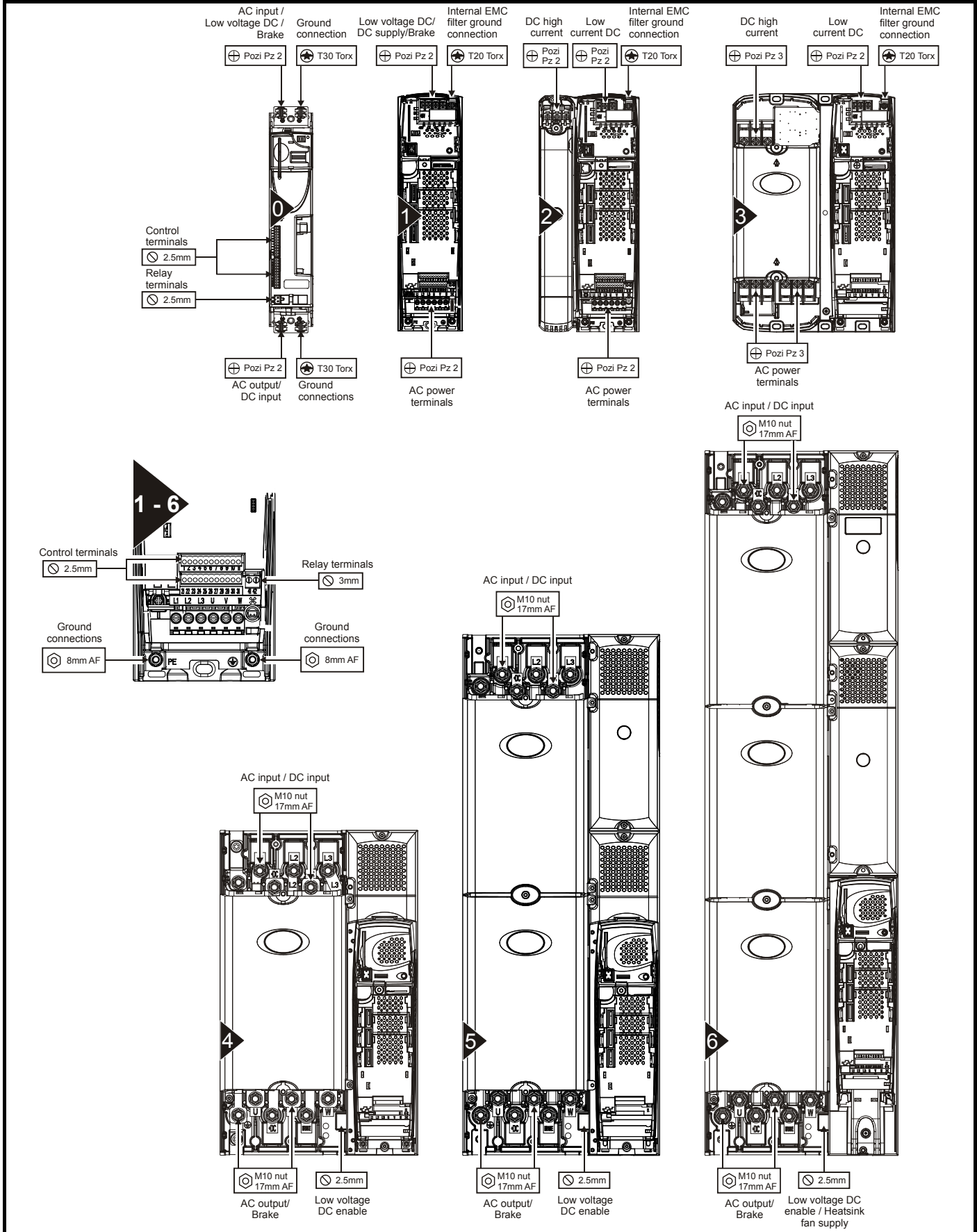
If the heatsink mounted braking resistor is to be used at more than half of its average power rating then the drive's cooling fan must be set to full speed by setting Pr 6.45 to On (1).

See section 4.9.1 *Heatsink mounted braking resistor* on page 68 for the resistor specifications.

## 3.12 Electrical terminals

### 3.12.1 Location of the power and ground terminals

Figure 3-58 Locations of the power and ground terminals



### 3.12.2 Terminal sizes and torque settings



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

**Table 3-7 Drive control and relay terminal data**

Model	Connection type	Torque setting
All	Plug-in terminal block	0.5 N m (0.4 b ft)

**Table 3-8 Drive power terminal data**

Model size	AC terminals	High current DC and braking	Low voltage DC	Ground terminal
SPz	Terminal block 1.0 N m (0.73 b ft)			Screw (M6) 4.0 N m (2.9 lb ft)
1	Plug-in terminal block 1.5 N m (1.1 lb ft)	Terminal block (M4 screws) 1.5 N m (1.1 b ft)		Stud (M5) 4.0 N m (2.9 lb ft)
2		Terminal block (M5 screws) 1.5 N m (1.1 lb ft)	Terminal block (M4 screws) 1.5 N m (1.1 lb ft)	
3	Terminal block (M6 screws) 2.5 N m (1.8 lb ft)			6.0 N m (4.4 lb ft)
4	M10 stud			M10 stud
5	15 N m			12 N m
6	(11.1 lb ft)			(8.8 lb ft)
Torque tolerance				±10%

**Table 3-9 Plug-in terminal block maximum cable sizes**

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm <sup>2</sup> (16 AWG)
All	2 way relay connector	2.5 mm <sup>2</sup> (12 AWG)
1 and 2	6 way AC power connector	8 mm <sup>2</sup> (8 AWG)
4, 5 and 6	Low Voltage DC Enable connector	1.5 mm <sup>2</sup> (16 AWG)
6	Heatsink fan supply connector	1.5 mm <sup>2</sup> (16 AWG)

The maximum cable size for the power terminals on Unidrive SP SPz is 4mm<sup>2</sup> (10 AWG).

**Table 3-10 Schaffner external EMC filter terminal data (SPz)**

Reference	Power and ground connections	
	Max cable size	Max torque
FS23072-19-07	4mm <sup>2</sup> 12AWG	0.8 N m (0.6 lb ft)
FS23073-17-07		
FS23074-11-07		

**Table 3-11 Schaffner external EMC filter terminal data (size 1 to 6)**

Reference	Power connections		Ground connections	
	Max cable size	Max torque	Ground stud size	Max torque
FS6008-10-07	4mm <sup>2</sup>	0.8 N m (0.6 b ft)	M5	3.5 N m (2.6 lb ft)
FS6008-16-07	12AWG			
FS6008-32-07	10mm <sup>2</sup> 8AWG	2 N m (1.5 b ft)	M5	3.5 N m (2.6 lb ft)
FS6008-62-07	16mm <sup>2</sup> 6AWG	2.2 N m (1.6 b ft)	M6	3.9 N m (2.9 lb ft)
FS6008-75-07				
FS6008-30-07				
FS6008-101-35	50mm <sup>2</sup> 0AWG	8 N m (5.9 b ft)	M10	25 N m (18.4 b ft)
FS6008-58-53	25mm <sup>2</sup> 4AWG	2.3 N m (1.7 b ft)	M6	3.9 N m (2.9 lb ft)
FS6008-164-40	95mm <sup>2</sup> 4/0AWG	20 N m (14.7 lb ft)	M10	25 N m (18.4 b ft)
FS6008-95-35	50mm <sup>2</sup> 0AWG	8 N m (5.9 b ft)	M10	25 N m (18.4 b ft)
FS6008-260-99			M10	25 N m (18.4 b ft)
FS6008-160-99				

**Table 3-12 Epcos external EMC Filter terminal data**

Reference	Power connections		Ground connections	
	Max cable size	Max torque	Ground stud size	Max torque
B84143-A16-R207	4mm <sup>2</sup>	0.6 N m (0.4 b ft)	M5	3.0 N m (2.2 lb ft)
B84143-A10-R207	12AWG			
B84143-A32-R207	10mm <sup>2</sup> 8AWG	1.35 N m (1.0 b ft)	M5	3.0 N m (2.2 lb ft)
B84143-A75-R207	16mm <sup>2</sup> 6AWG	2.2 N m (1.6 b ft)	M6	5.1 N m (3.8 lb ft)
B84143-A30-R207	10mm <sup>2</sup> 8AWG	1.35 N m (1.0 b ft)		
B84143-A101-R207	50mm <sup>2</sup>	6.8 N m (5.0 b ft)	M10	10 N m (7.4 lb ft)
B84143-A58-R207	0AWG			
B84143-A165-R207	95mm <sup>2</sup> 4/0AWG	20 N m (14.7 lb ft)		
B84143-A95-R207				
B84143-A260-S207				
B84143-A0160-S207				

### 3.13 Routine maintenance

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

Regular checks of the following should be carried out to ensure drive / installation reliability are maximised:

Environment	
Ambient temperature	Ensure the enclosure temperature remains at or below maximum specified
Dust	Ensure the drive remains dust free – check that the heatsink and drive fan are not gathering dust. The lifetime of the fan is reduced in dusty environments.
Moisture	Ensure the drive enclosure shows no signs of condensation
Enclosure	
Enclosure door filters	Ensure filters are not blocked and that air is free to flow
Electrical	
Screw connections	Ensure all screw terminals remain tight
Crimp terminals	Ensure all crimp terminals remains tight – check for any discoloration which could indicate overheating
Cables	Check all cables for signs of damage



## 4 Electrical Installation

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

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



### Electric shock risk

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

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

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



### 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.



### STOP function

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



**SAFE TORQUE OFF (SECURE DISABLE) function**  
The SAFE TORQUE OFF (SECURE DISABLE) function does not remove dangerous voltages from the drive, the motor or any external option units.



### Stored charge

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

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



### Equipment supplied by plug and socket

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



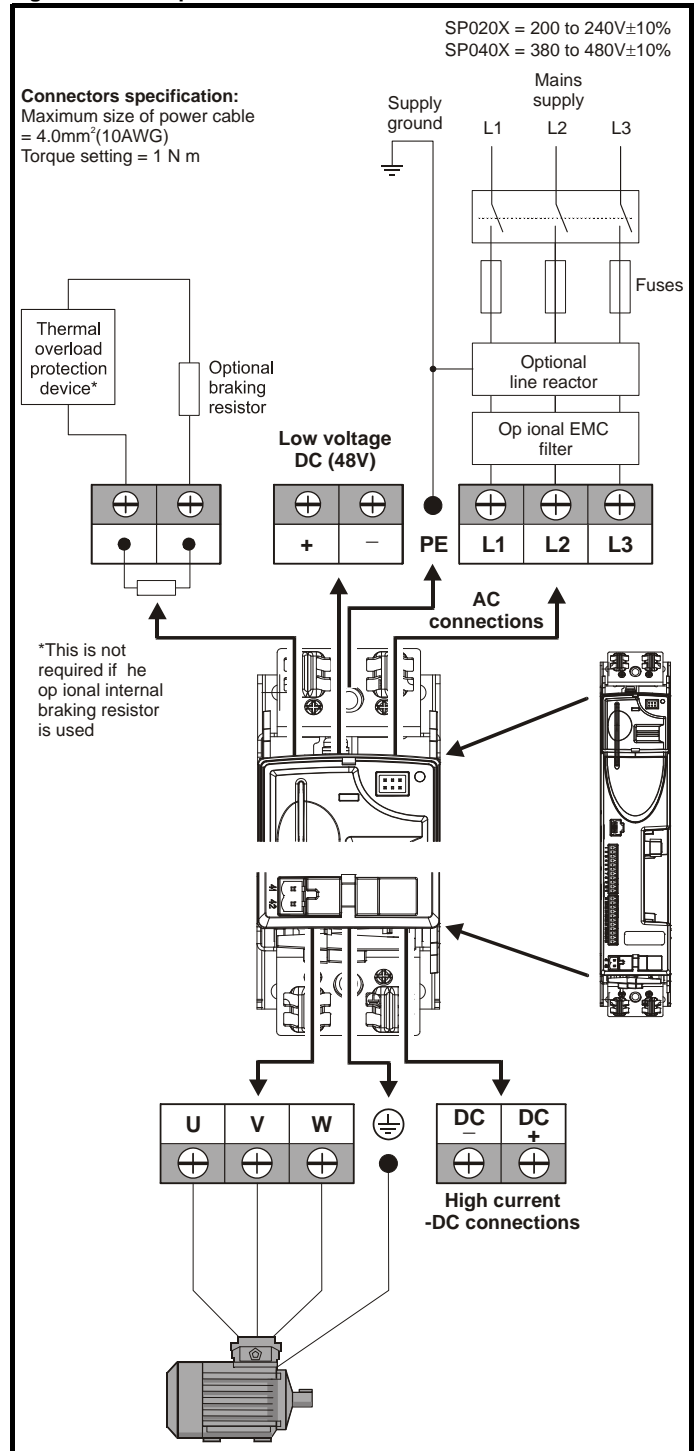
### Permanent magnet motors

Permanent magnet motors generate electrical power if they are rotated, even when the supply to the drive is disconnected. If that happens then the drive will become energized through its motor terminals. If the motor load is capable of rotating the motor when the supply is disconnected, then the motor must be isolated from the drive before gaining access to any live parts.

## 4.1 Power connections

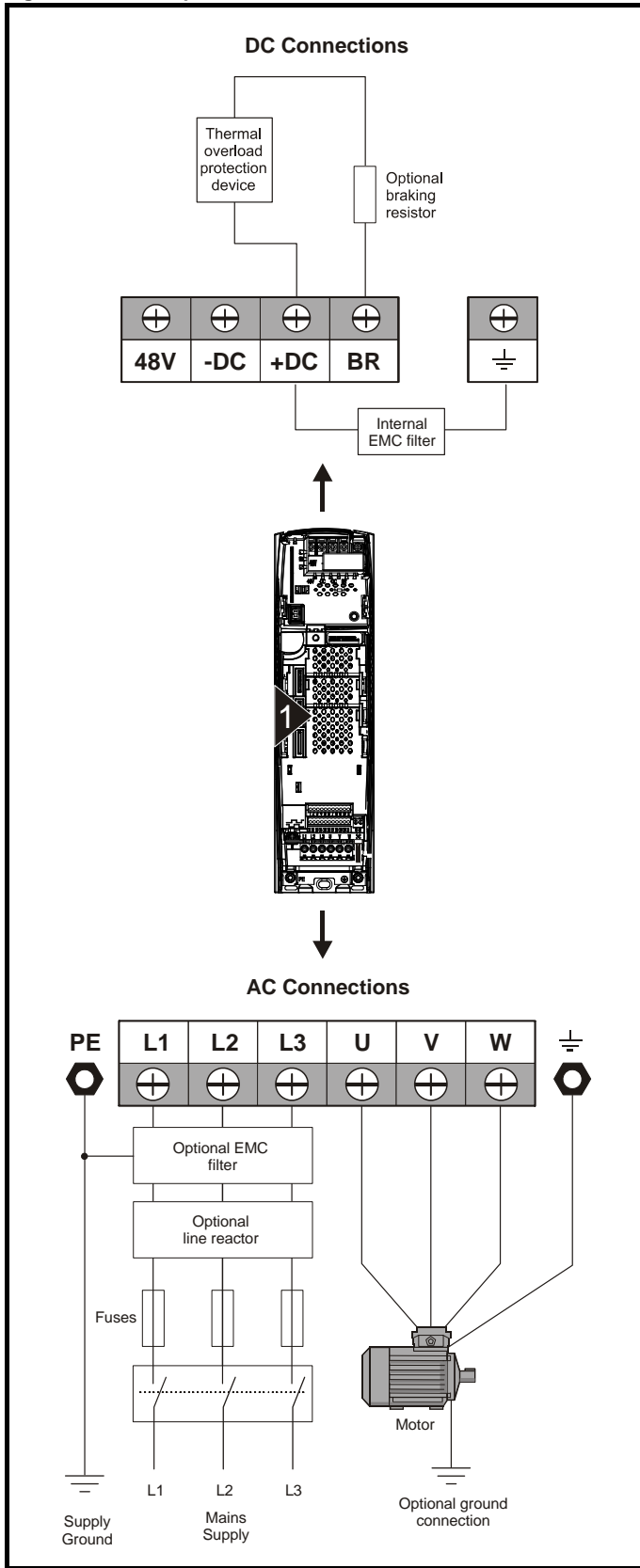
### 4.1.1 AC and DC connections

Figure 4-1 SPz power connections

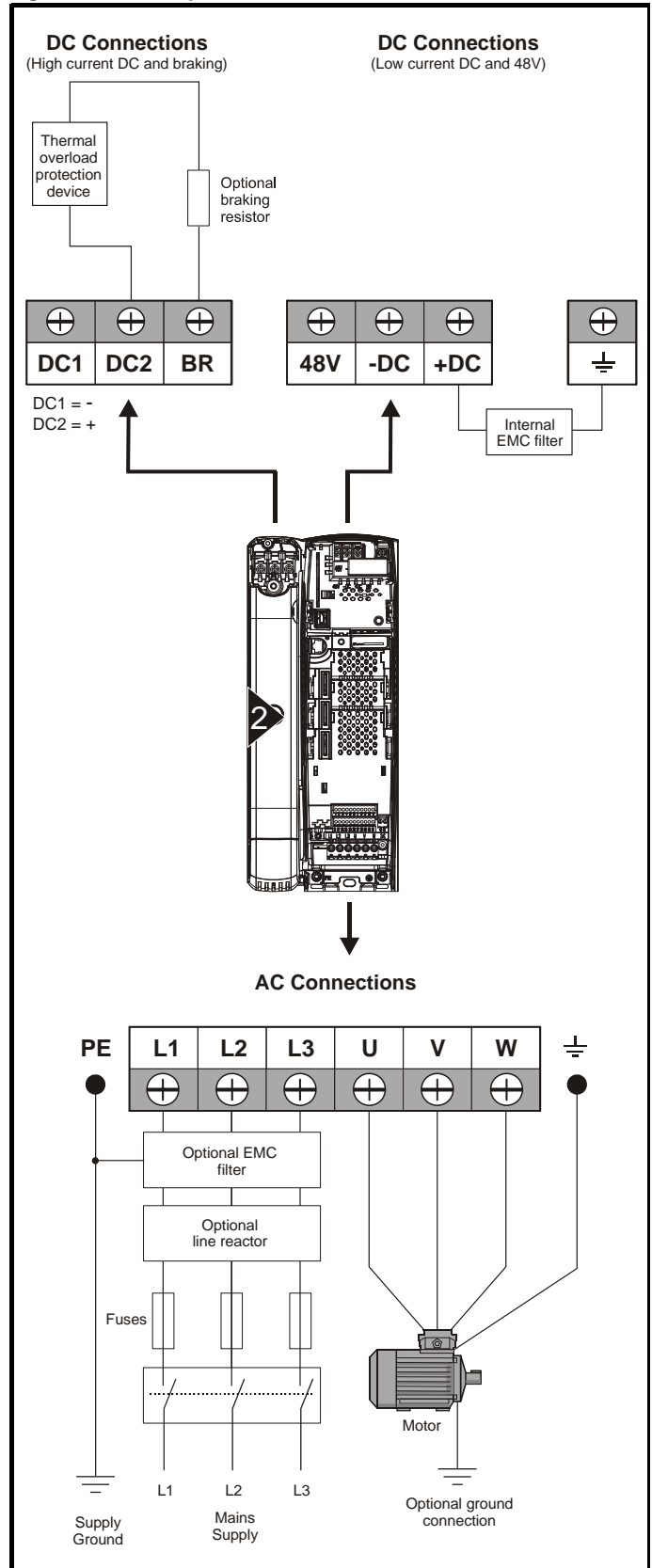


When using a 200V Unidrive SP SPz on a single-phase supply, the live and neutral conductors can be connected to any of the AC input connections on the drive.

**Figure 4-2 Size 1 power connections**



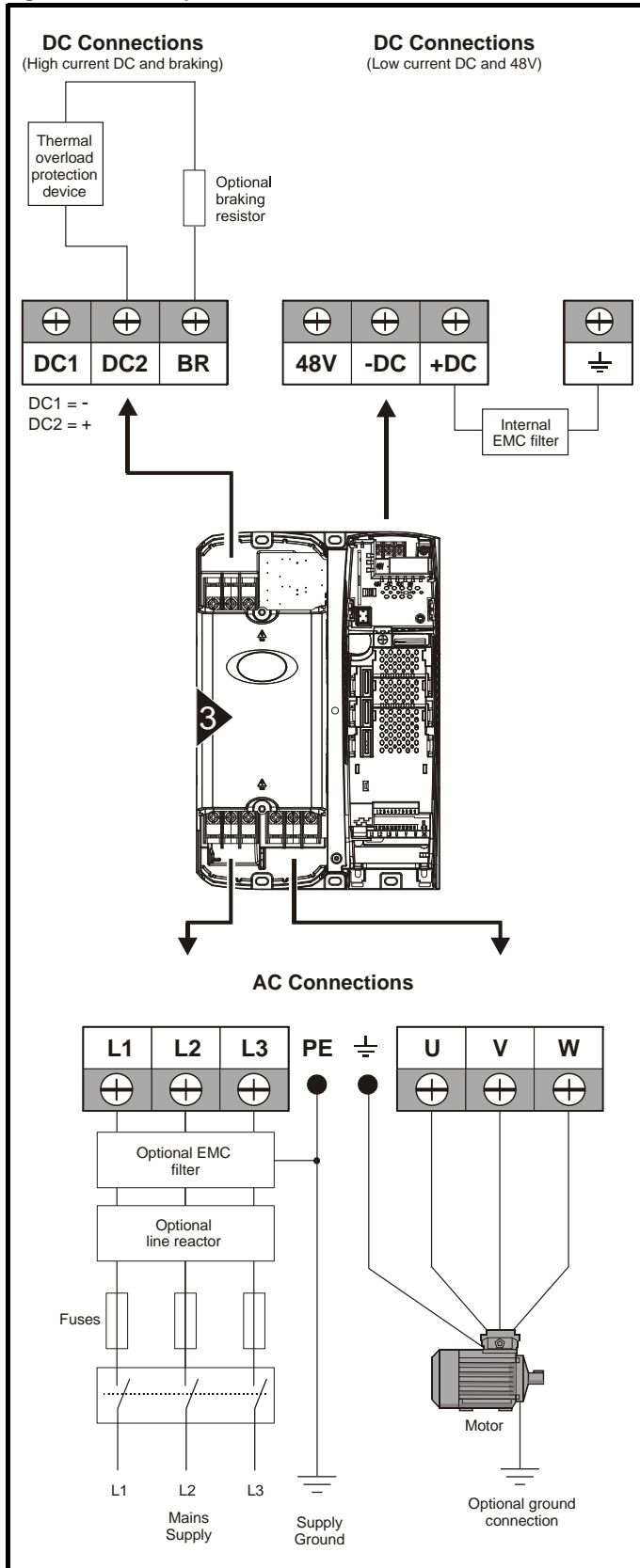
**Figure 4-3 Size 2 power connections**



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 4-6 for further information on ground connections.

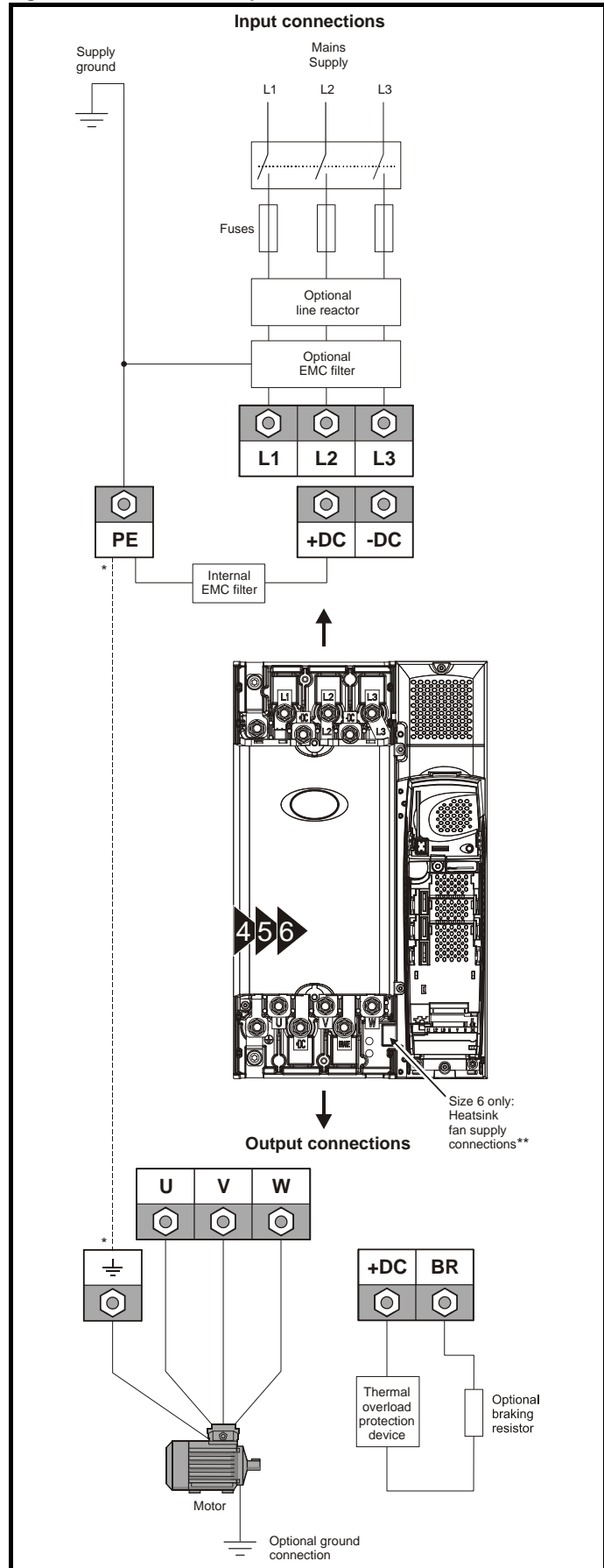
**Figure 4-4 Size 3 power connections**



On 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 DC or high voltage DC) or using the drive in a parallel DC bus system. The low current DC connection is used to connect low voltage DC to the drive internal power supply and to connect the internal EMC filter.

See Figure 4-7 for further information on ground connections.

**Figure 4-5 Size 4, 5 and 6 power connections**



\* See section 4.1.2 *Ground connections* .

\*\* See section 4.4 *Heatsink fan supply* on page 62 for more information.

## 4.1.2 Ground connections

### SPz

On a SPz, the supply and motor ground connections are made using an M6 screw at the top (supply) and bottom (motor) of the drive. See Figure 4-1 on page 57.

### Size 1

On a 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 4-2 on page 58.

### Size 2

On a size 2, the supply and motor ground connections are made using the grounding bridge that locates at the bottom of the drive. See Figure 4-6 for details.

### Size 3

On a 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 4-7 for details.

### Size 4, 5 and 6

On a size 4, 5 and 6, the supply and motor ground connections are made using an M10 bolt at the top (supply) and bottom (motor) of the drive. See Figure 4-8 on page 61.

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<sup>2</sup> (0.03in<sup>2</sup>, or slightly bigger than 6 AWG)

Size 5: 60mm<sup>2</sup> (0.09in<sup>2</sup>, or slightly bigger than 1 AWG)

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

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

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

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

Figure 4-6 Size 2 ground connections

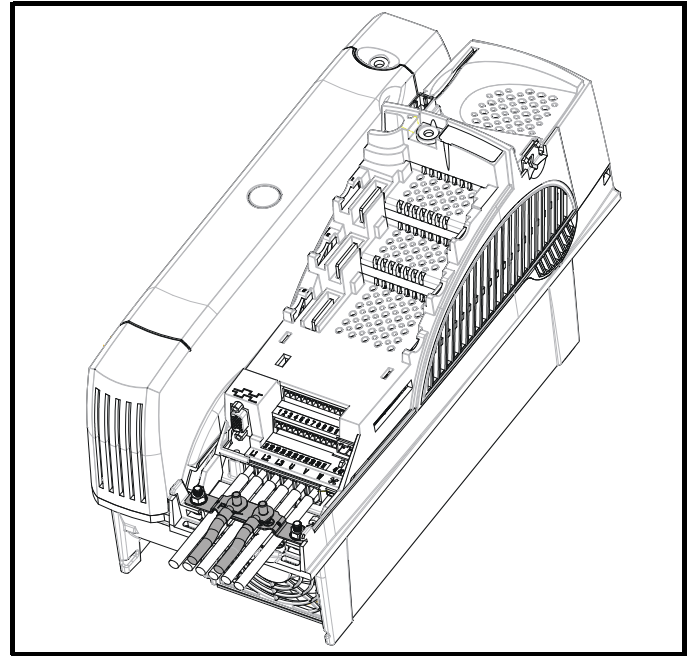
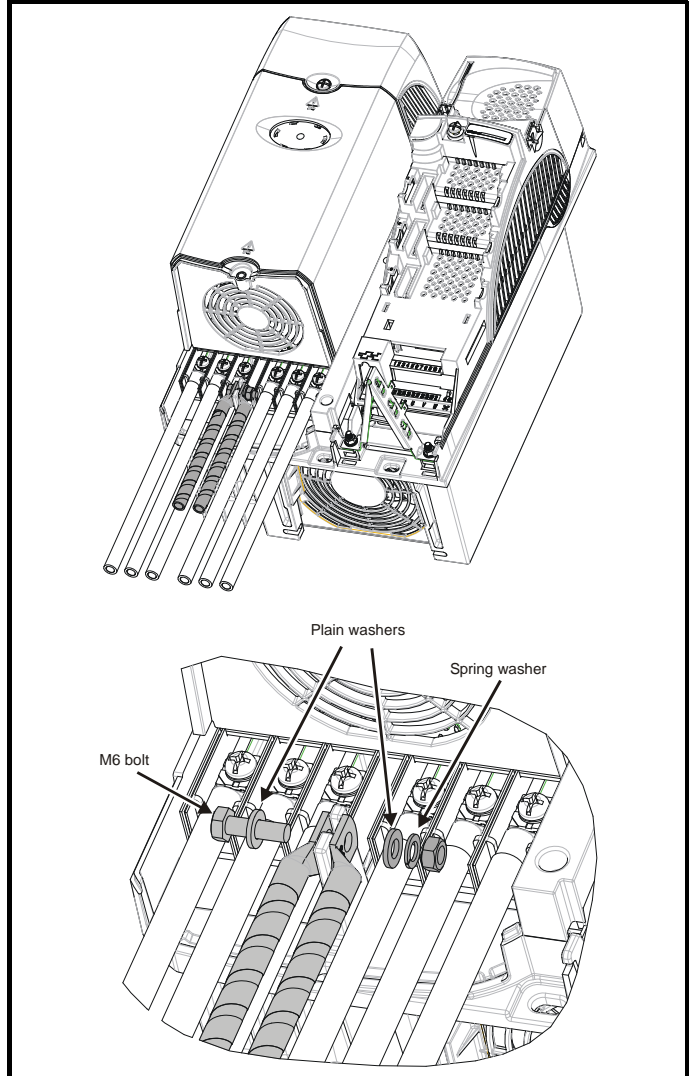
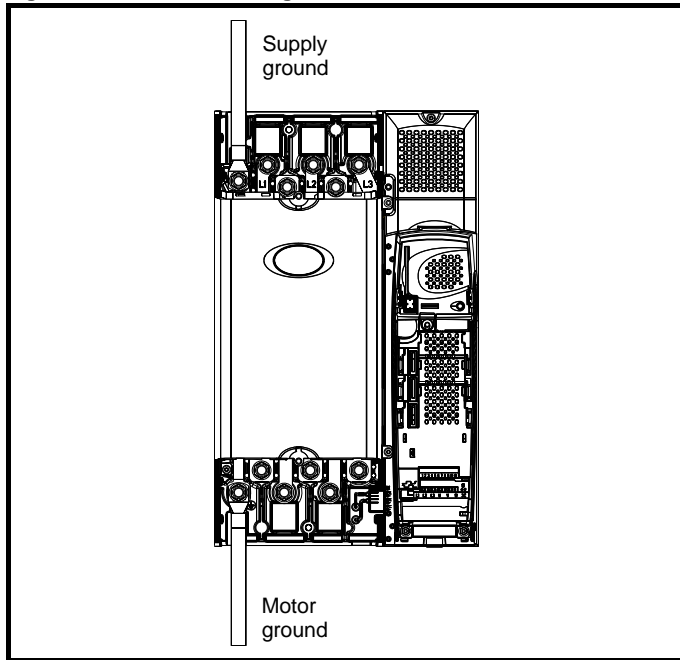


Figure 4-7 Size 3 ground connections



**Figure 4-8 Size 4, 5 and 6 ground connections**



**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.

## 4.2 AC supply requirements

Voltage:

- SPx2xx (M/TL) 200V to 240V ±10%
- SPx4xx (T) 380V to 480V ±10%
- SPx5xx (TM) 500V to 575V ±10%
- SPx6xx (TH) 500V to 690V ±10%

Number of phases: 3\*

\*200V SPz drives can also be used on a single phase supply.

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

Frequency range: 48 to 65 Hz

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

### 4.2.1 Supply types

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

- Supplies with voltage up to 600V may have grounding at any potential, i.e. neutral, centre or corner ("grounded delta")
- Supplies with voltage above 600V may not have corner grounding

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.



**WARNING**

### Operation with IT (ungrounded) supplies:

Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used (removed) or additional independent motor ground fault protection must be provided. Refer to Table 4-1.

For instructions on removal, refer to Figure 4-22 *Removal of internal EMC filter and line to ground varistors (SPz)*, Figure 4-23 *Removal of internal EMC filter (size 1 to 3)* and Figure 4-24 *Removal of internal EMC filter (sizes 4 to 6)* on page 74.

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

A ground fault in the supply has no effect in any case. If the motor must continue to run with a ground fault in its own circuit then an input isolating transformer must be provided and if an EMC filter is required it must be located in the primary circuit.

Unusual hazards can occur on ungrounded supplies with more than one source, for example on ships. Contact the supplier of the drive for more information.

**Table 4-1 Behaviour of the drive in the event of a motor circuit ground (earth) fault with an IT supply**

Drive size	Internal filter only	External filter (with internal)
SPz (200V)	May not trip – precautions required	Drive trips on fault
SPz (400V)	Drive trips on fault	Drive trips on fault
1 and 2	Drive trips on fault	Drive trips on fault
3	May not trip – precautions required	Drive trips on fault
4 to 6	May not trip – precautions required	May not trip – precautions required

### 4.2.2 Supplies requiring line reactors

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

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

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

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

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

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

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

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

- SPz 1M/TL to 2.5M/TL
- SPz 1T to 2.5T
- 1.5TL to 3.5TL
- 1.5T to 2T

Model sizes 4.5T to 60TH have an internal DC choke and 40TL to

150TH have internal AC line chokes, so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

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

#### Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

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

#### 4.2.3 Input inductor calculation

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

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

Where:

I = drive rated input current (A)

L = inductance (H)

f = supply frequency (Hz)

V = voltage between lines

### 4.3 Supplying the drive with DC / DC bus paralleling

The connecting of the DC bus between several drives is typically used to:

1. Return energy from a drive which is being overhauled by the load to a second motoring drive.
2. Allow the use of one braking resistor to dissipate regenerative energy from several drives.

There are limitations to the combinations of drives which can be used in this configuration.

For application data, contact the supplier of the drive.

### 4.4 Heatsink fan supply

The heatsink fan on SPz and sizes 1 to 5 is supplied internally by the drive. The heatsink fan on size 6 requires an external 24Vdc supply. The connections for the heatsink fan supply must be made to the upper terminal connector near to the W phase output on the drive. Figure 4-9 shows the position of the heatsink fan supply connections.

Figure 4-9 Location of the size 6 heatsink fan supply connections

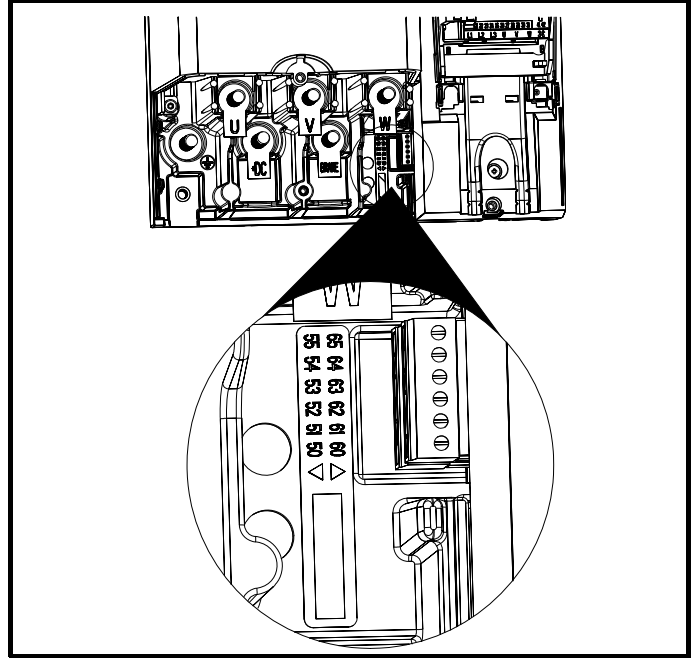
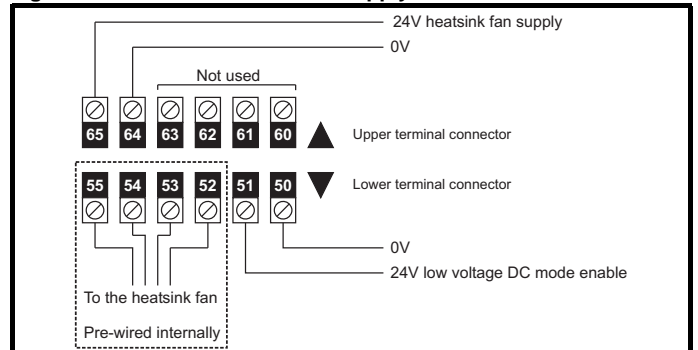


Figure 4-10 Size 6 heatsink fan supply connections



The heatsink fan supply requirements are as follows:

Nominal voltage:	24Vdc
Minimum voltage:	23.5Vdc
Maximum voltage:	27Vdc
Current drawn:	3.3A
Recommended power supply:	24V, 100W, 4.5A
Recommended fuse:	4A fast blow ( $I^2t$ less than $20A^2s$ )

An external supply could be ordered as an option. Please contact LEROY-SOMER.

### 4.5 Control 24Vdc supply

The 24Vdc input has three main functions.

- It can be used to supplement the drive's own internal 24V when multiple SM-Universal Encoder Plus, SM-Encoder Output Plus, SM-I/O Plus, or SM-I/O 32 modules are being used and the current drawn by these modules is greater than the drive can supply. (If too much current is drawn from the drive, the drive will initiate a 'PS.24V' trip)
- It can be used as a back-up power supply to keep the control circuits of the drive powered up when the line power supply is removed. This allows any fieldbus modules, application modules, encoders or serial communications to continue to operate.

- It can be used to commission the drive when the line power supply is not available, as the display operates correctly. However, the drive will be in the UV trip state unless either line power supply or low voltage DC operation is enabled, therefore diagnostics may not be possible. (Power down save parameters are not saved when using the 24V back-up power supply input.)

The working voltage range of the 24V power supply is as follows:

Maximum continuous operating voltage:	30.0 V
Minimum continuous operating voltage:	19.2 V
Nominal operating voltage:	24.0 V
Minimum start up voltage:	21.6 V
Maximum power supply requirement at 24V:	60 W
Recommended fuse:	3 A, 50 Vdc

Minimum and maximum voltage values include ripple and noise. Ripple and noise values must not exceed 5%.

## 4.6 Low voltage DC power supply

The drive can be operated from low voltage DC supplies, nominally 24Vdc (control) and 48Vdc (power). The low voltage DC power operating mode is designed either, to allow for motor operation in an emergency back-up situation following failure of the AC supply, for example in elevators; or to limit the speed of a servo motor during commissioning / start-up of equipment, for example a robot cell.

The working voltage range of the low voltage DC power supply is as follows:

### SPz

Minimum continuous operating voltage:	36V
Minimum start up voltage:	40V
Nominal continuous operating voltage:	48 to 72V
Maximum braking IGBT turn on voltage:	95.4V
Maximum over voltage trip threshold:	104.4V

### Size 1

Minimum continuous operating voltage:	36V
Minimum start up voltage:	40V
Nominal continuous operating voltage:	48V
Maximum braking IGBT turn on voltage:	63.6V
Maximum over voltage trip threshold:	69.6V

### Size 2 and 3

Minimum continuous operating voltage:	36V
Minimum start up voltage:	40V
Nominal continuous operating voltage:	48 to 72V
Maximum braking IGBT turn on voltage:	95.4V
Maximum over voltage trip threshold:	104.4V

### Size 4 (200V drives)

Minimum continuous operating voltage:	36V
Nominal continuous operating voltage:	48 to 72V
Maximum braking IGBT turn on voltage:	95.4V
Maximum over voltage trip threshold:	104.4V

### Size 4, 5 and 6 (400V and 690V drives)

Minimum continuous operating voltage:	36V
Nominal continuous operating voltage:	48 to 96V
Maximum braking IGBT turn on voltage:	127.2V
Maximum over voltage trip threshold:	139.2V

See section 4.5 *Control 24Vdc supply* on page 62 for 24V back-up to control.

#### NOTE

The nominal low voltage supply level is set by the user in Pr 6.46.

The default setting is 48V for all drive sizes.

The over voltage trip threshold and braking IGBT turn on voltage are scaled from this value as follows:

- Brake IGBT turn on = 1.325 x Pr 6.46 (V)
- Over voltage trip = 1.45 x Pr 6.46 (V)

## 4.7 Ratings

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

### Typical input current

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

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

### Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance.

The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

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

**Table 4-2 Supply fault current used to calculate maximum input currents**

Model	Symmetrical fault level (kA)
All	100

**Table 4-3 SPz and sizes 1 to 3 input current, fuse and cable size ratings (European)**

Model		Typical input current A	Maximum continuous input current A	Fuse rating IEC gG A	Cable size EN60204	
LS	CT				Input mm <sup>2</sup>	Output mm <sup>2</sup>
SPz 1M/TL	SP0201	3.2 (5.0)*	3.6 (5.0)*	6	0.75	0.75
SPz 1.2M/TL	SP0202	4.8 (7.6)*	5.6 (7.6)*	10	1	0.75
SPz 1.5M/TL	SP0203	6.0 (9.6)*	6.9 (9.6)*	12	1.5	0.75
SPz 2M/TL	SP0204	7.9 (13.5)*	8.9 (13.5)*	16	2.5	0.75
SPz 2.5M/TL	SP0205	10.6 (17.4)*	12.3 (17.4)*	20	4	0.75
1.5TL	SP1201	7.1	9.5	10	1.5	1.0
2TL	SP1202	9.2	11.3	12	1.5	1.0
2.5TL	SP1203	12.5	16.4	20	4.0	1.0
3.5TL	SP1204	15.4	19.1	20	4.0	1.5
4.5TL	SP2201	13.4	18.1	20	4.0	2.5
5.5TL	SP2202	18.2	22.6	25	4.0	4.0
8TL	SP2203	24.2	28.3	32	6.0	6.0
11TL	SP3201	35.4	43.1	50	16	16
16TL	SP3202	46.8	54.3	63	25	25
1T	SP0401	2.0	2.3	4	0.75	0.75
1.2T	SP0402	2.6	2.8	4	0.75	0.75
1.5T	SP0403	3.2	3.3	6	0.75	0.75
2T	SP0404	4.3	4.4	6	0.75	0.75
2.5T	SP0405	5.6	5.7	8	0.75	0.75
1.5T	SP1401	4.1	4.8	8	1.0	1.0
2T	SP1402	5.1	5.8	8	1.0	1.0
2.5T	SP1403	6.8	7.4	8	1.0	1.0
3.5T	SP1404	9.3	10.6	12	1.5	1.0
4.5T	SP1405	10	11	12	1.5	1.0
5.5T	SP1406	12.6	13.4	16	2.5	1.5
8T	SP2401	15.7	17	20	4.0	2.5
11T	SP2402	20.2	21.4	25	4.0	4.0
16T	SP2403	26.6	27.6	32	6.0	6.0
20T	SP2404	26.6	27.6	32	6.0	6.0
22T	SP3401	34.2	36.2	40	10	10
27T	SP3402	40.2	42.7	50	16	16
33T	SP3403	51.3	53.5	63	25	25
3.5TM	SP3501	5.0	6.7	8	1.0	1.0
4.5TM	SP3502	6.0	8.2	10	1.0	1.0
5.5TM	SP3503	7.8	11.1	12	1.5	1.0
8TM	SP3504	9.9	14.4	16	2.5	1.5
11TM	SP3505	13.8	18.1	20	4.0	2.5
16TM	SP3506	18.2	22.2	25	4.0	4.0
22TM	SP3507	22.2	26.0	32	6.0	6.0

\*The value in the bracket is when the drive is used on a 1 phase supply.

**Table 4-4 SPz and sizes 1 to 3 input current, fuse and cable size ratings (USA)**

Model		Typical input current A	Maximum continuous input current A	Fuse rating Class CC or J** <30A Class J** >30A A	Cable size UL508C	
LS	CT				Input AWG	Output AWG
SPz 1M/TL	SP0201	3.2 (5.0)*	3.6 (5.0)*	10	16	24
SPz 1.2M/TL	SP0202	4.8 (7.6)*	5.6 (7.6)*	10	16	22
SPz 1.5M/TL	SP0203	6.0 (9.6)*	6.9 (9.6)*	16	14	20
SPz 2M/TL	SP0204	7.9 (13.5)*	8.9 (13.5)*	20	12	18
SPz 2.5M/TL	SP0205	10.6 (17.4)*	12.3 (17.4)*	20	12	18
1.5TL	SP1201	7.1	9.5	10	14	18
2TL	SP1202	9.2	11.3	15	14	16
2.5TL	SP1203	12.5	16.4	20	12	14
3.5TL	SP1204	15.4	19.1	20	12	14
4.5TL	SP2201	13.4	18.1	20	12	14
5.5TL	SP2202	18.2	22.6	25	10	10
8TL	SP2203	24.2	28.3	30	8	8
11TL	SP3201	35.4	43.1	45	6	6
16TL	SP3202	46.8	54.3	60	4	4
1T	SP0401	2.0	2.3	10	16	24
1.2T	SP0402	2.6	2.8	10	16	24
1.5T	SP0403	3.2	3.3	10	16	24
2T	SP0404	4.3	4.4	10	16	22
2.5T	SP0405	5.6	5.7	10	16	20
1.5T	SP1401	4.1	4.8	8	16	22
2T	SP1402	5.1	5.8	8	16	20
2.5T	SP1403	6.8	7.4	10	16	18
3.5T	SP1404	9.3	10.6	15	14	16
4.5T	SP1405	10	11	15	14	14
5.5T	SP1406	12.6	13.4	15	14	14
8T	SP2401	15.7	17	20	12	14
11T	SP2402	20.2	21.4	25	10	10
16T	SP2403	26.6	27.6	30	8	8
20T	SP2404	26.6	27.6	30	8	8
22T	SP3401	34.2	36.2	40	6	6
27T	SP3402	40.2	42.7	45	6	6
33T	SP3403	51.3	53.5	60	4	4
3.5TM	SP3501	5.0	6.7	10	16	18
4.5TM	SP3502	6.0	8.2	10	16	16
5.5TM	SP3503	7.8	11.1	15	14	14
8TM	SP3504	9.9	14.4	15	14	14
11TM	SP3505	13.8	18.1	20	12	14
16TM	SP3506	18.2	22.2	25	10	10
22TM	SP3507	22.2	26.0	30	8	8

\*The value in the bracket is when the drive is used on a 1 phase supply.

\*\* Fast acting or high speed class J fuses only.



**Table 4-5 Size 4 and larger input current, fuse and cable size ratings**

Model		Typical input current	Maximum input current	Fuse option 1		Fuse option 2 semiconductor fuse in series with HRC fuse or breaker		Cable size			
				IEC class gR	North America: Ferraz HSJ	HRC IEC class gG UL class J	Semi-conductor IEC class aR	EN60204		UL508C	
LS	CT	A	A	A	A	A	A	Input mm <sup>2</sup>	Output mm <sup>2</sup>	Input AWG	Output AWG
22TL	SP4201	62.1	68.9	100	90	90	160	25	25	3	3
27TL	SP4202	72.1	78.1	100	100	100	160	35	35	3	3
33TL	SP4203	94.5	99.9	125	125	125	200	70	70	1	1
40TL	SP5201	116	142	200	175	160	200	95	95	2/0	2/0
50TL	SP5202	137	165	250	225	200	250	120	120	4/0	4/0
40T	SP4401	61.2	62.3	80	80	80	160	25	25	3	3
50T	SP4402	76.3	79.6	110	110	100	200	35	35	2	2
60T	SP4403	94.1	97.2	125	125	125	200	70	70	1	1
75T	SP5401	126	131	200	175	160	200	95	95	2/0	2/0
100T	SP5402	152	156	250	225	200	250	120	120	4/0	4/0
120T	SP6401	224	241	315	300	250	315	2 x 70	2 x 70	2 x 2/0	2 x 2/0
150T	SP6402	247	266	315	300	300	350	2 x 120	2 x 120	2 x 4/0	2 x 4/0
22TH	SP4601	23	26.5	63	60	32	125	4	4	10	10
27TH	SP4602	26.1	28.8	63	60	40	125	6	6	8	8
33TH	SP4603	32.9	35.1	63	60	50	125	10	10	8	8
40TH	SP4604	39	41	63	60	50	125	16	16	6	6
50TH	SP4605	46.2	47.9	63	60	63	125	16	16	6	6
60TH	SP4606	55.2	56.9	80	60	63	125	25	25	4	4
75TH	SP5601	75.5	82.6	125	100	90	160	35	35	2	2
100TH	SP5602	89.1	94.8	125	100	125	160	50	50	1	1
120TH	SP6601	128	138	200	200	200	200	2 x 50	2 x 50	2 x 1	2 x 1
150TH	SP6602	144	156	200	200	200	200	2 x 50	2 x 50	2 x 1	2 x 1

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

B1 - Separate cables in conduit.

B2 - Multicore cable in conduit

C - Multicore cable in free air.

**NOTE**

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

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


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 100kA. See Chapter 14 *UL Listing Information* on page 278 for sizing information.



**Fuses**  
The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 4-3, Table 4-4 and Table 4-5 show recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

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

An MCB (miniature circuit breaker) or MCCB (moulded-case circuit-breaker) with type C may be used in place of fuses on 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

See Chapter 14 *UL Listing Information* for UL listing requirements.

**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.


**4.7.1 Main AC supply contactor**

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

## 4.8 Output circuit and motor protection

The output circuit has fast-acting electronic short-circuit protection which limits the fault current to typically no more than five times the rated output current, and interrupts the current in approximately 20µs. No additional short-circuit protection devices are required.

The drive provides overload protection for the motor and its cable. For this to be effective, Pr **0.46 Motor rated current** must be set to suit the motor.



Pr 0.46 *Motor rated current* must be set correctly to avoid a risk of fire in the event of motor overload.

**WARNING**

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

### 4.8.1 Cable types and lengths

Since capacitance in the motor cable causes loading on the output of the drive, ensure the cable length does not exceed the values given in Table 4-6, Table 4-7 and Table 4-8.

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

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

**Table 4-6 Maximum motor cable lengths (200V drives)**

200V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SPz 1M/TL	SP0201	50m (165ft)					
SPz 1.2M/TL	SP0202						
SPz 1.5M/TL	SP0203						
SPz 2M/TL	SP0204						
SPz 2.5M/TL	SP0205						
1.5TL	SP1201	65m (210ft)			50m (165ft)	37m (120ft)	
2TL	SP1202	100m (330ft)					
2.5TL	SP1203	130m (425ft)					
3.5TL	SP1204	200m (660ft)	150m (490ft)	100m (330ft)			
4.5TL	SP2201						75m (245ft)
5.5TL	SP2202						
8TL	SP2203	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
11TL	SP3201						
16TL	SP3202	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
22TL	SP4201						
27TL	SP4202	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
33TL	SP4203						
40TL	SP5201	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
50TL	SP5202						

**Table 4-7 Maximum motor cable lengths (400V drives)**

400V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
1T	SP0401	50m (165ft)					
1.2T	SP0402						
1.5T	SP0403						
2T	SP0404						
2.5T	SP0405						
1.5T	SP1401	65m (210ft)			50m (165ft)	37m (120ft)	
2T	SP1402	100m (330ft)					
2.5T	SP1403	130m (425ft)					
3.5T	SP1404	200m (660ft)	150m (490ft)	100m (330ft)			
4.5T	SP1405						75m (245ft)
5.5T	SP1406						
8T	SP2401	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
11T	SP2402						
16T	SP2403						
20T	SP2404						
22T	SP3401						
27T	SP3402	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
33T	SP3403						
40T	SP4401	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
50T	SP4402						
60T	SP4403	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
75T	SP5401						
100T	SP5402	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
120T	SP6401						
150T	SP6402	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		

**Table 4-8 Maximum motor cable lengths (575V drives)**

575V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
3.5TM	SP3501	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)		
4.5TM	SP3502						
5.5TM	SP3503						
8TM	SP3504						
11TM	SP3505						
16TM	SP3506						
22TM	SP3507						

**Table 4-9 Maximum motor cable lengths (690V drives)**

690V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
22TH	SP4601	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
27TH	SP4602						
33TH	SP4603						
40TH	SP4604						
50TH	SP4605						
60TH	SP4606						
75TH	SP5601						
100TH	SP5602						
120TH	SP6601						
150TH	SP6602						

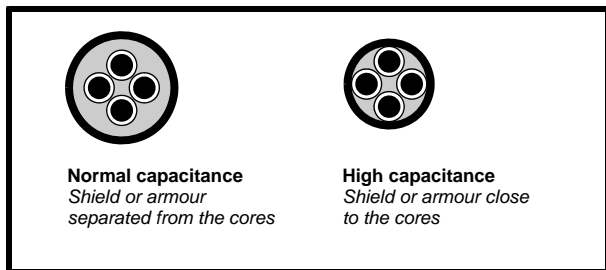
- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
- The default switching frequency is 3kHz for open-loop and closed-loop vector and 6kHz for servo.

**High-capacitance cables**

The maximum cable length is reduced from that shown in Table 4-6, Table 4-7, Table 4-8 and Table 4-9 if high capacitance motor cables are used.

Most cables have an insulating jacket between the cores and the armor or shield; these cables have a low capacitance and are recommended. Cables that do not have an insulating jacket tend to have high capacitance; if a cable of this type is used, the maximum cable length is half that quoted in the tables. (Figure 4-11 shows how to identify the two types.)

**Figure 4-11 Cable construction influencing the capacitance**



The cable used for Table 4-6, Table 4-7, Table 4-8 and Table 4-9 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).

**4.8.2 Motor winding voltage**

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

For normal operation with AC supplies up to 500Vac and a standard motor with a good quality insulation system, there is no need for any special precautions. In case of doubt the motor supplier should be consulted.

Special precautions are recommended under the following conditions, but only if the motor cable length exceeds 10m:

- AC supply voltage exceeds 500V
- DC supply voltage exceeds 670V
- Operation of 400V drive with continuous or very frequent sustained braking
- Multiple motors connected to a single drive

For multiple motors, the precautions given in section 4.8.3 *Multiple motors* should be followed.

For the other cases listed, it is recommended that an inverter-rated motor be used. This has a reinforced insulation system intended by the manufacturer for repetitive fast-rising pulsed voltage operation.

Users of 575V NEMA rated motors should note that the specification for inverter-rated motors given in NEMA MG1 section 31 is sufficient for motoring operation but not where the motor spends significant periods braking. In that case an insulation peak voltage rating of 2.2kV is recommended.

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

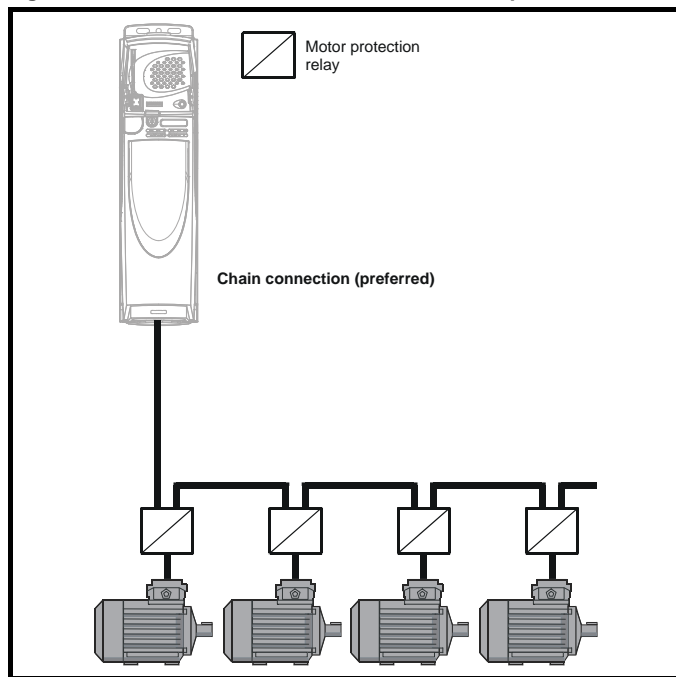
**4.8.3 Multiple motors**

**Open-loop only**

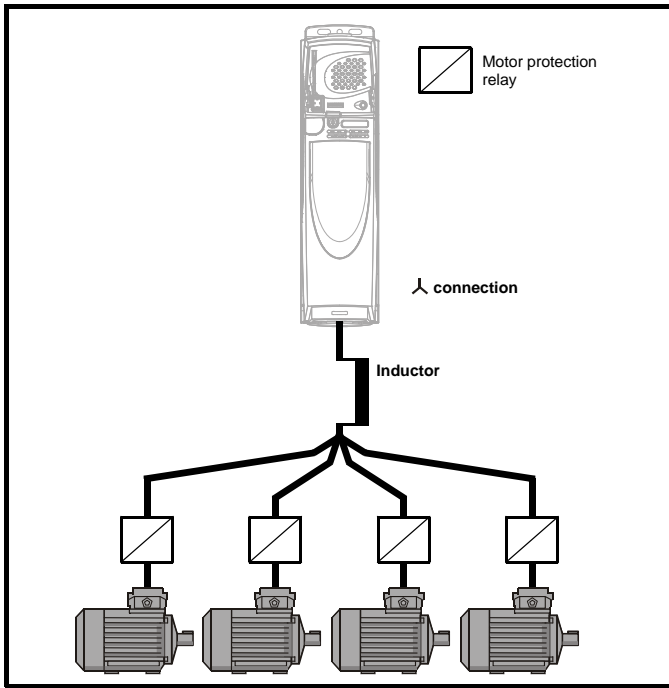
If the drive is to control more than one motor, one of the fixed V/F modes should be selected (Pr 5.14 = Fd or SrE). Make the motor connections as shown in Figure 4-12 and Figure 4-13. The maximum cable lengths in Table 4-6, Table 4-7, Table 4-8 and Table 4-9 apply to the sum of the total cable lengths from the drive to each motor.

It is recommended that each motor is connected through a protection relay since the drive cannot protect each motor individually. For  $\Delta$  connection, a sinusoidal filter or an output inductor must be connected as shown in Figure 4-13, even when the cable lengths are less than the maximum permissible. For details of inductor sizes refer to the supplier of the drive.

**Figure 4-12 Preferred chain connection for multiple motors**



**Figure 4-13 Alternative connection for multiple motors**



#### 4.8.4 $\Delta$ / $\Delta$ motor operation

The voltage rating for  $\Delta$  and  $\Delta$  connections of the motor should always be checked before attempting to run the motor.

The default setting of the motor rated voltage parameter is the same as the drive rated voltage, i.e.

- 400V drive 400V rated voltage
- 200V drive 200V rated voltage

A typical 3 phase motor would be connected in  $\Delta$  for 400V operation or  $\Delta$  for 200V operation, however, variations on this are common e.g.

$\Delta$  690V  $\Delta$  400V

Incorrect connection of the windings will cause severe under or over fluxing of the motor, leading to a very poor output torque or motor saturation and overheating respectively.

#### 4.8.5 Output contactor



If the cable between the drive and the motor is to be interrupted by a contactor or circuit breaker, ensure that the drive is disabled before the contactor or circuit breaker is opened or closed. Severe arcing may occur if this circuit is interrupted with the motor running at high current and low speed.

A contactor is sometimes required to be installed between the drive and motor for safety purposes.

The recommended motor contactor is the AC3 type.

Switching of an output contactor should only occur when the output of the drive is disabled.

Opening or closing of the contactor with the drive enabled will lead to:

1. OI.AC trips (which cannot be reset for 10 seconds)
2. High levels of radio frequency noise emission
3. Increased contactor wear and tear

The Drive Enable terminal (T31) when opened provides a SAFE TORQUE OFF (SECURE DISABLE) function. This can in many cases replace output contactors.

For further information see section 4.16 *SAFE TORQUE OFF (SECURE DISABLE)* on page 89.

## 4.9 Braking

Braking occurs when the drive is decelerating the motor, or is preventing the motor from gaining speed due to mechanical influences. During braking, energy is returned to the drive from the motor.

When the motor is being braked by the drive, the maximum regenerated power that the drive can absorb is equal to the power dissipation (losses) of the drive.

When the regenerated power is likely to exceed these losses, the DC bus voltage of the drive increases. Under default conditions, the drive brakes the motor under PI control, which extends the deceleration time as necessary in order to prevent the DC bus voltage from rising above a user defined set-point.

If the drive is expected to rapidly decelerate a load, or to hold back an overhauling load, a braking resistor must be installed.

Table 4-10 shows the DC voltage level at which the drive turns on the braking transistor.

**Table 4-10 Braking transistor turn on voltage**

Drive voltage rating	DC bus voltage level
200V	390V
400V	780V
575V	930V
690V	1120V

#### NOTE

When a braking resistor is used, Pr **0.15** should be set to FAST ramp mode.



High temperatures  
Braking resistors can reach high temperatures. Locate braking resistors so that damage cannot result. Use cable having insulation capable of withstanding high temperatures.

#### 4.9.1 Heatsink mounted braking resistor

A resistor has been especially designed to be mounted internal to the drive (SPz) or within the heatsink of the drive (sizes 1 and 2). See section 3.11 *Internal/heatsink mounted braking resistor* on page 50 for mounting details. The design of the resistor is such that no thermal protection circuit is required, as the device will fail safely under fault conditions. On SPz, sizes 1 and 2, the in built software overload protection is set up at default for the designated heatsink mounted resistor. Table 4-11 provides the resistor data for each drive rating.



The internal braking resistor for SPz is fitted with a thermistor which must be connected to the drive whenever the internal braking resistor is installed.

#### NOTE

The internal/heatsink mounted resistor is suitable for applications with a low level of regen energy only. See Table 4-11.



**Braking resistor overload protection parameter settings**  
**Failure to observe the following information may damage the resistor.**

**CAUTION**

The drive's software contains an overload protection function for a braking resistor. On SPz and sizes 1 and 2 this function is enabled at default to protect the heatsink mounted resistor. Below are the parameter settings.

Parameter		SPz		Sizes 1 and 2	
		200V drive	400V drive	200V drive	400V drive
Full power braking time	Pr 10.30	0.06	0.01	0.04	0.02
Full power braking period	Pr 10.31	2.6	1.7	3.3	

For more information on the braking resistor software overload protection, see Pr 10.30 and Pr 10.31 full descriptions in the *Advanced User Guide*.

If the heatsink mounted braking resistor is to be used at more than half of its average power rating then the drive's cooling fan must be at full speed controlled by setting Pr 6.45 to On (1).

**Table 4-11 Heatsink mounted braking resistor data**

Parameter	SPz	Size 1	Size 2
Part number	1299-0001-00	1220-2756-01	1220-2758-01
DC resistance at 25 C	70Ω	75Ω	37.5Ω
Peak instantaneous power over 1ms at nominal resistance	8.7kW	8kW	16kW
Average power over 60s *	50W	50W	100W
Ingress Protection (IP) rating	N/A	IP54	
Maximum altitude	2000m		

\* To keep the temperature of the resistor below 70°C (158°F) in a 30°C (86°F) ambient, the average power rating is 50W for size 1 and 100W for size 2. The above parameter settings ensure this is the case.

Size 3 and larger do not have heatsink mounted braking resistors, hence the default values of Pr 10.30 and Pr 10.31 are 0 (i.e. software braking resistor overload protection disabled).

The internal braking resistor for SPz can be used with the drive even though its resistance is lower than the minimum resistance values given in Table 4-12, because of the following reasons.

- The braking resistor overload protection function in the drive is set up to limit the power dissipated in the resistor
- The braking resistor is fitted with a thermistor which will trip the drive if the resistor is too hot
- The power rating of the resistor is only 50W

If an external resistor is used with the drive, its resistance must be equal to or greater than the value given in Table 4-12.

**4.9.2 External braking resistor**



**Overload protection**  
 When an external braking resistor is used, it is essential that an overload protection device is incorporated in the braking resistor circuit; this is described in Figure 4-14 on page 70.

When a braking resistor is to be mounted outside the enclosure, ensure that it is mounted in a ventilated metal housing that will perform the following functions:

- Prevent inadvertent contact with the resistor
- Allow adequate ventilation for the resistor

When compliance with EMC emission standards is required, external

connection requires the cable to be armored or shielded, since it is not fully contained in a metal enclosure. See section 4.11.5 *Compliance with generic emission standards* on page 77 for further details.

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

**Minimum resistances and power ratings**

**Table 4-12 Minimum resistance values and peak power rating for the braking resistor at 40°C (104°F)**

Model		Minimum resistance* Ω	Instantaneous power rating kW	Average power for 60s kW
LS	CT			
SPz 1M/TL	SP0201	35	4.35	0.74
SPz 1.2M/TL	SP0202			1.1
SPz 1.5M/TL	SP0203			1.5
SPz 2M/TL	SP0204			2.2
SPz 2.5M/TL	SP0205			3.0
1.5TL	SP1201	43	3.5	1.5
2TL	SP1202			2.2
2.5TL	SP1203			3.0
3.5TL	SP1204	29	5.3	4.4
4.5TL	SP2201	18	8.9	6.0
5.5TL	SP2202			8.0
8TL	SP2203			8.9
11TL	SP3201			13.1
16TL	SP3202	5.0	30.3	19.3
22TL	SP4201**	5.0	30.3	22.5
27TL	SP4202**			27.8
33TL	SP4203**			30.3
40TL	SP5201**	3.5	53	43.5
50TL	SP5202**			
1T	SP0401	105	5.79	0.74
1.2T	SP0402			1.1
1.5T	SP0403			1.5
2T	SP0404			2.2
2.5T	SP0405			3.0
1.5T	SP1401	74	8.3	1.5
2T	SP1402			2.2
2.5T	SP1403			3.0
3.5T	SP1404			4.4
4.5T	SP1405	58	10.6	6.0
5.5T	SP1406			8.0
8T	SP2401	19	33.1	9.6
11T	SP2402			13.1
16T	SP2403			19.3
20T	SP2404			22.5
22T	SP3401	18	35.5	22.5
27T	SP3402			27.8
33T	SP3403			33.0
40T	SP4401**	11	55.3	45.0
50T	SP4402**			53.0
60T	SP4403**	9	67.6	67.5
75T	SP5401**	7	86.9	82.5
100T	SP5402**			86.9
120T	SP6401**	5	122	122
150T	SP6402**			

Model		Minimum resistance* Ω	Instantaneous power rating kW	Average power for 60s kW
LS	CT			
3.5TM	SP3501	18	50.7	4.4
4.5TM	SP3502			6.0
5.5TM	SP3503			8.0
8TM	SP3504			9.6
11TM	SP3505			13.1
16TM	SP3506			19.3
22TM	SP3507			22.5
22TH	SP4601**	13	95.0	19.3
27TH	SP4602**			22.5
33TH	SP4603**			27.8
40TH	SP4604**			33.0
50TH	SP4605**			45.0
60TH	SP4606**			55.5
75TH	SP5601**	10	125	67.5
100TH	SP5602**	10	125	82.5
120TH	SP6601**			113
150TH	SP6602**			125

\* Resistor tolerance: ±10%

\*\* The power ratings specified are for a stand-alone drive only. If the drive is part of a common DC bus system different ratings must be used. Contact the supplier of the drive for more information.

For high-inertia loads or under continuous braking, the *continuous power* dissipated in the braking resistor may be as high as the power rating of the drive. The total *energy* dissipated in the braking resistor is dependent on the amount of energy to be extracted from the load.

The instantaneous power rating refers to the short-term maximum power dissipated during the *on* intervals of the pulse width modulated braking control cycle. The braking resistor must be able to withstand this dissipation for short intervals (milliseconds). Higher resistance values require proportionately lower instantaneous power ratings.

In most applications, braking occurs only occasionally. This allows the continuous power rating of the braking resistor to be much lower than the power rating of the drive. It is essential, though, that the instantaneous power rating and energy rating of the braking resistor are sufficient for the most extreme braking duty that is likely to be encountered.

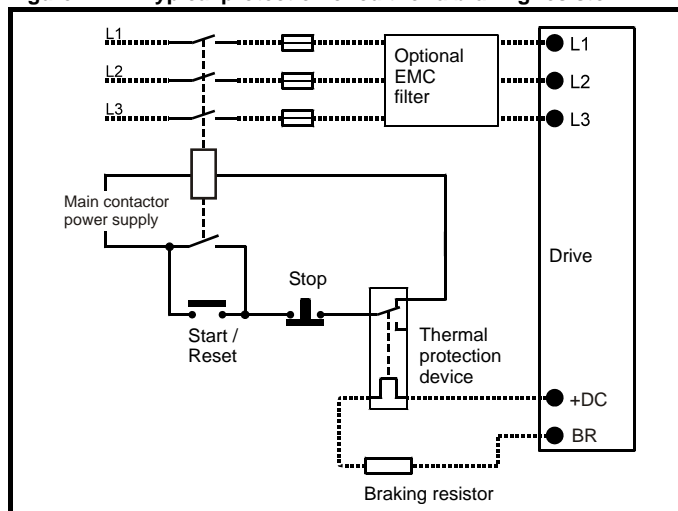
Optimization of the braking resistor requires a careful consideration of the braking duty.

Select a value of resistance for the braking resistor that is not less than the specified minimum resistance. Larger resistance values may give a cost saving, as well as a safety benefit in the event of a fault in the braking system. Braking capability will then be reduced, which could cause the drive to trip during braking if the value chosen is too large.

### Thermal protection circuit for the braking resistor

The thermal protection circuit must disconnect the AC supply from the drive if the resistor becomes overloaded due to a fault. Figure 4-14 shows a typical circuit arrangement.

Figure 4-14 Typical protection circuit for a braking resistor



See Figure 4-2 on page 58, Figure 4-3 and Figure 4-4 on page 59, and Figure 4-5 on page 59 for the location of the +DC and braking resistor connections.

### 4.9.3 Braking resistor software overload protection

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

- Resistor short-time overload time (Pr 10.30)
- Resistor minimum time between repeated short-time overloads (Pr 10.31)

This data should be obtained from the manufacturer of the braking resistors.

Pr 10.39 gives an indication of braking resistor temperature based on a simple thermal model. Zero indicates the resistor is close to ambient and 100% is the maximum temperature the resistor can withstand. A br.rS alarm is given if this parameter is above 75% and the braking IGBT is active. An It.br trip will occur if Pr 10.39 reaches 100%, when Pr 10.37 is set to 0 (default value) or 1.

If Pr 10.37 is equal to 2 or 3 an It.br trip will not occur when Pr 10.39 reaches 100%, but instead the braking IGBT will be disabled until Pr 10.39 falls below 95%. This option is intended for applications with parallel connected DC buses where there are several braking resistors, each of which cannot withstand full DC bus voltage continuously. With this type of application it is unlikely the braking energy will be shared equally between the resistors because of voltage measurement tolerances within the individual drives. Therefore with Pr 10.37 set to 2 or 3, then as soon as a resistor has reached its maximum temperature the drive will disable the braking IGBT, and another resistor on another drive will take up the braking energy. Once Pr 10.39 has fallen below 95% the drive will allow the braking IGBT to operate again.

See the *Advanced User Guide* for more information on Pr 10.30, Pr 10.31, Pr 10.37 and Pr 10.39.

This software overload protection should be used in addition to an external overload protection device.

## 4.10 Ground leakage

The ground leakage current depends upon whether the internal EMC filter is installed. The drive is supplied with the filter installed. Instructions for removing the internal filter are given in Figure 4-23 *Removal of internal EMC filter (size 1 to 3)* and Figure 4-24 *Removal of internal EMC filter (sizes 4 to 6)* on page 74.

### With internal filter installed:

**SPz:** 12mA\* AC at 400V 50Hz  
30µA DC with a 600V DC bus (10MΩ)

**Size 1 to 3:** 28mA\* AC at 400V 50Hz  
30µA DC with a 600V DC bus (10MΩ)

**Size 4 to 6:** 56mA\* AC at 400V 50Hz  
18µA DC with a 600V DC bus (33MΩ)

\* Proportional to the supply voltage and frequency.

### With internal filter removed:

<1mA

Note that in both cases there is an internal voltage surge protection device connected to ground. Under normal circumstances this carries negligible current.



When the internal filter is installed the leakage current is high. In this case a permanent fixed ground connection must be provided, or other suitable measures taken to prevent a safety hazard occurring if the connection is lost.

### 4.10.1 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

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



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

If an external EMC filter is used, a delay of at least 50ms should be incorporated to ensure spurious trips are not seen. The leakage current is likely to exceed the trip level if all of the phases are not energized simultaneously.

## 4.11 EMC (Electromagnetic compatibility)

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

**Section 4.11.3, 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* on page 79 for increased surge immunity of control circuits where control wiring is extended.

**Section 4.11.4, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN61800-3).**

**Section 4.11.5, Requirements for meeting the generic emission standards** for the industrial environment, IEC61000-6-4, EN61000-6-4, EN50081-2.

The recommendations of section 4.11.3 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 4.11.4 or

section 4.11.5 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
- Chapter 12 *Technical Data* on page 242

...the correct external EMC filter must be used and all of the guidelines in section 4.11.3 *General requirements for EMC* and section 4.11.5 *Compliance with generic emission standards* must be followed.

**Table 4-13 Unidrive SP and EMC filter cross reference**

Drive		Reference	
LS	CT	Schaffner	Epcos
SPz 1M/TL to SPz 2.5M/TL (1 phase)	SP0201 to SP0205 (1 phase)	FS23072-19-07	
SPz 1M/TL to SPz 2.5M/TL (3 phase)	SP0201 to SP0205 (3 phase)	FS23073-17-07	
1.5TL & 2TL	SP1201 to SP1202	FS6008-10-07	B84143-A10-R207
2.5TL & 3.5TL	SP1203 to SP1204	FS6008-16-07	B84143-A16-R207
4.5TL to 8TL	SP2201 to SP2203	FS6008-32-07	B84143-A32-R207
11TL & 16TL	SP3201 to SP3202	FS6008-75-07	B84143-A75-R207
22TL to 33TL	SP4201 to SP4203	FS6008-101-35	B84143-A101-R207
40TL & 50TL	SP5201 to SP5202	FS6008-164-40	B84143-A165-R207
SPz 1T to SPz 2.5T	SP0401 to SP0405	FS23074-11-07	
1.5T to 3.5T	SP1401 to SP1404	FS6008-10-07	B84143-A10-R207
4.5T & 5.5T	SP1405 to SP1406	FS6008-16-07	B84143-A16-R207
8T to 20T	SP2401 to SP2404	FS6008-32-07	B84143-A32-R207
22T to 33T	SP3401 to SP3403	FS6008-62-07	B84143-A75-R207
40T to 60T	SP4401 to SP4403	FS6008-101-35	B84143-A101-R207
75T & 100T	SP5401 to SP5402	FS6008-164-40	B84143-A165-R207
120T & 150T	SP6401 to SP6402	FS6008-260-99	B84143-A260-S207
3.5TM to 22TM	SP3501 to SP3507	FS6008-30-07	B84143-A30-R207
22TH to 60TH	SP4601 to SP4606	FS6008-58-53	B84143-A58-R207
75TH & 100TH	SP5601 to SP5602	FS6008-95-35	B84143-A95-R207
120TH & 150TH	SP6601 to SP6602	FS6008-160-99	B84143-A0160-S207



### High ground leakage current

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

### NOTE

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

### 4.11.1 Grounding hardware

The drive is supplied with a grounding bracket, and sizes 1 to 3 with a grounding clamp, to facilitate EMC compliance. They provide a convenient method for direct grounding of cable shields without the use of "pig-tails". Cable shields can be bared and clamped to the grounding bracket using metal clips or clamps<sup>1</sup> (not supplied) or cable ties. Note that the shield must in all cases be continued through the clamp to the intended terminal on the drive, in accordance with the connection details for the specific signal.

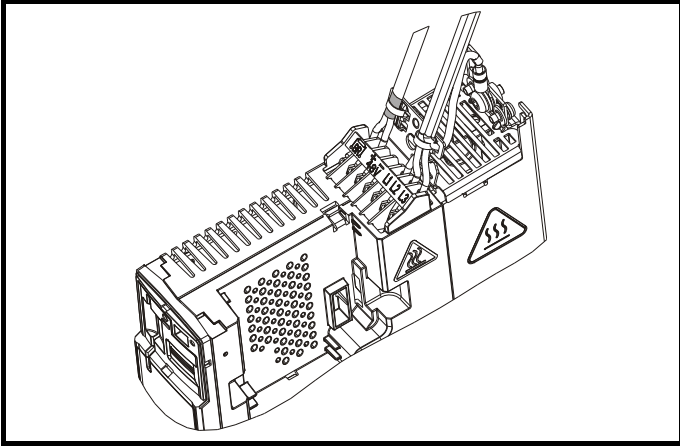
<sup>1</sup> A suitable clamp is the Phoenix DIN rail mounted SK14 cable clamp (for cables with a maximum outer diameter of 14mm).

See Figure 4-15 for details of using the grounded metal panel on SPz.

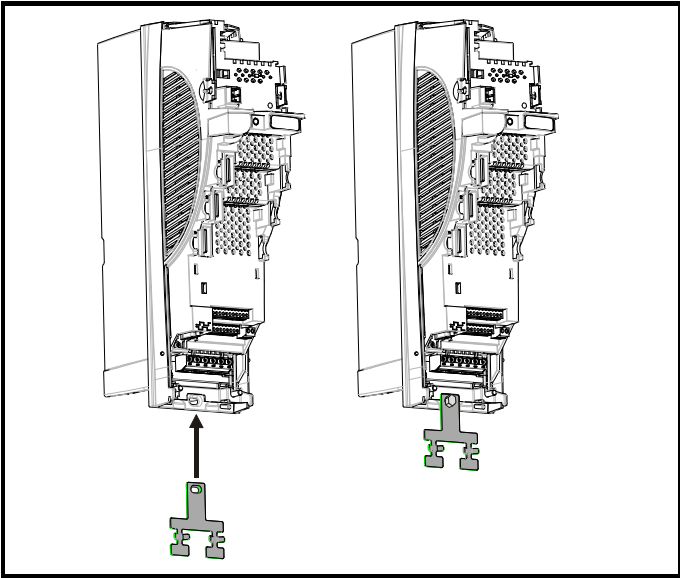
See Figure 4-16 and Figure 4-17 for details on installing the grounding clamp.

See Figure 4-18 and Figure 4-19 for details on installing the grounding bracket.

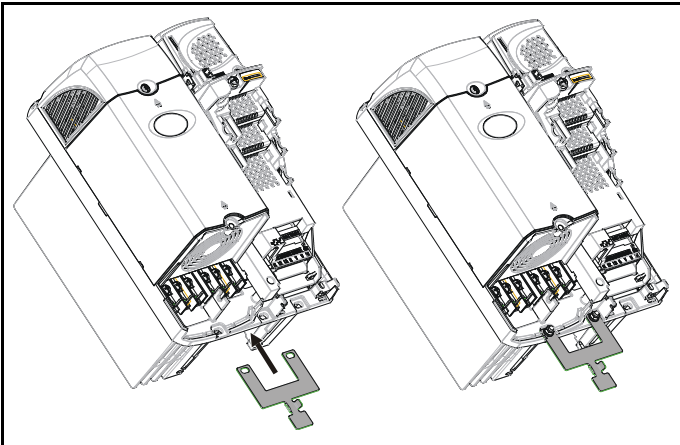
**Figure 4-15 Use of the EMC bracket on SPz**



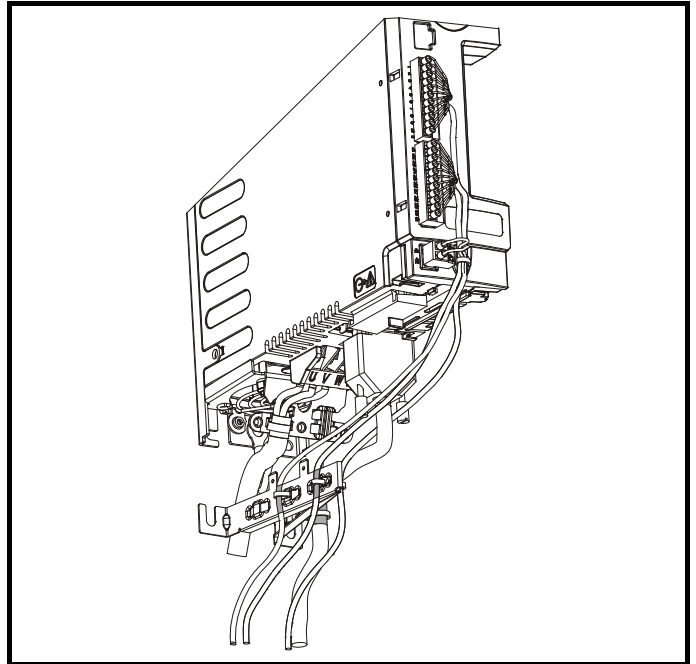
**Figure 4-16 Installation of grounding clamp (size 1 and 2)**



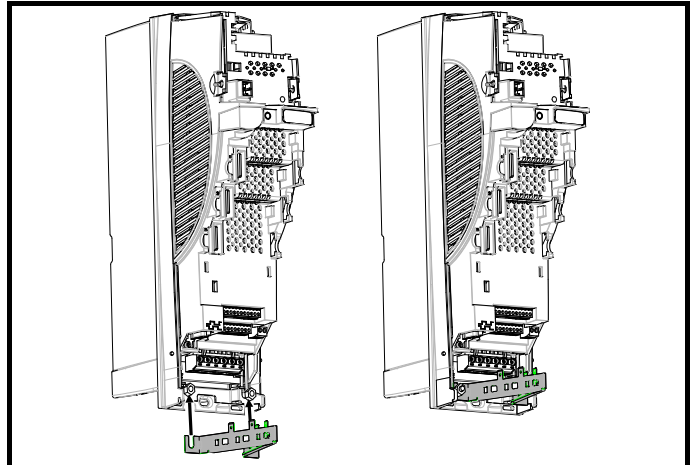
**Figure 4-17 Installation of grounding clamp (size 3)**



**Figure 4-18 Installation of grounding bracket (SPz)**



**Figure 4-19 Installation of grounding bracket (sizes 1 to 6)**



Loosen the ground connection nuts and slide the grounding bracket in the direction shown. Once in place, re-tighten the ground connection nuts.



**WARNING**

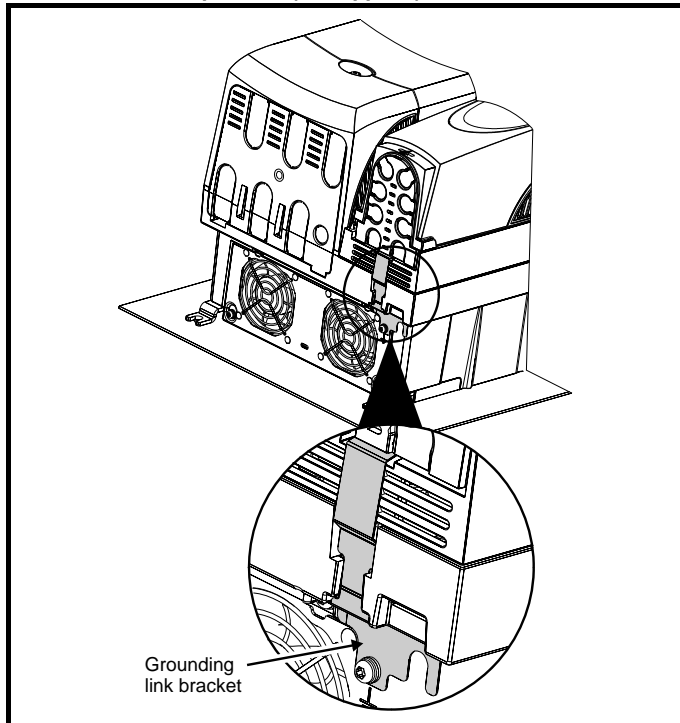
On size 1 and 2, the grounding bracket is secured using the power ground terminal of the drive. Ensure that the supply ground connection is secure after installing / removing the grounding bracket. Failure to do so will result in the drive not being grounded.

A faston tab is located on the grounding bracket for the purpose of connecting the drive 0V to ground should the user require to do so.

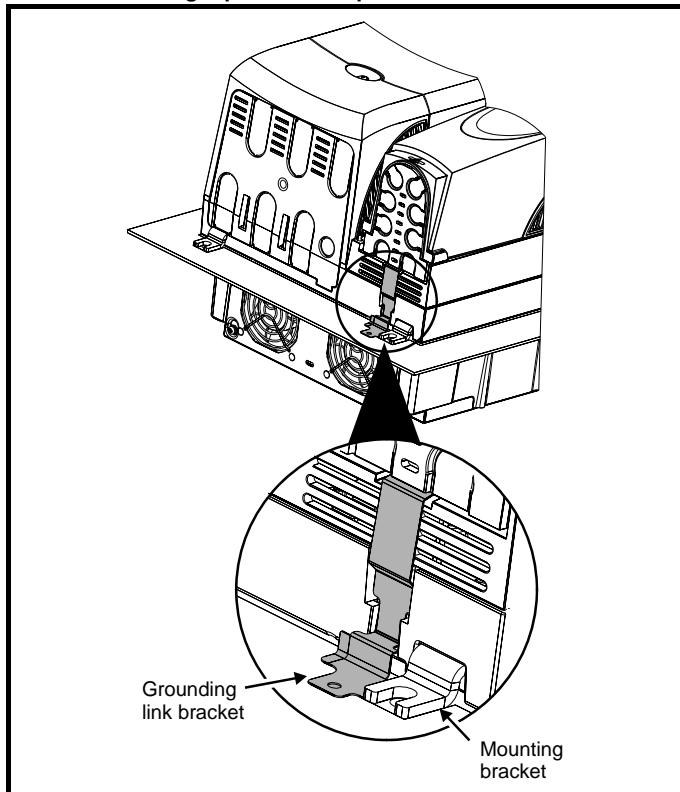
When a size 4 or 5 is through-panel mounted, the grounding link bracket must be folded upwards. A screw can be used to secure the bracket or it can be located under the mounting bracket to ensure that a ground connection is made. This is required to provide a grounding point for the grounding bracket as shown in Figure 4-20.



**Figure 4-20** Size 4 and 5 grounding link bracket in its surface mount position (as supplied)



**Figure 4-21** Size 4 and 5 grounding link bracket folded up into its through-panel mount position



#### 4.11.2 Internal EMC filter

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



**WARNING**

For 200V SPz and frame sizes 3 and above, when the drive is used with ungrounded (IT) supplies the internal EMC filter must be removed unless additional motor ground fault protection is installed or, in the case of 200V SPz and size 3 only, the external filter is also used.

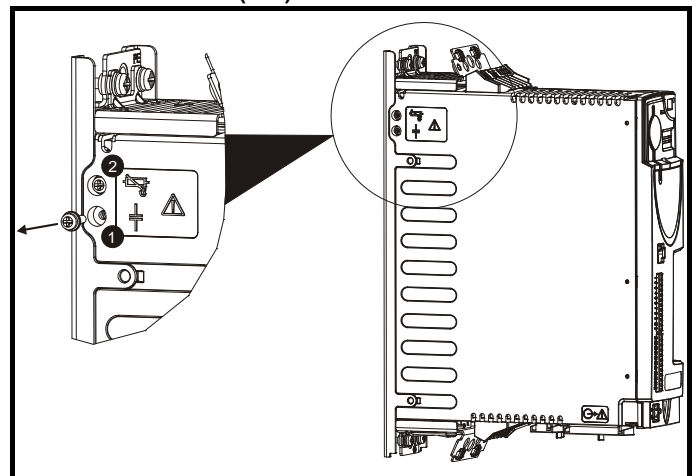
For instructions on removal, refer to Figure 4-22, Figure 4-23 and Figure 4-24.

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

If the drive is used as a motoring drive as part of a Unidrive SP regen system, then the internal EMC filter must be removed.

The internal EMC filter reduces radio-frequency emission into the line power supply. Where the motor cable is short, it permits the requirements of EN61800-3 to be met for the second environment - see section 4.11.4 *Compliance with EN 61800-3 (standard for Power Drive Systems)* on page 76 and section 12.1.24 *Electromagnetic compatibility (EMC)* on page 254. For longer motor cables the filter continues to provide a useful reduction in emission level, and when used with any length of shielded motor cable up to the limit for the drive, it is unlikely that nearby industrial equipment will be disturbed. It is recommended that the filter be used in all applications unless the instructions given above require it to be removed or the ground leakage current of 12mA for SPz, 28mA for size 1 to 3 or 56mA for size 4 to 6 is unacceptable. See Figure 4-22, Figure 4-23 and Figure 4-24 for details of removing and installing the internal EMC filter.

**Figure 4-22** Removal of internal EMC filter and line to ground varistors (SPz)



**WARNING**

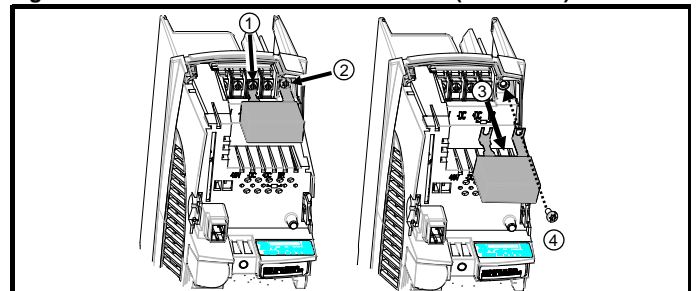
The supply must be disconnected before removing the internal EMC filter or line to ground varistor screws.

1. Internal EMC filter. Remove the bottom screw as shown.
2. Line to ground varistors. Remove the top screw as shown.

**NOTE**

The line to ground varistors should only be removed in special circumstances.

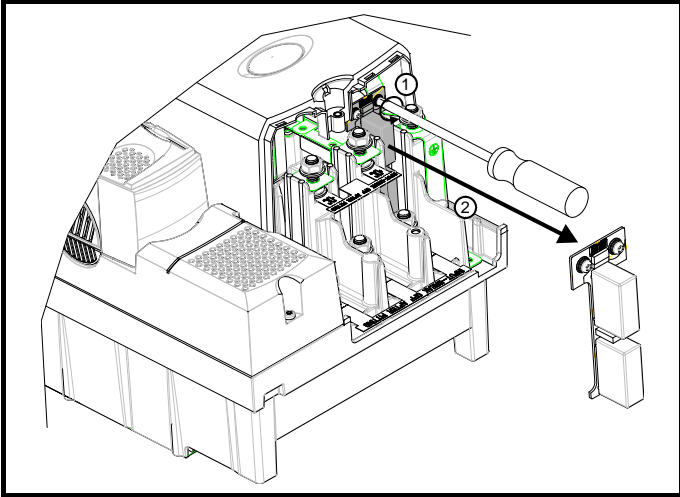
**Figure 4-23** Removal of internal EMC filter (size 1 to 3)



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

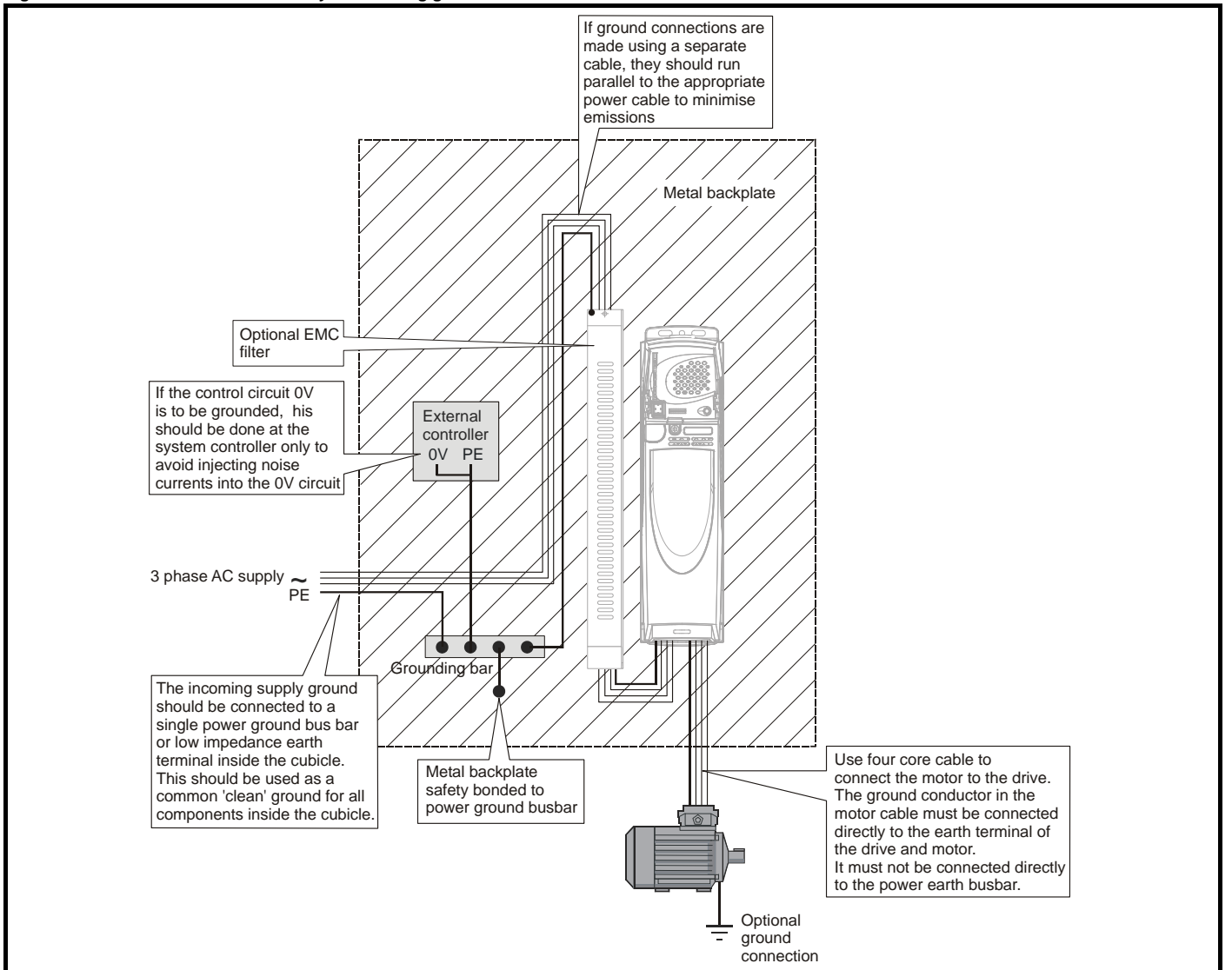
Remove filter (3), and ensure the screws are replaced and re-tightened (4).

**Figure 4-24 Removal of internal EMC filter (sizes 4 to 6)**



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

**Figure 4-25 General EMC enclosure layout showing ground connections**



### 4.11.3 General requirements for EMC

#### Ground (earth) connections

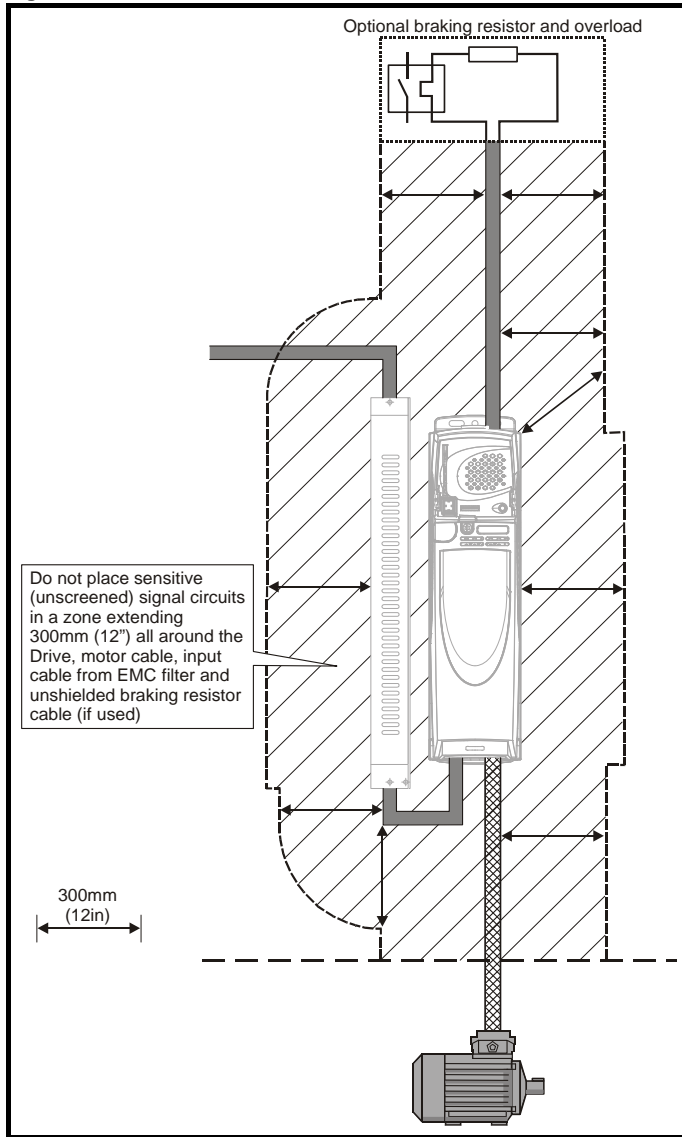
The grounding arrangements should be in accordance with Figure 4-25, which shows a single drive on a back-plate with or without an additional enclosure.

Figure 4-25 shows how to manage EMC when using an unshielded motor cable. However a shielded cable is preferable, in which case it should be installed as shown in section 4.11.5 *Compliance with generic emission standards* on page 77.

### Cable layout

Figure 4-26 indicates the clearances which should be observed around the drive and related 'noisy' power cables by all sensitive control signals / equipment.

**Figure 4-26 Drive cable clearances**



**NOTE**

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

### Feedback device cable shielding

Shielding considerations are important for PWM drive installations due to the high voltages and currents present in the output (motor) circuit with a very wide frequency spectrum, typically from 0 to 20 MHz.

The following guidance is divided into two parts:

1. Ensuring correct transfer of data without disturbance from electrical noise originating either within the drive or from outside.
2. Additional measures to prevent unwanted emission of radio frequency noise. These are optional and only required where the installation is subject to specific requirements for radio frequency emission control.

### To ensure correct transfer of data, observe the following:

#### Resolver connections:

- Use a cable with an overall shield and twisted pairs for the resolver signals
- Connect the cable shield to the drive 0V connection by the shortest possible link ("pigtail")
- It is generally preferable not to connect the cable shield to the resolver. However in cases where there is an exceptional level of common-mode noise voltage present on the resolver body, it may be helpful to connect the shield there. If this is done then it becomes essential to ensure the absolute minimum length of "pigtails" at both shield connections, and possibly to clamp the cable shield directly to the resolver body and to the drive grounding bracket.
- The cable should preferably not be interrupted. If interruptions are unavoidable, ensure the absolute minimum length of "pigtail" in the shield connections at each interruption.

#### Encoder connections:

- Use a cable with the correct impedance
- Use a cable with individually shielded twisted pairs
- Connect the cable shields to 0V at both the drive and the encoder, using the shortest possible links ("pigtails")
- The cable should preferably not be interrupted. If interruptions are unavoidable, ensure the absolute minimum length of "pigtail" in the shield connections at each interruption. Preferably, use a connection method which provides substantial metallic clamps for the cable shield terminations.

The above applies where the encoder body is isolated from the motor and where the encoder circuit is isolated from the encoder body. Where there is no isolation between the encoder circuits and the motor body, and in case of doubt, the following additional requirement must be observed. This gives the best possible noise immunity.

- The shields must be directly clamped to the encoder body (no pigtail) and to the drive grounding bracket. This may be achieved by clamping of the individual shields or by providing an additional overall shield which is clamped.

**NOTE**

The recommendations of the encoder manufacturer must also be adhered to for the encoder connections.

**NOTE**

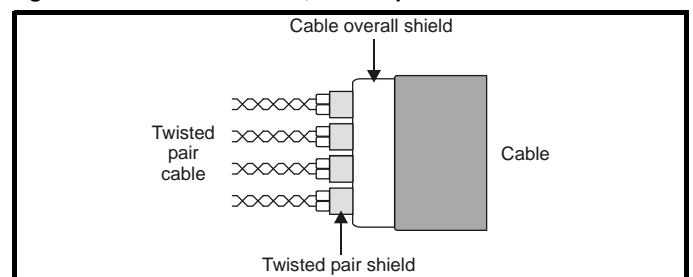
In order to guarantee maximum noise immunity for any application double shielded cable as shown should be used.

In some cases single shielding of each pair of differential signals cables, or a single overall shield with individual shield on the thermistor connections is sufficient. In these cases all the shields should be connected to ground and 0V at both ends.

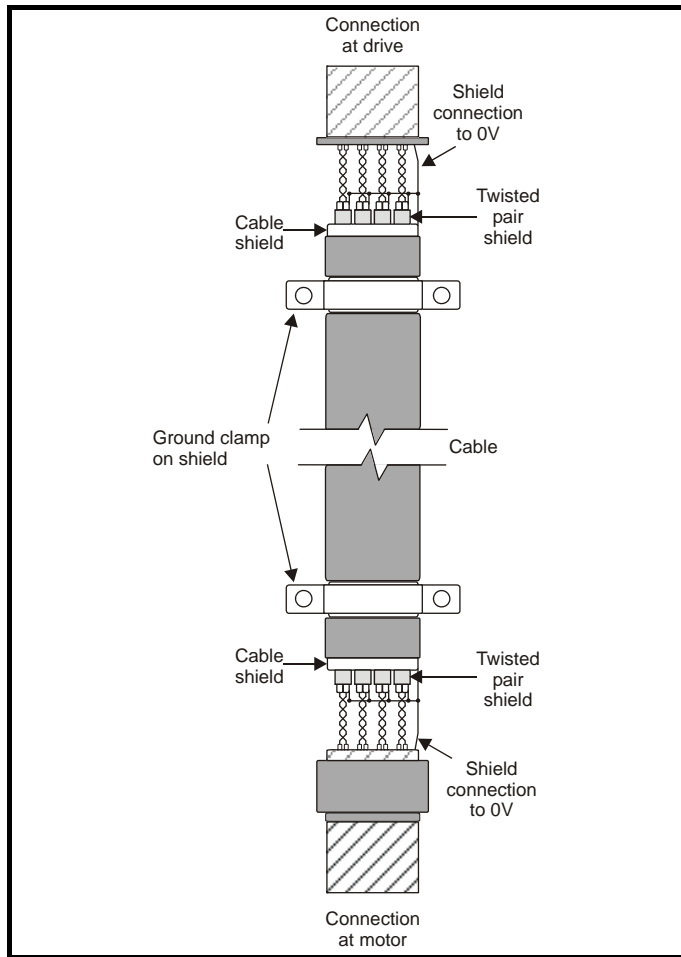
If the 0V is required to be left floating a cable with individual shields and an overall shield must be used.

Figure 4-27 and Figure 4-28 illustrate the preferred construction of cable and the method of clamping. The outer sheath of the cable should be stripped back enough to allow the clamp to be installed. The shield must not be broken or opened at this point. The clamps should be installed close to the drive or feedback device, with the ground connections made to a ground plate or similar metallic ground surface.

**Figure 4-27 Feedback cable, twisted pair**



**Figure 4-28 Feedback cable connections**



**To ensure suppression of radio frequency emission, observe the following:**

- Use a cable with an overall shield
- Clamp the overall shield to grounded metallic surfaces at both the encoder and the drive, as illustrated in Figure 4-28

**4.11.4 Compliance with EN 61800-3 (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 4.11.5 *Compliance with generic emission standards* on page 77. An external EMC filter will always be required.

This is a product of the restricted distribution class according to IEC 61800-3

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

**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.

The drive contains an in-built filter for basic emission control. In some cases feeding the motor cables (U, V and W) once through a ferrite ring can maintain compliance for longer cable lengths. The requirements of operating in the second environment are met, depending on the motor cable length for 3kHz switching frequency as stated in Table 4-14 and Table 4-15.

**Table 4-14 Second environment emission compliance (SPz)**

Drive size	Filter	Voltage	Motor cable length (m)		
			0 to 12	12 to 14	>14
SPz	In-built	200	Unrestricted	Restricted	
		400	Unrestricted		Restricted

**Table 4-15 Second environment emission compliance (size 1 to 6)**

Drive size	Filter	Voltage	Motor cable length (m)		
			0 to 4	4 to 10	10 to 100
1	In-built	Any	Unrestricted	Restricted	
	In-built and ferrite ring	Any	Unrestricted		Restricted
2	In-built	Any	Restricted		
	In-built and ferrite ring	Any	Unrestricted		Restricted
3	In-built	Any	Restricted		
4	In-built	Any	Restricted		
5	In-built	200 & 400	Unrestricted		
		690	Restricted		
6	In-built	Any	Unrestricted		

**Key:**

Restricted: EN 61800-3 second environment, restricted distribution  
(Additional measures may be required to prevent interference)

Unrestricted: EN 61800-3 second environment, unrestricted distribution

For longer motor cables, an external filter is required. Where a filter is required, follow the guidelines in section 4.11.5 *Compliance with generic emission standards*.

Where a filter is not required, follow the guidelines given in section 4.11.3 *General requirements for EMC* on page 74.

The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in section 4.11.5 *Compliance with generic emission standards* be adhered to.

Refer to section 12.1.24 *Electromagnetic compatibility (EMC)* on page 254 for further information on compliance with EMC standards and definitions of environments.

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

### 4.11.5 Compliance with generic emission standards

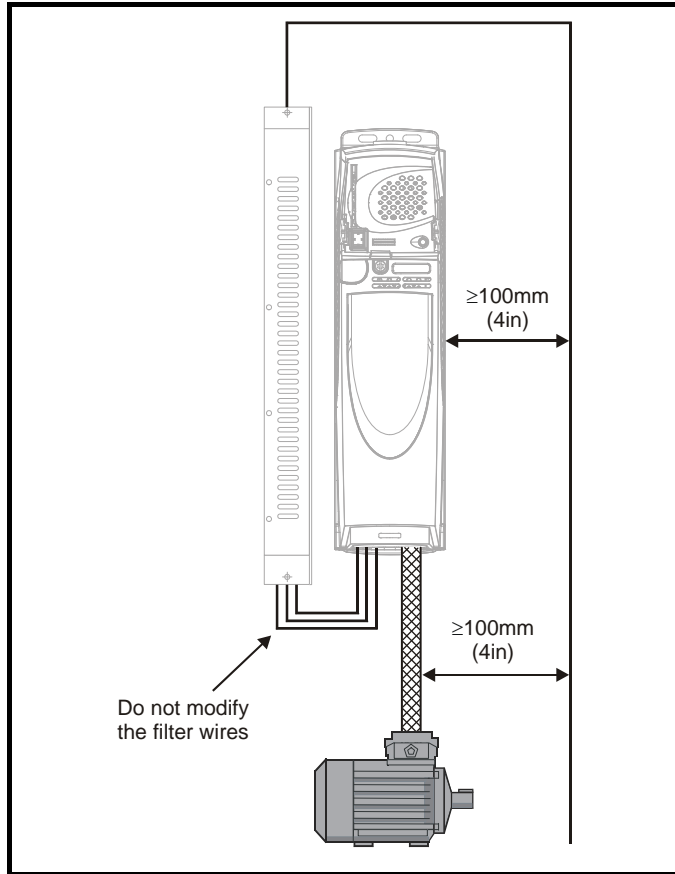
The following information applies to frame SPz and size 1 to 5.

Size 6 upwards does not comply with the requirements of the generic standards for radiated emission.

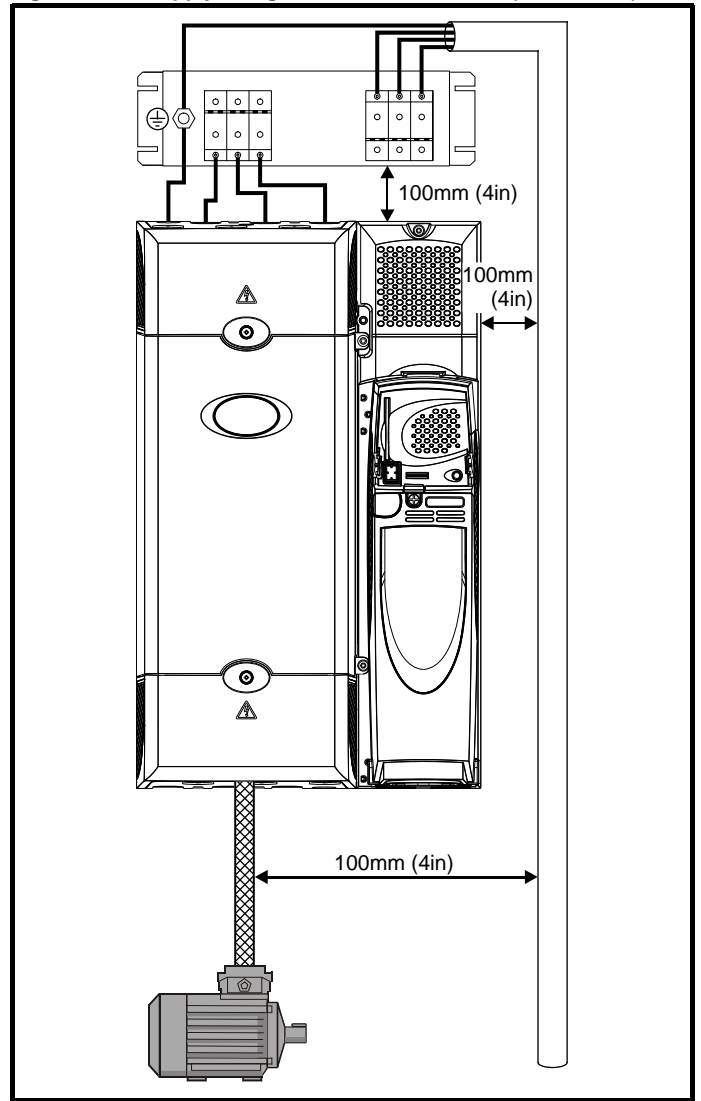
Size 6 complies with the requirements for conducted emission.

Use the recommended filter and shielded motor cable. Observe the layout rules given in Figure 4-29. Ensure the AC supply and ground cables are at least 100mm from the power module and motor cable.

**Figure 4-29 Supply and ground cable clearance (SPz and sizes 1 to 3)**

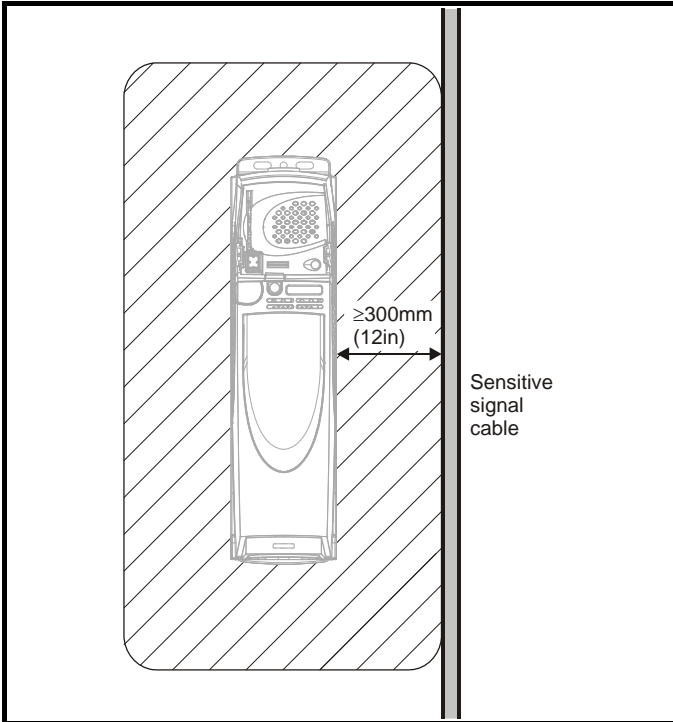


**Figure 4-30 Supply and ground cable clearance (sizes 4 to 6)**



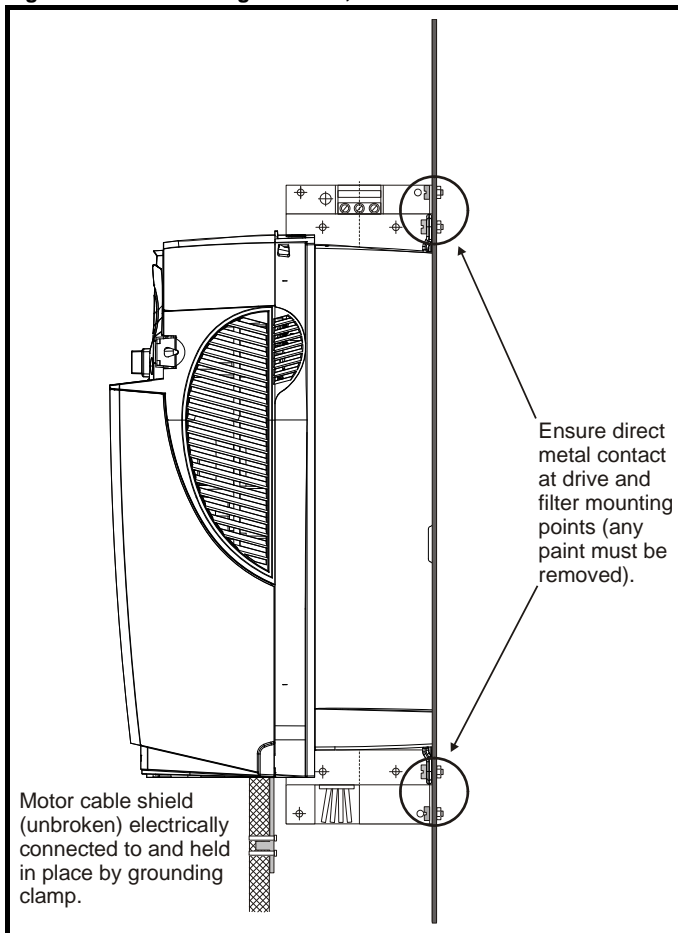
Avoid placing sensitive signal circuits in a zone 300mm (12in) all around the power module.

**Figure 4-31 Sensitive signal circuit clearance**



Ensure good EMC grounding.

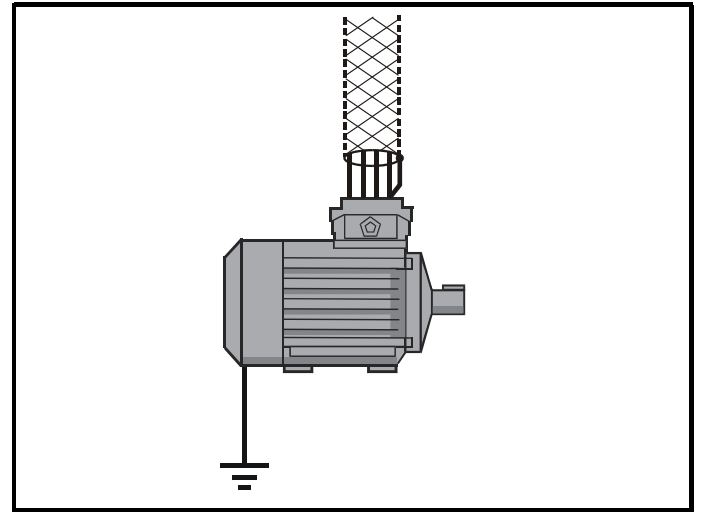
**Figure 4-32 Grounding the drive, motor cable shield and filter**



Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50mm (2in) long. A full 360° termination of the shield to the terminal housing of the motor is beneficial.

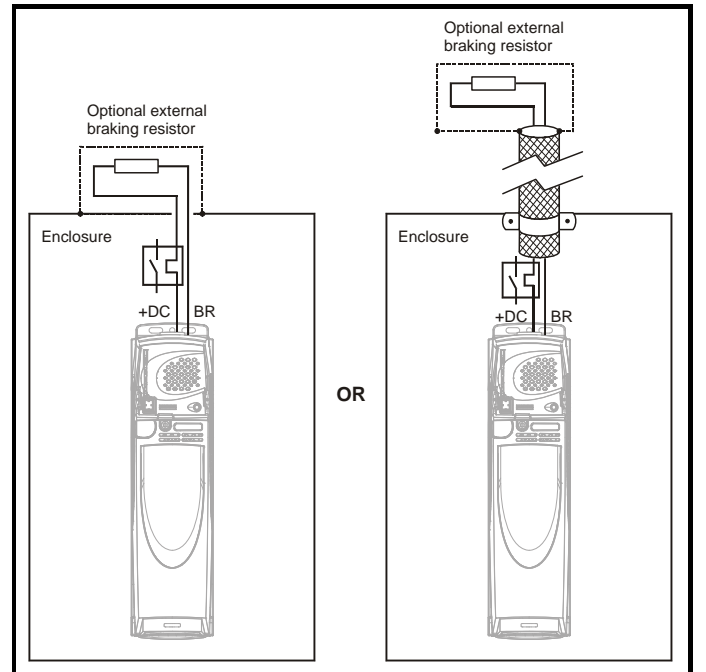
It is unimportant for EMC purposes whether the motor cable contains an internal (safety) ground core, or there is a separate external ground conductor, or grounding is through the shield alone. An internal ground core will carry a high noise current and therefore it must be terminated as close as possible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

**Figure 4-33 Grounding the motor cable shield**



Unshielded wiring to the optional braking resistor(s) may be used, provided the wiring does not run external to the enclosure. Ensure a minimum spacing of 300mm (12in) from signal wiring and the AC supply wiring to the external EMC filter. Otherwise this wiring must be shielded.

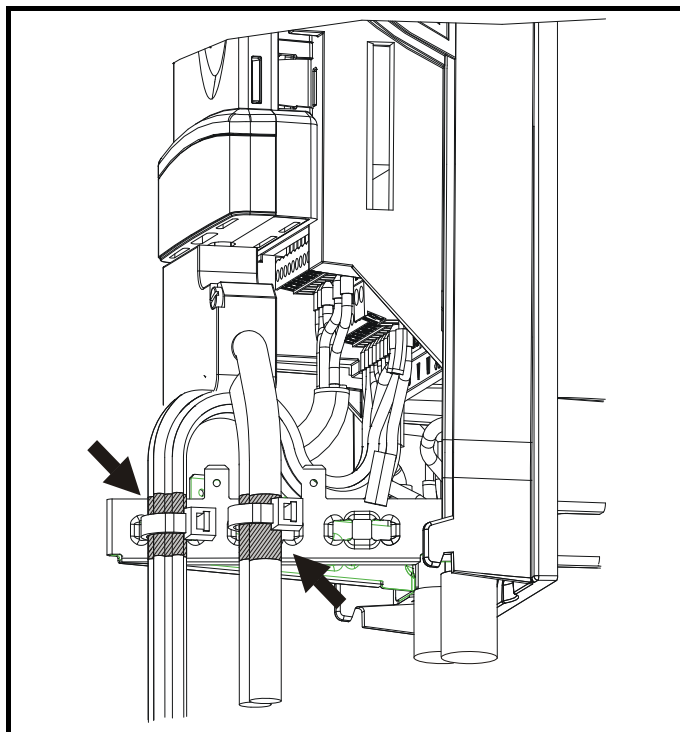
**Figure 4-34 Shielding requirements of optional external braking resistor**



If the control wiring is to leave the enclosure, it must be shielded and the shield(s) clamped to the drive using the grounding bracket as shown in Figure 4-35. Remove the outer insulating cover of the cable to ensure the shield(s) make contact with the bracket, but keep the shield(s) intact until as close as possible to the terminals

Alternatively, wiring may be passed through a ferrite ring.

**Figure 4-35 Grounding of signal cable shields using the grounding bracket**



#### 4.11.6 Variations in the EMC wiring Interruptions to the motor cable

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

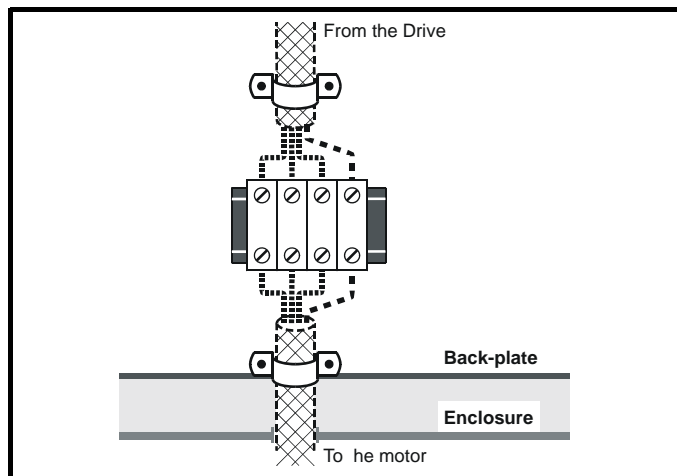
- Connecting the motor cable to a terminal block in the drive enclosure
- Installing a motor isolator / disconnect switch for safety when work is done on the motor

In these cases the following guidelines should be followed.

##### Terminal block in the enclosure

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

**Figure 4-36 Connecting the motor cable to a terminal block in the enclosure**



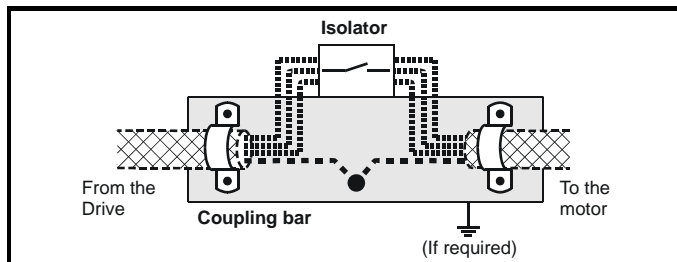
##### Using a motor isolator / disconnect-switch

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

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

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

**Figure 4-37 Connecting the motor cable to an isolator / disconnect switch**



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

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

These circuits meet the requirements of EN61000-6-2 (1kV surge) provided the 0V connection is not grounded.

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

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

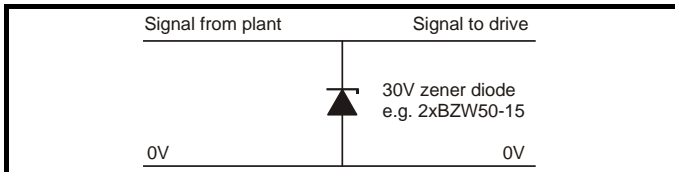
1. Galvanic isolation, i.e. do not connect the control 0V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is accompanied by its return (0V) wire.
2. Shielded cable with additional power ground bonding. The cable shield may be connected to ground at both ends, but in addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equipotential bonding cable) with

cross-sectional area of at least 10mm<sup>2</sup>, or 10 times the area of the signal cable shield, or to suit the electrical safety requirements of the plant. This ensures that fault or surge current passes mainly through the ground cable and not in the signal cable shield. If the building or plant has a well-designed common bonded network this precaution is not necessary.

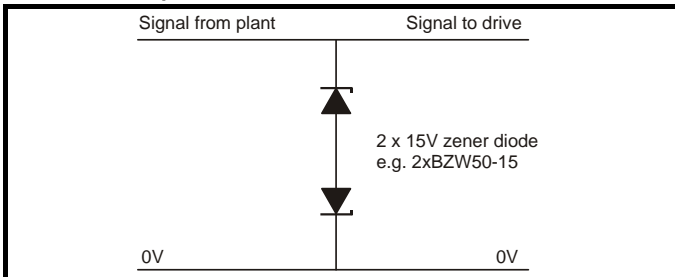
3. Additional over-voltage suppression - for the analog and digital inputs and outputs, a zener diode network or a commercially available surge suppressor may be connected in parallel with the input circuit as shown in Figure 4-38 and Figure 4-39.

If a digital port experiences a severe surge its protective trip may operate (O.Ld1 trip code 26). For continued operation after such an event, the trip can be reset automatically by setting Pr **10.34** to 5.

**Figure 4-38 Surge suppression for digital and unipolar inputs and outputs**



**Figure 4-39 Surge suppression for analog and bipolar inputs and outputs**



Surge suppression devices are available as rail-mounting modules, e.g. from Phoenix Contact:

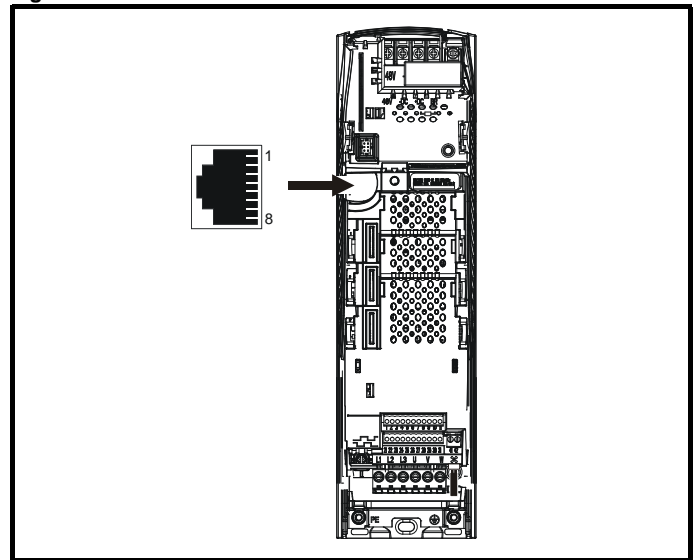
- Unipolar TT-UKK5-D/24 DC
- Bipolar TT-UKK5-D/24 AC

These devices are not suitable for encoder signals or fast digital data networks because the capacitance of the diodes adversely affects the signal. Most encoders have galvanic isolation of the signal circuit from the motor frame, in which case no precautions are required. For data networks, follow the specific recommendations for the particular network.

## 4.12 Serial communications connections

The drive has a serial communications port (serial port) as standard supporting 2 wire EIA485 communications. Please see Table 4-16 for the connection details for the RJ45 connector.

**Figure 4-40 Location of the RJ45 serial comms connector**



**Table 4-16 Connection details for RJ45 connector**

Pin	Function
1	120Ω Termination resistor
2	RX TX
3	Isolated 0V
4	+24V (100mA)
5	Isolated 0V
6	TX enable
7	RX\ TX\
8	RX\ TX\ (if termination resistors are required, link to pin 1)
Shell	Isolated 0V

The communications port applies a 2 unit load to the communications network.

Minimum number of connections are 2, 3, 7 and shield. Shielded cable must be used at all times.

### 4.12.1 Isolation of the serial communications port

The serial PC communications port is double insulated and meets the requirements for SELV in EN50178.



**WARNING**

In order to meet the requirements for SELV in IEC60950 (IT equipment) it is necessary for the control computer to be grounded. Alternatively, when a lap-top or similar device is used which has no provision for grounding, an isolation device must be incorporated in the communications lead.

An isolated serial communications lead has been designed to connect the drive to IT equipment (such as lap-top computers), and is available from the supplier of the drive. See below for details:

**Table 4-17 Isolated serial comms lead details**

Reference	Description
CT COMMS CABLE	CT EIA232 Comms cable
USB/485 converter	CT USB Comms cable

The "isolated serial communications" lead has reinforced insulation as defined in IEC60950 for altitudes up to 3,000m.

**NOTE**

When using the CT EIA232 Comms cable the available baud rate is limited to 19.2k baud.



### 4.12.2 Multi-drop network

The drive can be used on a 2 wire EIA485 multi-drop network using the drive's serial communications port when the following guidelines are adhered to.

#### Connections

The network should be a daisy chain arrangement and not a star, although short stubs to the drive are allowed.

The minimum connections are pins 2 (RX TX), 3 (isolated 0V), 7 (RX TX) and the shield.

Pin 4 (+24V) on each drive can be connected together but there is no power sharing mechanism between drives and therefore the maximum power available is the same as a single drive. (If pin 4 is not linked to the other drives on the network and has an individual load then the maximum power can be taken from pin 4 of each drive.)

#### Termination resistors

If a drive is on the end of the network chain then pins 1 and 8 should be linked together. This will connect an internal 120Ω termination resistor between RXTX and RX\TX\ (If the end unit is not a drive or the user wishes to use their own termination resistor, a 120Ω termination resistor should be connected between RXTX and RX\TX\ at the end unit.)

If the host is connected to a single drive then termination resistors should not be used unless the baud rate is high.

#### CT Comms Cable

The CT Comms Cable can be used on a multi-drop network but should only be used occasionally for diagnostic and set up purposes. The network must also be made up entirely of Unidrive SPs.

If the CT Comms Cable is to be used, then pin 6 (TX enable) should be connected on all drives and pin 4 (+24V) should be linked to at least 1 drive to supply power to the converter in the cable.

Only one CT Comms Cable can be used on a network.

## 4.13 Control connections

### 4.13.1 General

Table 4-18 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Differential analog input	1	Destination, offset, offset trim, invert, scaling	5,6
Single ended analog input	2	Mode, offset, scaling, invert, destination	7,8
Analog output	2	Source, mode, scaling,	9,10
Digital input	3	Destination, invert, logic select	27, 28, 29
Digital input / output	3	Input / output mode select, destination / source, invert, logic select	24, 25, 26
Relay	1	Source, invert	41,42
Drive enable (SAFE TORQUE OFF (SECURE DISABLE))	1		31
+10V User output	1		4
+24V User output	1	Source, invert	22
0V common	6		1, 3, 11, 21, 23, 30
+24V External input	1		2

#### Key:

**Destination parameter:** indicates the parameter which is being controlled by the terminal / function

**Source parameter:** indicates the parameter being output by the terminal

**Mode parameter:** analog - indicates the mode of operation of the terminal, i.e. voltage 0-10V, current 4-20mA etc.

digital - indicates the mode of operation of the terminal, i.e. positive / negative logic (the Drive Enable terminal is fixed in positive logic), open collector.

All analog terminal functions can be programmed in menu 7.

All digital terminal functions (including the relay) can be programmed in menu 8.

The setting of Pr 1.14 and Pr 6.04 can cause the function of digital inputs T25 to T29 to change. For more information, please refer to section 11.21.1 *Reference modes* on page 233 and section 11.21.7 *Start / stop logic modes* on page 238.



**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**

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

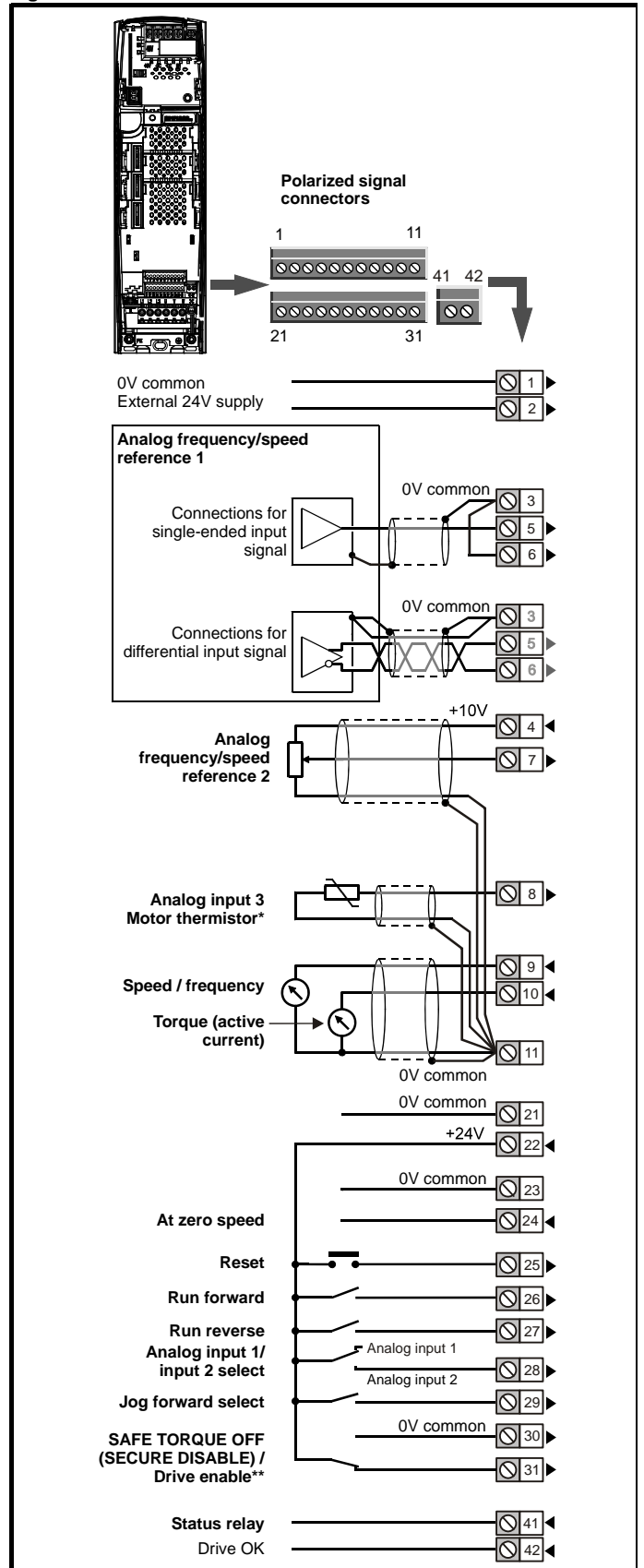
**NOTE**

The SAFE TORQUE OFF (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 analog 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 analog signals and terminals 21, 23 and 30 for digital signals. This is to prevent small voltage drops in the terminal connections causing inaccuracies in the analog signals.

**Figure 4-41 Default terminal functions**



\* With software V01.07.00 and later, Analog input 3 is configured as a motor thermistor input. With software V01.06.02 and earlier, Analog input 3 has no default function. Refer to *Analog input 3* on page 83.

\*\*The SAFE TORQUE OFF (SECURE DISABLE) / Drive enable terminal is a positive logic input only.

### 4.13.2 Control terminal specification

<b>1</b>	<b>0V common</b>
<b>Function</b>	<b>Common connection for all external devices</b>

<b>2</b>	<b>+24V external input</b>
<b>Function</b>	<b>To supply the control circuit without providing a supply to the power stage</b>
Nominal voltage	+24.0Vdc
Minimum continuous operating voltage	+19.2Vdc
Maximum continuous operating voltage	+30.0Vdc
Minimum start-up voltage	21.6Vdc
Recommended power supply	60W 24Vdc nominal
Recommended fuse	3A, 50Vdc

<b>3</b>	<b>0V common</b>
<b>Function</b>	<b>Common connection for all external devices</b>

<b>4</b>	<b>+10V user output</b>
<b>Function</b>	<b>Supply for external analog devices</b>
Voltage tolerance	±1%
Nominal output current	10mA
Protection	Current limit and trip @ 30mA

<b>Precision reference Analog input 1</b>	
<b>5</b>	<b>Non-inverting input</b>
<b>6</b>	<b>Inverting input</b>
<b>Default function</b>	<b>Frequency/speed reference</b>
Type of input	Bipolar differential analog (For single-ended use, connect terminal 6 to terminal 3)
Full scale voltage range	±9.8V ±1%
Absolute maximum voltage range	±36V relative to 0V
Working common mode voltage range	±13V relative to 0V
Input resistance	100kΩ ±1%
Resolution	16-bit plus sign (as speed reference)
Monotonic	Yes (including 0V)
Dead band	None (including 0V)
Jumps	None (including 0V)
Maximum offset	700μV
Maximum non linearity	0.3% of input
Maximum gain asymmetry	0.5%
Input filter bandwidth single pole	~1kHz
Sampling period	250μs with destinations as Pr 1.36, Pr 1.37 or Pr 3.22 in closed loop vector or servo mode. 4ms for open loop mode and all other destinations in closed loop vector or servo mode.

<b>7</b>	<b>Analog input 2</b>
<b>Default function</b>	<b>Frequency/speed reference</b>
Type of input	Bipolar single-ended analog voltage or unipolar current
Mode controlled by...	Pr 7.11
<b>Operating in Voltage mode</b>	
Full scale voltage range	±9.8V ±3%
Maximum offset	±30mV
Absolute maximum voltage range	±36V relative to 0V
Input resistance	>100kΩ
<b>Operating in current mode</b>	
Current ranges	0 to 20mA ±5%, 20 to 0mA ±5%, 4 to 20mA ±5%, 20 to 4mA ±5%
Maximum offset	250μA
Absolute maximum voltage (reverse bias)	-36V max
Absolute maximum current	+70mA
Equivalent input resistance	≤200Ω at 20mA
<b>Common to all modes</b>	
Resolution	10 bit + sign
Sample period	250μs when configured as voltage input with destinations as Pr 1.36, Pr 1.37, Pr 3.22 or Pr 4.08 in closed loop vector or servo mode. 4ms for open loop mode, all other destinations in closed loop vector or servo mode, or any destination when configured as a current input.

<b>8</b>	<b>Analog input 3</b>
<b>Default function</b>	<b>V01.07.00 and later: Motor thermistor input (PTC) V01.06.02 and earlier: Not configured</b>
Type of input	Bipolar single-ended analog voltage, unipolar current or motor thermistor input
Mode controlled by...	Pr 7.15
<b>Operating in Voltage mode (default)</b>	
Voltage range	±9.8V ±3%
Maximum offset	±30mV
Absolute maximum voltage range	±36V relative to 0V
Input resistance	>100kΩ
<b>Operating in current mode</b>	
Current ranges	0 to 20mA ±5%, 20 to 0mA ±5%, 4 to 20mA ±5%, 20 to 4mA ±5%
Maximum offset	250μA
Absolute maximum voltage (reverse bias)	-36V max
Absolute maximum current	+70mA
Equivalent input resistance	≤200Ω at 20mA
<b>Operating in thermistor input mode</b>	
Internal pull-up voltage	<5V
Trip threshold resistance	3.3kΩ ±10%
Reset resistance	1.8kΩ ±10%
Short-circuit detection resistance	50Ω ±40%
<b>Common to all modes</b>	
Resolution	10 bit + sign
Sample period	250μs when configured as voltage input with destinations as Pr 1.36, Pr 1.37, Pr 3.22 or Pr 4.08 in closed loop vector or servo mode. 4ms for open loop mode, all other destinations in closed loop vector or servo mode, or any destination when configured as a current input.

T8 analog input 3 has a parallel connection to terminal 15 of the drive encoder connector.

<b>9</b>	<b>Analog output 1</b>
<b>10</b>	<b>Analog output 2</b>
Terminal 9 default function	OL> Motor FREQUENCY output signal CL> SPEED output signal
Terminal 10 default function	Motor active current
Type of output	Bipolar single-ended analog voltage or unipolar single ended current
Mode controlled by...	Pr 7.21 and Pr 7.24
<b>Operating in Voltage mode (default)</b>	
Voltage range	±10V ±3%
Maximum offset	±200mV
Maximum output current	±35mA
Load resistance	1kΩ min
Protection	35mA max. Short circuit protection
<b>Operating in current mode</b>	
Current ranges	0 to 20mA ±5% 4 to 20mA ±5%
Maximum offset	600μA
Maximum open circuit voltage	+15V
Maximum load resistance	600Ω
<b>Common to all modes</b>	
Resolution	10-bit (plus sign in voltage mode)
Update period	250μs when configured as a high speed output with sources as Pr 4.02, Pr 4.17 in all modes or Pr 3.02, Pr 5.03 in closed loop vector or servo mode. 4ms when configured as any other type of output or with all other sources.

<b>11</b>	<b>0V common</b>
Function	Common connection for all external devices

<b>21</b>	<b>0V common</b>
Function	Common connection for all external devices

<b>22</b>	<b>+24V user output (selectable)</b>
Terminal 22 default function	+24V user output
Programmability	Can be switched on or off to act as a fourth digital output (positive logic only) by setting the source Pr 8.28 and source invert Pr 8.18
Nominal output current	200mA (including all digital I/O)
Maximum output current	240mA (including all digital I/O)
Protection	Current limit and trip

<b>23</b>	<b>0V common</b>
Function	Common connection for all external devices

<b>24</b>	<b>Digital I/O 1</b>
<b>25</b>	<b>Digital I/O 2</b>
<b>26</b>	<b>Digital I/O 3</b>
Terminal 24 default function	AT ZERO SPEED output
Terminal 25 default function	DRIVE RESET input
Terminal 26 default function	RUN FORWARD input
Type	Positive or negative logic digital inputs, positive or negative logic push-pull outputs or open collector outputs
Input / output mode controlled by...	Pr 8.31, Pr 8.32 and Pr 8.33
<b>Operating as an input</b>	
Logic mode controlled by...	Pr 8.29
Absolute maximum applied voltage range	±30V
Impedance	6kΩ
Input thresholds	10.0V ±0.8V
<b>Operating as an output</b>	
Open collector outputs selected	Pr 8.30
Nominal maximum output current	200mA (total including terminal 22)
Maximum output current	240mA (total including terminal 22)
<b>Common to all modes</b>	
Voltage range	0V to +24V
Sample / Update period	250μs when configured as an input with destinations as Pr 6.35 or Pr 6.36. 600μs when configured as an input with destination as Pr 6.29. 4ms in all other cases.

<b>27</b>	<b>Digital Input 4</b>
<b>28</b>	<b>Digital Input 5</b>
<b>29</b>	<b>Digital Input 6</b>
Terminal 27 default function	RUN REVERSE input
Terminal 28 default function	Analog INPUT 1 / INPUT 2 select
Terminal 29 default function	JOG SELECT input
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr 8.29
Voltage range	0V to +24V
Absolute maximum applied voltage range	±30V
Impedance	6kΩ
Input thresholds	10.0V ±0.8V
Sample / Update period	250μs with destinations as Pr 6.35 or Pr 6.36. 600μs with destination as Pr 6.29. 4ms in all other cases.

<b>30</b>	<b>0V common</b>
Function	Common connection for all external devices

<b>31</b>	<b>Drive enable (SAFE TORQUE OFF (SECURE DISABLE) function)</b>
Type	Positive logic only digital input
Voltage range	0V to +24V
Absolute maximum applied voltage	±30V
Thresholds	15 5V ±2.5V
Response time	Nominal: 8ms Maximum: 20ms
<p>The drive enable terminal (T31) provides a SAFE TORQUE OFF (SECURE DISABLE) function. The SAFE TORQUE OFF (SECURE DISABLE) function meets the requirements of EN954-1 category 3 for the prevention of unexpected starting of the drive. It may be used in a safety-related application in preventing the drive from generating torque in the motor to a high level of integrity.</p>	

Refer to section 4.16 *SAFE TORQUE OFF (SECURE DISABLE)* on page 89 for further information.

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



A fuse or other over-current protection should be installed to the relay circuit.

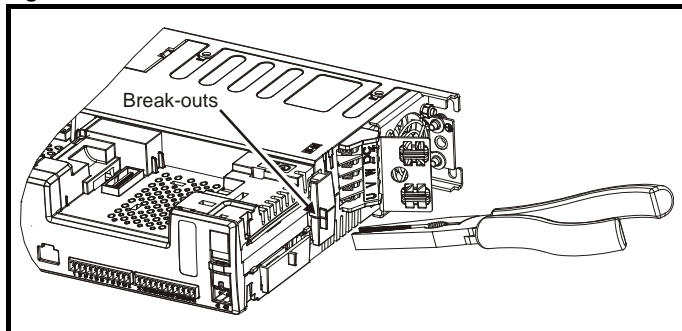
**WARNING**

## 4.14 Encoder connections

### 4.14.1 Location of encoder connector (SPz)

Before using the encoder connector on SPz for the first time, the break-out need removing as shown in Figure 4-42.

Figure 4-42 Access to encoder connections



After removing the break-out, ensure that the ground tab is connected to ground. This will connect 0V of the drive to ground. This is required to enable the drive to meet IP20 when the break-out is removed.

**NOTE**

Do not remove the break-out if the encoder connection is not required.

Figure 4-43 Location of encoder connector (SPz)

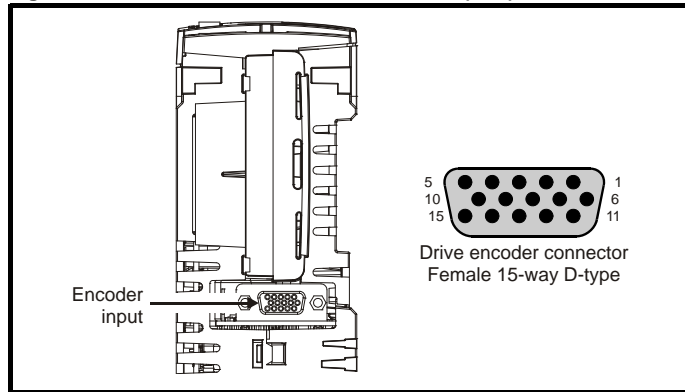
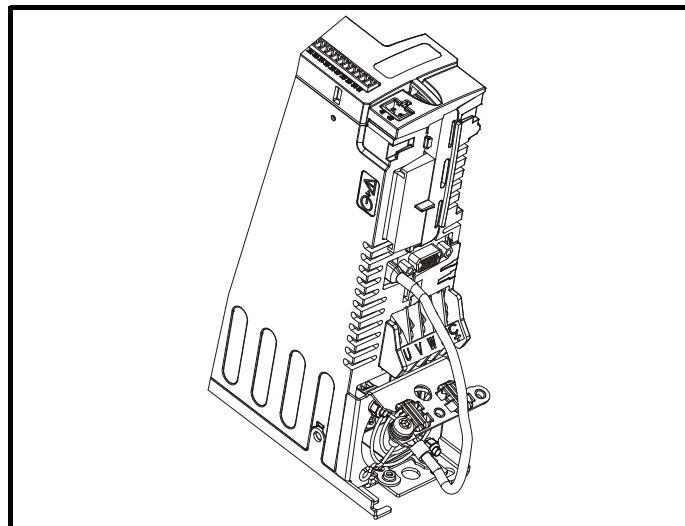


Figure 4-44 Connecting the encoder ground tab to the EMC bracket

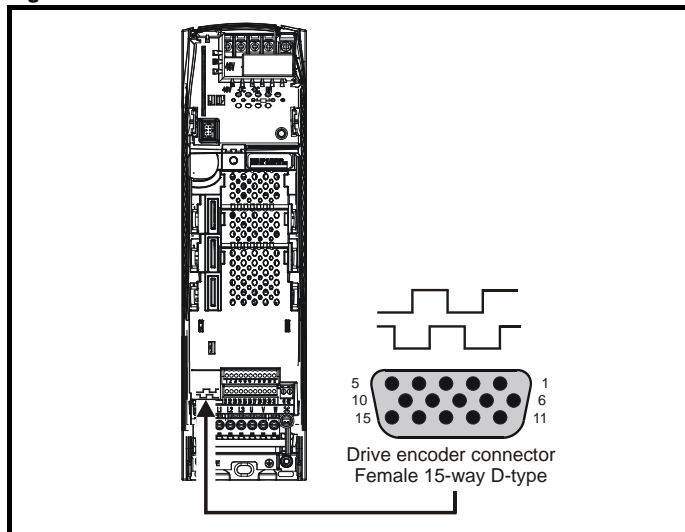


**NOTE**

The size of the connecting cable between the encoder ground tab and the EMC bracket should be equal to the input cable.

### 4.14.2 Location of encoder connector (size 1 to 6)

Figure 4-45 Location of encoder connector



### 4.14.3 Encoder types

Table 4-19 Encoder types

Setting of Pr 3.38	Description
<b>Ab</b> (0)	Quadrature incremental encoder with or without marker pulse
<b>Fd</b> (1)	Incremental encoder with frequency pulses and direction, with or without marker pulse
<b>Fr</b> (2)	Incremental encoder with forward pulses and reverse pulses, with or without marker pulse
<b>Ab.SErVO</b> (3)	Quadrature incremental encoder with UVW commutation signals, with or without marker pulse Encoder with UVW commutation signals only (Pr 3.34 set to zero)*
<b>Fd.SErVO</b> (4)	Incremental encoder with frequency pulses and direction with commutation signals**, with or without marker pulse
<b>Fr.SErVO</b> (5)	Incremental encoder with forward pulses and reverse pulses with commutation signals**, with or without marker pulse
<b>SC</b> (6)	SinCos encoder without serial communications
<b>SC.HiPEr</b> (7)	Absolute SinCos encoder with HiperFace serial communications protocol (Stegmann)
<b>EndAt</b> (8)	Absolute EndAt serial communications encoder (Heidenhain)
<b>SC.EndAt</b> (9)	Absolute SinCos encoder with EnDat serial communications protocol (Heidenhain)
<b>SSI</b> (10)	Absolute SSI only encoder
<b>SC.SSI</b> (11)	Absolute SinCos encoder with SSI

\* This feedback device provides very low resolution feedback and should not be used for applications requiring a high level of performance

\*\* The U, V & W commutation signals are required with an incremental type encoder when used with a servo motor. The UVW commutation signals are used to define the motor position during the first 120 electrical rotation after the drive is powered-up or the encoder is initialized.

### 4.14.4 Encoder connection details

Table 4-20 Drive encoder connector details

Terminal	Setting of Pr 3.38											
	Ab (0)	Fd (1)	Fr (2)	Ab.SErVO (3)	Fd.SErVO (4)	Fr.SErVO (5)	SC (6)	SC.HiPEr (7)	EndAt (8)	SC.EndAt (9)	SSI (10)	SC.SSI (11)
1	A	F	F	A	F	F	Cos			Cos		Cos
2	A\	F\	F\	A\	F\	F\	Cosref			Cosref		Cosref
3	B	D	R	B	D	R	Sin			Sin		Sin
4	B\	D\	R\	B\	D\	R\	Sinref			Sinref		Sinref
5	Z*							Encoder input - Data (input/output)				
6	Z\*							Encoder input - Data\ (input/output)				
7	Simulated encoder Aout, Fout**			U			Simulated encoder Aout, Fout**					
8	Simulated encoder Aout\, Fout\**			U\			Simulated encoder Aout\, Fout\**					
9	Simulated encoder Bout, Dout**			V			Simulated encoder Bout, Dout**					
10	Simulated encoder Bout\, Dout\**			V\			Simulated encoder Bout\, Dout\**					
11							W		Encoder input - Clock (output)			
12							W\		Encoder input - Clock\ (output)			
13	+V***											
14	0V common											
15	th****											

\* Marker pulse is optional

\*\* Simulated encoder output only available in open-loop

\*\*\* The encoder supply is selectable through parameter configuration to 5Vdc, 8Vdc and 15Vdc

\*\*\*\* Terminal 15 is a parallel connection to T8 analog input 3. If this is to

be used as a thermistor input, ensure that Pr 7.15 is set to 'th.sc' (7), 'th' (8) or 'th.diSP' (9).

**NOTE**

SSI encoders typically have maximum baud rate of 500kbaud. When a SSI only encoder is used for speed feedback with a closed loop vector or

servo motor, a large speed feedback filter (Pr 3.42) is required due to the time taken for the position information to be transferred from the encoder into the drive. The addition of this filter means that SSI only encoders are not suitable for speed feedback in dynamic or high-speed applications.

#### 4.14.5 Specifications

##### Feedback device connections

Ab, Fd, Fr, Ab.SErVO, Fd.SErVO and Fr.SErVO encoders

<b>1</b>	<b>Channel A, Frequency or Forward inputs</b>
<b>2</b>	<b>Channel A\, Frequency\ or Forward\ inputs</b>
<b>3</b>	<b>Channel B, Direction or Reverse inputs</b>
<b>4</b>	<b>Channel B\, Direction\ or Reverse\ inputs</b>
Type	EIA 485 differential receivers
Maximum input frequency	V01.06.01 and later: 500kHz V01.06.00 and earlier: 410kHz
Line loading	<2 unit loads
Line termination components	120Ω (switchable)
Working common mode range	+12V to -7V
Absolute maximum applied voltage relative to 0V	±25V
Absolute maximum applied differential voltage	±25V

<b>5</b>	<b>Marker pulse channel Z</b>
<b>6</b>	<b>Marker pulse channel Z\</b>
<b>7</b>	<b>Phase channel U</b>
<b>8</b>	<b>Phase channel U\</b>
<b>9</b>	<b>Phase channel V</b>
<b>10</b>	<b>Phase channel V\</b>
<b>11</b>	<b>Phase channel W</b>
<b>12</b>	<b>Phase channel W\</b>
Type	EIA 485 differential receivers
Maximum input frequency	512kHz
Line loading	32 unit loads (for terminals 5 and 6) 1 unit load (for terminals 7 to 12)
Line termination components	120Ω (switchable for terminals 5 and 6, always in circuit for terminals 7 to 12)
Working common mode range	+12V to -7V
Absolute maximum applied voltage relative to 0V	+14V to -9V
Absolute maximum applied differential voltage	+14V to -9V

#### SC, SC.HiPER, EndAt, SC.EndAt, SSI and SC.SSI encoders

<b>1</b>	<b>Channel Cos*</b>
<b>2</b>	<b>Channel Cosref*</b>
<b>3</b>	<b>Channel Sin*</b>
<b>4</b>	<b>Channel Sinref*</b>
Type	Differential voltage
Maximum Signal level	1.25V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-21
Maximum applied differential voltage and common mode voltage range	±4V

For the SinCos encoder to be compatible with Unidrive SP, the output signals from the encoder must be a 1V peak to peak differential voltage (across Sin to Sinref and Cos to Cosref).

The majority of encoders have a DC offset on all signals. Stegmann encoders typically have a 2.5Vdc offset. The Sinref and Cosref are a flat DC level at 2.5Vdc and the Cos and Sin signals have a 1V peak to peak waveform biased at 2.5Vdc.

Encoders are available which have a 1V peak to peak voltage on Sin, Sinref, Cos and Cosref. This results in a 2V peak to peak voltage seen at the drive's encoder terminals. It is not recommended that encoders of this type are used with Unidrive SP, and that the encoder feedback signals should meet the above parameters (1V peak to peak).

**Resolution:** The sinewave frequency can be up to 500kHz but the resolution is reduced at high frequency. Table 4-21 shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port. The total resolution in bits per revolution is the ELPR plus the number of bits of interpolated information. Although it is possible to obtain 11 bits of interpolation information, the nominal design value is 10 bits.

\* Not used with EndAt and SSI communications only encoders.

**Table 4-21 Feedback resolution based on frequency and voltage level**

Volt/Freq	1kHz	5kHz	50kHz	100kHz	200kHz	500kHz
1.2	11	11	10	10	9	8
1.0	11	11	10	9	9	7
0.8	10	10	10	9	8	7
0.6	10	10	9	9	8	7
0.4	9	9	9	8	7	6

<b>5</b>	<b>Data**</b>
<b>6</b>	<b>Data\**</b>
<b>11</b>	<b>Clock***</b>
<b>12</b>	<b>Clock\***</b>
Type	EIA 485 differential transceivers
Maximum frequency	2MHz
Line loading	32 unit loads (for terminals 5 and 6) 1 unit load (for terminals 11 and 12)
Working common mode range	+12V to -7V
Absolute maximum applied voltage relative to 0V	±14V
Absolute maximum applied differential voltage	±14V

\*\* Not used with SC encoders.

\*\*\* Not used with SC and SC.HiPER encoders.

**Frequency slaving outputs (open loop only)**  
Ab, Fd, Fr, SC, SC.HiPEr, EndAt, SC.EndAt, SSI and SC.SSI encoders

<b>7</b>	<b>Frequency slaving out channel A</b>
<b>8</b>	<b>Frequency slaving out channel A\</b>
<b>9</b>	<b>Frequency slaving out channel B</b>
<b>10</b>	<b>Frequency slaving out channel B\</b>
Type	EIA 485 differential transceivers
Maximum output frequency	512kHz
Absolute maximum applied voltage relative to 0V	±14V
Absolute maximum applied differential voltage	±14V

**Common to all Encoder types**

<b>13</b>	<b>Encoder supply voltage</b>
Supply voltage	5.15V ±2%, 8V ±5% or 15V ±5%
Maximum output current	300mA for 5V and 8V 200mA for 15V
The voltage on terminal 13 is controlled by Pr <b>3.36</b> . The default for this parameter is 5V (0) but this can be set to 8V (1) or 15V (2). Setting the encoder voltage supply too high for the encoder could result in damage to the feedback device.	
The termination resistors should be disabled if the outputs from the encoder are higher than 5V.	

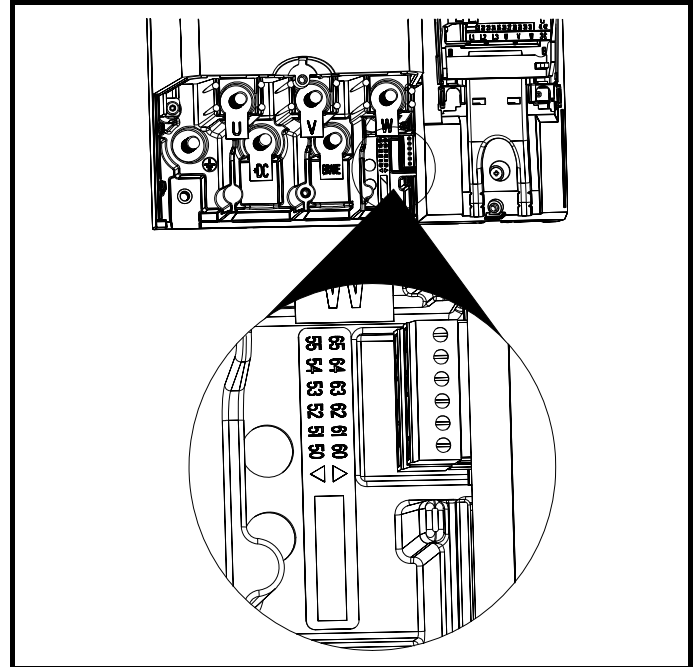
<b>14</b>	<b>0V common</b>
-----------	------------------

<b>15</b>	<b>Motor thermistor input</b>
This terminal is connected internally to terminal 8 of the signal connector. Connect only one of these terminals to a motor thermistor. Analog input 3 must be in thermistor mode, Pr <b>7.15</b> = th.SC (7), th (8) or th.diSP (9).	

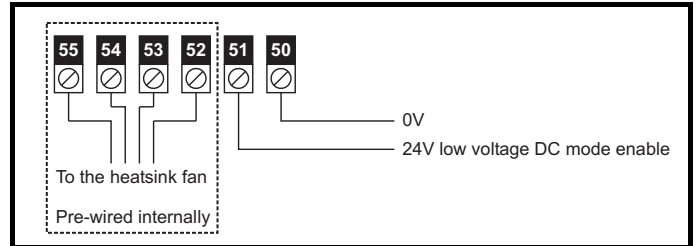
**4.15 Low voltage DC mode enable and heatsink fan supply connections (size 4 to 6)**

Sizes 4 to 6 require a 24V enable signal to terminal 50 and 51 of the lower terminal connector near the W phase output, to allow the drive to be used from a low voltage DC supply.

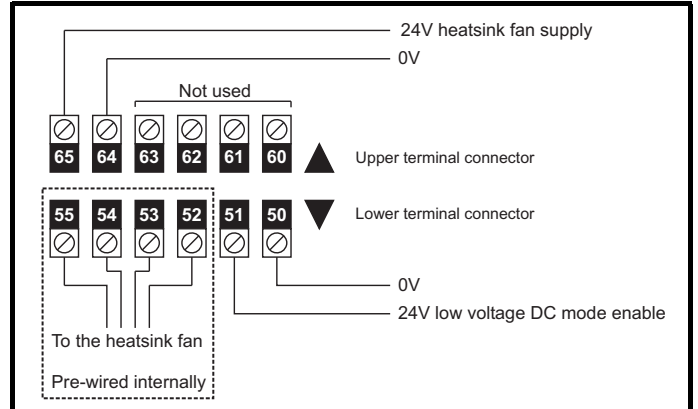
**Figure 4-46** Location of the size 4 to 6 low voltage DC mode enable connections



**Figure 4-47** Size 4 and 5 low voltage DC mode enable connections



**Figure 4-48** Size 6 low voltage DC mode enable connections





#### 4.15.1 Low voltage DC mode enable connections (sizes 4 to 6)

<b>50</b>	<b>0V</b>
<b>51</b>	<b>24V low voltage DC mode enable</b>
<b>Function</b>	<b>To allow the drive to be used from low voltage DC supply</b>
Nominal voltage	24.0Vdc
Minimum continuous operating voltage	19.2Vdc
Maximum continuous operating voltage	30.0Vdc
Nominal current consumption	500mA
Recommended fuse	8A 600V AC fast acting class CC type fuse

<b>52</b>	
<b>53</b>	
<b>54</b>	<b>Heatsink fan connections</b>
<b>55</b>	
No user connections	

#### 4.15.2 Heatsink fan supply connections (size 6 only)

<b>60</b>	
<b>61</b>	<b>No connection</b>
<b>62</b>	
<b>63</b>	
No user connections	

<b>64</b>	<b>0V</b>
<b>65</b>	<b>24V heatsink fan supply</b>
<b>Function</b>	<b>To provide the power supply to the heatsink mounted fan</b>
Nominal voltage	24Vdc
Minimum continuous operating voltage	23.5V
Maximum continuous operating voltage	27V
Current consumption	3.3A
Recommended power supply	24V, 100W, 4.5A
Recommended fuse	4A fast blow ( $I^2t$ less than $20A^2s$ )

### 4.16 SAFE TORQUE OFF (SECURE DISABLE)

The SAFE TORQUE OFF (SECURE DISABLE) function provides a means for preventing the drive from generating torque in the motor, with a very high level of integrity. It is suitable for incorporation into a safety system for a machine. It is also suitable for use as a conventional drive enable input.

The SAFE TORQUE OFF (SECURE DISABLE) function makes use of the special property of an inverter drive with an induction motor, which is that torque cannot be generated without the continuous correct active behaviour of the inverter circuit. All credible faults in the inverter power circuit cause a loss of torque generation.

The SAFE TORQUE OFF (SECURE DISABLE) function is fail-safe, so when the SAFE TORQUE OFF (SECURE DISABLE) input is disconnected the drive will not operate the motor, even if a combination of components within the drive has failed. Most component failures are revealed by the drive failing to operate. SAFE TORQUE OFF (SECURE DISABLE) is also independent of the drive firmware. This meets the requirements of EN954-1 category 3 for the prevention of operation of the motor.<sup>1</sup> On drives with date code P04 and later the SAFE TORQUE OFF (SECURE DISABLE) input also meets the requirements of EN 81-1 clause 12.7.3 b) as part of a system for preventing unwanted operation of the motor in a lift (elevator).<sup>2</sup>

<sup>1</sup> Independent approval has been given by BGIA.

<sup>2</sup> Independent approval of concept has been given by TÜV.

SAFE TORQUE OFF (SECURE DISABLE) can be used to eliminate electro-mechanical contactors, including special safety contactors, which would otherwise be required for safety applications.

#### Note on response time of SAFE TORQUE OFF (SECURE DISABLE), and use with safety controllers with self-testing outputs (drives with date code P04 and later).

SAFE TORQUE OFF (SECURE DISABLE) has been designed to have a response time of greater than 1ms, so that it is compatible with safety controllers whose outputs are subject to a dynamic test with a pulse width not exceeding 1ms.

For applications where a fast-acting disable function is required, please see section 11.21.10 *Fast Disable* on page 241

#### Note on the use of servo motors, other permanent-magnet motors, reluctance motors and salient-pole induction motors

When the drive is disabled through SAFE TORQUE OFF (SECURE DISABLE), a possible (although highly unlikely) failure mode is for two power devices in the inverter circuit to conduct incorrectly.

This fault cannot produce a steady rotating torque in any AC motor. It produces no torque in a conventional induction motor with a cage rotor. If the rotor has permanent magnets and/or saliency, then a transient alignment torque may occur. The motor may briefly try to rotate by up to 180° electrical, for a permanent magnet motor, or 90° electrical, for a salient pole induction motor or reluctance motor. This possible failure mode must be allowed for in the machine design.



**WARNING**

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



**WARNING**

To maintain category 3 according to EN954-1 the environment limits given in section 12.1 *Drive technical data* on page 242 must be adhered to.



**WARNING**

SAFE TORQUE OFF (SECURE DISABLE) inhibits the operation of the drive, this includes inhibiting braking. If the drive is required to provide both braking and SAFE TORQUE OFF (SECURE DISABLE) in the same operation (e.g. for emergency stop) then a safety timer relay or similar device must be used to ensure that the drive is disabled a suitable time after braking. The braking function in the drive is provided by an electronic circuit which is not fail-safe. If braking is a safety requirement, it must be supplemented by an independent fail-safe braking mechanism.

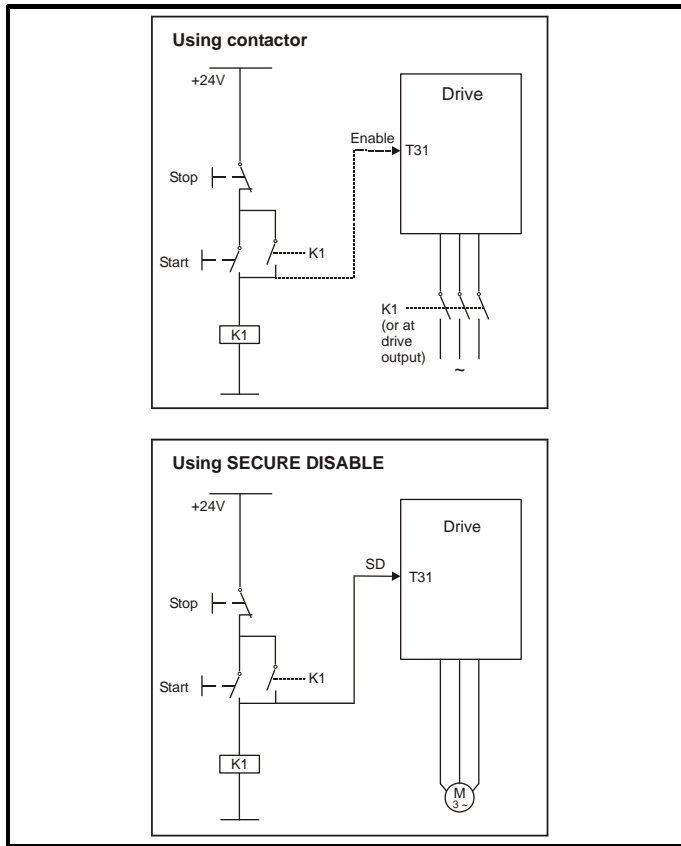


**SAFE TORQUE OFF (SECURE DISABLE)** does not provide electrical isolation. The supply to the drive must be disconnected by an approved isolation device before gaining access to power connections.

The following diagrams illustrate how the **SAFE TORQUE OFF (SECURE DISABLE)** input can be used to eliminate contactors and safety contactors from control systems. Please note these are provided for illustration only, every specific arrangement must be verified for suitability in the proposed application.

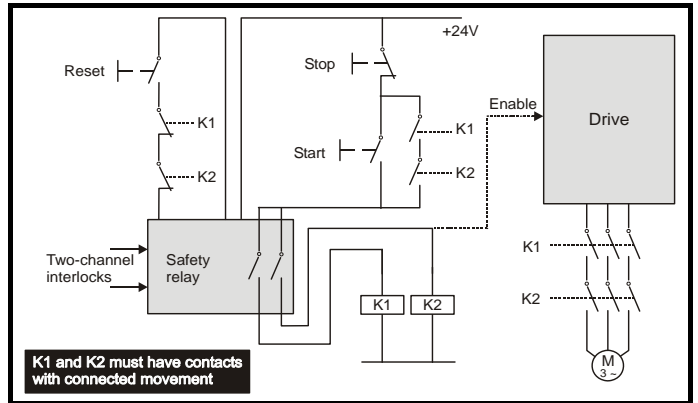
In the first example, illustrated in Figure 4-49, the **SAFE TORQUE OFF (SECURE DISABLE)** function is used to replace a simple power contactor in applications where the risk of injury from unexpected starting is small, but it is not acceptable to rely on the complex hardware and firmware/software used by the stop/start function within the drive.

**Figure 4-49 Start / stop control EN954-1 category B - replacement of contactor**



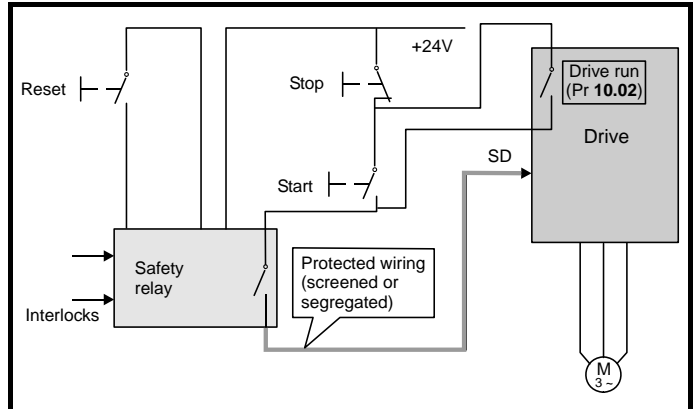
In the second example, illustrated in Figure 4-50 and Figure 4-51, a conventional high-integrity system which uses two safety contactors with auxiliary contacts with connected movement is replaced by a single **SAFE TORQUE OFF (SECURE DISABLE)** system. This arrangement meets EN954-1 category 3.

**Figure 4-50 Category 3 interlock using electromechanical safety contactors**



The safety function of the example circuit is to ensure that the motor does not operate when the interlocks are not signalling a safe state. The safety relay is used to check the two interlock channels and detect faults in those channels. The stop/start buttons are shown for completeness as part of a typical arrangement, they do not carry out a safety function and are not necessary for the safe operation of the circuit.

**Figure 4-51 Category 3 interlock using SAFE TORQUE OFF (SECURE DISABLE) with protected wiring**



In the conventional system, a contactor failure in the unsafe direction is detected the next time the safety relay is reset. Since the drive is not part of the safety system it has to be assumed that AC power is always available to drive the motor, so two contactors in series are required in order to prevent the first failure from causing an unsafe event (i.e. the motor driven).

With **SAFE TORQUE OFF (SECURE DISABLE)** there are no single faults in the drive which can permit the motor to be driven. Therefore it is not necessary to have a second channel to interrupt the power connection, nor a fault detection circuit.

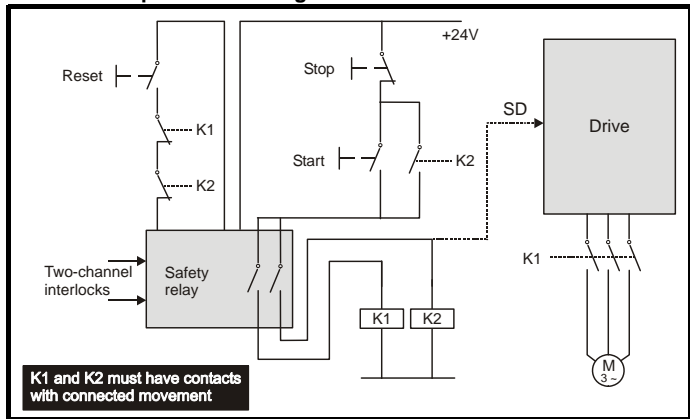
It is important to note that a single short-circuit from the Enable input (**SAFE TORQUE OFF (SECURE DISABLE)**) to a DC supply of approximately +24V would cause the drive to be enabled. For this reason, Figure 4-51 shows the wire from the Enable input to the safety relay as "protected wiring" so that the possibility of a short circuit from this wire to the DC supply can be excluded, as specified in ISO 13849-2. The wiring can be protected by placing it in a segregated cable duct or other enclosure, or by providing it with a grounded shield. The shield is provided to avoid a hazard from an electrical fault. It may be grounded by any convenient method, no special EMC precautions are required.

If the use of protected wiring is not acceptable, so that the possibility of this short circuit must be allowed for, then a relay must be used to monitor the state of the Enable input, together with a single safety contactor to prevent operation of the motor after a fault. This is illustrated in Figure 4-52.

**NOTE**

The auxiliary relay K2 must be located in the same enclosure and close to the drive, with its coil connected as closely as possible to the drive enable / SAFE TORQUE OFF (SECURE DISABLE) input.

**Figure 4-52 Use of contactor and relay to avoid the need for protected wiring**



# 5 Getting Started

This chapter introduces the user interfaces, menu structure and security level of the drive.

## 5.1 Understanding the display

There are two types of keypad available for the Unidrive SP, LED and LCD. The SM-Keypad and SPz Keypad have an LED display, and the SM-Keypad Plus has an LCD display. The SPz Keypad can only be fitted to SPz, and the SM-Keypad can only be fitted to size 1 to 6. The SM-Keypad Plus can either be fitted to the size 1 to 6, or it can be remotely mounted on an enclosure door.

### 5.1.1 SM-Keypad/SPz Keypad (LED)

The display consists of two horizontal rows of 7 segment LED displays.

The upper display shows the drive status or the current menu and parameter number being viewed.

The lower display shows the parameter value or the specific trip type.

Figure 5-1 SM-Keypad

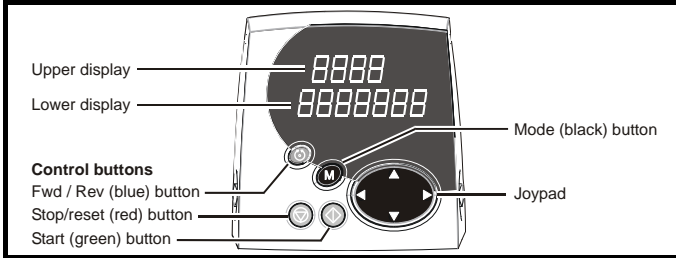
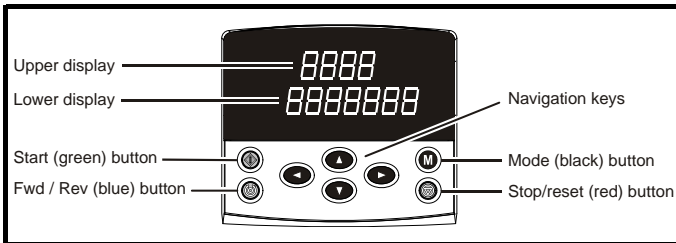


Figure 5-3 SPz Keypad



**NOTE** The red stop button is also used to reset the drive.

The SM-Keypad/SPz Keypad and the SM-Keypad Plus can indicate when a SMARTCARD access is taking place or when the second motor map is active (menu 21). These are indicated on the displays as follows.

	SM-Keypad / SPz Keypad	SM-Keypad Plus
SMARTCARD access taking place	The decimal point after the fourth digit in the upper display will flash.	The symbol 'CC' will appear in the lower left hand corner of the display
Second motor map active	The decimal point after the third digit in the upper display will flash.	The symbol 'Mot2' will appear in the lower left hand corner of the display

## 5.2 Keypad operation

### 5.2.1 Control buttons

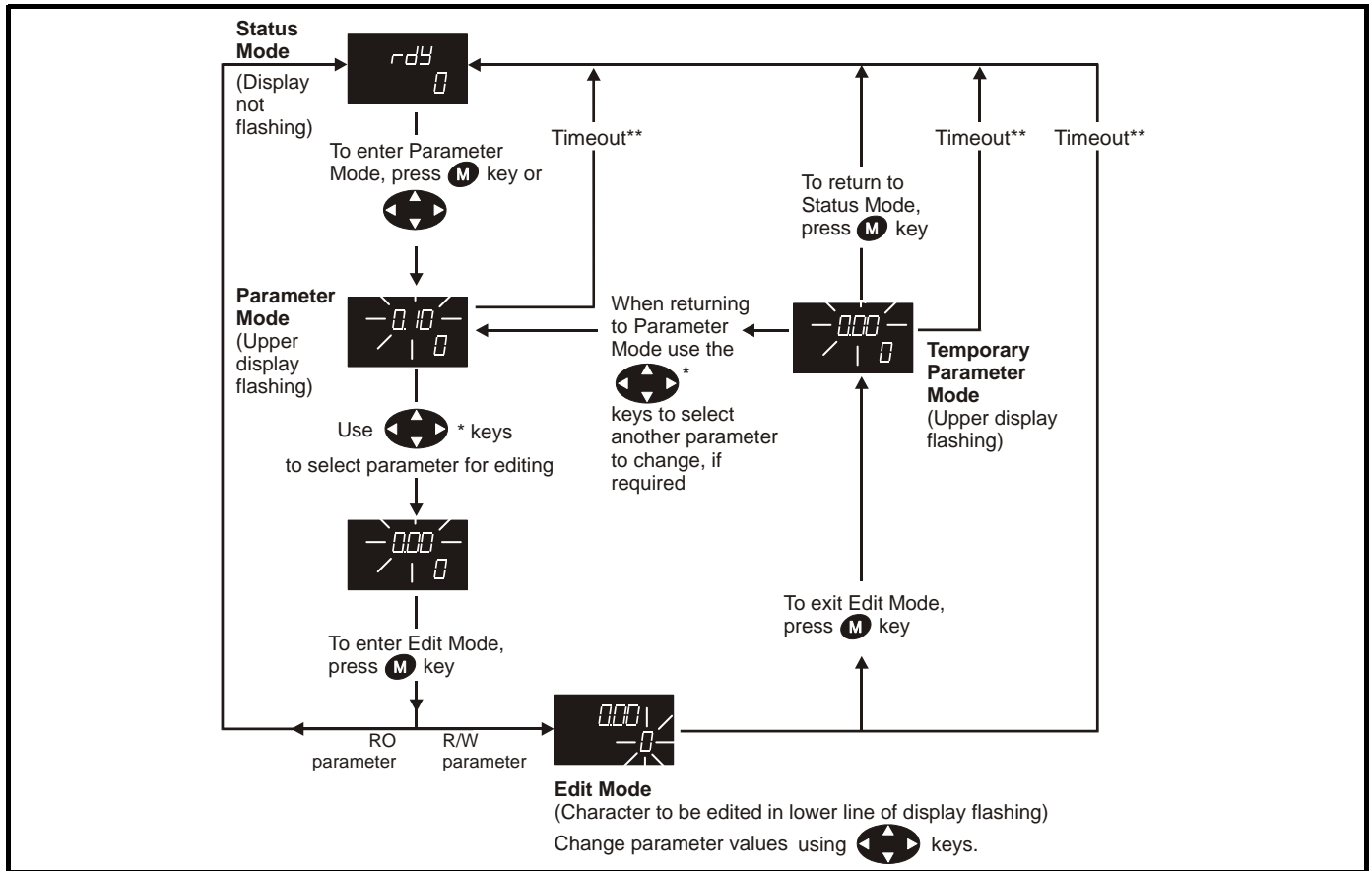
The keypad consists of:

1. Joypad - used to navigate the parameter structure and change parameter values.
2. Mode button - used to change between the display modes – parameter view, parameter edit, status.
3. Three control buttons - used to control the drive if keypad mode is selected.
4. Help button (SM-Keypad Plus only) - displays text briefly describing the selected parameter.

The Help button toggles between other display modes and parameter help mode. The up and down functions on the joypad scroll the help text to allow the whole string to be viewed. The right and left functions on the joypad have no function when help text is being viewed.

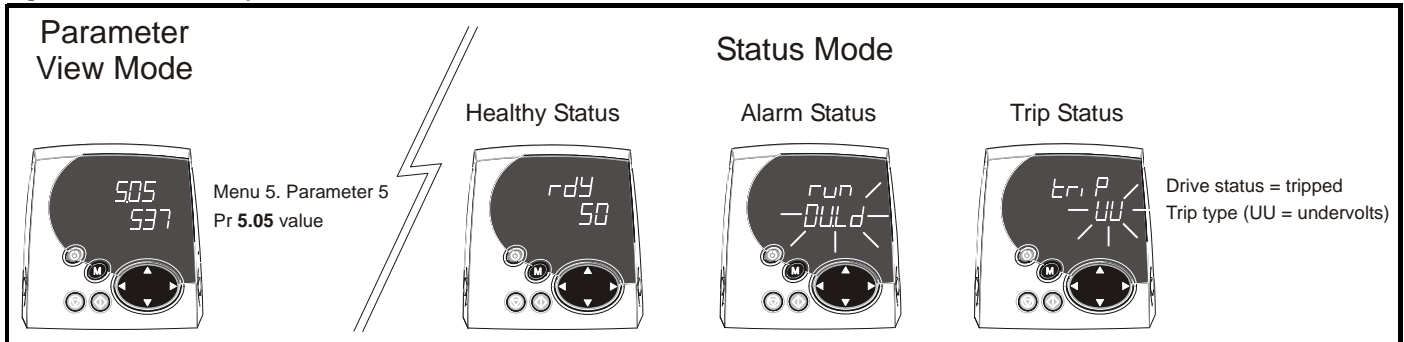
The display examples in this section show the SM-Keypad 7 segment LED display. The examples are the same for the SM-Keypad Plus except that the information displayed on the lower row on the SM-Keypad is displayed on the right hand side of the top row on the SM-Keypad Plus.

**Figure 5-4 Display modes**



\* can only be used to move between menus if L2 access has been enabled (Pr 0.49). Refer to section 5.9 on page 97.  
 \*\*Timeout defined by Pr 11.41 (default value = 240s).

**Figure 5-5 Mode examples**



**WARNING**  
 Do not change parameter values without careful consideration; incorrect values may cause damage or a safety hazard.

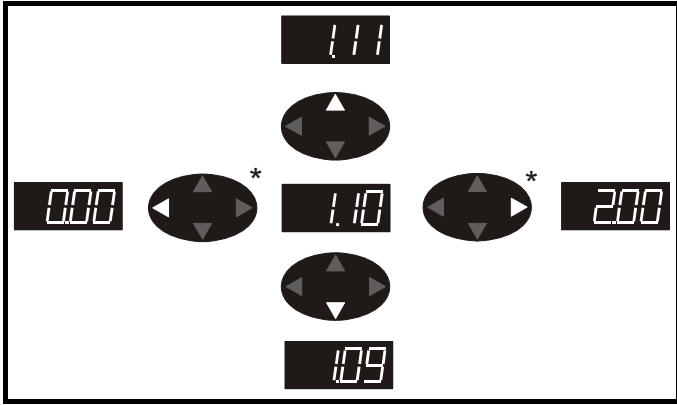
**NOTE**  
 When changing the values of parameters, make a note of the new values in case they need to be entered again.

**NOTE**  
 For new parameter-values to apply after the AC supply to the drive is interrupted, new values must be saved. Refer to section 5.7 *Saving parameters* on page 96.

### 5.3 Menu structure

The drive parameter structure consists of menus and parameters. The drive initially powers up so that only menu 0 can be viewed. The up and down arrow buttons are used to navigate between parameters and once level 2 access (L2) has been enabled (see Pr 0.49) the left and right buttons are used to navigate between menus. For further information, refer to section 5.9 *Parameter access level and security* on page 97.

**Figure 5-6 Parameter navigation**



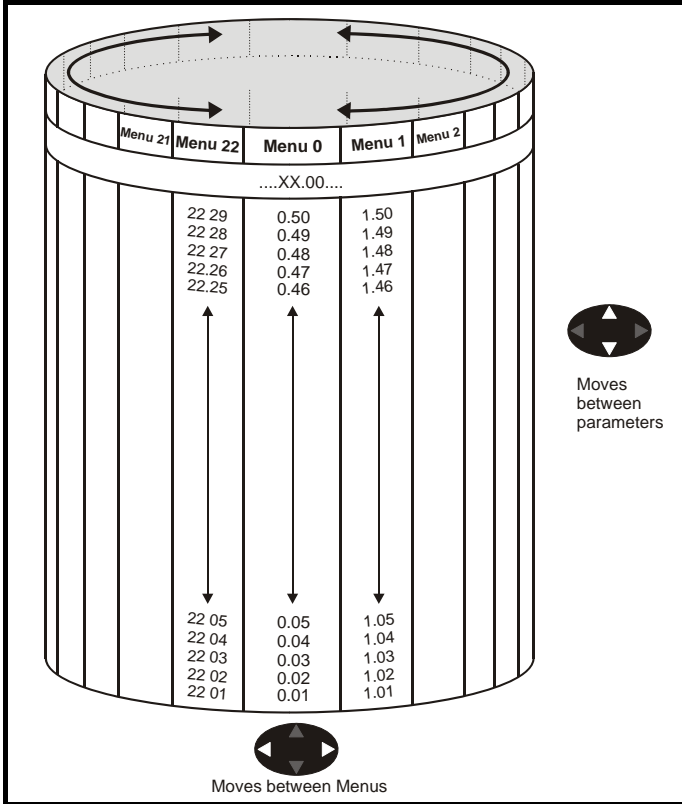
\* can only be used to move between menus if L2 access has been enabled (Pr 0.49). Refer to section 5.9 *Parameter access level and security* on page 97.

The menus and parameters roll over in both directions.

i.e. if the last parameter is displayed, a further press will cause the display to rollover and show the first parameter.

When changing between menus the drive remembers which parameter was last viewed in a particular menu and thus displays that parameter.

**Figure 5-7 Menu structure**



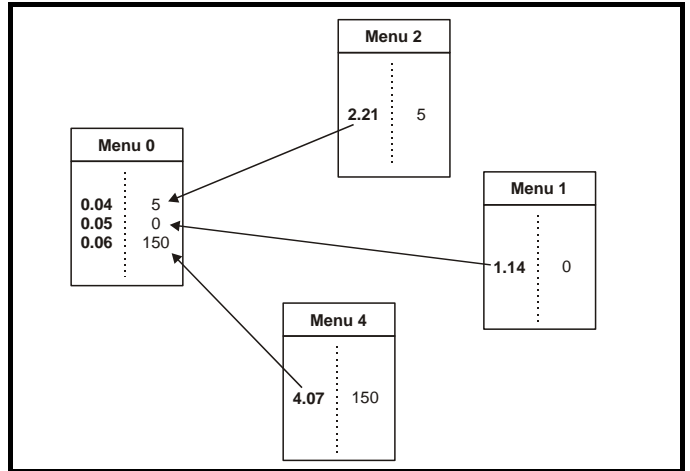
## 5.4 Menu 0

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive.

Appropriate parameters are copied from the advanced menus into menu 0 and thus exist in both locations.

For further information, refer to Chapter 6 *Basic parameters* on page 99.

**Figure 5-8 Menu 0 copying**



## 5.5 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. Menus 0 to 22 can be viewed on all keypads. Menus 40 and 41 are specific to the SM-Keypad Plus (LCD). Menus 70 to 91 can be viewed with an SM-Keypad Plus (LCD) only when an SM-Applications is installed.

**Table 5-1 Advanced menu descriptions**

Menu	Description	LED	LCD
0	Commonly used basic set up parameters for quick / easy programming	✓	✓
1	Frequency / speed reference	✓	✓
2	Ramps	✓	✓
3	Slave frequency, speed feedback and speed control	✓	✓
4	Torque and current control	✓	✓
5	Motor control	✓	✓
6	Sequencer and clock	✓	✓
7	Analog I/O	✓	✓
8	Digital I/O	✓	✓
9	Programmable logic, motorized pot and binary sum	✓	✓
10	Status and trips	✓	✓
11	General drive set-up	✓	✓
12	Threshold detectors and variable selectors	✓	✓
13	Position control	✓	✓
14	User PID controller	✓	✓
15, 16, 17	Solutions Module set-up	✓	✓
18	Application menu 1	✓	✓
19	Application menu 2	✓	✓
20	Application menu 3	✓	✓
21	Second motor parameters	✓	✓
22	Additional Menu 0 set-up	✓	✓
40	Keypad configuration menu	X	✓
41	User filter menu	X	✓
70	PLC registers	X	✓
71	PLC registers	X	✓
72	PLC registers	X	✓
73	PLC registers	X	✓
74	PLC registers	X	✓
75	PLC registers	X	✓
85	Timer function parameters	X	✓
86	Digital I/O parameters	X	✓
88	Status parameters	X	✓
90	General parameters	X	✓
91	Fast access parameters	X	✓

### 5.5.1 SM-Keypad Plus set-up menus

**Table 5-2 Menu 40 parameter descriptions**

Parameter	Range(⇅)	
40.00	Parameter 0	0 to 32767
40.01	Language selection	English (0), Custom (1), French (2), German (3), Spanish (4), Italian (5)
40.02	Software version	999999
40.03	Save to flash	Idle (0), Save (1), Restore (2), Default (3)
40.04	LCD contrast	0 to 31
40.05	Drive and attribute database upload was bypassed	Updated (0), Bypass (1)
40.06	Browsing favourites control	Normal (0), Filter (1)
40.07	Keypad security code	0 to 999
40.08	Communication channel selection	Disable (0), Slot1 (1), Slot2 (2), Slot3 (3), Slave (4), Direct (5)
40.09	Hardware key code	0 to 999
40.10	Drive node ID (Address)	0 to 255
40.11	Flash ROM memory size	4Mbit (0), 8Mbit (1)
40.19	String database version number	0 to 999999
40.20	Screen saver strings and enable	None (0), Default (1), User (2)
40.21	Screen saver interval	0 to 600
40.22	Turbo browse time interval	0 to 200ms

**Table 5-3 Menu 41 parameter descriptions**

Parameter	Range(⇅)	
41.00	Parameter 0	0 to 32767
41.01 to 41.50	Browsing filter source F01 to F50	Pr 0.00 to Pr 391.51
41.51	Browsing favourites control	Normal (0), Filter (1)

## 5.5.2 Display messages

The following tables indicate the various possible mnemonics which can be displayed by the drive and their meaning.

Trip types are not listed here but can be found in Chapter 6 *Basic parameters* on page 99 if required.

**Table 5-4 Alarm indications**

Lower display	Description
<b>br.rS</b>	Braking resistor overload Braking resistor I <sup>2</sup> t accumulator (Pr <b>10.39</b> ) in the drive has reached 75.0% of the value at which the drive will trip and the braking IGBT is active.
<b>Hot</b>	Heatsink or control board or inverter IGBT over temperature alarms are active <ul style="list-style-type: none"> <li>The drive heatsink temperature has reached a threshold and the drive will trip 'Oh2' if the temperature continues to rise (see the 'Oh2' trip).</li> </ul> or <ul style="list-style-type: none"> <li>The ambient temperature around the control PCB is approaching the over temperature threshold (see the 'O.CtL' trip).</li> </ul>
<b>OVLd</b>	Motor overload The motor I <sup>2</sup> t accumulator in the drive has reached 75% of the value at which the drive will be tripped and the load on the drive is >100%
<b>Auto tune</b>	Autotune in progress The autotune procedure has been initialised. 'Auto' and 'tunE' will flash alternatively on the display.
<b>Lt</b>	Limit switch is active Indicates that a limit switch is active and that it is causing the motor to be stopped (i.e. forward limit switch with forward reference etc.)
<b>PLC</b>	Onboard PLC program is running An Onboard PLC program is installed and running. The lower display will flash 'PLC' once every 10s.

**Table 5-5 Solutions Module and SMARTCARD status indications on power-up**

Lower display	Description
<b>boot</b>	A parameter set is being transferred from the SMARTCARD to the drive during power-up. For further information, please refer to section 9.2.4 <i>Booting up from the SMARTCARD on every power up</i> (Pr <b>11.42 = boot (4)</b> ) on page 141.
<b>cArd</b>	The drive is writing a parameter set to the SMARTCARD during power-up. For further information, please refer to section 9.2.3 <i>Auto saving parameter changes</i> (Pr <b>11.42 = Auto (3)</b> ) on page 141.
<b>IoAding</b>	The drive is writing information to a Solutions Module.





## 5.6 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. (Pr **0.49 Security status** and Pr **0.34 User security code** are not affected by this procedure.)

### Procedure


Use the following procedure only if a different operating mode is required:

- Ensure the drive is not enabled, i.e. terminal 31 is open or Pr **6.15** is Off (0)
- Enter either of the following values in Pr **xx.00**, as appropriate:  
1253 (EUR, 50Hz AC supply frequency)  
1254 (USA, 60Hz AC supply frequency)
- Change the setting of Pr **0.48** as follows:

Pr 0.48 setting	Operating mode
	1 Open-loop
	2 Closed-loop vector
	3 Closed-loop Servo
	4 Regen

The figures in the second column apply when serial communications are used.


### 4. Either:

- Press the red  reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.38** to 100 (ensure that Pr. **xx.00** returns to 0).

### NOTE

Entering 1253 or 1254 in Pr **xx.00** will only load defaults if the setting of Pr **0.48** has been changed.

## 5.7 Saving parameters


When changing a parameter in Menu 0, the new value is saved when pressing the  Mode button to return to parameter view mode from parameter edit mode.

If parameters have been changed in the advanced menus, then the change will not be saved automatically. A save function must be carried out.

### Procedure

Enter 1000\* in Pr. **xx.00**

Either:


- Press the red  reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.38** to 100 (ensure that Pr. **xx.00** returns to 0).

\*If the drive is in the under voltage trip state or is being supplied from a low voltage DC supply, a value of 1001 must be entered into Pr **xx.00** to perform a save function.

## 5.8 Restoring parameter defaults

Restoring parameter defaults by this method saves the default values in the drive's memory. (Pr **0.49** and Pr **0.34** are not affected by this procedure.)

### Procedure

- Ensure the drive is not enabled, i.e. terminal 31 is open or Pr **6.15** is Off (0)
- Enter 1233 (EUR 50Hz settings) or 1244 (USA 60Hz settings) in Pr **xx.00**.
- Either:
  - Press the red  reset button



- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.38** to 100 (ensure that Pr. **xx.00** returns to 0).

## 5.9 Parameter access level and security

The parameter access level determines whether the user has access to menu 0 only or to all the advanced menus (menus 1 to 22) in addition to menu 0.

The User Security determines whether the access to the user is read only or read write.

Both the User Security and Parameter Access Level can operate independently of each other as shown in the table below:

Parameter Access Level	User Security	Menu 0 status	Advanced menus status
L1	Open	RW	Not visible
L1	Closed	RO	Not visible
L2	Open	RW	RW
L2	Closed	RO	RO

RW = Read / write access RO = Read only access

The default settings of the drive are Parameter Access Level L1 and user Security Open, i.e. read / write access to Menu 0 with the advanced menus not visible.

### 5.9.1 Access Level

The access level is set in Pr **0.49** and allows or prevents access to the advanced menu parameters.

**L1 access selected** - Menu 0 only visible

Pr 0.00			
Pr 0.01			
Pr 0.02			
Pr 0.03			
Pr 0.49			
Pr 0.50			

**L2 access selected** - All parameters visible

Pr 0.00	Pr 1.00	.....	Pr 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

### 5.9.2 Changing the Access Level

The Access Level is determined by the setting of Pr **0.49** as follows:

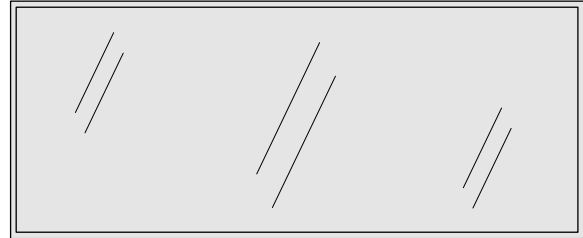
String	Value	Effect
L1	0	Access to menu 0 only
L2	1	Access to all menus (menu 0 to menu 22)

The Access Level can be changed through the keypad even if the User Security has been set.

### 5.9.3 User Security

The User Security, when set, prevents write access to any of the parameters (other than Pr. **0.49** and Pr **11.44 Access Level**) in any menu.

**User security open** - All parameters: Read / Write access



Pr 0.00	Pr 1.00	.....	Pr 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

**User security closed** - All parameters: Read Only access (except Pr **0.49** and Pr **11.44**)

Pr 0.00	Pr 1.00	.....	Pr 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

### Setting User Security

Enter a value between 1 and 999 in Pr **0.34** and press the **M** button; the security code has now been set to this value. In order to activate the security, the Access level must be set to Loc in Pr **0.49**. When the drive is reset, the security code will have been activated and the drive returns to Access Level L1. The value of Pr **0.34** will return to 0 in order to hide the security code. At this point, the only parameter that can be changed by the user is the Access Level Pr **0.49**.

### Unlocking User Security

Select a read write parameter to be edited and press the **M** button, the upper display will now show CodE. Use the arrow buttons to set the security code and press the **M** button.

With the correct security code entered, the display will revert to the parameter selected in edit mode.

If an incorrect security code is entered the display will revert to parameter view mode.

To lock the User Security again, set Pr **0.49** to Loc and press the **∇** reset button.

### Disabling User Security

Unlock the previously set security code as detailed above. Set Pr **0.34** to 0 and press the **M** button. The User Security has now been disabled, and will not have to be unlocked each time the drive is powered up to allow read / write access to the parameters.

## 5.10 Displaying parameters with non-default values only

By entering 12000 in Pr **xx.00**, the only parameters that will be visible to the user will be those containing a non-default value. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **xx.00** and enter a value of 0.

Please note that this function can be affected by the access level enabled, refer to *section 5.9 Parameter access level and security* for further information regarding access level.

## 5.11 Displaying destination parameters only

By entering 12001 in Pr **xx.00**, the only parameters that will be visible to the user will be destination parameters. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **xx.00** and enter a value of 0.

Please note that this function can be affected by the access level enabled, refer to *section 5.9 Parameter access level and security* for further information regarding access level.

## 5.12 Serial communications

### 5.12.1 Introduction

The Unidrive SP has a standard 2-wire EIA485 interface (serial communications interface) which enables all drive set-up, operation and monitoring to be carried out with a PC or controller if required. Therefore, it is possible to control the drive entirely by serial communications without the need for an SM-keypad or other control cabling. The drive supports two protocols selected by parameter configuration:

- Modbus RTU
- CT ANSI

Modbus RTU has been set as the default protocol, as it is used with the PC-tools commissioning/start-up software as provided on the CD ROM.

The serial communications port of the drive is a RJ45 socket, which is isolated from the power stage and the other control terminals (see *section 4.12 Serial communications connections* on page 80 for connection and isolation details).

The communications port applies a 2 unit load to the communications network.

#### USB/EIA232 to EIA485 Communications

An external USB/EIA232 hardware interface such as a PC cannot be used directly with the 2-wire EIA485 interface of the drive. Therefore a suitable converter is required.

Suitable USB to EIA485 and EIA232 to EIA485 isolated converters are available from LEROY-SOMER as follows:

- CT USB Comms cable
- CT EIA232 Comms cable

When using one of the above converters or any other suitable converter with the Unidrive SP, it is recommended that no terminating resistors be connected on the network. It may be necessary to 'link out' the terminating resistor within the converter depending on which type is used. The information on how to link out the terminating resistor will normally be contained in the user information supplied with the converter.

### 5.12.2 Serial communications set-up parameters

The following parameters need to be set according to the system requirements.

0.35 {11.24} Serial mode	
RW	Txt
↕	AnSI (0) rtU (1)
	⇒ rtU (1)

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 send 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.)

Comms value	String	Communications mode
0	AnSI	ANSI
1	rtU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but with an SM-Keypad Plus only

#### ANSIx3.28 protocol

Full details of the CT ANSI communications protocol are the *Advanced User Guide*.

#### Modbus RTU protocol

Full details of the CT implementation of Modbus RTU are given in the *Advanced User Guide*.

#### Modbus RTU protocol, but with an SM-Keypad Plus only

This setting is used for disabling communications access when the SM-Keypad Plus is used as a hardware key. See the *Advanced User Guide* for more details.

0.36 {11.25} Serial communications baud rate	
RW	Txt
↕	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8)*, 115200 (9)*
	⇒ 19200 (6)

\* only applicable to Modbus RTU mode

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.

#### NOTE

When using the CT EIA232 Comms cable the available baud rate is limited to 19.2k baud.

0.37 {11.23} Serial communications address	
RW	Txt
↕	0 to 247
	⇒ 1

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

#### 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

#### 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 **0.37** 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.

## 6 Basic parameters

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. All the parameters in menu 0 appear in other menus in the drive (denoted by {...}).

Menus 11 and 22 can be used to change most of the parameters in menu 0. Menu 0 can also contain up to 59 parameters by setting up menu 22.

### 6.1 Single line descriptions

Parameter			Range(⇅)			Default(⇔)			Type					
			OL	VT	SV	OL	VT	SV						
<b>0.00</b>	<b>xx.00</b>	{x.00}	0 to 32,767			0			RW	Uni				
<b>0.01</b>	Minimum reference clamp	{1.07}	±3,000.0Hz	±SPEED_LIMIT_MAX Hz/rpm		0.0			RW	Bi			PT	US
<b>0.02</b>	Maximum reference clamp	{1.06}	0 to 3,000.0Hz	SPEED_LIMIT_MAX Hz/rpm		EUR> 50.0 USA> 60.0	EUR> 1,500.0 USA> 1,800.0	3,000.0	RW	Uni				US
<b>0.03</b>	Acceleration rate	{2.11}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm		5.0	2.000	0.200	RW	Uni				US
<b>0.04</b>	Deceleration rate	{2.21}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm		10.0	2.000	0.200	RW	Uni				US
<b>0.05</b>	Reference select	{1.14}	A1.A2 (0), A1.Pr (1), A2.Pr (2), Pr (3), PAd (4), Prc (5)			A1.A2 (0)			RW	Txt		NC		US
<b>0.06</b>	Current limit	{4.07}	0 to Current_limit_max %			165.0	175.0		RW	Uni		RA		US
<b>0.07</b>	OL> Voltage mode select	{5.14}	Ur_S (0), Ur (1), Fd (2), Ur_Auto (3), Ur_I (4), SrE (5)			Ur_I (4)			RW	Txt				US
	CL> Speed controller P gain	{3.10}		0.0000 to 6.5535 1/rad s <sup>-1</sup>			0.0300	0.0100	RW	Uni				US
<b>0.08</b>	OL> Voltage boost	{5.15}	0.0 to 25.0% of motor rated voltage			SPz to 3: 3.0 Size 4 & 5: 2.0 Size 6: 1.0			RW	Uni				US
	CL> Speed controller I gain	{3.11}		0.00 to 655.35 1/rad			0.10	1.00	RW	Uni				US
<b>0.09</b>	OL> Dynamic V/F	{5.13}	OFF (0) or On (1)			0			RW	Bit				US
	CL> Speed controller D gain	{3.12}		0.00000 to 0.65535 (s)			0.00000		RW	Uni				US
<b>0.10</b>	OL> Estimated motor speed	{5.04}	±180,000 rpm						RO	Bi	FI	NC	PT	
	CL> Motor speed	{3.02}	±Speed_max rpm						RO	Bi	FI	NC	PT	
<b>0.11</b>	OL & VT> Drive output frequency	{5.01}	±Speed_freq_max Hz	±1250 Hz						RO	Bi	FI	NC	PT
	SV> Drive encoder position	{3.29}			0 to 65,535 1/2 <sup>16</sup> ths of a revolution					RO	Uni	FI	NC	PT
<b>0.12</b>	Total motor current	{4.01}	0 to Drive_current_max A						RO	Uni	FI	NC	PT	
<b>0.13</b>	OL & VT> Motor active current	{4.02}	±Drive_current_max A						RO	Bi	FI	NC	PT	
	SV> Analog input 1 offset trim	{7.07}			±10.000 %			0.000	RW	Bi				US
<b>0.14</b>	Torque mode selector	{4.11}	0 to 1	0 to 4		Speed control mode (0)			RW	Uni				US
<b>0.15</b>	Ramp mode select	{2.04}	FAST (0) Std (1) Std.hV (2)	FAST (0) Std (1)		Std (1)			RW	Txt				US
<b>0.16</b>	OL> T28 and T29 auto-selection disable	{8.39}	OFF (0) or On (1)			OFF (0)			RW	Bit				US
	CL> Ramp enable	{2.02}		OFF (0) or On (1)		On (1)			RW	Bit				US
<b>0.17</b>	OL> T29 digital input destination	{8.26}	Pr <b>0.00</b> to Pr <b>21.51</b>			Pr <b>6.31</b>			RW	Uni	DE		PT	US
	CL> Current demand filter time constant	{4.12}	0.0 to 25.0 ms			0.0			RW	Uni				US
<b>0.18</b>	Positive logic select	{8.29}	OFF (0) or On (1)			On (1)			RW	Bit			PT	US
<b>0.19</b>	Analog input 2 mode	{7.11}	0-20 (0), 20-0 (1), 4-20tr (2), 20-4tr (3), 4-20 (4), 20-4 (5), VOLt (6)			VOLt (6)			RW	Txt				US
<b>0.20</b>	Analog input 2 destination	{7.14}	Pr <b>0.00</b> to Pr <b>21.51</b>			Pr <b>1.37</b>			RW	Uni	DE		PT	US
<b>0.21</b>	Analog input 3 mode	{7.15}	0-20 (0), 20-0 (1), 4-20tr (2), 20-4tr (3), 4-20 (4), 20-4 (5), VOLt (6), th.SC (7), th (8), th.diSp (9)			th (8)			RW	Txt			PT	US
<b>0.22</b>	Bipolar reference select	{1.10}	OFF (0) or On (1)			OFF (0)			RW	Bit				US
<b>0.23</b>	Jog reference	{1.05}	0 to 400.0 Hz	0 to 4000.0 rpm		0.0			RW	Uni				US
<b>0.24</b>	Pre-set reference 1	{1.21}	±Speed_limit_max rpm			0.0			RW	Bi				US
<b>0.25</b>	Pre-set reference 2	{1.22}	±Speed_limit_max rpm			0.0			RW	Bi				US
<b>0.26</b>	OL> Pre-set reference 3	{1.23}	±Speed_freq_max Hz/rpm			0.0			RW	Bi				US
	CL> Overspeed threshold	{3.08}	0 to 40,000 rpm			0			RW	Uni				US
<b>0.27</b>	OL> Pre-set reference 4	{1.24}	±Speed_freq_max Hz/rpm			0.0			RW	Bi				US
	CL> Drive encoder lines per revolution	{3.34}	0 to 50,000			1024		4096	RW	Uni				US
<b>0.28</b>	Keypad fwd/rev key enable	{6.13}	OFF (0) or On (1)			OFF (0)			RW	Bit				US

Parameter			Range(↕)			Default(↔)			Type					
			OL	VT	SV	OL	VT	SV						
0.29	SMARTCARD parameter data	{11.36}	0 to 999			0			RO	Uni		NC	PT	US
0.30	Parameter copying	{11.42}	nonE (0), rEAd (1), Prog (2), Auto (3), boot (4)			nonE (0)			RW	Txt		NC		*
0.31	Drive rated voltage	{11.33}	200 (0), 400 (1), 575 (2), 690 (3) V						RO	Txt		NC	PT	
0.32	Maximum Heavy Duty current rating	{11.32}	0.00 to 9999.99A						RO	Uni		NC	PT	
0.33	OL> Catch a spinning motor	{6.09}	0 to 3			0			RW	Uni				US
	VT> Rated rpm autotune	{5.16}		0 to 2			0		RW	Uni				US
0.34	User security code	{11.30}	0 to 999			0			RW	Uni		NC	PT	PS
0.35	Serial comms mode	{11.24}	AnSI (0), rtu (1), Lcd (2)			rtU (1)			RW	Txt				US
0.36	Serial comms baud rate	{11.25}	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8) Modbus RTU only, 115200 (9) Modbus RTU only			19200 (6)			RW	Txt				US
0.37	Serial comms address	{11.23}	0 to 247			1			RW	Uni				US
0.38	Current loop P gain	{4.13}	0 to 30,000			All voltage ratings: 20	200V drive: 75 400V drive: 150 575V drive: 180 690V drive: 215		RW	Uni				US
0.39	Current loop I gain	{4.14}	0 to 30,000			All voltage ratings: 40	200V drive: 1000 400V drive: 2000 575V drive: 2400 690V drive: 3000		RW	Uni				US
0.40	Autotune	{5.12}	0 to 2	0 to 4	0 to 6	0			RW	Uni				
0.41	Maximum switching frequency	{5.18}	3 (0), 4 (1), 6 (2), 8 (3), 12 (4), 16 (5) kHz			3 (0)		6 (2)	RW	Txt		RA		US
0.42	No. of motor poles	{5.11}	0 to 60 (Auto to 120 pole)			0 (Auto)		6 POLE (3)	RW	Txt				US
0.43	OL & VT> Motor rated power factor	{5.10}	0.000 to 1.000			0.850			RW	Uni				US
	SV> Encoder phase angle	{3.25}			0.0 to 359.9°			0.0	RW	Uni				US
0.44	Motor rated voltage	{5.09}	0 to AC_voltage_set_max V			200V drive: 230 400V drive: EUR> 400, USA> 460 575V drive: 575 690V drive: 690			RW	Uni		RA		US
0.45	OL & VT> Motor rated full load speed (rpm)	{5.08}	0 to 180,000 rpm	0.00 to 40,000.00 rpm		EUR> 1,500 USA> 1,800	EUR> 1,450.00 USA> 1,770.00		RW	Uni				US
	SV> Motor thermal time constant	{4.15}			0.0 to 3000.0			20.0	RW	Uni				US
0.46	Motor rated current	{5.07}	0 to Rated_current_max A			Drive rated current [11.32]			RW	Uni		RA		US
0.47	Rated frequency	{5.06}	0 to 3,000.0 Hz	0 to 1,250.0 Hz		EUR> 50.0 USA> 60.0			RW	Uni				US
0.48	Operating mode selector	{11.31}	OPEn LP (1), CL VECt (2), SERVO (3), rEgEn (4)			OPEn LP (1)	CL VECt (2)	SERVO (3)	RW	Txt		NC	PT	
0.49	Security status	{11.44}	L1 (0), L2 (1), Loc (2)						RW	Txt			PT	US
0.50	Software version	{11.29}	1.00 to 99.99						RO	Uni		NC	PT	
0.51	Action on trip detection	{10.37}	0 to 15			0			RW	Uni				US

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

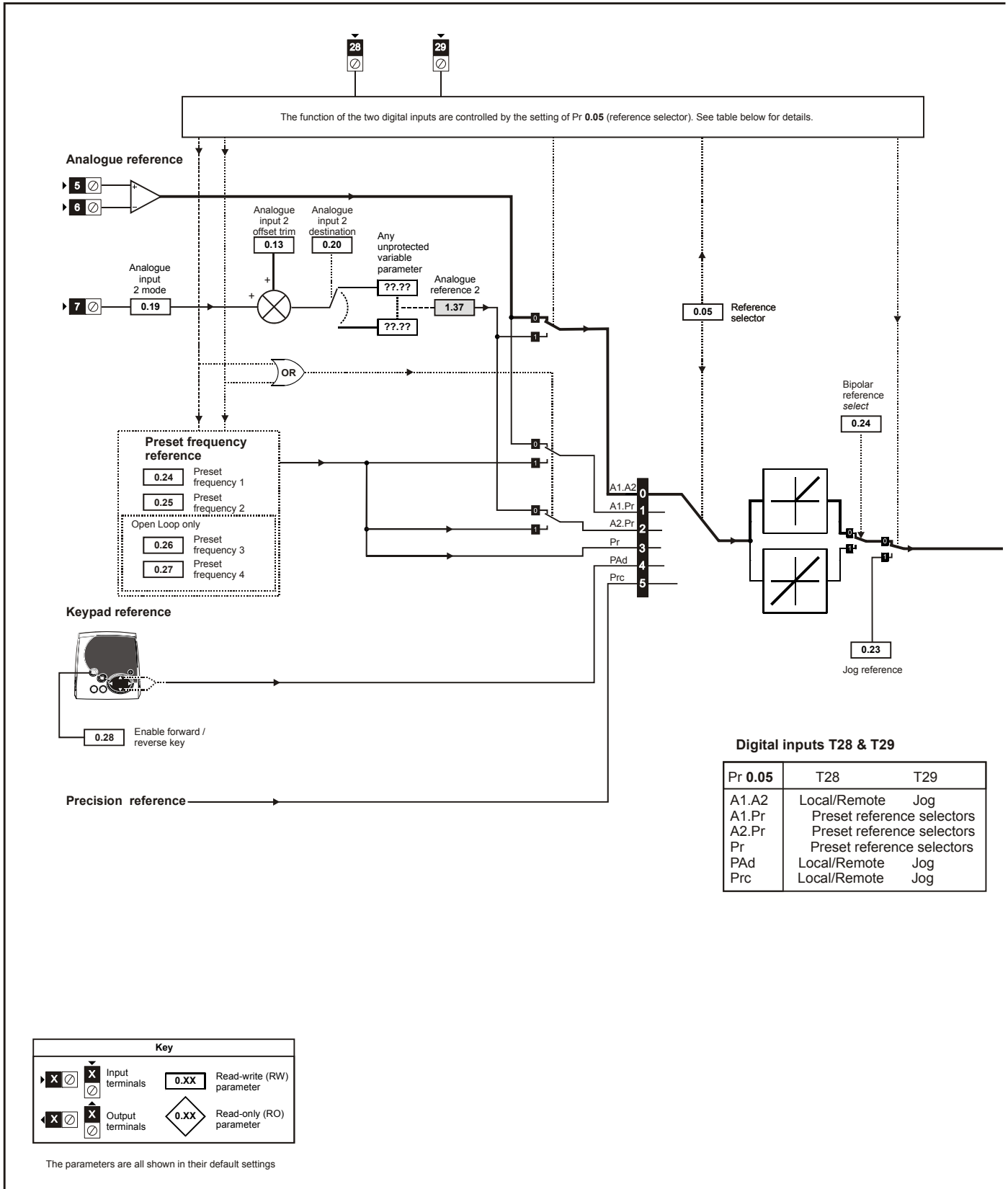
**Key:**

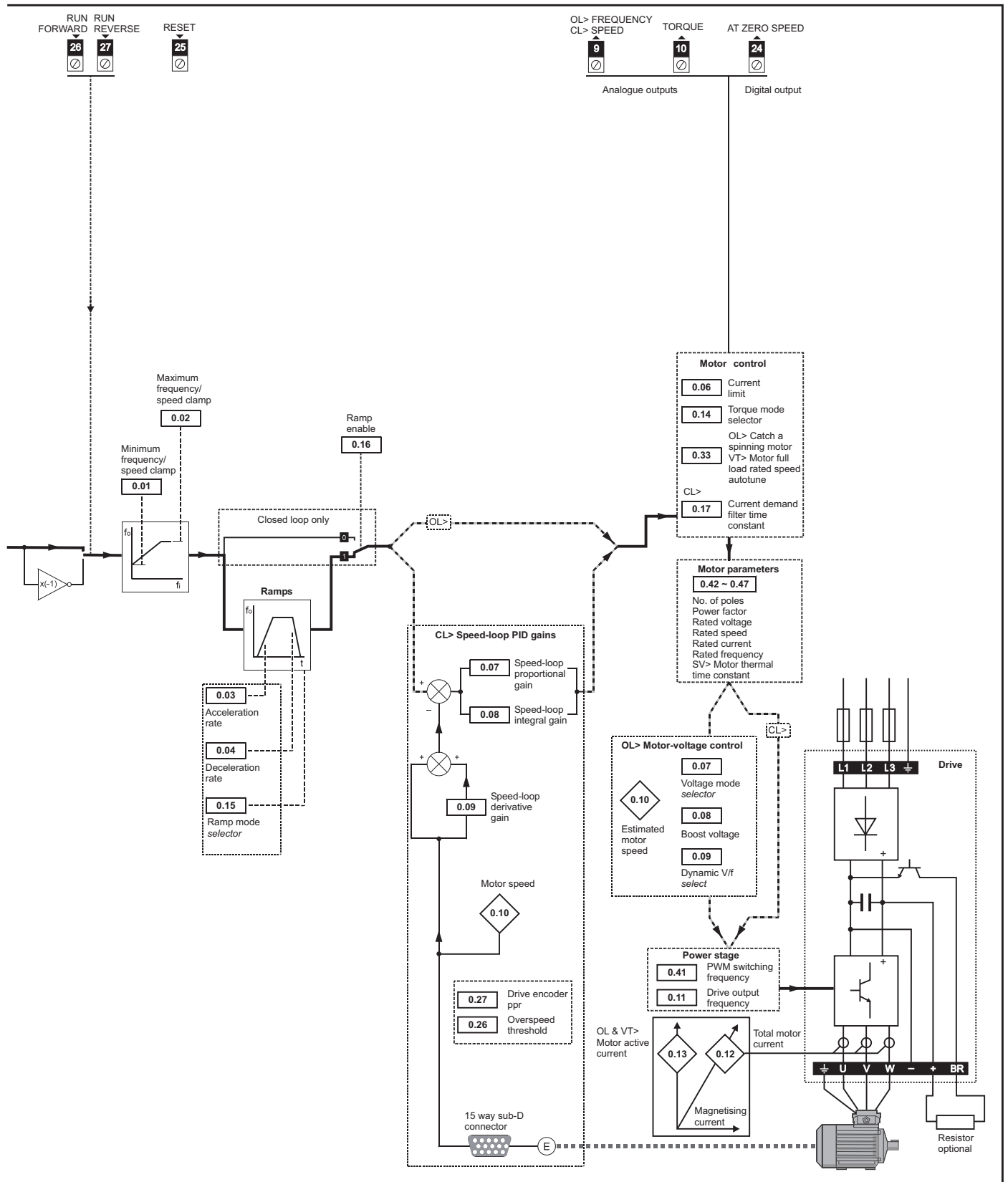
Coding	Attribute
OL	Open loop
CL	Closed loop vector and Servo
VT	Closed loop vector
SV	Servo
{X.XX}	Copied advanced parameter
RW	Read/write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter: 'On' or 'OFF' on the display
Bi	Bipolar parameter
Uni	Unipolar parameter
Txt	Text: the parameter uses text strings instead of numbers.
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: This parameter selects the destination of an input or logic function.

Coding	Attribute
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. However, with software V01.09.00 and later the value will be transferred if only the current rating is different and the file is a differences from default type file.
NC	Not copied: not transferred to or from SMARTCARDS during copying.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs. With software version V01.08.00 and later, power-down save parameters are also saved in the drive when the user initiates a parameter save.



Figure 6-1 Menu 0 logic diagram





## 6.2 Full descriptions

### 6.2.1 Parameter x.00

<b>0.00 {x.00}</b>		<b>Parameter zero</b>												
RW	Uni													
↕		0 to 32,767						⇒	0					

Pr **x.00** is available in all menus and has the following functions.

Value	Action
1000	Save parameters when under voltage is not active (Pr <b>10.16</b> = 0) and low voltage DC supply is not active (Pr <b>6.44</b> = 0).
1001	Save parameters under all conditions
1070	Reset all option modules
1233	Load standard defaults
1244	Load US defaults
1253	Change drive mode with standard defaults
1254	Change drive mode with US defaults
1255	Change drive mode with standard defaults (excluding menus 15 to 20)
1256	Change drive mode with US defaults (excluding menus 15 to 20)
2001*	Transfer drive parameters as difference from default to a bootable SMARTCARD block in data block number 001
3yyy*	Transfer drive EEPROM data to a SMART Card block number yyy
4yyy*	Transfer drive data as difference from defaults to SMART Card block number yyy
5yyy*	Transfer drive ladder program to SMART Card block number yyy
6yyy*	Transfer SMART Card data block number yyy to the drive
7yyy*	Erase SMART Card data block number yyy
8yyy*	Compare drive parameters with SMART Card data block number yyy
9555*	Clear SMARTCARD warning suppression flag
9666*	Set SMARTCARD warning suppression card
9777*	Clear SMARTCARD read-only flag
9888*	Set SMARTCARD read-only flag
9999*	Erase SMARTCARD data block 1 to 499
110zy	Transfer electronic nameplate parameters to/from drive from/ to encoder. See the <i>Advanced User Guide</i> for more information on this function.
12000**	Display non-default values only
12001**	Display destination parameters only

\* See Chapter 9 *SMARTCARD operation* on page 139 for more information of these functions.

\*\* These functions do not require a drive reset to become active. All other functions require a drive reset to initiate the function.

### 6.2.2 Speed limits

<b>0.01 {1.07}</b>		<b>Minimum reference clamp</b>												
RW	Bi											PT	US	
OL	↕	±3,000.0Hz						⇒	0.0					
CL	↕	±SPEED_LIMIT_MAX Hz/rpm						⇒	0.0					

(When the drive is jogging, [0.01] has no effect.)

#### Open-loop

Set Pr **0.01** at the required minimum output frequency of the drive for both directions of rotation. The drive speed reference is scaled between Pr **0.01** and Pr **0.02**. [0.01] is a nominal value; slip compensation may cause the actual frequency to be higher.

#### Closed-loop

Set Pr **0.01** at the required minimum motor speed for both directions of rotation. The drive speed reference is scaled between Pr **0.01** and Pr **0.02**.

<b>0.02 {1.06}</b>		<b>Maximum reference clamp</b>													
RW	Uni												US		
OL	↕	0 to 3,000.0Hz						⇒	EUR> 50.0 USA> 60.0						
CL	↕	SPEED_LIMIT_MAX Hz/rpm						⇒	VT	EUR> 1,500.0 USA> 1,800.0					
									SV	3,000.0					

(The drive has additional over-speed protection.)

#### Open-loop

Set Pr **0.02** at the required maximum output frequency for both directions of rotation. The drive speed reference is scaled between Pr **0.01** and Pr **0.02**. [0.02] is a nominal value; slip compensation may cause the actual frequency to be higher.

#### Closed-loop

Set Pr **0.02** at the required maximum motor speed for both directions of rotation. The drive speed reference is scaled between Pr **0.01** and Pr **0.02**. For operating at high speeds see section 8.6 *High speed operation* on page 137.

### 6.2.3 Ramps, speed reference selection, current limit

<b>0.03 {2.11}</b>		<b>Acceleration rate</b>													
RW	Uni												US		
OL	↕	0.0 to 3,200.0 s/100Hz						⇒	5.0						
CL	↕	0.000 to 3,200.000 s/1,000rpm						⇒	VT	2.000					
									SV	0.200					

Set Pr **0.03** at the required rate of acceleration.

Note that larger values produce lower acceleration. The rate applies in both directions of rotation.

<b>0.04 {2.21}</b>		<b>Deceleration rate</b>													
RW	Uni												US		
OL	↕	0.0 to 3,200.0 s/100Hz						⇒	10.0						
CL	↕	0.000 to 3,200.000 s/1,000rpm						⇒	VT	2.000					
									SV	0.200					

Set Pr **0.04** at the required rate of deceleration.

Note that larger values produce lower deceleration. The rate applies in both directions of rotation.



<b>0.05 {1.14} Reference selector</b>	
RW	Txt
↕	0 to 5 ⇒ A1.A2 (0)

Use Pr **0.05** to select the required frequency/speed reference as follows:

Setting		
A1.A2	0	Analog input 1 OR analog input 2 selectable by digital input, terminal 28
A1.Pr	1	Analog input 1 OR preset frequency/speed selectable by digital input, terminal 28 and 29
A2.Pr	2	Analog input 2 OR preset frequency/speed selectable by digital input, terminal 28 and 29
Pr	3	Pre-set frequency/speed
PAd	4	Keypad reference
Prc	5	Precision reference

Setting Pr **0.05** to 1, 2 or 3 will re-configure T28 and T29. Refer to Pr **8.39** (Pr **0.16** in OL) to disable this function.

<b>0.06 {4.07} Current Limit</b>	
RW	Uni
↕	0 to Current_limit_max % ⇒ OL 165.0 CL 175.0

Pr **0.06** limits the maximum output current of the drive (and hence maximum motor torque) to protect the drive and motor from overload.

Set Pr **0.06** at the required maximum torque as a percentage of the rated torque of the motor, as follows:

$$[0,06] = \frac{T_R}{T_{RATED}} \times 100 (\%)$$

Where:

$T_R$  Required maximum torque  
 $T_{RATED}$  Motor rated torque

Alternatively, set 0.06 at the required maximum active (torque-producing) current as a percentage of the rated active current of the motor, as follows:

$$[0,06] = \frac{I_R}{I_{RATED}} \times 100 (\%)$$

Where:

$I_R$  Required maximum active current  
 $I_{RATED}$  Motor rated active current

## 6.2.4 Voltage boost, (open-loop), Speed-loop PID gains (closed-loop)

<b>0.07 {5.14} Voltage mode selector</b>	
RW	Txt
OL	↕ Ur_S (0), Ur (1), Fd (2), Ur_Auto (3), Ur_I (4), SrE (5) ⇒ Ur_I (4)

### Open-loop

There are six voltage modes available, which fall into two categories, vector control and fixed boost. For further details, refer to section Pr **0.07 {5.14} Voltage mode** on page 127.

<b>0.07 {3.10} Speed controller proportional gain</b>	
RW	Uni
CL	↕ 0.0000 to 6.5535 1/rad s <sup>-1</sup> ⇒ VT 0.0300 SV 0.0100

Software V01.10.00 and later, the defaults are as above.

Software V01.09.01 and earlier, the default is 0.0100 in Closed-loop vector and servo mode.

### Closed-loop

Pr **0.07 (3.10)** operates in the feed-forward path of the speed-control loop in the drive. See Figure 11-4 on page 164 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 126.

<b>0.08 {5.15} Low frequency voltage boost</b>	
RW	Uni
OL	↕ 0.0 to 25.0% of motor rated voltage ⇒ Size 1 to 3: 3.0 Size 4 & 5: 2.0, Size 6: 1.0

### Open-loop

When **0.07 Voltage mode selector** is set at **Fd** or **SrE**, set Pr **0.08 (5.15)** at the required value for the motor to run reliably at low speeds.

Excessive values of Pr **0.08** can cause the motor to be overheated.

<b>0.08 {3.11} Speed controller integral gain</b>	
RW	Uni
CL	↕ 0.00 to 655.35 1/rad ⇒ VT 0.10 SV 1.00

Software V01.10.00 and later, the defaults are as above.

Software V01.09.01 and earlier, the default is 1.00 in Closed-loop vector and servo modes.

### Closed-loop

Pr **0.08 (3.11)** operates in the feed-forward path of the speed-control loop in the drive. See Figure 11-4 on page 164 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 126.

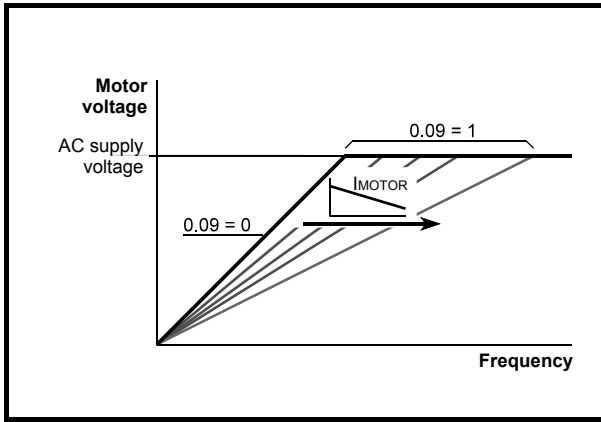
<b>0.09 {5.13} Dynamic V/f / flux optimize select</b>	
RW	Bit
OL	↕ OFF (0) or On (1) ⇒ OFF (0)

### Open-loop

Set Pr **0.09 (5.13)** at 0 when the V/f characteristic applied to the motor is to be fixed. It is then based on the rated voltage and frequency of the motor.

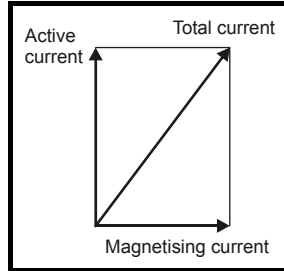
Set Pr **0.09** at 1 when reduced power dissipation is required in the motor when it is lightly loaded. The V/f characteristic is then variable resulting in the motor voltage being proportionally reduced for lower motor currents. Figure 6-2 shows the change in V/f slope when the motor current is reduced.

**Figure 6-2 Fixed and variable V/f characteristics**



<b>0.12 {4.01} Total motor current</b>	
RO	Uni
FL	
NC	PT
↕	0 to Drive_current_max A

Pr 0.12 displays the rms value of the output current of the drive in each of the three phases. The phase currents consist of an active component and a reactive component, which can form a resultant current vector as shown in the following diagram.



The active current is the torque producing current and the reactive current is the magnetising or flux-producing current.

<b>0.09 {3.12} Speed controller differential feedback gain</b>	
RW	Uni
US	
CL	↕
	0.00000 to 0.65535(s)
	⇒
	0.00000

**Closed-loop**

Pr 0.09 (3.12) operates in the feedback path of the speed-control loop in the drive. See Figure 11-4 on page 164 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 126.

**6.2.5 Monitoring**

<b>0.10 {5.04} Estimated motor speed</b>	
RO	Bit
FI	
NC	PT
OL	↕
	±180,000 rpm
	⇒

**Open-loop**

Pr 0.10 (5.04) indicates the value of motor speed that is estimated from the following:

- 0.12 Post-ramp frequency reference
- 0.42 Motor - no. of poles

<b>0.10 {3.02} Motor speed</b>	
RO	Bi
FI	
NC	PT
VT	↕
	±Speed_max rpm
	⇒

**Closed-loop**

Pr 0.10 (3.02) indicates the value of motor speed that is obtained from the speed feedback.

<b>0.11 {5.01} Drive output frequency</b>	
RO	Bi
FI	
NC	PT
OL	↕
	±SPEED_FREQ_MAX Hz
VT	↕
	±1250.0 Hz
	⇒

**Open-loop & closed loop vector**

Pr 0.11 displays the frequency at the drive output.

<b>0.11 {3.29} Drive encoder position</b>	
RO	Uni
FI	
NC	PT
SV	↕
	0 to 65,535
	1/2 <sup>16</sup> ths of a revolution
	⇒

**Servo**

Pr 0.11 displays the position of the encoder in mechanical values of 0 to 65,535. There are 65,536 units to one mechanical revolution.

<b>0.13 {4.02} Motor active current</b>	
RO	Bi
FI	
NC	PT
OL	↕
VT	↕
	±Drive_current_max A
	⇒

**Open-loop & closed loop vector**

When the motor is being driven below its rated speed, the torque is proportional to [0.13].

<b>0.13 {7.07} Analog input 1 offset trim</b>	
RW	Bi
US	
SV	↕
	±10.000 %
	⇒
	0.000

**Servo**

Pr 0.13 can be used to trim out any offset in the user signal to analog input 1.

**6.2.6 Jog reference, Ramp mode selector, Stop and torque mode selectors**

Pr 0.14 is used to select the required control mode of the drive as follows:

<b>0.14 {4.11} Torque mode selector</b>	
RW	Uni
US	
OL	↕
	0 to 1
CL	↕
	0 to 4
	⇒
	Speed control (0)

Setting	Open-Loop	Closed-Loop
0	Frequency control	Speed control
1	Torque control	Torque control
2		Torque control with speed override
3		Coiler/uncoiler mode
4		Speed control with torque feed-forward

0.15 {2.04} Ramp mode select	
RW	Txt
OL	FAST (0) Std (1) Std.hV (2)
CL	FAST (0) Std (1)

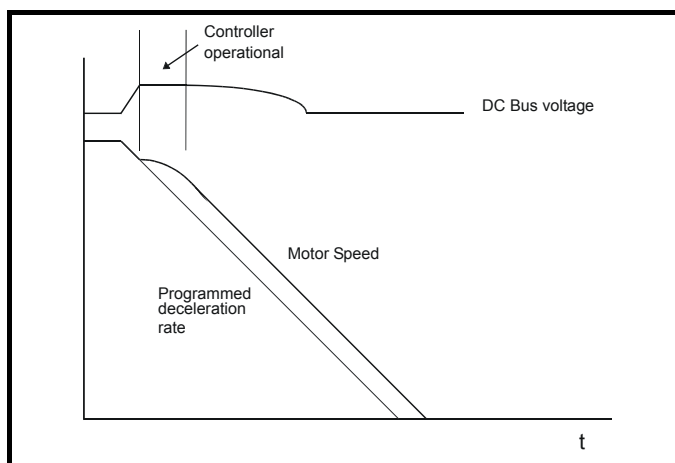
Pr 0.15 sets the ramp mode of the drive as shown below:

### 0: Fast ramp

Fast ramp is used where the deceleration follows the programmed deceleration rate subject to current limits. This mode must be used if a braking resistor is connected to the drive.

### 1: Standard ramp

Standard ramp is used. During deceleration, if the voltage rises to the standard ramp level (Pr 2.08) it causes a controller to operate, the output of which changes the demanded load current in the motor. As the controller regulates the link voltage, the motor deceleration increases as the speed approaches zero speed. When the motor deceleration rate reaches the programmed deceleration rate the controller ceases to operate and the drive continues to decelerate at the programmed rate. If the standard ramp voltage (Pr 2.08) is set lower than the nominal DC bus level the drive will not decelerate the motor, but it will coast to rest. The output of the ramp controller (when active) is a current demand that is fed to the frequency changing current controller (Open-loop modes) or the torque producing current controller (Closed-loop vector or Servo modes). The gain of these controllers can be modified with Pr 4.13 and Pr 4.14.



### 2: Standard ramp with motor voltage boost

This mode is the same as normal standard ramp mode except that the motor voltage is boosted by 20%. This increases the losses in the motor, dissipating some of the mechanical energy as heat giving faster deceleration.

0.16 {8.39} T28 and T29 auto-selection disable	
RW	Bit
OL	OFF (0) or On (1)

### Open-loop

When Pr 0.16 is set to 0, digital inputs T28 and T29 are set up automatically with destinations according to the setting of the reference select Pr 0.05.

Reference select 0.05		Terminal 28 function	Terminal 29 function
A1.A2 (0)	Reference selection by terminal input	Local / remote selector	Jog select
A1.Pr (1)	Analogue reference 1 or presets selected by terminal input	Preset select bit 0	Preset select bit 1
A2.Pr (2)	Analogue reference 2 or presets selected by terminal input	Preset select bit 0	Preset select bit 1
Pr (3)	Preset reference selected by terminal input	Preset select bit 0	Preset select bit 1
PAd (4)	Keypad reference selected	Local / remote selector	Jog select
Prc (5)	Precision reference selected	Local / remote selector	Jog select

Setting Pr 0.16 to 1 disables this automatic set-up, allowing the user to define the function of digital inputs T28 and T29.

0.16 {2.02} Ramp enable	
RW	Bit
CL	OFF (0) or On (1)

Setting Pr 0.16 to 0 allows the user to disable the ramps. This is generally used when the drive is required to closely follow a speed reference which already contains acceleration and deceleration ramps.

0.17 {8.26} T29 digital input destination	
RW	Uni
OL	Pr 0.00 to Pr 21.51

### Open-loop

Pr 0.17 sets the destination of digital input T29. This parameter is normally set-up automatically according to the reference selected by Pr 0.05. In order to manually set-up this parameter, the T28 and T29 auto-selection disable (Pr 0.16) must be set.

0.17 {4.12} Current demand filter time constant	
RW	Uni
CL	0.0 to 25.0 ms

### Closed-loop

A first order filter, with a time constant defined by Pr 0.17, is provided on the current demand to reduce acoustic noise and vibration produced as a result of position feedback quantisation noise. The filter introduces a lag in the speed loop, and so the speed loop gains may need to be reduced to maintain stability as the filter time constant is increased.

0.18 {8.29} Positive logic select	
RW	Bit
OL	OFF (0) or On (1)

Pr 0.18 sets the logic polarity for digital inputs and digital outputs. This does not affect the drive enable input or the relay output.

0.19 {7.11} Analog input 2 mode	
RW	Txt
OL	0 to 6

In modes 2 & 3 a current loop loss trip is generated if the current falls below 3mA.

In modes 2 & 4 the analog input level goes to 0.0% if the input current falls below 4mA.

Pr value	Pr 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	0.0% if I ≤ 4mA
5	20-4	20 - 4mA with no trip on loss	100% if I ≤ 4mA
6	VOLt	Voltage mode	

0.20 {7.14} Analog input 2 destination				
RW	Uni	DE	PT	US
↕	Pr 0.00 to Pr 21.51		⇒	Pr 1.37

Pr 0.20 sets the destination of analog input 2.

0.21 {7.15} Analog input 3 mode			
RW	Txt	PT	US
↕	0 to 9		⇒ th (8)

Software V01.07.00 and later, the default is th (8)

Software V01.06.02 and earlier, the default is VOLt (6)



In modes 2 & 3 a current loop loss trip is generated if the current falls below 3mA.

In modes 2 & 4 the analog input level goes to 0.0% if the input current falls below 4mA.

Pr value	Pr 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	0.0% if I ≤ 4mA
5	20-4	20 - 4mA with no trip on loss	100% if I ≤ 4mA
6	VOLt	Voltage mode	
7	th.SC	Thermistor mode with short-circuit detection	Th trip if R > 3K3 Th reset if R < 1K8 ThS trip if R < 50R
8	th	Thermistor mode with no short-circuit detection	Th trip if R > 3K3 Th reset if R < 1K8
9	th.diSp	Thermistor mode with display only and no trip	

0.22 {1.10} Bipolar reference select			
RW	Bit	US	
↕	OFF (0) or On (1)		⇒ OFF (0)

Pr 0.22 determines whether the reference is uni-polar or bi-polar as follows:

Pr 0.22	Function
0	Unipolar speed/frequency reference 
1	Bipolar speed/frequency reference 

0.23 {1.05} Jog reference			
RW	Uni	US	
OL	↕	0 to 400.0 Hz	⇒ 0.0
CL	↕	0 to 4,000.0 rpm	⇒ 0.0

Enter the required value of jog frequency/speed.

The frequency/speed limits affect the drive when jogging as follows:

Frequency-limit parameter	Limit applies
Pr 0.01 Minimum reference clamp	No
Pr 0.02 Maximum reference clamp	Yes

0.24 {1.21} Preset reference 1			
RW	Bi	US	
↕	±Speed_limit_max rpm		⇒ 0.0

0.25 {1.22} Preset reference 2			
RW	Bi	US	
↕	±Speed_limit_max rpm		⇒ 0.0

0.26 {1.23} Preset reference 3			
RW	Bi	US	
OL	↕	±Speed_freq_max Hz/rpm	⇒ 0.0

#### Open-loop

If the preset reference has been selected (see Pr 0.05), the speed at which the motor runs is determined by these parameters.

0.26 {3.08} Overspeed threshold			
RW	Uni	US	
CL	↕	0 to 40,000 rpm	⇒ 0

#### Closed-loop

If the speed feedback (Pr 3.02) exceeds this level in either direction, an overspeed trip is produced. If this parameter is set to zero, the overspeed threshold is automatically set to 120% x SPEED\_FREQ\_MAX.

0.27 {1.24} Preset reference 4			
RW	Bi	US	
OL	↕	±Speed_freq_max Hz/rpm	⇒ 0.0

#### Open-loop

Refer to Pr 0.24 to Pr 0.26.

0.27 {3.34} Drive encoder lines per revolution			
RW	Uni	US	
VT	↕	0 to 50,000	⇒ 1024
SV	↕		⇒ 4096

#### Closed-loop

Enter in Pr 0.27 the number of lines per revolution of the drive encoder.

<b>0.28 {6.13} Keypad fwd/rev key enable</b>												
RW	Bit										US	
↕	OFF (0) or On (1)					⇒	OFF (0)					

When a keypad is installed, this parameter enables the forward/reverse key.

<b>0.29 {11.36} SMARTCARD parameter data</b>												
RO	Uni					NC	PT				US	
↕	0 to 999					⇒	0					

This parameter shows the number of the data block last transferred from a SMARTCARD to the drive.

<b>0.30 {11.42} Parameter copying</b>												
RW	Txt					NC					*	
↕	0 to 4					⇒	nonE (0)					

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

**NOTE**

If Pr 0.30 is equal to 1 or 2 this value is not transferred to the EEPROM or the drive. If Pr 0.30 is set to a 3 or 4 the value is transferred.

Pr String	Pr value	Comment
nonE	0	Inactive
rEAd	1	Read parameter set from the SMARTCARD
Prog	2	Programming a parameter set to the SMARTCARD
Auto	3	Auto save
boot	4	Boot mode

For further information, please refer to Chapter 9 SMARTCARD operation on page 139.

<b>0.31 {11.33} Drive rated voltage</b>												
RO	Txt					NC	PT					
↕	200V (0), 400V (1), 575V (2), 690V (3)					⇒						

Pr 0.31 indicates the voltage rating of the drive.

<b>0.32 {11.32} Maximum Heavy Duty current rating</b>												
RO	Uni					NC	PT					
↕	0.00 to 9,999.99 A					⇒						

Pr 0.32 indicates the maximum continuous Heavy Duty current rating.

<b>0.33 {6.09} Catch a spinning motor</b>													
RW	Uni										US		
OL	↕	0 to 3					⇒	0					

**Open-loop**

When the drive is enabled with Pr 0.33 = 0, the output frequency starts at zero and ramps to the required reference. When the drive is enabled when Pr 0.33 has a non-zero value, the drive performs a start-up test to determine the motor speed and then sets the initial output frequency to the synchronous frequency of the motor. Restrictions may be placed on the frequencies detected by the drive as follows:

Pr 0.33	Function
0	Disabled
1	Detect all frequencies
2	Detect positive frequencies only
3	Detect negative frequencies only

<b>0.33 {5.16} Rated rpm autotune</b>													
RW	Uni										US		
VT	↕	0 to 2					⇒	0					

**Closed-loop vector**

The motor rated full load rpm parameter (Pr 0.45) in conjunction with the motor rated frequency parameter (Pr 0.46) defines the full load slip of the motor. The slip is used in the motor model for closed-loop vector control. The full load slip of the motor varies with rotor resistance which can vary significantly with motor temperature. When Pr 0.33 is set to 1 or 2, the drive can automatically sense if the value of slip defined by Pr 0.45 and Pr 0.46 has been set incorrectly or has varied with motor temperature. If the value is incorrect parameter Pr 0.45 is automatically adjusted. The adjusted value in Pr 0.45 is not saved at power-down. If the new value is required at the next power-up it must be saved by the user.

Automatic optimisation is only enabled when the speed is above 12.5% of rated speed, and when the load on the motor load rises above 62.5% rated load. Optimisation is disabled again if the load falls below 50% of rated load.

For best optimisation results the correct values of stator resistance (Pr 5.17), transient inductance (Pr 5.24), stator inductance (Pr 5.25) and saturation breakpoints (Pr 5.29, Pr 5.30) should be stored in the relevant parameters. These values can be obtained by the drive during an autotune (see Pr 0.40 for further details).

Rated rpm auto-tune is not available if the drive is not using external position/speed feedback.

The gain of the optimiser, and hence the speed with which it converges, can be set at a normal low level when Pr 0.33 is set to 1. If this parameter is set to 2 the gain is increased by a factor of 16 to give faster convergence.

<b>0.34 {11.30} User security code</b>												
RW	Uni					NC	PT				PS	
↕	0 to 999					⇒	0					

If any number other than 0 is programmed into this parameter, user security is applied so that no parameters except parameter 0.49 can be adjusted with the keypad. When this parameter is read via a keypad it appears as zero.

For further details refer to section 5.9.3 User Security on page 97.

<b>0.35 {11.24} Serial comms mode</b>												
RW	Txt										US	
↕	AnSI (0), rtu (1), Lcd (2)					⇒	rtU (1)					

This parameter defines the communications protocol used by the EIA485 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 send 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.)

Comms value	String	Communications mode
0	AnSI	ANSI
1	rTU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but with an SM-Keypad Plus only

#### ANSI3.28 protocol

Full details of the CT ANSI communications protocol are the *Advanced User Guide*.

#### Modbus RTU protocol

Full details of the CT implementation of Modbus RTU are given in the *Advanced User Guide*.

#### Modbus RTU protocol, but with an SM-Keypad Plus only

This setting is used for disabling communications access when the SM-Keypad Plus is used as a hardware key.

0.36 {11.25} Serial comms baud rate	
RW	Uni
↕	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8)*, 115200 (9)*
	19200 (6)

\* only applicable to Modbus RTU mode

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 send a new message using the new baud rate.

0.37 {11.23} Serial comms address	
RW	Uni
↕	0 to 247
	1

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

#### 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

#### 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 0.37 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.

0.38 {4.13} Current loop P gain	
RW	Uni
↕	0 to 30,000
	All voltage ratings: 20 200V drive: 75 400V drive: 150 575V drive: 180 690V drive: 215

0.39 {4.14} Current loop I gain	
RW	Uni
↕	0 to 30,000
	All voltage ratings: 40 200V drive: 1,000 400V drive: 2,000 575V drive: 2,400 690V drive: 3,000

These parameters control the proportional and integral gains of the current controller used in the open loop drive. The current controller either provides current limits or closed loop torque control by modifying the drive output frequency. The control loop is also used in its torque mode during line power supply loss, or when the controlled mode standard ramp is active and the drive is decelerating, to regulate the flow of current into the drive.

0.40 {5.12} Autotune	
RW	Uni
↕	0 to 2
	0
↕	0 to 4
	0
↕	0 to 6
	0

#### Open-Loop

There are two autotune tests available in open loop mode, a stationary and a rotating test. A rotating autotune should be used whenever possible, so the measured value of power factor of the motor is used by the drive.

- The stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft.
- A rotating autotune first performs a stationary autotune, before rotating the motor at  $2/3$  base speed in the forward direction for several seconds. The motor must be free from load for the rotating autotune.

To perform an autotune, set Pr 0.40 to 1 for a stationary test or 2 for a rotating test, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr 6.15 to OFF (0) or disabling the drive via the control word (Pr 6.42 & Pr 6.43).

For further information refer to section *Pr 0.40 {5.12} Autotune* on page 126.

#### Closed-loop

There are three autotune tests available in closed loop vector mode, a stationary test, a rotating test and an inertia measurement test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. An inertia measurement test should be performed separately to a stationary or rotating autotune.

- The stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft.
- A rotating autotune first performs a stationary autotune, before rotating the motor at  $2/3$  base speed in the forward direction for approximately 30 seconds. The motor must be free from load for the rotating autotune.
- The inertia measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains (see *Speed loop gains*, below) and to provide torque feed forwards when

required during acceleration. During the inertia measurement test the motor speed changes from  $\frac{1}{3}$  to  $\frac{2}{3}$  rated speed in the forward direction several times. The motor can be loaded with a constant torque load and still give an accurate result, however, non-linear loads and loads that change with speed will cause measurement errors.

To perform an autotune, set Pr **0.40** to 1 for a stationary test, 2 for a rotating test, or 3 for an inertia measurement test and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr **6.15** to OFF (0) or disabling the drive via the control word (Pr **6.42** & Pr **6.43**).

Setting Pr **0.40** to 4 will cause the drive to calculate the current loop gains based on the previously measured values of motor resistance and inductance. The drive does apply any voltage to the motor during this test. The drive will change Pr **0.40** back to 0 as soon as the calculations are complete (approximately 500ms).

For further information refer to section *Pr 0.40 {5.12} Autotune* on page 129.

### Servo

There are five autotune tests available in servo mode, a short low speed test, a normal low speed test, an inertia measurement test, a stationary test and a minimal movement test. A normal low speed should be done where possible as the drive measures the stator resistance and inductance of the motor, and from these calculates the current loop gains. An inertia measurement test should be performed separately to a short low speed or normal low speed autotune.

- A short low speed test will rotate the motor by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the forward direction, and measure the encoder phase angle. The motor must be free from load for this test.
- A normal low speed test will rotate the motor by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the forward direction. This test measures the encoder phase angle and updates other parameters including the current loop gains. The motor must be free from load for this test.
- The inertia measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains and to provide torque feed forwards when required during acceleration. During the inertia measurement test the motor speed changes from  $\frac{1}{3}$  to  $\frac{2}{3}$  rated speed in the forward direction several times. The motor can be loaded with a constant torque load and still give an accurate result, however, non-linear loads and loads that change with speed will cause measurement errors.
- The stationary test only measures the motor resistance and inductance, and updates the current loop gain parameters. This test does not measure the encoder phase angle so this test needs to be done in conjunction with either the short low speed or minimal movement tests.
- The minimal movement test will move the motor through a small angle to measure the encoder phase angle. This test will operate correctly when the load is an inertia, and although a small amount of cogging and stiction is acceptable, this test cannot be used for a loaded motor.

To perform an autotune, set Pr **0.40** to 1 for a short low speed test, 2 for a normal low speed test, 3 for an inertia measurement test, 4 for a stationary test or 5 for a minimal movement test, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition

before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr **6.15** to OFF (0) or disabling the drive via the control word (Pr **6.42** & Pr **6.43**).

Setting Pr **0.40** to 6 will cause the drive to calculate the current loop gains based on the previously measured values of motor resistance and inductance. The drive does apply any voltage to the motor during this test. The drive will change Pr **0.40** back to 0 as soon as the calculations are complete (approximately 500ms).

For further information refer to section *Pr 0.40 {5.12} Autotune* on page 134.

0.41 {5.18}		Maximum switching frequency					
RW	Txt				RA		US
OL	↕				⇒	3 (0)	
CL	↕	3 (0), 4 (1), 6 (2), 8 (3), 12 (4), 16 (5) kHz			⇒	VT	3 (0)
					⇒	SV	6 (2)

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. A thermal model of the IGBT junction temperature is used 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 145 C the switching frequency is reduced if this is possible (i.e >3kHz). 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 again above 145 C and the drive cannot reduce the switching frequency further the drive will initiate an 'O.ht1' trip. Every second the drive will attempt to restore the switching frequency to the level set in Pr **0.41**.

The full range of switching frequencies is not available on all ratings of Unidrive SP. See section 8.5 *Switching frequency* on page 137, for the maximum available switching frequency for each drive rating.

### 6.2.7 Motor parameters

0.42 {5.11}		No. of motor poles					
RW	Txt						US
OL	↕				⇒	Auto (0)	
CL	↕	0 to 60 (Auto to 120 Pole)			⇒	VT	Auto (0)
					⇒	SV	6 POLE (3)

#### Open-loop

This parameter is used in the calculation of motor speed, and in applying the correct slip compensation. When auto is selected, the number of motor poles is automatically calculated from the rated frequency (Pr **0.47**) and the rated full load rpm (Pr **0.45**). The number of poles =  $120 * \text{rated frequency} / \text{rpm}$  rounded to the nearest even number.

#### Closed-loop vector

This parameter must be set correctly for the vector control algorithms to operate correctly. When auto is selected, the number of motor poles is automatically calculated from the rated frequency (Pr **0.47**) and the rated full load rpm (Pr **0.45**). The number of poles =  $120 * \text{rated frequency} / \text{rpm}$  rounded to the nearest even number.

#### Servo

This parameter must be set correctly for the vector control algorithms to operate correctly. When auto is selected the number of poles is set to 6.

0.43 {5.10} Motor rated power factor	
RW	Uni
OL	↕
VT	↕
0.000 to 1.000	
⇒ 0.850	

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current.

#### Open-loop

The power factor is used in conjunction with the motor rated current (Pr 0.46) to calculate the rated active current and magnetising current of the motor. The rated active current is used extensively to control the drive, and the magnetising current is used in vector mode Rs compensation. It is important that this parameter is set up correctly.

This parameter is obtained by the drive during a rotational autotune. If a stationary autotune is carried out, then the nameplate value should be entered in Pr 0.43.

#### Closed-loop vector

If the stator inductance (Pr 5.25) contains a non-zero value, the power factor used by the drive is continuously calculated and used in the vector control algorithms (this will not update Pr 0.43).

If the stator inductance is set to zero (Pr 5.25) then the power factor written in Pr 0.43 is used in conjunction with the motor rated current and other motor parameters to calculate the rated active and magnetising currents which are used in the vector control algorithm.

This parameter is obtained by the drive during a rotational autotune. If a stationary autotune is carried out, then the nameplate value should be entered in Pr 0.43.

0.43 {3.25} Encoder phase angle	
RW	Uni
SV	↕
0.0 to 359.9°	
⇒ 0.0	

The phase angle between the rotor flux in a servo motor and the encoder position is required for the motor to operate correctly. If the phase angle is known it can be set in this parameter by the user. Alternatively the drive can automatically measure the phase angle by performing a phasing test (see autotune in servo mode Pr 0.40). When the test is complete the new value is written to this parameter. The encoder phase angle can be modified at any time and becomes effective immediately. This parameter has a factory default value of 0.0, but is not affected when defaults are loaded by the user.

0.44 {5.09} Motor rated voltage	
RW	Uni
↕	↕
0 to AC_VOLTAGE_SET_MAX V	
⇒ 200V drive: 230 400V drive: EUR> 400 USA> 460 575V drive: 575 690V drive: 690	

#### Open-loop & Closed-loop vector

Enter the value from the rating plate of the motor.

0.45 {5.08} Motor rated full load speed (rpm)	
RW	Uni
OL	↕
VT	↕
0 to 180,000 rpm	
⇒ EUR> 1,500 USA> 1,800	
0.00 to 40,000.00 rpm	
⇒ EUR> 1,450.00 USA> 1,770.00	

#### Open-loop

This is the speed at which the motor would rotate when supplied with its base frequency at rated voltage, under rated load conditions (=

synchronous speed - slip speed). Entering the correct value into this parameter allows the drive to increase the output frequency as a function of load in order to compensate for this speed drop.

Slip compensation is disabled if Pr 0.45 is set to 0 or to synchronous speed, or if Pr 5.27 is set to 0.

If slip compensation is required this parameter should be set to the value from the rating plate of the motor, which should give the correct rpm for a hot machine. Sometimes it will be necessary to adjust this when the drive is commissioned because the nameplate value may be inaccurate. Slip compensation will operate correctly both below base speed and within the field weakening region. Slip compensation is normally used to correct for the motor speed to prevent speed variation with load. The rated load rpm can be set higher than synchronous speed to deliberately introduce speed droop. This can be useful to aid load sharing with mechanically coupled motors.

#### Closed loop vector

Rated load rpm is used with motor rated frequency to determine the full load slip of the motor which is used by the vector control algorithm. Incorrect setting of this parameter can result in the following:

- Reduced efficiency of motor operation
- Reduction of maximum torque available from the motor
- Failure to reach maximum speed
- Over-current trips
- Reduced transient performance
- Inaccurate control of absolute torque in torque control modes

The nameplate value is normally the value for a hot machine, however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate.

The rated full load rpm can be optimised by the drive (For further information, refer to section 8.1.3 *Closed loop vector motor control* on page 131).

0.45 {4.15} Motor thermal time constant	
RW	Uni
SV	↕
0 to 3000.0	
⇒ 20.0	

#### Servo

Pr 0.45 is the motor thermal time constant of the motor, and is used (along with the motor rated current Pr 0.46, and total motor current Pr 0.12) in the thermal model of the motor in applying thermal protection to the motor.

Setting this parameter to 0 disables the motor thermal protection.

For further details, refer to section 8.4 *Motor thermal protection* on page 136.

0.46 {5.07} Motor rated current	
RW	Uni
↕	↕
0 to Rated_current_max A	
⇒ Drive rated current [11.32]	

Enter the name-plate value for the motor rated current.

0.47 {5.06} Rated frequency	
RW	Uni
OL	↕
VT	↕
0 to 3,000.0Hz	
⇒ EUR> 50.0, USA> 60.0	
0 to 1,250.0Hz	
⇒ EUR> 50.0, USA> 60.0	

#### Open-loop & Closed-loop vector

Enter the value from the rating plate of the motor.



## 6.2.8 Operating-mode selection

0.48 {11.31} Operating mode selector									
RW	Txt	NC					PT		
⇅	1 to 4				⇒	OL	1		
						VT	2		
						SV	3		

The settings for Pr **0.48** are as follows:

Setting	Operating mode
OPEn LP	1 Open-loop
CL VECt	2 Closed-loop vector
SerVO	3 Servo
rEgEn	4 Regen

This parameter defines the drive operating mode. Pr **xx.00** must be set to 1253 (European defaults) or 1254 (USA defaults) before this parameter can be changed. When the drive is reset to implement any change in this parameter, the default settings of all parameters will be set according to the drive operating mode selected and saved in memory.

## 6.2.9 Status information

0.49 {11.44} Security status									
RW	Txt						PT	US	
⇅	0 to 2				⇒	0			

This parameter controls access via the drive keypad as follows:

Value	String	Action
0	L1	Only menu 0 can be accessed
1	L2	All menus can be accessed
2	Loc	Lock user security when drive is reset. (This parameter is set to L1 after reset.)

The keypad can adjust this parameter even when user security is set.

0.50 {11.29} Software version number									
RO	Uni					NC	PT		
⇅	1.00 to 99.99				⇒				

The parameter displays the software version of the drive.

0.51 {10.37} Action on trip detection									
RW	Uni							US	
⇅	0 to 15				⇒	0			

Each bit in this parameter has the following functions:

Bit	Function
0	Stop on non-important trips
1	Disable braking IGBT trips
2	Disable phase loss trip (Unidrive SP SPz only)
3	Disable braking resistor temperature monitoring failure detection. (Unidrive SPz only)

### Stop on non-important trips

If bit 0 is set to zero then the drive simply trips when a non-important trip occurs. Non-important trips are: th, ths, Old1, cL2, cL3, SCL. If bit 0 is set to one the drive will stop before tripping when one of these trips is initiated, except in Regen mode where the drive trips immediately.

### Disable braking IGBT trips

For details of braking IGBT trip mode see Pr **10.31**.

### Disable phase loss trip (SPz only)

The user can disable the phase loss trip in 200V SPz drives as these are allowed to operate from a single phase supply. If bit 2 is set to zero the phase loss trip is enabled. If bit 2 is set to one the phase loss trip is disabled in 200V SPz drives only.


### Disable braking resistor temperature monitoring failure detection (SPz only)

SPz drives have an internal user fit braking resistor with a thermistor to detect overheating of the resistor. As default bit 3 of Pr **10.37** is set to zero, and so if the braking resistor and its thermistor is not installed the drive will produce a trip (br.th) because the thermistor appears to be open-circuit. This trip can be disabled so that the drive can run by setting bit 3 of Pr **10.37** to one. If the resistor is installed then no trip is produced unless the thermistor fails, and so bit 3 of Pr **10.37** can be left at zero. This feature only applies to SPz drives.

## 7 Running the motor


This chapter takes the new user through all the essential steps to running a motor for the first time, in each of the possible operating modes.

For information on tuning the drive for the best performance, see *Chapter 8 Optimization*.




Ensure that no damage or safety hazard could arise from the motor starting unexpectedly.


**WARNING**




The values of the motor parameters affect the protection of the motor. The default values in the drive should not be relied upon. It is essential that the correct value is entered in Pr **0.46 Motor rated current**. This affects the thermal protection of the motor.

**CAUTION**



If the keypad mode has been used previously, ensure that the keypad reference has been set to 0 using the  buttons as if the drive is started using the keypad it will run to the speed defined by the keypad reference (Pr **0.35**).

**CAUTION**



If the intended maximum speed affects the safety of the machinery, additional independent over-speed protection must be used.

**WARNING**

### 7.1 Quick start Connections

#### 7.1.1 Basic requirements

This section shows the basic connections which must be made for the drive to run in the required mode. For minimal parameter settings to run in each mode please see the relevant part of section 7.3 *Quick Start commissioning/start-up* on page 118.

**Table 7-1 Minimum control connection requirements for each control mode**

Drive control method	Requirements
Terminal mode	Drive Enable Speed reference Run forward or run reverse command
Keypad mode	Drive Enable
Serial communications	Drive Enable Serial communications link

**Table 7-2 Minimum control connection requirements for each mode of operation**

Operating mode	Requirements
Open loop mode	Induction motor
Closed loop vector - RFC mode	Induction motor
Closed loop vector mode	Induction motor with speed feedback
Closed loop servo mode	Permanent magnet motor with speed and position feedback

#### Speed feedback

Suitable devices are:

- Incremental encoder (A, B or F, D with or without Z)
- Incremental encoder with forward and reverse outputs (F, R with or without Z)
- SINCOS encoder (with, or without Stegmann Hiperface, EnDat or SSI communications protocols)
- EnDat absolute encoder

#### Speed and position feedback

Suitable devices are:

- Incremental encoder (A, B or F, D with or without Z) with commutation signals (U, V, W)
- Incremental encoder with forward and reverse outputs (F, R with or without Z) and commutation outputs (U, V, W)
- SINCOS encoder (with Stegmann Hiperface, EnDat or SSI communications protocols)
- EnDat absolute encoder

For Solutions Module terminal information see section 11.15 *Menus 15, 16 and 17: Solutions Module set-up* on page 205 or the appropriate Solutions Module option user guide.

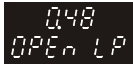


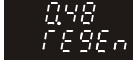
### 7.2 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. (Pr **0.49** and Pr **0.34** are not affected by this procedure.)

#### Procedure


Use the following procedure only if a different operating mode is required:

1. Enter either of the following values in Pr **xx.00**, as appropriate:  
1253 (EUR, 50Hz AC supply frequency)  
1254 (USA, 60Hz AC supply frequency)
2. Change the setting of Pr **0.48** as follows:

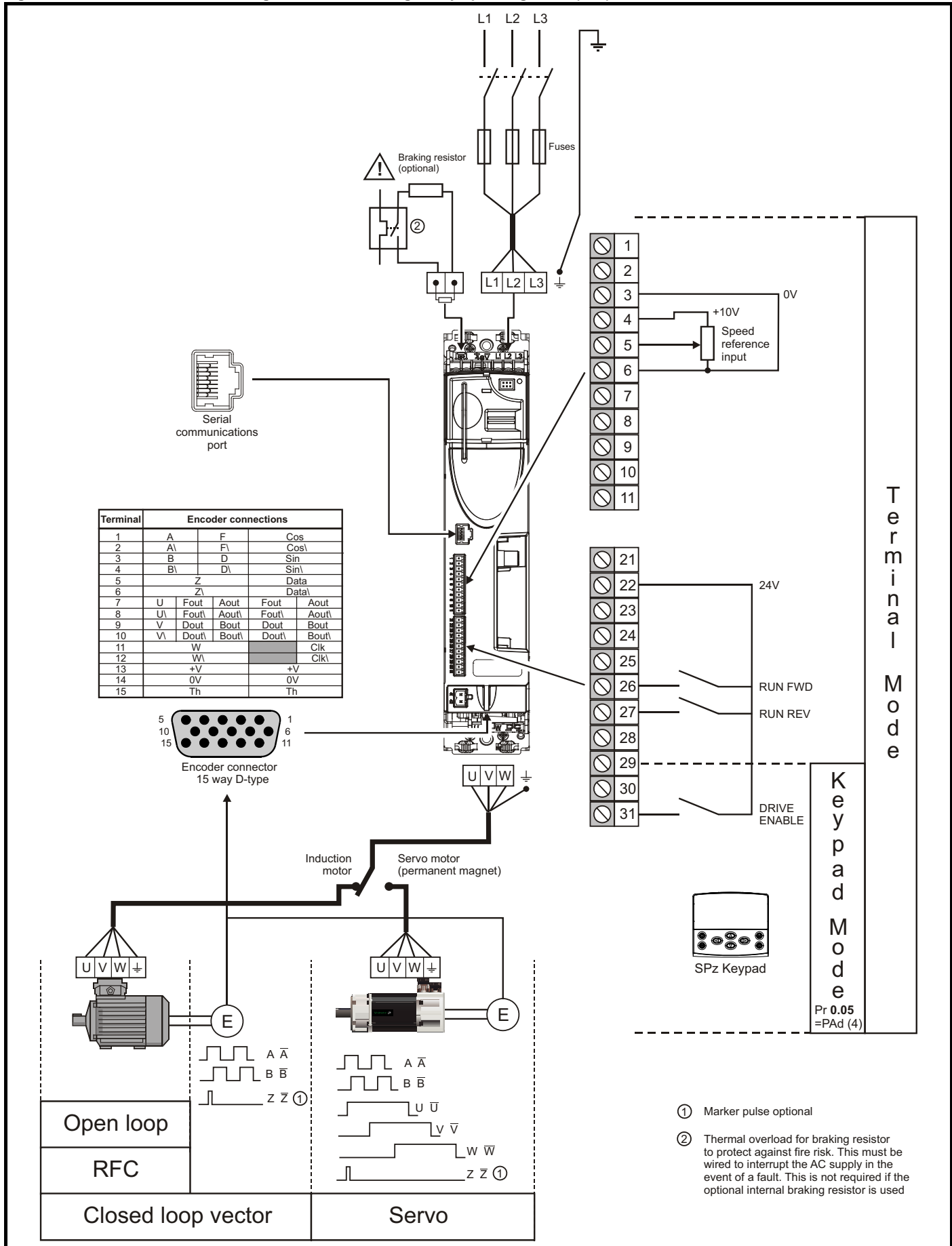
Pr 0.48 setting		Operating mode
	1	Open-loop
	2	Closed-loop vector
	3	Closed-loop Servo
	4	Regen

The figures in the second column apply when serial communications are used.

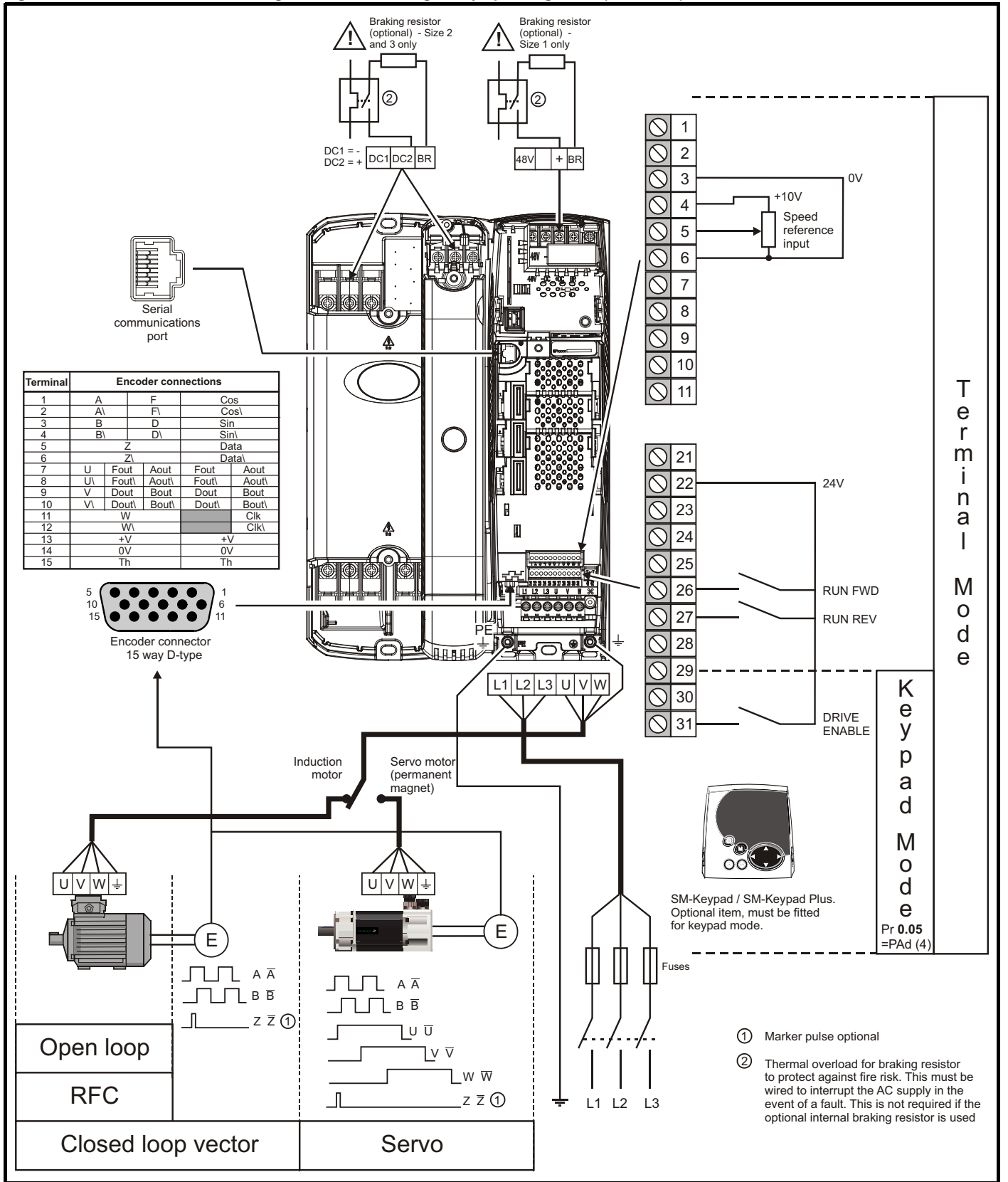
3. Either:

- Press the red  reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.38** to 100 (ensure that Pr. **xx.00** returns to 0).

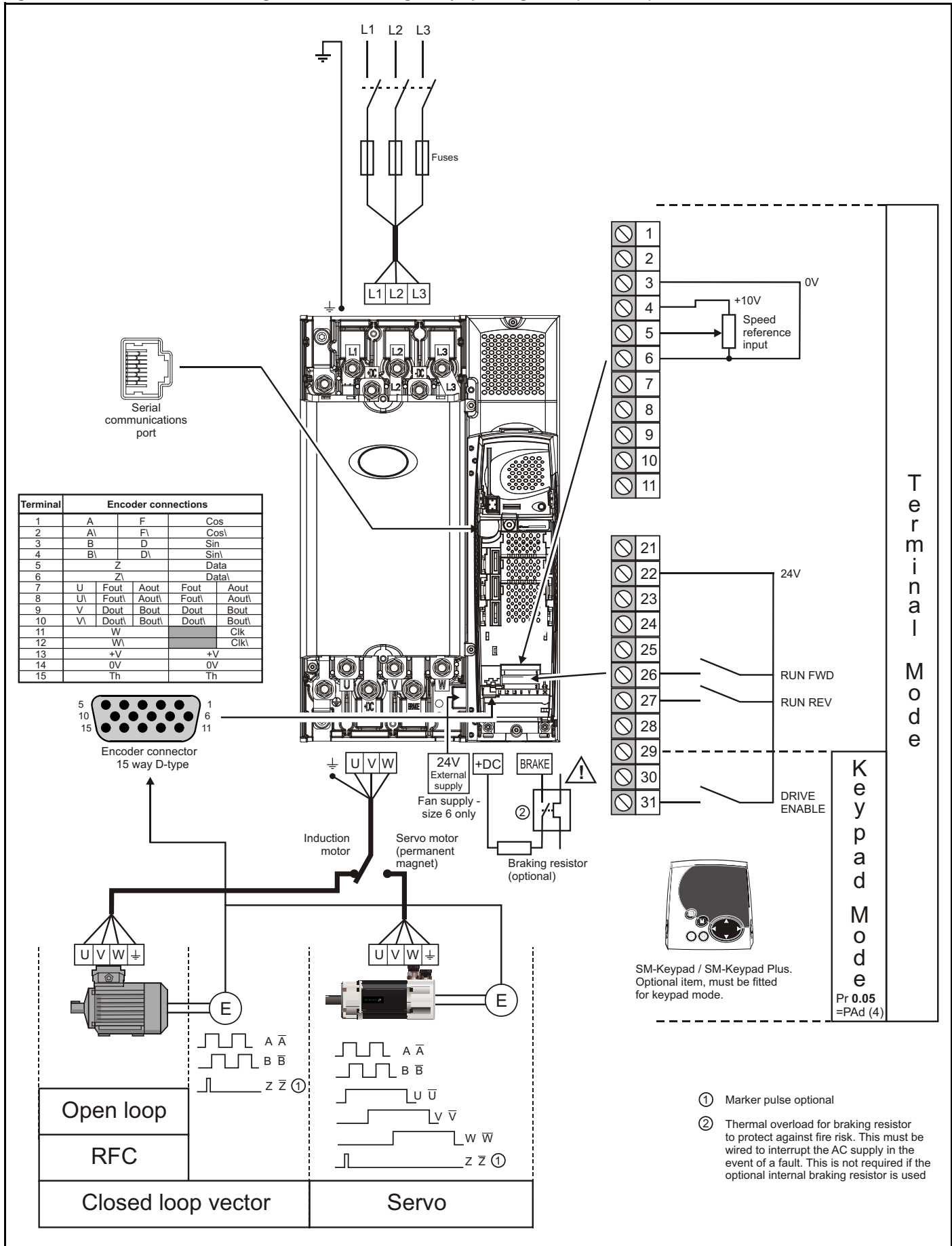
**Figure 7-1 Minimum connections to get the motor running in any operating mode (SPz)**



**Figure 7-2 Minimum connections to get the motor running in any operating mode (size 1 to 3)**



**Figure 7-3 Minimum connections to get the motor running in any operating mode (size 4 to 6)**



## 7.3 Quick Start commissioning/start-up




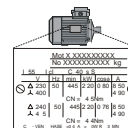
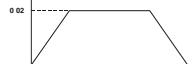
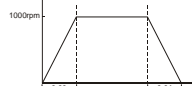

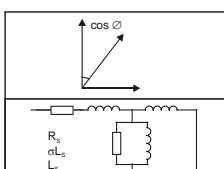
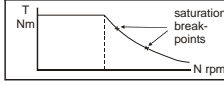


### 7.3.1 Open loop

Action	Detail	
Before power-up	<p>Ensure:</p> <ul style="list-style-type: none"> <li>The drive enable signal is not given (terminal 31)</li> <li>Run signal is not given</li> <li>Motor is connected</li> </ul>	
Power-up the drive	<p>Ensure:</p> <ul style="list-style-type: none"> <li>Drive displays 'inh'</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>SPz only: If no internal braking resistor is installed, then the drive will trip 'br.th'. If no internal braking resistor is required, then set Pr <b>0.51</b> to 8 to disable the trip.</p>	
Enter motor nameplate details	<p>Enter:</p> <ul style="list-style-type: none"> <li>Motor rated frequency in Pr <b>0.47</b> (Hz)</li> <li>Motor rated current in Pr <b>0.46</b> (A)</li> <li>Motor rated speed in Pr <b>0.45</b> (rpm)</li> <li>Motor rated voltage in Pr <b>0.44</b> (V) - check if <math>\Delta</math> or <math>\lambda</math> connection</li> </ul>	
Set maximum frequency	<p>Enter:</p> <ul style="list-style-type: none"> <li>Maximum frequency in Pr <b>0.02</b> (Hz)</li> </ul>	
Set acceleration / deceleration rates	<p>Enter:</p> <ul style="list-style-type: none"> <li>Acceleration rate in Pr <b>0.03</b> (s/100Hz)</li> <li>Deceleration rate in Pr <b>0.04</b> (s/100Hz) (If braking resistor installed, set Pr <b>0.15</b> = FAST. Also ensure Pr <b>10.30</b> and Pr <b>10.31</b> are set correctly, otherwise premature 'lt.br' trips may be seen.)</li> </ul>	
Autotune	<p>The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p>A rotating autotune will cause the motor to accelerate up to <math>\frac{2}{3}</math> base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable.</p> </div> <ul style="list-style-type: none"> <li>A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. A stationary autotune measures the stator resistance of the motor and the voltage offset in the drive. These are required for good performance in vector control modes. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr <b>0.43</b>.</li> <li>A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at <math>\frac{2}{3}</math> base speed in the direction selected. The rotating autotune measures the power factor of the motor.</li> </ul> <p>To perform an autotune:</p> <ul style="list-style-type: none"> <li>Set Pr <b>0.40</b> = 1 for a stationary autotune or set Pr <b>0.40</b> = 2 for a rotating autotune</li> <li>Close the Drive Enable signal (terminal 31). The drive will display 'rdY'.</li> <li>Close the run signal (terminal 26 or 27). The lower display will flash 'Auto' and 'tunE' alternatively, while the drive is performing the autotune.</li> <li>Wait for the drive to display 'rdY' or 'inh' and for the motor to come to a standstill.</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260. Remove the drive enable and run signal from the drive.</p>	
Save parameters	<p>Enter 1000 in Pr <b>xx.00</b></p> <p>Press the red  reset button or toggle the reset digital input (ensure Pr <b>xx.00</b> returns to 0)</p>	
Run	Drive is now ready to run	

### 7.3.2 RFC mode

Software V01.10.00 or later should be used for RFC mode.

#### Induction motor

Action	Detail	
Before power-up	Ensure: <ul style="list-style-type: none"> <li>Drive Enable signal is not given (terminal 31)</li> <li>Run signal is not given</li> <li>Motor and feedback device are connected</li> </ul>	
Power-up the drive	Ensure: <ul style="list-style-type: none"> <li>Drive displays 'inh'</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>SPz only: If no internal braking resistor is installed, then the drive will trip 'br.th'. If no internal braking resistor is required, then set Pr <b>0.51</b> to 8 to disable the trip.</p>	
Select RFC mode and disable encoder wire-break trip	<ul style="list-style-type: none"> <li>Set Pr <b>3.24</b> = 1 or 3 to select RFC mode</li> <li>Set Pr <b>3.40</b> = 0</li> </ul>	
Enter motor nameplate details	Enter: <ul style="list-style-type: none"> <li>Motor rated frequency in Pr <b>0.47</b> (Hz)</li> <li>Motor rated current in Pr <b>0.46</b> (A)</li> <li>Motor rated speed (base speed - slip speed) in Pr <b>0.45</b> (rpm)</li> <li>Motor rated voltage in Pr <b>0.44</b> (V) - check if <math>\Delta</math> or <math>\text{Y}</math> connection</li> </ul>	
Set maximum speed	Enter: <ul style="list-style-type: none"> <li>Maximum speed in Pr <b>0.02</b> (rpm)</li> </ul>	
Set acceleration / deceleration rates	Enter: <ul style="list-style-type: none"> <li>Acceleration rate in Pr <b>0.03</b> (s/1000rpm)</li> <li>Deceleration rate in Pr <b>0.04</b> (s/1000rpm) (If braking resistor installed, set Pr <b>0.15</b> = FAST. Also ensure Pr <b>10.30</b> and Pr <b>10.31</b> are set correctly, otherwise premature 'lt.br' trips may be seen.)</li> </ul>	
Select or deselect catch a spinning motor mode	<p>If catch a spinning motor mode is not required then set Pr <b>6.09</b> to 0.</p> <p>If catch a spinning motor mode is required then leave Pr <b>6.09</b> at the default of 1, but depending on the size of the motor the value in Pr <b>5.40</b> may need to be adjusted.</p> <p>Pr <b>5.40</b> defines a scaling function used by the algorithm that detects the speed of the motor. The default value of Pr <b>5.40</b> is 1 which is suitable for small motors (&lt;4kW). For larger motors the value in Pr <b>5.40</b> will need to be increased. Approximate values of Pr <b>5.40</b> for different motor sizes are as follows, 2 for 11kW, 3 for 55kW and 5 for 150kW. If the value of Pr <b>5.40</b> is too large the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small the drive will detect the motor speed as zero even if the motor is spinning.</p>	
Autotune	<p>The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive.</p> <p><b>NOTE</b> It is highly recommended that a rotating autotune is performed (Pr <b>0.40</b> set to 2).</p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;">  <p>A rotating autotune will cause the motor to accelerate up to <math>\frac{2}{3}</math> base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference.</p> <p><b>WARNING</b> The drive can be stopped at any time by removing the run signal or removing the drive enable.</p> </div> <ul style="list-style-type: none"> <li>A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. The stationary autotune measures the stator resistance and transient inductance of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr <b>0.38</b> and Pr <b>0.39</b> are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr <b>0.43</b>.</li> <li>A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at <math>\frac{2}{3}</math> base speed in the direction selected. The rotating autotune measures the stator inductance of the motor and calculates the power factor.</li> </ul> <p>To perform an autotune:</p> <ul style="list-style-type: none"> <li>Set Pr <b>0.40</b> = 1 for a stationary autotune or set Pr <b>0.40</b> = 2 for a rotating autotune</li> <li>Close the Drive Enable signal (terminal 31). The drive will display 'rdY'.</li> <li>Close the run signal (terminal 26 or 27). The lower display will flash 'Auto' and 'tunE' alternatively, while the drive is performing the autotune.</li> <li>Wait for the drive to display 'rdY' or 'inh' and for the motor to come to a standstill</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>Remove the drive enable and run signal from the drive.</p>	 
Save parameters	Enter 1000 in Pr <b>xx.00</b> Press the red  reset button or toggle the reset digital input (ensure Pr <b>xx.00</b> returns to 0)	
Run	Drive is now ready to run	

### 7.3.3 Closed loop vector mode

#### Induction motor with incremental encoder feedback

For simplicity only an incremental quadrature encoder will be considered here. For information on setting up one of the other supported speed feedback devices, refer to section 7.5 *Setting up a feedback device* on page 122.




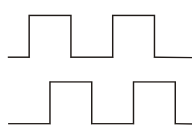

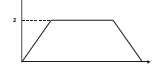
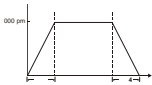

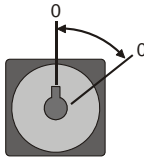


Action	Detail	
Before power-up	Ensure: <ul style="list-style-type: none"> <li>Drive Enable signal is not given (terminal 31)</li> <li>Run signal is not given</li> <li>Motor and feedback device are connected</li> </ul>	
Power-up the drive	Ensure: <ul style="list-style-type: none"> <li>Drive displays 'inh'</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>SPz only: If no internal braking resistor is installed, then the drive will trip 'br.th'. If no internal braking resistor is required, then set Pr <b>0.51</b> to 8 to disable the trip.</p>	
Set motor feedback parameters	<b>Incremental encoder basic set-up</b> Enter: <ul style="list-style-type: none"> <li>Drive encoder type in Pr <b>3.38</b> = Ab (0): Quadrature encoder</li> <li>Encoder power supply in Pr. <b>3.36</b> = 5V (0), 8V (1) or 15V (2).</li> </ul> <p><b>NOTE</b> If output voltage from the encoder is &gt;5V, then the termination resistors must be disabled Pr <b>3.39</b> to 0.</p> <p><b>CAUTION</b> Setting the encoder voltage supply too high for the encoder could result in damage to the feedback device.</p> <ul style="list-style-type: none"> <li>Drive encoder Lines Per Revolution (LPR) in Pr <b>3.34</b> (set according to encoder)</li> <li>Drive encoder termination resistor setting in Pr. <b>3.39</b>: <ul style="list-style-type: none"> <li>0 = A-A\, B-B\, Z-Z\ termination resistors disabled</li> <li>1 = A-A\, B-B\, termination resistors enabled, Z-Z\ termination resistors disabled</li> <li>2 = A-A\, B-B\, Z-Z\ termination resistors enabled</li> </ul> </li> </ul>	
Enter motor nameplate details	Enter: <ul style="list-style-type: none"> <li>Motor rated frequency in Pr <b>0.47</b> (Hz)</li> <li>Motor rated current in Pr <b>0.46</b> (A)</li> <li>Motor rated speed (base speed - slip speed) in Pr <b>0.45</b> (rpm)</li> <li>Motor rated voltage in Pr <b>0.44</b> (V) - check if <math>\Delta</math> or <math>\text{Y}</math> connection</li> </ul>	
Set maximum speed	Enter: <ul style="list-style-type: none"> <li>Maximum speed in Pr <b>0.02</b> (rpm)</li> </ul>	
Set acceleration / deceleration rates	Enter: <ul style="list-style-type: none"> <li>Acceleration rate in Pr <b>0.03</b> (s/1000rpm)</li> <li>Deceleration rate in Pr <b>0.04</b> (s/1000rpm) (If braking resistor installed, set Pr <b>0.15</b> = FAST. Also ensure Pr <b>10.30</b> and Pr <b>10.31</b> are set correctly, otherwise premature 'lt.br' trips may be seen.)</li> </ul>	
Autotune	Unidrive SP is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. <p><b>WARNING</b> A rotating autotune will cause the motor to accelerate up to <math>\frac{2}{3}</math> base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable.</p> <ul style="list-style-type: none"> <li>A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. The stationary autotune measures the stator resistance and transient inductance of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr <b>0.38</b> and Pr <b>0.39</b> are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr <b>0.43</b>.</li> <li>A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at <math>\frac{2}{3}</math> base speed in the direction selected. The rotating autotune measures the stator inductance of the motor and calculates the power factor.</li> </ul> <p>To perform an autotune:</p> <ul style="list-style-type: none"> <li>Set Pr <b>0.40</b> = 1 for a stationary autotune or set Pr <b>0.40</b> = 2 for a rotating autotune</li> <li>Close the Drive Enable signal (terminal 31). The drive will display 'rdY'</li> <li>Close the run signal (terminal 26 or 27). The lower display will flash 'Auto' and 'tunE' alternatively, while the drive is performing the autotune.</li> <li>Wait for the drive to display 'rdY' or 'inh' and for the motor to come to a standstill</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>Remove the drive enable and run signal from the drive.</p>	
Save parameters	Enter 1000 in Pr <b>xx.00</b> Press the red  reset button or toggle the reset digital input (ensure Pr <b>xx.00</b> returns to 0)	
Run	Drive is now ready to run	



### 7.3.4 Servo

#### Permanent magnet motor with a speed and position feedback device

For simplicity only an incremental quadrature encoder with commutation outputs will be considered here. For information on setting up one of the other supported speed feedback devices, refer to section 7.5 *Setting up a feedback device* on page 122.

Action	Detail	
Before power-up	<p>Ensure:</p> <ul style="list-style-type: none"> <li>Drive Enable signal is not given (terminal 31)</li> <li>Run signal is not given</li> <li>Motor is connected</li> <li>Feedback device is connected</li> </ul>	
Power-up the drive	<p>Ensure:</p> <ul style="list-style-type: none"> <li>Drive displays 'inh'</li> </ul> <p>If the drive trips, see Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>SPz only: If no internal braking resistor is installed, then the drive will trip 'br.th'. If no internal braking resistor is required, then set Pr <b>0.51</b> to 8 to disable the trip.</p>	
Set motor feedback parameters	<p><b>Incremental encoder basic set-up</b></p> <p>Enter:</p> <ul style="list-style-type: none"> <li>Drive encoder type in Pr. <b>3.38</b> = Ab.SErVO (3): Quadrature encoder with commutation outputs</li> <li>Encoder power supply in Pr. <b>3.36</b> = 5V (0), 8V (1) or 15V (2).</li> </ul> <p><b>NOTE</b> If output voltage from the encoder is &gt;5V, then the termination resistors must be disabled Pr <b>3.39</b> to 0.</p> <div style="border: 1px solid black; padding: 5px;">  <p>Setting the encoder voltage supply too high for the encoder could result in damage to the feedback device.</p> <p><b>CAUTION</b></p> </div> <ul style="list-style-type: none"> <li>Drive encoder Pulses Per Revolution in Pr. <b>3.34</b> (set according to encoder)</li> <li>Drive encoder termination resistor setting in Pr. <b>3.39</b>: <ul style="list-style-type: none"> <li>0 = A-A\, B-B\, Z-Z\ termination resistors disabled</li> <li>1 = A-A\, B-B\, termination resistors enabled, Z-Z\ termination resistors disabled</li> <li>2 = A-A\, B-B\, Z-Z\ termination resistors enabled</li> </ul> </li> </ul>	
Enter motor nameplate details	<p>Enter:</p> <ul style="list-style-type: none"> <li>Motor rated current in Pr <b>0.46</b> (A)</li> </ul> <p>Ensure that this equal to or less than the Heavy Duty rating of the drive otherwise It.AC trips may occur during the autotune.</p> <ul style="list-style-type: none"> <li>Number of poles in Pr <b>0.42</b></li> </ul>	
Set maximum speed	<p>Enter:</p> <ul style="list-style-type: none"> <li>Maximum speed in Pr <b>0.02</b> (rpm)</li> </ul>	
Set acceleration / deceleration rates	<p>Enter:</p> <ul style="list-style-type: none"> <li>Acceleration rate in Pr <b>0.03</b> (s/1000rpm)</li> <li>Deceleration rate in Pr <b>0.04</b> (s/1000rpm) (If braking resistor installed, set Pr <b>0.15</b> = FAST. Also ensure Pr <b>10.30</b> and Pr <b>10.31</b> are set correctly, otherwise premature 'lt.br' trips may be seen.)</li> </ul>	
Autotune	<p>Unidrive SP is able to perform a short low speed, a normal low speed or a minimal movement autotune. The motor must be at a standstill before an autotune is enabled. A normal low speed autotune will measure the encoder phase offset angle and calculate the current gains.</p> <div style="border: 1px solid black; padding: 5px;">  <p>The short low speed and normal low speed tests will rotate the motor by up to 2 revolutions in the direction selected, regardless of the reference provided. The minimal movement test will move the motor through an angle defined by Pr <b>5.38</b>.</p> <p>Once complete the motor will come to a standstill. The enable signal must be removed before the drive can be made to run at the required reference.</p> <p>The drive can be stopped at any time by removing the run signal or removing the Drive Enable.</p> </div> <p>The motor must not be loaded when attempting an autotune.</p> <ul style="list-style-type: none"> <li>The short low speed and normal low speed tests will rotate the motor by up to 2 rotations in the direction selected and the drive measures the encoder phase angle and updates the value in Pr <b>3.25</b>. The normal low speed test also measures the stator resistance, and inductance of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr <b>0.38</b> and Pr <b>0.39</b> are updated. The short low speed test takes approximately 2s and the normal low speed test approximately 20s to complete.</li> <li>The minimal movement autotune will move the motor through an angle defined by Pr <b>5.38</b>. The motor must not be loaded for this test although it will operate correctly when the load is an inertia.</li> </ul> <p>To perform an autotune:</p> <ul style="list-style-type: none"> <li>Set Pr <b>0.40</b> = 1 for a short low speed autotune, Pr <b>0.40</b> = 2 for a normal low speed test or Pr <b>0.40</b> = 5 for a minimal movement autotune.</li> <li>Close the run signal (terminal 26 or 27).</li> <li>Close the Drive Enable signal (terminal 31). The lower display will flash 'Auto' and 'tunE' alternatively, while the drive is performing the test.</li> <li>Wait for the drive to display 'rdy' or 'inh' and for the motor to come to a standstill.</li> </ul> <p>If the drive trips it cannot be reset until the drive enable signal (terminal 31) has been removed. See Chapter 13 <i>Diagnostics</i> on page 260.</p> <p>Remove the drive enabled and run signal from the drive.</p>	
Save parameters	<p>Enter 1000 in Pr <b>xx.00</b></p> <p>Press the red  reset button or toggle the reset digital input (ensure Pr <b>xx.00</b> returns to 0)</p>	
Run	Drive is now ready to run	

## 7.4 Quick start commissioning/start-up (LS Soft)

LS Soft is a Windows™ based software commissioning/start-up tool for Unidrive SP and other LEROY-SOMER products.

LS Soft can be used for commissioning/start-up and monitoring, drive parameters can be uploaded, downloaded and compared, and simple or custom menu listings can be created. Drive menus can be displayed in standard list format or as live block diagrams. LS Soft is able to communicate with a single drive or a network.

LS Soft can be found on the CD which is supplied with the drive and is also available for download from [www.leroy-somer.com](http://www.leroy-somer.com).

LS Soft system requirements:

- Windows 2000/XP/Vista. **Windows 95/98/98SE/ME/NT4 and Windows 2003 server are NOT supported**
- Internet Explorer V5.0 or later must be installed
- Minimum of 800x600 screen resolution with 256 colors. 1024x768 is recommended.
- 128MB RAM
- Pentium III 500MHz or better recommended.
- Adobe Acrobat Reader 5.1 or later (for parameter help). See CD provided
- Microsoft.Net Frameworks 2.0
- Note that you must have administrator rights to install LS Soft.

To install LS Soft from the CD, insert the CD and the auto-run facility should start up the front-end screen from which LS Soft can be selected. Any previous copy of LS Soft should be uninstalled before proceeding with the installation (existing projects will not be lost).

Included with LS Soft are the user guides for the supported drive models. When help on a particular parameter is request by the user, LS Soft links to the parameter in the relevant advanced user guide.

## 7.5 Setting up a feedback device

This section shows the parameter settings which must be made to use each of the compatible encoder types with Unidrive SP. For more information on the parameters listed here please refer to the *Unidrive SP Advanced User Guide*.

### 7.5.1 Overview

Table 7-3 Parameters required for feedback device set-up

Parameter	Ab, Fd, Fr, Ab.SErVO, Fd.SErVO, Fr.SErVO, or SC encoders	SC.HiPEr encoder	SC.EndAt or SC.SSI encoders	EndAt encoder	SSI encoder
<b>3.33</b> Drive encoder turns		✓ x	✓ x	✓ x	✓
<b>3.34</b> Drive encoder lines per revolution	✓	✓ x	✓ x		
<b>3.35</b> Drive encoder comms resolution		✓ x	✓ x	✓ x	✓
<b>3.36</b> Drive encoder supply voltage*	✓	✓	✓	✓	✓
<b>3.37</b> Drive encoder comms baud rate			✓	✓	✓
<b>3.38</b> Drive encoder type	✓	✓	✓	✓	✓
<b>3.41</b> Drive encoder auto configuration enable or SSI binary format select		✓	✓	✓	✓

✓ Information required

x Parameter can be set-up automatically by the drive through auto-configuration

\* Pr **3.36**: If the output voltage from the encoder is >5V, then termination resistors must be disabled by setting Pr **3.39** to 0.

Table 7-3 shows a summary of the parameters required to set-up each feedback device. More detailed information follows.

## 7.5.2 Detailed feedback device commissioning/start-up information

### Standard quadrature encoder with or without commutation signals (A, B, Z or A, B, Z, U, V, W), or Sincos encoder without serial communications

Encoder type	Pr 3.38	Ab (0) for a quadrature encoder without commutation signals * Ab.SERVO (3) for a quadrature encoder with commutation signals SC (6) for a Sincos encoder without serial communications *
Encoder power supply voltage	Pr 3.36	5V (0), 8V (1) or 15V (2) <b>NOTE</b> If output voltage from the encoder is >5V, then the termination resistors must be disabled Pr 3.39 to 0
Encoder number of lines per revolution	Pr 3.34	Set to the number of lines or sine waves per revolution of the encoder. See section 7.5.3 <i>Restriction of encoder number of lines per revolution</i> on page 125 for restrictions on this parameter.
Encoder termination selection (Ab or Ab.SERVO only)	Pr 3.39	0 = A, B, Z termination resistors disabled 1 = A, B termination resistors enabled and Z termination resistors disabled 2 = A, B, Z termination resistors enabled
Encoder error detection level	Pr 3.40	0 = Error detection disable 1 = Wire break detection on A, B and Z inputs enabled 2 = Phase error detection (Ab.SERVO only) 3 = Wire break detection on A, B and Z inputs and phase error detection (Ab.SERVO only) Termination resistors must be enabled for wire break detection to operate

\* These settings should only be used in closed loop vector mode, otherwise a phase offset test must be performed after every power up.

### Incremental encoder with frequency and direction (F and D), or Forward and Reverse (CW and CCW) signals, with or without commutation signals

Encoder type	Pr 3.38	Fd (1) for frequency and direction signals without commutation signals * Fr (2) for forward and reverse signals without commutation signals * Fd.SERVO (4) for a frequency and direction encoder with commutation signals Fr.SERVO (5) for forward and reverse signals with commutation signals
Encoder power supply voltage	Pr 3.36	5V (0), 8V (1) or 15V (2) <b>NOTE</b> If output voltage from the encoder is >5V, then the termination resistors must be disabled Pr 3.39 to 0
Encoder number of lines per revolution	Pr 3.34	Set to the number of pulses per revolution of the encoder divide by 2. See section 7.5.3 <i>Restriction of encoder number of lines per revolution</i> on page 125 for restrictions on this parameter.
Encoder termination selection	Pr 3.39	0 = F or CW, D or CCW, Z termination resistors disabled 1 = F or CW, D or CCW termination resistors enabled and Z termination resistors disabled 2 = For CW, D or CCW, Z termination resistors enabled
Encoder error detection level	Pr 3.40	0 = Error detection disable 1 = Wire break detection on F & D or CW & CCW, and Z inputs enabled 2 = Phase error detection (Fd.SERVO and Fr.SERVO only) 3 = Wire break detection on F & D or CW & CCW, and Z inputs and Phase error detection (Fd.SERVO and Fr.SERVO only) Termination resistors must be enabled for wire break detection to operate

\* These settings should only be used in closed loop vector mode, otherwise a phase offset test must be performed after every power up.

### Absolute Sincos encoder with Hiperface or EnDat serial communications, or Absolute EnDat communications only encoder

The Unidrive SP is compatible with the following Hiperface encoders:

SCS 60/70, SCM 60/70, SRS 50/60, SRM 50/60, SHS 170, LINCODER, SCS-KIT 101, SKS36, SKM36, SEK-53.

Encoder type	Pr 3.38	<b>SC.HiPEr</b> (7) for a Sincos encoder with Hiperface serial communications <b>EndAt</b> (8) for an EnDat communications only encoder <b>SC.EndAt</b> (9) for a Sincos encoder with EnDat serial communications
Encoder power supply voltage	Pr 3.36	<b>5V</b> (0), <b>8V</b> (1) or <b>15V</b> (2)
Encoder auto configure enable	Pr 3.41	Setting this to 1 automatically sets up the following parameters: Pr 3.33 Encoder turn bits Pr 3.34 Encoder number of lines of revolution (SC.HiPEr and SC.EndAt only) * Pr 3.35 Encoder single turn comms resolution Alternatively these parameters can be entered manually.
Encoder comms baud rate (EndAt and SC.EndAt only)	Pr 3.37	<b>100</b> = 100k, <b>200</b> = 200k, <b>300</b> = 300k, <b>500</b> = 500k, <b>1000</b> = 1M, <b>1500</b> = 1.5M, or <b>2000</b> = 2M
Encoder error detection level (SC.HiPEr and SC.EndAt only)	Pr 3.40	<b>0</b> = Error detection disabled <b>1</b> = Wire break detection on Sin and Cos inputs <b>2</b> = Phase error detection <b>3</b> = Wire break detection on Sin and Cos inputs and phase error detection

\* See section 7.5.3 *Restriction of encoder number of lines per revolution* on page 125 for restrictions on this parameter.

### Absolute SSI communications only encoder, or Absolute Sincos encoder with SSI

Encoder type	Pr 3.38	<b>SSI</b> (10) for a SSI communications only encoder <b>SC.SSI</b> (11) for a Sincos encoder with SSI
Encoder power supply voltage	Pr 3.36	<b>5V</b> (0), <b>8V</b> (1) or <b>15V</b> (2)
Encoder number of lines per revolution. (SC.SSI only)	Pr 3.34	Set to the number of sine waves per revolution of the encoder. See section 7.5.3 <i>Restriction of encoder number of lines per revolution</i> on page 125 for restrictions on this parameter.
SSI binary format select	Pr 3.41	<b>OFF</b> (0) for gray code, or <b>On</b> (1) for binary format SSI encoders
Encoder turn bits	Pr 3.33	Set to the number of turn bits for the encoder (this is usually 12bits for a SSI encoder)
Encoder single turn comms resolution	Pr 3.35	Set to the single turn comms resolution for the encoder (this is usually 13bits for a SSI encoder)
Encoder comms baud rate	Pr 3.37	<b>100</b> = 100k, <b>200</b> = 200k, <b>300</b> = 300k, <b>500</b> = 500k, <b>1000</b> = 1M, <b>1500</b> = 1.5M, or <b>2000</b> = 2M
Encoder error detection level	Pr 3.40	<b>0</b> = Error detection disabled <b>1</b> = Wire break detection on Sin and Cos inputs (SC.SSI only) <b>2</b> = Phase error detection (SC.SSI only) <b>3</b> = Wire break detection and phase error detection (SC.SSI only) <b>4</b> = SSI power supply bit monitor <b>5</b> = SSI power supply bit monitor and wire break detection (SC.SSI only) <b>6</b> = SSI power supply bit monitor and phase error detection (SC.SSI only) <b>7</b> = SSI power supply bit monitor, wire break detection and phase error detection (SC.SSI only)

### UVW commutation signal only encoders\*

Encoder type	Pr 3.38	Ab.servo
Encoder power supply voltage	Pr 3.36	<b>5V</b> (0), <b>8V</b> (1) or <b>15V</b> (2)
Encoder number of lines per revolution	Pr 3.34	Set to zero
Encoder error detection level	Pr 3.40	Set to zero to disable wire break detection

\* This feedback device provides very low resolution feedback and should not be used for applications requiring a high level of performance.

### 7.5.3 Restriction of encoder number of lines per revolution

Although Pr 3.34 can be set to any value from 0 to 50,000 there are restrictions on the values actually used by the drive. These restrictions are dependent on the software version as follows:

#### Software version V01.06.01 and later

**Table 7-4 Restrictions of drive encoder lines per revolution with software version V01.06.01 and later**

Position feedback device	Equivalent Lines per revolution used by the drive
Ab, Fd, Fr, Ab.SErVO, Fd.SErVO, Fr.SErVO, SC	The drive uses the value in Pr 3.34.
SC.HiPEr, SC.EndAt, SC.SSI (rotary encoders)	If Pr 3.34 $\leq 1$ , the drive uses the value of 1. If $1 < \text{Pr } 3.34 < 32,768$ , the drive uses the value in Pr 3.34 rounded down to nearest value that is a power of 2. If Pr 3.34 $\geq 32,768$ , the drive uses the value of 32,768.
SC.HiPEr, SC.EndAt, SC.SSI (linear encoders)	The drive uses the value in Pr 3.34.

#### Software version V01.06.00 and earlier

**Table 7-5 Restrictions of drive encoder lines per revolution with software version V01.06.00 and earlier**

Position feedback device	Equivalent Lines per revolution used by the drive
Ab, Fd, Fr	If Pr 3.34 $< 2$ , the drive uses the value of 2. If $2 \leq \text{Pr } 3.34 \leq 16,384$ , the drive uses the value in Pr 3.34. If Pr 3.34 $> 16,384$ , the drive uses the value in Pr 3.34 rounded down to nearest value divisible by 4.
Ab.SErVO, Fd.SErVO, Fr.SErVO	If Pr 3.34 $\leq 2$ , the drive uses the value of 2. If $2 < \text{Pr } 3.34 < 16,384$ , the drive uses the value in Pr 3.34 rounded down to nearest value that is a power of 2. If Pr 3.34 $\geq 16,384$ , the drive uses the value of 16,384.
SC, SC.HiPEr, SC.EndAt, SC.SSI	If Pr 3.34 $\leq 2$ , the drive uses the value of 2. If $2 < \text{Pr } 3.34 < 32,768$ , the drive uses the value in Pr 3.34 rounded down to nearest value that is a power of 2. If Pr 3.34 $\geq 32,768$ , the drive uses the value of 32,768.

At power-up Pr 3.48 is initially zero, but is set to one when the drive encoder and any encoders connected to any Solutions Modules have been initialised. The drive cannot be enabled until this parameter is one.

Encoder initialisation will occur as follows:

- At drive power-up
- When requested by the user via Pr 3.47
- When trips PS.24V, Enc1 to Enc8, or Enc11 to Enc17 trips are reset
- The encoder number of lines per revolution (Pr 3.34) or the number of motor poles (Pr 5.11 and Pr 21.11) are changed (software version V01.08.00 and later).

Initialisation causes an encoder with communications to be re-initialised and auto-configuration to be performed if selected. After initialisation Ab.SErVO, Fd.SErVO and Fr.SErVO encoders will use the UVW commutations signals to give position feedback for the first 120° (electrical) of rotation when the motor is restarted.

## 8 Optimization

This chapter takes the user through methods of optimizing the product set-up, maximizing performance. The auto-tuning features of the drive simplify this task.

### 8.1 Motor map parameters

#### 8.1.1 Open loop motor control

<b>Pr 0.46 {5.07} Motor rated current</b>	<b>Defines the maximum continuous motor current</b>
<p>The motor rated current parameter must be set to the maximum continuous current of the motor. (See section 8.2 <i>Maximum motor rated current</i> on page 136, for information about setting this parameter higher than the maximum Heavy Duty current rating.) The motor rated current is used in the following:</p> <ul style="list-style-type: none"> <li>• Current limits (see section 8.3 <i>Current limits</i> on page 136, for more information)</li> <li>• Motor thermal overload protection (see section 8.4 <i>Motor thermal protection</i> on page 136, for more information)</li> <li>• Vector mode voltage control (see Voltage mode Pr <b>0.07</b>, later in this table)</li> <li>• Slip compensation (see Slip compensation Pr <b>5.27</b>, later in this table)</li> <li>• Dynamic V/F control</li> </ul>	
<b>Pr 0.44 {5.09} Motor rated voltage</b>	<b>Defines the voltage applied to the motor at rated frequency</b>
<b>Pr 0.47 {5.06} Motor rated frequency</b>	<b>Defines the frequency at which rated voltage is applied</b>
<p>The motor rated voltage Pr <b>0.44</b> and the motor rated frequency Pr <b>0.47</b> are used to define the voltage to frequency characteristic applied to the motor (see voltage mode Pr <b>0.07</b>, later in this table). The motor rated frequency is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see motor rated speed Pr <b>0.45</b>, later in this table).</p>	
<p>The graph shows 'Output voltage' on the y-axis and 'Output frequency' on the x-axis. A line starts at the origin and rises linearly to a point where the frequency is Pr 0.47 and the voltage is Pr 0.44. From this point, the line becomes horizontal, indicating constant voltage for frequencies above Pr 0.47. A dashed line from the origin passes through the point (Pr 0.47/2, Pr 0.44/2).</p>	
<b>Pr 0.45 {5.08} Motor rated speed</b>	<b>Defines the full load rated speed of the motor</b>
<b>Pr 0.42 {5.11} Motor number of poles</b>	<b>Defines the number of motor poles</b>
<p>The motor rated speed and the number of poles are used with the motor rated frequency to calculate the rated slip of induction machines in Hz.</p> $\text{Rated slip (Hz)} = \text{Motor rated frequency} - (\text{Number of pole pairs} \times [\text{Motor rated speed} / 60]) = 0,47 - \left( \frac{0,42}{2} \times \frac{0,45}{60} \right)$ <p>If Pr <b>0.45</b> is set to 0 or to synchronous speed, slip compensation is disabled. If slip compensation is required this parameter should be set to the nameplate value, which should give the correct rpm for a hot machine. Sometimes it will be necessary to adjust this when the drive is commissioned because the nameplate value may be inaccurate. Slip compensation will operate correctly both below base speed and within the field-weakening region. Slip compensation is normally used to correct for the motor speed to prevent speed variation with load. The rated load rpm can be set higher than synchronous speed to deliberately introduce speed droop. This can be useful to aid load sharing with mechanically coupled motors.</p> <p>Pr <b>0.42</b> is also used in the calculation of the motor speed display by the drive for a given output frequency. When Pr <b>0.42</b> is set to 'Auto', the number of motor poles is automatically calculated from the rated frequency Pr <b>0.47</b>, and the motor rated speed Pr <b>0.45</b>.</p> $\text{Number of poles} = 120 \times (\text{Motor rated frequency Pr } 0.47 / \text{Motor rated speed Pr } 0.45) \text{ rounded to the nearest even number}$	
<b>Pr 0.43 {5.10} Motor rated power factor</b>	<b>Defines the angle between the motor voltage and current</b>
<p>The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. The power factor is used in conjunction with the motor rated current Pr <b>0.46</b>, to calculate the rated active current and magnetising current of the motor. The rated active current is used extensively to control the drive, and the magnetising current is used in vector mode stator resistance compensation. It is important that this parameter is set up correctly. The drive can measure the motor rated power factor by performing a rotating autotune (see Autotune Pr <b>0.40</b>, below).</p>	
<b>Pr 0.40 {5.12} Autotune</b>	
<p>There are two autotune tests available in open loop mode, a stationary and a rotating test. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive.</p> <ul style="list-style-type: none"> <li>• A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary test measures the stator resistance (Pr <b>5.17</b>) and voltage offset (Pr <b>5.23</b>), which are required for good performance in vector control modes (see Voltage mode Pr <b>0.07</b>, later in this table). The stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr <b>0.43</b>. To perform a Stationary autotune, set Pr <b>0.40</b> to 1, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> <li>• A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune, as above, before rotating the motor at <math>\frac{2}{3}</math> base speed in the direction selected for several seconds (regardless of the speed reference). In addition to the stator resistance (Pr <b>5.17</b>) and voltage offset (Pr <b>5.23</b>), the rotating autotune measures the power factor of the motor and updates Pr <b>0.43</b> with the correct value. To perform a Rotating autotune, set Pr <b>0.40</b> to 2, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> </ul> <p>Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr <b>6.15</b> to OFF (0) or disabling the drive via the control word (Pr <b>6.42</b> &amp; Pr <b>6.43</b>).</p>	

## Pr 0.07 {5.14} Voltage mode

There are six voltage modes available which fall into two categories, vector control and fixed boost.

### Vector control

Vector control mode provides the motor with a linear voltage characteristic from 0Hz to motor rated frequency (Pr 0.47), and then a constant voltage above motor rated frequency. When the drive operates between motor rated frequency/50 and motor rated frequency/4, full vector based stator resistance compensation is applied. When the drive operates between motor rated frequency/4 and motor rated frequency/2 the stator resistance compensation is gradually reduced to zero as the frequency increases. For the vector modes to operate correctly the motor rated power factor (Pr 0.43), stator resistance (Pr 5.17) and voltage offset (Pr 5.23) are all required to be set up accurately. The drive can be made to measure these by performing an autotune (see Pr 0.40 Autotune). The drive can also be made to measure the stator resistance and voltage offset automatically every time the drive is enabled or the first time the drive is enabled after it is powered up, by selecting one of the vector control voltage modes.

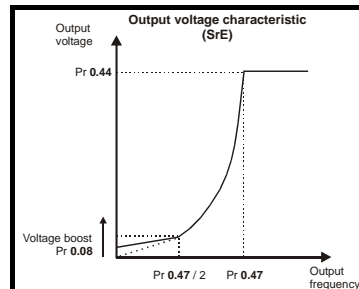
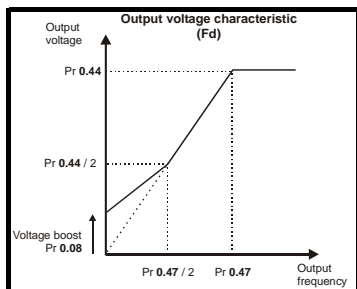
- (0) **Ur\_S** = The stator resistance and the voltage offset are measured and the parameters for the selected motor map are over-written each time the drive is made to run. This test can only be done with a stationary motor where the flux has decayed to zero. Therefore this mode should only be used if the motor is guaranteed to be stationary each time the drive is made to run. To prevent the test from being done before the flux has decayed there is a period of 1 second after the drive has been in the ready state during which the test is not done if the drive is made to run again. In this case, previously measured values are used. Ur\_s mode ensures that the drive compensates for any change in motor parameters due to changes in temperature. The new values of stator resistance and voltage offset are not automatically saved to the drive's EEPROM.
- (4) **Ur\_I** = The stator resistance and voltage offset are measured when the drive is first made to run after each power-up. This test can only be done with a stationary motor. Therefore this mode should only be used if the motor is guaranteed to be stationary the first time the drive is made to run after each power-up. The new values of stator resistance and voltage offset are not automatically saved to the drive's EEPROM.
- (1) **Ur** = The stator resistance and voltage offset are not measured. The user can enter the motor and cabling resistance into the stator resistance parameter (Pr 5.17). However this will not include resistance effects within the drive inverter. Therefore if this mode is to be used, it is best to use an autotune test initially to measure the stator resistance and voltage offset.
- (3) **Ur\_Auto** = The stator resistance and voltage offset are measured once, the first time the drive is made to run. After the test has been completed successfully the voltage mode (Pr 0.07) is changed to Ur mode. The stator resistance (Pr 5.17) and voltage offset (Pr 5.23) parameters are written to, and along with the voltage mode (Pr 0.07), are saved in the drive's EEPROM. If the test fails, the voltage mode will stay set to Ur\_Auto and the test will be repeated next time the drive is made to run.

### Fixed boost

Neither the stator resistance nor the voltage offset are used in the control of the motor, instead a fixed characteristic with low frequency voltage boost as defined by parameter Pr 0.08, is used. Fixed boost mode should be used when the drive is controlling multiple motors. There are two settings of fixed boost available:

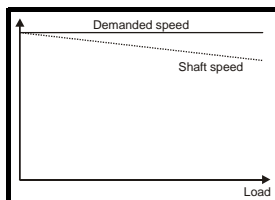
- (2) **Fd** = This mode provides the motor with a linear voltage characteristic from 0Hz to rated frequency (Pr 0.47), and then a constant voltage above rated frequency.
- (5) **SrE** = This mode provides the motor with a square law voltage characteristic from 0Hz to rated frequency (Pr 0.47), and then a constant voltage above rated frequency. This mode is suitable for variable torque applications like fans and pumps where the load is proportional to the square of the speed of the motor shaft. This mode should not be used if a high starting torque is required.

For both these modes, at low frequencies (from 0Hz to  $\frac{1}{2} \times$  Pr 0.47) a voltage boost is applied defined by Pr 0.08 as shown below:



## Pr 5.27 Slip compensation

When a motor, being controlled in open loop mode, has load applied a characteristic of the motor is that the output speed droops in proportion to the load applied as shown:



In order to prevent the speed droop shown above slip compensation should be enabled.

To enable slip compensation Pr 5.27 must be set to a 1 (this is the default setting), and the motor rated speed must be entered in Pr 0.45 (Pr 5.08). The motor rated speed parameter should be set to the synchronous speed of the motor minus the slip speed. This is normally displayed on the motor nameplate, i.e. for a typical 18.5kW, 50Hz, 4 pole motor, the motor rated speed would be approximately 1465rpm. The synchronous speed for a 50Hz, 4 pole motor is 1500rpm, so therefore the slip speed would be 35rpm.

If the synchronous speed is entered in Pr 0.45, slip compensation will be disabled. If too small a value is entered in Pr 0.45, the motor will run faster than the demanded frequency.

The synchronous speeds for 50Hz motors with different numbers of poles are as follows:

2 pole = 3000rpm, 4 pole = 1500rpm, 6pole = 1000rpm, 8 pole = 750rpm

## 8.1.2 RFC mode

Software V01.10.00 or later should be used for RFC mode.

<b>Pr 0.46 {5.07} Motor rated current</b>	<b>Defines the maximum motor continuous current</b>
<p>The motor rated current parameter must be set to the maximum continuous current of the motor. (See section 8.2 <i>Maximum motor rated current</i> on page 136, for information about setting this parameter higher than the maximum Heavy Duty current rating.) The motor rated current is used in the following:</p> <ul style="list-style-type: none"> <li>• Current limits (see section 8.3 <i>Current limits</i> on page 136, for more information)</li> <li>• Motor thermal overload protection (see section 8.4 <i>Motor thermal protection</i> on page 136, for more information)</li> <li>• Vector control algorithm</li> </ul>	
<b>Pr 0.44 {5.09} Motor rated voltage</b>	<b>Defines the voltage applied to the motor at rated frequency</b>
<b>Pr 0.47 {5.06} Motor rated frequency</b>	<b>Defines the frequency at which rated voltage is applied</b>
<p>The motor rated voltage Pr <b>0.44</b> and the motor rated frequency Pr <b>0.47</b> are used to define the relationship between the voltage and frequency applied to the motor, as shown.</p> <p>The motor rated voltage is used by the field controller to limit the voltage applied to the motor. Normally this is set to the nameplate value. To allow current control to be maintained, it is necessary for the drive to leave some 'headroom' between the motor terminal voltage and the maximum available drive output voltage. For good transient performance at high speed, the motor rated voltage should be set below 95% of the minimum supply voltage to the drive.</p> <p>The motor rated voltage and motor rated frequency are also used during the rotating autotune test (see Autotune Pr <b>0.40</b> later in this table) and in the calculations required for automatic optimization of the motor rated speed (see Motor rated speed optimization Pr <b>5.16</b>, later in this table). Therefore, it is important that the correct value for motor rated voltage is used.</p>	
<p>The graph, titled 'Output voltage characteristic', plots Output voltage on the vertical axis against Output frequency on the horizontal axis. A solid line starts at the origin and rises linearly to a point where the frequency is Pr 0.47 and the voltage is Pr 0.44. From this point, the line becomes horizontal, indicating constant voltage. A dashed line from the point (Pr 0.47 / 2, Pr 0.44 / 2) shows that the voltage is proportional to the frequency in the linear region.</p>	
<b>Pr 0.45 {5.08} Motor rated speed</b>	<b>Defines the full load rated speed of the motor</b>
<b>Pr 0.42 {5.11} Motor number of poles</b>	<b>Defines the number of motor poles</b>
<p>The motor rated speed and motor rated frequency are used to determine the full load slip of the motor which is used by the vector control algorithm. Incorrect setting of this parameter has the following effects:</p> <ul style="list-style-type: none"> <li>• Reduced efficiency of motor operation</li> <li>• Reduction of maximum torque available from the motor</li> <li>• Reduced transient performance</li> <li>• Inaccurate control of absolute torque in torque control modes</li> </ul> <p>The nameplate value is normally the value for a hot motor; however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate. Either a fixed value can be entered in this parameter or an optimization system may be used to automatically adjust this parameter (see Motor rated speed autotune Pr <b>5.16</b>, later in this table).</p> <p>When Pr <b>0.42</b> is set to 'Auto', the number of motor poles is automatically calculated from the motor rated frequency Pr <b>0.47</b>, and the motor rated speed Pr <b>0.45</b></p> $\text{Number of poles} = 120 \times (\text{Motor rated frequency Pr } 0.47 / \text{Motor rated speed Pr } 0.45) \text{ rounded to the nearest even number}$	
<b>Pr 0.43 {5.10} Motor rated power factor</b>	<b>Defines the angle between the motor voltage and current</b>
<p>The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. If the stator inductance is set to zero (Pr <b>5.25</b>) then the power factor is used in conjunction with the motor rated current Pr <b>0.46</b> and other motor parameters to calculate the rated active and magnetising currents of the motor, which are used in the vector control algorithm. If the stator inductance has a non-zero value this parameter is not used by the drive, but is continuously written with a calculated value of power factor. The stator inductance can be measured by the drive by performing a rotating autotune (see Autotune Pr <b>0.40</b>, later in this table).</p>	



### Pr 0.40 {5.12} Autotune

There are three autotune tests available in RFC mode, a stationary test, a rotating test and an inertia measurement test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. An inertia measurement test should be performed separately to a stationary or rotating autotune.

#### NOTE

It is highly recommended that a rotating autotune is performed (Pr 0.40 set to 2).

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the stator resistance (Pr 5.17) and transient inductance (Pr 5.24) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr 4.13 and Pr 4.14 are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr 0.43. To perform a Stationary autotune, set Pr 0.40 to 1, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).
- A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune before rotating the motor at  $\frac{2}{3}$  of motor rated frequency in the direction selected for approximately 30s. During the rotating autotune the stator inductance (Pr 5.25), and the motor saturation breakpoints (Pr 5.29 and Pr 5.30) are modified by the drive. The power factor is also modified for user information only, but is not used after this point as the stator inductance is used in the vector control algorithm instead. To perform a Rotating autotune, set Pr 0.40 to 2, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).
- The inertia measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains (see *Speed loop gains*) and to provide torque feed-forwards when required during acceleration.  
During the inertia measurement test the drive attempts to accelerate the motor in the direction selected up to  $\frac{3}{4}$  x rated load rpm and then back to standstill. The drive uses rated torque/16, but if the motor cannot be accelerated to the required speed the drive then increases the torque progressively to  $x^{1/8}$ ,  $x^{1/4}$ ,  $x^{1/2}$  and  $x1$  rated torque. If the required speed is not achieved on the final attempt the test is aborted and a tunE1 trip is initiated. If the test is successful the acceleration and deceleration times are used to calculate the motor and load inertia which is then written to Pr 3.18. The motor map parameters must be set up correctly including the power factor before performing an inertia measurement test. To perform an Inertia measurement autotune, set Pr 0.40 to 3, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).

Following the completion of an autotune test the drive will go into the inh bit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr 6.15 to OFF (0) or disabling the drive via the control word (Pr 6.42 & Pr 6.43).

### Pr 0.38 {4.13} / Pr 0.39 {4.14} Current loop gains

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. However, for optimal performance in dynamic applications it may be necessary to change the gains to improve the performance. The proportional gain (Pr 4.13) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by one of the following:

- During a stationary or rotating autotune (see *Autotune Pr 0.40*, earlier in this table) the drive measures the stator resistance (Pr 5.17) and transient inductance (Pr 5.24) of the motor and calculates the current loop gains.
- By setting Pr 0.40 to 4 the drive will calculate the current loop gains from the values of stator resistance (Pr 5.17) and transient inductance (Pr 5.24) set in the drive.

This will give a step response with minimum overshoot after a step change of current reference. 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. The equation for the integral gain gives a conservative value. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed RFC induction motor applications) the integral gain may need to have a significantly higher value.

### Pr 3.42 Drive encoder filter

In RFC mode Pr 3.42 defines a filter on the output of the speed estimator which is used as the speed feedback. A filter with a 4ms time constant is always present on the output of the speed estimator, but this filter may be extended as follows:

0 = 4ms, 1 = 8ms, 2 = 16ms, 3 = 32ms, 4 = 64ms, 5 = 128ms.

The output of the speed estimator can include some ripple, which increases as the drive passes into field weakening and the filter can be used to remove this ripple. This is particularly useful when using standard ramp or spinning start with a low friction, high inertia load, and can prevent over voltage trips when the drive has no braking resistor.

### Pr 5.40 Spin start boost

If Pr 6.09 is set to enable the catch a spinning motor function in open-loop mode or RFC modes, this parameter defines a scaling function used by the algorithm that detects the speed of the motor. It is likely that for smaller motors (~4kW) the default value of 1.0 is suitable, but for larger motors this parameter may need to be increased. If the value of this parameter is too large the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small the drive will detect the motor speed as zero even if the motor is spinning.

### Speed loop gains (Pr 0.07 {3.10}, Pr 0.08 {3.11}, Pr 0.09 {3.12})

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional ( $K_p$ ) and integral ( $K_i$ ) feed forward terms, and a differential ( $K_d$ ) feedback term. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr 3.16. If Pr 3.16 = 0, gains  $K_{p1}$ ,  $K_{i1}$  and  $K_{d1}$  (Pr 0.07 to Pr 0.09) are used, and if Pr 3.16 = 1, gains  $K_{p2}$ ,  $K_{i2}$  and  $K_{d2}$  (Pr 3.13 to Pr 3.15) are used. Pr 3.16 may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required  $K_p$  and  $K_i$  gains to give a required compliance angle or bandwidth dependant on the setting of Pr 3.17.

#### Proportional gain ( $K_p$ ), Pr 0.07 {3.10} and Pr 3.13

If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the stability limit is reached.

#### Integral gain ( $K_i$ ), Pr 0.08 {3.11} and Pr 3.14

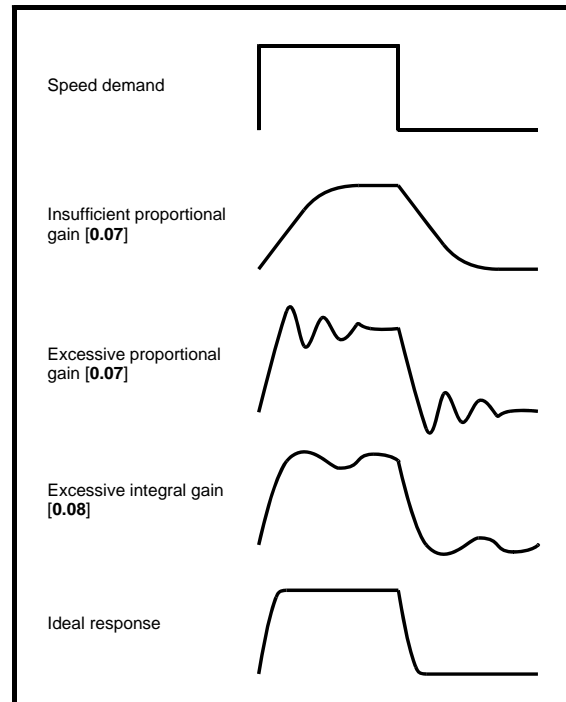
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain. A compromise must be reached where the system response, stiffness and damping are all adequate for the application. For RFC mode, it is unlikely that the integral gain can be increased much above 0.50.

#### Differential gain ( $K_d$ ), Pr 0.09 {3.12} and Pr 3.15

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.

There are three methods of tuning the speed loop gains dependant on the setting of Pr 3.17:

1. Pr 3.17 = 0, User set-up.  
This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.  
Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.  
The proportional gain ( $K_p$ ) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.  
The integral gain ( $K_i$ ) should then be increased up to the point where the speed becomes unstable and then reduced slightly.  
It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.  
The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
2. Pr 3.17 = 1, Bandwidth set-up  
If bandwidth based set-up is required, the drive can calculate  $K_p$  and  $K_i$  if the following parameters are set up correctly:  
Pr 3.20 - Required bandwidth,  
Pr 3.21 - Required damping factor,  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).
3. Pr 3.17 = 2, Compliance angle set-up  
If compliance angle based set-up is required, the drive can calculate  $K_p$  and  $K_i$  if the following parameters are set up correctly:  
Pr 3.19 - Required compliance angle,  
Pr 3.21 - Required damping factor,  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).



### 8.1.3 Closed loop vector motor control

#### Pr 0.46 {5.07} Motor rated current

**Defines the maximum motor continuous current**

The motor rated current parameter must be set to the maximum continuous current of the motor. (See section 8.2 *Maximum motor rated current* on page 136, for information about setting this parameter higher than the maximum Heavy Duty current rating.) The motor rated current is used in the following:

- Current limits (see section 8.3 *Current limits* on page 136, for more information)
- Motor thermal overload protection (see section 8.4 *Motor thermal protection* on page 136, for more information)
- Vector control algorithm

#### Pr 0.44 {5.09} Motor rated voltage

**Defines the voltage applied to the motor at rated frequency**

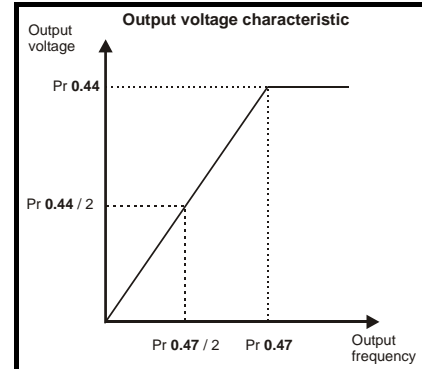
#### Pr 0.47 {5.06} Motor rated frequency

**Defines the frequency at which rated voltage is applied**

The motor rated voltage Pr **0.44** and the motor rated frequency Pr **0.47** are used to define the relationship between the voltage and frequency applied to the motor, as shown.

The motor rated voltage is used by the field controller to limit the voltage applied to the motor. Normally this is set to the nameplate value. To allow current control to be maintained, it is necessary for the drive to leave some 'headroom' between the motor terminal voltage and the maximum available drive output voltage. For good transient performance at high speed, the motor rated voltage should be set below 95% of the minimum supply voltage to the drive.

The motor rated voltage and motor rated frequency are also used during the rotating autotune test (see Autotune Pr **0.40** later in this table) and in the calculations required for automatic optimization of the motor rated speed (see Motor rated speed optimization Pr **5.16**, later in this table). Therefore, it is important that the correct value for motor rated voltage is used.



#### Pr 0.45 {5.08} Motor rated speed

**Defines the full load rated speed of the motor**

#### Pr 0.42 {5.11} Motor number of poles

**Defines the number of motor poles**

The motor rated speed and motor rated frequency are used to determine the full load slip of the motor which is used by the vector control algorithm. Incorrect setting of this parameter has the following effects:

- Reduced efficiency of motor operation
- Reduction of maximum torque available from the motor
- Reduced transient performance
- Inaccurate control of absolute torque in torque control modes

The nameplate value is normally the value for a hot motor; however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate. Either a fixed value can be entered in this parameter or an optimization system may be used to automatically adjust this parameter (see Motor rated speed autotune Pr **5.16**, later in this table).

When Pr **0.42** is set to 'Auto', the number of motor poles is automatically calculated from the motor rated frequency Pr **0.47**, and the motor rated speed Pr **0.45**

$$\text{Number of poles} = 120 \times (\text{Motor rated frequency Pr } 0.47 / \text{Motor rated speed Pr } 0.45) \text{ rounded to the nearest even number}$$

#### Pr 0.43 {5.10} Motor rated power factor

**Defines the angle between the motor voltage and current**

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. If the stator inductance is set to zero (Pr **5.25**) then the power factor is used in conjunction with the motor rated current Pr **0.46** and other motor parameters to calculate the rated active and magnetising currents of the motor, which are used in the vector control algorithm. If the stator inductance has a non-zero value this parameter is not used by the drive, but is continuously written with a calculated value of power factor. The stator inductance can be measured by the drive by performing a rotating autotune (see Autotune Pr **0.40**, later in this table).

## Pr 0.40 {5.12} Autotune

There are three autotune tests available in closed loop vector mode, a stationary test, a rotating test and an inertia measurement test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. An inertia measurement test should be performed separately to a stationary or rotating autotune.

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the stator resistance (Pr 5.17) and transient inductance (Pr 5.24) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr 4.13 and Pr 4.14 are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr 0.43. To perform a Stationary autotune, set Pr 0.40 to 1, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).
- A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune before rotating the motor at  $\frac{2}{3}$  of motor rated frequency in the direction selected for approximately 30s. During the rotating autotune the stator inductance (Pr 5.25), and the motor saturation breakpoints (Pr 5.29 and Pr 5.30) are modified by the drive. The power factor is also modified for user information only, but is not used after this point as the stator inductance is used in the vector control algorithm instead. To perform a Rotating autotune, set Pr 0.40 to 2, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).
- The inertia measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains (see *Speed loop gains*) and to provide torque feed-forwards when required during acceleration.

During the inertia measurement test the drive attempts to accelerate the motor in the direction selected up to  $\frac{3}{4}$  x rated load rpm and then back to standstill. The drive uses rated torque/16, but if the motor cannot be accelerated to the required speed the drive then increases the torque progressively to  $x\frac{1}{8}$ ,  $x\frac{1}{4}$ ,  $x\frac{1}{2}$  and  $x1$  rated torque. If the required speed is not achieved on the final attempt the test is aborted and a tunE1 trip is initiated. If the test is successful the acceleration and deceleration times are used to calculate the motor and load inertia which is then written to Pr 3.18. The motor map parameters must be set up correctly including the power factor before performing an inertia measurement test.

To perform an Inertia measurement autotune, set Pr 0.40 to 3, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr 6.15 to OFF (0) or disabling the drive via the control word (Pr 6.42 & Pr 6.43).

## Pr 5.16 Motor rated speed autotune

The motor rated speed parameter (Pr 0.45) in conjunction with the motor rated frequency parameter (Pr 0.47) defines the full load slip of the motor. The slip is used in the motor model for closed-loop vector control. The full load slip of the motor varies with rotor resistance which can vary significantly with motor temperature. When Pr 5.16 is set to 1 or 2 the drive can automatically sense if the value of slip defined by Pr 0.47 and Pr 0.45 has been set incorrectly or if it has varied with motor temperature. If the value is incorrect Pr 0.45 is automatically adjusted. Pr 0.45 is not saved at power-down, and so when the drive is powered-down and up again it will return to the last saved value. If the new value is required at the next power-up it must be saved by the user. Automatic optimization is only enabled when the speed is above rated speed/8, and when the load on the motor load rises above  $\frac{5}{8}$  rated load. Optimization is disabled again if the load falls below  $\frac{1}{2}$  rated load. For best optimization results the correct values of stator resistance (Pr 5.17), transient inductance (Pr 5.24), stator inductance (Pr 5.25) and saturation breakpoints (Pr 5.29, Pr 5.30) should be stored in the relevant parameters (all these can be measured by the drive by performing a rotating autotune). Motor rated speed autotune is not available if the drive is not using external position/speed feedback.

The gain of the optimizer, and hence the speed with which it converges, can be set at a normal low level when Pr 5.16 is set to 1. If this parameter is set to 2, the gain is increased by a factor of 16 to give faster convergence.

## Pr 0.38 {4.13} / Pr 0.39 {4.14} Current loop gains

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. However, for optimal performance in dynamic applications it may be necessary to change the gains to improve the performance. The proportional gain (Pr 4.13) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by one of the following:

- During a stationary or rotating autotune (see *Autotune Pr 0.40*, earlier in this table) the drive measures the stator resistance (Pr 5.17) and transient inductance (Pr 5.24) of the motor and calculates the current loop gains.
- By setting Pr 0.40 to 4 the drive will calculate the current loop gains from the values of stator resistance (Pr 5.17) and transient inductance (Pr 5.24) set in the drive.

This will give a step response with minimum overshoot after a step change of current reference. 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. The equation for the integral gain gives a conservative value. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed closed-loop induction motor applications) the integral gain may need to have a significantly higher value.

## Speed loop gains (Pr 0.07 {3.10}, Pr 0.08 {3.11}, Pr 0.09 {3.12})

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr 3.16. If Pr 3.16 = 0, gains Kp1, Ki1 and Kd1 (Pr 0.07 to Pr 0.09) are used, and if Pr 3.16 = 1, gains Kp2, Ki2 and Kd2 (Pr 3.13 to Pr 3.15) are used. Pr 3.16 may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains to give a required compliance angle or bandwidth dependant on the setting of Pr 3.17.

### Proportional gain (Kp), Pr 0.07 {3.10} and Pr 3.13

If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the closed-loop stability limit is reached.

### Integral gain (Ki), Pr 0.08 {3.11} and Pr 3.14

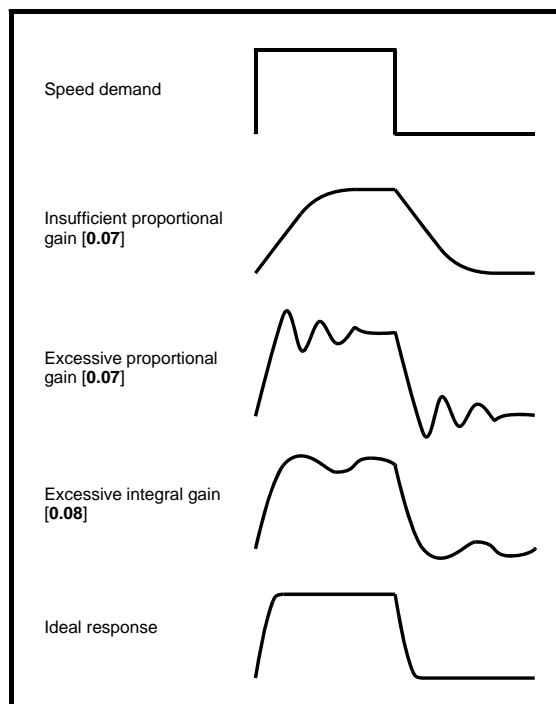
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain. A compromise must be reached where the system response, stiffness and damping are all adequate for the application.

### Differential gain (Kd), Pr 0.09 {3.12} and Pr 3.15

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.

There are three methods of tuning the speed loop gains dependant on the setting of Pr 3.17:

- Pr 3.17 = 0, User set-up.  
This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.  
Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.  
The proportional gain (Kp) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.  
The integral gain (Ki) should then be increased up to the point where the speed becomes unstable and then reduced slightly.  
It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.  
The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
- Pr 3.17 = 1, Bandwidth set-up  
If bandwidth based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:  
Pr 3.20 - Required bandwidth,  
Pr 3.21 - Required damping factor,  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).
- Pr 3.17 = 2, Compliance angle set-up  
If compliance angle based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:  
Pr 3.19 - Required compliance angle,  
Pr 3.21 - Required damping factor,  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).



## 8.1.4 Servo motor control

<b>Pr 0.46 {5.07} Motor rated current</b>	<b>Defines the maximum motor continuous current</b>
<p>The motor rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following:</p> <ul style="list-style-type: none"> <li>• Current limits (see section 8.3 <i>Current limits</i> on page 136, for more information)</li> <li>• Motor thermal overload protection (see section 8.4 <i>Motor thermal protection</i> on page 136, for more information)</li> </ul>	
<b>Pr 0.42 {5.11} Motor number of poles</b>	<b>Defines the number of motor poles</b>
<p>The motor number of poles parameter defines the number of electrical revolutions in one whole mechanical revolution of the motor. This parameter must be set correctly for the control algorithms to operate correctly. When Pr <b>0.42</b> is set to "Auto" the number of poles is 6.</p>	
<b>Pr 0.40 {5.12} Autotune</b>	
<p>There are five autotune tests available in servo mode, a short low speed test, a normal low speed test, an inertia measurement test, a stationary test to set up current controller gains and a minimal movement phasing test. A normal low speed should be done where possible as the drive measures the stator resistance and inductance of the motor, and from these calculates the current loop gains. An inertia measurement test should be performed separately to a short low speed or normal low speed autotune.</p> <ul style="list-style-type: none"> <li>• A short low speed test will rotate the motor by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the direction selected. The drive applies rated current to the motor during the test and measures the encoder phase angle (Pr <b>3.25</b>). The phase angle measurement is taken when the motor has stopped at the end of the test, therefore there must be no load on the motor when it is at rest for the correct angle to be measured. This test takes approximately 2 seconds to complete and can only be used where the rotor settles to a stable position in a short time. To perform a short low speed autotune, set Pr <b>0.40</b> to 1, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> <li>• A normal low speed test will rotate the motor by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the direction selected. The drive applies rated current to the motor during the test and measures the encoder phase angle (Pr <b>3.25</b>). The phase angle measurement is taken when the motor has stopped at the end of the test, therefore there must be no load on the motor when it is at rest for the correct angle to be measured. The motor resistance (Pr <b>5.17</b>) and inductance (Pr <b>5.24</b>) are then measured, and the values are used to set up the current loop gains (Pr <b>0.38 {4.13}</b> and Pr <b>0.39 {4.14}</b>). The whole test takes approximately 20 seconds and can be used with motors that take time to settle after the rotor has moved. During the motor inductance measurement the drive applies current pulses to the motor that produces flux that opposes the flux produced by the magnets. The maximum current applied is a quarter of rated current (Pr <b>0.46</b>). This current is unlikely to affect the motor magnets, however, if this level of current could permanently de-magnetise the magnets the rated current should be set to a lower level for the tests to avoid this. To perform a normal low speed autotune, set Pr <b>0.40</b> to 2, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> </ul> <div style="text-align: center;">  </div> <ul style="list-style-type: none"> <li>• The inertia measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains (see <i>Speed loop gains</i>) and to provide torque feed-forwards when required during acceleration. During the inertia measurement test the drive attempts to accelerate the motor in the direction selected up to <math>\frac{3}{4}</math> x rated load rpm and then back to standstill. The drive uses rated torque/16, but if the motor cannot be accelerated to the required speed the drive then increases the torque progressively to <math>\frac{1}{8}</math>, <math>\frac{1}{4}</math>, <math>\frac{1}{2}</math> and x1 rated torque. If the required speed is not achieved on the final attempt the test is aborted and a tunE1 trip is initiated. If the test is successful the acceleration and deceleration times are used to calculate the motor and load inertia which is then written to Pr <b>3.18</b>. The value of the value of motor torque per amp in Pr <b>5.32</b> and the motor rated speed in Pr <b>5.08</b> must be set up correctly before performing an inertia measurement test. To perform an Inertia measurement autotune, set Pr <b>0.40</b> to 3, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> <li>• The stationary test to set up current controller gains measures the stator resistance and the transient inductance of the motor, calculates the current loop gains and updates the current loop gain parameters. This test does not measure the encoder phase angle. This test should only be performed when the correct phasing angle has been set in Pr <b>0.43</b>. If the phasing angle is not correct the motor may move and the results may be incorrect. To perform a stationary test to set up current controller gains, set Pr <b>0.40</b> to 4, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> <li>• A minimal movement phasing test can measure the encoder phase offset by moving the motor through a small angle. Short current pulses are applied to the motor to produce a small movement and then to move the motor back to the original position. The size and length of the pulses are gradually increased (up to a maximum of motor rated current) until the movement is approximately at the level defined by Pr <b>5.38</b> electrical degrees. The resulting movements are used to estimate the phase angle. To perform a minimal movement phasing test, set Pr <b>0.40</b> to 5, and provide the drive with both an enable signal (on terminal 31) and a run signal (on terminal 26 or 27).</li> </ul> <p>Following the completion of an autotune test the drive will go into the inh bit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the SAFE TORQUE OFF (SECURE DISABLE) signal from terminal 31, setting the drive enable parameter Pr <b>6.15</b> to OFF (0) or disabling the drive via the control word (Pr <b>6.42</b> &amp; Pr <b>6.43</b>).</p>	
<b>Current loop gains (Pr 0.38 {4.13} / Pr 0.39 {4.14})</b>	
<p>The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. However, for optimal performance in dynamic applications it may be necessary to change the gains to improve the performance. The proportional gain (Pr <b>4.13</b>) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by one of the following:</p> <ul style="list-style-type: none"> <li>• During a stationary or rotating autotune (see <i>Autotune Pr 0.40</i>, earlier in this table) the drive measures the stator resistance (Pr <b>5.17</b>) and transient inductance (Pr <b>5.24</b>) of the motor and calculates the current loop gains.</li> <li>• By setting Pr <b>0.40</b> to 6 the drive will calculate the current loop gains from the values of stator resistance (Pr <b>5.17</b>) and transient inductance (Pr <b>5.24</b>) set in the drive.</li> </ul> <p>This will give a step response with minimum overshoot after a step change of current reference. 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. The equation for the integral gain gives a conservative value. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed closed-loop induction motor applications) the integral gain may need to have a significantly higher value.</p>	

### Speed loop gains (Pr 0.07 {3.10}, Pr 0.08 {3.11}, Pr 0.09 {3.12})

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr 3.16. If Pr 3.16 = 0, gains Kp1, Ki1 and Kd1 (Pr 0.07 to Pr 0.09) are used, and if Pr 3.16 = 1, gains Kp2, Ki2 and Kd2 (Pr 3.13 to Pr 3.15) are used. Pr 3.16 may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains to give a required compliance angle or bandwidth dependant on the setting of Pr 3.17.

#### Proportional gain (Kp), Pr 0.07 {3.10} and Pr 3.13

If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the closed-loop stability limit is reached.

#### Integral gain (Ki), Pr 0.08 {3.11} and Pr 3.14

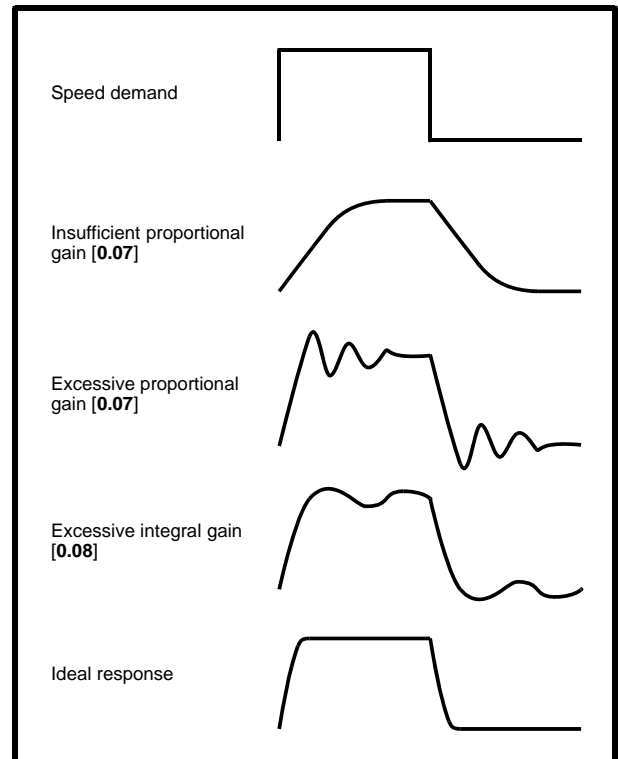
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain. A compromise must be reached where the system response, stiffness and damping are all adequate for the application.

#### Differential gain (Kd), Pr 0.09 {3.12} and Pr 3.15

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.

There are three methods of tuning the speed loop gains dependant on the setting of Pr 3.17:

- Pr 3.17 = 0, User set-up.  
This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.  
Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.  
The proportional gain (Kp) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.  
The integral gain (Ki) should then be increased up to the point where the speed becomes unstable and then reduced slightly.  
It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.  
The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
- Pr 3.17 = 1, Bandwidth set-up  
If bandwidth based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:  
Pr 3.20 - Required bandwidth,  
Pr 3.21 - Required damping factor,  
Pr 5.32 - Motor torque per amp (Kt).  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).
- Pr 3.17 = 2, Compliance angle set-up  
If compliance angle based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:  
Pr 3.19 - Required compliance angle,  
Pr 3.21 - Required damping factor,  
Pr 5.32 - Motor torque per amp (Kt).  
Pr 3.18 - Motor and load inertia. The drive can be made to measure the motor and load inertia by performing an inertia measurement autotune (see Autotune Pr 0.40, earlier in this table).



## 8.2 Maximum motor rated current

The maximum motor rated current allowed by the drive is greater than the maximum Heavy Duty current rating in Pr 11.32. The ratio between the Normal Duty rating and the Heavy Duty rating (Pr 11.32) varies between drive sizes. The values for the Normal and Heavy Duty rating can be found in section 2.1 *Ratings* on page 7.

If the motor rated current (Pr 0.46) is set above the maximum Heavy Duty current rating (Pr 11.32), the current limits and the motor thermal protection scheme are modified (see section 8.3 *Current limits* and section 8.4 *Motor thermal protection*, for more information).

## 8.3 Current limits

The default settings for the current limit parameters for SPz and sizes 1 to 5 are:

- 165% x motor rated current for open loop mode
- 175% x motor rated current for closed loop vector and servo modes (except SP2403 which is 150.1% for open loop, 175% for closed loop vector and 161.2% for servo).

The default settings for the current limit parameters for Unidrive SP size 6 are:

- 138.1% x motor rated current for open loop mode
- 165.7% x motor rated current for closed loop vector mode
- 150% x motor rated current for servo mode

There are three parameters which control the current limits:

- Motoring current limit: power flowing from the drive to the motor
- Regen current limit: power flowing from the motor to the drive
- Symmetrical current limit: current limit for both motoring and regen operation

The lowest of either the motoring and regen current limit, or the symmetrical current limit applies.

The maximum setting of these parameters depends on the values of motor rated current, drive rated current and the power factor.

Increasing the motor rated current (Pr 0.46/5.07) above the Heavy Duty rating (default value), will automatically reduce the current limits in Pr 4.05 to Pr 4.07. If the motor rated current is then set to or below the Heavy Duty rating, the current limits will be left at their reduced values.

The drive can be oversized to permit a higher current limit setting to provide higher accelerating torque as required up to a maximum of 1000%.

## 8.4 Motor thermal protection

The drive models the temperature of the motor using the motor rated current (Pr 5.07), the thermal time constant (Pr 4.15), whether low speed thermal protection mode has been enabled (Pr 4.25) and the actual current flowing at any point in time. Pr 4.19 gives the estimated motor temperature as a percentage of maximum temperature.

The temperature of the motor (Pr 4.19) as a percentage of maximum temperature, with a constant current magnitude of  $I$ , constant value of  $K$  and constant value of Motor rated current (Pr 5.07) after time  $t$  is given by:

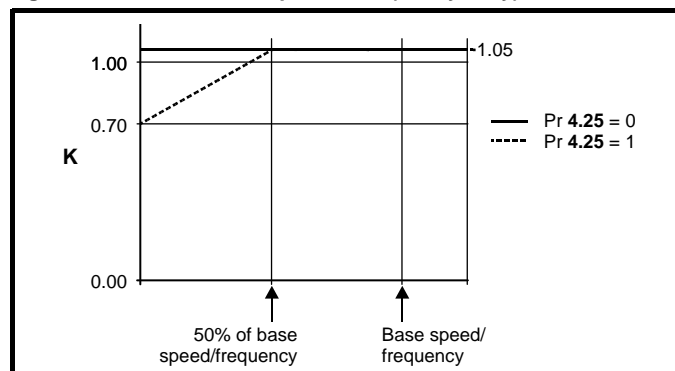
$$\text{Percentage motor temperature (Pr 4.19)} = [I^2 / (K \times \text{Motor rated current}^2)] (1 - e^{-t/\tau}) \times 100\%$$

This assumes that the maximum allowed motor temperature is produced by  $K \times \text{Motor rated current}$  and that  $\tau$  is the thermal time constant of the point in the motor that reaches its maximum allowed temperature first.  $\tau$  is defined by Pr 4.15. If Pr 4.15 has a value between 0.0 and 1.0 the thermal time constant is taken as 1.0.

The value of  $K$  is defined as shown in Figure 8-1 and Figure 8-2.

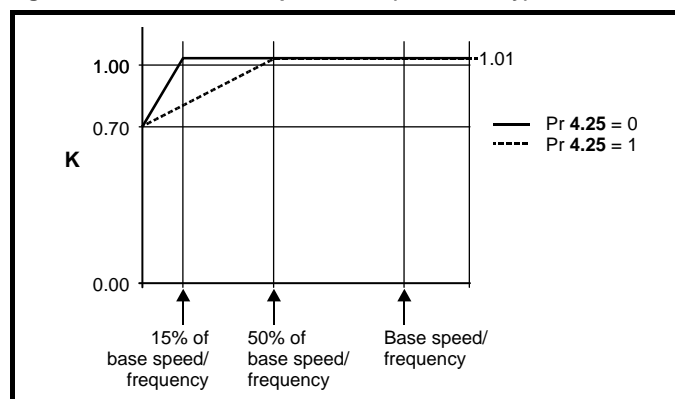
For both Heavy and Normal duty ratings, Pr 4.25 can be used to select two alternative protection characteristics.

Figure 8-1 Motor thermal protection (Heavy Duty)



If Pr 4.25 is 0 the characteristic is for a motor which can operate at rated current over the whole speed range. Induction motors with this type of characteristic normally have forced cooling. If Pr 4.25 is 1 the characteristic is intended for motors where the cooling effect of motor fan reduces with reduced motor speed below 50% of base speed/frequency. The maximum value for  $K$  is 1.05, so that above the knee of the characteristics the motor can operate continuously up to 105% current.

Figure 8-2 Motor thermal protection (Normal Duty)



Both settings of Pr 4.25 are intended for motors where the cooling effect of the motor fan reduces with reduced motor speed, but with different speeds below which the cooling effect is reduced. If Pr 4.25 is 0 the characteristic is intended for motors where the cooling effect reduces with motor speed below 15% of base speed/frequency. If Pr 4.25 is 1 the characteristic is intended for motors where the cooling effect reduces with motor speed below 50% of base speed/frequency. The maximum value for  $K$  is 1.01, so that above the knee of the characteristics the motor can operate continuously up to 101% current.

When the estimated temperature in Pr 4.19 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 Pr 4.19 reaches 100%. If Pr 4.16 is 1, the current limit is reduced to  $(K - 0.05) \times 100\%$  when Pr 4.19 reaches 100%. The current limit is set back to the user defined level when Pr 4.19 falls below 95%. The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the motor while the drive remains powered-up. If the rated current defined by Pr 5.07 is altered, the accumulator is reset to zero.

The default setting of the thermal time constant (Pr 4.15) is 89s for an induction motor (open loop and closed loop vector), which is equivalent to an overload of 150% for 60s from cold. The default value for a servo motor is 20s, which is equivalent to an overload of 175% for 9s from cold.

The time for the drive to trip from cold with constant motor current is given by:

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



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

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

The maximum value for the thermal time constant can be increased up to a maximum value of 3000s to allow an increased overload if the motor thermal characteristics permit.

For applications using Unimotors the thermal time constants can be found in the Unimotor manual.

## 8.5 Switching frequency

The default switching frequency is 3kHz (6kHz in Servo mode), however this can be increased up to a maximum of 16kHz by Pr 5.18 (dependent on drive size). The available switching frequencies are shown below.

**Table 8-1 Available switching frequencies**

Drive size	Model	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
0	All	✓	✓	✓	✓	✓	✓
1	All	✓	✓	✓	✓	✓	✓
2	All	✓	✓	✓	✓	✓	✓
3	11TL & 16TL	✓	✓	✓	✓	✓	
	22T & 27T	✓	✓	✓	✓	✓	✓
	33T	✓	✓	✓	✓	✓	
	3,5TM to 22TM	✓	✓	✓	✓		
4	All	✓	✓	✓	✓		
5	All	✓	✓	✓	✓		
6	All	✓	✓	✓			

If switching frequency is increased from 3kHz the following apply:

- Increased heat loss in the drive, which means that derating to the output current must be applied.  
See the derating tables for switching frequency and ambient temperature in section 12.1.1 *Power and current ratings (Derating for switching frequency and temperature)*.
- Reduced heating of the motor - due to improved output waveform quality.
- Reduced acoustic noise generated by the motor.
- Increased sample rate on the speed and current controllers. A trade off must be made between motor heating, drive heating and the demands of the application with respect to the sample time required.

**Table 8-2 Sample rates for various control tasks at each switching frequency**

	3, 6, 12 kHz	4, 8, 16 kHz	Open loop	Closed loop vector and Servo
Level 1	3kHz = 167µs 6kHz = 83µs 12kHz = 83µs	125µs	Peak limit	Current controllers
Level 2	250µs		Current limit and ramps	Speed controller and ramps
Level 3	1ms		Voltage controller	
Level 4	4ms		Time critical user interface	
Background			Non-time critical user interface	

## 8.6 High speed operation

### 8.6.1 Encoder feedback limits

The maximum encoder frequency should be prevented from exceeding 500kHz (or 410kHz for software V01.06.00 and earlier). In closed loop and servo modes the maximum speed that can be entered in to the speed reference clamps (Pr 1.06 and Pr 1.07) can be limited by the drive. This is defined by the following (subject to an absolute maximum of 40,000rpm):

$$\text{Maximum speed limit (rpm)} = \frac{500\text{kHz} \times 60}{\text{ELPR}}$$

$$= \frac{3.0 \times 10^7}{\text{ELPR}}$$

Where:

ELPR is the equivalent encoder lines per revolution and is the number of lines that would be produced by a quadrature encoder.

- Quadrature encoder ELPR = number of lines per revolution
- F and D encoder ELPR = number of lines per revolution / 2
- SINCOS encoder ELPR = number of sine waves per revolution

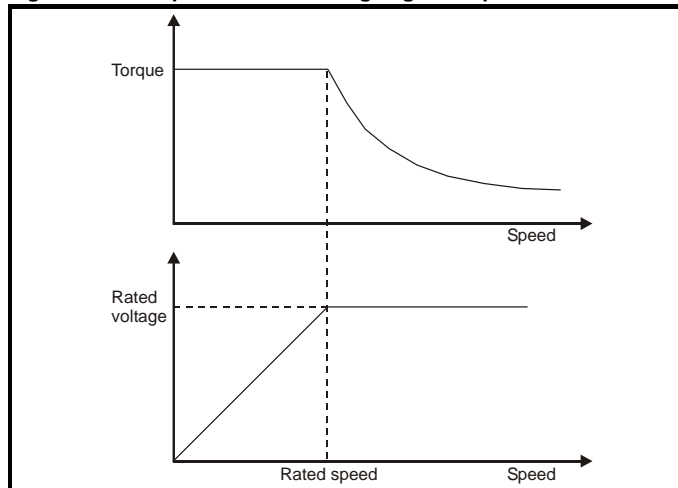
This maximum speed limit is defined by the device selected with the speed feedback selector (Pr 3.26), and the ELPR set for the position feedback device. In closed-loop vector mode it is possible to disable this limit via Pr 3.24, so that the drive can be switched between operation with and without feedback when the speed becomes too high for the feedback device. The maximum speed limit is defined as above when Pr 3.24 = 0 or 1, and is 40,000rpm when Pr 3.24 = 2 or 3.

### 8.6.2 Field weakening (constant power) operation

(Open loop and closed loop vector mode only)

The drive can be used to run an induction machine above synchronous speed into the constant power region. The speed continues to increase and the available shaft torque reduces. The characteristics below show the torque and output voltage characteristics as the speed is increased above the rated value.

**Figure 8-3 Torque and rated voltage against speed**



Care must be taken to ensure the torque available above base speed is sufficient for the application to run satisfactorily.

The saturation breakpoint parameters (Pr 5.29 and Pr 5.30) found during the autotune in closed loop vector mode ensure the magnetising current is reduced in the correct proportion for the specific motor. (In open loop mode the magnetising current is not actively controlled.)

### 8.6.3 Servo high speed operation

High speed servo mode is enabled by setting Pr 5.22 = 1. Care must be taken when using this mode with servo motors to avoid damaging the drive. The voltage produced by the servo motor magnets is proportional to speed. For high speed operation the drive must apply currents to the motor to counter-act the flux produced by the magnets. It is possible to operate the motor at very high speeds that would give a very high motor terminal voltage, but this voltage is prevented by the action of the drive.

If however, the drive is disabled (or tripped) when the motor voltages would be higher than the rating of the drive without the currents to counter-act the flux from the magnets, it is possible to damage the drive. If high speed mode is enabled the motor speed must be limited to the levels given in the table below unless an additional hardware protection system is used to limit the voltages applied to the drive output terminals to a safe level.

Drive voltage rating	Maximum motor speed (rpm)	Maximum safe line to line voltage at the motor terminals (V rms)
200	$400 \times 1000 / (K_e \times \sqrt{2})$	$400 / \sqrt{2}$
400	$800 \times 1000 / (K_e \times \sqrt{2})$	$800 / \sqrt{2}$
575	$955 \times 1000 / (K_e \times \sqrt{2})$	$955 / \sqrt{2}$
690	$1145 \times 1000 / (K_e \times \sqrt{2})$	$1145 / \sqrt{2}$

$K_e$  is the ratio between r.m.s. line to line voltage produced by the motor and the speed in V/1000rpm. Care must also be taken not to demagnetize the motor. The motor manufacturer should always be consulted before using this mode.

### 8.6.4 Switching frequency

With a default switching frequency of 3 kHz the maximum output frequency should be limited to 250 Hz. Ideally a minimum ratio of 12:1 should be maintained between the output frequency and the switching frequency. This ensures the number of switchings per cycle is sufficient to ensure the output waveform quality is maintained at a minimum level. If this is not possible, quasi-square switching should be enabled (Pr 5.20 =1). The output waveform will be quasi square above base speed ensuring a symmetrical output waveform, which results in a better quality output than would otherwise result.

### 8.6.5 Maximum speed / frequency

In open loop mode the maximum frequency is 3,000 Hz.

In closed loop vector mode the maximum output frequency is 600 Hz.

In servo mode the maximum output frequency is 1250Hz, however the speed is limited by the voltage constant ( $K_e$ ) of the motor.  $K_e$  is a specific constant for the servo motor being used. It can normally be found on the motor data sheet in V/krpm (volts per 1,000rpm).

### 8.6.6 Quasi-Square wave (open-loop only)

The maximum output voltage level of the drive is normally limited to an equivalent of the drive input voltage minus voltage drops within the drive (the drive will also retain a few percent of the voltage in order to maintain current control). If the motor rated voltage is set at the same level as the supply voltage, some pulse deletion will occur as the drive output voltage approaches the rated voltage level. If Pr 5.20 (Quasi-square wave enable) is set to 1 the modulator will allow over modulation, so that as the output frequency increases beyond the rated frequency the voltage continues to increase above the rated voltage. The modulation depth will increase beyond unity; first producing trapezoidal and then quasi-square waveforms.

This can be used for example:

- To obtain high output frequencies with a low switching frequency which would not be possible with space vector modulation limited to unity modulation depth,

or

- In order to maintain a higher output voltage with a low supply voltage.

The disadvantage is that the machine current will be distorted as the modulation depth increases above unity, and will contain a significant amount of low order odd harmonics of the fundamental output frequency. The additional low order harmonics cause increased losses and heating in the motor.

# 9 SMARTCARD operation

## 9.1 Introduction

This is a standard feature that enables simple configuration of parameters in a variety of ways. The SMARTCARD can be used for:

- Parameter copying between drives
- Saving whole drive parameter sets
- Saving 'differences from default' parameter sets
- Storing Onboard PLC programs
- Automatically saving all user parameter changes for maintenance purposes
- Loading complete motor map parameters

### SPz

When inserting the SMARTCARD, always ensure that ST SPz arrow points upwards.

### Size 1 to 6

The SMARTCARD is located at the top of the module under the drive display (if installed) on the left-hand side. Ensure the SMARTCARD is inserted with the SP1-9 arrow pointing upwards.

The drive only communicates with the SMARTCARD when commanded to read or write, meaning the card may be "hot swapped".



### Encoder phase angle (servo mode only)

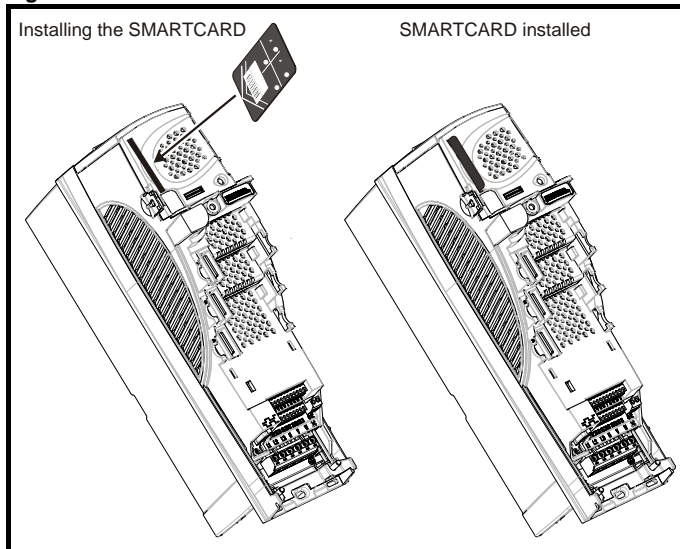
With drive software version V01.08.00 onwards, the encoder phase angles in Pr 3.25 and Pr 21.20 are copied to the SMARTCARD when using any of the SMARTCARD transfer methods.

With drive software version V01.05.00 to V01.07.01, the encoder phase angles in Pr 3.25 and Pr 21.20 are only copied to the SMARTCARD when using either Pr 0.30 set to Prog (2) or Pr xx.00 set to 3yyy.

This is useful when the SMARTCARD is used to back-up the parameter set of a drive but caution should be used if the SMARTCARD is used to transfer parameter sets between drives. Unless the encoder phase angle of the servo motor connected to the destination drive is known to be the same as the servo motor connected to the source drive, an autotune should be performed or the encoder phase angle should be entered manually into Pr 3.25 (or Pr 21.20). If the encoder phase angle is incorrect the drive may lose control of the motor resulting in an O.SPd or Enc10 trip when the drive is enabled.

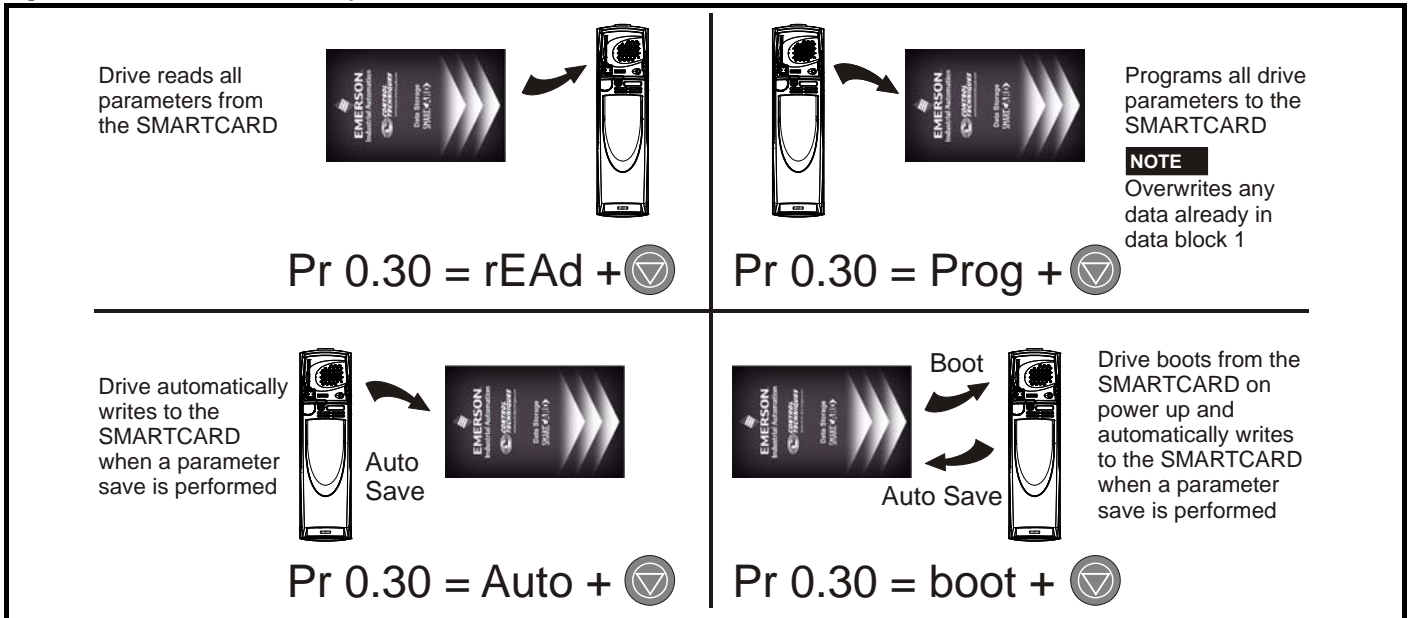
With drive software version V01.04.00 and earlier, or when using software version V01.05.00 to V01.07.01 and Pr xx.00 set to 4yyy is used, then the encoder phase angles in Pr 3.25 and Pr 21.20 are not copied to the SMARTCARD. Therefore, Pr 3.25 and Pr 21.20 in the destination would not be changed during a transfer of this data block from the SMARTCARD.

Figure 9-1 Installation of the SMARTCARD



## Easy saving and reading

Figure 9-2 Basic SMARTCARD operation



The SMARTCARD has 999 individual data block locations. Each individual location from 1 to 499 can be used to store data until the capacity of the SMARTCARD is used. With software V01.07.00 and later the drive can support SMARTCARDS with a capacity of between 4kB and 512kB. With software V01.06.02 and earlier the drive can support SMARTCARDS with a capacity of 4kB.

The data block locations of the SMARTCARD are arranged to have the following usage:

Table 9-1 SMARTCARD data blocks

Data Block	Type	Example Use
1 to 499	Read / Write	Application set ups
500 to 999	Read Only	Macros

'Differences from default' parameter sets will be much smaller than whole parameter sets and thus take up a lot less memory as most applications only require a few parameters to be changed from the default setting.

The whole card may be protected from writing or erasing by setting the read-only flag as detailed section 9.2.9 9888 / 9777 - *Setting and clearing the SMARTCARD read only flag* on page 142.

Data transfer to or from the SMARTCARD is indicated by one the following:

- SM-Keypad/SPz Keypad: The decimal point after the fourth digit in the upper display will flash.
- SM-Keypad Plus: The symbol 'CC' will appear in the lower left hand corner of the display

The card should not be removed during data transfer, as the drive will produce a trip. If this occurs then either the transfer should be reattempted or in the case of a card to drive transfer, default parameters should be loaded.

## 9.2 Transferring data

Data transfer, erasing and protecting the information is performed by entering a code in Pr **xx.00** and then resetting the drive as shown in Table 9-2.

Table 9-2 SMARTCARD codes

Code	Action
2001	Transfer drive parameters as difference from defaults to a bootable SMARTCARD block in data block number 001
3yyy	Transfer drive parameters to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive Onboard PLC 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
9555	Clear SMARTCARD warning suppression flag (V01.07.00 and later)
9666	Set SMARTCARD warning suppression flag (V01.07.00 and later)
9777	Clear SMARTCARD read-only flag
9888	Set SMARTCARD read-only flag
9999	Erase SMARTCARD

Where yyy indicates the block number 001 to 999. See Table 9-1 for restrictions on block numbers.

### NOTE

If the read only flag is set then only codes 6yyy or 9777 are effective.

### 9.2.1 Writing to the SMARTCARD

#### 3yyy - Transfer data to the SMARTCARD

The data block contains the complete parameter data from the drive, i.e. all user save (US) parameters except parameters with the NC coding bit set. Power-down save (PS) parameters are not transferred to the SMARTCARD.

With software V01.06.02 and earlier, a save must have been performed on the drive to transfer the parameters from the drive RAM to the EEPROM before the transfer to the SMARTCARD is carried out.

## 4yyy - Write default differences to a SMARTCARD

The data block only contains the parameter differences from the last time default settings were loaded.

Six bytes are required for each parameter difference. The data density is not as high as when using the 3yyy transfer method as 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. Power-down save (PS) parameters are not transferred to the SMARTCARD.

The data block format is different depending on the software version. The data block holds the following parameters:

### Software V01.06.02 and earlier

All user save (US) parameters, except those with the NC (Not copied) coding bit set or those that do not have a default value, can be transferred to the SMARTCARD.

### Software V01.07.xx

All user save (US) parameters, except those with the NC (Not copied) coding bit set or those that do not have a default value, can be transferred to the SMARTCARD. In addition to these parameters all menu 20 parameters (except Pr 20.00), can be transferred to the SMARTCARD even though they are not user save parameters and have the NC coding bit set.

### Software V01.08.00 onwards

All user save (US) parameters including those that do not have a default value (i.e. Pr 3.25 or Pr 21.20 *Encoder phase angle*), but not including those with the NC (Not copied) coding bit set can be transferred to the SMARTCARD. In addition to these parameters all menu 20 parameters (except Pr 20.00), can be transferred to the SMARTCARD even though they are not user save parameters and have the NC coding bit set.

It is possible to transfer parameters between drives with each of the different formats, however, the data block compare function does not work with data produced by different formats.

## Writing a parameter set to the SMARTCARD (Pr 11.42 = Prog (2))

Setting Pr 11.42 to Prog (2) and resetting the drive will save the parameters to the SMARTCARD, i.e. this is equivalent to writing 3001 to Pr xx.00. All SMARTCARD trips apply except 'C.Chg'. If the data block already exists it is automatically overwritten. When the action is complete this parameter is automatically reset to nonE (0).

## 9.2.2 Reading from the SMARTCARD

### 6yyy - Read default differences from a SMARTCARD

When the data is transferred back to a drive, using 6yyy in Pr xx.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. Set up data for any Solutions Modules installed are stored on the card and are transferred to the destination drive. If the Solutions Modules are different between the source and destination drive, the menus for the slots where the Solutions Module categories are different are not updated from the card and will contain their default values after the copying action. The drive will produce a 'C.Optn' trip if the Solutions Modules installed to the source and destination drive are different or are in different slots. If the data is being transferred to a drive of a different voltage or current rating a 'C.rtg' trip will occur.

The following drive rating dependant parameters (RA coding bit set) will not be transferred to the destination drive by a SMARTCARD when the rating of the destination drive is different from the source drive and the file is a parameter file (i.e. created using the 3yyy transfer method). However, with software V01.09.00 and later drive rating dependent parameters will be transferred if only the current rating is different and the file is a differences from default type file (i.e. created using the 4yyy transfer method). If drive rating dependant parameters are not transferred to the destination drive they will contain their default values.

Pr 2.08 *Standard ramp voltage*

Pr 4.05 to Pr 4.07 and Pr 21.27 to Pr 21.29 *Current limits*

Pr 4.24, *User current maximum scaling*

Pr 5.07, Pr 21.07 *Motor rated current*

Pr 5.09, Pr 21.09 *Motor rated voltage*

Pr 5.10, Pr 21.10 *Rated power factor*

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*

Pr 6.48 *Line power supply loss ride through detection level*

## Reading a parameter set from the SMARTCARD (Pr 11.42 = rEAd (1))

Setting Pr 11.42 to rEAd (1) and resetting the drive will transfer the parameters from the card into the drive parameter set and the drive EEPROM, i.e. this is equivalent to writing 6001 to Pr xx.00. All SMARTCARD trips apply. Once the parameters are successfully copied this parameter is automatically reset to nonE (0). Parameters are saved to the drive EEPROM after this action is complete.

### NOTE

This operation is only performed if data block 1 on the card is a full parameter set (3yyy transfer) and not a default difference file (4yyy transfer). If block 1 does not exist a 'C.dAt' trip occurs.

## 9.2.3 Auto saving parameter changes (Pr 11.42 = Auto (3))

This setting causes the drive to automatically save any changes made to menu 0 parameters on the drive to the SMARTCARD. The latest menu 0 parameter set in the drive is therefore always backed up on the SMARTCARD. Changing Pr 11.42 to Auto (3) and resetting the drive will immediately save the complete parameter set from the drive to the card, i.e. all user save (US) parameters except parameters with the NC coding bit set. Once the whole parameter set is stored only the individual modified menu 0 parameter setting is updated.

Advanced parameter changes are only saved to the card when Pr xx.00 is set to a 1000 and the drive reset.

All SMARTCARD trips apply, except 'C.Chg'. If the data block already contains information it is automatically overwritten.

If the card is removed when Pr 11.42 is set to 3 Pr 11.42 is then automatically set to nonE (0).

When a new SMARTCARD is installed Pr 11.42 must be set back to Auto (3) by the user and the drive reset so the complete parameter set is rewritten to the new SMARTCARD if auto mode is still required.

When Pr 11.42 is set to Auto (3) and the parameters in the drive are saved, the SMARTCARD is also updated, therefore the SMARTCARD becomes a copy of the drives stored configuration.

At power up, if Pr 11.42 is set to Auto (3), the drive will save the complete parameter set to the SMARTCARD. The drive will display 'cArD' during this operation. This is done to ensure that if a user puts a new SMARTCARD in during power down the new SMARTCARD will have the correct data.

### NOTE

When Pr 11.42 is set to Auto (3) the setting of Pr 11.42 itself is saved to the drive EEPROM but NOT to the SMARTCARD.

## 9.2.4 Booting up from the SMARTCARD on every power up (Pr 11.42 = boot (4))

When Pr 11.42 is set to boot (4) the drive operates the same as Auto mode except when the drive is powered-up. The parameters on the SMARTCARD will be automatically transferred to the drive at power up if the following are true:

- A card is inserted in the drive
- Parameter data block 1 exists on the card
- The data in block 1 is type 1 to 5 (as defined in Pr 11.38)
- Pr 11.42 on the card set to boot (4)

The drive will display 'boot' during this operation. 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 'boot' mode is stored on the copying SMARTCARD this makes the copying SMARTCARD the master device. This provides a very fast and efficient way of re-programming a number of drives.

If data block 1 contains a bootable parameter set and data block 2 contains an Onboard PLC program (type 17 as defined in Pr 11.38), then if the drive software version is V01.07.00 and later, the onboard PLC program will be transferred to the drive at power up along with the parameter set in data block 1.

**NOTE**

'Boot' mode is saved to the card, but when the card is read, the value of Pr 11.42 is not transferred to the drive.

**9.2.5 Booting up from the SMARTCARD on every power up (Pr xx.00 = 2001), software V01.08.00 and later**

It is possible to create a difference from default bootable file by setting Pr xx.00 to 2001 and resetting the drive. This type of file causes the drive to behave in the same way at power-up as a file created with boot mode set up with Pr 11.42. The difference from the default file is that it has the added advantage of including menu 20 parameters.

Setting Pr xx.00 to 2001 will overwrite data block 1 on the card if it already exists.

If a data block 2 exists and contains an Onboard PLC program (type 17 as defined in Pr 11.38), this will also be loaded after the parameters have been transferred

A bootable difference from default file can only be created in one operation and parameters cannot be added as they are saved via menu 0.

**9.2.6 8yyy - Comparing the drive full parameter set with the SMARTCARD values**

Setting 8yyy in Pr xx.00, will compare the SMARTCARD file with the data in the drive. If the compare is successful Pr xx.00 is simply set to 0. If the compare fails a 'C.cpr' trip is initiated.

**9.2.7 7yyy / 9999 - Erasing data from the SMARTCARD**

Data can be erased from the SMARTCARD either one block at a time or all blocks in one go.

- Setting 7yyy in Pr xx.00 will erase SMARTCARD data block yyy.
- Setting 9999 in Pr xx.00 will erase all SMARTCARD data blocks

**9.2.8 9666 / 9555 - Setting and clearing the SMARTCARD warning suppression flag (V01.07.00 and later)**

If the Solutions Modules installed to the source and destination drive are different or are in different slots the drive will produce a 'C.Optn' trip. If the data is being transferred to a drive of a different voltage or current rating a 'C.rtg' trip will occur. It is possible to suppress these trips by setting the warning suppression flag. If this flag is set the drive will not trip if the Solutions Module(s) or drive ratings are different between the source and destination drives. The Solutions Module or rating dependent parameters will not be transferred.

- Setting 9666 in Pr xx.00 will set the warning suppression flag
- Setting 9555 in Pr xx.00 will clear the warning suppression flag

**9.2.9 9888 / 9777 - Setting and clearing the SMARTCARD read only flag**

The SMART CARD may be protected from writing or erasing by setting the read only flag. If an attempt is made to write or erase a data block when the read only flag is set, a 'C.rdo' trip is initiated. When the read only flag is set only codes 6yyy or 9777 are effective.

- Setting 9888 in Pr xx.00 will set the read only flag
- Setting 9777 in Pr xx.00 will clear the read only flag.

**9.3 Data block header information**

Each data block stored on a SMARTCARD has header information detailing the following:

- A number which identifies the block (Pr 11.37)
- The type of data stored in the block (Pr 11.38)
- The drive mode if the data is parameter data (Pr 11.38)
- The version number (Pr 11.39)
- The checksum (Pr 11.40)
- The read-only flag
- The warning suppression flag (V01.07.00 and later)

The header information for each data block which has been used can be viewed in Pr 11.38 to Pr 11.40 by increasing or decreasing the data block number set in Pr 11.37.

**Software V01.07.00 and later**

If Pr 11.37 is set to 1000 the checksum parameter (Pr 11.40) shows the number of 16 byte pages left on the card.

If Pr 11.37 is set to 1001 the checksum parameter (Pr 11.40) shows the total capacity of the card in 16 byte pages. Therefore, for a 4kB card this parameter would show 254.

If Pr 11.37 is set to 1002 the checksum parameter (Pr 11.40) shows the state of the read-only (bit 0) and warning suppression flags (bit 1).

Software version V01.11.00 and later: If Pr 11.37 is set to 1003, the checksum parameter (Pr 11.40) shows the product identifier (255 = Unidrive SP, 2 = Digitax ST).

If there is no data on the card Pr 11.37 can only have values of 0 or 1000 to 1003.

**Software V01.06.02 and earlier**

If Pr 11.37 is set to 1000 the checksum parameter (Pr 11.40) 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 version number 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, Pr 11.39 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 Pr 11.39.

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.

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 file number in the card.

**9.4 SMARTCARD parameters**

**Table 9-3 Key to parameter table coding**

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

<b>11.36 {0.29} SMARTCARD parameter data previously loaded</b>	
RO	Uni
↕	0 to 999
⇒	0

This parameter shows the number of the data block last transferred from a SMARTCARD to the drive.

<b>11.37 SMARTCARD data number</b>	
RW	Uni
↕	0 to 1003
⇒	0

This parameter should have the data block number entered for which the user would like information displayed in Pr 11.38, Pr 11.39 and Pr 11.40.

<b>11.38</b>		<b>SMARTCARD data type/mode</b>													
RW	Txt											NC	PT		
⇅	0 to 18										⇒				

Gives the type/mode of the data block selected with Pr 11.37:

Pr 11.38	String	Type/mode	Data stored
0	FrEE	Value when Pr 11.37 = 0, 1000 to 1003	Data from EEPROM
1		Reserved	
2	3OpEn.LP	Open-loop mode parameters	
3	3CL.VECt	Closed-loop vector mode parameters	
4	3SErVO	Servo mode parameters	
5	3rEgEn	Regen mode parameters	
5		Reserved	
6 to 8	3Un	Unused	
9		Reserved	
10	4OpEn.LP	Open-loop mode parameters	Defaults last loaded and differences
11	4CL.VECt	Closed-loop vector mode parameters	
12	4SErVO	Servo mode parameters	
13	4rEgEn	Regen mode parameters	
14 to 16	4Un	Unused	
17	LAddEr	Onboard PLC program	
18	Option	A Solutions Module file	

<b>11.39</b>		<b>SMARTCARD data version</b>													
RW	Uni												NC		
⇅	0 to 9,999										⇒	0			

Gives the version number of the data block selected in Pr 11.37.

<b>11.40</b>		<b>SMARTCARD data checksum</b>													
R0	Uni												NC	PT	
⇅	0 to 65,335										⇒				

Gives the checksum of the data block selected in Pr 11.37.

<b>11.42 {0.30}</b>		<b>Parameter copying</b>													
RW	Txt												NC		US*
⇅	0 to 4										⇒	nonE (0)			

**NOTE**




If Pr 11.42 is equal to 1 or 2, this value is not transferred to the drive or saved to the EEPROM. If Pr 11.42 is set to a 3 or 4 the value is transferred.

- nonE (0) = Inactive
- rEAd (1) = Read parameter set from the SMARTCARD
- Prog (2) = Programming a parameter set to the SMARTCARD
- Auto (3) = Auto save
- boot (4) = Boot mode

## 9.5 SMARTCARD trips



After an attempt to read, write or erase data to or from a SMARTCARD a trip may occur if there has been a problem with the command. The following trips indicate various problems as detailed in Table 9-4.

Table 9-4 Trip conditions

Trip	Diagnosis
<b>C.Acc</b>	<b>SMARTCARD trip: SMARTCARD Read / Write fail</b>
185	Check SMARTCARD is installed / located correctly Ensure SMARTCARD is not writing data to data location 500 to 999 Replace SMARTCARD
<b>C.boot</b>	<b>SMARTCARD trip: The menu 0 parameter modification cannot be saved to the SMARTCARD because the necessary file has not been created on the SMARTCARD</b>
177	A write to a menu 0 parameter has been initiated via the keypad with Pr 11.42 set to auto(3) or boot(4), but the necessary file on the SMARTCARD has not been created Ensure that Pr 11.42 is correctly set and reset the drive to create the necessary file on the SMARTCARD Re-attempt the parameter write to the menu 0 parameter
<b>C.bUSY</b>	<b>SMARTCARD trip: SMARTCARD can not perform the required function as it is being accessed by a Solutions Module</b>
178	Wait for the Solutions Module to finish accessing the SMARTCARD and then re-attempt the required function
<b>C.Chg</b>	<b>SMARTCARD trip: Data location already contains data</b>
179	Erase data in data location Write data to an alternative data location
<b>C.Cpr</b>	<b>SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different</b>
188	Press the red  reset button
<b>C.dat</b>	<b>SMARTCARD trip: Data location specified does not contain any data</b>
183	Ensure data block number is correct
<b>C.Err</b>	<b>SMARTCARD trip: SMARTCARD data is corrupted</b>
182	Ensure the card is located correctly Erase data and retry Replace SMARTCARD
<b>C.Full</b>	<b>SMARTCARD trip: SMARTCARD full</b>
184	Delete a data block or use a different SMARTCARD
<b>C.Optn</b>	<b>SMARTCARD trip: Solutions Modules installed are different between source drive and destination drive</b>
180	Ensure correct Solutions Modules are installed Ensure Solutions Modules are in the same Solutions Module slot Press the red  reset button
<b>C.Prod</b>	<b>SMARTCARD trip: The data blocks on the SMARTCARD are not compatible with this product</b>
175	Erase all data on the SMARTCARD by setting Pr <b>xx.00</b> to 9999 and pressing the red  reset button Replace SMARTCARD
<b>C.rdo</b>	<b>SMARTCARD trip: SMARTCARD has the Read only bit set</b>
181	Enter 9777 in Pr <b>xx.00</b> to allow SMARTCARD Read / Write access Ensure the drive is not writing to data locations 500 to 999 on the card



**Table 9-4 Trip conditions**

Trip	Diagnosis																												
<b>C.rtg</b>	<b>SMARTCARD trip: The voltage and/or current rating of the source and destination drives are different</b>																												
186	<p>Drive rating dependent parameters (parameters with the RA coding) are likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDs when the rating of the destination drive is different from the source drive and the file is a parameter file. However, with software V01.09.00 and later drive rating dependent parameters will be transferred if only the current rating is different and the file is a differences from default type file.</p> <p>Press the red  reset button</p> <p>Drive rating parameters are:</p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>2.08</td> <td>Standard ramp voltage</td> </tr> <tr> <td>4.05/6/7, 21.27/8/9</td> <td>Current limits</td> </tr> <tr> <td>4.24</td> <td>User current maximum scaling</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>5.10, 21.10</td> <td>Rated power factor</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> <tr> <td>6.48</td> <td>Line power supply loss ride through detection level</td> </tr> </tbody> </table> <p>The above parameters will be set to their default values.</p>	Parameter	Function	2.08	Standard ramp voltage	4.05/6/7, 21.27/8/9	Current limits	4.24	User current maximum scaling	5.07, 21.07	Motor rated current	5.09, 21.09	Motor rated voltage	5.10, 21.10	Rated power factor	5.17, 21.12	Stator resistance	5.18	Switching frequency	5.23, 21.13	Voltage offset	5.24, 21.14	Transient inductance	5.25, 21.24	Stator inductance	6.06	DC injection braking current	6.48	Line power supply loss ride through detection level
Parameter	Function																												
2.08	Standard ramp voltage																												
4.05/6/7, 21.27/8/9	Current limits																												
4.24	User current maximum scaling																												
5.07, 21.07	Motor rated current																												
5.09, 21.09	Motor rated voltage																												
5.10, 21.10	Rated power factor																												
5.17, 21.12	Stator resistance																												
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5.23, 21.13	Voltage offset																												
5.24, 21.14	Transient inductance																												
5.25, 21.24	Stator inductance																												
6.06	DC injection braking current																												
6.48	Line power supply loss ride through detection level																												
<b>C.Typ</b>	<b>SMARTCARD trip: SMARTCARD parameter set not compatible with drive</b>																												
187	<p>Press the red  reset button</p> <p>Ensure destination drive type is the same as the source parameter file drive type</p>																												

**Table 9-5 SMARTCARD status indications**

Lower display	Description	Lower display	Description
<b>boot</b>	A parameter set is being transferred from the SMARTCARD to the drive during power-up. For further information, please refer to section 9.2.4 <i>Booting up from the SMARTCARD on every power up (Pr 11.42 = boot (4))</i> .	<b>cArd</b>	The drive is writing a parameter set to the SMARTCARD during power-up. For further information, please refer to section 9.2.3 <i>Auto saving parameter changes (Pr 11.42 = Auto (3))</i> .

## 10 Onboard PLC

### 10.1 Onboard PLC and SYPTLite

The drive has the ability to store and execute a 4KB Onboard PLC ladder logic program without the need for additional hardware in the form of a Solutions Module.

The ladder logic program is written using SYPTLite, a Windows™ based ladder diagram editor allowing the development of programs for execution in Unidrive SP or SM-Applications Lite.

SYPTLite is designed to be easy to use and to make program development as simple as possible. The features provided are a sub-set of those in the SYPT program editor. SYPTLite programs are developed using ladder logic, a graphical language widely used to program PLCs (IEC61131-3). SYPTLite allows the user to "draw" a ladder diagram representing a program.

SYPTLite provides a complete environment for the development of ladder diagrams. Ladder diagrams can be created, compiled into user programs and downloaded to a Unidrive SP or SM-Applications Lite for execution, via the RJ45 serial communications port on the front of the drive. The run-time operation of the compiled ladder diagram on the target can also be monitored using SYPTLite and facilities are provided to interact with the program on the target by setting new values for target parameters.

SYPTLite is available on the CD which is supplied with the drive.

### 10.2 Benefits

The combination of the Onboard PLC and SYPTLite, means that the drive can replace nano and some micro PLCs in many applications. The Onboard PLC programs can consist of up to a maximum of 50 ladder logic rungs (up to 7 function blocks and 10 contacts per rung). The Onboard PLC program can also be transferred to and from a SMARTCARD for backup or quick commissioning/start-up

In addition to the basic ladder symbols, SYPTLite contains a sub-set of the function from the full version of SYPT. These include,

- Arithmetic blocks
- Comparison blocks
- Timers
- Counters
- Multiplexers
- Latches
- Bit manipulation

Typical applications for the Onboard PLC include,

- Ancillary pumps
- Fans and control valves
- Interlocking logic
- Sequences routines
- Custom control words.

### 10.3 Limitations

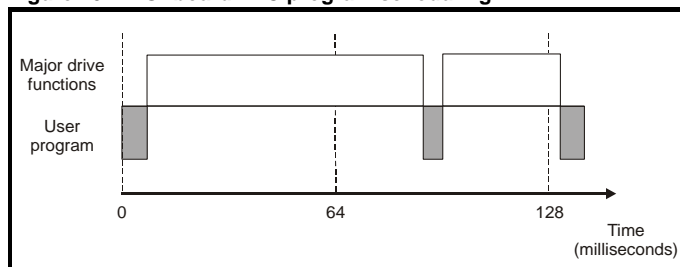
Compared with the Applications Modules (SM-Applications, SM-Applications Lite and SM-Applications Plus) when programmed with SYPT, the Onboard PLC program has the following limitations:

- The maximum program size is 4032 bytes including header and optional source code.
- The drive is rated for 100 program downloads. This limitation is imposed by the flash memory used to store the program within the drive.
- The user cannot create user variables. The user is only able to manipulate the drive parameter set.
- The program cannot be downloaded or monitored over CTNet. The program is only accessible via the drives RJ45 serial communications port.
- There are no real-time tasks, i.e. the scheduling rate of the program cannot be guaranteed. Applications Modules tasks such as Clock, Event, Pos0 or Speed are not available. The Onboard PLC should

not be used for time-critical applications. For time-critical applications Unidrive SP and an SM-Applications Plus, SM-Applications or SM-Applications Lite should be used.

- The program runs at a low priority. The drive provides a single background task in which to run a ladder diagram. The drive is prioritised to perform its major functions first, e.g. motor control, and will use any remaining processing time to execute the ladder diagram as a background activity. As the drive's processor becomes more heavily loaded, less time is spent executing the program.

**Figure 10-1 Onboard PLC program scheduling**

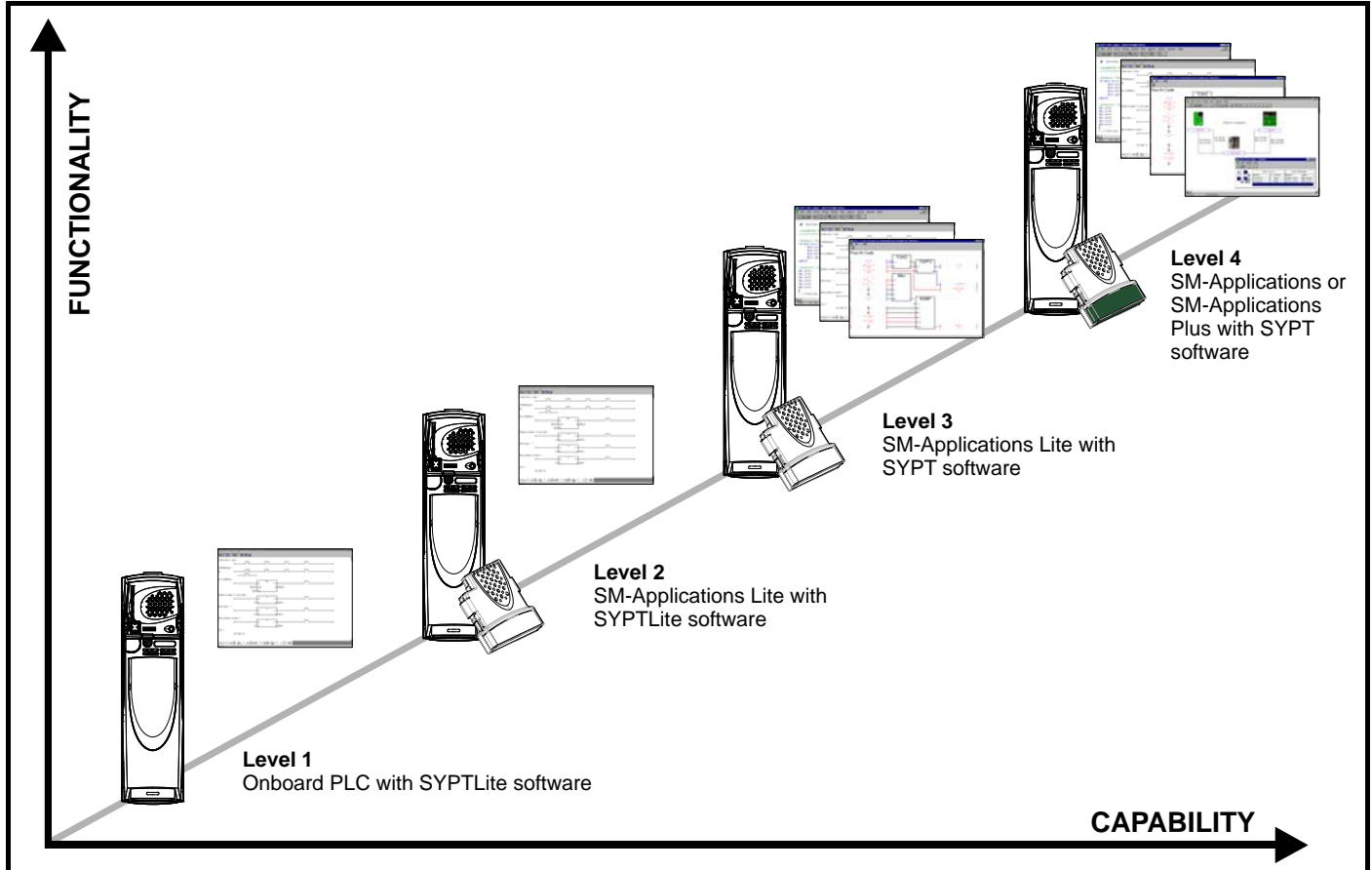


The user program is scheduled for a short period approximately once every 64ms. The time for which the program is scheduled will vary between 0.2ms and 2ms depending on the loading of the drive's processor.

When scheduled, several scans of the user program may be performed. Some scans may execute in microseconds. However, when the main drive functions are scheduled there will be a pause in the execution of the program causing some scans to take many milliseconds. SYPTLite displays the average execution time calculated over the last 10 scans of the user program.

The Onboard PLC and SYPTLite form the first level of functionality in a range of programmable options for Unidrive SP.

**Figure 10-2 Programming options for Unidrive SP**



SYPTLite can be used with either the Onboard PLC in the Unidrive SP or with SM-Applications Lite to create ladder logic programs.

SYPT can be used with any of the Applications Modules to create fully flexible programs using ladder logic, function blocks or DPL script.

## 10.4 Getting started

SYPTLite can be found on the CD which is supplied with the drive.

### SYPTLite system requirements

- Windows 2000/XP/Vista. **Windows 95/98/98SE/Me/NT4 are not supported**
- Pentium III 500MHz or better recommended
- 128MB RAM
- Minimum of 800x600 screen resolution. 1024x768 is recommended
- Adobe Acrobat 5.10 or later (for viewing User Guides)
- Microsoft Internet Explorer V5.0 or later
- RS232 to RS485, RJ45 communications lead to connect the PC to the drive
- Administrator rights are required to install the software

To install SYPTLite, insert the CD and the auto-run facility should start up the front-end screen, from which SYPTLite can be selected.

See the SYPTLite help file for more information regarding using SYPTLite, creating ladder diagrams and the available function blocks.

## 10.5 Onboard PLC parameters

The following parameters are associated with the Onboard PLC program.

11.47		Drive Onboard PLC program enable							
RW	Uni							US	
↕		0 to 2				⇒	2		

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 installed). 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 installed). Any out-of-range parameter writes attempted will cause a 'UP ovr' trip.

11.48		Drive Onboard PLC program status					
RO	Bi				NC	PT	
↕		-128 to +127				⇒	

The drive Onboard PLC program status parameter indicates to the user the actual state of the drive Onboard PLC program.

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 installed.
1	Onboard PLC program is installed but stopped.
2	Onboard PLC program is installed and running.

When an Onboard PLC program is installed and running, the lower display of the drive flashes 'PLC' once every 10s.

11.49		Drive Onboard PLC programming events																
RO	Uni													NC	PT			PS
↕		0 to 65,535										⇒						

The drive Onboard PLC programming events parameter holds the number of times an Onboard PLC program download has taken place and is 0 on dispatch from the factory. The drive is rated for one hundred ladder program downloads. This parameter is not altered when defaults are loaded.

11.50		Drive Onboard PLC program average scan time																
RO	Uni														NC	PT		
↕		0 to 65,535 ms										⇒						

This parameter is updated once per second or once per Onboard PLC program scan whichever is the longest. If more than one program scan occurs within the one second update period the parameter shows the average scan time. If the program scan time is longer than one second the parameter shows the time for the last program scan.

11.51		Drive Onboard PLC program first run																
RO	Bit														NC	PT		
↕		OFF (0) or On (1)										⇒						

The Drive Onboard PLC program first run parameter is set for the duration of program scan from the stopped state. This enables the user to perform any required initialisation every time the program is run. This parameter is set every time the program is stopped.

## 10.6 Onboard PLC trips

The following trips are associated with the Onboard PLC program.

Trip	Diagnosis
<b>UP ACC</b>	<b>Onboard PLC program: Cannot access Onboard PLC program file on drive</b>
<b>98</b>	Disable drive - write access is not allowed when the drive is enabled. Another source is already accessing Onboard PLC program - retry once the other action is complete.
<b>UP div0</b>	<b>Onboard PLC program attempted divide by zero</b>
<b>90</b>	Check program
<b>UP OFL</b>	<b>Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)</b>
<b>95</b>	Check program
<b>UP ovr</b>	<b>Onboard PLC program attempted out of range parameter write</b>
<b>94</b>	Check program
<b>UP PAr</b>	<b>Onboard PLC program attempted access to a non-existent parameter</b>
<b>91</b>	Check program
<b>UP ro</b>	<b>Onboard PLC program attempted write to a read-only parameter</b>
<b>92</b>	Check program
<b>UP So</b>	<b>Onboard PLC program attempted read of a write-only parameter</b>
<b>93</b>	Check program
<b>UP udF</b>	<b>Onboard PLC program undefined trip</b>
<b>97</b>	Check program
<b>UP uSer</b>	<b>Onboard PLC program requested a trip</b>
<b>96</b>	Check program

## 10.7 Onboard PLC and the SMARTCARD

The Onboard PLC program in a drive may be transferred from the drive to a SMARTCARD and vice versa.

- To transfer an Onboard PLC program from the drive to a SMARTCARD, set Pr **xx.00** to 5yyy and reset the drive
- To transfer an Onboard PLC program from the SMARTCARD to a drive, set Pr **xx.00** to 6yyy and reset the drive.


(Where yyy is the data block location, see Table 9-1 *SMARTCARD data blocks* on page 140 for restrictions on block numbers).

If an attempt is made to transfer an Onboard PLC program from a drive to the SMARTCARD when the drive contains no program, the block is still created on the SMARTCARD but it will contain no data. If this data block is then transferred to a drive, the destination drive will then have no Onboard PLC program.

The smallest SMARTCARD compatible with Unidrive SP has a capacity of 4064 bytes and each block can be up to 4064 bytes in size. The maximum size of a user program is 4032 bytes so it is guaranteed that any Onboard PLC program downloaded to a Unidrive SP will fit on an empty SMARTCARD. A SMARTCARD can contain a number of Onboard PLC programs until the capacity of the card is used.

# 11 Advanced parameters

This is a quick reference to all parameters in the drive showing units, ranges limits etc, with block diagrams to illustrate their function. Full descriptions of the parameters can be found in the *Advanced User Guide* on the supplied CD ROM.

	<p>These advanced parameters are listed for reference purposes only. The lists in this chapter do not include sufficient information for adjusting these parameters. Incorrect adjustment can affect the safety of the system, and damage the drive and or external equipment. Before attempting to adjust any of these parameters, refer to the <i>Advanced User Guide</i>.</p>
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**Table 11-1 Menu descriptions**

Menu number	Description
0	Commonly used basic set up parameters for quick / easy programming
1	Frequency / speed reference
2	Ramps
3	Frequency slaving, speed feedback and speed control
4	Torque and current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
9	Programmable logic, motorized pot and binary sum
10	Status and trips
11	General drive set-up
12	Threshold detectors and variable selectors
13	Position control
14	User PID controller
18	Application menu 1
19	Application menu 2
20	Application menu 3
21	Second motor parameters
22	Additional Menu 0 set-up

**Operation mode abbreviations:**

- OL> Open loop
- CL> Closed loop (which incorporates closed loop vector and servo mode)
- VT> Closed loop vector mode
- SV> Servo

**Default abbreviations:**

- EUR> European default value (50Hz AC supply frequency)
- USA> USA default value (60Hz AC supply frequency)

**NOTE**

Parameter numbers shown in brackets {...} are the equivalent Menu 0 parameters. Some Menu 0 parameters appear twice since their function depends on the operating mode.

The Range - CL column applies to both Closed-loop Vector and Closed-loop Servo. For some parameters, this column applies only to one of these modes; this is indicated accordingly in the Default columns.

In some cases, the function or range of a parameter is affected by the setting of another parameter; the information in the lists relates to the default condition of such parameters.

**Table 11-2 Key to parameter table coding**

Coding	Attribute
RW	Read/write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter. 'On' or 'OFF' on the display
Bi	Bipolar parameter
Uni	Unipolar parameter
Txt	Text: the parameter uses text strings instead of numbers.
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: This parameter selects the destination of an input or logic function.
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. However, with software V01.09.00 and later the value will be transferred if only the current rating is different and the file is a differences from default type file.
NC	Not copied: not transferred to or from SMARTCARDS during copying.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs. With software version V01.08.00 and later, power-down save parameters are also saved in the drive when the user initiates a parameter save.

Table 11-3 Feature look-up table

Feature	Related parameters (Pr)												
Acceleration rates	2.10	2.11 to 2.19		2.32	2.33	2.34	2.02						
Analog speed reference 1	1.36	7.10	7.01	7.07	7.08	7.09	7.25	7.26	7.30				
Analog speed reference 2	1.37	7.14	1.41	7.02	7.11	7.12	7.13	7.28	7.31				
Analog I/O	Menu 7												
Analog input 1	7.01	7.07	7.08	7.09	7.10	7.25	7.26	7.30					
Analog input 2	7.02	7.11	7.12	7.13	7.14	7.28	7.31						
Analog input 3	7.03	7.15	7.16	7.17	7.18	7.29	7.32						
Analog output 1	7.19	7.20	7.21	7.33									
Analog output 2	7.22	7.23	7.24										
Application menu	Menu 18			Menu 19			Menu 20						
At speed indicator bit	3.06	3.07	3.09	10.06	10.05	10.07							
Auto reset	10.34	10.35	10.36	10.01									
Autotune	5.12	5.16	5.17	5.23	5.24	5.25	5.10	5.29	5.30				
Binary sum	9.29	9.30	9.31	9.32	9.33	9.34							
Bipolar speed	1.10												
Brake control	12.40 to 12.49												
Braking	10.11	10.10	10.30	10.31	6.01	2.04	2.02	10.12	10.39	10.40			
Catch a spinning motor	6.09	5.40											
Coast to stop	6.01												
Comms	11.23 to 11.26												
Copying	11.42	11.36 to 11.40											
Cost - per kWh electricity	6.16	6.17	6.24	6.25	6.26	6.40							
Current controller	4.13	4.14											
Current feedback	4.01	4.02	4.17	4.04	4.12	4.20	4.23	4.24	4.26	10.08	10.09	10.17	
Current limits	4.05	4.06	4.07	4.18	4.15	4.19	4.16	5.07	5.10	10.08	10.09	10.17	
DC bus voltage	5.05	2.08											
DC injection braking	6.06	6.07	6.01										
Deceleration rates	2.20	2.21 to 2.29		2.04	2.35 to 2.37		2.02	2.08	6.01	10.30	10.31	10.39	
Defaults	11.43	11.46											
Digital I/O	Menu 8												
Digital I/O read word	8.20												
Digital I/O T24	8.01	8.11	8.21	8.31									
Digital I/O T25	8.02	8.12	8.22	8.32									
Digital I/O T26	8.03	8.13	8.23	8.33									
Digital input T27	8.04	8.14	8.24										
Digital input T28	8.05	8.15	8.25	8.39									
Digital input T29	8.06	8.16	8.26	8.39									
Digital lock	13.10	13.01 to 13.09		13.11	13.12	13.16	3.22	3.23	13.19 to 13.23				
Digital output T22	8.08	8.18	8.28										
Direction	10.13	6.30	6.31	1.03	10.14	2.01	3.02	8.03	8.04	10.40			
Display timeout	11.41												
Drive active	10.02	10.40											
Drive derivative	11.28												
Drive OK	10.01	8.27	8.07	8.17	10.36	10.40							
Dynamic performance	5.26												
Dynamic V/F	5.13												
Electronic nameplate	3.49												
Enable	6.15	8.09	8.10										
Encoder reference	3.43	3.44	3.45	3.46									
Encoder set up	3.33	3.34 to 3.42		3.47	3.48								
External trip	10.32	8.10	8.07										
Fan speed	6.45												
Fast disable	6.29												
Field weakening - induction motor	5.29	5.30	1.06	5.28									
Field weakening - servo	5.22	1.06	5.09										
Filter change	6.19	6.18											
Frequency reference selection	1.14	1.15											
Frequency slaving	3.01	3.13	3.14	3.15	3.16	3.17	3.18						
Hard speed reference	3.22	3.23											
Heavy duty rating	5.07	11.32											
High stability space vector modulation	5.19												
I/O sequencer	6.04	6.30	6.31	6.32	6.33	6.34	6.42	6.43	6.41				

Feature	Related parameters (Pr)												
Inertia compensation	2.38	5.12	4.22	3.18									
Jog reference	1.05	2.19	2.29										
Ke	5.33												
Keypad reference	1.17	1.14	1.43	1.51	6.12	6.13							
Kt	5.32												
Limit switches	6.35	6.36											
Line power supply loss	6.03	10.15	10.16	5.05									
Local position reference	13.20 to 13.23												
Logic function 1	9.01	9.04	9.05	9.06	9.07	9.08	9.09	9.10					
Logic function 2	9.02	9.14	9.15	9.16	9.17	9.18	9.19	9.20					
Low voltage supply	6.44	6.46											
Marker pulse	3.32	3.31											
Maximum speed	1.06												
Menu 0 set up	11.01 to 11.22		Menu 22										
Minimum speed	1.07	10.04											
Modules - number of	11.35												
Motor map	5.06	5.07	5.08	5.09	5.10	5.11							
Motor map 2	Menu 21		11.45										
Motorized potentiometer	9.21	9.22	9.23	9.24	9.25	9.26	9.27	9.28					
Offset speed reference	1.04	1.38	1.09										
Onboard PLC	11.47 to 11.51												
Open collector digital outputs	8.30												
Open loop vector mode	5.14	5.17	5.23										
Operating mode	0.48	11.31	3.24	5.14									
Orientation	13.10	13.13 to 13.15											
Output	5.01	5.02	5.03	5.04									
Overspeed threshold	3.08												
Phase angle	3.25	5.12											
PID controller	Menu 14												
Position feedback - drive	3.28	3.29	3.30	3.50									
Positive logic	8.29												
Power up parameter	11.22	11.21											
Precision reference	1.18	1.19	1.20	1.44									
Preset speeds	1.15	1.21 to 1.28		1.16	1.14	1.42	1.45 to 1.48		1.50				
Programmable logic	Menu 9												
Quasi square operation	5.20												
Ramp (accel / decel) mode	2.04	2.08	6.01	2.02	2.03	10.30	10.31	10.39					
Rated speed autotune	5.16	5.08											
Regenerating	10.10	10.11	10.30	10.31	6.01	2.04	2.02	10.12	10.39	10.40			
Relative jog	13.17 to 13.19												
Relay output	8.07	8.17	8.27										
Reset	10.33	8.02	8.22	10.34	10.35	10.36	10.01						
RFC mode (encoder less CLV mode)	3.24	3.42	4.12	5.40									
S ramp	2.06	2.07											
Sample rates	5.18												
SAFE TORQUE OFF (SECURE DISABLE) input	8.09	8.10											
Security code	11.30	11.44											
Serial comms	11.23 to 11.26												
Skip speeds	1.29	1.30	1.31	1.32	1.33	1.34	1.35						
Slip compensation	5.27	5.08											
SMARTCARD	11.36 to 11.40		11.42										
Software version	11.29	11.34											
Speed controller	3.10 to 3.17		3.19	3.20	3.21								
Speed feedback	3.02	3.03	3.04										
Speed feedback - drive	3.26	3.27	3.28	3.29	3.30	3.31	3.42						
Speed reference selection	1.14	1.15	1.49	1.50	1.01								
Status word	10.40												
Supply	6.44	5.05	6.46										
Switching frequency	5.18	5.35	7.34	7.35									
Thermal protection - drive	5.18	5.35	7.04	7.05	7.06	7.32	7.35	10.18					
Thermal protection - motor	4.15	5.07	4.19	4.16	4.25	7.15							
Thermistor input	7.15	7.03											
Threshold detector 1	12.01	12.03 to 12.07											

Feature	Related parameters (Pr)												
Threshold detector 2	12.02	12.23 to 12.27											
Time - filter change	6.19	6.18											
Time - powered up log	6.20	6.21	6.28										
Time - run log	6.22	6.23	6.28										
Torque	4.03	4.26	5.32										
Torque mode	4.08	4.11	4.09	4.10									
Trip detection	10.37	10.38	10.20 to 10.29										
Trip log	10.20 to 10.29		10.41 to 10.51		6.28								
Under voltage	5.05	10.16	10.15										
V/F mode	5.15	5.14											
Variable selector 1	12.08 to 12.15												
Variable selector 2	12.28 to 12.35												
Velocity feed forward	1.39	1.40											
Voltage controller	5.31												
Voltage mode	5.14	5.17	5.23	5.15									
Voltage rating	11.33	5.09	5.05										
Voltage supply	6.44	6.46	5.05										
Warning	10.19	10.12	10.17	10.18	10.40								
Zero speed indicator bit	3.05	10.03											



### 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 11-4 are the variable maximums used in the drive.

**Table 11-4 Definition of parameter ranges & variable maximums**

Maximum	Definition
SPEED_FREQ_MAX [Open-loop 3000.0Hz, Closed-loop vector and Servo 40000.0rpm]	<b>Maximum speed (closed-loop mode) reference or frequency (open-loop mode) reference</b> If Pr 1.08 = 0: SPEED_FREQ_MAX = Pr 1.06 If Pr 1.08 = 1: SPEED_FREQ_MAX is Pr 1.06 or – Pr 1.07 whichever is the largest (If the second motor map is selected Pr 21.01 is used instead of Pr 1.06 and Pr 21.02 instead of Pr 1.07)
SPEED_LIMIT_MAX [40000.0rpm]	<b>Maximum applied to speed reference limits</b> A maximum limit may be applied to the speed reference to prevent the nominal encoder frequency from exceeding 500kHz (410kHz for software version V01.06.00 and earlier). The maximum is defined by SPEED_LIMIT_MAX (in rpm) = 500kHz x 60 / ELPR = 3.0 x 10 <sup>7</sup> / ELPR subject to an absolute maximum of 40,000 rpm. ELPR is equivalent encoder lines per revolution and is the number of lines that would be produced by a quadrature encoder. Quadrature encoder ELPR = number of lines per revolution F and D encoder ELPR = number of lines per revolution / 2 Resolver ELPR = resolution / 4 SINCOS encoder ELPR = number of sine waves per revolution Serial comms encoder ELPR = resolution / 4 This maximum is defined by the device selected with the speed feedback selector (Pr 3.26) and the ELPR set for the position feedback device. In closed-loop vector RFC mode SPEED_LIMIT_MAX = 40,000rpm.
SPEED_MAX [40000.0rpm]	<b>Maximum speed</b> This maximum is used for some speed related parameters in menu 3. To allow headroom for overshoot etc. the maximum speed is twice the maximum speed reference. SPEED_MAX = 2 x SPEED_FREQ_MAX
RATED_CURRENT_MAX [9999.99A]	<b>Maximum motor rated current (Maximum Normal Duty current rating)</b> RATED_CURRENT_MAX = 1.36 x K <sub>C</sub> . The motor rated current can be increased above K <sub>C</sub> up to a level not exceeding 1.36 x K <sub>C</sub> . (Maximum motor rated current is the maximum normal duty current rating.) The actual level varies from one drive size to another, refer to Table 11-5.
DRIVE_CURRENT_MAX [9999.99A]	<b>Maximum drive current</b> The maximum drive current is the current at the over current trip level and is given by: DRIVE_CURRENT_MAX = K <sub>C</sub> / 0.45
AC_VOLTAGE_SET_MAX [690V]	<b>Maximum output voltage set-point</b> Defines the maximum motor voltage that can be selected. 200V drives: 240V, 400V drives: 480V 575V drives: 575V, 690V drives: 690V
AC_VOLTAGE_MAX [930V]	<b>Maximum AC output voltage</b> This maximum has been chosen to allow for maximum AC voltage that can be produced by the drive including quasi-square wave operation as follows: AC_VOLTAGE_MAX = 0.78 x DC_VOLTAGE_MAX 200V drives: 325V, 400V drives: 650V, 575V drives: 780V, 690V drives: 930V
DC_VOLTAGE_SET_MAX [1150V]	<b>Maximum DC voltage set-point</b> 200V rating drive: 0 to 400V, 400V rating drive: 0 to 800V 575V rating drive: 0 to 955V, 690V rating drive: 0 to 1150V
DC_VOLTAGE_MAX [1190V]	<b>Maximum DC bus voltage</b> The maximum measurable DC bus voltage. 200V drives: 415V, 400V drives: 830V, 575V drives: 990V, 690V drives: 1190V

Maximum	Definition
MOTOR1_CURRENT_LIMIT_MAX [1000.0%]	<p><b>Maximum current limit settings for motor map 1</b> This maximum current limit setting is the maximum applied to the current limit parameters in motor map 1.</p> <p><b>Open Loop</b></p> $\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + \text{PF}^2 - 1\right]}}{\text{PF}} \times 100\%$ <p>Where: The Maximum current is either (1.5 x K<sub>C</sub>) when the motor rated current set in Pr 5.07 is less than or equal to the maximum Heavy Duty current rating given by Pr 11.32, otherwise it is (1.1 x Normal Duty rating). Motor rated current is given by Pr 5.07 PF is motor rated power factor given by Pr 5.10</p> <p><b>Closed Loop vector</b></p> $\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + \cos(\varphi_1)^2 - 1\right]}}{\cos(\varphi_1)} \times 100\%$ <p>Where: The Maximum current is either (1.75 x K<sub>C</sub>) when the motor rated current set in Pr 5.07 is less than or equal to the maximum Heavy Duty current rating given by Pr 11.32, otherwise it is (1.1 x Normal Duty rating). Motor rated current is given by Pr 5.07 φ<sub>1</sub> = cos<sup>-1</sup>(PF) - φ<sub>2</sub>. This is measured by the drive during an autotune. See Menu 4 in the <i>Advanced User Guide</i> for more information regarding φ<sub>2</sub>. PF is motor rated power factor given by Pr 5.10</p> <p><b>Servo</b></p> $\text{Maximum current limit} = \left[ \frac{\text{Maximum current}}{\text{Motor rated current}} \right] \times 100\%$ <p>Where: The Maximum current is either (1.75 x K<sub>C</sub>) when the motor rated current set in Pr 5.07 is less than or equal to the maximum Heavy Duty current rating given by Pr 11.32, otherwise it is (1.1 x Normal Duty rating). Motor rated current is given by Pr 5.07</p>
MOTOR2_CURRENT_LIMIT_MAX [1000.0%]	<p><b>Maximum current limit settings for motor map 2</b> This maximum current limit setting is the maximum applied to the current limit parameters in motor map 2. The formulae for MOTOR2_CURRENT_LIMIT_MAX are the same for MOTOR1_CURRENT_LIMIT_MAX except that Pr 5.07 is replaced with Pr 21.07 and Pr 5.10 is replaced with Pr 21.10.</p>
TORQUE_PROD_CURRENT_MAX [1000.0%]	<p><b>Maximum torque producing current</b> This is used as a maximum for torque and torque producing current parameters. It is MOTOR1_CURRENT_LIMIT_MAX or MOTOR2_CURRENT_LIMIT_MAX depending on which motor map is currently active.</p>
USER_CURRENT_MAX [1000.0%]	<p><b>Current parameter limit selected by the user</b> The user can select a maximum for Pr 4.08 (torque reference) and Pr 4.20 (percentage load) to give suitable scaling for analog I/O with Pr 4.24. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT_MAX. or MOTOR2_CURRENT_LIMIT_MAX depending on which motor map is currently active. USER_CURRENT_MAX = Pr 4.24</p>
POWER_MAX [9999.99kW]	<p><b>Maximum power in kW</b> The maximum power has been chosen to allow for the maximum power that can be output by the drive with maximum AC output voltage, maximum controlled current and unity power factor. Therefore: Software V01.07.01 and earlier: POWER_MAX = √3 x AC_VOLTAGE_MAX x RATED_CURRENT x 1.75 Software V01.08.00 and later: POWER_MAX = √3 x AC_VOLTAGE_MAX x DRIVE_CURRENT_MAX</p>

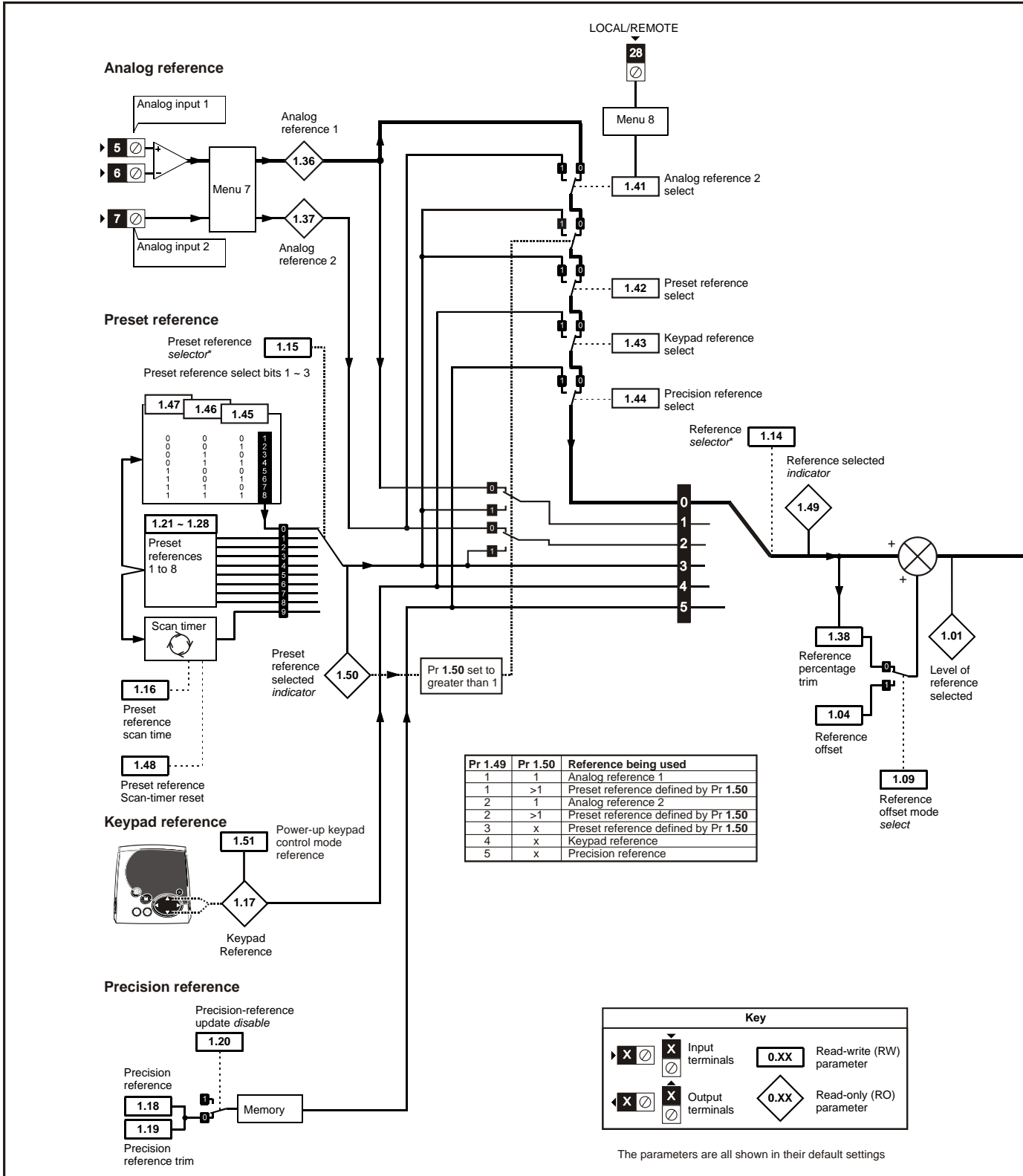
The values given in square brackets indicate the absolute maximum value allowed for the variable maximum.

**Table 11-5 Maximum motor rated current**

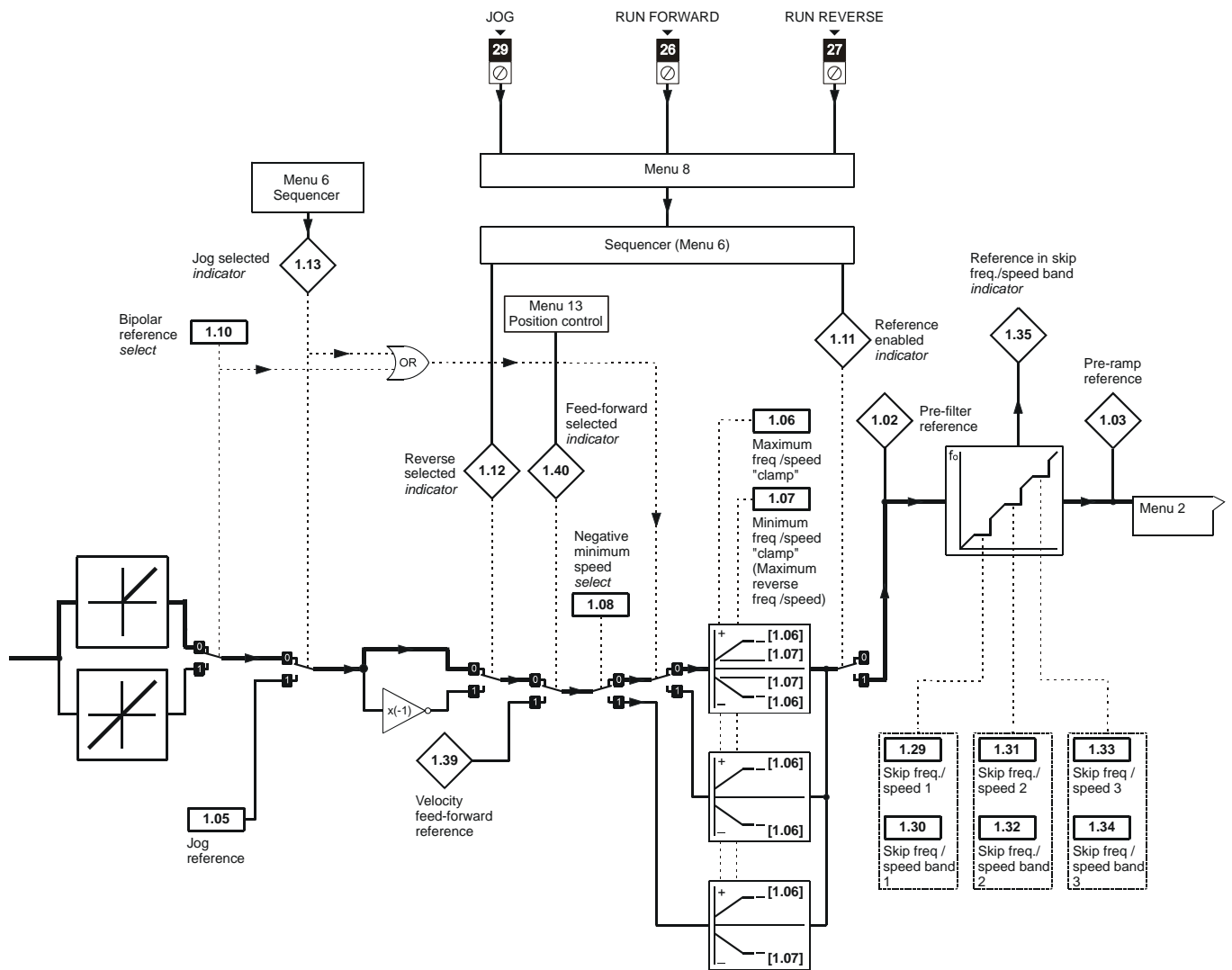
Model	K <sub>C</sub>	Maximum Heavy Duty current rating (Pr 11.32) A	Maximum Normal Duty current rating A
SP0201	2.2	2.2	2.2
SP0202	3.1	3.1	3.1
SP0203	4.0	4.0	4.0
SP0204	5.7	5.7	5.7
SP0205	7.5	7.5	7.5
SP1201	4.3	4.3	5.2
SP1202	5.8	5.8	6.8
SP1203	7.5	7.5	9.6
SP1204	10.6	10.6	11
SP2201	12.6	12.6	15.5
SP2202	17.0	17.0	22.0
SP2203	25.0	25.0	28.0
SP3201	31.0	31.0	42.0
SP3202	42.0	42.0	54.0
SP4201	56.0	56.0	68.0
SP4202	68.0	68.0	80.0
SP4203	80.0	80.0	104.0
SP5201	105.0	105.0	130.0
SP5202	130.0	130.0	154.0
SP0401	1.3	1.3	1.3
SP0402	1.7	1.7	1.7
SP0403	2.1	2.1	2.1
SP0404	3.0	3.0	3.0
SP0405	4.2	4.2	4.2
SP1401	2.1	2.1	2.8
SP1402	3.0	3.0	3.8
SP1403	4.2	4.2	5.0
SP1404	5.8	5.8	6.9
SP1405	7.6	7.6	8.8
SP1406	9.5	9.5	11.0
SP2401	13.0	13.0	15.3
SP2402	16.5	16.5	21.0
SP2403	23.0	25.0	29.0
SP2404	29.0	29.0	29.0
SP3401	32.0	32.0	35.0
SP3402	40.0	40.0	43.0
SP3403	46.0	46.0	56.0
SP4401	60.0	60.0	68.0
SP4402	74.0	74.0	83.0
SP4403	96.0	96.0	104.0
SP5401	124.0	124.0	138.0
SP5402	156.0	156.0	168.0
SP6401	154.2	180.0	205.0
SP6402	180.0	210.0	236.0
SP3501	4.1	4.1	5.4
SP3502	5.4	5.4	6.1
SP3503	6.1	6.1	8.4
SP3504	9.5	9.5	11.0
SP3505	12.0	12.0	16.0
SP3506	18.0	18.0	22.0
SP3507	22.0	22.0	27.0
SP4601	19.0	19.0	22.0
SP4602	22.0	22.0	27.0
SP4603	27.0	27.0	36.0
SP4604	36.0	36.0	43.0
SP4605	43.0	43.0	52.0
SP4606	52.0	52.0	62.0
SP5601	63.0	63.0	84.0
SP5602	85.0	85.0	99.0
SP6601	85.7	100.0	125.0
SP6602	107.1	125.0	144.0

# 11.1 Menu 1: Frequency / speed reference

Figure 11-1 Menu 1 logic diagram



\*For more information, refer to section 11.21.1 Reference modes on page 233



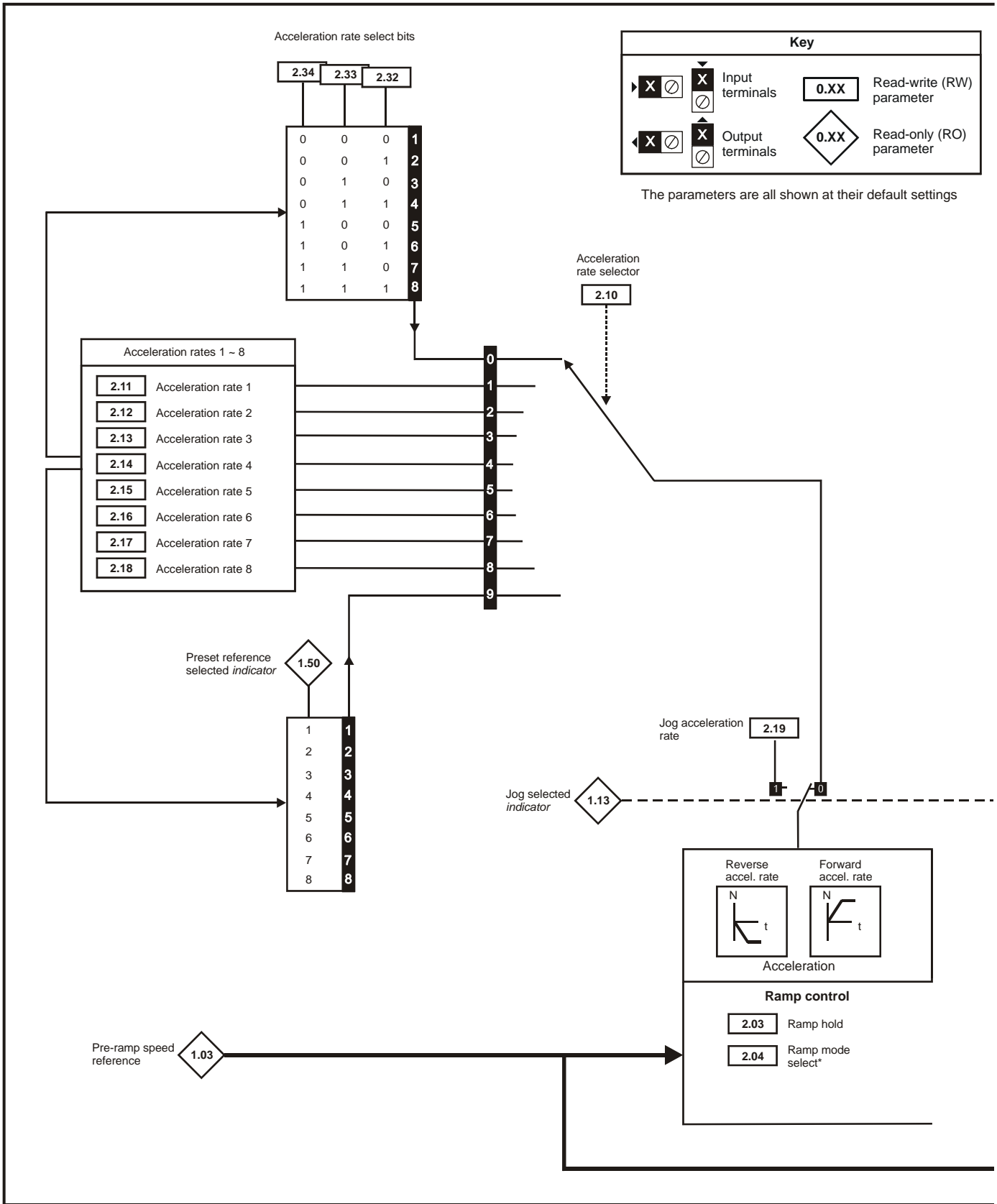
Parameter	Range(⇅)		Default(⇔)			Type					
	OL	CL	OL	VT	SV	RO	Bi	NC	PT	US	
1.01	Frequency / speed reference selected		±SPEED_FREQ_MAX Hz/rpm				RO	Bi	NC	PT	
1.02	Pre-skip filter reference		±SPEED_FREQ_MAX Hz/rpm				RO	Bi	NC	PT	
1.03	Pre-ramp reference		±SPEED_FREQ_MAX Hz/rpm				RO	Bi	NC	PT	
1.04	Reference offset		±3,000.0Hz	±40,000.0 rpm	0.0	RW	Bi			US	
1.05	Jog reference {0.23}	0 to 400.0 Hz	0 to 4,000.0 rpm		0.0	RW	Uni			US	
1.06	Maximum reference clamp {0.02}	0 to 3,000.0 Hz	SPEED_LIMIT_MAX rpm	EUR> 50.0 USA> 60.0	EUR> 1,500.0 USA> 1,800.0	3,000.0	RW	Uni		US	
1.07	Minimum reference clamp {0.01}	±3,000.0 Hz	±SPEED_LIMIT_MAX rpm		0.0	RW	Bi		PT	US	
1.08	Negative minimum reference clamp enable		OFF (0) or On (1)			OFF (0)	RW	Bit		US	
1.09	Reference offset select		OFF (0) or On (1)			OFF (0)	RW	Bit		US	
1.10	Bipolar reference enable {0.22}		OFF (0) or On (1)			OFF (0)	RW	Bit		US	
1.11	Reference enabled indicator		OFF (0) or On (1)				RO	Bit	NC	PT	
1.12	Reverse selected indicator		OFF (0) or On (1)				RO	Bit	NC	PT	
1.13	Jog selected indicator		OFF (0) or On (1)				RO	Bit	NC	PT	
1.14	Reference selector {0.05}	A1.A2 (0), A1.Pr (1), A2.Pr (2), Pr (3), PAd (4), Prc (5)		A1.A2 (0)			RW	Txt		US	
1.15	Preset reference selector		0 to 9			0	RW	Uni		US	
1.16	Preset reference selector timer		0 to 400.0s			10.0	RW	Uni		US	
1.17	Keypad control mode reference		±SPEED_FREQ_MAX Hz/rpm			0.0	RO	Bi	NC	PT	PS
1.18	Precision reference coarse		±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi		US	
1.19	Precision reference fine		0.000 to 0.099 Hz	0.000 to 0.099 rpm	0.000	RW	Uni			US	
1.20	Precision reference update disable		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.21	Preset reference 1 {0.24}	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.22	Preset reference 2 {0.25}	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.23	Preset reference 3 {0.26}	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.24	Preset reference 4 {0.27}	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.25	Preset reference 5	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.26	Preset reference 6	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.27	Preset reference 7	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.28	Preset reference 8	±SPEED_FREQ_MAX Hz/rpm			0.0	RW	Bi			US	
1.29	Skip reference 1	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0	RW	Uni			US	
1.30	Skip reference band 1	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5	RW	Uni			US	
1.31	Skip reference 2	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0	RW	Uni			US	
1.32	Skip reference band 2	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5	RW	Uni			US	
1.33	Skip reference 3	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0	RW	Uni			US	
1.34	Skip reference band 3	0.0 to 25.0Hz	0 to 250 rpm	0.5	5	RW	Uni			US	
1.35	Reference in rejection zone		OFF (0) or On (1)				RO	Bit	NC	PT	
1.36	Analog reference 1		±SPEED_FREQ_MAX Hz/rpm				RO	Bi	NC		
1.37	Analog reference 2		±SPEED_FREQ_MAX Hz/rpm				RO	Bi	NC		
1.38	Percentage trim		±100 00%			0.00	RW	Bi	NC		
1.39	Velocity feed-forward		±3,000.0 Hz	±40,000.0 rpm			RO	Bi	NC	PT	
1.40	Velocity feed-forward select		OFF (0) or On (1)				RO	Bit	NC	PT	
1.41	Analog reference 2 select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.42	Preset reference select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.43	Keypad reference select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.44	Precision reference select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.45	Preset reference 1 select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.46	Preset reference 2 select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.47	Preset reference 3 select		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.48	Reference timer reset flag		OFF (0) or On (1)			OFF (0)	RW	Bit	NC		
1.49	Reference selected indicator		1 to 5				RO	Uni	NC	PT	
1.50	Preset reference selected indicator		1 to 8				RO	Uni	NC	PT	
1.51	Power-up keyboard control mode reference		rESEt (0), LAsT (1), PrS1 (2)			rESEt (0)	RW	Txt		US	

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



## 11.2 Menu 2: Ramps

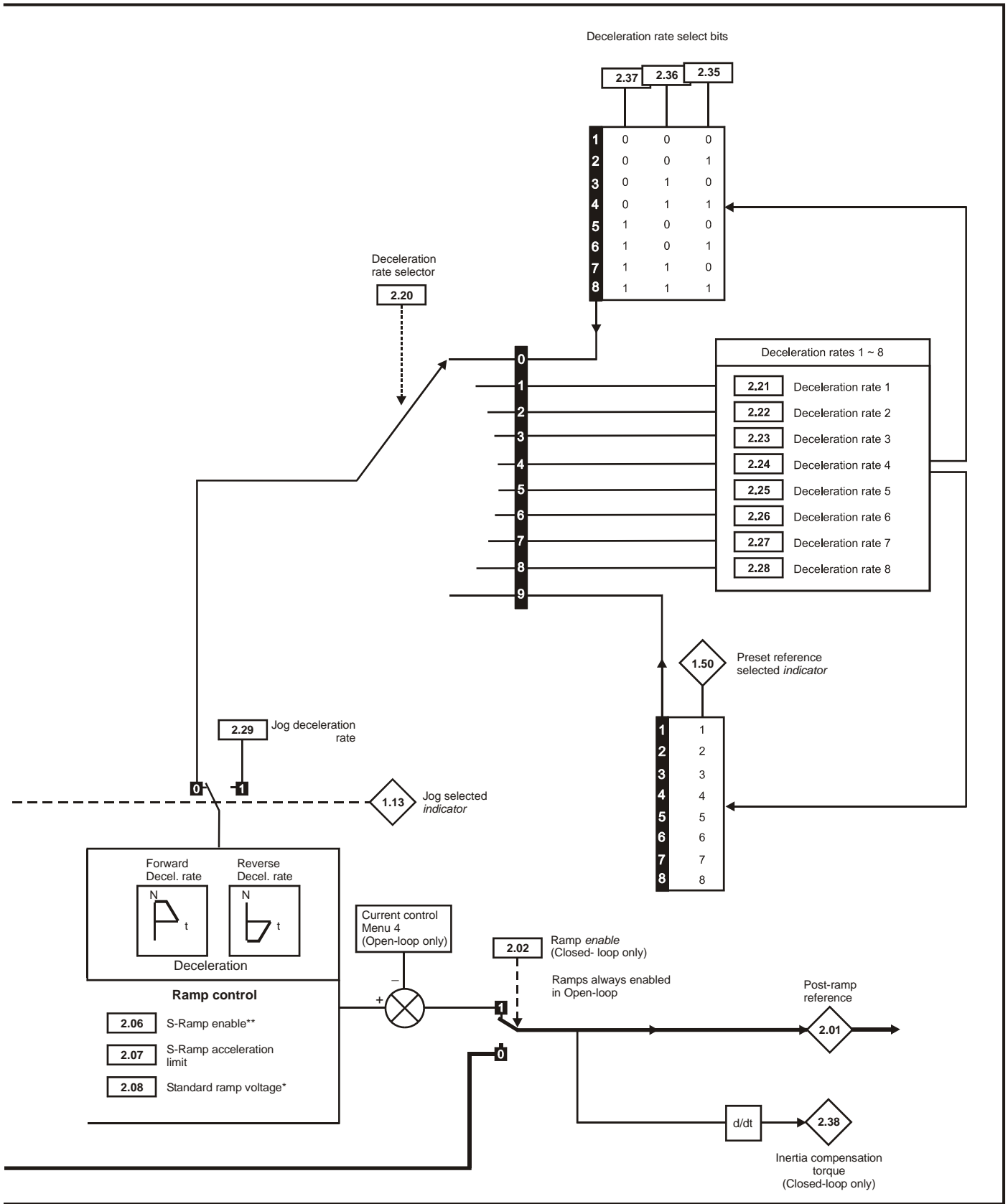
Figure 11-2 Menu 2 logic diagram



\*For more information, refer to section 11.21.2 *Braking Modes* on page 234.

\*\*For more information, refer to section 11.21.3 *S ramps* on page 234.





Parameter	Range(⇅)		Default(⇔)			Type			
	OL	CL	OL	VT	SV	RO	Bi	NC	PT
2.01 Post ramp reference	±SPEED_FREQ_MAX Hz/rpm					RO	Bi	NC	PT
2.02 Ramp enable {0.16}		OFF (0) or On (1)	On (1)			RW	Bit		US
2.03 Ramp hold	OFF (0) or On (1)		OFF (0)			RW	Bit		US
2.04 Ramp mode select {0.15}	FAST (0) Std (1) Std.hV (2)	FAST (0) Std (1)	Std (1)			RW	Txt		US
2.06 S ramp enable	OFF (0) or On (1)		OFF (0)			RW	Bit		US
2.07 S ramp acceleration limit	0.0 to 300.0 s <sup>2</sup> /100Hz	0.000 to 100.000 s <sup>2</sup> /1000rpm	3.1	1.500	0.030	RW	Uni		US
2.08 Standard ramp voltage	0 to DC_VOLTAGE_SET_MAX V		200V drive: 375 400V drive: EUR> 750 USA> 775 575V drive: 895 690V drive: 1075			RW	Uni	RA	US
2.10 Acceleration rate selector	0 to 9		0			RW	Uni		US
2.11 Acceleration rate 1 {0.03}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.12 Acceleration rate 2	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.13 Acceleration rate 3	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.14 Acceleration rate 4	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.15 Acceleration rate 5	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.16 Acceleration rate 6	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.17 Acceleration rate 7	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.18 Acceleration rate 8	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	5.0	2.000	0.200	RW	Uni		US
2.19 Jog accelera ion rate	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	0.2	0.000		RW	Uni		US
2.20 Deceleration rate selector	0 to 9		0			RW	Uni		US
2.21 Deceleration rate 1 {0.04}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.22 Deceleration rate 2	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.23 Deceleration rate 3	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.24 Deceleration rate 4	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.25 Deceleration rate 5	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.26 Deceleration rate 6	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.27 Deceleration rate 7	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.28 Deceleration rate 8	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	10.0	2.000	0.200	RW	Uni		US
2.29 Jog deceleration rate	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	0.2	0.000		RW	Uni		US
2.32 Acceleration select bit 0	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.33 Acceleration select bit 1	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.34 Acceleration select bit 2	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.35 Deceleration select bit 0	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.36 Deceleration select bit 1	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.37 Deceleration select bit 2	OFF (0) or On (1)		OFF (0)			RW	Bit	NC	
2.38 Inertia compensation torque		± 1,000.0 %				RO	Bi	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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

### 11.3 Menu 3: Frequency slaving, speed feedback and speed control

Figure 11-3 Menu 3 Open-loop logic diagram

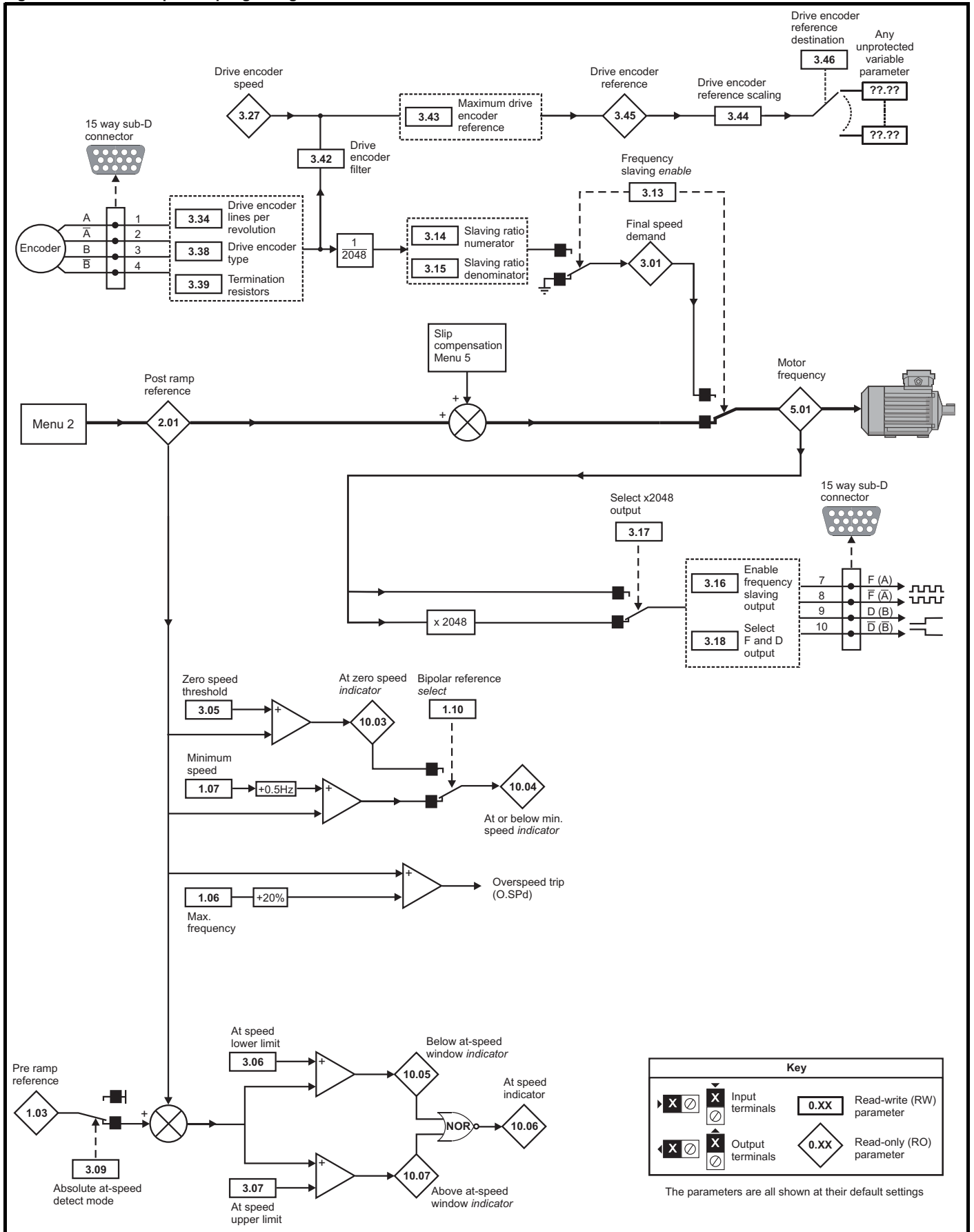
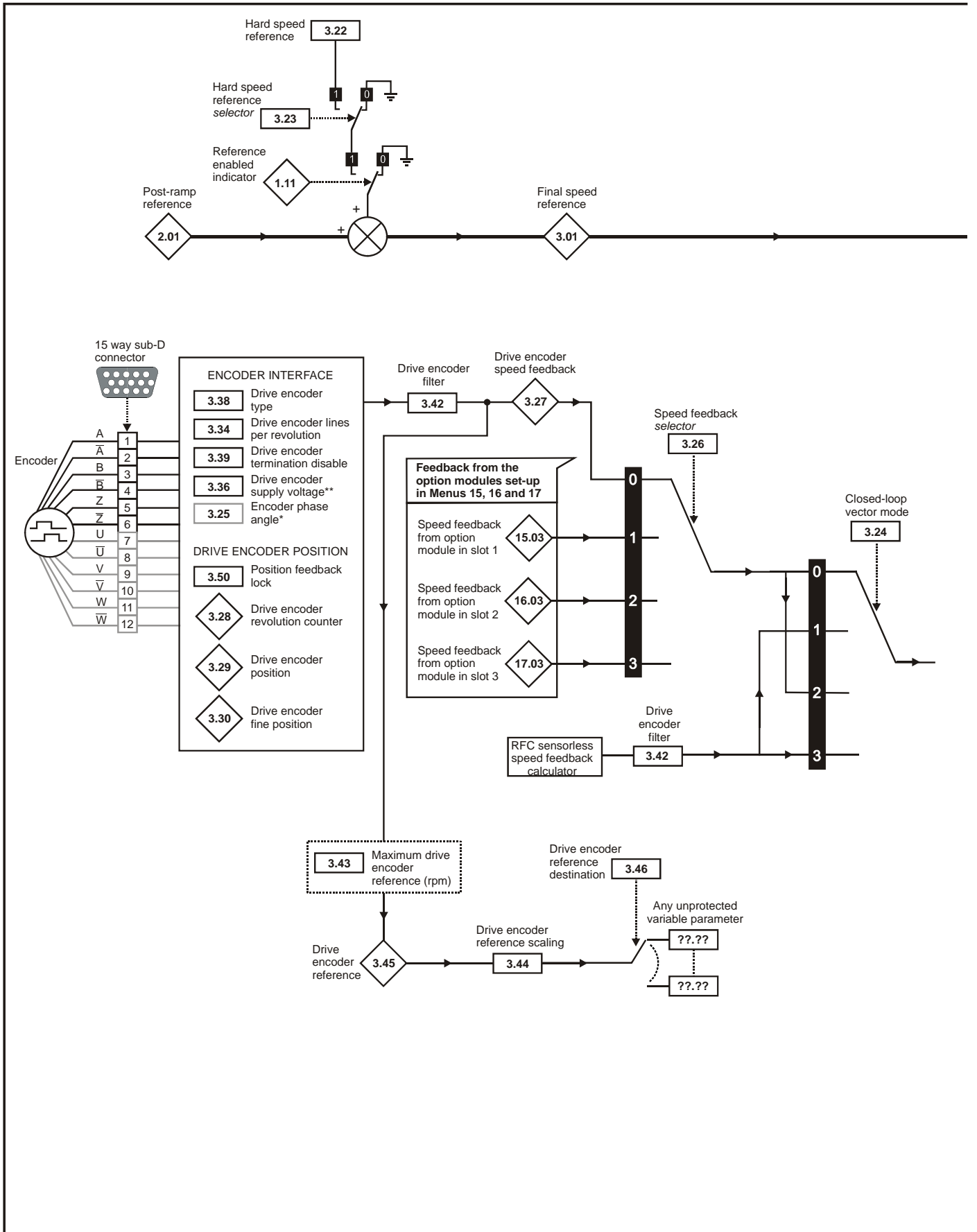
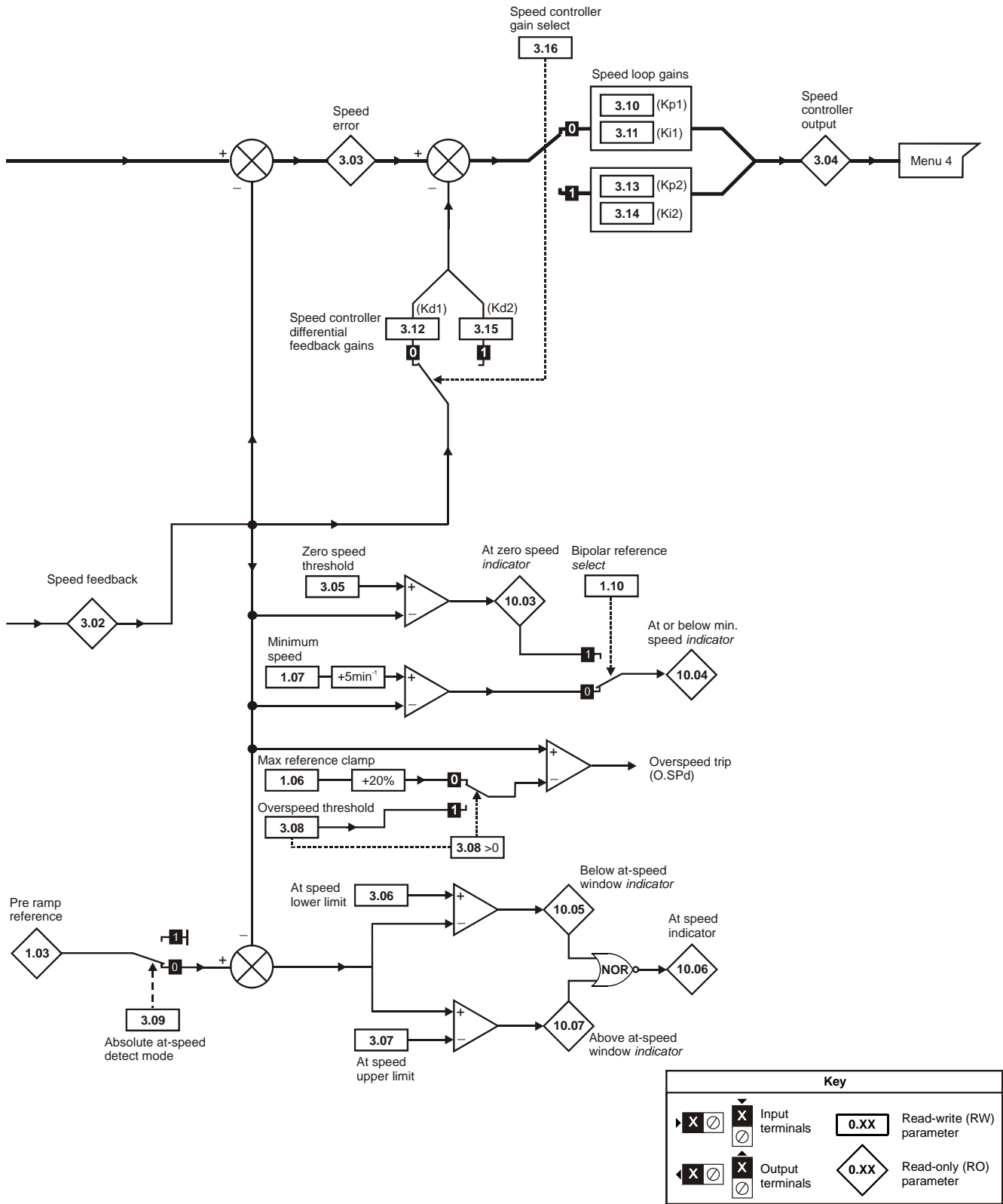


Figure 11-4 Menu 3 Closed loop logic diagram



**NOTE** \*\*If output voltage from the encoder is >5V, then the termination resistors must be disabled Pr 3.39 to 0.




Key			
		Input terminals	Read-write (RW) parameter
		Output terminals	Read-only (RO) parameter

The parameters are all shown at their default settings

Parameter	Range(↕)		Default(⇔)			Type				
	OL	CL	OL	VT	SV	RO	Bi	Fi	NC	PT
3.01	OL> Frequency slaving demand CL> Final speed reference	±1,000.0 Hz				RO	Bi	Fi	NC	PT
3.02	Speed feedback {0.10}		±SPEED_MAX rpm			RO	Bi	Fi	NC	PT
3.03	Speed error		±SPEED_MAX rpm			RO	Bi	Fi	NC	PT
3.04	Speed controller output		±Torque_prod_current_max %			RO	Bi	Fi	NC	PT
3.05	Zero speed threshold	0.0 to 20.0 Hz	0 to 200 rpm	1.0	5	RW	Uni			US
3.06	At speed lower limit	0.0 to 3,000.0 Hz	0 to 40,000 rpm	1.0	5	RW	Uni			US
3.07	At speed upper limit	0.0 to 3,000.0 Hz	0 to 40,000 rpm	1.0	5	RW	Uni			US
3.08	Overspeed threshold {0.26}		0 to 40,000 rpm		0	RW	Uni			US
3.09	Absolute 'at speed' detect	OFF (0) or On (1)		OFF (0)		RW	Bit			US
3.10	Speed controller proportional gain (Kp1) {0.07}		0.0000 to 6.5535 1/rad s <sup>-1</sup>		0.0300   0.0100	RW	Uni			US
3.11	Speed controller integral gain (Ki1) {0.08}		0.00 to 655.35 s/rad s <sup>-1</sup>		0.10   1.00	RW	Uni			US
3.12	Speed controller differential feedback gain (Kd1) {0.09}		0.00000 to 0.65535 s <sup>-1</sup> /rad s <sup>-1</sup>		0.00000	RW	Uni			US
3.13	OL> Enable frequency slaving	OFF (0) or On (1)		OFF (0)		RW	Bit			US
	CL> Speed controller proportional gain (Kp2)		0.0000 to 6.5535 1/rad s <sup>-1</sup>		0.0300   0.0100	RW	Uni			US
3.14	OL> Slaving ratio numerator	0.000 to 1.000		1.000		RW	Uni			US
	CL> Speed controller integral gain (Ki2)		0.00 to 655.35 1/rad		0.10   1.00	RW	Uni			US
3.15	OL> Slaving ratio denominator	0.001 to 1.000		1.000		RW	Uni			US
	CL> Speed controller differential feedback gain (Kd2)		0.00000 to 0.65535 s		0.00000	RW	Uni			US
3.16	OL> Enable frequency slaving output	OFF (0) or On (1)		OFF (0)		RW	Bit			US
	CL> Speed controller gain select		OFF (0) or On (1)		OFF (0)	RW	Bit			US
3.17	OL> Select x2048 output	OFF (0) or On (1)		On (1)		RW	Bit			US
	CL> Speed controller set-up method		0 to 3		0	RW	Uni			US
3.18	OL> Select F and D frequency slaving output	OFF (0) or On (1)		OFF (0)		RW	Bit			US
	CL> Motor and load inertia		0.000100.00000 to 90.00000 kg m <sup>2</sup>		0.00000	RW	Uni			US
3.19	Compliance angle		0.0 to 359.9		4.0	RW	Uni			US
3.20	Bandwidth		0 to 255 Hz		10	RW	Uni			US
3.21	Damping factor		0.0 to 10.0		1.0	RW	Uni			US
3.22	Hard speed reference		±SPEED_FREQ_MAX rpm		0.0	RW	Bi			US
3.23	Hard speed reference selector		OFF (0) or On (1)		OFF (0)	RW	Bit			US
3.24	Closed-loop vector mode		VT> 0 to 3		0	RW	Uni			US
3.25	Encoder phase angle* {0.43}		SV> 0.0 to 359.9		0.0	RW	Uni			US
3.26	Speed feedback selector		drv (0), SLOt1 (1), SLOt2 (2), SLOt3 (3)		drv (0)	RW	Txt			US
3.27	Drive encoder speed feedback	±40,000.0 rpm				RO	Bi	Fi	NC	PT
3.28	Drive encoder revolution counter	0 to 65,535 revolutions				RO	Uni	Fi	NC	PT
3.29	Drive encoder position {0.11}	0 to 65,535 1/2 <sup>16</sup> ths of a revolution				RO	Uni	Fi	NC	PT
3.30	Drive encoder fine position	0 to 65,535 1/2 <sup>32</sup> nds of a revolution				RO	Uni	Fi	NC	PT
3.31	Drive encoder marker position reset disable	OFF (0) or On (1)		OFF (0)		RW	Bit			US
3.32	Drive encoder marker flag	OFF (0) or On (1)		OFF (0)		RW	Bit	NC		
3.33	Drive encoder turn bits / Linear encoder comms to sine wave ratio	0 to 255		16		RW	Uni			US
3.34	Drive encoder lines per revolution {0.27}	0 to 50,000		1024	4096	RW	Uni			US
3.35	Drive encoder single turn comms bits / Linear encoder comms bits / Marker mode	0 to 32 bits		0		RW	Uni			US
3.36	Drive encoder supply voltage**	5V (0), 8V (1), 15V (2)		5V (0)		RW	Txt			US
3.37	Drive encoder comms baud rate	100 (0), 200 (1), 300 (2), 400 (3), 500 (4), 1000 (5), 1500 (6), 2000 (7) kBaud		300 (2)		RW	Txt			US
3.38	Drive encoder type	Ab (0), Fd (1), Fr (2), Ab.SErvo (3), Fd.SErvo (4), Fr.SErvo (5), SC (6), SC.Hiper (7), EndAt (8), SC.EndAt (9), SSI (10), SC.SSI (11)		Ab (0)	Ab.SErvo (3)	RW	Txt			US
3.39	Drive encoder termination select / Rotary encoder select / Comms only encoder mode	0 to 2		1		RW	Uni			US
3.40	Drive encoder error detection level	Bit 0 (LSB) = Wire break detect Bit 1 = Phase error detect Bit 2 (MSB) = SSI power supply bit monitor Value is binary sum		0	1	RW	Uni			US

Parameter	Range(⇅)		Default(⇔)			Type					
	OL	CL	OL	VT	SV	RW	Bit	FI	NC	PT	US
3.41 Drive encoder auto-configuration / SSI binary format select	OFF (0) or On (1)		OFF (0)			RW	Bit				US
3.42 Drive encoder filter	0 (0), 1 (1), 2 (2), 4 (3), 8 (4), 16 (5) ms		0			RW	Txt				US
3.43 Maximum drive encoder reference	0 to 40,000 rpm		1500	3000		RW	Uni				US
3.44 Drive encoder reference scaling	0.000 to 4.000		1 000			RW	Uni				US
3.45 Drive encoder reference	±100.0%					RO	Bi	FI	NC	PT	
3.46 Drive encoder reference destination	Pr <b>0.00</b> to <b>21.50</b>		Pr <b>0.00</b>			RW	Uni		DE	PT	US
3.47 Re-initialise position feedback	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
3.48 Position feedback initialised	OFF (0) or On (1)					RO	Bit		NC	PT	
3.49 Full motor object electronic nameplate transfer	OFF (0) or On (1)		OFF (0)			RW	Bit				US
3.50 Position feedback lock	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		

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



**\*Encoder phase angle (servo mode only)**

With drive software version V01.08.00 onwards, the encoder phase angles in Pr **3.25** and Pr **21.20** are copied to the SMARTCARD when using any of the SMARTCARD transfer methods.

With drive software version V01.05.00 to V01.07.01, the encoder phase angles in Pr **3.25** and Pr **21.20** are only copied to the SMARTCARD when using either Pr **0.30** set to Prog (2) or Pr **xx.00** set to 3yyy.

This is useful when the SMARTCARD is used to back-up the parameter set of a drive but caution should be used if the SMARTCARD is used to transfer parameter sets between drives. Unless the encoder phase angle of the servo motor connected to the destination drive is known to be the same as the servo motor connected to the source drive, an autotune should be performed or the encoder phase angle should be entered manually into Pr **3.25** (or Pr **21.20**). If the encoder phase angle is incorrect the drive may lose control of the motor resulting in an O.SPd or Enc10 trip when the drive is enabled.

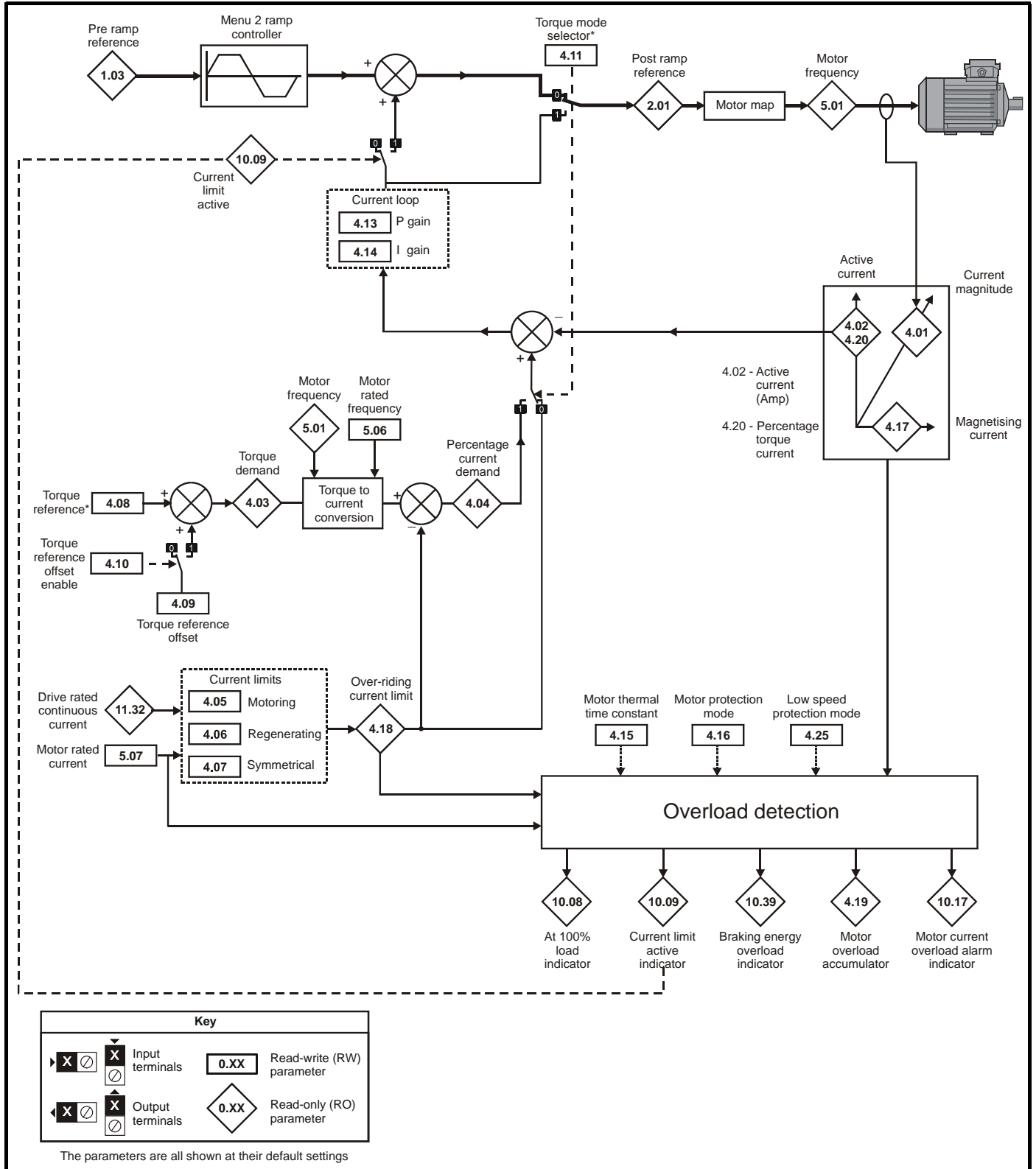
With drive software version V01.04.00 and earlier, or when using software version V01.05.00 to V01.07.01 and Pr **xx.00** set to 4yyy is used, then the encoder phase angles in Pr **3.25** and Pr **21.20** are not copied to the SMARTCARD. Therefore, Pr **3.25** and Pr **21.20** in the destination would not be changed during a transfer of this data block from the SMARTCARD.

**NOTE**

\*\*If output voltage from the encoder is >5V, then the termination resistors must be disabled Pr **3.39** to 0.

## 11.4 Menu 4: Torque and current control

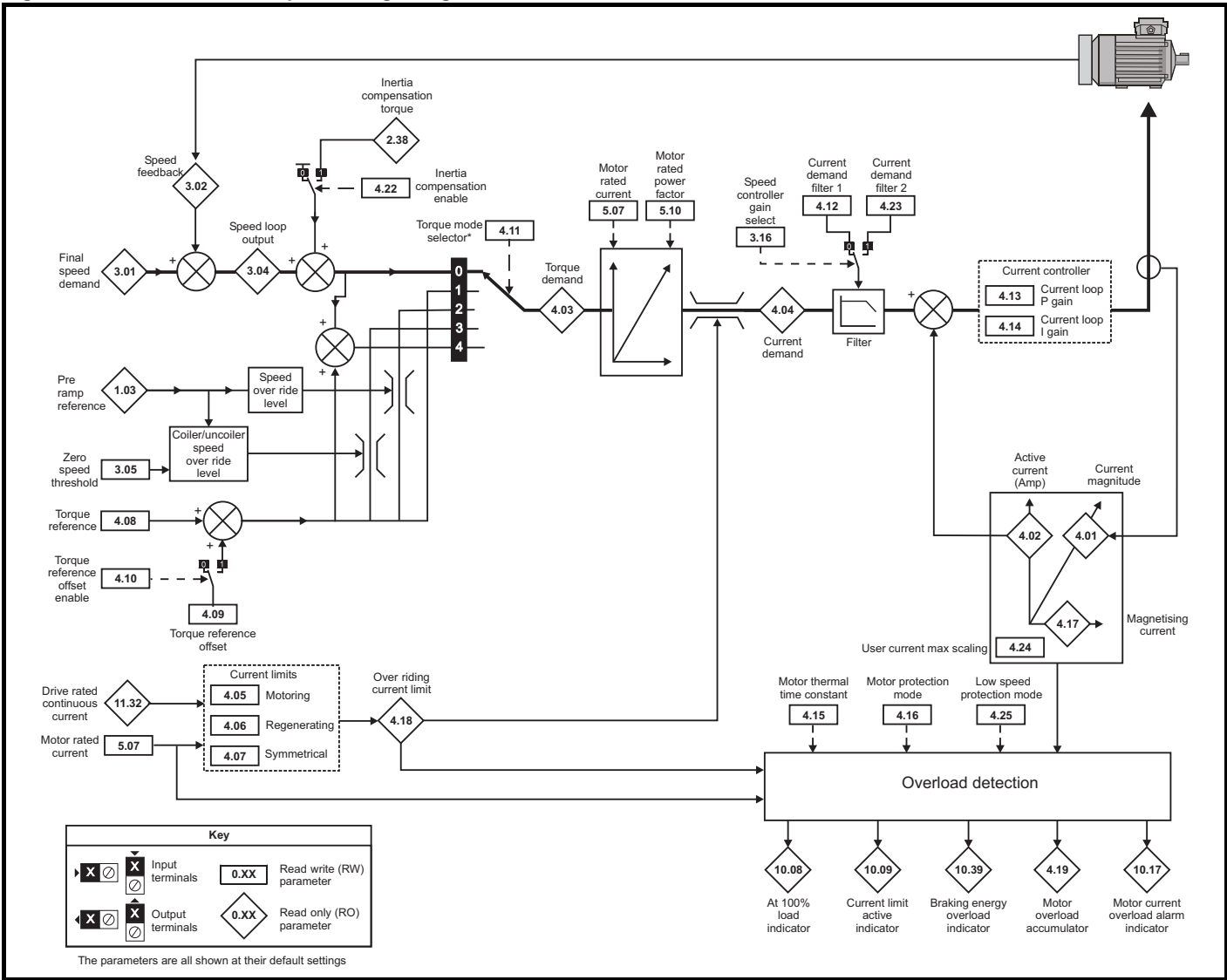
Figure 11-5 Menu 4 Open loop logic diagram



For more information, refer to section 11.21.4 *Torque modes* on page 235.

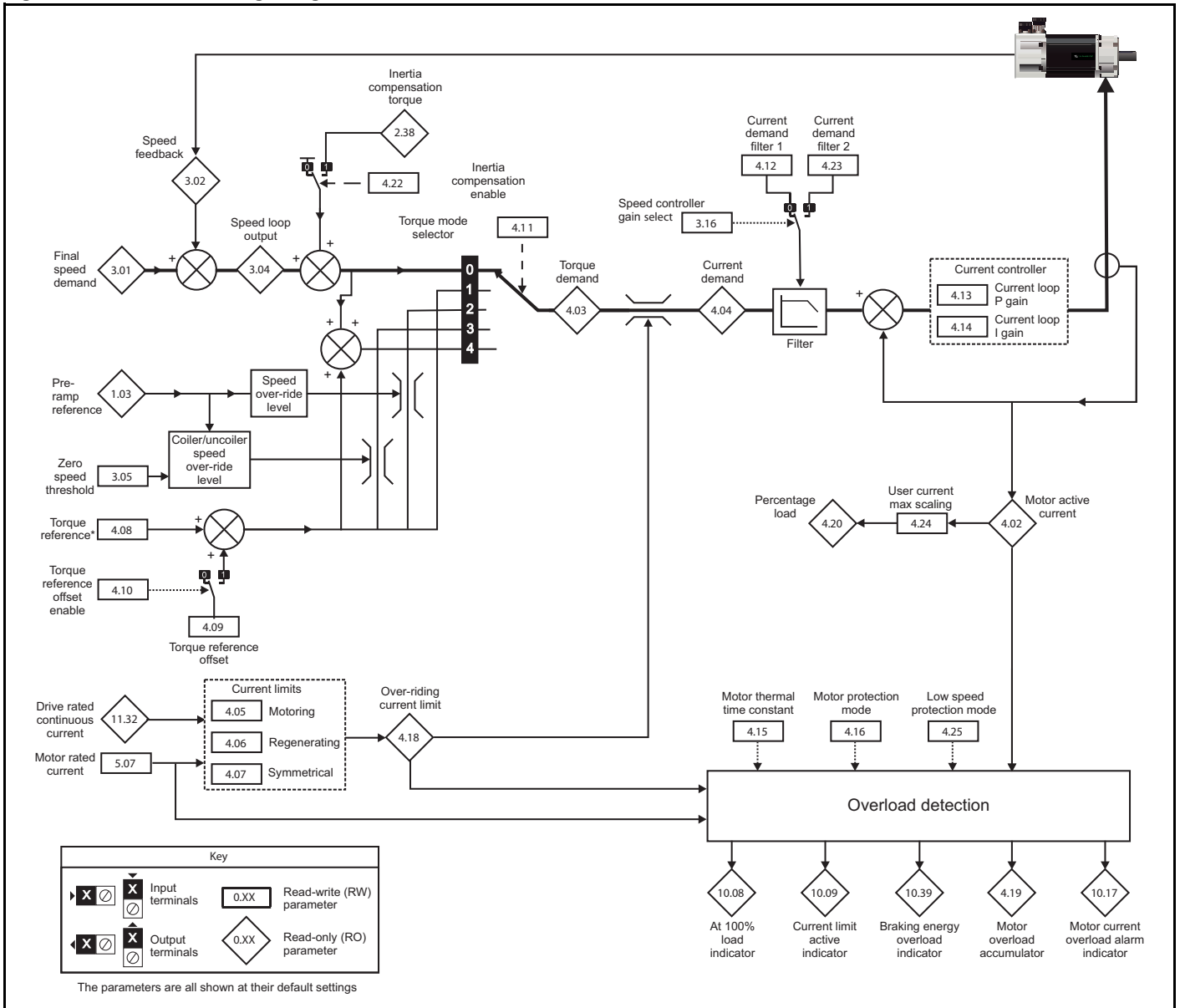


**Figure 11-6 Menu 4 Closed-loop vector logic diagram**



\*For more information, refer to section 11.21.4 *Torque modes* on page 235.

**Figure 11-7 Menu 4 Servo logic diagram**



\*For more information, refer to section 11.21.4 *Torque modes* on page 235.

Parameter	Range(⇅)		Default(⇄)			Type					
	OL	CL	OL	VT	SV						
4.01 Current magnitude {0.12}	0 to DRIVE_CURRENT_MAX A					RO	Uni	FI	NC	PT	
4.02 Active current {0.13}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
4.03 Torque demand	±TORQUE_PROD_CURRENT_MAX %					RO	Bi	FI	NC	PT	
4.04 Current demand	±TORQUE_PROD_CURRENT_MAX %					RO	Bi	FI	NC	PT	
4.05 Motoring current limit	0 to MOTOR1_CURRENT_LIMIT_MAX %		165.0*	175.0**		RW	Uni		RA		US
4.06 Regen current limit	0 to MOTOR1_CURRENT_LIMIT_MAX %		165.0*	175.0**		RW	Uni		RA		US
4.07 Symmetrical current limit {0.06}	0 to MOTOR1_CURRENT_LIMIT_MAX %		165.0*	175.0**		RW	Uni		RA		US
4.08 Torque reference	±USER_CURRENT_MAX %		0.00			RW	Bi				US
4.09 Torque offset	±USER_CURRENT_MAX %		0.0			RW	Bi				US
4.10 Torque offset select	OFF (0) or On (1)		OFF (0)			RW	Bit				US
4.11 Torque mode selector {0.14}	0 to 1	0 to 4	0			RW	Uni				US
4.12 Current demand filter 1 {0.17}		0.0 to 25 0 ms		0 0		RW	Uni				US
4.13 Current controller Kp gain {0.38}	0 to 30,000		20	200V drive: 75 400V drive: 150 575V drive: 180 690V drive: 215		RW	Uni				US
4.14 Current controller Ki gain {0.39}	0 to 30,000		40	200V drive: 1000 400V drive: 2000 575V drive: 2400 690V drive: 3000		RW	Uni				US
4.15 Thermal time constant {0.45}	0.0 to 3000 0		89.0	89.0	20.0	RW	Uni				US
4.16 Thermal protection mode	0 to 1		0			RW	Bit				US
4.17 Reactive current	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
4.18 Overriding current limit	±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	
4.22 Inertia compensation enable		OFF (0) or On (1)		OFF (0)		RW	Bit				US
4.23 Current demand filter 2		0.0 to 25 0 ms		0 0		RW	Uni				US
4.24 User current maximum scaling	0.0 to TORQUE_PROD_CURRENT_MAX %		165.0	175.0		RW	Uni		RA		US
4.25 Low speed thermal protection mode	OFF (0) or On (1)		OFF (0)			RW	Bit				US
4.26 Percentage torque	±USER_CURRENT_MAX %					RO	Bi	FI	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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\* For size 6 the default is 138.1%

\*\*For size 6 the default is 165.7% in closed loop mode and 150.0% in servo mode.

## 11.5 Menu 5: Motor control

Figure 11-8 Menu 5 Open-loop logic diagram

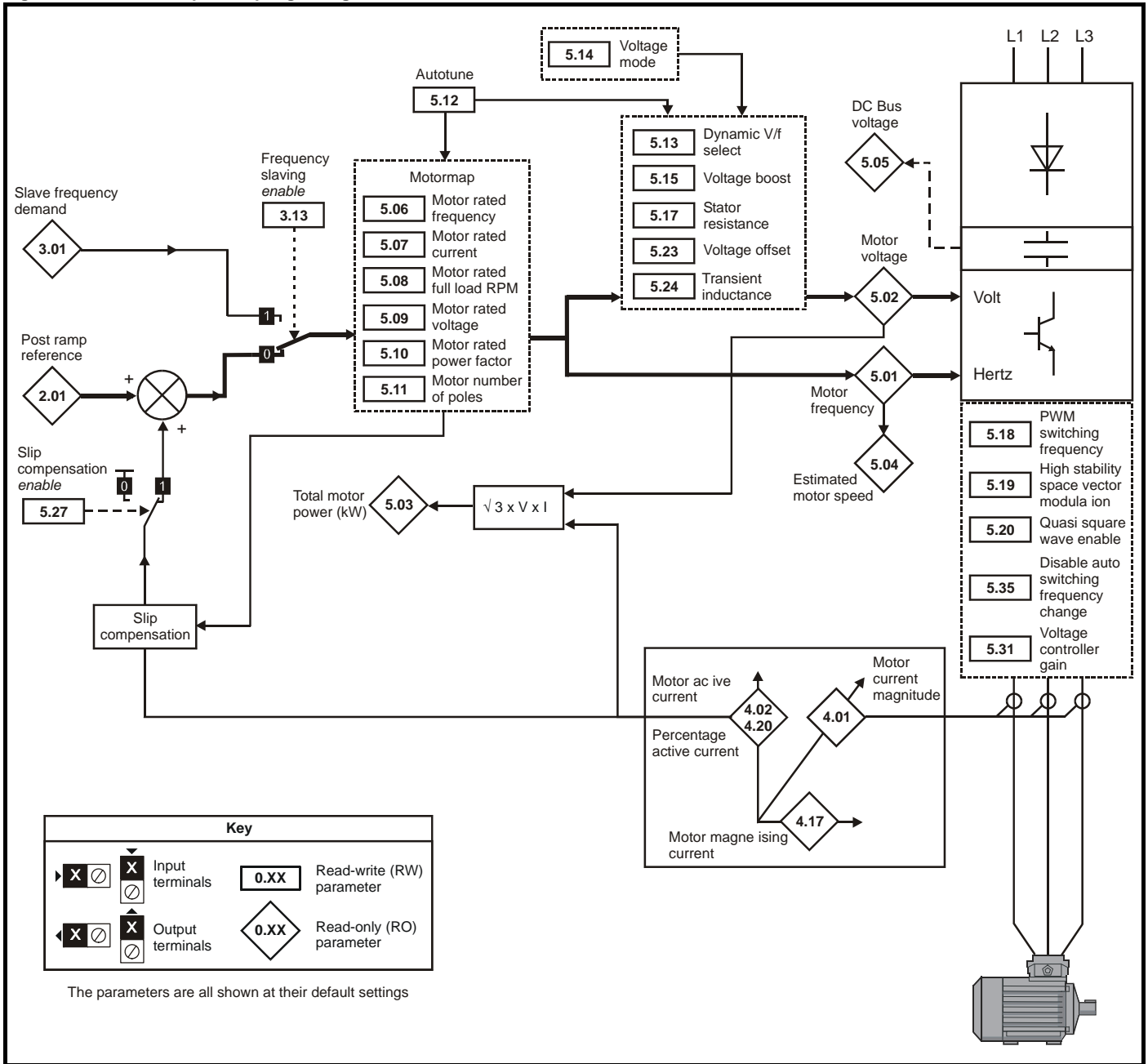
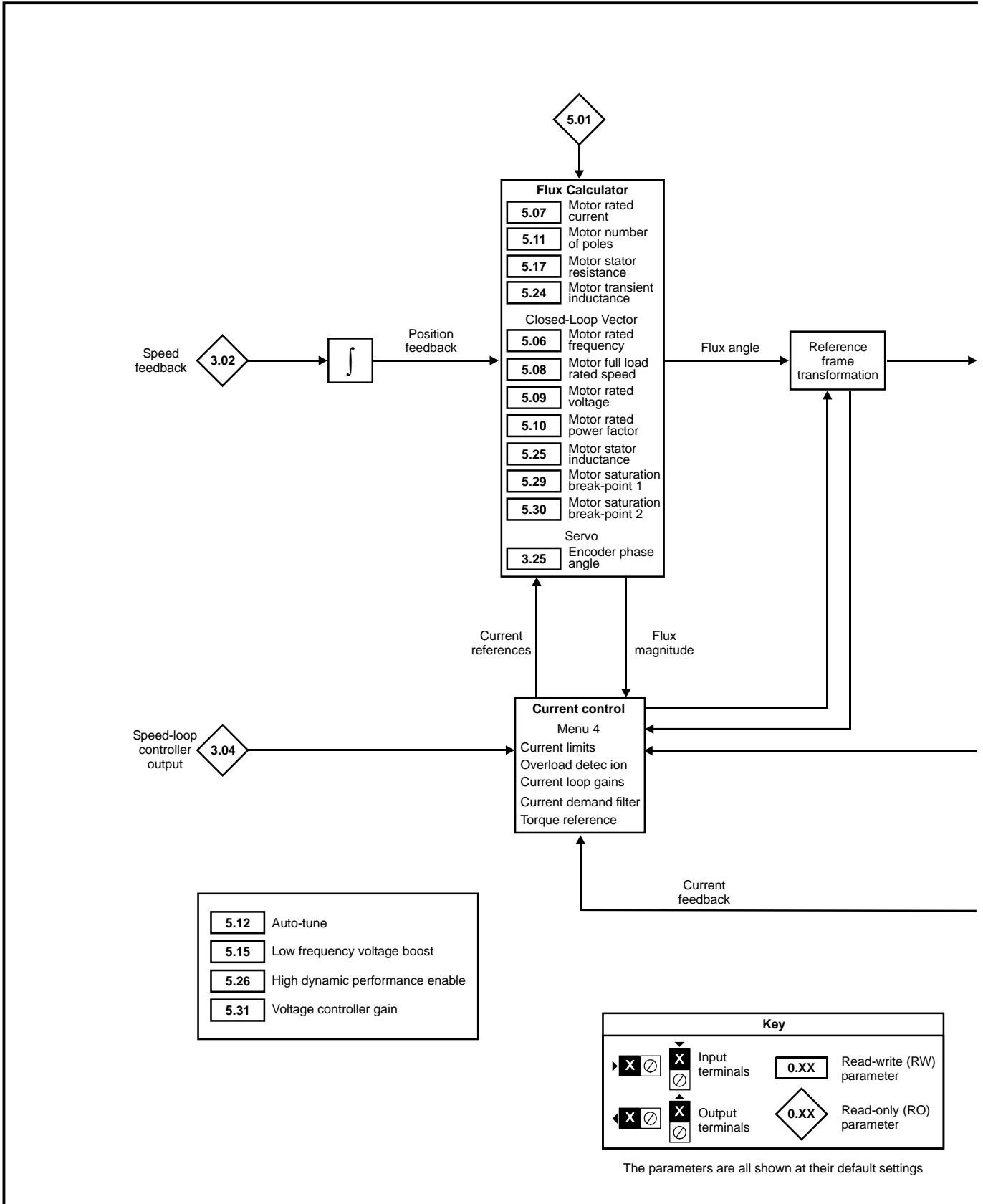
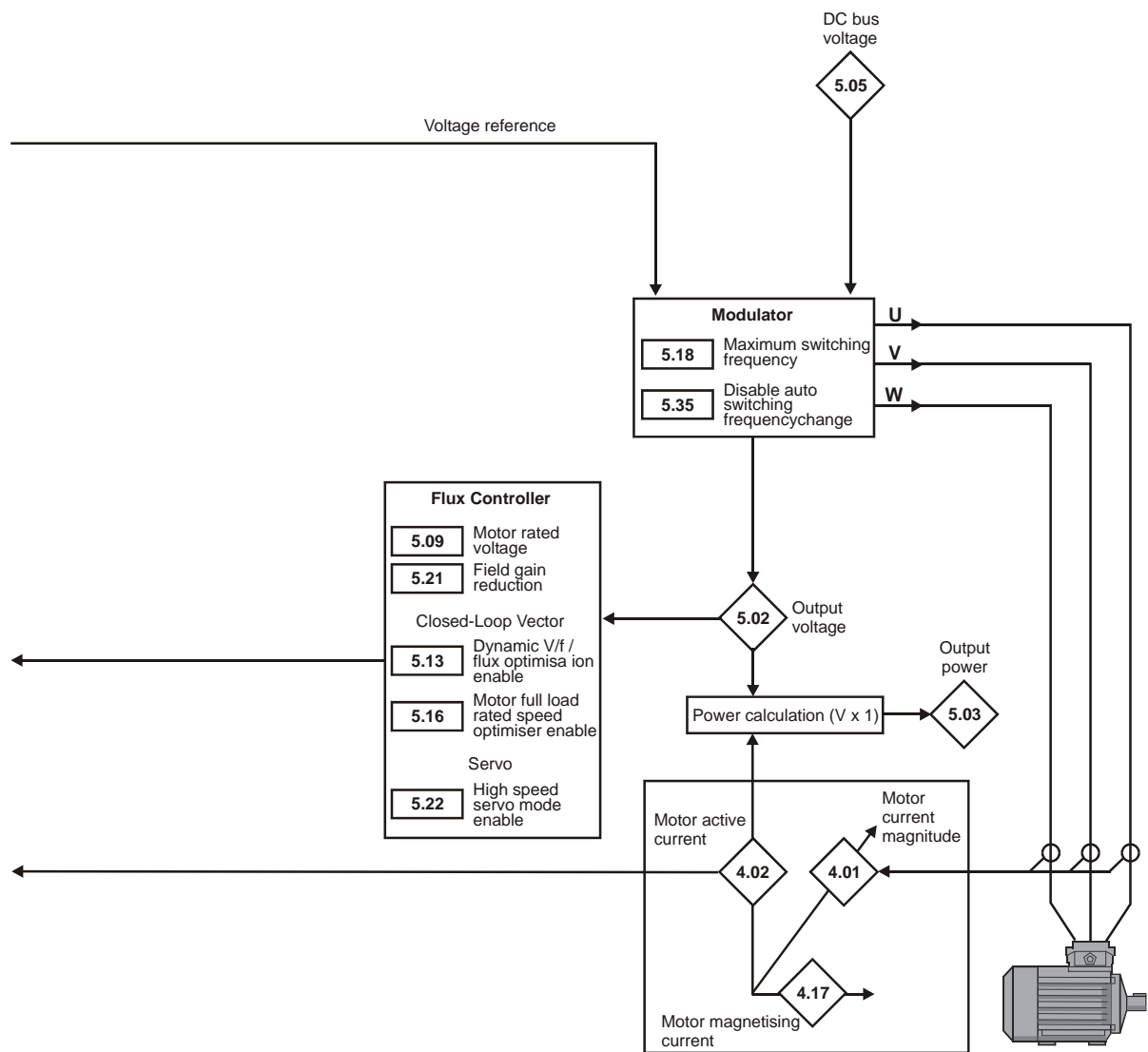




Figure 11-9 Menu 5 Closed-loop logic diagram





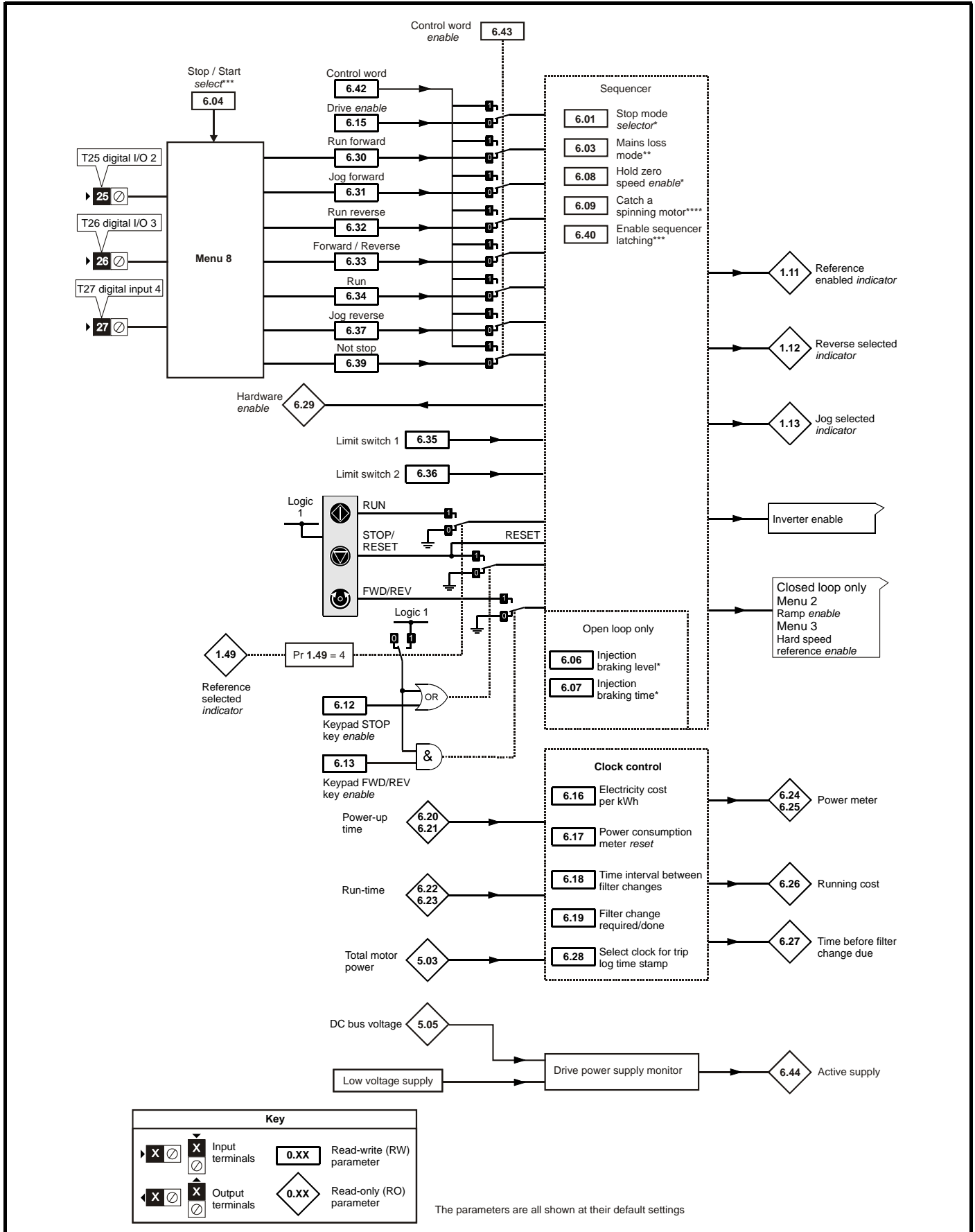
Parameter		Range(⇅)		Default(⇨)			Type						
		OL	CL	OL	VT	SV							
5.01	Output frequency {0.11}	±SPEED_FREQ_ MAX Hz		±1,250.0 Hz			RO	Bi	FI	NC	PT		
5.02	Output voltage	0 to AC_voltage_max V					RO	Uni	FI	NC	PT		
5.03	Output power	±Power_max kW					RO	Bi	FI	NC	PT		
5.04	Motor rpm {0.10}	±180,000 rpm					RO	Bi	FI	NC	PT		
5.05	D.C bus voltage	0 to +DC_voltage_max V					RO	Uni	FI	NC	PT		
5.06	Rated frequency {0.47}	0 to 3,000 Hz	VT> 0 to 1,250.0 Hz	EUR> 50.0, USA> 60.0			RW	Uni					US
5.07	Motor rated current {0.46}	0 to Rated_current_max A		Drive rated current [11.32]			RW	Uni		RA			US
5.08	Rated load rpm / rated speed {0.45}	0 to 180,000 rpm	0.00 to 40,000.00 rpm	EUR> 1,500 USA> 1,800	EUR> 1,450.00 USA> 1,770 00	3,000.00	RW	Uni					US
5.09	Rated voltage {0.44}	0 to AC_VOLTAGE_SET_MAX V		200V drive: 230 400V drive: EUR> 400, USA> 460 575V drive: 575 690V drive: 690			RW	Uni		RA			US
5.10	Rated power factor {0.43}	OL & VT> 0.000 to 1.000		0.850			RW	Uni		RA			US
5.11	Number of motor poles {0.42}	Auto to 120 Pole (0 to 60)		Auto (0) 6 POLE (3)			RW	Txt					US
5.12	Autotune {0.40}	0 to 2	VT> 0 to 4 SV> 0 to 6	0			RW	Uni		NC			
5.13	Dynamic V/F / flux optimise select {0.09}	OFF (0) or On (1)		VT> OFF (0) or On (1)		OFF (0)	RW	Bit					US
5.14	Voltage mode select {0.07}	Ur_S (0), Ur (1), Fd (2), Ur_Auto (3), Ur_I (4), SrE (5)		Ur_I (4)			RW	Txt					US
	Action on enable			SV> nonE (0), Ph EnL (1), Ph Init (2)			nonE(0)	RW	Txt				US
5.15	Low frequency voltage boost {0.08}	0.0 to 25.0 % of motor rated voltage		SPz to 3: 3.0 Size 4 & 5: 2 0 Size 6: 1.0			RW	Uni					US
5.16	Rated rpm autotune {0.33}			VT> 0 to 2			RW	Uni					US
5.17	Stator resistance	SPz: 0.000 to 65.000 x 10 Ω Size 1 to 5: 0.000 to 65.000 Ω Size 6: 0.000 to 65.000 x 10 mΩ		0.0			RW	Uni		RA			US
5.18	Maximum switching frequency {0.41}	3 (0), 4 (1), 6 (2), 8 (3), 12 (4), 16 (5) kHz		3 (0) 6 (2)			RW	Txt		RA			US
5.19	High stability space vector modulation	OFF (0) or On (1)		OFF (0)			RW	Bit					US
5.20	Quasi-square enable	OFF (0) or On (1)		OFF (0)			RW	Bit					US
5.21	Field gain reduction			OFF (0) or On (1)			RW	Bit					US
5.22	High speed servo mode enable			SV> OFF (0) or On (1)			RW	Bit					US
5.23	Voltage offset	0 0 to 25.0 V		0.0			RW	Uni		RA			US
5.24	Transient inductance (σL <sub>s</sub> )	0.000 to 500.000 mH		0.000			RW	Uni		RA			US
5.25	Stator inductance (L <sub>s</sub> )			VT> 0.00 to 5,000.00 mH			RW	Uni		RA			US
5.26	High dynamic performance enable			OFF (0) or On (1)			RW	Bit					US
5.27	Enable slip compensation	OFF (0) or On (1)		On (1)			RW	Bit					US
5.28	Field weakening compensation disable			VT> OFF (0) or On (1)			RW	Bit					US
5.29	Motor saturation breakpoint 1			VT> 0 to 100% of rated flux			RW	Uni					US
5.30	Motor saturation breakpoint 2			VT> 0 to 100% of rated flux			RW	Uni					US
5.31	Voltage controller gain	0 to 30		1			RW	Uni					US
5.32	Motor torque per amp, K <sub>t</sub>			VT> 0.00 to 500.00 N m A <sup>-1</sup>			RO	Uni					US
				SV> 0 00 to 500.00 N m A <sup>-1</sup>			1.60	RW	Uni				US
5.33	Motor volts per 1,000 rpm, K <sub>e</sub>			SV> 0 to 10,000 V			98	RW	Uni				US
5.35	Disable auto switching frequency change	OFF (0) or On (1)		OFF (0)			RW	Bit					US
5.36	Motor pole pitch	0 to 655.35 mm		0.00			RW	Uni					US
5.37	Actual switching frequency	3 (0), 4 (1), 6 (2), 8 (3), 12 (4), 16 (5), 6 rEd (6), 12 rEd (7)					RO	Txt		NC	PT		
5.38	Minimal movement phasing test angle			SV> 0.0 to 25.5			5.0	RW	Uni				US
5.39	Minimal movement phasing test pulse length			SV> 0 to 3			0	RW	Uni				US
5.40	Spin start boost	0.0 to 10.0		VT> 0.0 to 10.0			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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save



# 11.6 Menu 6: Sequencer and clock

Figure 11-10 Menu 6 logic diagram



Parameter		Range(↕)		Default(⇒)			Type								
		OL	CL	OL	VT	SV									
6.01	Stop mode	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4), diSAbLE (5)		COASt (0), rP (1), no.rP (2)		rP (1)		no.rP (2)			RW	Txt		US	
6.03	Line power supply loss mode	diS (0), StoP (1), ridE.th (2)		diS (0)								RW	Txt		US
6.04	Start / stop logic select	0 to 4		4								RW	Uni		US
6.06	Injection braking level	0 to 150.0%		100.0%								RW	Uni	RA	US
6.07	Injection braking time	0.0 to 25.0s		1.0								RW	Uni		US
6.08	Hold zero speed	OFF (0) or On (1)		OFF (0)			On (1)					RW	Bit		US
6.09	Catch a spinning motor {0.33}	0 to 3		0 to 1			0		1			RW	Uni		US
6.12	Enable stop key	OFF (0) or On (1)		OFF (0)								RW	Bit		US
6.13	Enable forward / reverse key {0.28}	OFF (0) or On (1)		OFF (0)								RW	Bit		US
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								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		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
6.23	Run time: hours.minutes	0 to 23.59 hours.minutes										RO	Uni	NC	PT
6.24	Energy meter: MWh	±999.9 MWh										RO	Bi	NC	PT
6.25	Energy meter: kWh	±99.99 kWh										RO	Bi	NC	PT
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
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
6.30	Sequencing bit: Run forward	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.31	Sequencing bit: Jog forward	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.32	Sequencing bit: Run reverse	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.33	Sequencing bit: Forward / reverse	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.34	Sequencing bit: Run	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.35	Forward limit switch	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.36	Reverse limit switch	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.37	Sequencing bit: Jog reverse	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.39	Sequencing bit: Not stop	OFF (0) or On (1)		OFF (0)								RW	Bit	NC	
6.40	Enable sequencer latching	OFF (0) or On (1)		OFF (0)								RW	Bit		US
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	Nominal low voltage supply	Size 1: 48V Size 2, 3 and 200V size 4: 48V to 72V 400V size 4 to 6: 48V to 96V		48								RW	Uni		PT
6.47	Disable line power supply / phase loss detection from input rectifier	OFF (0) or On (1)		OFF (0)								RW	Bit		US
6.48	Line powersupply loss ride through detection level	0 to DC_VOLTAGE_SET_MAX V		200V drive: 205, 400V drive: 410, 575V drive: 540, 690V drive: 540								RW	Uni	RA	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	drv (0), SLOt 1(1), SLOt 2 (2), SLOt 3 (3)										RO	Txt	NC	PT
6.51	External rectifier not active	OFF (0) or On (1)		OFF (0)								RW	Bit		

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

\*For more information, refer to section 11.21.5 *Stop modes* on page 236.

\*\*For more information, refer to section 11.21.6 *Line power supply loss modes* on page 237.

\*\*\*For more information, refer to section 11.21.7 *Start / stop logic modes* on page 238.

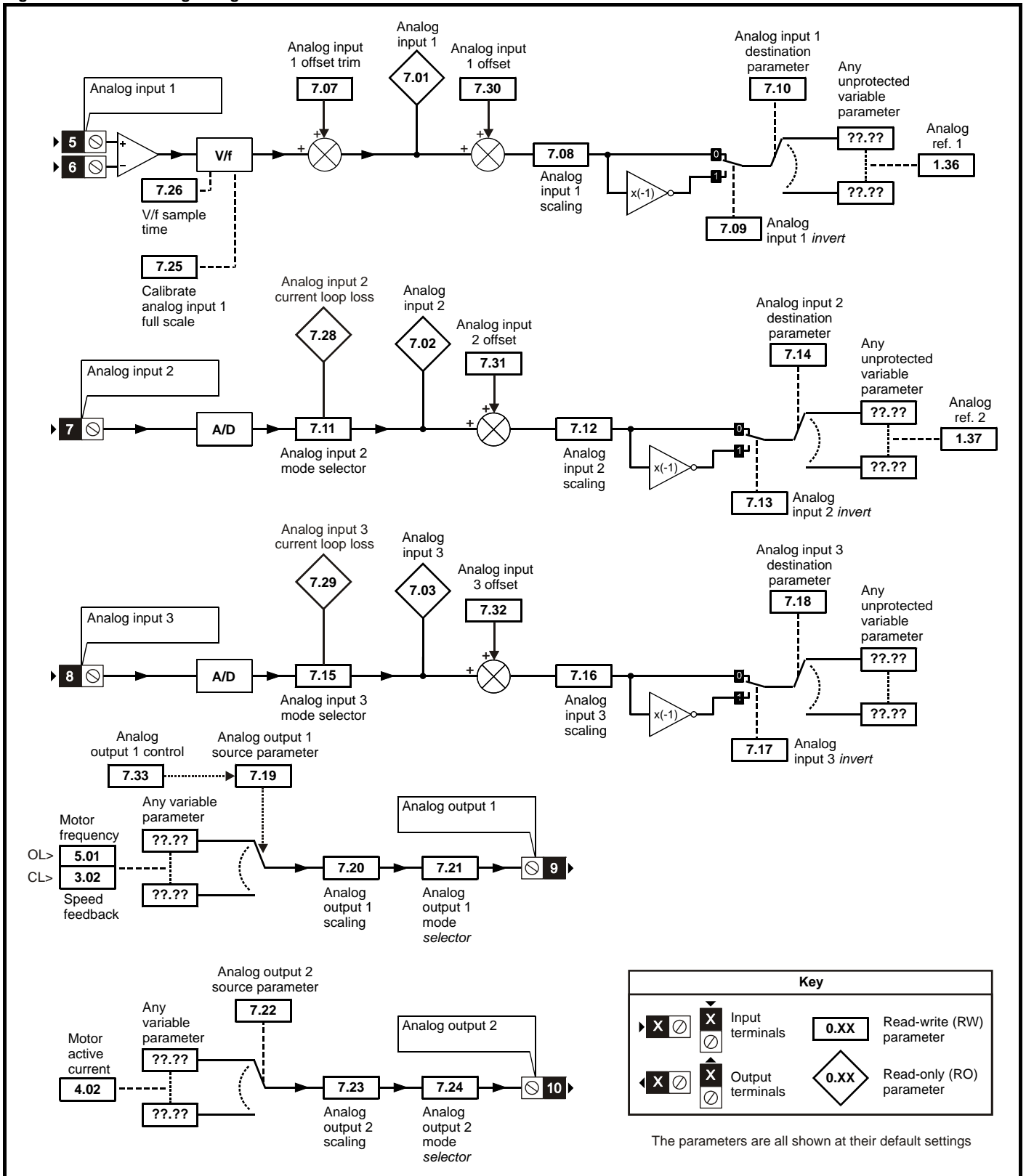
\*\*\*\*For more information, refer to section 11.21.8 *Catch a spinning*

*motor* on page 239.

\*\*\*\*\*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. Note that the fan will only run at full speed if the drive is not in a UU condition.

## 11.7 Menu 7: Analog I/O

Figure 11-11 Menu 7 logic diagram



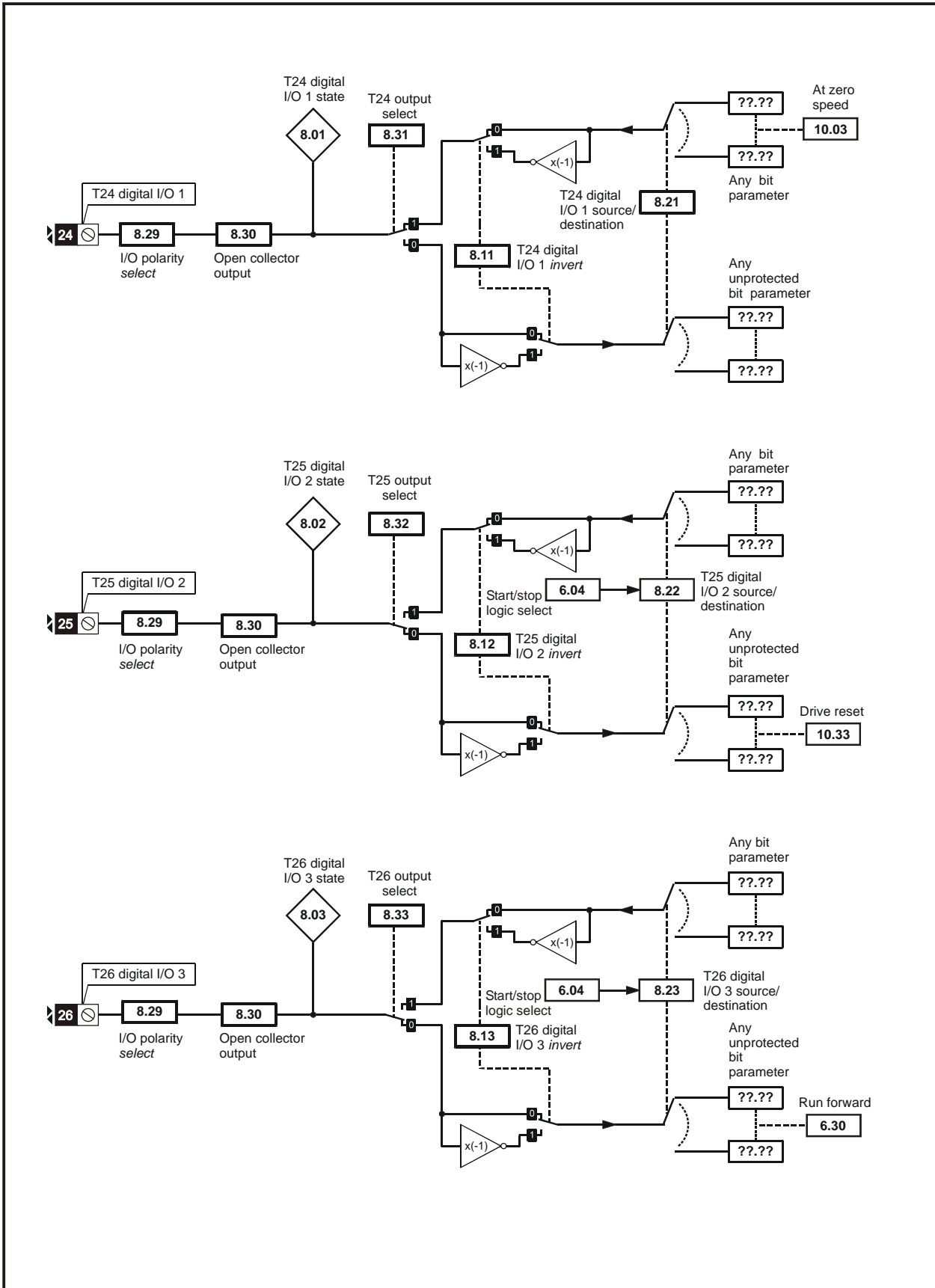
Parameter	Range(⇅)		Default(⇔)			Type						
	OL	CL	OL	VT	SV							
7.01	T5/6 analog input 1 level	±100.00 %					RO	Bi		NC	PT	
7.02	T7 analog input 2 level	±100.0 %					RO	Bi		NC	PT	
7.03	T8 analog input 3 level	±100.0 %					RO	Bi		NC	PT	
7.04	Power circuit temperature 1	-128 to 127 C					RO	Bi		NC	PT	
7.05	Power circuit 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 analog input 1 offset trim {0.13}	±10.000 %		0.000			RW	Bi				US
7.08	T5/6 analog input 1 scaling	0 to 4.000		1.000			RW	Uni				US
7.09	T5/6 analog input 1 invert	OFF (0) or On (1)		OFF (0)			RW	Bit				US
7.10	T5/6 analog input 1 destination	Pr 0.00 to 21.51		Pr 1.36			RW	Uni	DE		PT	US
7.11	T7 analog 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 analog input 2 scaling	0 to 4.000		1.000			RW	Uni				US
7.13	T7 analog input 2 invert	OFF (0) or On (1)		OFF (0)			RW	Bit				US
7.14	T7 analog input 2 destination {0.20}	Pr 0.00 to 21.51		Pr 1.37			RW	Uni	DE		PT	US
7.15	T8 analog 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)		th (8)			RW	Txt				US
7.16	T8 analog input 3 scaling	0 to 4.000		1.000			RW	Uni				US
7.17	T8 analog input 3 invert	OFF (0) or On (1)		OFF (0)			RW	Bit				US
7.18	T8 analog input 3 destination	Pr 0.00 to 21.51		Pr 0.00			RW	Uni	DE		PT	US
7.19	T9 analog output 1 source	Pr 0.00 to 21.51		Pr 5.01	Pr 3.02		RW	Uni			PT	US
7.20	T9 analog output 1 scaling	0.000 to 4.000		1.000			RW	Uni				US
7.21	T9 analog output 1 mode	VOLt (0), 0-20 (1), 4-20 (2), H.SPd (3)		VOLt (0)			RW	Txt				US
7.22	T10 analog output 2 source	Pr 0.00 to 21.51		Pr 4.02			RW	Uni			PT	US
7.23	T10 analog output 2 scaling	0.000 to 4.000		1.000			RW	Uni				US
7.24	T10 analog output 2 mode	VOLt (0), 0-20 (1), 4-20 (2), H.SPd (3)		VOLt (0)			RW	Txt				US
7.25	Calibrate T5/6 analog input 1 full scale	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
7.26	T5/6 analog input 1 sample time	0 to 8.0 ms		4.0			RW	Uni				US
7.28	T7 analog input 2 current loop loss	OFF (0) or On (1)					RO	Bit		NC	PT	
7.29	T8 analog input 3 current loop loss	OFF (0) or On (1)					RO	Bit		NC	PT	
7.30	T5/6 analog input 1 offset	±100.00 %		0.00			RW	Bi				US
7.31	T7 analog input 2 offset	±100.0 %		0.0			RW	Bi				US
7.32	T8 analog input 3 offset	±100.0 %		0.0			RW	Bi				US
7.33	T9 analog 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	
7.36	Power circuit temperature 3	-128 to 127 C					RO	Bi		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

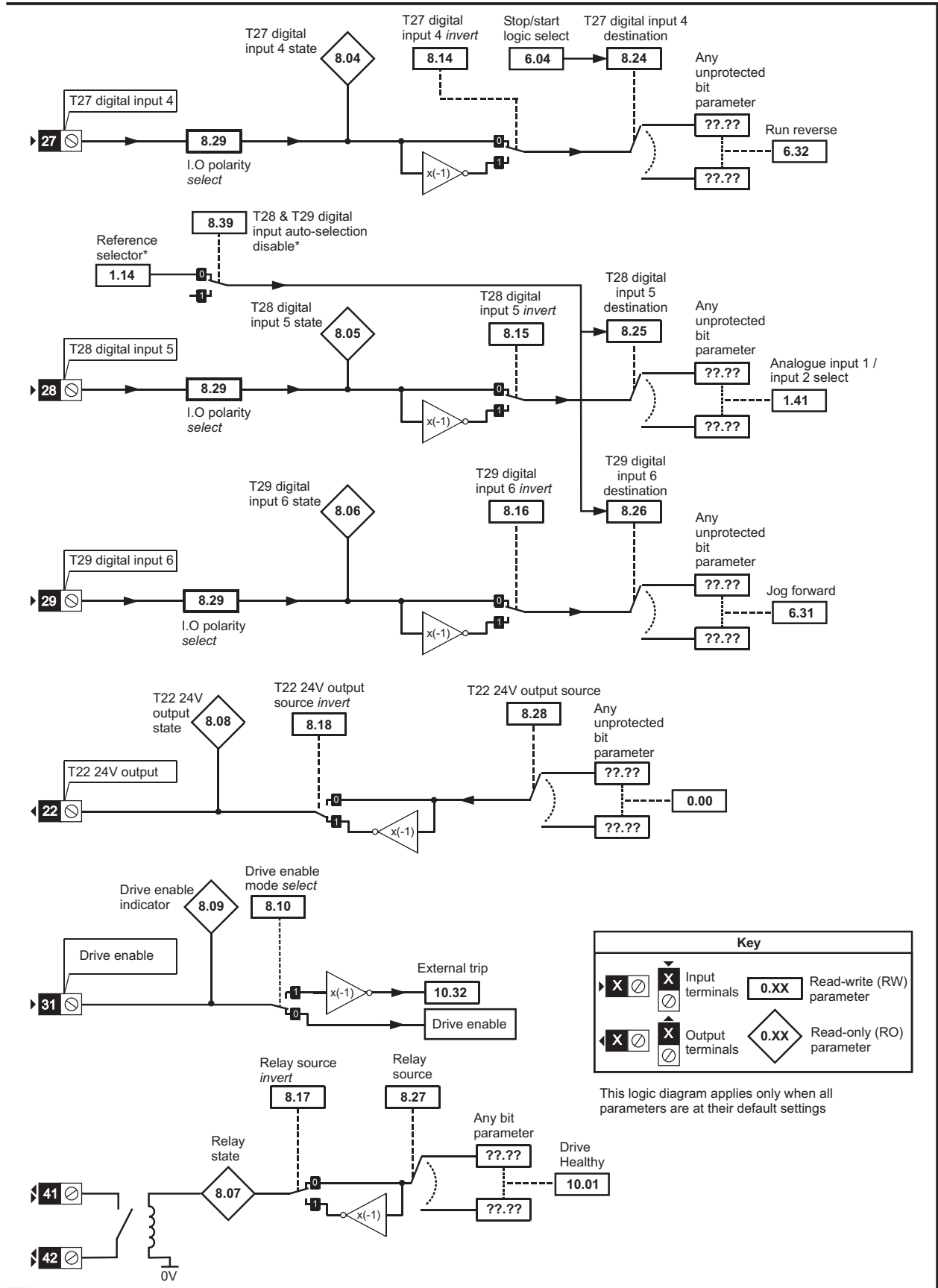


## 11.8 Menu 8: Digital I/O

Figure 11-12 Menu 8 logic diagram



\*For more information, refer to section 11.21.1 Reference modes on page 233.



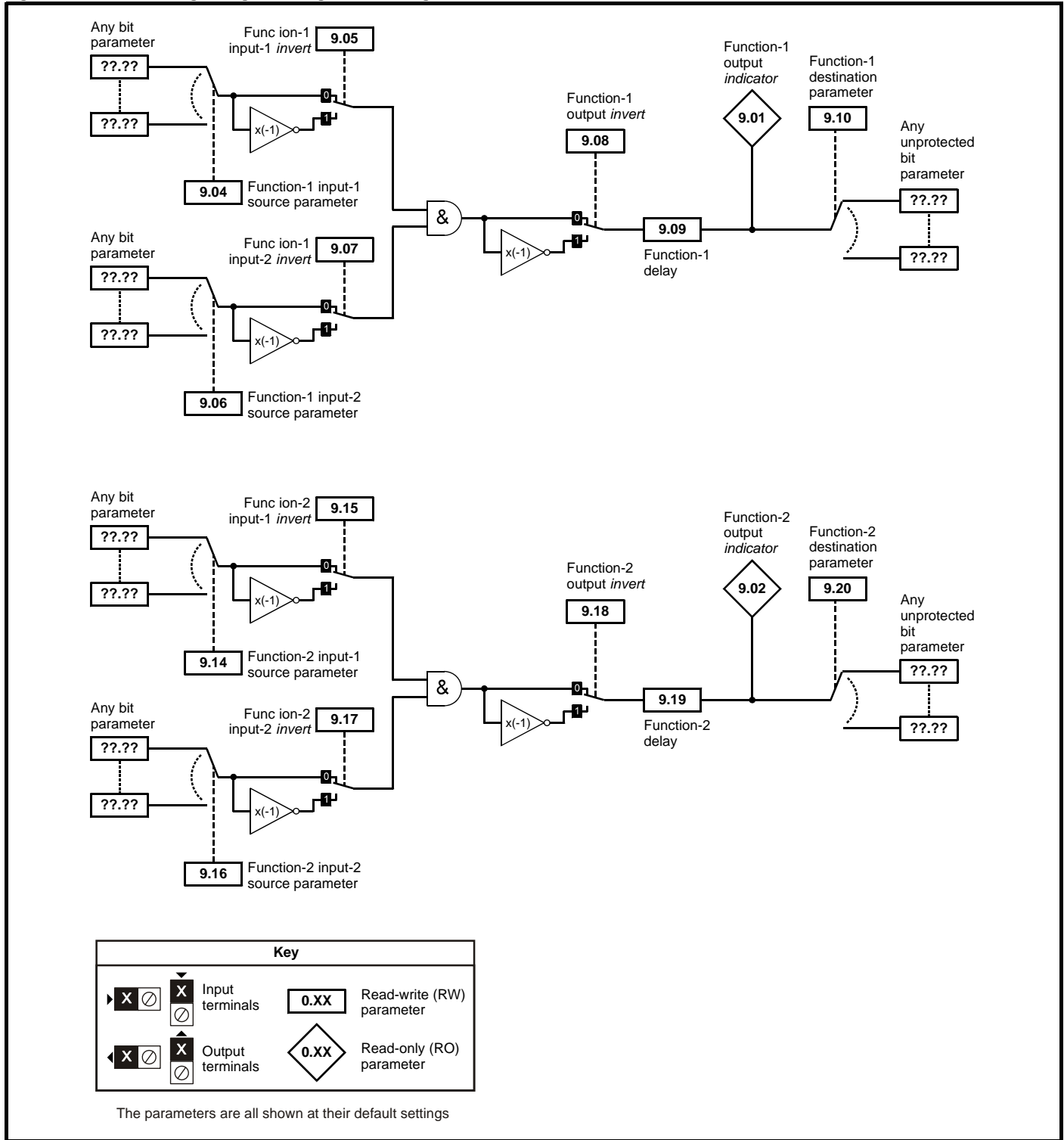
Parameter	Range(⇅)		Default(⇔)			Type				
	OL	CL	OL	VT	SV					
8.01	T24 digital I/O 1 state	OFF (0) or On (1)				RO	Bit		NC	PT
8.02	T25 digital I/O 2 state	OFF (0) or On (1)				RO	Bit		NC	PT
8.03	T26 digital I/O 3 state	OFF (0) or On (1)				RO	Bit		NC	PT
8.04	T27 digital input 4 state	OFF (0) or On (1)				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 10.03		RW	Uni	DE		PT US
8.22	T25 digital I/O 2 source/destination	Pr 0.00 to 21.51		Pr 10.33		RW	Uni	DE		PT US
8.23	T26 digital I/O 3 source/destination	Pr 0.00 to 21.51		Pr 6.30		RW	Uni	DE		PT US
8.24	T27 digital input 4 destination	Pr 0.00 to 21.51		Pr 6.32		RW	Uni	DE		PT US
8.25	T28 digital input 5 destination	Pr 0.00 to 21.51		Pr 1.41		RW	Uni	DE		PT US
8.26	T29 digital input 6 destination {0.17}	Pr 0.00 to 21.51		Pr 6.31		RW	Uni	DE		PT US
8.27	Relay source	Pr 0.00 to 21.51		Pr 10.01		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)		OFF (0)		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

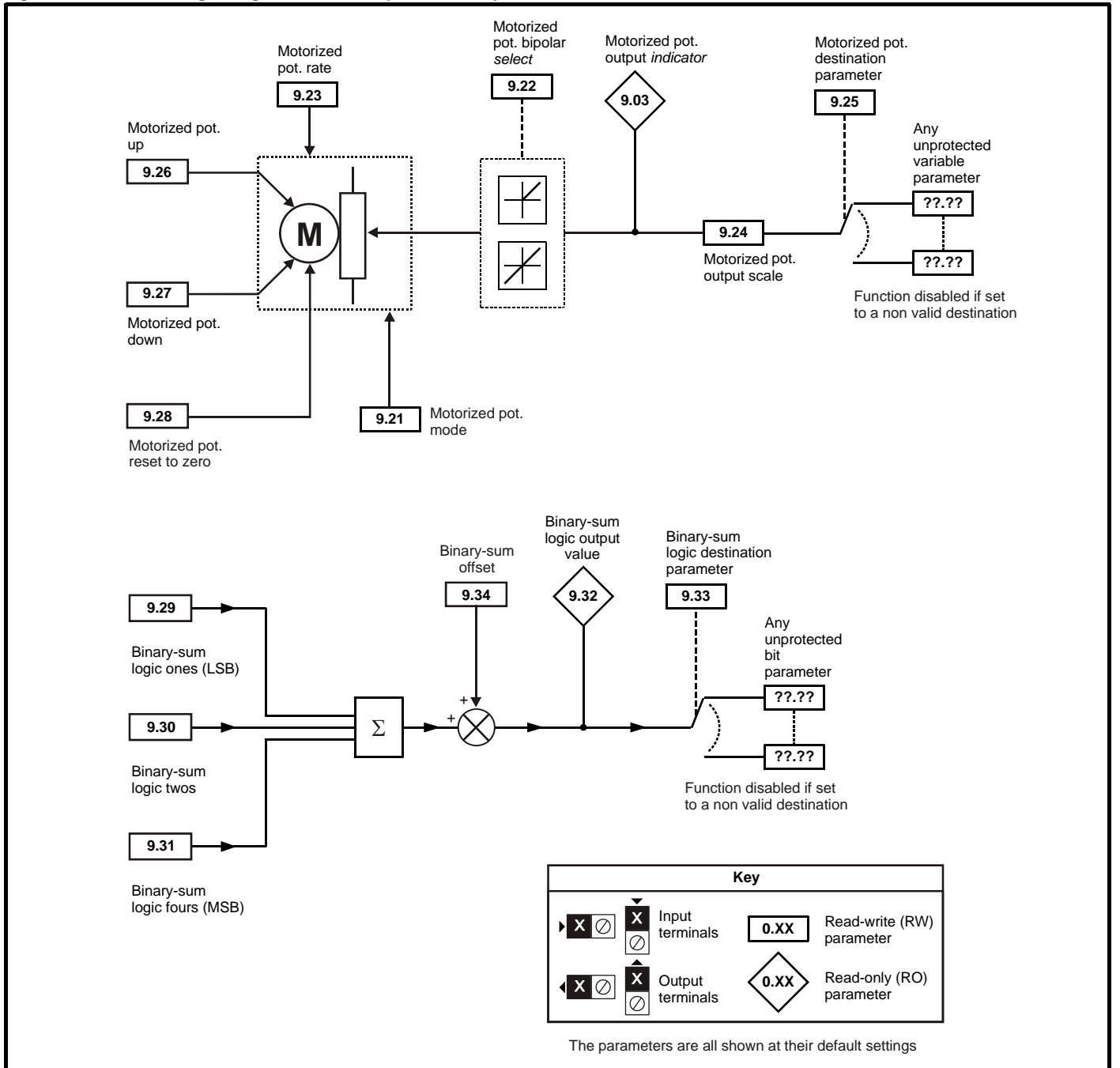


## 11.9 Menu 9: Programmable logic, motorized pot, binary sum and timers

Figure 11-13 Menu 9 logic diagram: Programmable logic



**Figure 11-14 Menu 9 logic diagram: Motorized pot and binary sum**



Parameter	Range(⇅)		Default(⇄)			Type										
	OL	CL	OL	VT	SV											
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	Motorized 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	Motorized pot mode	0 to 3					2				RW	Uni				US
9.22	Motorized pot bipolar select	OFF (0) or On (1)					OFF (0)				RW	Bit				US
9.23	Motorized pot rate	0 to 250 s					20				RW	Uni				US
9.24	Motorized pot scale factor	0.000 to 4.000					1.000				RW	Uni				US
9.25	Motorized pot destination	Pr 0.00 to 21.51					Pr 0.00				RW	Uni	DE		PT	US
9.26	Motorized pot up	OFF (0) or On (1)					OFF (0)				RW	Bit		NC		
9.27	Motorized pot down	OFF (0) or On (1)					OFF (0)				RW	Bit		NC		
9.28	Motorized 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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

## 11.10 Menu 10: Status and trips

Parameter	Range(⇅)		Default(⇔)			Type				
	OL	CL	OL	VT	SV					
10.01	Drive OK	OFF (0) or On (1)				RO	Bit		NC	PT
10.02	Drive active	OFF (0) or On (1)				RO	Bit		NC	PT
10.03	Zero speed	OFF (0) or On (1)				RO	Bit		NC	PT
10.04	Running at or below minimum speed	OFF (0) or On (1)				RO	Bit		NC	PT
10.05	Below set speed	OFF (0) or On (1)				RO	Bit		NC	PT
10.06	At speed	OFF (0) or On (1)				RO	Bit		NC	PT
10.07	Above set speed	OFF (0) or On (1)				RO	Bit		NC	PT
10.08	Load reached	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
10.13	Direction commanded	OFF (0) or On (1) [0 = FWD, 1 = REV]				RO	Bit		NC	PT
10.14	Direction running	OFF (0) or On (1) [0 = FWD, 1 = REV]				RO	Bit		NC	PT
10.15	Line powersupply 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 232*				RO	Txt		NC	PT PS
10.21	Trip 1	0 to 232*				RO	Txt		NC	PT PS
10.22	Trip 2	0 to 232*				RO	Txt		NC	PT PS
10.23	Trip 3	0 to 232*				RO	Txt		NC	PT PS
10.24	Trip 4	0 to 232*				RO	Txt		NC	PT PS
10.25	Trip 5	0 to 232*				RO	Txt		NC	PT PS
10.26	Trip 6	0 to 232*				RO	Txt		NC	PT PS
10.27	Trip 7	0 to 232*				RO	Txt		NC	PT PS
10.28	Trip 8	0 to 232*				RO	Txt		NC	PT PS
10.29	Trip 9	0 to 232*				RO	Txt		NC	PT PS
10.30	Full power braking time	0.00 to 400.00 s			See Table 11-6	RW	Uni			US
10.31	Full power braking period	0.0 to 1500.0 s			See Table 11-6	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 OK until last attempt	OFF (0) or On (1)			OFF (0)	RW	Bit			US
10.37	Action on trip detection	0 to 15			0	RW	Uni			US
10.38	User trip	0 to 255			0	RW	Uni		NC	
10.39	Braking energy overload accumulator	0.0 to 100.0 %				RO	Uni		NC	PT
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	Module number for trip 0, or, Trip 0 time: hours.minutes	00.00 to 23.59 hours.minutes				RO	Uni		NC	PT PS
10.43	Module number for trip 1, or, Trip 1 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.44	Module number for trip 2, or, Trip 2 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.45	Module number for trip 3, or, Trip 3 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.46	Module number for trip 4, or, Trip 4 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.47	Module number for trip 5, or, Trip 5 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.48	Module number for trip 6, or, Trip 6 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.49	Module number for trip 7, or, Trip 7 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.50	Module number for trip 8, or, Trip 8 time	0 to 600.00 hours.minutes				RO	Uni		NC	PT PS
10.51	Module number for trip 9, or, 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 copied	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 Chapter 13 *Diagnostics* on page 260.

**Table 11-6 Defaults for Pr 10.30 and Pr 10.31**

Drive rating	Pr 10.30	Pr 10.31
200V, SPz	0.06	2.6
400V, SPz	0.01	1.7
200V, size 1 & 2	0.09	3.3
400V, size 1 & 2	0.02	3.3
All other ratings and frame sizes	0.00	

## 11.11 Menu 11: General drive set-up

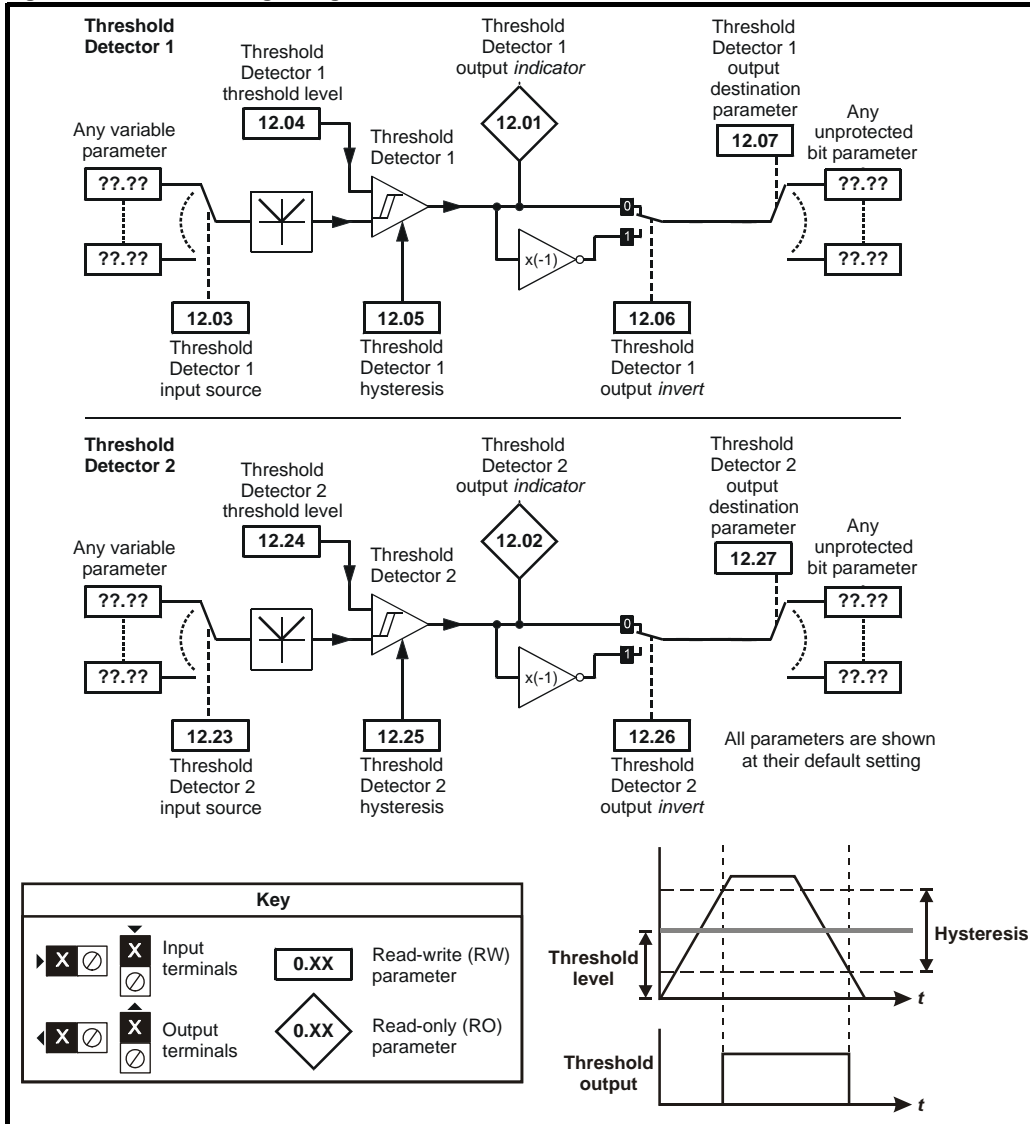
Parameter	Range(⇅)		Default(⇄)			Type					
	OL	CL	OL	VT	SV						
11.01 Parameter 0.11 set up	Pr 1.00 to Pr 21.51		Pr 5.01			Pr 3.29	RW	Uni		PT	US
11.02 Parameter 0.12 set up	Pr 1.00 to Pr 21.51		Pr 4.01				RW	Uni		PT	US
11.03 Parameter 0.13 set up	Pr 1.00 to Pr 21.51		Pr 4.02			Pr 7.07	RW	Uni		PT	US
11.04 Parameter 0.14 set up	Pr 1.00 to Pr 21.51		Pr 4.11				RW	Uni		PT	US
11.05 Parameter 0.15 set up	Pr 1.00 to Pr 21.51		Pr 2.04				RW	Uni		PT	US
11.06 Parameter 0.16 set up	Pr 1.00 to Pr 21.51		Pr 8.39	Pr 2.02			RW	Uni		PT	US
11.07 Parameter 0.17 set up	Pr 1.00 to Pr 21.51		Pr 8.26	Pr 4.12			RW	Uni		PT	US
11.08 Parameter 0.18 set up	Pr 1.00 to Pr 21.51		Pr 8.29				RW	Uni		PT	US
11.09 Parameter 0.19 set up	Pr 1.00 to Pr 21.51		Pr 7.11				RW	Uni		PT	US
11.10 Parameter 0.20 set up	Pr 1.00 to Pr 21.51		Pr 7.14				RW	Uni		PT	US
11.11 Parameter 0.21 set up	Pr 1.00 to Pr 21.51		Pr 7.15				RW	Uni		PT	US
11.12 Parameter 0.22 set up	Pr 1.00 to Pr 21.51		Pr 1.10				RW	Uni		PT	US
11.13 Parameter 0.23 set up	Pr 1.00 to Pr 21.51		Pr 1.05				RW	Uni		PT	US
11.14 Parameter 0.24 set up	Pr 1.00 to Pr 21.51		Pr 1.21				RW	Uni		PT	US
11.15 Parameter 0.25 set up	Pr 1.00 to Pr 21.51		Pr 1.22				RW	Uni		PT	US
11.16 Parameter 0.26 set up	Pr 1.00 to Pr 21.51		Pr 1.23	Pr 3.08			RW	Uni		PT	US
11.17 Parameter 0.27 set up	Pr 1.00 to Pr 21.51		Pr 1.24	Pr 3.34			RW	Uni		PT	US
11.18 Parameter 0.28 set up	Pr 1.00 to Pr 21.51		Pr 6.13				RW	Uni		PT	US
11.19 Parameter 0.29 set up	Pr 1.00 to Pr 21.51		Pr 11.36				RW	Uni		PT	US
11.20 Parameter 0.30 set up	Pr 1.00 to Pr 21.51		Pr 11.42				RW	Uni		PT	US
11.21 Parameter 0.30 scaling	0.000 to 9.999		1.000				RW	Uni			US
11.22 Parameter displayed at power-up	Pr 0.00 to 00.59		Pr 0.10				RW	Uni		PT	US
11.23 Serial address {0.37}	0 to 247		1				RW	Uni			US
11.24 Serial mode {0.35}	AnSI (0), rTU (1), Lcd (2)		rtU (1)				RW	Txt		PT	US
11.25 Baud rate {0.36}	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
11.26 Minimum comms transmit delay	0 to 250ms		2				RW	Uni			US
11.28 Drive derivative	0 to 16						RO	Uni	NC	PT	
11.29 Software version {0.50}	1.00 to 99.99						RO	Uni	NC	PT	
11.30 User security code {0.34}	0 to 999		0				RW	Uni	NC	PT	PS
11.31 User drive mode {0.48}	OPEn LP (1), CL VECT (2), SERVO (3), rEGEn (4)		OPEn LP (1)	CL VECT (2)	SERVO (3)		RW	Txt	NC	PT	
11.32 Maximum Heavy Duty current rating {0.32}	0.00 to 9999.99A						RO	Uni	NC	PT	
11.33 Drive voltage rating {0.31}	200 (0), 400 (1), 575 (2), 690 (3)						RO	Txt	NC	PT	
11.34 Software sub-version	0 to 99						RO	Uni	NC	PT	
11.35 Number of modules	0 to 10		0				RW	Uni		PT	US
11.36 SMARTCARD parameter data previously loaded {0.29}	0 to 999		0				RO	Uni	NC	PT	US
11.37 SMARTCARD data number	0 to 1003		0				RW	Uni	NC		
11.38 SMARTCARD data type / mode	0 to 18						RO	Txt	NC	PT	
11.39 SMARTCARD data version	0 to 9,999		0				RW	Uni	NC		
11.40 SMARTCARD data checksum	0 to 65,335						RO	Uni	NC	PT	
11.41 Status mode timeout	0 to 250s		240				RW	Uni			US
11.42 Parameter copying {0.30}	nonE (0), rEAd (1), Prog (2), AutO (3), boot (4)		nonE (0)				RW	Txt	NC		*
11.43 Load defaults	nonE (0), Eur (1), USA (2)		nonE (0)				RW	Txt	NC		
11.44 Security status {0.49}	L1 (0), L2 (1), Loc (2)						RW	Txt		PT	US
11.45 Select motor 2 parameters	OFF (0) or On (1)		OFF (0)				RW	Bit			US
11.46 Defaults previously loaded	0 to 2000						RO	Uni	NC	PT	US
11.47 Drive Onboard PLC program enable	Halt program (0) Run program: out of range = clip (1) Run program: out of range = trip (2)		Run program: out of range = trip (2)				RW	Uni			US
11.48 Drive Onboard PLC program status	-128 to +127						RO	Bi	NC	PT	
11.49 Drive Onboard PLC programming events	0 to 65,535						RO	Uni	NC	PT	PS
11.50 Drive Onboard PLC program average scan time	0 to 65,535 ms						RO	Uni	NC	PT	
11.51 Drive Onboard PLC program first run	OFF (0) or On (1)						RO	Bit	NC	PT	

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

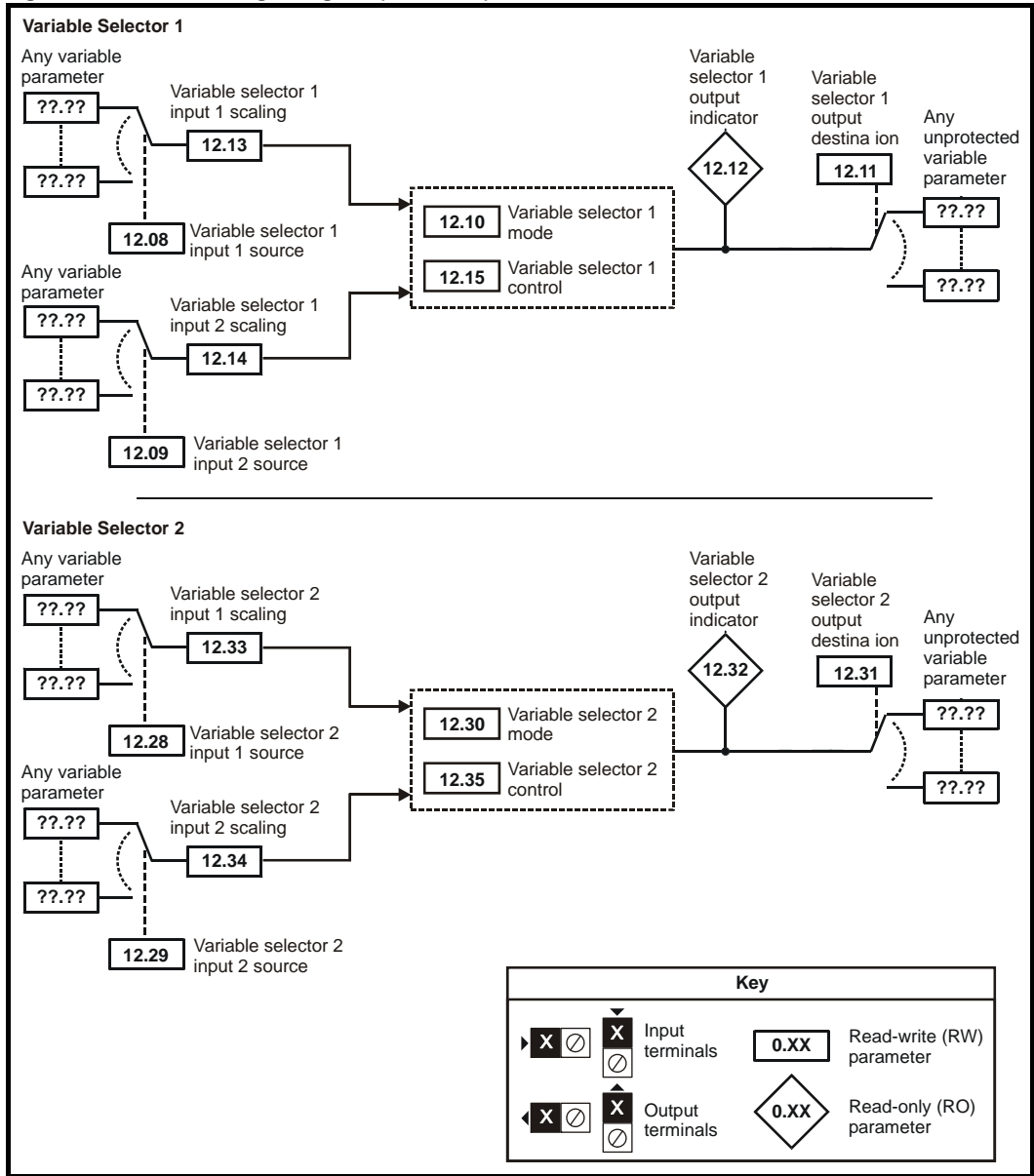
RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
Fl	Filtered	DE	Destination	NC	Not copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

## 11.12 Menu 12: Threshold detectors, variable selectors and brake control function

Figure 11-15 Menu 12 logic diagram



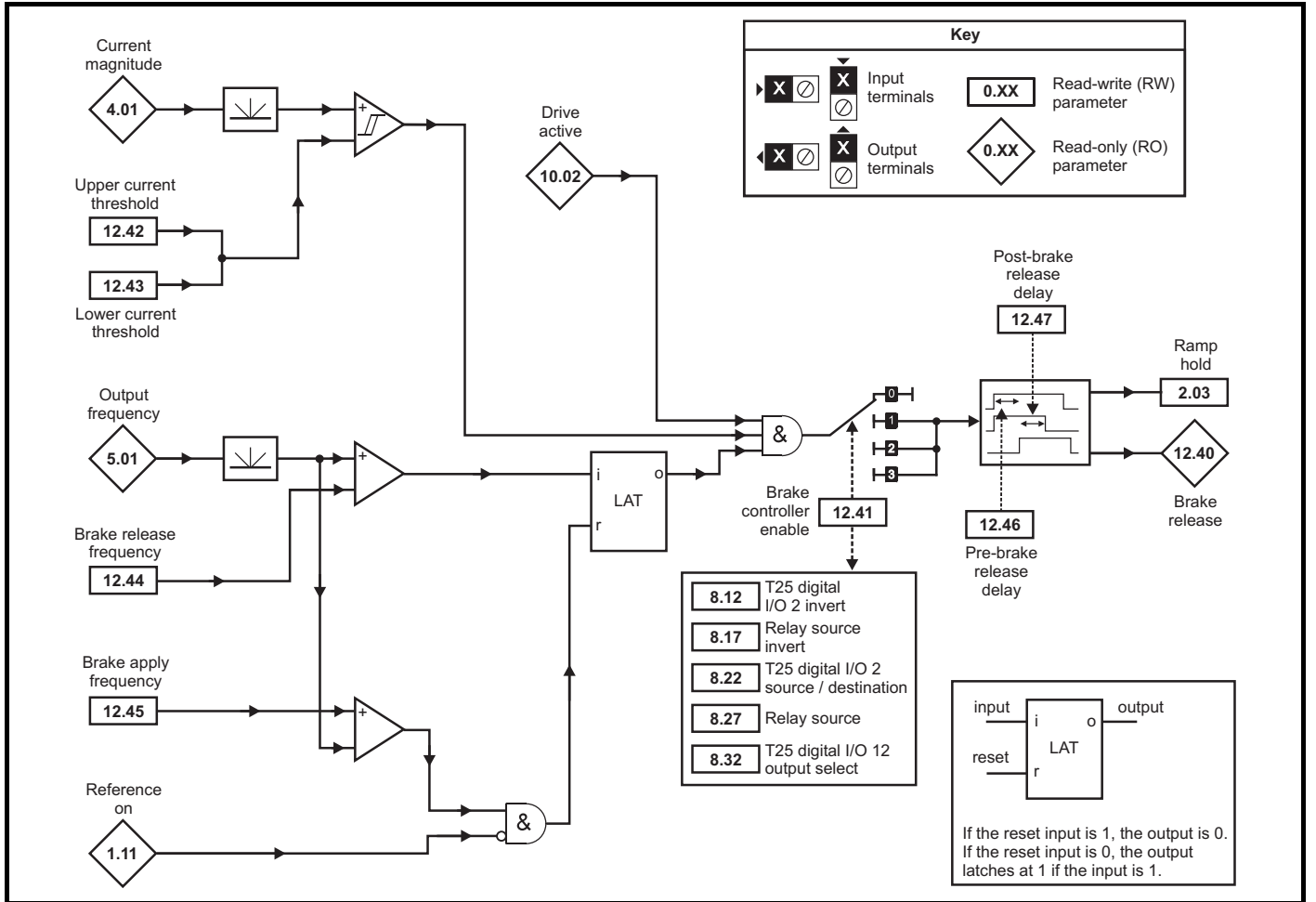
**Figure 11-16 Menu 12 logic diagram (continued)**



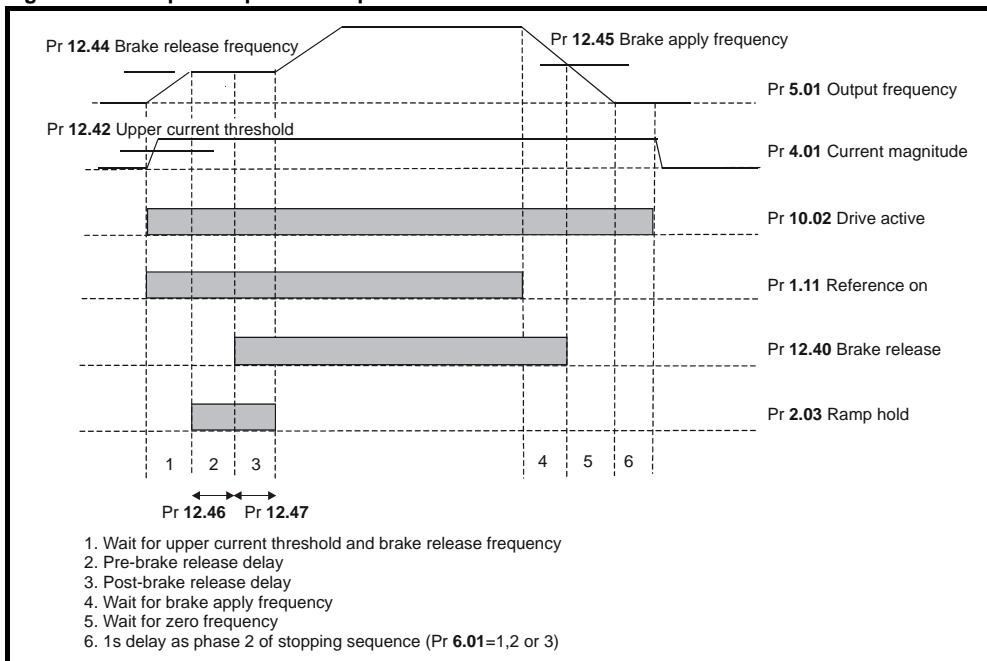


The control terminal relay can be selected as an output to release a brake. If a drive is set up in this manner and a drive replacement takes place, prior to programming the drive on initial power up, the brake may be released. When drive terminals are programmed to non default settings the result of incorrect or delayed programming must be considered. The use of a Smartcard in boot mode or an SM-Applications module can ensure drive parameters are immediately programmed to avoid this situation.

**Figure 11-17 Open-loop brake function**



**Figure 11-18 Open-loop brake sequence**

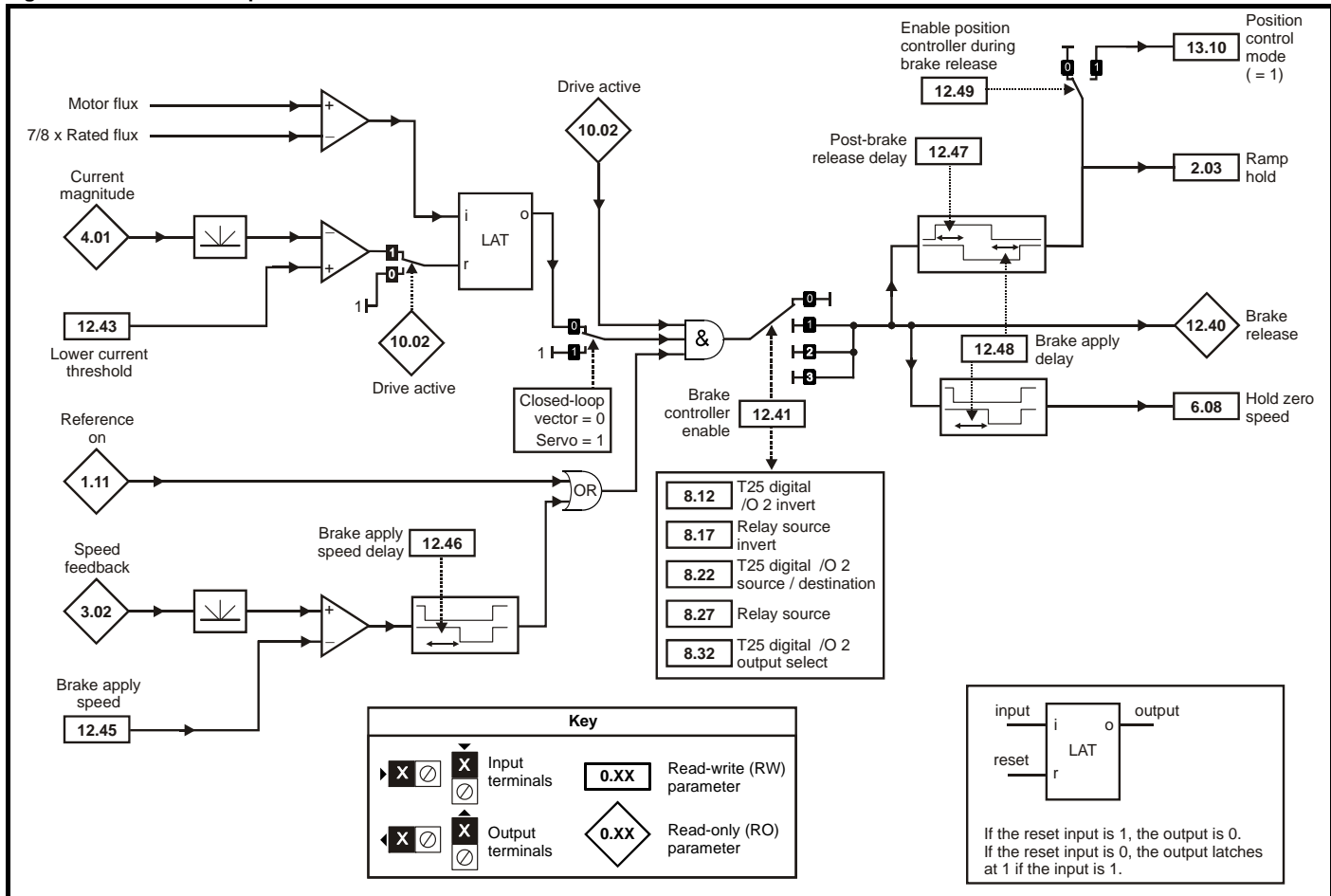




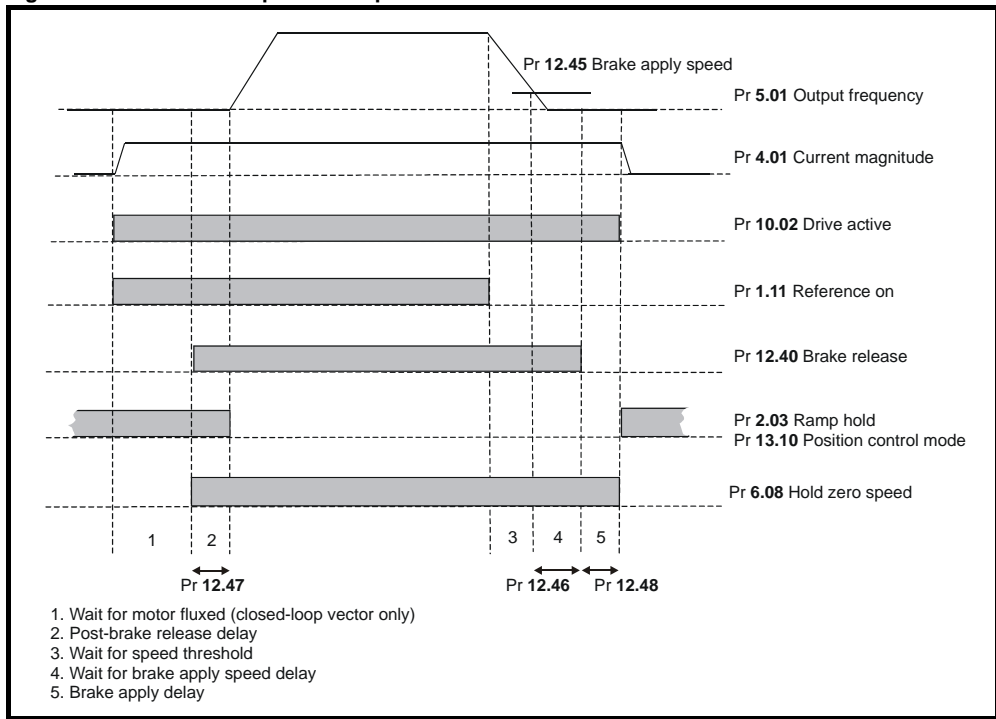


The control terminal relay can be selected as an output to release a brake. If a drive is set up in this manner and a drive replacement takes place, prior to programming the drive on initial power up, the brake may be released. When drive terminals are programmed to non default settings the result of incorrect or delayed programming must be considered. The use of a Smartcard in boot mode or an SM-Applications module can ensure drive parameters are immediately programmed to avoid this situation.

**Figure 11-19 Closed-loop brake function**



**Figure 11-20 Closed-loop brake sequence**





The control terminal relay can be selected as an output to release a brake. If a drive is set up in this manner and a drive replacement takes place, prior to programming the drive on initial power up, the brake may be released.

When drive terminals are programmed to non default settings the result of incorrect or delayed programming must be considered. The use of a Smartcard in boot mode or an SM-Applications module can ensure drive parameters are immediately programmed to avoid this situation.

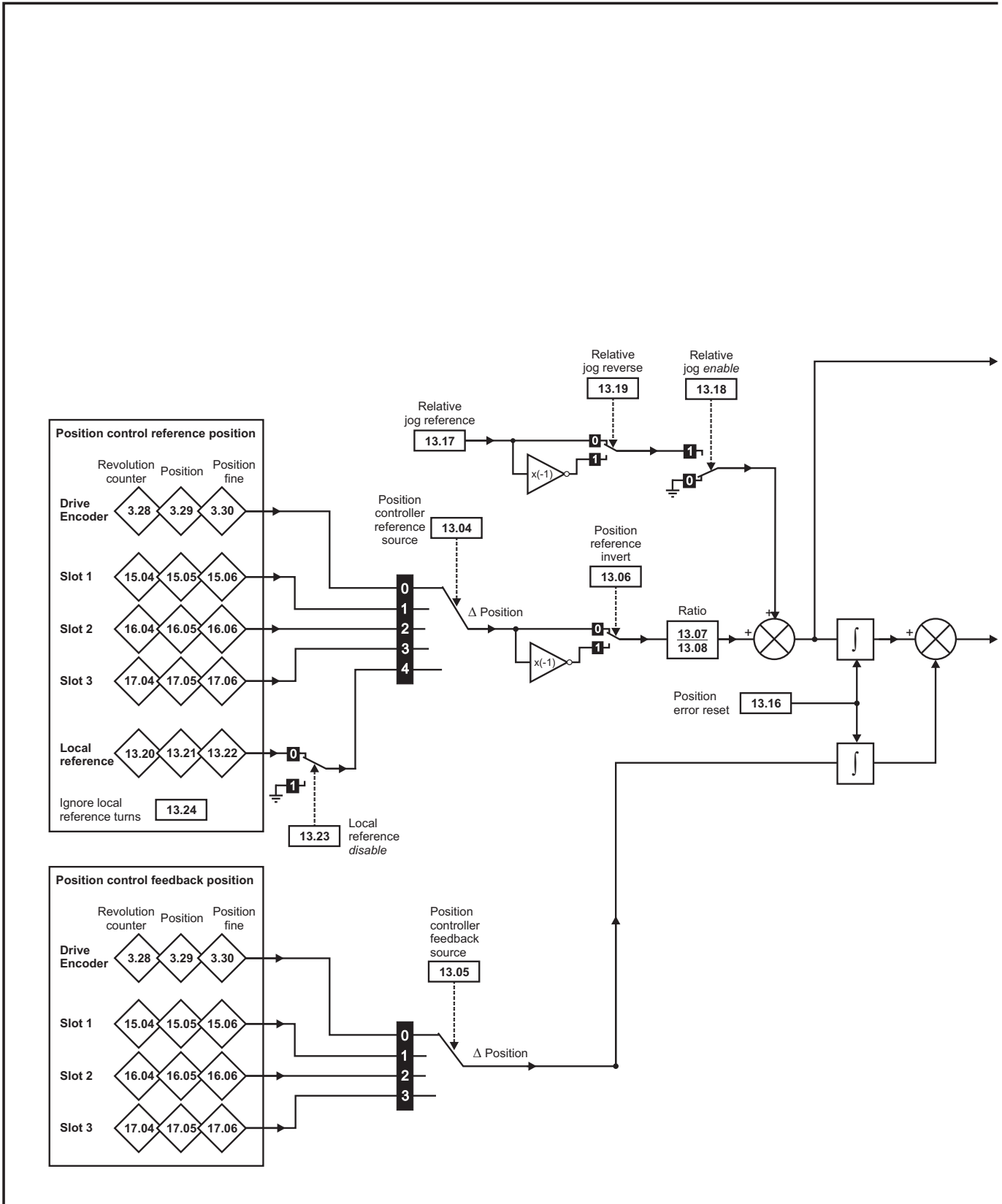
Parameter	Range(⇅)		Default(⇔)			Type					
	OL	CL	OL	VT	SV	RO	Bit	NC	PT	US	
12.01	Threshold detector 1 output		OFF (0) or On (1)			RO	Bit	NC	PT	US	
12.02	Threshold detector 2 output		OFF (0) or On (1)			RO	Bit	NC	PT	US	
12.03	Threshold detector 1 source		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.04	Threshold detector 1 level		0.00 to 100.00 %			RW	Uni			US	
12.05	Threshold detector 1 hysteresis		0.00 to 25.00 %			RW	Uni			US	
12.06	Threshold detector 1 output invert		OFF (0) or On (1)			RW	Bit			US	
12.07	Threshold detector 1 destination		Pr 0.00 to 21.51			RW	Uni	DE	PT	US	
12.08	Variable selector 1 source 1		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.09	Variable selector 1 source 2		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.10	Variable selector 1 mode		Select input 1 (0), select input 2 (1), add (2), subtract (3), multiply (4), divide (5), time constant (6), linear ramp (7), modulus (8), powers (9), sectional control (10), external rectifier monitor (11)			RW	Uni			US	
12.11	Variable selector 1 destination		Pr 0.00 to 21.51			RW	Uni	DE	PT	US	
12.12	Variable selector 1 output		±100.00 %			RO	Bi	NC	PT	US	
12.13	Variable selector 1 source 1 scaling		±4.000			RW	Bi			US	
12.14	Variable selector 1 source 2 scaling		±4.000			RW	Bi			US	
12.15	Variable selector 1 control		0.00 to 100.00 s			RW	Uni			US	
12.23	Threshold detector 2 source		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.24	Threshold detector 2 level		0.00 to 100.00 %			RW	Uni			US	
12.25	Threshold detector 2 hysteresis		0.00 to 25.00 %			RW	Uni			US	
12.26	Threshold detector 2 output invert		OFF (0) or On (1)			RW	Bit			US	
12.27	Threshold detector 2 destination		Pr 0.00 to 21.51			RW	Uni	DE	PT	US	
12.28	Variable selector 2 source 1		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.29	Variable selector 2 source 2		Pr 0.00 to 21.51			RW	Uni		PT	US	
12.30	Variable selector 2 mode		Select input 1 (0), select input 2 (1), add (2), subtract (3), multiply (4), divide (5), time constant (6), linear ramp (7), modulus (8), powers (9), sectional control (10), external rectifier monitor (11)			RW	Uni			US	
12.31	Variable selector 2 destination		Pr 0.00 to 21.51			RW	Uni	DE	PT	US	
12.32	Variable selector 2 output		±100.00 %			RO	Bi	NC	PT	US	
12.33	Variable selector 2 source 1 scaling		±4.000			RW	Bi			US	
12.34	Variable selector 2 source 2 scaling		±4.000			RW	Bi			US	
12.35	Variable selector 2 control		0.00 to 100.00 s			RW	Uni			US	
12.40	Brake release indicator		OFF (0) or On (1)			RO	Bit	NC	PT	US	
12.41	Brake controller enable		dis (0), rEL (1), d IO (2), USEr (3)			RW	Txt			US	
12.42	Upper current hreshold		0 to 200 %			50				US	
12.43	Lower current hreshold		0 to 200 %			10				US	
12.44	Brake release frequency		0.0 to 20.0 Hz			1.0				US	
12.45	Brake apply frequency / speed		0.0 to 20.0 Hz			0 to 200 rpm	2.0	5		US	
12.46	OL> Pre-brake release delay		0.0 to 25.0 s			1.0			RW	Uni	US
12.46	CL> Brake apply speed delay										
12.47	Post brake release delay		0.0 to 25.0 s			1.0			RW	Uni	US
12.48	Brake apply delay					1.0			RW	Uni	US
12.49	Enable position controller during brake release		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save



## 11.13 Menu 13: Position control

Figure 11-21 Menu 13 Open-loop logic diagram



\*For more information, refer to section 11.21.9 *Position modes* on page 240.

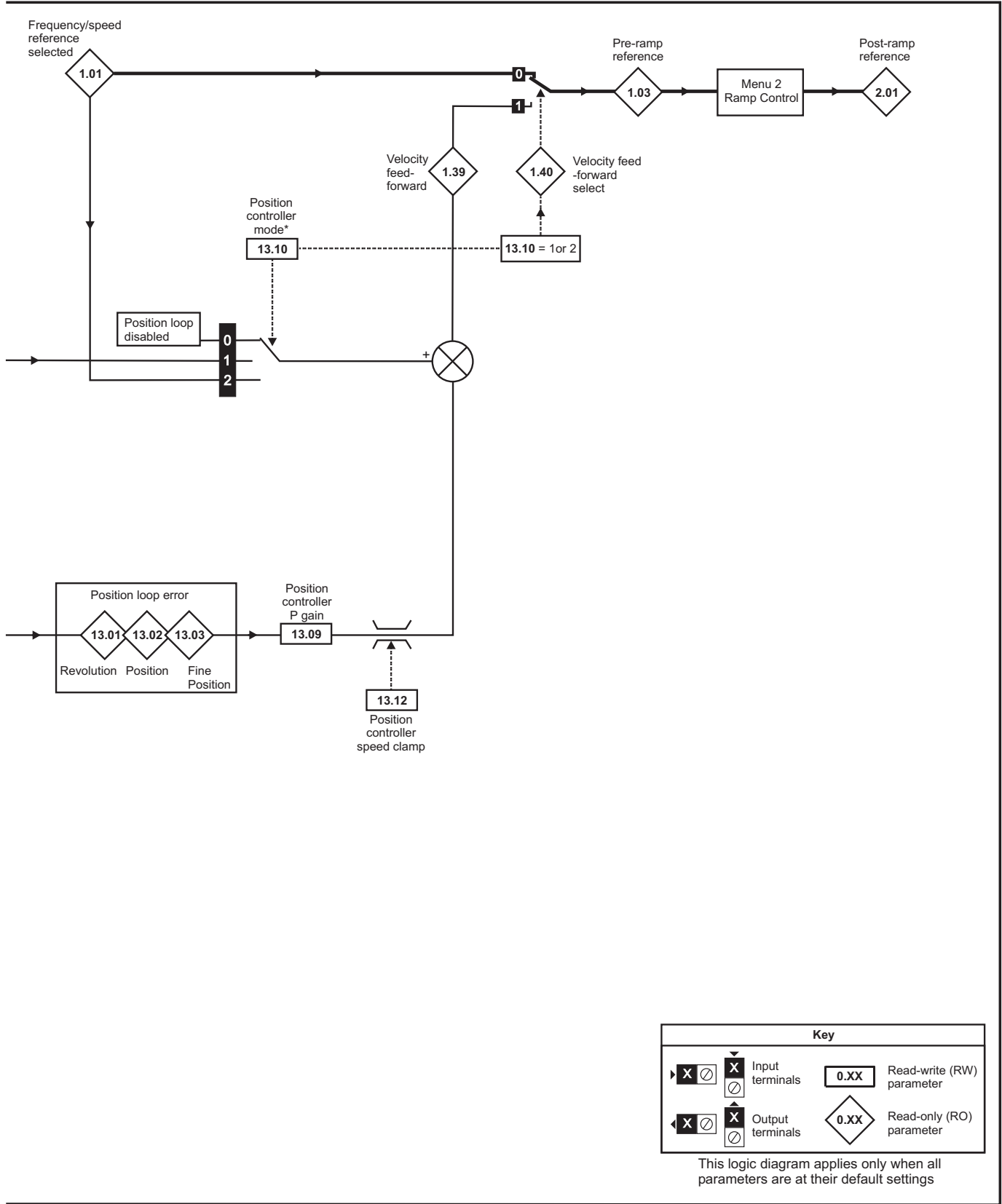
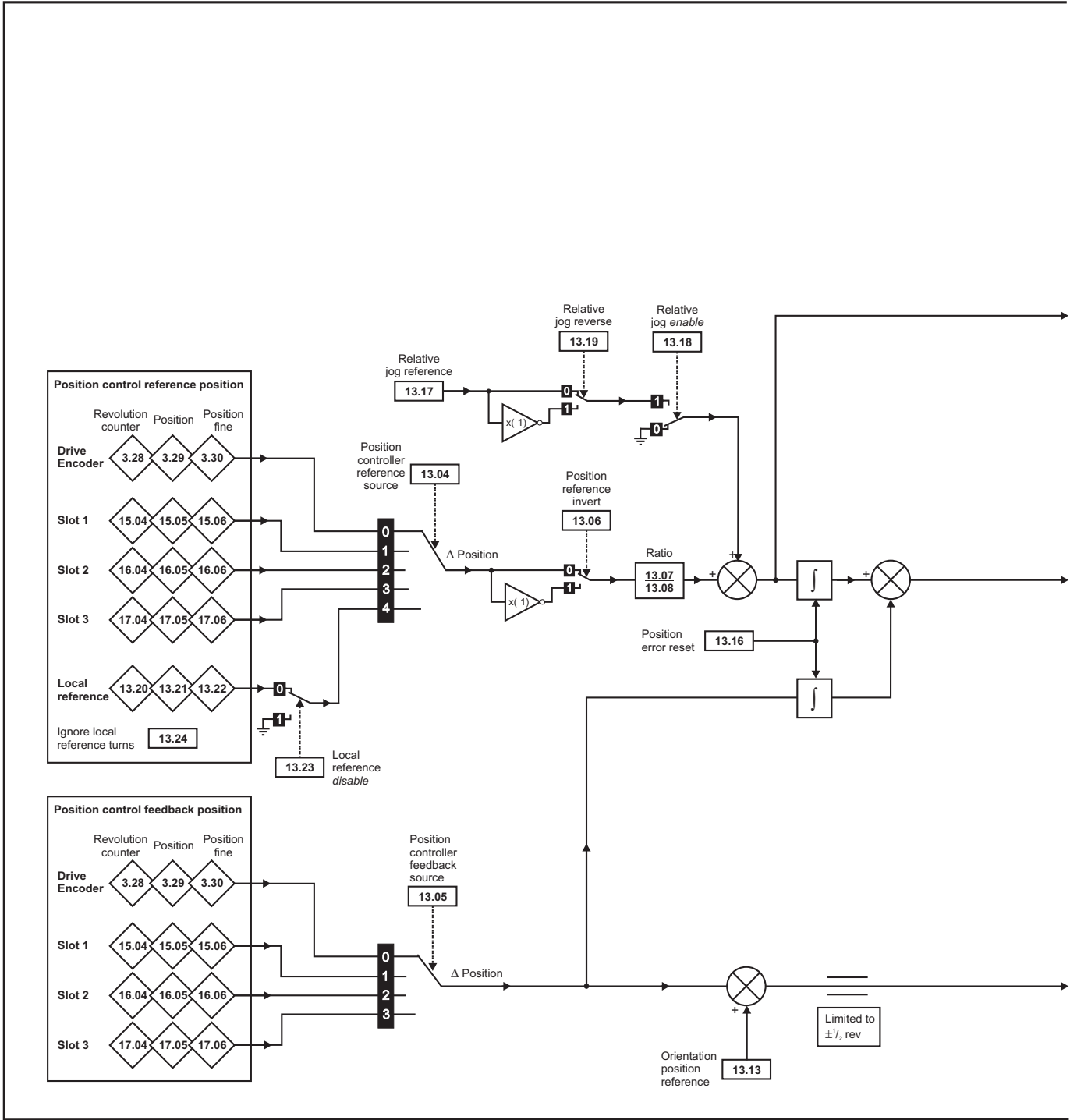
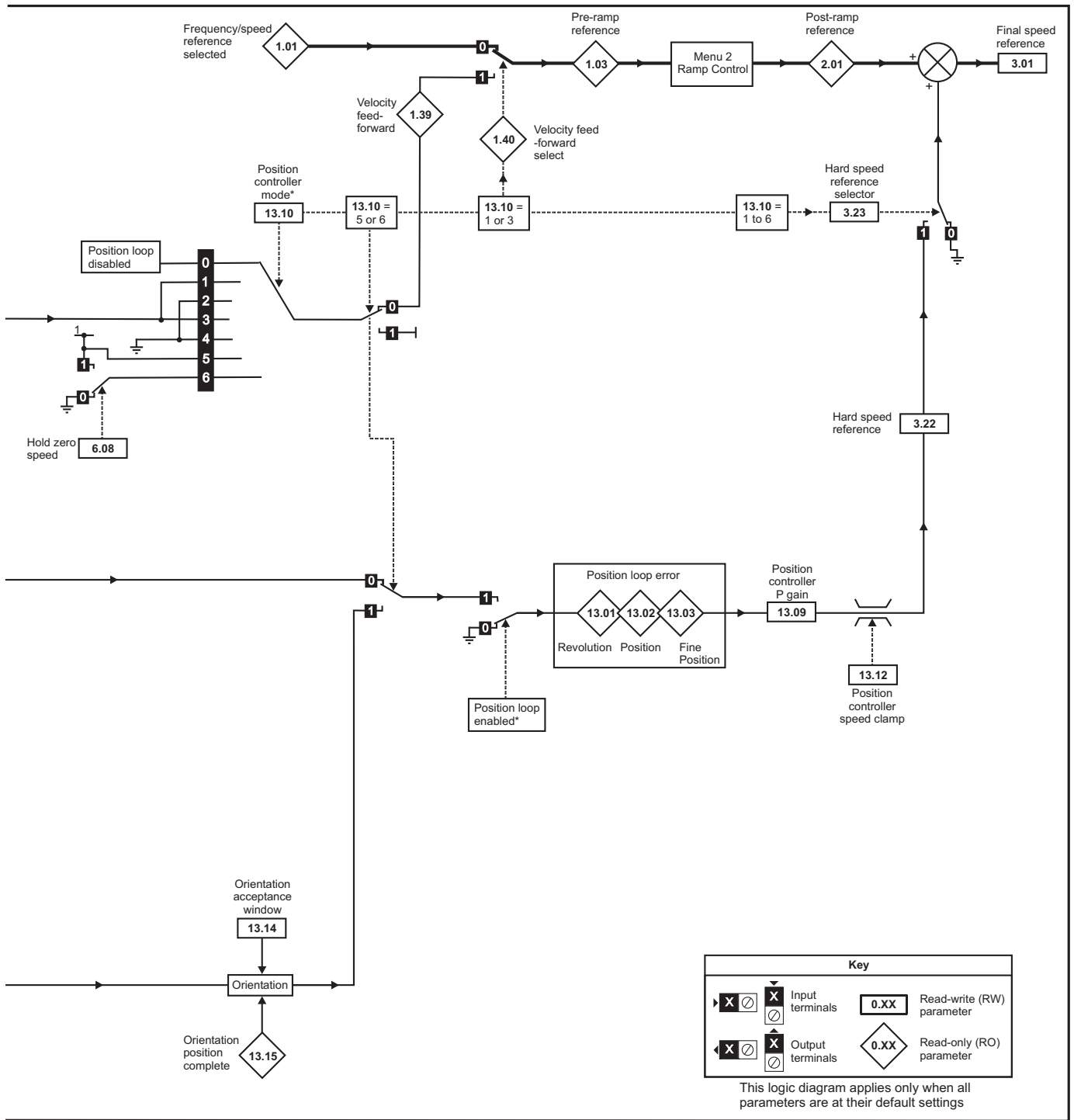


Figure 11-22 Menu 13 Closed-loop logic diagram



\*For more information, refer to section 11.21.9 *Position modes* on page 240.



\* The position controller is disabled and the error integrator is also reset under the following conditions:

1. If the drive is disabled (i.e. inhibited, ready or tripped)
2. If the position controller mode (Pr 13.10) is changed. The position controller is disabled transiently to reset the error integrator.
3. The absolute mode parameter (Pr 13.11) is changed. The position controller is disabled transiently to reset the error integrator.
4. One of the position sources is invalid.
5. The position feedback initialised parameter (Pr 3.48) is zero.

Parameter	Range(⇅)		Default(⇔)			Type						
	OL	CL	OL	VT	SV							
13.01	Revolutions error	-32,768 to +32,767					RO	Bi		NC	PT	
13.02	Position error	-32,768 to +32,767					RO	Uni		NC	PT	
13.03	Fine position error	-32,768 to +32,767					RO	Uni		NC	PT	
13.04	Position controller reference source	drv (0), Slot1 (1), Slot2 (2), Slot3 (3), LocAL (4)		drv (0)			RW	Uni				US
13.05	Position controller feedback source	drv (0), Slot1 (1), Slot2 (2), Slot3 (3)		drv (0)			RW	Uni				US
13.06	Position reference invert	OFF (0) or On (1)		OFF (0)			RW	Bit				US
13.07	Ratio numerator	0.000 to 4.000		1.000			RW	Uni				US
13.08	Ratio denominator	0.000 to 1.000		1.000			RW	Uni				US
13.09	Position controller P gain	0.00 to 100.00 rad s <sup>-1</sup> /rad		25.00			RW	Uni				US
13.10	Position controller mode	Position controller disabled (0) Rigid position control - feed fwd (1) Rigid position control (2)	Position controller disabled (0) Rigid position control - feed fwd (1) Rigid position control (2) Non-rigid position control - feed fwd (3) Non-rigid position control (4) Orientation on stop (5) Orientation on stop and when drive enabled (6)	Position controller disabled (0)			RW	Uni				US
13.11	Absolute mode enable	OFF (0) or On (1)		OFF (0)			RW	Bit				US
13.12	Position controller speed clamp	0 to 250 rpm		150			RW	Uni				US
13.13	Orientation position reference		0 to 65,535		0		RW	Uni				US
13.14	Orientation acceptance window		0 to 4,096		256		RW	Uni				US
13.15	Orientation position complete		OFF (0) or On (1)				RO	Bit		NC	PT	
13.16	Position error reset	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
13.17	Relative jog reference	0.0 to 4,000.0 rpm		0.0			RW	Uni		NC		
13.18	Relative jog enable	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
13.19	Relative jog reverse	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
13.20	Local reference turns	0 to 65,535		0			RW	Uni		NC		
13.21	Local reference position	0 to 65,535		0			RW	Uni		NC		
13.22	Local reference fine position	0 to 65,535		0			RW	Uni		NC		
13.23	Local reference disable	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
13.24	Ignore local reference turns	OFF (0) or On (1)		OFF (0)			RW	Bit				US

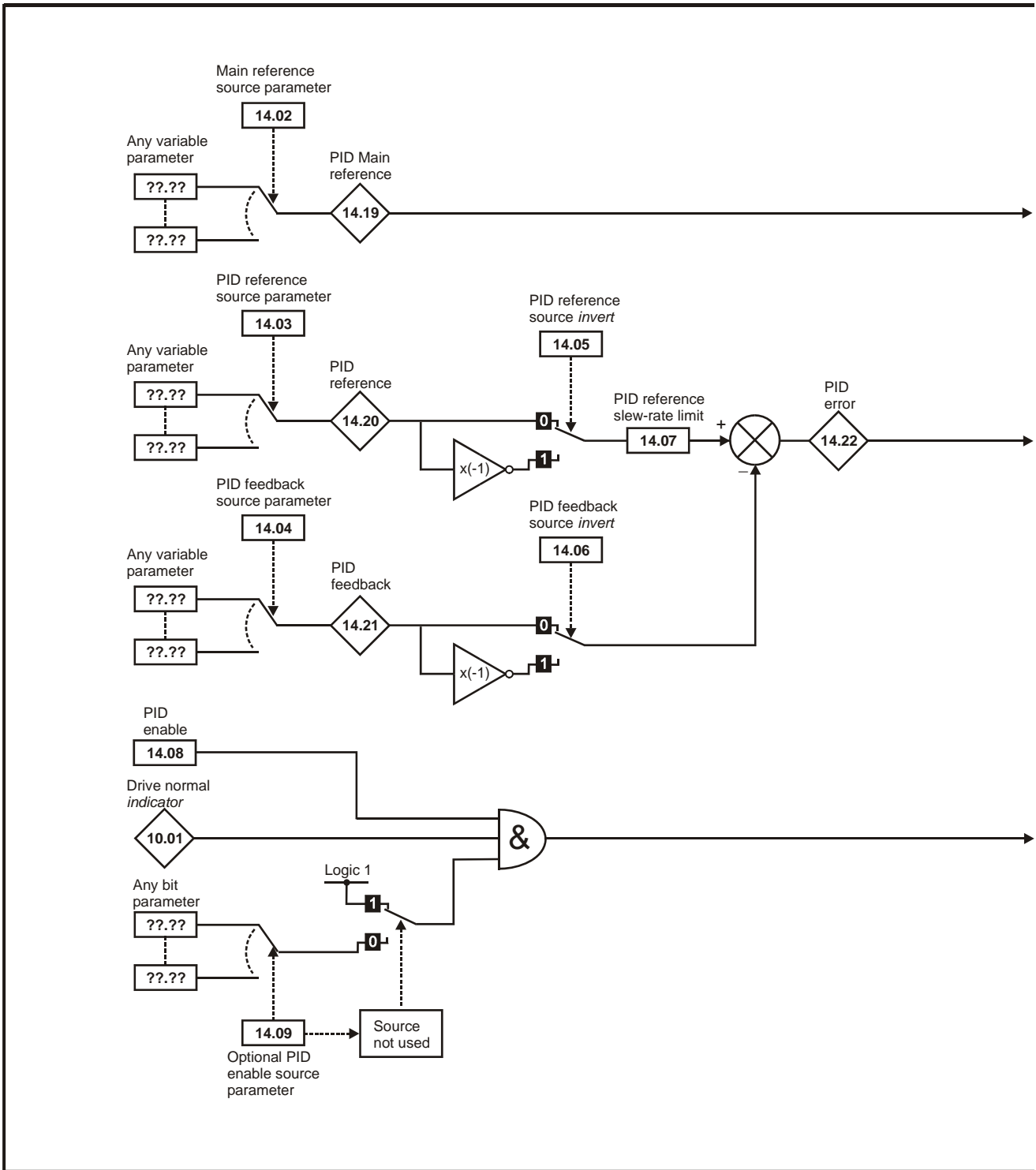
RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

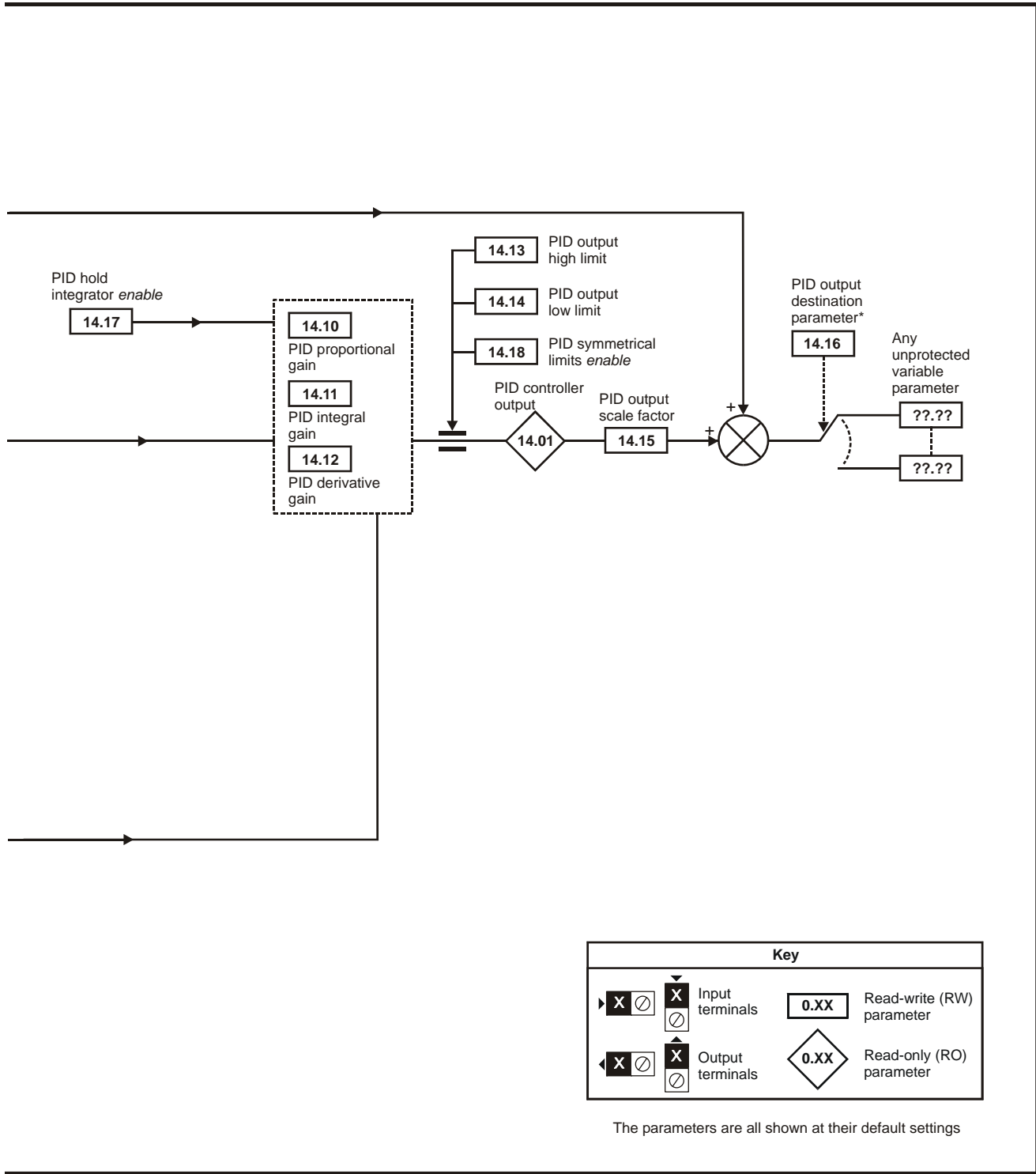




## 11.14 Menu 14: User PID controller

Figure 11-23 Menu 14 Logic diagram





Parameter	Range(⇅)		Default(⇔)			Type								
	OL	CL	OL	VT	SV									
14.01	PID control output		±100.00 %			RO	Bi		NC	PT				
14.02	PID main reference source		Pr 0.00 to 21.51			Pr 0.00			RW	Uni		PT	US	
14.03	PID reference source		Pr 0.00 to 21.51			Pr 0.00			RW	Uni		PT	US	
14.04	PID feedback source		Pr 0.00 to 21.51			Pr 0.00			RW	Uni		PT	US	
14.05	PID reference source invert		OFF (0) or On (1)			OFF (0)			RW	Bit			US	
14.06	PID feedback source invert		OFF (0) or On (1)			OFF (0)			RW	Bit			US	
14.07	PID reference slew-rate limit		0.0 to 3,200.0 s			0.0			RW	Uni			US	
14.08	PID enable		OFF (0) or On (1)			OFF (0)			RW	Bit			US	
14.09	PID optional enable source		Pr 0.00 to 21.51			Pr 0.00			RW	Uni		PT	US	
14.10	PID proportional gain		0.000 to 4 000			1.000			RW	Uni			US	
14.11	PID integral gain		0.000 to 4 000			0.500			RW	Uni			US	
14.12	PID derivative gain		0.000 to 4.000			0.000			RW	Uni			US	
14.13	PID upper limit		0.00 to 100.00 %			100.00			RW	Uni			US	
14.14	PID lower limit		±100.00 %			-100.00			RW	Bi			US	
14.15	PID output scaling factor		0.000 to 4.000			1.000			RW	Uni			US	
14.16	PID output destination		Pr 0.00 to 21.51			Pr 0.00			RW	Uni	DE		PT	US
14.17	PID hold integrator enable		OFF (0) or On (1)			OFF (0)			RW	Bit		NC		
14.18	PID symmetrical limits enable		OFF (0) or On (1)			OFF (0)			RW	Bit			US	
14.19	PID main reference		±100 00 %						RO	Bi		NC	PT	
14.20	PID reference		±100 00 %						RO	Bi		NC	PT	
14.21	PID feedback		±100.00 %						RO	Bi		NC	PT	
14.22	PID error		±100 00 %						RO	Bi		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

## 11.15 Menus 15, 16 and 17: Solutions Module set-up

Figure 11-24 Location of Solutions Module slots and their corresponding menu numbers (SPz)

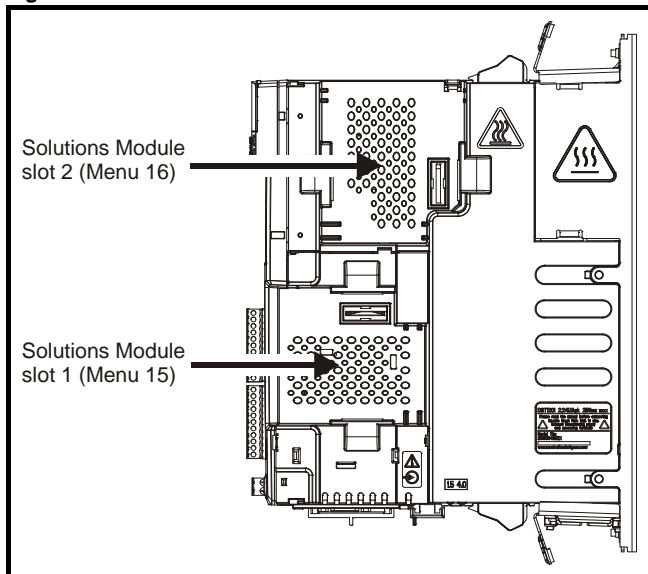
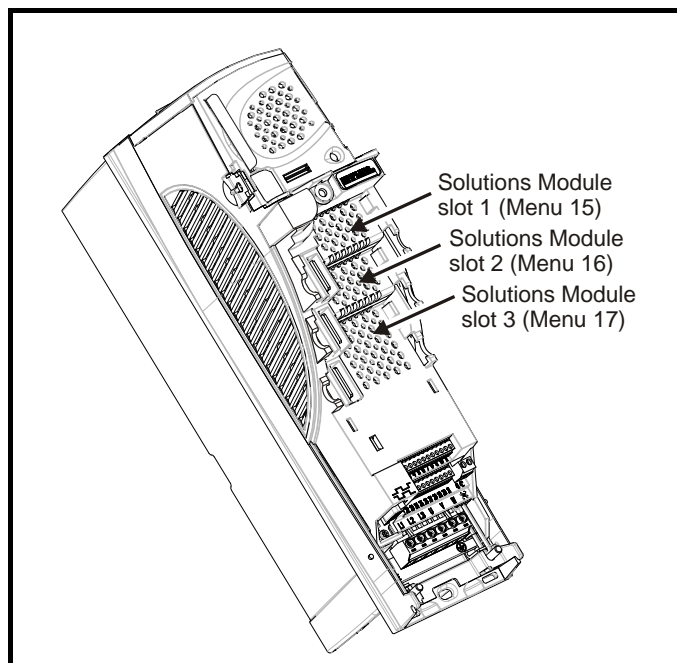


Figure 11-25 Location of Solutions Module slots and their corresponding menu numbers (size 1 to 6)



**NOTE**

SPz has two Solution Module slots, and sizes 1 to 6 have three Solution Module slots.

### 11.15.1 Parameters common to all categories

Parameter		Range(⇅)	Default(⇔)	Type						
<b>x.01</b>	Solutions Module ID	0 to 599		RO	Uni			PT	US	
<b>x.02</b>	Solutions Module software version	0.00 to 99.99		RO	Uni		NC	PT		
<b>x.50</b>	Solutions Module error status	0 to 255		RO	Uni		NC	PT		
<b>x.51</b>	Solutions Module software sub-version	0 to 99		RO	Uni		NC	PT		

The Solutions Module ID indicates the type of module that is installed in the corresponding slot.

Solutions Module ID	Module	Category
0	No module installed	
101	SM-Resolver	Feedback
102	SM-Universal Encoder Plus	
104	SM-Encoder Plus / SM-Encoder Output Plus	
201	SM-I/O Plus	Automation (I/O Expansion)
203	SM-I/O Timer	
207	SM-I/O Lite	
208	SM-I/O 32	
301	SM-Applications	Automation (Applications)
302	SM-Applications Lite	
304	SM-Applications Plus	
305	SM-Applications Lite V2	
401	SM-LON	Fieldbus
403	SM-PROFIBUS-DP	
404	SM-INTERBUS	
407	SM-DeviceNet	
408	SM-CANopen	
409	SM-SERCOS	
410	SM-Ethernet	
421	SM-EtherCAT	

#### Solutions Module software

Most Solutions Modules contain software. The software version of the module can be checked by looking at Pr **x.02** and Pr **x.51**.

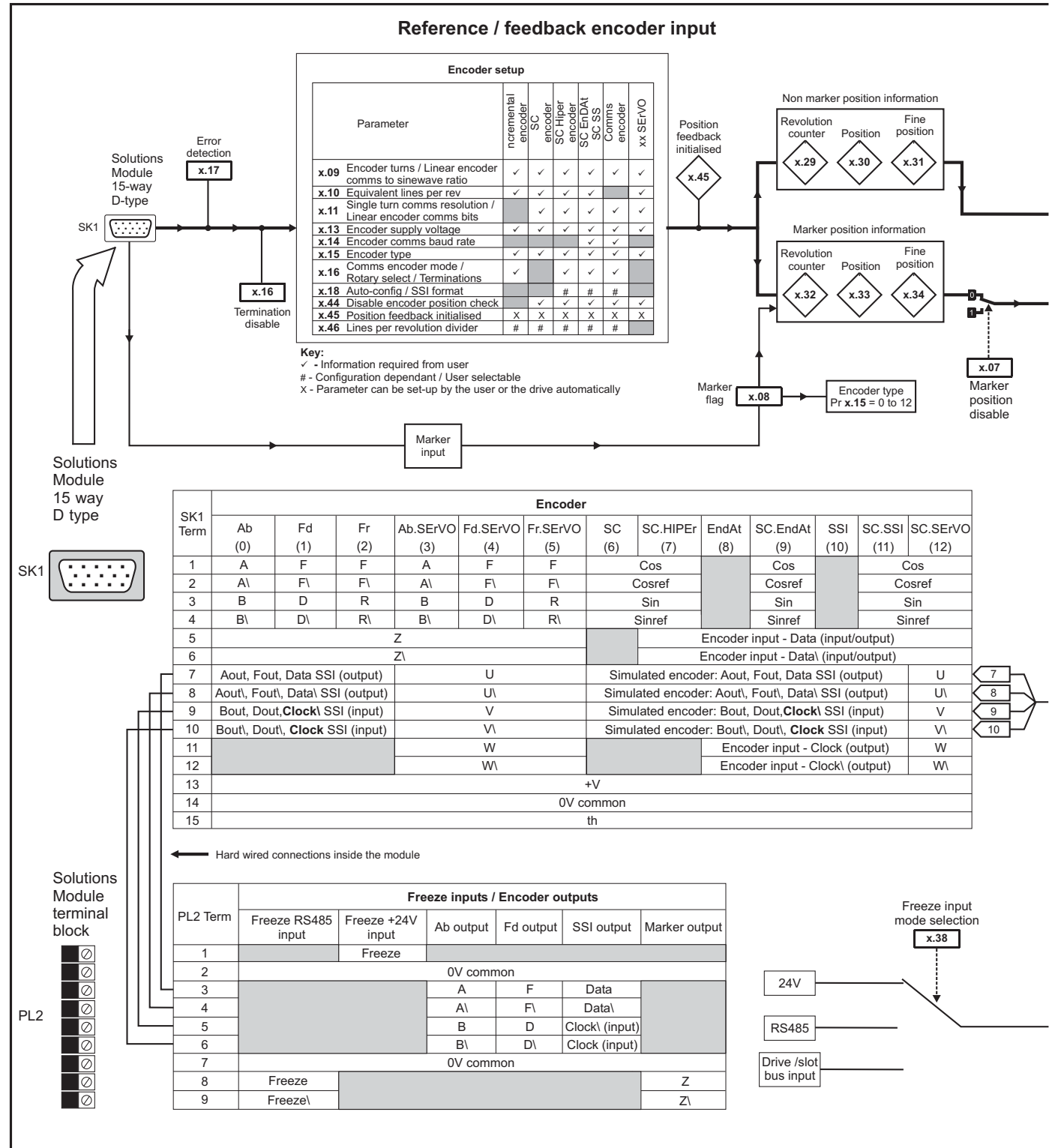
The software version takes the form of zz.yy.xx, where Pr **x.02** displays zz.yy and Pr **x.51** displays xx. I.e. for software version 01.01.00, Pr **x.02** would display 1.01 and Pr **x.51** would display 0

The SM-Resolver, SM-Encoder Plus, SM-Encoder Output Plus and SM-I/O Plus modules do not contain any software, so Pr **x.02** and Pr **x.51** either show 0 (software V01.07.01 and earlier) or the parameters do not appear (software V01.08.00 and later).



### 11.15.2 Feedback module category

Figure 11-26 SM-Universal Encoder Plus logic diagram



SK1 Term	Encoder												
	Ab (0)	Fd (1)	Fr (2)	Ab.SERVO (3)	Fd.SERVO (4)	Fr.SERVO (5)	SC (6)	SC.HIPer (7)	EndAt (8)	SC.EndAt (9)	SSI (10)	SC.SSI (11)	SC.SERVO (12)
1	A	F	F	A	F	F		Cos		Cos			Cos
2	A\	F\	F\	A\	F\	F\		Cosref		Cosref			Cosref
3	B	D	R	B	D	R		Sin		Sin			Sin
4	B\	D\	R\	B\	D\	R\		Sinref		Sinref			Sinref
5	Z								Encoder input - Data (input/output)				
6	Z\								Encoder input - Data\ (input/output)				
7	Aout, Fout, Data SSI (output)			U			Simulated encoder: Aout, Fout, Data SSI (output)			U			
8	Aout\, Fout\, Data\ SSI (output)			U\			Simulated encoder: Aout\, Fout\, Data\ SSI (output)			U\			
9	Bout, Dout, Clock\ SSI (input)			V			Simulated encoder: Bout, Dout, Clock\ SSI (input)			V			
10	Bout\, Dout\, Clock SSI (input)			V\			Simulated encoder: Bout\, Dout\, Clock SSI (input)			V\			
11				W			Encoder input - Clock (output)			W			
12				W\			Encoder input - Clock\ (output)			W\			
13	+V												
14	0V common												
15	th												

← Hard wired connections inside the module

PL2 Term	Freeze inputs / Encoder outputs					
	Freeze RS485 input	Freeze +24V input	Ab output	Fd output	SSI output	Marker output
1		Freeze				
2	0V common					
3			A	F	Data	
4			A\	F\	Data\	
5			B	D	Clock\ (input)	
6			B\	D\	Clock (input)	
7	0V common					
8	Freeze					Z
9	Freeze\					Z\

Freeze input mode selection x.38

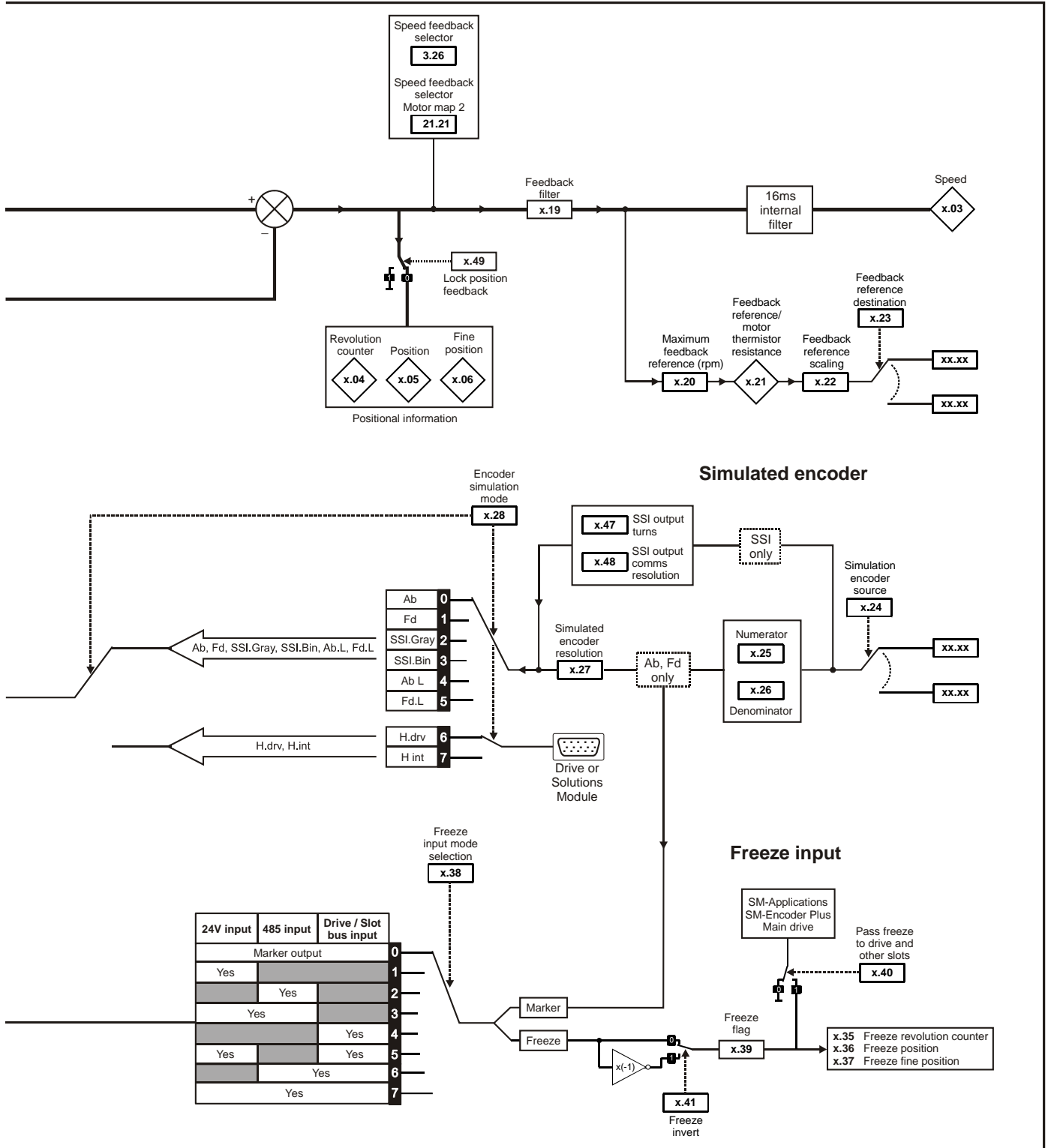


24V

RS485

Drive /slot bus input





### SM-Universal Encoder Plus parameters

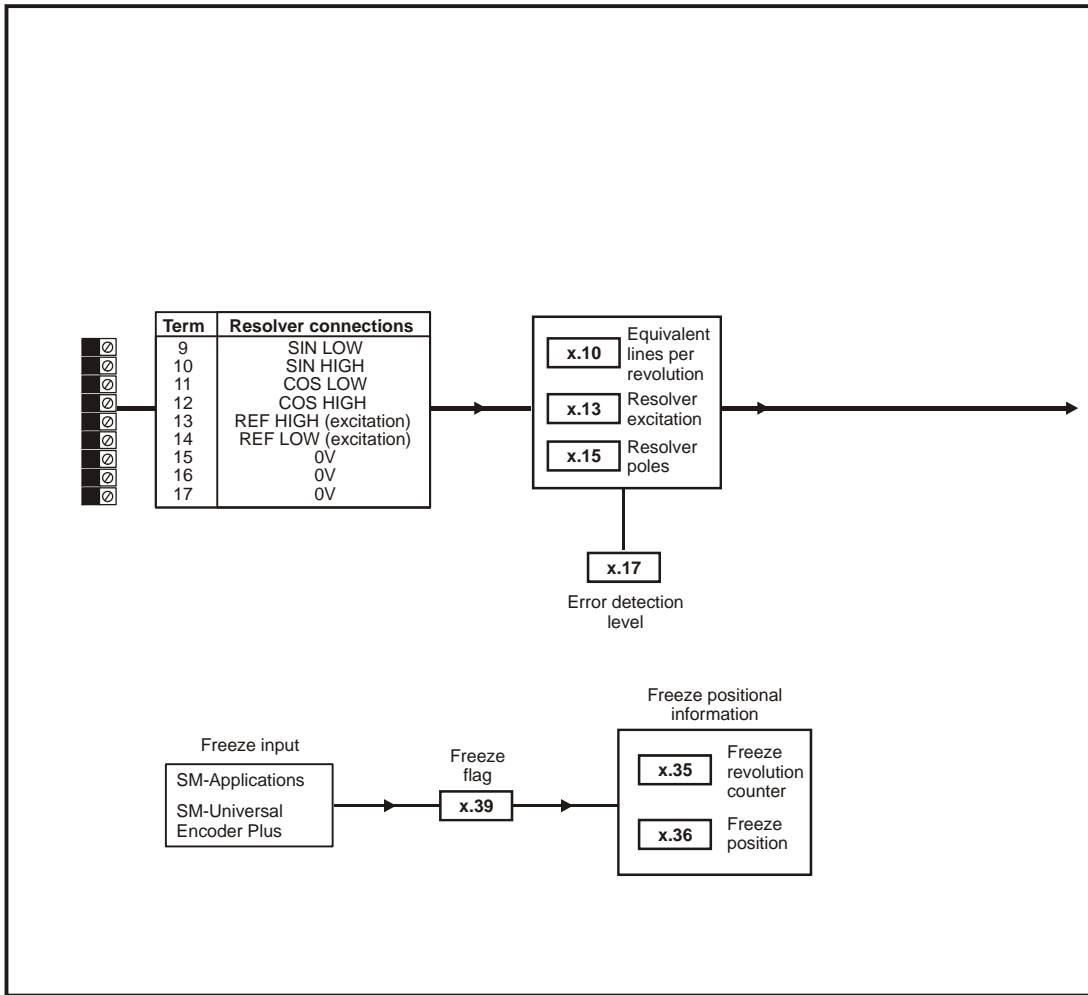
Parameter		Range(↕)	Default(↔)	Type					
x.01	Solutions Module ID	0 to 599	102	RO	Uni			PT	US
x.02	Solutions Module software version	0.00 to 99.99		RO	Uni		NC	PT	
x.03	Speed	±40,000.0 rpm		RO	Bi	FI	NC	PT	
x.04	Revolution counter	0 to 65,535 revolutions		RO	Uni	FI	NC	PT	
x.05	Position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni	FI	NC	PT	
x.06	Fine position	0 to 65,535 (1/2 <sup>32</sup> nds of a revolution)		RO	Uni	FI	NC	PT	
x.07	Marker position reset disable	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.08	Marker flag	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.09	Encoder turns/ linear encoder comms to sine wave ratio	0 to 16 bits	16	RW	Uni				US
x.10	Equivalent lines per revolution	0 to 50,000	4096	RW	Uni				US
x.11	Single turn comms bits/ linear encoder comms bits	0 to 32 bits	0	RW	Uni				US
x.12	Motor thermistor check <i>enable</i>	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.13	Encoder supply voltage	5V (0), 8V (1), 15V (2)	5V (0)	RW	Uni				US
x.14	Encoder comms baud rate	100 (0), 200 (1), 300 (2), 400 (3), 500 (4), 1,000 (5), 1,500 (6), 2,000 (7)	300 (2)	RW	Txt				US
x.15	Encoder type	Ab (0), Fd (1), Fr (2), Ab.SErVO (3), Fd.SErVO (4), Fr.SErVO (5), SC (6), SC.HiPEr (7), EndAt (8), SC.EndAt (9), SSI (10), SC.SSI (11), SC.UVW (12)	Ab (0)	RW	Uni				US
x.16	Rotary encoder select/ comms only encoder mode/ terminations	0 to 2	1	RW	Uni				US
x.17	Error detection level	0 to 7	1	RW	Uni				US
x.18	Auto configuration/ SSI binary format select	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.19	Feedback filter	0 to 5 (0 to 16 ms)	0	RW	Uni				US
x.20	Maximum feedback reference	0.0 to 40,000.0 rpm	1500.0	RW	Uni				US
x.21	Feedback reference/ motor thermistor resistance	±100 0 %		RO	Bi		NC	PT	
x.22	Feedback reference scaling	0.000 to 4.000	1.000	RW	Uni				US
x.23	Feedback reference destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT	US
x.24	Encoder simulation source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni			PT	US
x.25	Encoder simulation ratio numerator	0.0000 to 3.0000	0.2500	RW	Uni				US
x.26	Encoder simulation ratio denominator	0.0000 to 3.0000	1.0000	RW	Uni				US
x.27	Encoder simulation resolution select	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.28	Encoder simulation mode	Ab (0), Fd (1), SSI.Gray (2), SSI.Bin (3), Ab.L (4), Fd.L (5), H-drv (6), H-int (7)	Ab (0)	RW	Txt				US
x.29	Non-marker reset revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT	
x.30	Non-marker reset position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT	
x.31	Non-marker reset fine position	0 to 65,535 (1/2 <sup>32</sup> nds of a revolution)		RO	Uni		NC	PT	
x.32	Marker revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT	
x.33	Marker position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT	
x.34	Marker fine position	0 to 65,535 (1/2 <sup>32</sup> nds of a revolution)		RO	Uni		NC	PT	
x.35	Freeze revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT	
x.36	Freeze position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT	
x.37	Freeze fine position	0 to 65,535 (1/2 <sup>32</sup> nds of a revolution)		RO	Uni		NC	PT	
x.38	Freeze input mode selection	Bit 0 (LSB) = 24V input Bit 1 = EI485 input Bit 2 (MSB) = From another Solutions Module	1	RW	Uni				US
x.39	Freeze flag	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.40	Pass freeze to drive and other slots	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		US
x.41	Freeze invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.42	Encoder comms transmit register/ Sin signal value	0 to 65,535	0	RW	Uni		NC		
x.43	Encoder comms receive register/ Cos signal value	0 to 65,535	0	RW	Uni		NC		
x.44	Disable encoder position check	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.45	Position feedback initialised	OFF (0) or On (1)		RO	Bit		NC	PT	
x.46	Lines per revolution divider	1 to 1024	1	RW	Uni				US
x.47	SSI output turns	0 to 16 bits	16	RW	Uni				US
x.48	SSI output comms resolution	0 to 32 bits	0	RW	Uni				US
x.49	Lock position feedback	OFF (0) or On (1)	OFF (0)	RW	Bit				
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	

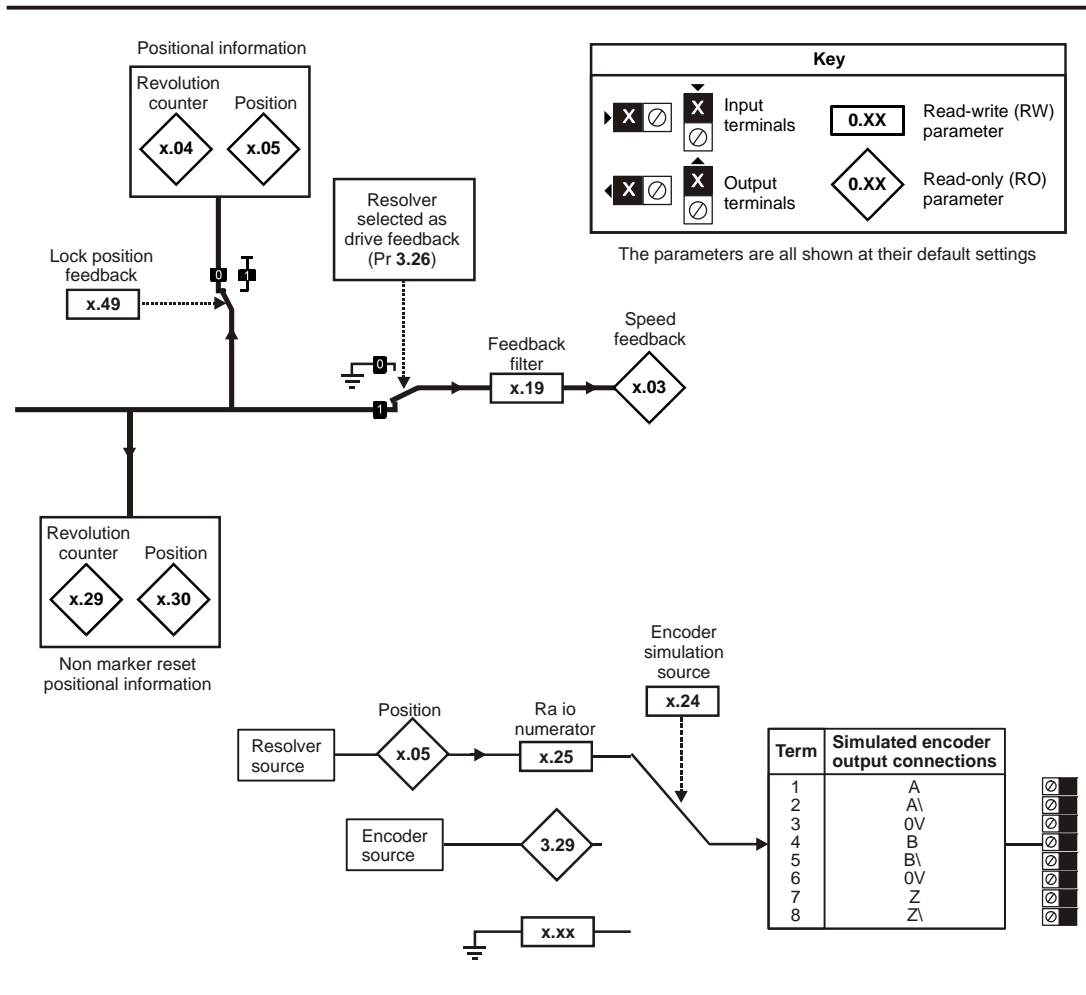
RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\*See trip SLX.Er, *Feedback module category* on page 269.



Figure 11-27 SM-Resolver logic diagram





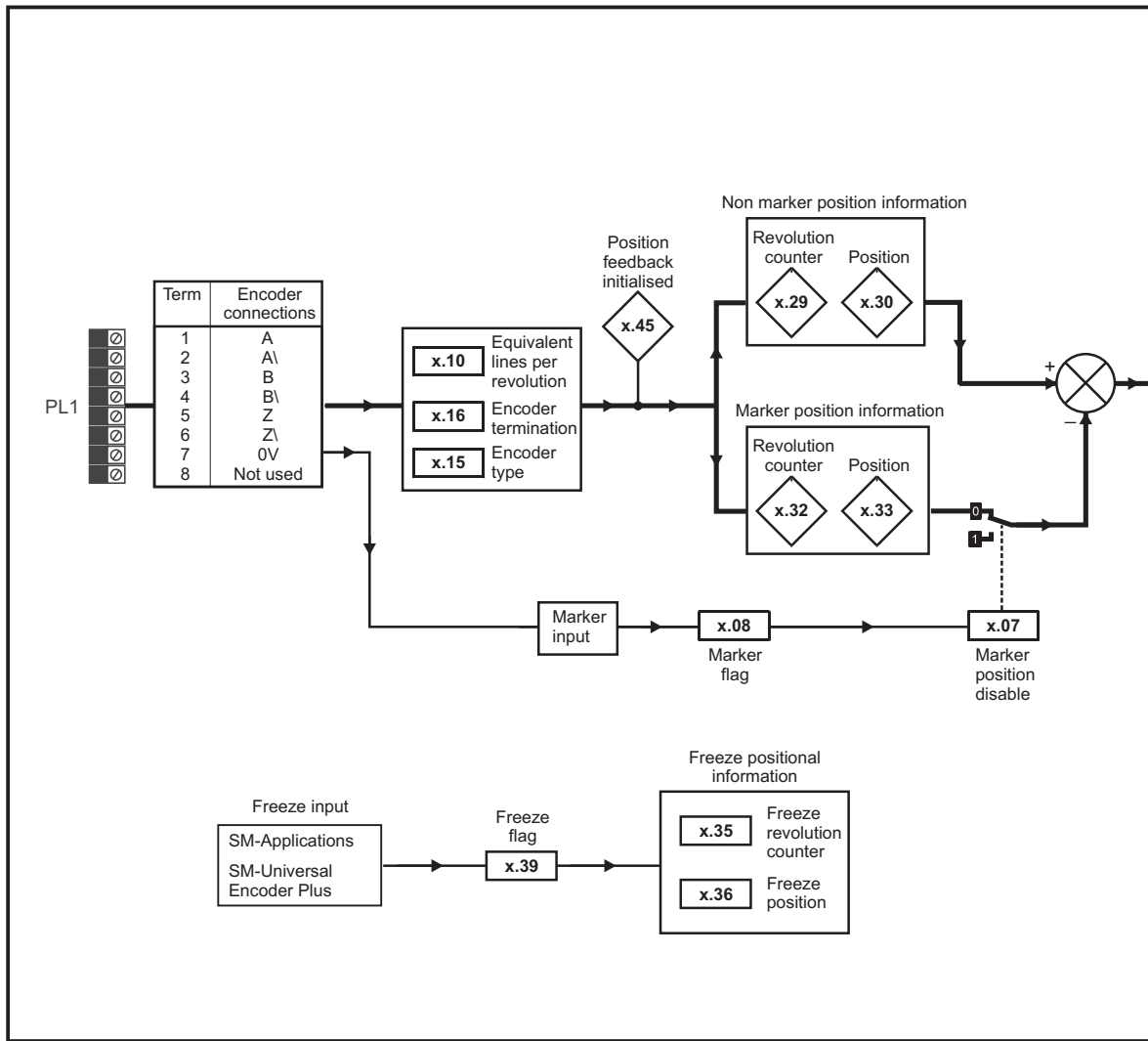
**SM-Resolver parameters**

Parameter	Range(↕)	Default(⇨)	Type						
x.01	Solutions Module ID	0 to 599	101	RO	Uni			PT	US
x.03	Speed	±40,000.0 rpm		RO	Bi	FI	NC	PT	
x.04	Revolution counter	0 to 65,535 revolutions		RO	Uni	FI	NC	PT	
x.05	Position	0 to 65,535 1/2 <sup>16</sup> ths of a revolution		RO	Uni	FI	NC	PT	
x.10	Equivalent lines per revolution	0 to 50,000	4096	RW	Uni				US
x.13	Resolver excitation	3:1 (0), 2:1 (1 or 2)	3:1 (0)	RW	Uni				US
x.15	Resolver poles	2 pole (0), 4 pole (1), 6 pole (2), 8 pole (3 to 12)	2 pole (0)	RW	Uni				US
x.17	Error detection level	Bit 0 (LSB) = Wire break detect Bit 1 = Not used Bit 2 (MSB) = Not used	1	RW	Uni				US
x.19	Feedback filter	0 (0), 1 (1), 2 (2), 4 (3), 8 (4), 16 (5) ms	0	RW	Txt				US
x.24	Encoder simulation source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni			PT	US
x.25	Encoder simulation ratio numerator	0.0000 to 3.0000	0.25	RW	Uni				US
x.29	Non-marker reset revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT	
x.30	Non-marker reset position	0 to 65,535 1/2 <sup>16</sup> ths of a revolution		RO	Uni		NC	PT	
x.35	Freeze revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT	
x.36	Freeze position	0 to 65,535 1/2 <sup>16</sup> ths of a revolution		RO	Uni		NC	PT	
x.39	Freeze flag	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.45	Position feedback initialised	OFF (0) or On (1)		RO	Bit		NC	PT	
x.49	Lock position feedback	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.50	Solutions Module error status*	0 to 255		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\*See trip SLX.Er, Feedback module category on page 269.

Figure 11-28 SM-Encoder Plus logic diagram



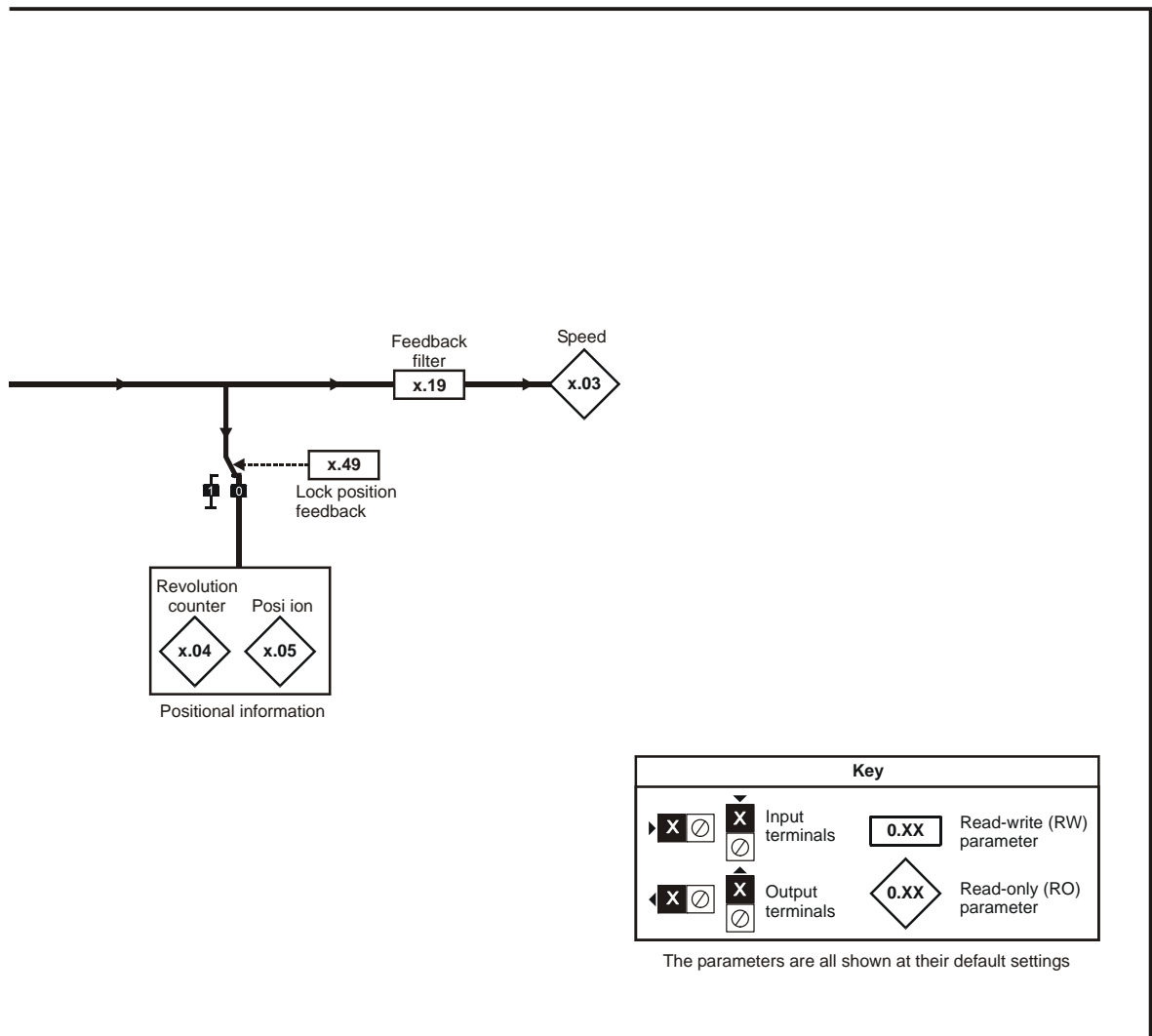
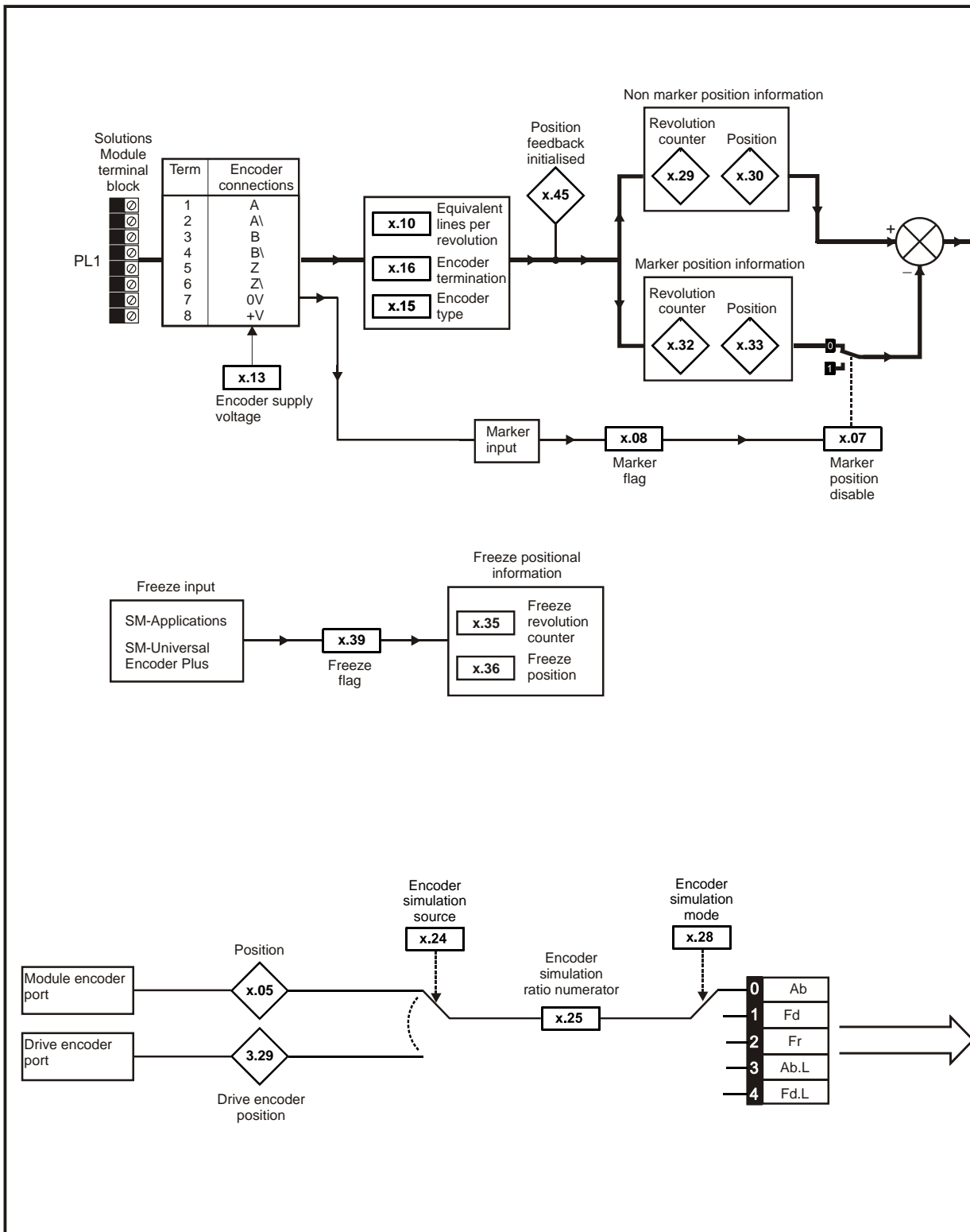
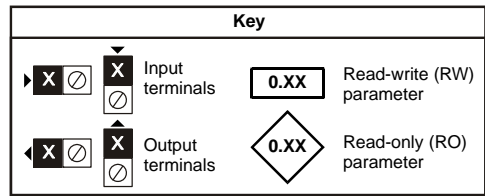
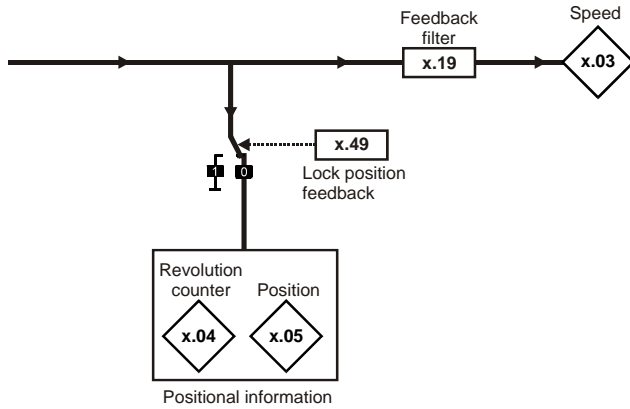


Figure 11-29 SM-Encoder Output Plus logic diagram

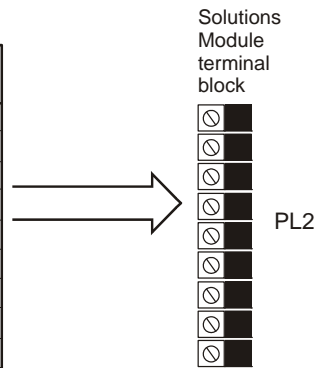






The parameters are all shown at their default settings

Ab	Fd	Fr	Ab.L	Fd.L	PL2 term
		0V			1
		0V			2
A	F	F	A	F	3
A\<	F\<	F\<	A\<	F\<	4
B	D	R\<	B	D	5
B\<	D\<	R\<	B\<	D\<	6
		0V			7
		Z			8
		Z\<			9



### SM-Encoder Plus / SM-Encoder Output Plus parameters

Parameter		Range(⇅)	Default(⇄)	Type						
x.01	Solutions Module ID	0 to 599	104	RO	Uni			PT	US	
x.03	Speed feedback	±40,000.0 rpm		RO	Bi	FI	NC	PT		
x.04	Revolution counter	0 to 65,535 revolutions		RO	Uni	FI	NC	PT		
x.05	Position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni	FI	NC	PT		
x.07	Marker position reset disable	OFF (0) or On (1)	OFF (0)	RW	Bit					US
x.08	Marker flag	OFF (0) or On (1)	OFF (0)	RW	Bit		NC			
x.10	Equivalent lines per revolution	0 to 50,000	4,096	RW	Uni					US
x.13*	Encoder supply voltage	0: 5V, 1: 8V, 2: 15V	0	RW	Uni					US
x.15	Encoder type	Ab (0), Fd (1), Fr (2 to 12)	Ab (0)	RW	Uni					US
x.16	Encoder termination	0 to 2	1	RW	Bit					US
x.19	Feedback filter	0 to 5 (0 to 16 ms)	0	RW	Uni					US
x.24*	Encoder simulation source	Pr <b>0.00</b> to Pr <b>21.51</b>	0.00	RW	Uni				PT	US
x.25*	Encoder simulation ratio numerator	0.0000 to 3.0000	0.2500	RW	Uni					US
x.28*	Encoder simulation mode	0: Ab, 1: Fd, 2: Fr, 3: Ab with marker lock, 4 to 7: Fd with marker lock	0	RW	Uni					US
x.29	Non-marker reset revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT		
x.30	Non-marker reset position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT		
x.32	Marker revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT		
x.33	Marker position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT		
x.35	Freeze revolution counter	0 to 65,535 revolutions		RO	Uni		NC	PT		
x.36	Freeze position	0 to 65,535 (1/2 <sup>16</sup> ths of a revolution)		RO	Uni		NC	PT		
x.39	Freeze flag	OFF (0) or On (1)	OFF (0)	RW	Bit		NC			
x.45	Position feedback initialised	OFF (0) or On (1)		RO	Bit		NC	PT		
x.49	Lock position feedback	OFF (0) or On (1)		RW	Bit					
x.50	Solutions Module error status**	0 to 255		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\*Pr x.13, Pr x.24, Pr x.25 and Pr x.28 are only used when operating with a SM-Encoder Output Plus module. These parameters are not used when operating with a SM-Encoder Plus module

\*\*See trip SLX.Er, *Feedback module category* on page 269.

### 11.15.3 Automation module category

Figure 11-30 SM-I/O Plus analog logic diagram

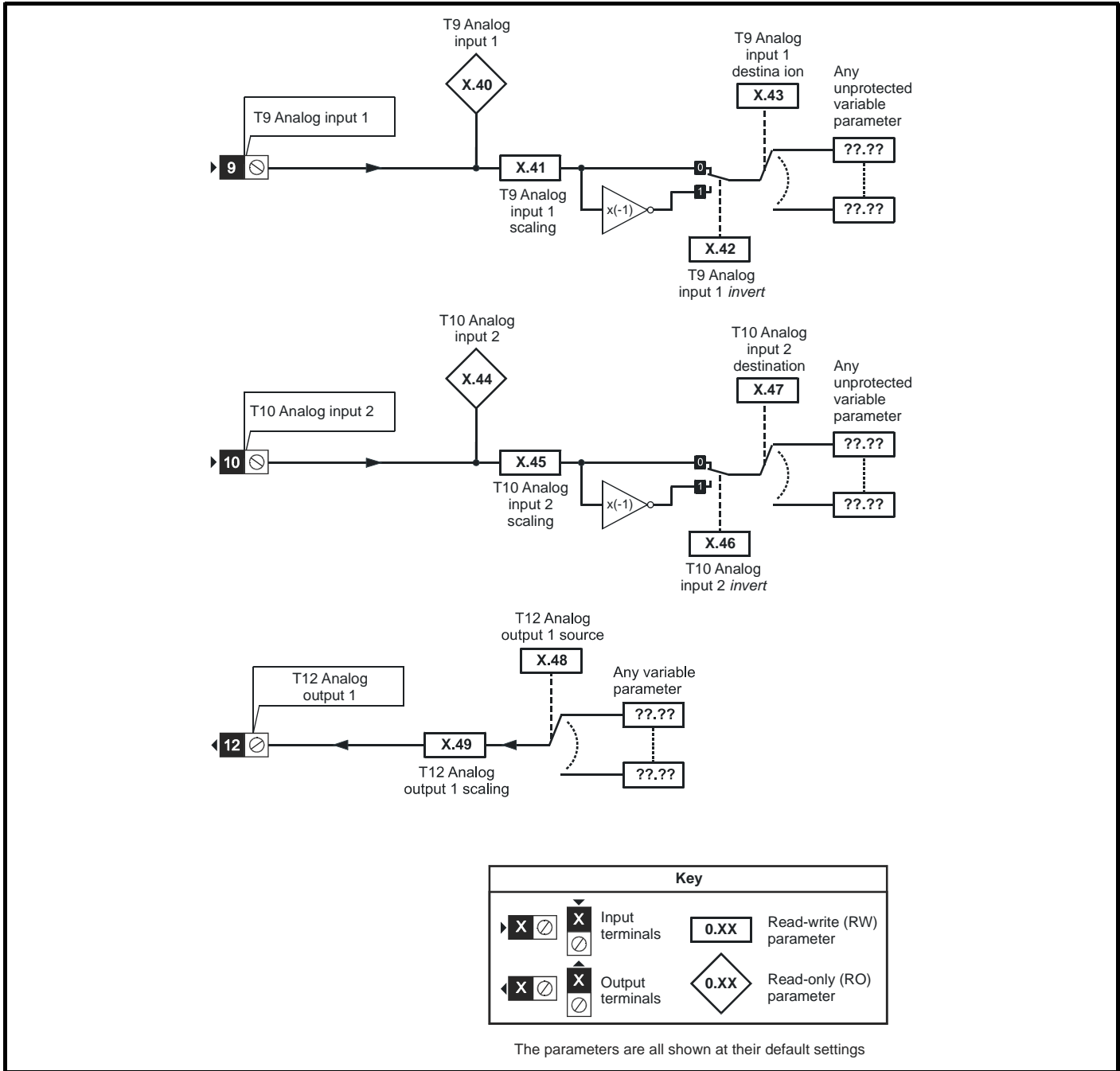


Figure 11-31 SM-I/O Plus digital logic diagram 1

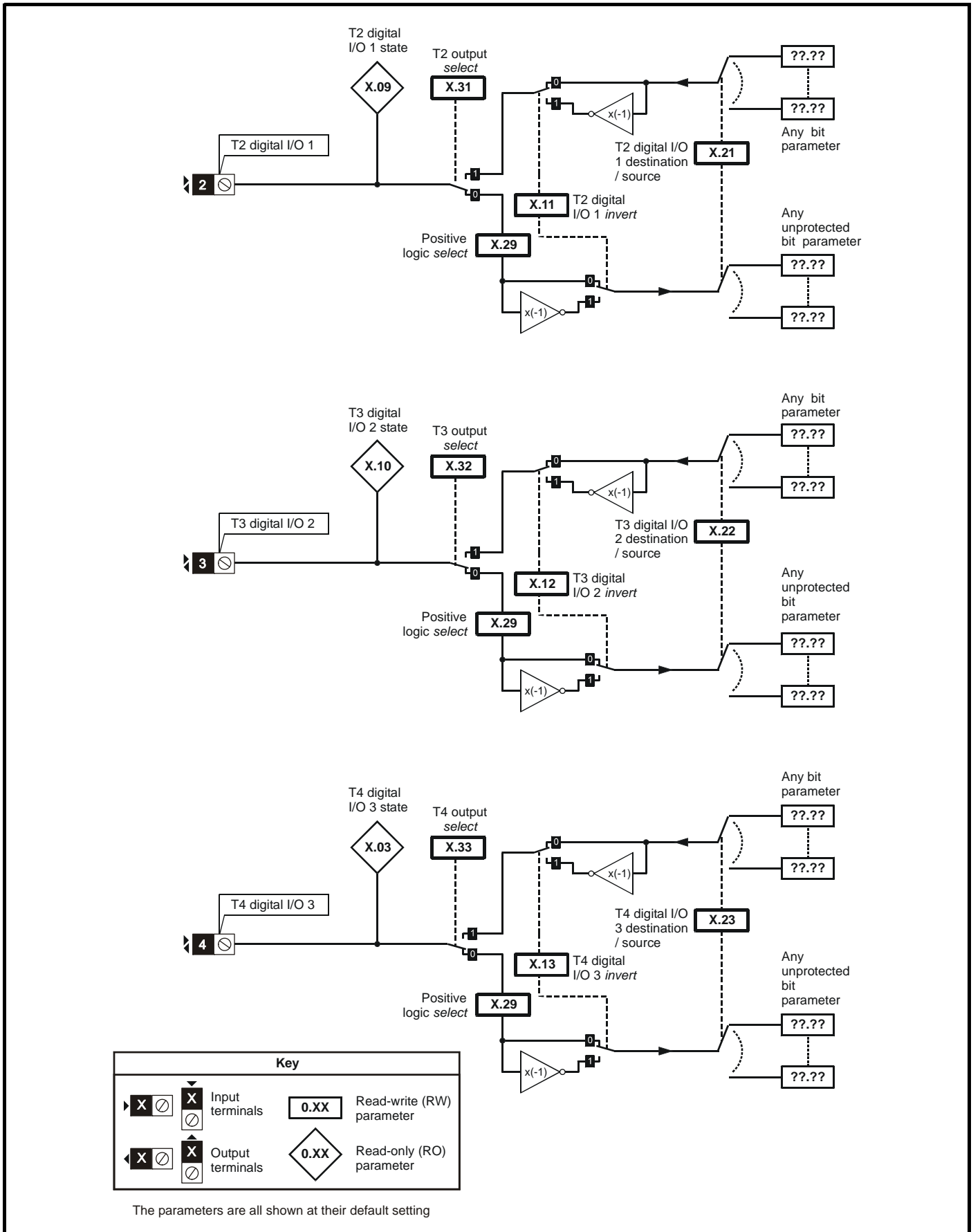
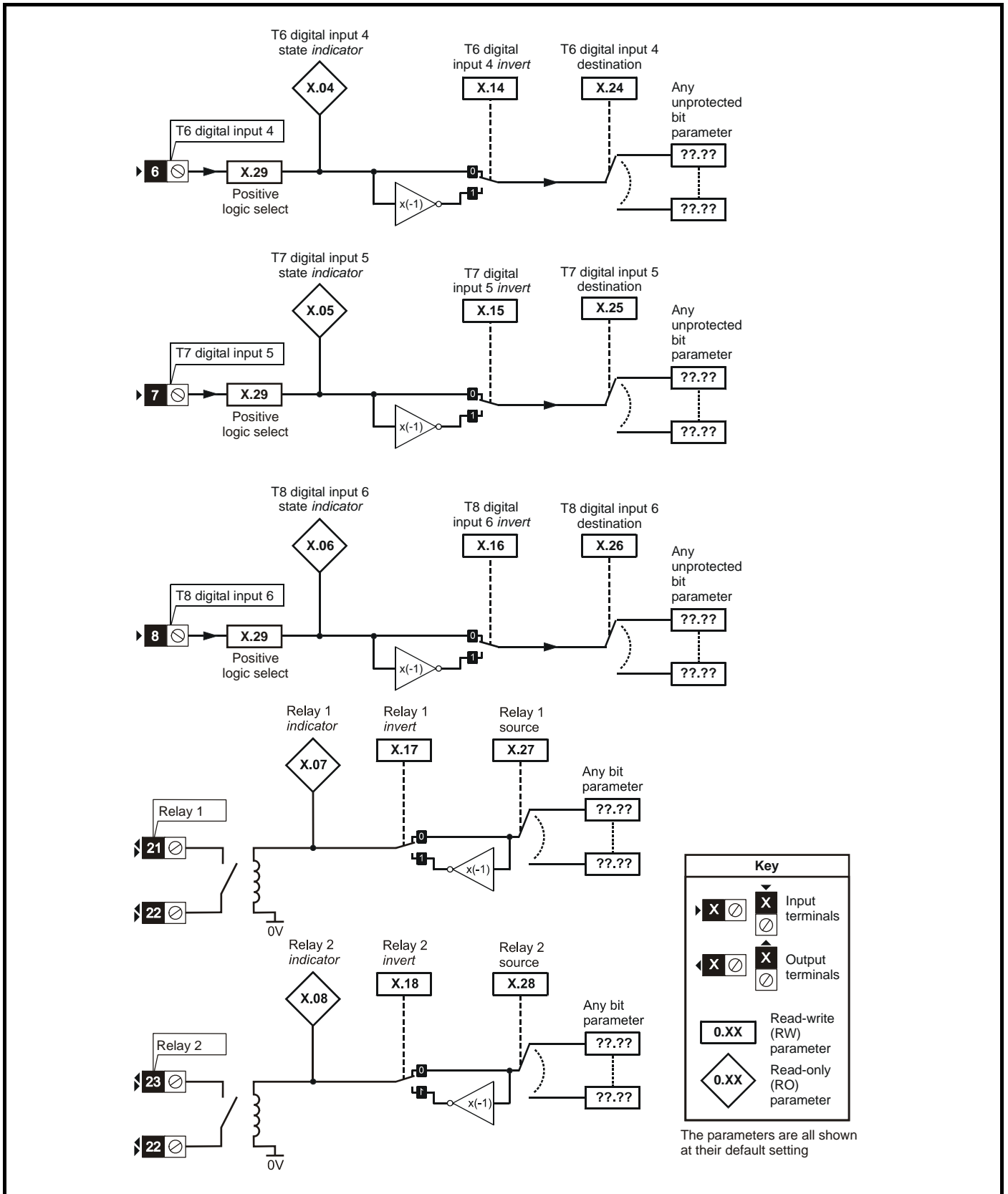


Figure 11-32 SM-I/O Plus digital logic diagram 2



### SM-I/O Plus parameters

Parameter		Range(⇅)	Default(⇨)	Type				
x.01	Solutions Module ID	0 to 599	201	RO	Uni		PT	US
x.03	T4 digital I/O 3 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.04	T6 digital input 4 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.05	T7 digital input 5 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.06	T8 digital input 6 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.07	Relay 1 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.08	Relay 2 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.09	T2 digital I/O 1 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.10	T3 digital I/O 2 state	OFF (0) or On (1)		RO	Bit	NC	PT	
x.11	T2 digital I/O 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.12	T3 digital I/O 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.13	T4 digital I/O 3 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.14	T6 digital input 4 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.15	T7 digital input 5 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.16	T8 digital input 6 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.17	Relay 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.18	Relay 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.20	Digital I/O read word	0 to 511		RO	Uni	NC	PT	
x.21	T2 digital I/O 1 source/ destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.22	T3 digital I/O 2 source/ destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.23	T4 digital I/O 3 source/ destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.24	T6 digital input 4 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.25	T7 digital input 5 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.26	T8 digital input 6 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.27	Relay 1 source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni		PT	US
x.28	Relay 2 source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni		PT	US
x.29	Input polarity select	OFF (0) or On (1)	On (1) (positive logic)	RW	Bit		PT	US
x.31	T2 digital I/O 1 output select	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.32	T3 digital I/O 2 output select	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.33	T4 digital I/O 3 output select	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.40	Analog input 1	±100.0%		RO	Bi	NC	PT	
x.41	Analog input 1 scaling	0 to 4.000	1.000	RW	Uni			US
x.42	Analog input 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.43	Analog input 1 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.44	Analog input 2	±100.0%		RO	Bi	NC	PT	
x.45	Analog input 2 scaling	0.000 to 4.000	1.000	RW	Uni			US
x.46	Analog input 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US
x.47	Analog input 2 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE	PT	US
x.48	Analog output 1 source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni		PT	US
x.49	Analog output 1 scaling	0.000 to 4.000	1.000	RW	Uni			US
x.50	Solutions Module error status*	0 to 255		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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\*See trip SLX.Er, *Automation (I/O Expansion) module category* on page 271.

Figure 11-33 SM-I/O Lite & SM-I/O Timer digital I/O logic diagram

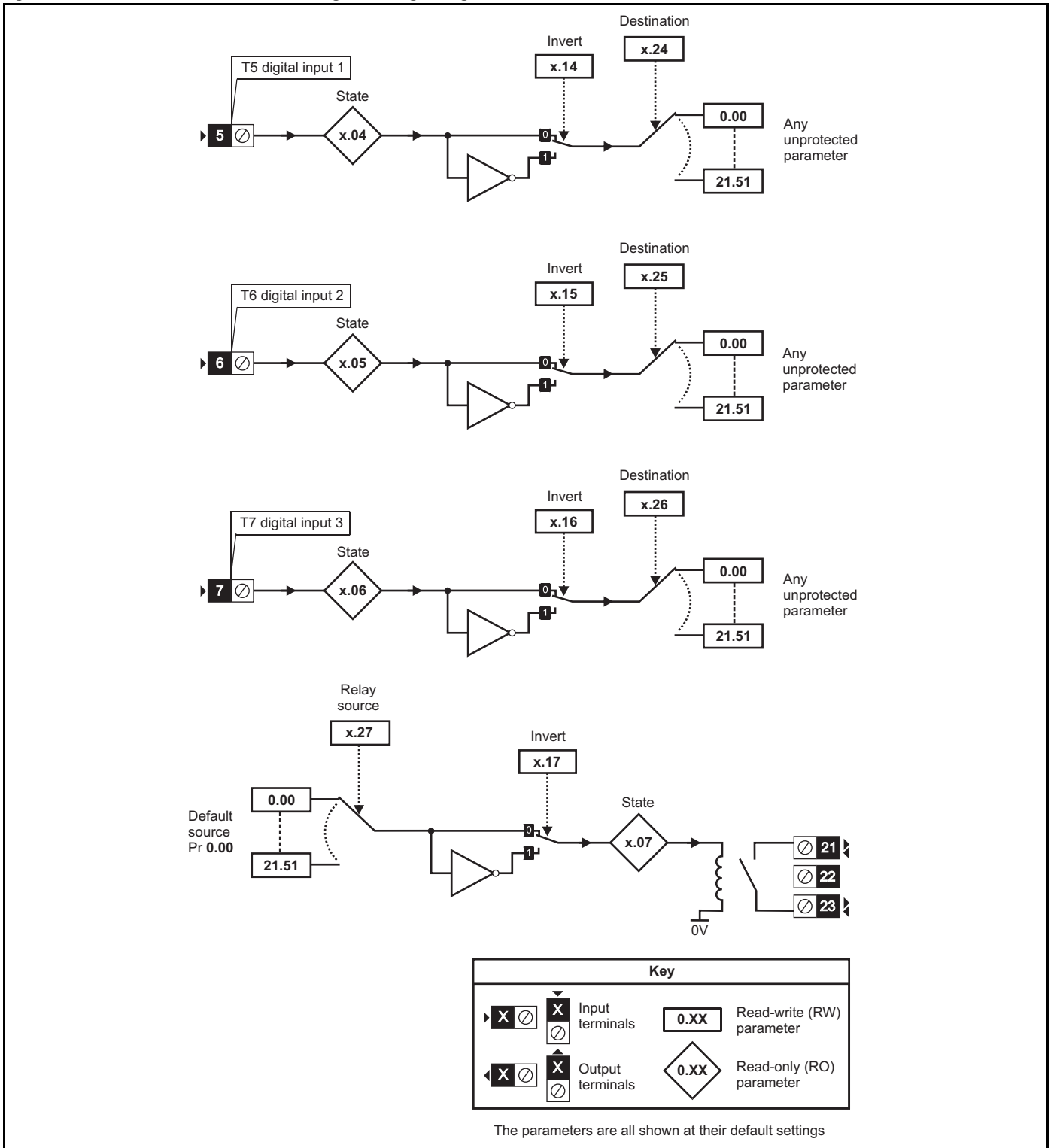


Figure 11-34 SM-I/O Lite & SM-I/O Timer analog I/O logic diagram

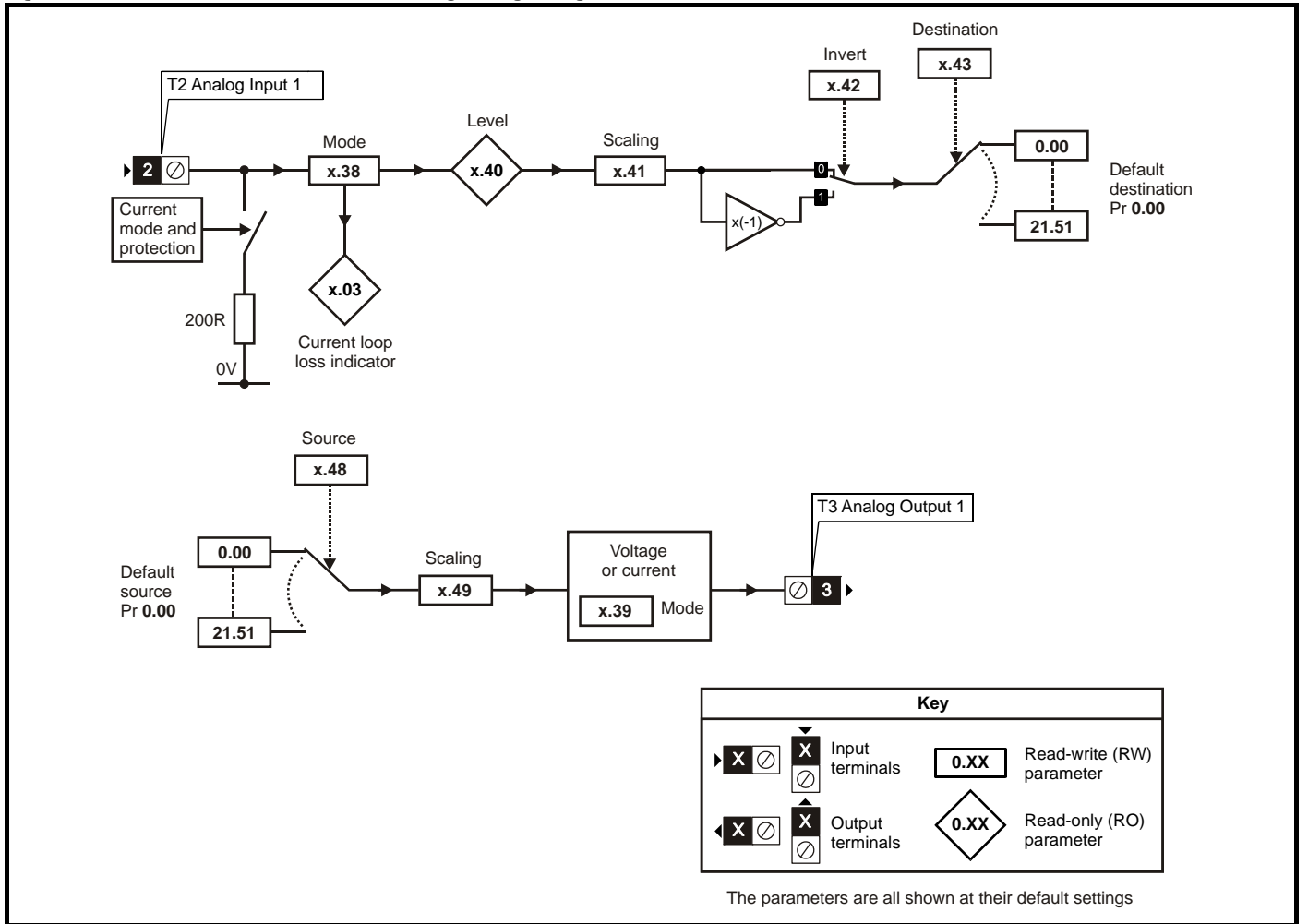
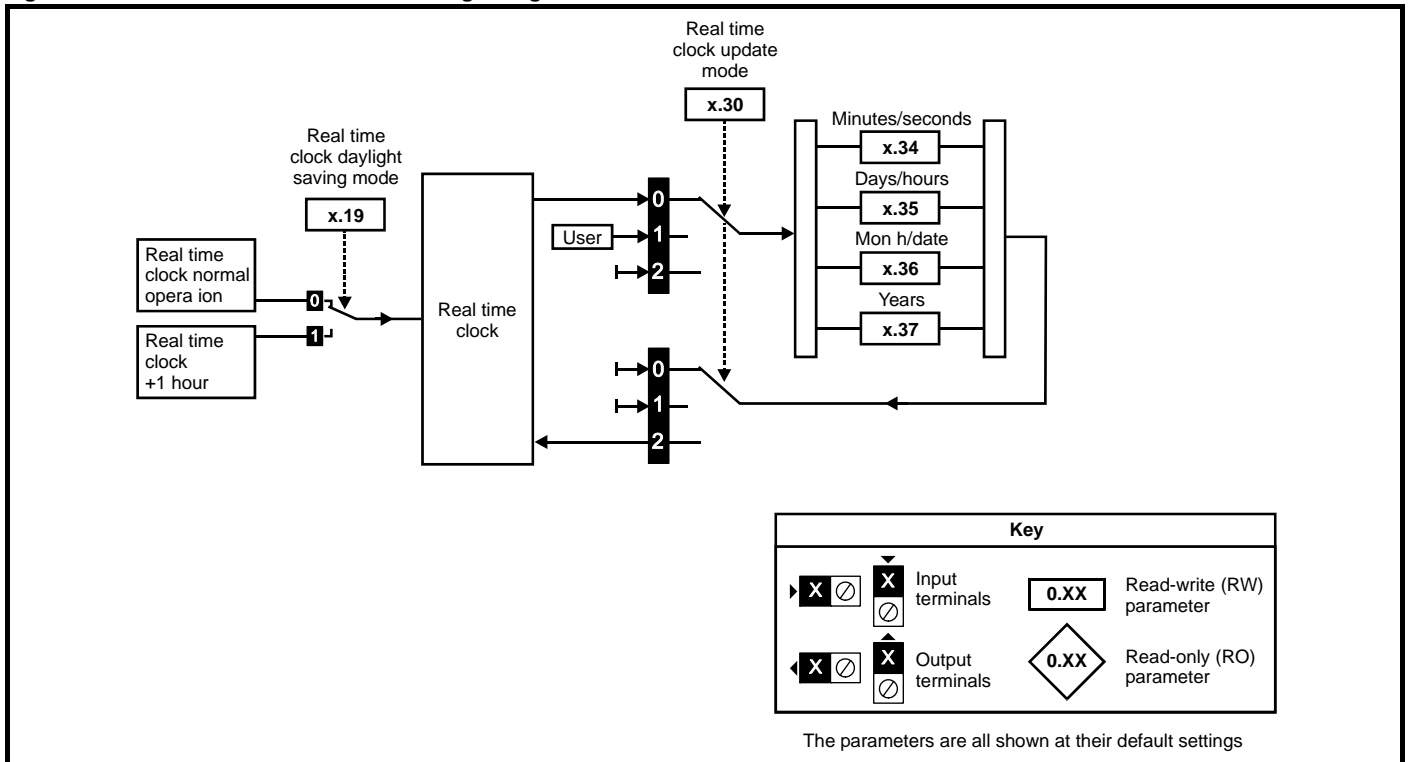


Figure 11-35 SM-I/O Timer real time clock logic diagram





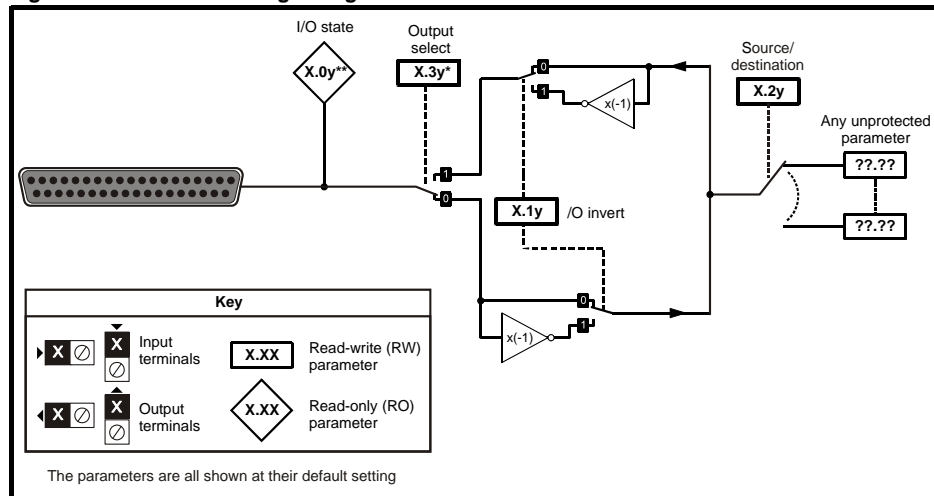
### SM-I/O Timer & SM-I/O Lite parameters

Parameter		Range(⇅)	Default(⇒)	Type				SM-I/O		
								Lite	Timer	
x.01	Solutions Module ID	0 to 599	SM-I/O Timer: 203 SM-I/O Lite: 207	RO	Uni		PT	US	✓	✓
x.02	Solutions Module software version	0.00 to 99.99		RO	Uni		NC PT		✓	✓
x.03	Current loop loss indicator	OFF (0) or On (1)		RO	Bit		NC PT		✓	✓
x.04	T5 digital input 1 state	OFF (0) or On (1)		RO	Bit		NC PT		✓	✓
x.05	T6 digital input 2 state	OFF (0) or On (1)		RO	Bit		NC PT		✓	✓
x.06	T7 digital input 3 state	OFF (0) or On (1)		RO	Bit		NC PT		✓	✓
x.07	Relay 1 state	OFF (0) or On (1)		RO	Bit		NC PT		✓	✓
x.14	T5 digital input 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US	✓	✓
x.15	T6 digital input 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US	✓	✓
x.16	T7 digital input 3 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US	✓	✓
x.17	Relay 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US	✓	✓
x.19	Real time clock daylight saving mode	OFF (0) or On (1)	OFF (0)	RW	Bit			US		✓
x.20	Digital I/O read word	0 to 255		RO	Uni		NC PT		✓	✓
x.24	T5 digital input 1 des ination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT US	✓	✓
x.25	T6 digital input 2 des ination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT US	✓	✓
x.26	T7 digital input 3 des ination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT US	✓	✓
x.27	Relay 1 source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni			PT US	✓	✓
x.30	Real time clock update mode	0 to 2	0	RW	Uni		NC			✓
x.34	Real time clock time: minutes.seconds	0.00 to 59.59		RW	Uni		NC PT			✓
x.35	Real time clock ime: days.hours	1.00 to 7.23		RW	Uni		NC PT			✓
x.36	Real time clock time: months.days	0.00 to 12.31		RW	Uni		NC PT			✓
x.37	Real time clock ime: years	2000 to 2099		RW	Uni		NC PT			✓
x.38	Analog input 1 mode	0-20 (0), 20-0 (1), 4-20.tr (2), 20-4.tr (3), 4-20 (4), 20-4 (5), VOLt(6)	0-20 (0)	RW	Txt			US	✓	✓
x.39	Analog output mode	0-20 (0), 20-0 (1), 4-20 (2), 20-4 (3), VOLt (4)	0-20 (0)	RW	Txt			US	✓	✓
x.40	Analog input 1	±100.0%		RO	Bi		NC PT		✓	✓
x.41	Analog input 1 scaling	0 to 4.000	1.000	RW	Uni			US	✓	✓
x.42	Analog input 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit			US	✓	✓
x.43	Analog input 1 destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT US	✓	✓
x.48	Analog output 1 source	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni			PT US	✓	✓
x.49	Analog output 1 scaling	0.000 to 4.000	1.000	RW	Uni			US	✓	✓
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		✓	✓

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

\*See trip SLX.Er, *Automation (I/O Expansion) module category* on page 271.

Figure 11-36 SM-I/O 32 logic diagram



SM-I/O 32 parameters

Parameter	Range(↕)	Default(⇒)	Type					
x.01	Solutions Module ID code	0 to 599	208	RO	Uni		PT	US
x.02	Solutions Module main software version	0.00 to 99.99	99.00	RO	Uni		NC	PT
x.03	Digital I/O 3 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.04	Digital I/O 4 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.05	Digital I/O 5 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.06	Digital I/O 6 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.07	Digital I/O 7 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.08	Digital I/O 8 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.09	Digital I/O 1 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.10	Digital I/O 2 state	OFF(0) or On(1)	OFF (0)	RO	Bit		NC	PT
x.11	Digital I/O 1 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.12	Digital I/O 2 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.13	Digital I/O 3 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.14	Digital I/O 4 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.15	Digital I/O 5 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.16	Digital I/O 6 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.17	Digital I/O 7 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.18	Digital I/O 8 invert	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.20	Digital I/O read word	0 to 255	0	RO	Uni		NC	PT
x.21	Digital I/O 1 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.22	Digital I/O 2 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.23	Digital I/O 3 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.24	Digital I/O 4 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.25	Digital I/O 5 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.26	Digital I/O 6 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.27	Digital I/O 7 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.28	Digital I/O 8 source/destination	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.29	Digital I/O 4 output select	OFF(0) or On(1)	On(1)	RW	Bit			PT
x.31	Digital I/O 1 output select	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.32	Digital I/O 2 output select	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.33	Digital I/O 3 output select	OFF(0) or On(1)	OFF (0)	RW	Bit			US
x.43	First update method direction register	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.47	Fast update method read register	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni	DE		PT
x.48	Fast update method write register	Pr 0.00 to Pr 21.51	Pr 0.00	RW	Uni			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

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

\*See trip SLX.Er, Automation (I/O Expansion) module category on page 271.

### Applications module parameters

Parameter		Range(⇅)	Default(⇄)	Type					
x.01	Solutions Module ID	0 to 599		RO	Uni			PT	US
x.02	Solutions Module software version	0.00 to 99.99		RO	Uni		NC	PT	
x.03	DPL program status	None (0), Stop (1), Run (2), Trip (3)		RO	Txt		NC	PT	
x.04	Available system resource	0 to 100		RO	Uni		NC	PT	
x.05	RS485 address	0 to 255	11	RW	Uni				US
x.06	RS485 mode	0 to 255	1	RW	Uni				US
x.07	RS485 baud rate	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 115200 (9) baud	4800 (4)	RW	Txt				US
x.08	RS485 Turnaround delay	0 to 255 ms	2	RW	Uni				US
x.09	RS485 Tx enable delay	0 to 1 ms	0	RW	Uni				US
x.10	DPL Print Routing	SYPT: OFF (0), RS485: On (1)	SYPT: OFF (0)	RW	Bit				US
x.11	Clock task scheduling (ms)	0 to 200	10	RW	Uni				US
x.12	POS task scheduling rate	disAbLEd (0), 0.25 ms (1), 0.5 ms (2), 1 ms (3), 2 ms (4), 4 ms (5), 8 ms (6)	disAbLEd (0)	RW	Txt				US
x.13	Enable autorun	OFF (0) or On (1)	On (1)	RW	Bit				US
x.14	Global run time trip enable	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.15	Disable reset on trip cleared	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.16	Encoder data update rate	0 to 3	0	RW	Uni				US
x.17	Enable parameter over range trips	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.18	Watchdog enable	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.19	Save request	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
x.20	Enable power down save	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.21	Enable menu 20 save and restore	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.22	CTNet Token Ring ID	0 to 255	0	RW	Uni				US
x.23	CTNet node address	0 to 255	0	RW	Uni				US
x.24	CTNet baud rate	5.000 (0), 2.500 (1), 1.250 (2), 0.625 (3)	2.500 (1)	RW	Txt				US
x.25	CTNet sync setup	0,000 to 9,999	0,000	RW	Uni				US
x.26	CTNet easy mode - first cyclic parameter destination node	0 to 25,503	0	RW	Uni				US
x.27	CTNet easy mode - first cyclic source parameter	0 to 9,999	0	RW	Uni				US
x.28	CTNet easy mode - second cyclic parameter destination node	0 to 25,503	0	RW	Uni				US
x.29	CTNet easy mode - second cyclic source parameter	0 to 9,999	0	RW	Uni				US
x.30	CTNet easy mode - third cyclic parameter destination node	0 to 25,503	0	RW	Uni				US
x.31	CTNet easy mode - third cyclic source parameter	0 to 9,999	0	RW	Uni				US
x.32	CTNet easy mode set-up - Transfer slot 1 destination parameter	0 to 9,999	0	RW	Uni				US
x.33	CTNet easy mode set-up - Transfer slot 2 destination parameter	0 to 9,999	0	RW	Uni				US
x.34	CTNet easy mode set-up - Transfer slot 3 destination parameter	0 to 9,999	0	RW	Uni				US
x.35	CTNet sync event task ID	Disabled (0), Event (1), Event1 (2), Event2 (3), Event3 (4)	Disabled (0)	RW	Txt				US
x.36	CTNet diagnostic parameter	-3 to +32,767		RO	Uni		NC	PT	
x.37	Reject download if drive enabled	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.38	APC run-time trip	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.39	Inter-module synchronisation status	0 to 3	0	RO	Uni		NC		
x.41	Indexer control	0 to 255	0	RW	Uni		NC		
x.42	Pass freeze through drive	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.43	Freeze invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
x.44	Task priority level	0 to 255	0	RW	Uni				US
x.45	User set-up parameter 1	0 to 65535		RO	Uni		NC		
x.46	User set-up parameter 2	-32,768 to +32,767		RO	Uni		NC		
x.47	User set-up parameter 3	0 to 255		RO	Uni		NC		
x.48	DPL line number in error	0 to 2,147,483,647	0	RO	Uni		NC	PT	
x.49	User program ID	-32,768 to +32,767	0	RO	Bi		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	

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

\*See trip SLX.Er, Automation (Applications) module category on page 270.

Safety Information	Product Information	Mechanical Installation	Electrical Installation	Getting Started	Basic parameters	Running the motor	Optimization	SMARTCARD operation	Onboard PLC	<b>Advanced parameters</b>	Technical Data	Diagnostics	UL Listing Information
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## 11.15.4 Fieldbus module category

### Fieldbus module parameters

For information regarding fieldbus module parameters, refer to the appropriate Solutions Module User Guide.

## 11.16 Menu 18: Application menu 1

Parameter		Range(⇅)	Default(⇔)	Type					
18.01	Application menu 1 power-down saved integer	-32,768 to +32,767	0	RW	Bi		NC		PS
18.02 to 18.10	Application menu 1 read-only integer	-32,768 to +32,767	0	RO	Bi		NC		
18.11 to 18.30	Application menu 1 read-write integer	-32,768 to +32,767	0	RW	Bi				US
18.31 to 18.50	Application menu 1 read-write bit	OFF (0) or On (1)	0	RW	Bit				US

## 11.17 Menu 19: Application menu 2

Parameter		Range(⇅)	Default(⇔)	Type					
19.01	Application menu 2 power-down saved integer	-32,768 to +32,767	0	RW	Bi		NC		PS
19.02 to 19.10	Application menu 2 read-only integer	-32,768 to +32,767	0	RO	Bi		NC		
19.11 to 19.30	Application menu 2 read-write integer	-32,768 to +32,767	0	RW	Bi				US
19.31 to 19.50	Application menu 2 read-write bit	OFF (0) or On (1)	0	RW	Bit				US

## 11.18 Menu 20: Application menu 3

Parameter		Range(⇅)	Default(⇔)	Type					
20.01 to 20.20	Application menu 3 read-write integer	-32,768 to +32,767	0	RW	Bi		NC		
20.21 to 20.40	Application menu 3 read-write long integer	$-2^{31}$ to $2^{31}-1$	0	RW	Bi		NC		

With software V01.07.00 and later, all menu 20 parameters are transferred to the SMARTCARD when a 4yyy transfer is performed. See section 9.2.1 *Writing to the SMARTCARD* on page 140 for more information.

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

## 11.19 Menu 21: Second motor parameters

Parameter	Range(⇅)		Default(⇄)			Type						
	OL	CL	OL	VT	SV							
21.01	Maximum reference clamp (0.02)*	0 to 3,000.0 Hz	SPEED_LIMIT_MAX rpm	EUR> 50.0 USA> 60.0	EUR> 1,500 0 USA> 1,800.0	3,000.0	RW	Uni				US
21.02	Minimum reference clamp (0.01)*	±3,000 0 Hz	±SPEED_LIMIT_MAX rpm	0.0			RW	Bi				PT US
21.03	Reference selector (0.05)*	A1.A2 (0), A1.Pr (1), A2.Pr (2), Pr (3), PAd (4), Prc (5)		A1.A2 (0)			RW	Txt				US
21.04	Acceleration rate (0.03)*	0 0 to 3,200 0 s/100Hz	0.000 to 3,200.000 s/1000rpm	5.0	2.000	0 200	RW	Uni				US
21.05	Deceleration rate (0.04)*	0.0 to 3200.0 s/100Hz	0.000 to 3,200.000 s/1000rpm	10.0	2.000	0 200	RW	Uni				US
21.06	Rated frequency (0.47)*	0 to 3000.0 Hz	VT> 0 to 1250.0Hz	EUR> 50 USA> 60			RW	Uni				US
21.07	Rated current (0.46)*	0 to RATED_CURRENT_MAX A		Drive rated current (Pr 11.32)			RW	Uni		RA		US
21.08	Rated load rpm (0.45)*	0 to 180,000 rpm	0 00 to 40,000.00 rpm	EUR> 1,500 USA> 1,800	EUR> 1,450.00 USA> 1,770.00	3,000.00	RW	Uni				US
21.09	Rated voltage (0.44)*	0 to AC_VOLTAGE_SET_MAX V		200V rating drive: 230V 400V rating drive: EUR> 400V, USA> 460V 575V rating drive: 575V 690V rating drive: 690V			RW	Uni		RA		US
21.10	Rated power factor (0.43)*	0 000 to 1.000	VT> 0.000 to 1.000	0.85			RW	Uni		RA		US
21.11	Number of motor poles (0.42)*	Auto to 120 pole (0 to 60)		Auto (0)		6 POLE (3)	RW	Txt				US
21.12	Stator resistance	Size 1 to 5: 0.000 to 65.000 Ω Size 6: 0.000 to 65.000 x 10 mΩ		0.0			RW	Uni		RA		US
21.13	Voltage offset	0.0 to 25.0 V		0.0			RW	Uni		RA		US
21.14	Transient inductance (σL <sub>s</sub> )	0.000 to 500.000mH		0.000			RW	Uni		RA		US
21.15	Motor 2 active	OFF (0) or On (1)					RO	Bit		NC	PT	
21.16	Thermal time constant (0.45)*	0.0 to 3000.0		89.0		20.0	RW	Uni				US
21.17	Speed controller Kp gain (0.07)*		0.000 to 6.5535 rad s <sup>-1</sup>		0.0300	0.0100	RW	Uni				US
21.18	Speed controller Ki gain (0.08)*		0.00 to 655.35 s/rad s <sup>-1</sup>		0.10	1.00	RW	Uni				US
21.19	Speed controller Kd gain (0.09)*		0.00000 to 0.65535 s <sup>-1</sup> /rad s <sup>-1</sup>		0.00000		RW	Uni				US
21.20	Encoder phase angle (0.43)*		0.0 to 359.9 electrical			0.0	RW	Uni				US
21.21	Speed feedback selector		drv (0), SLOt1 (1), SLOt2 (2), SLOt3 (3)		drv (0)		RW	Txt				US
21.22	Current controller Kp gain (0.38)*	0 to 30,000		20	200V: 75, 400V: 150, 575V: 180, 690V: 215		RW	Uni				US
21.23	Current controller Ki gain (0.39)*	0 to 30,000		40	200V: 1,000, 400V: 2,000, 575V: 2,400, 690V: 3,000		RW	Uni				US
21.24	Stator inductance (L <sub>s</sub> )		VT> 0 00 to 5,000.00 mH		0.00		RW	Uni		RA		US
21.25	Motor saturation breakpoint 1		VT> 0 to 100% of rated flux		50		RW	Uni				US
21.26	Motor saturation breakpoint 2		VT> 0 to 100% of rated flux		75		RW	Uni				US
21.27	Motoring current limit	0 to MOTOR2_CURRENT_LIMIT_MAX %		165.0	175.0		RW	Uni		RA		US
21.28	Regen current limit	0 to MOTOR2_CURRENT_LIMIT_MAX %		165.0	175.0		RW	Uni		RA		US
21.29	Symmetrical current limit (0.06)*	0 to MOTOR2_CURRENT_LIMIT_MAX %		165.0	175.0		RW	Uni		RA		US
21.30	Motor volts per 1,000 rpm, K <sub>e</sub>		SV> 0 to 10,000 V			98	RW	Uni				US
21.31	Motor pole pitch	0.00 to 655.35 mm		0 00			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 copied	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

\* The menu 0 references are only valid when the second motor map parameters have been made active by setting Pr 11.45 to 1. (The second motor map only becomes effective when the output stage of the drive is not enabled, i.e. inh, rdY, or trip states.)

When the second motor map parameters are active, the symbol 'Mot2' will appear in the lower left hand corner of the LCD display or the decimal point that is second from the right on the first row of the LED display is lit.



### Encoder phase angle (servo mode only)

With drive software version V01.08.00 onwards, the encoder phase angles in Pr **3.25** and Pr **21.20** are copied to the SMARTCARD when using any of the SMARTCARD transfer methods.

With drive software version V01.05.00 to V01.07.01, the encoder phase angles in Pr **3.25** and Pr **21.20** are only copied to the SMARTCARD when using either Pr **0.30** set to Prog (2) or Pr **xx.00** set to 3yyy.

This is useful when the SMARTCARD is used to back-up the parameter set of a drive but caution should be used if the SMARTCARD is used to transfer parameter sets between drives.

Unless the encoder phase angle of the servo motor connected to the destination drive is known to be the same as the servo motor connected to the source drive, an autotune should be performed or the encoder phase angle should be entered manually into Pr **3.25** (or Pr **21.20**). If the encoder phase angle is incorrect the drive may lose control of the motor resulting in an O.SPd or Enc10 trip when the drive is enabled.

With drive software version V01.04.00 and earlier, or when using software version V01.05.00 to V01.07.01 and Pr **xx.00** set to 4yyy is used, then the encoder phase angles in Pr **3.25** and Pr **21.20** are not copied to the SMARTCARD. Therefore, Pr **3.25** and Pr **21.20** in the destination would not be changed during a transfer of this data block from the SMARTCARD.

## 11.20 Menu 22: Additional Menu 0 set-up

Parameter	Range(⇅)	Default(⇄)			Type				
		OL	VT	SV					
22.01 Parameter 0.31 set-up	Pr 1.00 to Pr 21.51	Pr 11.33			RW	Uni		PT	US
22.02 Parameter 0.32 set-up	Pr 1.00 to Pr 21.51	Pr 11.32			RW	Uni		PT	US
22.03 Parameter 0.33 set-up	Pr 1.00 to Pr 21.51	Pr 6.09	Pr 5.16	Pr 0.00	RW	Uni		PT	US
22.04 Parameter 0.34 set-up	Pr 1.00 to Pr 21.51	Pr 11.30			RW	Uni		PT	US
22.05 Parameter 0.35 set-up	Pr 1.00 to Pr 21.51	Pr 11.24			RW	Uni		PT	US
22.06 Parameter 0.36 set-up	Pr 1.00 to Pr 21.51	Pr 11.25			RW	Uni		PT	US
22.07 Parameter 0.37 set-up	Pr 1.00 to Pr 21.51	Pr 11.23			RW	Uni		PT	US
22.10 Parameter 0.40 set-up	Pr 1.00 to Pr 21.51	Pr 5.12			RW	Uni		PT	US
22.11 Parameter 0.41 set-up	Pr 1.00 to Pr 21.51	Pr 5.18			RW	Uni		PT	US
22.18 Parameter 0.48 set-up	Pr 1.00 to Pr 21.51	Pr 11.31			RW	Uni		PT	US
22.20 Parameter 0.50 set-up	Pr 1.00 to Pr 21.51	Pr 11.29			RW	Uni		PT	US
22.21 Parameter 0.51 set-up	Pr 1.00 to Pr 21.51	Pr 10.37			RW	Uni		PT	US
22.22 Parameter 0.52 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.23 Parameter 0.53 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.24 Parameter 0.54 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.25 Parameter 0.55 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.26 Parameter 0.56 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.27 Parameter 0.57 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.28 Parameter 0.58 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US
22.29 Parameter 0.59 set-up	Pr 1.00 to Pr 21.51	Pr 0.00			RW	Uni		PT	US

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



## 11.21 Advanced features

This section gives information on some of the advanced functions of the drive. For additional information see the *Advanced User Guide*.

Reference modes	Pr 1.14, Pr 1.15 and Pr 8.39
Braking modes	Pr 2.04 and Pr 2.08
S ramps	Pr 2.06 and Pr 2.07
Torque modes	Pr 4.08 and Pr 4.11
Stop modes	Pr 6.01, Pr 6.06, Pr 6.07 and Pr 6.08
Main loss modes	Pr 6.03, Pr 6.48, Pr 4.13 and Pr 4.14
Start/stop logic modes	Pr 6.04 and Pr 6.40
Catch a spinning motor	Pr 6.09 and Pr 5.40
Position loop modes	Pr 13.10
Fast disable	Pr 6.29

### 11.21.1 Reference modes

<b>1.14</b>		<b>Reference selector</b>	
RW	Txt		
		NC	US
⇅	A1.A2 (0), A1.Pr (2), A2.Pr (2), Pr (3), PAd (4), Prc (5)	⇒	A1.A2 (0)

<b>1.15</b>		<b>Preset reference selector</b>	
RW	Uni		
		NC	US
⇅	0 to 9	⇒	0

<b>8.39</b>		<b>T28 and T29 auto-selection disable</b>	
RW	Bit		
			US
⇅	OFF (0) or On (1)	⇒	OFF (0)

If Pr 8.39 is set to OFF (0), then the setting of Pr 1.14 automatically changes the operation of digital inputs T28 and T29 by configuring the destination parameters Pr 8.25 and Pr 8.26. To allow Pr 8.25 and Pr 8.26 to be changed manually by the user, the automatic set-up must be disabled by setting Pr 8.39 to 1.

If Pr 8.39 is 0 and Pr 1.14 is changed, then a drive reset is required before the function of terminal T28 or T29 will become active.

Table 11-7 Active reference

Pr 1.14	Pr 1.15	Digital Input T28		Digital Input T29		Pr 1.49	Pr 1.50	Active Reference
		State	Function	State	Function			
A1.A2 (0)	0 or 1	0	Local Remote		Jog forward**	1	1	Analog input 1
		1				2	1	Analog input 2
	2 to 8	No function	1 or 2			2 to 8	Preset reference 2 to 8	
	9 *	0	Local Remote			1	1	Analog input 1
		1				2	1	Analog input 2
		No function	1 or 2	2 to 8	Preset reference 2 to 8			
A1.Pr (1)	0	0	Preset select bit 0	0	Preset select bit 1	1	1	Analog input 1
		1					2	Preset reference 2
		0		3			Preset reference 3	
		1		4			Preset reference 4	
	1	No function		No function	1	1	Analog input 1	
	2 to 8				2 to 8	Preset reference 2 to 8		
	9 *				1	1	Analog input 1	
		No function	2 to 8	2 to 8	Preset reference 2 to 8			
A2.Pr (2)	0	0	Preset select bit 0	0	Preset select bit 1	2	1	Analog input 2
		1					2	Preset reference 2
		0		3			Preset reference 3	
		1		4			Preset reference 4	
	1	No function		No function	1	1	Analog input 2	
	2 to 8				2 to 8	Preset reference 2 to 8		
	9 *				1	1	Analog input 2	
		No function	2 to 8	2 to 8	Preset reference 2 to 8			
Pr (3)	0	0	Preset select bit 0	0	Preset select bit 1	3	1	Preset reference 1
		1					2	Preset reference 2
		0		3			Preset reference 3	
		1		4			Preset reference 4	
	1 to 8	No function		No function	1 to 8	Preset reference 1 to 8		
9 *	1 to 8				Preset reference 1 to 8			
PAd (4)		No function		No function	4		Keypad reference	
Prc (5)		No function		No function	5		Precision reference	

\* Setting Pr 1.15 to 9 enables the Preset reference scan timer. With the scan timer enabled analog 1 and preset references 2 to 8 are selected automatically in turn. Pr 1.16 defines the time between each change.

\*\* Jog forward can only be selected when the drive is in either the ready (rdy), inhibit (inh) or trip states.

### Preset references

Preset references 1 to 8 are contained in Pr 1.21 to Pr 1.28.

### Keypad reference

If Keypad reference is selected the drive sequencer is controlled directly by the keypad keys and the keypad reference parameter (Pr 1.17) is selected. The sequencing bits, Pr 6.30 to Pr 6.34, and Pr 6.37 have no effect and jog is disabled.

### Precision reference

If Precision reference is selected the speed reference is given Pr 1.18 and Pr 1.19.

## 11.21.2 Braking Modes

2.04		Ramp mode select	
RW	Txt		US
OL	↕	FASt (0), Std (1), Std.hV (2)	⇒ Std (1)
CL		FASt (0), Std (1)	

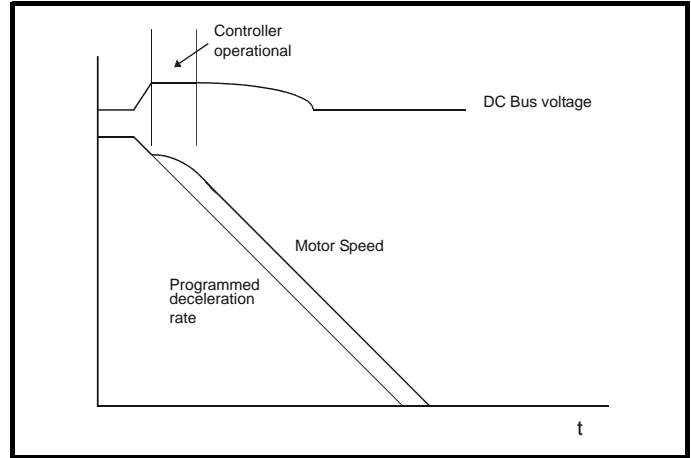
This parameter does not affect the acceleration ramp, as the ramp output always rises at the programmed acceleration rate subject to the current limits. It is possible in under some unusual circumstances in open-loop mode (i.e. highly inductive supply) for the motor to reach a low speed in standard ramp mode, but not completely stop. It is also possible if the drive attempts to stop the motor with an overhauling load in any mode that the motor will not stop when standard ramp mode or fast ramp mode is used. If the drive is in the deceleration state the rate of fall of the frequency or speed is monitored. If this does not fall for 10 seconds the drive forces the frequency or the speed reference to zero. This only applies when the drive is in the deceleration state and not when the reference is simply set to zero.

#### 0: Fast ramp

Fast ramp is used where the deceleration follows the programmed deceleration rate subject to current limits.

#### 1: Standard ramp

Standard ramp is used. During deceleration, if the voltage rises to the standard ramp level (Pr 2.08) it causes a controller to operate, the output of which changes the demanded load current in the motor. As the controller regulates the link voltage, the motor deceleration increases as the speed approaches zero speed. When the motor deceleration rate reaches the programmed deceleration rate the controller ceases to operate and the drive continues to decelerate at the programmed rate. If the standard ramp voltage (Pr 2.08) is set lower than the nominal DC Bus level the drive will not decelerate the motor, but it will coast to rest. The output of the ramp controller (when active) is a current demand that is fed to the frequency changing current controller (Open-loop modes) or the torque producing current controller (Closed-loop vector or Servo modes). The gain of these controllers can be modified with Pr 4.13 and Pr 4.14.



#### 2: Standard ramp with motor voltage boost

This mode is the same as normal standard ramp mode except that the motor voltage is boosted by 20%. This increases the losses in the motor giving faster deceleration.

2.08		Standard ramp voltage	
RW	Uni	RA	US
↕		0 to DC_VOLTAGE_SET_MAX V	⇒ 200V drive: 375 400V drive: EUR> 750 USA> 775 575V drive: 895 690V drive: 1075

This voltage is used as the control level for standard ramp mode. If this parameter is set too low the machine will coast to rest, and if it is set too high and no braking resistor is used the drive may give an over-volt 'OV' trip. The minimum level should be greater than the voltage produced on the DC Bus by the highest supply voltage. Normally the DC Bus voltage will be approximately the rms supply line voltage x  $\sqrt{2}$ .

Care should be taken in the setting of this parameter. It is recommended that the setting should be at least 50V higher than the maximum expected level of the DC Bus voltage. If this is not done, the motor may fail to decelerate on a STOP command.

**WARNING**

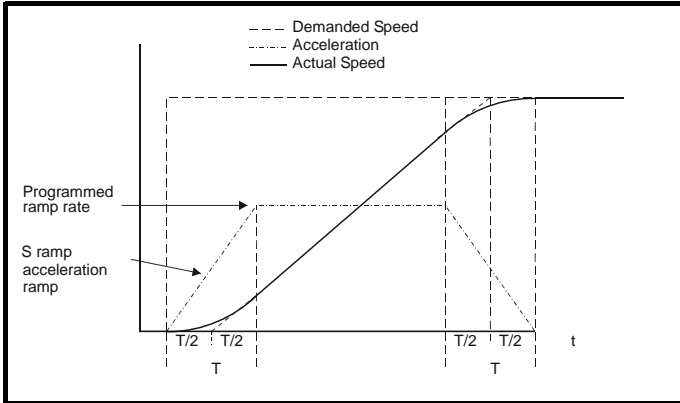
## 11.21.3 S ramps

2.06		S ramp enable	
RW	Bit		US
↕		OFF (0) or On (1)	⇒ OFF (0)

Setting this parameter enables the S ramp function. S ramp is disabled during deceleration using standard ramp. When the motor is accelerated again after decelerating in standard ramp the acceleration ramp used by the S ramp function is reset to zero.

2.07		S ramp acceleration limit	
RW	Uni		US
OL	↕	0.0 to 300.0 s <sup>2</sup> /100Hz	⇒ 3.1
VT		0.000 to 100.000 s <sup>2</sup> /1000rpm	⇒ 1.500
SV			⇒ 0.030

This parameter defines the maximum rate of change of acceleration/ deceleration. The default values have been chosen such that for the default ramps and maximum speed, the curved parts of the S will be 25% of the original ramp if S ramp is enabled.



Since the ramp rate is defined in s/100Hz or s/1000rpm and the S ramp parameter is defined in s<sup>2</sup>/100Hz or s<sup>2</sup>/1000rpm, the time T for the 'curved' part of the S can be determined from:

$$T = S \text{ ramp rate of change} / \text{Ramp rate}$$

Enabling S ramp increases the total ramp time by the period T since an additional T/2 is added to each end of the ramp in producing the S.

### 11.21.4 Torque modes

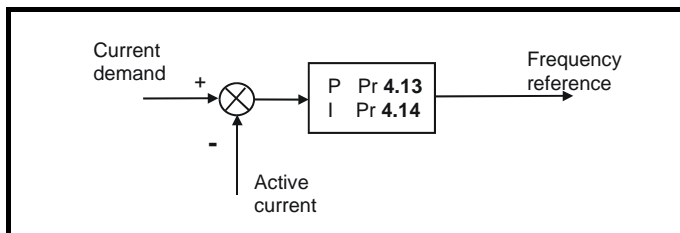
4.08		Torque reference											
RW	Bi											US	
↕		±USER_CURRENT_MAX %										⇒	0.00

Parameter for main torque reference. The normal update rate for the torque reference is 4ms. However if analog inputs 2 or 3 on the drive are used as the source of the reference, the drive is in closed-loop vector or servo mode and the analog inputs are in voltage mode with zero offset, the sample time is reduced to 250µs.

4.11		Torque mode selector											
RW	Uni											US	
OL	↕	0 to 1										⇒	0
CL		0 to 4											

#### Open loop

If this parameter is 0 normal frequency control is used. If this parameter is set to 1 the current demand is connected to the current PI controller giving closed loop torque/current demand as shown below. The current error is passed through proportional and integral terms to give a frequency reference which is limited to the range: -SPEED\_FREQ\_MAX to +SPEED\_FREQ\_MAX.



#### Closed loop vector and Servo

When this parameter is set to 1, 2 or 3 the ramps are not active while the drive is in the run state. When the drive is taken out of the run state, but not disabled, the appropriate stopping mode is used. It is recommended that coast stopping or stopping without ramps are used. However, if ramp stop mode is used the ramp output is pre-loaded with the actual speed at the changeover point to avoid unwanted jumps in the speed reference.

#### 0: Speed control mode

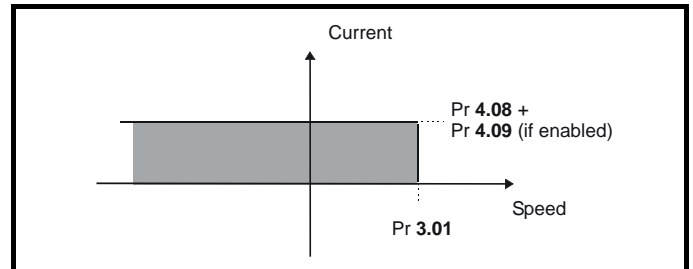
The torque demand is equal to the speed loop output.

#### 1: Torque control

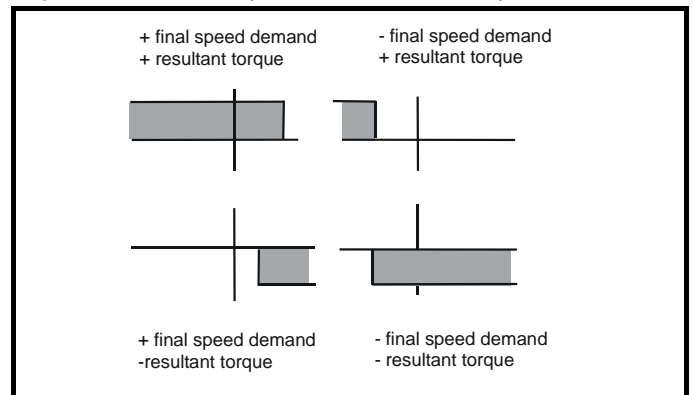
The torque demand is given by the sum of the torque reference and the torque offset, if enabled. The speed is not limited in any way, however, the drive will trip at the overspeed threshold if runaway occurs.

#### 2: Torque control with speed override

The output of the speed loop defines the torque demand, but is limited between 0 and the resultant torque reference (Pr 4.08 and Pr 4.09 (if enabled)). The effect is to produce an operating area as shown below if the final speed demand and the resultant torque reference are both positive. The speed controller will try and accelerate the machine to the final speed demand level with a torque demand defined by the resultant torque reference. However, the speed cannot exceed the reference because the required torque would be negative, and so it would be clamped to zero.



Depending on the sign of the final speed demand and the resultant torque the four areas of operation shown below are possible.



This mode of operation can be used where torque control is required, but the maximum speed must be limited by the drive.

#### 3: Coiler/uncoiler mode

Positive final speed demand:

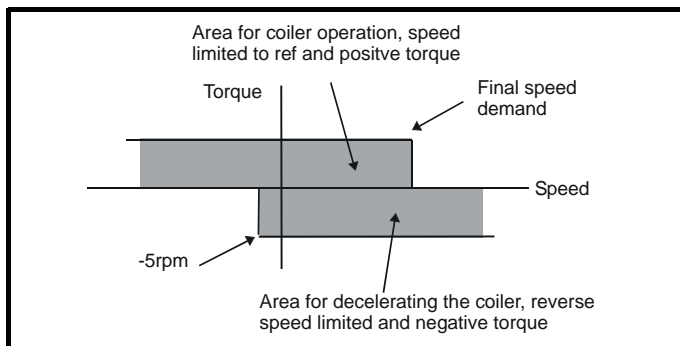
A positive resultant torque will give torque control with a positive speed limit defined by the final speed demand. A negative resultant torque will give torque control with a negative speed limit of -5rpm.

Negative final speed demand:

A negative resultant torque will give torque control with a negative speed limit defined by the final speed demand. A positive resultant torque will give torque control with a positive speed limit of +5rpm.

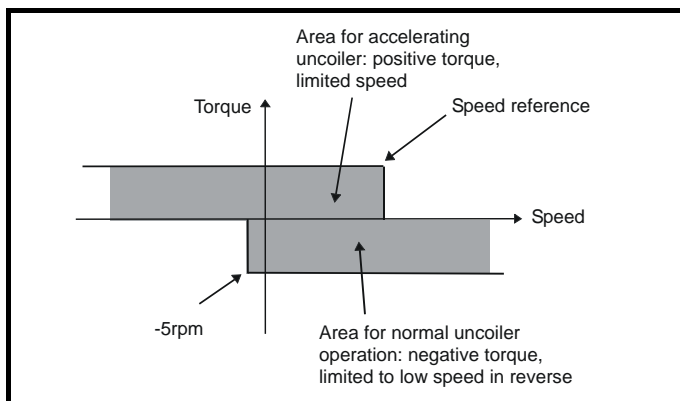
#### Example of coiler operation:

This is an example of a coiler operating in the positive direction. The final speed demand is set to a positive value just above the coiler reference speed. If the resultant torque demand is positive the coiler operates with a limited speed, so that if the material breaks the speed does not exceed a level just above the reference. It is also possible to decelerate the coiler with a negative resultant torque demand. The coiler will decelerate down to -5rpm until a stop is applied. The operating area is shown in the following diagram.



#### Example of uncoiler operation:

This is an example for an uncoiler operating in the positive direction. The final speed demand should be set to a level just above the maximum normal speed. When the resultant torque demand is negative the uncoiler will apply tension and try and rotate at 5rpm in reverse, and so take up any slack. The uncoiler can operate at any positive speed applying tension. If it is necessary to accelerate the uncoiler a positive resultant torque demand is used. The speed will be limited to the final speed demand. The operating area is the same as that for the coiler and is shown below:



#### 4: Speed control with torque feed-forward

The drive operates under speed control, but a torque value may be added to the output of the speed controller. This can be used to improve the regulation of systems where the speed loop gains need to be low for stability.

### 11.21.5 Stop modes

6.01		Stop mode	
RW	Txt		US
OL	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4), diSABLE (5)	⇒	rP (1)
VT	COASt (0), rP (1), no.rP (2)	⇒	no.rP (2)
SV			

#### Open-loop

Stopping is in two distinct phases: decelerating to stop, and stopped.

Stopping Mode	Phase 1	Phase 2	Comments
0: Coast	Inverter disabled	Drive cannot be re-enabled for 1s	Delay in phase 2 allows rotor flux to decay
1: Ramp	Ramp down to zero frequency	Wait for 1s with inverter enabled	
2: Ramp followed by DC injection	Ramp down to zero frequency	Inject DC at level specified by Pr 6.06 for time defined by Pr 6.07	
3: DC injection with zero speed detection	Low frequency current injection with detection of low speed before next phase	Inject DC at level specified by Pr 6.06 for time defined by Pr 6.07	The drive automatically senses low speed and therefore it adjusts the injection time to suit the application. If the injection current level is too small the drive will not sense low speed (normally a minimum of 50-60% is required).
4: Timed DC injection braking stop	Inject DC at level specified by Pr 6.06 for time specified by Pr 6.07		
5: Disable	Inverter disabled		Allows the drive to be immediately disabled and then re-enabled again immediately if required.

Once modes 3 or 4 have begun the drive must go through the ready state before being restarted either by stopping, tripping or being disabled.

If this parameter is set to DISABLE (5), the disable stopping mode is used when the run command is removed. This mode will allow the drive to be started immediately by re-applying the run command. However, if the drive is disabled by removing the drive enable (i.e. via the Enable SAFE TORQUE OFF (SECURE DISABLE) input or Pr 6.15 *Drive enable*) then the drive cannot be re-enabled for 1s.

#### Closed loop vector and Servo

Only one stopping phases exists and the ready state is entered as soon as the single stopping action is complete.

Stopping Mode	Action
0: Coast	Inhibits the inverter
1: Ramp	Stop with ramp
2: No ramp	Stop with no ramp

The motor can be stopped with position orientation after stopping. This mode is selected with the position controller mode parameter (Pr 13.10). When this mode is selected Pr 6.01 has no effect.

6.06		Injection braking level	
RW	Uni	RA	US
OL	⇕	0.0 to 150.0 %	⇒ 100.0

Defines the current level used during DC injection braking as a percentage of motor rated current as defined by Pr 5.07.

<b>6.07</b>		<b>Injection braking time</b>											
RW	Uni												US
OL	↕	0.0 to 25.0 s						⇒	1.0				

Defines the time of injection braking during phase 1 with stopping modes 3 and 4, and during phase 2 with stopping mode 2 (see Pr 6.01).

<b>6.08</b>		<b>Hold zero speed</b>																
RW	Bit												US					
OL		OFF (0) or On (1)						⇒	OFF (0)									
VT	↕							On (1)										
SV																		

When this bit is set the drive remains active even when the run command has been removed and the motor has reached standstill. The drive goes to the 'StoP' state instead of the 'rdy' state.

### 11.21.6 Line power supply loss modes

<b>6.03</b>		<b>Line power supply loss mode</b>											
RW	Txt												US
↕		diS (0), StoP (1), ridE.th (2)						⇒	diS (0)				

#### 0: diS

There is no line power supply loss detection and the drive operates normally only as long as the DC bus voltage remains within specification (i.e. >Vuu). Once the voltage falls below Vuu an under-voltage 'UV' trip occurs. This will reset itself if the voltage rises above Vuu Restart, as stated in the table below.

#### 1: StoP - Open-loop

The action taken by the drive is the same as for ride through mode, except the ramp down rate is at least as fast as the deceleration ramp setting and the drive will continue to decelerate and stop even if the line power supply is re-applied. If normal or timed injection braking is selected the drive will use ramp mode to stop on loss of the supply. If ramp stop followed by injection braking is selected, the drive will ramp to a stop and then attempt to apply dc injection. At this point, unless the line power supply has been restored, the drive is likely to initiate a trip.

#### 1: StoP - Closed-loop vector or Servo

The speed reference is set to zero and the ramps are disabled allowing the drive to decelerate the motor to a stop under current limit. If the Line power supply is re-applied while the motor is stopping any run signal is ignored until the motor has stopped. If the current limit value is set very low level the drive may trip UV before the motor has stopped.

#### 2: ridE.th

The drive detects line power supply loss when the DC Bus voltage falls below Vml<sub>1</sub>. The drive then enters a mode where a closed-loop controller attempts to hold the DC Bus level at Vml<sub>1</sub>. This causes the motor to decelerate at a rate that increases as the speed falls. If the line power supply is re-applied it will force the DC Bus voltage above the detection threshold Vml<sub>3</sub> and the drive will continue to operate normally. The output of the line power supply loss controller is a current demand that is fed into the current control system and therefore the gain Pr 4.13 and Pr 4.14 must be set up for optimum control. See parameters Pr 4.13 and Pr 4.14 for set-up details.

The following table shows the voltage levels used by drives with each voltage rating.

Voltage level	200V drive	400V drive	575V drive	690V drive
Vuu	175	330	435	
Vml <sub>1</sub>	205*	410*	540*	
Vml <sub>2</sub>	Vml <sub>1</sub> - 10V	Vml <sub>1</sub> - 20V	Vml <sub>1</sub> - 25V	
Vml <sub>3</sub>	Vml <sub>1</sub> + 10V	Vml <sub>1</sub> + 15V	Vml <sub>1</sub> + 50V	
Vuu Restart	215	425	590	

\* Vml<sub>1</sub> is defined by Pr 6.48. The values in the table above are the default values.

<b>6.48</b>		<b>Line power supply loss ride through detection level</b>											
RW	Uni											RA	US
↕		0 to DC_VOLTAGE_SET_MAX V						⇒	200V drive: 205 400V drive: 410 575V drive: 540 690V drive: 540				

The line power supply loss detection level can be adjusted using this parameter. If the value is reduced below the default value, the default value is used by the drive. If the level is set too high, so that the line power supply loss detection becomes active under normal operating conditions, the motor will coast to a stop.

<b>4.13</b>		<b>Current loop P gain</b>											
RW	Uni												US
OL	↕	0 to 30,000						⇒	All voltage ratings: 20				
CL	↕							0 to 30,000					⇒

<b>4.14</b>		<b>Current loop I gain</b>											
RW	Uni												US
OL	↕	0 to 30,000						⇒	All voltage ratings: 40				
CL	↕							0 to 30,000					⇒

#### Open-loop

These parameters control the proportional and integral gains of the current controller used in the open loop drive. As already mentioned the current controller either provides current limits or closed loop torque control by modifying the drive output frequency. The control loop is also used in its torque mode during line power supply loss, or when the controlled mode standard ramp is active and the drive is decelerating, to regulate the flow of current into the drive. Although the default settings have been chosen to give suitable gains for less demanding applications it may be necessary for the user to adjust the performance of the controller. The following is a guide to setting the gains for different applications.

#### Current limit operation:

The current limits will normally operate with an integral term only, particularly below the point where field weakening begins. The proportional term is inherent in the loop. The integral term must be increased enough to counter the effect of the ramp which is still active even in current limit. For example, if the drive is operating at constant frequency and is overloaded the current limit system will try to reduce the output frequency to reduce the load. At the same time the ramp will try to increase the frequency back up to the demand level. If the integral gain is increased too far the first signs of instability will occur when operating around the point where field

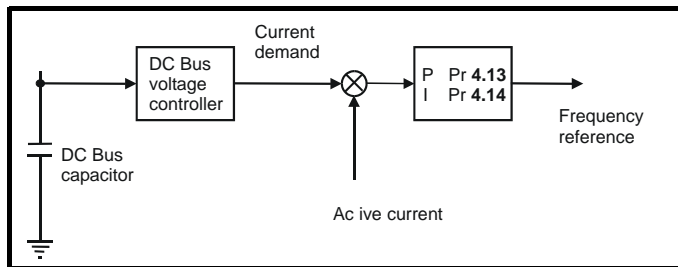
weakening begins. These oscillations can be reduced by increasing the proportional gain. A system has been included to prevent regulation because of the opposite actions of the ramps and the current limit. This can reduce the actual level that the current limit becomes active by 12.5%. This still allows the current to increase up to the current limit set by the user. However the current limit flag (Pr 10.09) could become active up to 12.5% below the current limit depending on the ramp rate used.

#### Torque control:

Again the controller will normally operate with an integral term only, particularly below the point where field weakening begins. The first signs of instability will appear around base speed, and can be reduced by increasing the proportional gain. The controller can be less stable in torque control mode rather than when it is used for current limiting. This is because load helps to stabilise the controller, and under torque control the drive may operate with light load. Under current limit the drive is often under heavy load unless the current limits are set at a low level.

#### Line power supply loss and controlled standard ramp:

The DC bus voltage controller becomes active if line power supply loss detection is enabled and the drive supply is lost or controlled standard ramp is being used and the machine is regenerating. The DC bus controller attempts to hold the DC bus voltage at a fixed level by controlling the flow of current from the drive inverter into its DC bus capacitors. The output of the DC bus controller is a current demand which is fed into the current PI controller as shown in the following diagram.



Although it is not usually necessary the DC bus voltage controller can be adjusted with Pr 5.31. However, it may often be necessary to adjust the current controller gains to obtain the required performance. If the gains are not suitable it is best to set up the drive in torque control first. Set the gains to a value that does not cause instability around the point at which field weakening occurs. Then revert back to open loop speed control in standard ramp mode. To test the controller the supply should be removed while the motor is running. It is likely that the gains can be increased further if required because the DC bus voltage controller has a stabilising effect, provided that the drive is not required to operate in torque control mode.

#### Closed-loop vector and Servo

The Kp and Ki gains are used in the voltage based current controller. The default values give satisfactory operation with most motors. However it may be necessary to change the gains to improve the performance. The proportional gain (Pr 4.13) is the most critical value in controlling the performance. Either the value can be set by auto-tuning (see Pr 5.12) or it can be set by the user so that

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

Where:

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

L is the motor inductance. For a servo motor this is half the phase to phase inductance that is normally specified by the manufacturer. For an induction motor this is the per phase transient inductance ( $\sigma L_s$ ).

This is the inductance value stored in Pr 5.24 after the autotune test

is carried out. If  $\sigma L_s$  cannot be measured it can be calculated from the steady state per-phase equivalent circuit of the motor as follows:

$$\sigma L_s = L_s - \left( \frac{L_m^2}{L_r} \right)$$

$I_{fs}$  is the peak full scale current feedback =  $K_C \times \sqrt{2} / 0.45$ . Where  $K_C$  is defined in Table 11-5.

$V_{fs}$  is the maximum DC Bus voltage.

Therefore:

$$\text{Pr 4.13} = K_p = (L / 167\mu s) \times (K_C \times \sqrt{2} / 0.45 / V_{fs}) \times (256 / 5) \\ = K \times L \times K_C$$

Where:

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

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 at step response with approximately 12.5% overshoot.

Switching frequency kHz	Current control sample time µs	Gain bandwidth Hz	Phase delay µs
3	167	TBA	1160
4	125	TBA	875
6	83	TBA	581
8	125	TBA	625
12	83	TBA	415
16	125	TBA	625

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

$$\text{Pr 4.14} = K_i = K_p \times 256 \times T / \tau_m$$

Where:

$\tau_m$  is the motor time constant (L / R).

R is the per phase stator resistance of the motor (i.e. half the resistance measured between two phases).

Therefore

$$\text{Pr 4.14} = K_i = (K \times L \times K_C) \times 256 \times 167\mu s \times R / L \\ = 0.0427 \times K \times R \times K_C$$

The above equation gives a conservative value of integral gain. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed closed-loop induction motor applications) the integral gain may need to have a significantly higher value.

## 11.21.7 Start / stop logic modes

6.04		Start / stop logic select					
RW	Uni						US
↕		0 to 4				⇒	0

This parameter is provided to allow the user to select several predefined digital input routing macros to control the sequencer. When a value between 0 and 3 is selected the drive processor continuously updates the destination parameters for digital I/O T25, T26 and T27, and the enable sequencer latching bit (Pr 6.40). When a value of 4 is selected the destination parameters for these digital I/O and Pr 6.40 can be modified by the user.

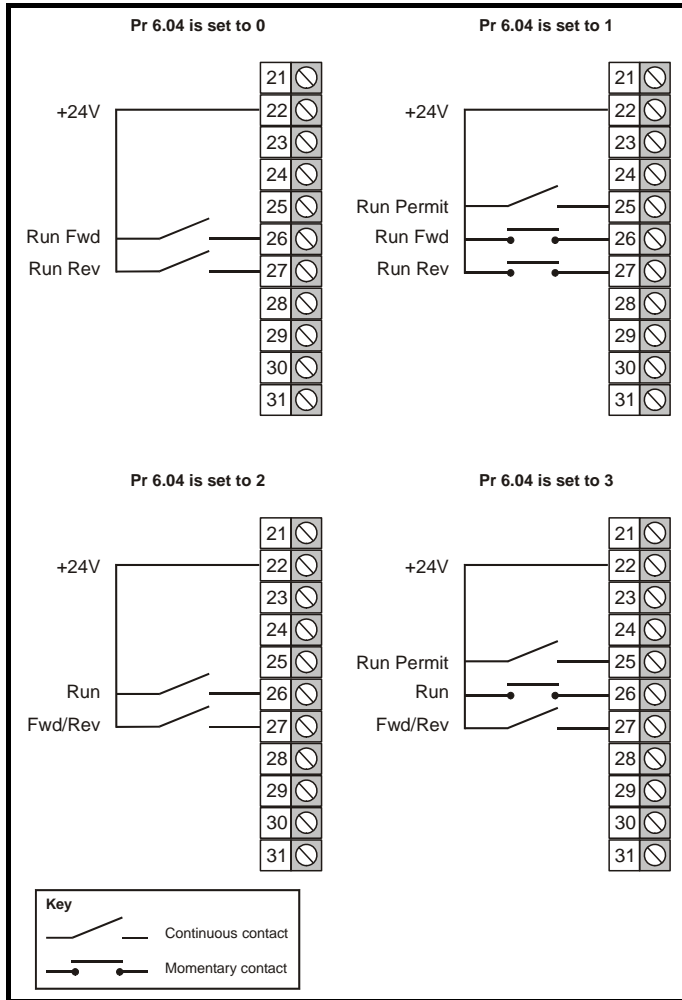
If Pr 6.04 is changed then a drive reset is required before the function of T25, T26 or T27 will become active.

Pr 6.04	T25 (Pr 8.22)	T26 (Pr 8.23)	T27 (Pr 8.24)	Pr 6.40
0	Pr 6.29 (Fast Disable)	Pr 6.30 (Run Forward)	Pr 6.32 (Run Reverse)	0 (Non Latching)
1	Pr 6.39 (Run Permit)	Pr 6.30 (Run Forward)	Pr 6.32 (Run Reverse)	1 (Latching)
2	Pr 6.29 (Fast Disable)	Pr 6.34 (Run)	Pr 6.33 (Fwd/Rev)	0 (Non Latching)
3	Pr 6.39 (Run Permit)	Pr 6.34 (Run)	Pr 6.33 (Fwd/Rev)	1 (Latching)
4	User programmable	User programmable	User programmable	User programmable

If Pr 6.04 has been set to a value of 0 to 3, then setting Pr 6.04 to 4 does not automatically reconfigure terminals T25, T26 and T27 to their default functions. To return terminals T25, T26 and T27 to their default functions, one of the following operations should be performed.

- Drive defaults should be restored. See section 5.8 *Restoring parameter defaults* on page 96 for details.
- Manually set Pr 6.04 to 4, Pr 6.40 to 0, Pr 8.22 to 10.33, Pr 8.23 to 6.30, and Pr 8.24 to 6.32.

Figure 11-37 Digital input connections when Pr 6.04 is set to 0 to 3



6.40		Enable sequencer latching	
RW	Bit		US
↕	OFF (0) or On (1)	⇒	OFF (0)

This parameter enables sequencer latching. When sequencer latching is

used, a digital input must be used as a run permit or not stop input. The digital input should write to Pr 6.39. The run permit or not stop input must be made active to allow the drive to run. Making the run permit or not stop input inactive resets the latch and stops the drive.

### 11.21.8 Catch a spinning motor

6.09		Catch a spinning motor	
RW	Uni		US
OL	↕	0 to 3	0
CL	↕	0 to 1	1

#### Open-loop

When the drive is enabled with this parameter at zero, the output frequency starts at zero and ramps to the required reference. When the drive is enabled with this parameter at a non-zero value, the drive performs a start-up test to determine the motor speed and then sets the initial output frequency to the synchronous frequency of the motor.

The test is not carried out and the motor frequency starts at zero if one of the following is true.

- The run command is given when the drive is in the stop state
- The drive is first enabled after power-up with Ur\_I voltage mode (Pr 5.14 = Ur\_I).
- The run command is given with Ur\_S voltage mode (Pr 5.14 = Ur\_S).

With default parameters the length of the test is approximately 250ms, however, if the motor has a long rotor time constant (usually large motors) it may be necessary to extend the test time. The drive will do this automatically if the motor parameters including the rated load rpm are set up correctly for the motor.

For the test to operate correctly it is important that the stator resistance (Pr 5.17 or Pr 21.12) is set up correctly. This applies even if fixed boost (Pr 5.14 = Fd) or square law (Pr 5.14 = SrE) voltage mode is being used. The test uses the rated magnetising current of the motor during the test, therefore the rated current (Pr 5.07, Pr 21.07 and Pr 5.10, Pr 21.10) and power factor should be set to values close to those of the motor, although these parameters are not as critical as the stator resistance. For larger motors it may be necessary to increase Pr 5.40 *Spin start boost* from its default value of 1.0 for the drive to successfully detect the motor speed.

It should be noted that a stationary lightly loaded motor with low inertia might move slightly during the test. The direction of the movement is undefined. Restrictions may be placed on the direction of this movement and on the frequencies detected by the drive as follows:

Pr 6.09	Function
0	Disabled
1	Detect all frequencies
2	Detect positive frequencies only
3	Detect negative frequencies only

#### Closed-loop vector and Servo

When the drive is enabled with this bit at zero, the post ramp reference (Pr 2.01) starts at zero and ramps to the required reference. When the drive is enabled with this bit at one, the post ramp reference is set to the motor speed.

When closed-loop vector mode is used without position feedback, and catch a spinning motor is not required, this parameter should be set to zero as this avoids unwanted movement of the motor shaft when zero speed is required. When closed-loop vector mode without position feedback is used with larger motors it may be necessary to increase Pr 5.40 *Spin start boost* from its default value of 1.0 for the drive to successfully detect the motor speed.

<b>5.40</b>		<b>Spin start boost</b>											
RW	Uni											US	
OL	VT	↕	0.0 to 10.0					⇒	1.0				

If Pr 6.09 is set to enable the catch a spinning motor function in open-loop mode or closed-loop vector mode without position feedback, (Pr 3.24 = 1 or 3) this parameter defines a scaling function used by the algorithm that detects the speed of the motor. It is likely that for smaller motors the default value of 1.0 is suitable, but for larger motors this parameter may need to be increased. If the value of this parameter is too large the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small the drive will detect the motor speed as zero even if the motor is spinning.

## 11.21.9 Position modes

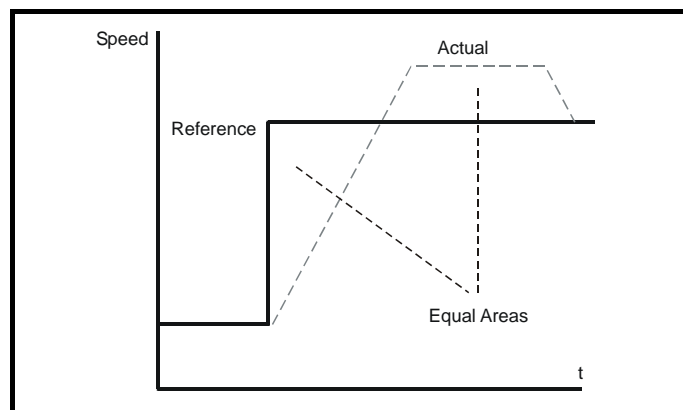
<b>13.10</b>		<b>Position controller mode</b>											
RW	Uni											US	
OL	CL	↕	0 to 2					⇒	0				
			0 to 6										

This parameter is used to set the position controller mode as shown in the table below.

Parameter value	Mode	Feed forward active
0	Position controller disabled	
1	Rigid position control	✓
2	Rigid position control	
3	Non-rigid position control	✓
4	Non-rigid position control	
5	Orientation on stop	
6	Orientation on stop and when drive enabled	

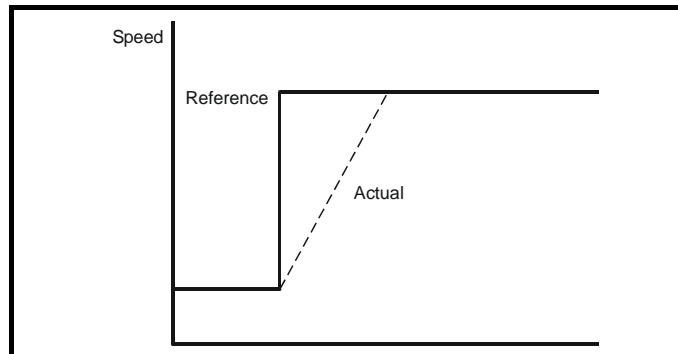
### Rigid position control

In rigid position control the position error is always accumulated. This means that, if for example, the slave shaft is slowed down due to excessive load, the target position will eventually be recovered by running at a higher speed when the load is removed.



### Non-rigid position control

In non-rigid position control the position loop is only active when the 'At Speed' condition is met (see Pr 3.06). This allows slippage to occur while the speed error is high.



### Velocity feed forward

The position controller can generate a velocity feed forwards value from the speed of the reference encoder. The feed-forwards value is passed to menu, and so ramps may be included if required. Because the position controller only has a proportional gain, it is necessary to use velocity feed-forwards to prevent a constant position error that would be proportional to the speed of the reference position.

If for any reason the user wishes to provide the velocity feed forward from a source other than the reference position, the feed forward system can be made inactive, i.e. Pr 13.10 = 2 or 4. The external feed forward can be provided via Menu 1 from any of the frequency/speed references. However, if the feed forward level is not correct a constant position error will exist.

### Relative jogging

If relative jogging is enabled the feedback position can be made to move relative the reference position at the speed defined by Pr 13.17.

### Orientation

If Pr 13.10 is 5 the drive orientates the motor following a stop command. If hold zero speed is enabled (Pr 6.08 = 1) the drive remains in position control when orientation is complete and hold the orientation position. If hold zero speed is not enabled the drive is disabled when orientation is complete.

If Pr 13.10 is 6 the drive orientates the motor following a stop command and whenever the drive is enabled provided that hold zero speed is enabled (Pr 6.08 = 1). This ensures that the spindle is always in the same position following the drive being enabled.

When orientating from a stop command the drive goes through the following sequence:

1. The motor is decelerated or accelerated to the speed limit programmed in Pr 13.12, using ramps if these are enabled, in the direction the motor was previously running.
2. When the ramp output reaches the speed set in Pr 13.12, ramps are disabled and the motor continues to rotate until the position is found to be close to the target position (i.e. within 1/32 of a revolution). At this point the speed demand is set to 0 and the position loop is closed.
3. When the position is within the window defined by Pr 13.14, the orientation complete indication is given in Pr 13.15.

The stop mode selected by Pr 6.01 has no effect if orientation is enabled.



## 11.21.10 Fast Disable

Software V01.10.00 and later

<b>6.29</b>		<b>Hardware enable</b>														
RO	Bit												NC	PT		
↕	OFF (0) or On (1)											⇒				

This bit is a duplicate of Pr **8.09** and reflects the state of the enable input. With software V01.10.00 and later, 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 SAFE TORQUE OFF (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 SAFE TORQUE OFF (SECURE DISABLE) input (T31) there can be a delay of up to 20ms (typically 8ms) before the drive is disabled. 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 an enable signal should be given to both the SAFE TORQUE OFF (SECURE DISABLE) input (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 SAFE TORQUE OFF (SECURE DISABLE) (T31) to enable the drive



**WARNING**

If the safety function of the SAFE TORQUE OFF (SECURE DISABLE) input is required then there must not be a direct connection between the SAFE TORQUE OFF (SECURE DISABLE) input (T31) and any other digital I/O on the drive. If the safety function of the SAFE TORQUE OFF (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 SAFE TORQUE OFF (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 SAFE TORQUE OFF (SECURE DISABLE) input to be forced high, including the case where a component such as a blocking diode has failed.

# 12 Technical Data

## 12.1 Drive technical data

### 12.1.1 Power and current ratings (Derating for switching frequency and temperature)

For a full explanation of 'Normal Duty' and 'Heavy Duty' refer to section 2.1 *Ratings* on page 7.

**Table 12-1 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							
LS	CT	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz		
SPz 1M/TL	SP0201*	0.37	0.5	2.2						0.37	0.5	2.2							
SPz 1 2M/TL	SP0202*	0.55	0.75	3.1						0.55	0.75	3.1							
SPz 1 5M/TL	SP0203*	0.75	1.0	4.0						0.75	1.0	4.0							
SPz 2M/TL	SP0204*	1.1	1.5	5.7						1.1	1.5	5.7							
SPz 2 5M/TL	SP0205*	1.5	2.0	7.5						1.5	2.0	7.5							
SP 1.5TL	SP1201	1.1	1.5	5.2						0.75	1.0	4.3							
SP 2TL	SP1202	1.5	2.0	6.8						1.1	1.5	5.8							
SP 2.5TL	SP1203	2.2	3.0	9.6						1.5	2.0	7.5							
SP 3.5TL	SP1204	3.0	3.0	11.0						2.2	3.0	10.6							
SP 4.5TL	SP2201	4.0	5.0	15.5						3.0	3.0	12.6							
SP 5.5TL	SP2202	5.5	7.5	22.0						4.0	5.0	17.0							
SP 8TL	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		
SP11TL	SP3201	11	15	42.0						7.5	10	31.0							
SP 16TL	SP3202	15	20	54.0				48.5			11	15	42.0				41.3		
SP 22TL	SP4201	18.5	25	68.0						15	20	56.0							
SP 27TL	SP4202	22	30	80.0						18.5	25	68.0							
SP 33TL	SP4203	30	40	104						22	30	80.0							
SP 40TL	SP5201	37	50	130						30	40	105							
SP 50TL	SP5202	45	60	154		143.2				37	50	130		121.7	102.1				
SPz 1T	SP0401*	0.37	0.5	1.3						0.37	0.5	1.3							
SPz 1.2T	SP0402*	0.55	0.75	1.7						0.55	0.75	1.7							
SPz 1.5T	SP0403*	0.75	1.0	2.1						0.75	1.0	2.1							
SPz 2T	SP0404*	1.1	1.5	3.0				2.53			1.1	1.5	3.0				2.53		
SPz 2.5T	SP0405*	1.5	2.0	4.2				3.57		2.53	1.5	2.0	4.2				3.57, 2.53		
SP 1.5T	SP1401	1.1	1.5	2.8						0.75	1.0	2.1							
SP 2T	SP1402	1.5	2.0	3.8						1.1	2.0	3.0							
SP 2.5T	SP1403	2.2	3.0	5.0						1.5	3.0	4.2							
SP 3.5T	SP1404	3.0	5.0	6.9						2.2	3.0	5.8				5.4, 4.3			
SP 4.5T	SP1405	4.0	5.0	8.8				7.4		5.7	3.0	5.0	7.6				5.6, 4.4		
SP 5.5T	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			
SP 8T	SP2401	7.5	10	15.3						5.5	10	13.0				12.6, 9.6, 7.6			
SP 11T	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		
SP 16T	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		
SP 20T	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		
SP 22T	SP3401	18.5	25	35.0						30.3	22.4	17.4	15	25	32.0		30.3	25.3	18.6, 14.5
SP 27T	SP3402	22	30	43.0		39.5		32.8	24.0	18.5	18.5	30	40.0		33.8	28.1	20.5, 15.7		
SP 33T	SP3403	30	40	56.0	48.7	39.5	32.8	24.0		22	30	46.0	41.8	33.8	28.1	20.5			
SP 40T	SP4401	37	50	68.0						62.0		30	50	60.0		51.9	42.4		
SP 50T	SP4402	45	60	83.0		74.0		63.0		37	60	74.0	65.0	51.9	42.4				
SP 60T	SP4403	55	75	104		95.1		78.8		45	75	96.0	83.6	66.6	55.2				
SP 75T	SP5401	75	100	138		118		97.1		55	100	124	106.5	82.4	67.0				
SP 100T	SP5402	90	125	168	158	129	107			75	125	156	137	109	91.0				
SP 120T	SP6401	110	150	205		164.1				90	150	180	174.4	134.5					
SP 150T	SP6402	132	200	236	210.4	157.7				110	150	210	174.8	129.7					
SP 3.5TM	SP3501	3.0	3.0	5.4						2.2	2.0	4.1							
SP 4.5TM	SP3502	4.0	5.0	6.1						3.0	3.0	5.4							
SP 5.5TM	SP3503	5.5	7.5	8.4						4.0	5.0	6.1							
SP 8TM	SP3504	7.5	10	11.0						5.5	7.5	9.5							
SP 11TM	SP3505	11	15	16.0						7.5	10	12.0							
SP 16TM	SP3506	15	20	22.0		21.6		18.2		11	15	18.0				15.5			
SP 22TM	SP3507	18.5	25	27.0	26.0	21.6	18.1			15	20	22.0		18.4	15.5				
SP 22TH	SP4601	18.5	25	22.0						15	20	19.0							
SP 27TH	SP4602	22	30	27.0						18.5	25	22.0							
SP 33TH	SP4603	30	40	36.0				33.9			22	30	27.0						
SP 40TH	SP4604	37	50	43.0		41.3		33.7		30	40	36.0				33.9			
SP 50TH	SP4605	45	60	52.0	51.9	41.2	33.7			37	50	43.0		41.3	33.7				
SP 60TH	SP4606	55	75	62.0	61.3	48.4	39.6			45	60	52.0		44.7	36.5				
SP 75TH	SP5601	75	100	84		69		54		55	75	63		52	41				
SP 100TH	SP5602	90	125	99	91	69	54			75	100	85	69	52	41				
SP 120TH	SP6601	110	150	125	100	74				90	125	100		74					
SP 150TH	SP6602	132	175	144	100	74				110	150	125	100	74					

**NOTE** For the definition of ambient temperature, see section 3.7 *Enclosure design and drive ambient temperature* on page 39.

\*See SPz and SP2404 power and current ratings on page 243.

**Table 12-2 Maximum permissible continuous output current @ 40°C (104°F) ambient with IP54 insert and standard fan installed**

Model		Normal Duty						Heavy Duty					
		Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP 1.5TL	SP1201	5.2						4.3					
SP 2TL	SP1202	6.8						5.8					
SP 2.5TL	SP1203	9.6			9.3	8.2	7.3	7.5					7.3
SP 3.5TL	SP1204	11.0	10.6	9.7	9.0	7.7	6.6	10.6	10.5	9.7	9.0	7.7	6.6
SP 4.5TL	SP2201	15.5						12.6					
SP 5.5TL	SP2202	22.0			20.7	18.0	15.7	17.0					15.5
SP 8TL	SP2203	24.5	23.7	22.0	20.5	17.9	15.6	24.2	23.4	21.8	20.3	17.7	15.5
SP 1.5T	SP1401	2.8						2.1					
SP 2T	SP1402	3.8					2.9	3.0					2.9
SP 2.5T	SP1403	5.0				3.9	2.9	4.2				3.9	2.9
SP 3.5T	SP1404	6.9		6.5	5.4	3.9	2.9	5.8			5.4	3.9	2.9
SP 4.5T	SP1405	8.3	7.3	5.8	4.7	3.2	2.3	7.6	7.3	5.8	4.7	3.2	2.3
SP 5.5T	SP1406	8.3	7.3	5.8	4.7	3.2	2.3	8.2	7.3	5.8	4.7	3.2	2.3
SP 8T	SP2401	15.3			13.3	10.1	7.9	13.0			12.6	9.4	7.3
SP 11T	SP2402	20.1	18.4	15.6	13.4	10.1	7.9	16.5		14.9	12.3	9.3	7.2
SP 16T	SP2403	21.7	19.7	16.4	13.9	10.2	7.7	21.6	19.6	16.4	13.8	10.2	7.7
SP 20T	SP2404*	20.1	17.7	14.0	11.2	7.3	4.6	20.1	17.7	14.0	11.2	7.3	4.6

**NOTE**

For the definition of ambient temperature, see section 3.7 *Enclosure design and drive ambient temperature* on page 39.

**SPz and SP2404 power and current ratings**

All drive models are dual rated except for SPz and model SP2404 which only have a Heavy Duty rating. However, if the current limits in **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 12-1, Table 12-2 and Table 12-3. Normal Duty ratings exist for the SPz and 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 12-3 Maximum permissible continuous output current @ 50°C (122°F) ambient**

Model		Normal Duty						Heavy Duty												
		Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies												
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz							
SPz 1M/TL	SP0201*	2.2						2.2												
SPz 1.2M/TL	SP0202*	3.1						3.1												
SPz 1.5M/TL	SP0203*	4.0						4.0												
SPz 2M/TL	SP0204*	5.7						5.7												
SPz 2.5M/TL	SP0205*	7.5				6.6		7.5				6.6								
SP 1.5TL	SP1201	5.2						4.3												
SP 2TL	SP1202	6.8						5.8												
SP 2.5TL	SP1203	9.6				9.0		7.5												
SP 3.5TL	SP1204	11.0			10.9		9.5		8.3			10.6		9.5		8.3				
SP 4.5TL	SP2201	15.5				13.5		11.5		12.6				11.4						
SP 5.5TL	SP2202	19.7	18.9	17.3	15.9	13.5	11.5	17.0			15.7	13.4	11.4							
SP 8TL	SP2203	19.5	18.6	17.2	15.8	13.4	11.5	19.2	18.4	17.0	15.7	13.3	11.4							
SP11TL	SP3201	42.0				38.2		31.0												
SP 16TL	SP3202	54.0		52.8		47.0		38.2			37.2									
SP 22TL	SP4201	68.0						56.0												
SP 27TL	SP4202	80.0						68.0												
SP 33TL	SP4203	87.4						80.0												
SP 40TL	SP5201	130.0						105.0						96.1						
SP 50TL	SP5202	143.0			129.2			130.0			110.1		92.3							
SPz 1T	SP0401*	1.3						1.3						1.28						
SPz 1.2T	SP0402*	1.7						1.7						1.61						
SPz 1.5T	SP0403*	2.1						2.1						1.91						
SPz 2T	SP0404*	3.0				2.08		3.0				2.08								
SPz 2.5T	SP0405*	4.2			3.02		2.08		4.2			3.02		2.08						
SP 1.5T	SP1401	2.8						2.1												
SP 2T	SP1402	3.8						3.0												
SP 2.5T	SP1403	5.0				3.9		4.2						3.8						
SP 3.5T	SP1404	6.9			5.1		3.9		5.8			4.8		3.7						
SP 4.5T	SP1405	8.8		7.3		6.0		4.2		3.1		7.6			7.2		6.0	4.2	3.1	
SP 5.5T	SP1406	10.1	9.0	7.3	6.0	4.2	3.1	9.5	9.0	7.2	6.0	4.2	3.1							
SP 8T	SP2401	15.3	14.2	11.8	10.0	7.3	5.5	13.0		11.7	9.9	7.3	5.5							
SP 11T	SP2402	15.7	14.2	11.8	10.0	7.3	5.5	15.5	14.1	11.7	9.9	7.3	5.5							
SP 16T	SP2403	16.8	15.0	12.2	10.1	7.1		16.7	15.0	12.2	10.1	7.1	5.1							
SP 20T	SP2404*	22.3	19.8	15.8	12.8	8.6	5.9	22.3	19.8	14.0	11.2	7.3	4.6							
SP 22T	SP3401	35.0		31.0		25.8		18.7		14.2		32.0			27.4		22.8		16.7	12.9
SP 27T	SP3402	43.0	39.5	31.6	26.0	18.5	13.8	40.0	37.9	30.1	25.0	17.6	12.5							
SP 33T	SP3403	44.5	39.5	31.6	26.0	18.5		42.8	37.9	30.0	24.7	18.1								
SP 40T	SP4401	68.0		66.8		54.9		60.0				46.7		38.3						
SP 50T	SP4402	83.0	81.6	66.8	54.9			68.2	60.0	46.7	38.3									
SP 60T	SP4403	86.5	86.2	71.3	59.3			86.5	74.7	60.1	49.8									
SP 75T	SP5401	138		105.9		87.4		112.7		96.4		74.5		59.9						
SP 100T	SP5402	141	140	112	92			140	123	99.0	82.0									
SP 120T	SP6401	191.5	190.1	147.6				180	157.9	121.5										
SP 150T	SP6402	198.4	180.6	138.1				190	157.9	116.2										
SP 3.5TM	SP3501	5.4						4.1												
SP 4.5TM	SP3502	6.1						5.4												
SP 5.5TM	SP3503	8.4						6.1												
SP 8TM	SP3504	11.0						9.5												
SP 11TM	SP3505	16.0			14.7		12.0													
SP 16TM	SP3506	22.0		17.8		14.7		18.0			16.8		13.9							
SP 22TM	SP3507	24.6	22.0	17.8	14.7	22.0						20.4		16.7	13.9					
SP 22TH	SP4601	22.0						19.0												
SP 27TH	SP4602	27.0			24.7			22.0												
SP 33TH	SP4603	36.0		30.7		24.7		27.0												
SP 40TH	SP4604	43.0	39.6	30.7	24.7	36.0						30.7		24.7						
SP 50TH	SP4605	45.6	39.5	30.7	24.7	43.0			39.6		30.7		24.7							
SP 60TH	SP4606	51.9	44.9	34.7	27.7	51.9			44.9		34.7		27.7							
SP 75TH	SP5601	83	69	51	40	63				47		38								
SP 100TH	SP5602	83	69	51	40	75		62		45		36								
SP 120TH	SP6601	98	81	59		98		81		59										
SP 150TH	SP6602	98	81	59		98		81		59										

**NOTE**

For the definition of ambient temperature, see section 3.7 *Enclosure design and drive ambient temperature* on page 39.  
 \*See *SPz and SP2404 power and current ratings* on page 243.

## 12.1.2 Power dissipation

Table 12-4 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	8kHz	12kHz	16kHz	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	
LS	CT	kW	hp							kW	hp							
SPz 1M/TL	SP0201	0.37	0.5	60			70			0.37	0.5	60			70			
SPz 1.2M/TL	SP0202	0.55	0.75	60		70			80		0.55	0.75	60		70		80	
SPz 1.5M/TL	SP0203	0.75	1.0	70			80			90		70		80			90	
SPz 2M/TL	SP0204	1.1	1.5	90			100			110		90		100			110	
SPz 2.5M/TL	SP0205	1.5	2.0	100			110		120		130		100		110		120	130
SP 1.5TL	SP1201	1.1	1.5	73	75	78	82	89	96	0.75	1	67	69	72	75	81	87	
SP 2TL	SP1202	1.5	2.0	85	87	91	96	104	113	1.1	1.5	78	80	83	87	95	102	
SP 2.5TL	SP1203	2.2	3.0	107	110	116	121	132	144	1.5	2.0	91	93	98	102	111	121	
SP 3.5TL	SP1204	3.0	3.0	118	122	129	137	153	169	2.2	3.0	115	118	126	134	149	164	
SP 4.5TL	SP2201	4.0	5.0	155	161	173	186	210	235	3.0	3.0	133	139	150	160	182	203	
SP 5.5TL	SP2202	5.5	7.5	210	218	234	250	282	314	4.0	5.0	170	176	190	203	229	256	
SP 8TL	SP2203	7.5	10	272	282	302	320		315	5.5	7.5	245	254	263	261	259	258	
SP11TL	SP3201	11	15	331	347	380	412	477		7.5	10	260	272	297	321	370		
SP 16TL	SP3202	15	20	431	451	492	532	551		11	15	349	365	398	430	486		
SP 22TL	SP4201	18.5	25	517	541	589	637			15	20	428	448	488	528			
SP 27TL	SP4202	22	30	611	639	694	750			18.5	25	517	541	589	637			
SP 33TL	SP4203	30	40	810	845	916	987			22	30	611	639	694	750			
SP 40TL	SP5201	37	50	1250	1340	1540	1730			30	40	1000	1080	1240	1400			
SP 50TL	SP5202	45	60	1500	1620	1840	1910			37	50	1250	1340	1440	1360			
SPz 1T	SP0401	0.37	0.5	50		60		70		0.37	0.5	50		60		70		
SPz 1.2T	SP0402	0.55	0.75	50	60			70	80	0.55	0.75	50	60			70	80	
SPz 1.5T	SP0403	0.75	1.0	60		70		80	90	0.75	1.0	60		70		80	90	
SPz 2T	SP0404	1.1	1.5	70			80	90	110	120	1.1	1.5	70		80	90	110	120
SPz 2.5T	SP0405	1.5	2.0	80	90	100	110	120		1.5	2.0	80	90	100	110	120		
SP 1.5T	SP1401	1.1	1.5	66	69	77	85	101	116	0.75	1.0	60	64	70	77	91	104	
SP 2T	SP1402	1.5	2.0	74	78	88	97	116	135	1.1	2.0	67	71	79	88	104	120	
SP 2.5T	SP1403	2.2	3.0	84	90	101	112	135	157	1.5	3.0	77	82	92	102	122	142	
SP 3.5T	SP1404	3.0	5.0	102	109	123	137	166	174	2.2	3.0	92	98	110	123	141	144	
SP 4.5T	SP1405	4.0	5.0	123	134	157	179	196	197	3.0	5.0	112	122	141	161	163	165	
SP 5.5T	SP1406	5.5	7.5	146	160	187	198	196	197	4.0	5.0	131	143	163		165		
SP 8T	SP2401	7.5	10	186	202	234	266	283	282	5.5	10	164	178	206	229		231	
SP 11T	SP2402	11	15	248	269	291	286	283	281	7.5	10	201	218	230	229		231	
SP 16T	SP2403	15	20	313	320			315		316	11	20	272	282	279	278	279	282
SP 20T	SP2404	15	20	311	343	376				15	20	311	308	301	299	302	284	
SP 22T	SP3401	18.5	25	384	420	490	489	471	462	15	25	356	388	431	418	406	402	
SP 27T	SP3402	22	30	461	503	541	521	500	491	18.5	30	433	473	470	455	441	435	
SP 33T	SP3403	30	40	583	563	535	517	498		22	30	500	494	470	455	441		
SP 40T	SP4401	37	50	714	781	914	956			30	50	629	689	704	674			
SP 50T	SP4402	45	60	882	961	995	970			37	60	780	745	704	674			
SP 60T	SP4403	55	75	1070	1158	1217	1144			45	75	976	920	854	821			
SP 75T	SP5401	75	100	1471	1618	1640	1560			55	100	1311	1236	1150	1112			
SP 100T	SP5402	90	125	1830	1881	1781	1717			75	125	1681	1600	1508	1464			
SP 120T	SP6401	110	150	2058	2259	2153				90	150	1817	1935	1772				
SP 150T	SP6402	132	200	2477	2455	2255				110	200	2192	2042	1888				
SP 3.5TM	SP3501	3.0	3.0	127	141	168	196			2.2	2.0	112	124	148	172			
SP 4.5TM	SP3502	4.0	5.0	135	150	180	209			3.0	3.0	127	141	168	196			
SP 5.5TM	SP3503	5.5	7.5	163	181	218	254			4.0	5.0	135	150	180	209			
SP 8TM	SP3504	7.5	10	197	219	263	306			5.5	7.5	178	198	237	276			
SP 11TM	SP3505	11	15	267	296	354	412			7.5	10	212	235	281	328			
SP 16TM	SP3506	15	20	362	399	475	471			11	15	300	332	396	405			
SP 22TM	SP3507	18.5	25	448	486	477	471			15	20	365	403	406	405			
SP 22TH	SP4601	18.5	25	409	470	590	711			15	20	360	413	519	625			
SP 27TH	SP4602	22	30	496	568	712	857			18.5	25	409	470	590	711			
SP 33TH	SP4603	30	40	660	754	941	1063			22	30	496	568	712	857			
SP 40TH	SP4604	37	50	798	908	1083	1058			30	40	660	754	941	1063			
SP 50TH	SP4605	45	60	985	1115	1080	1058			37	50	798	908	1083	1058			
SP 60TH	SP4606	55	75	1060	1179	1130	1105			45	60	873	987	1042	1023			
SP 75TH	SP5601	75	100	1818	2129	2258	2203			55	75	1345	1585	1763	1757			
SP 100TH	SP5602	90	125	2176	2320	2215	2189			75	100	1792	1744	1714	1706			
SP 120TH	SP6601	110	150	2573	2512	2438				90	125	2573	2512	2438				
SP 150TH	SP6602	132	175	3106	2512	2438				110	150	3106	2512	2438				

**Table 12-5 Losses @ 40°C (104°F) ambient with IP54 insert and standard fan installed**

Model		Drive losses (W) taking into consideration any current derating for the given conditions												
		Normal Duty						Heavy Duty						
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	
SP 1.5TL	SP1201	73	75	78	82	89	96	67	69	72	75	81	87	
SP 2TL	SP1202	85	87	91	96	104	113	78	80	83	87	95	102	
SP 2.5TL	SP1203	107	110	116	118			91	93	98	102	111	118	
SP 3.5TL	SP1204	118						115	118					
SP 4.5TL	SP2201	155	161	173	186	210	235	133	139	150	160	182	203	
SP 5.5TL	SP2202	210	218	234	237			170	176	190	203	229	237	
SP 8TL	SP2203	237						237						
SP 1.5T	SP1401	66	69	77	85	101	116	60	64	70	77	91	104	
SP 2T	SP1402	74	78	88	97	116	118	67	71	79	88	104	118	
SP 2.5T	SP1403	84	90	101	112	118		77	82	92	102	118		
SP 3.5T	SP1404	102	109	118				92	98	110	118			
SP 4.5T	SP1405	118						112	118					
SP 5.5T	SP1406	118						118						
SP 8T	SP2401	186	202	234	237			164	178	206	229	226		
SP 11T	SP2402	237						201	218	230	224		223	
SP 16T	SP2403	237						237						
SP 20T	SP2404	225					220	225						220

**Table 12-6 Losses @ 50°C (122°F) ambient**

Model		Drive losses (W) taking into consideration any current derating for the given conditions											
		Normal Duty						Heavy Duty					
		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SPz 1M/TL	SP0201	60			70			60			70		
SPz 1.2M/TL	SP0202	60		70		80		60		70		80	
SPz 1.5M/TL	SP0203	70			80			70			80		
SPz 2M/TL	SP0204	90				100		110		90			
SPz 2.5M/TL	SP0205	100			110			120			100		
SP 1.5TL	SP1201	73	75	78	82	89	96	67	69	72	75	81	87
SP 2TL	SP1202	85	87	91	96	104	113	78	80	83	87	95	102
SP 2.5TL	SP1203	107	110	116	121	132	137	91	93	98	102	111	121
SP 3.5TL	SP1204	118	122	129	137			115	118	126	134	137	
SP 4.5TL	SP2201	155	161	173	186	190		133	139	150	160	182	190
SP 5.5TL	SP2202	190						170	176	190			
SP 8TL	SP2203	190						190					
SP11TL	SP3201	331	347	380	412	436		260	272	297	321	370	
SP 16TL	SP3202	431	451	480	463	439		349	365	398	430	439	
SP 22TL	SP4201	517	541	589	637			428	448	488	528		
SP 27TL	SP4202	611	639	694	750			517	541	589	637		
SP 33TL	SP4203	671	701	761	821			611	639	694	750		
SP 40TL	SP5201	1250	1340	1540	1730			1000	1080	1240	1290		
SP 50TL	SP5202	1380	1490	1700	1720			1250	1340	1300	1240		
SPz 1T	SP0401	50		60		70		50		60		70	
SPz 1.2T	SP0402	50	60			70	80	50	60			70	80
SPz 1.5T	SP0403	60		70		80	90	60		70		80	
SPz 2T	SP0404	70		80	90	110		70		80	90	110	
SPz 2.5T	SP0405	80	90	100	110			80	90	100	110		
SP 1.5T	SP1401	66	69	97	85	101	116	60	64	70	77	91	104
SP 2T	SP1402	74	78	88	97	116	135	67	71	79	88	104	120
SP 2.5T	SP1403	84	90	101	112	135	137	77	82	92	102	122	135
SP 3.5T	SP1404	102	109	123	137			92	98	110	123	132	
SP 4.5T	SP1405	123	134	137				112	122	137			
SP 5.5T	SP1406	137				137			131	137			
SP 8T	SP2401	186	190			190			164	178	190		
SP 11T	SP2402	190						190					
SP 16T	SP2403	190						190					
SP 20T	SP2404	245						245					
SP 22T	SP3401	384	420	437	423	407	396	356	388	393	382	372	369
SP 27T	SP3402	461	462	439	424	406	396	433	448	423	412	392	372
SP 33T	SP3403	470	456	436	422	405		464	448	422	408	400	
SP 40T	SP4401	714	781	898	852			629	689	638	617		
SP 50T	SP4402	882	944	898	852			716	689	638	617		
SP 60T	SP4403	877	949	912	875			876	820	775	750		
SP 75T	SP5401	1471	1616	1462	1411			1186	1118	1047	1009		
SP 100T	SP5402	1500	1644	1543	1480			1500	1434	1366	1333		
SP 120T	SP6401	1942	2118	1939				1817	1747	1610			
SP 150T	SP6402	2068	2108	1997				1979	1851	1715			
SP 3.5TM	SP3501	127	141	168	196			112	124	148	172		
SP 4.5TM	SP3502	135	150	180	209			127	141	168	196		
SP 5.5TM	SP3503	163	181	218	254			135	150	180	209		
SP 8TM	SP3504	197	219	263	306			178	198	237	276		
SP 11TM	SP3505	267	296	354	383			212	235	281	328		
SP 16TM	SP3506	362	399	390	384			300	332	372	369		
SP 22TM	SP3507	405	399	390	384			365	374	369			
SP 22TH	SP4601	409	470	590	711			360	413	519	625		
SP 27TH	SP4602	496	568	712	789			409	470	590	711		
SP 33TH	SP4603	660	754	805	789			496	568	712	789		
SP 40TH	SP4604	798	831	805	789			660	754	805	789		
SP 50TH	SP4605	850	831	805	789			798	831	805	789		
SP 60TH	SP4606	871	848	816	797			871	848	816	797		
SP 75TH	SP5601	1785	1743	1689	1657			1345	1585	1763	1757		
SP 100TH	SP5602	1785	1743	1689	1657			1609	1557	1502	1504		
SP 120TH	SP6601	2084	2036	1978				2084	2036	1978			
SP 150TH	SP6602	2084	2036	1978				2084	2036	1978			

**Table 12-7 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

### 12.1.3 Supply requirements

Voltage:

- SPX2XX (M/TL) 200V to 240V ±10%
- SPX4XX (T) 380V to 480V ±10%
- SPX5XX (TM) 500V to 575V ±10%
- SPX6XX (TH) 500V to 690V ±10%

Number of phases: 3\*

\* 200V SPz drives can also be used on a single phase supply.

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

Frequency range: 48 to 65 Hz

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

#### Size 6 heatsink fan supply requirements

- Nominal voltage: 24V
- Minimum voltage: 23.5V
- Maximum voltage: 27V
- Current drawn: 3.3A
- Recommended power supply: 24V, 100W, 4.5A
- Recommended fuse: 4A fast blow ( $I^2t$  less than 20A<sup>2</sup>s)

### 12.1.4 Line reactors

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

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

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

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

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

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

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

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

- SPz 1M/TL to 2.5M/TL
- SPz 1T to 2.5T
- 1.5TL to 3.5TL
- 1.5T to 2T

Model sizes 4.5T to 60TH have an internal DC choke and 40TL to 150TH have internal AC line chokes, so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

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

### Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

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

### 12.1.5 Motor requirements

No. of phases: 3

Maximum voltage:

- Unidrive SP (200V): 240V
- Unidrive SP (400V): 480V
- Unidrive SP (575V): 575V
- Unidrive SP (690V): 690V

### 12.1.6 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)

### 12.1.7 Storage

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

### 12.1.8 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%.

### 12.1.9 IP / UL Rating

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 Figure 3-4 and Figure 3-5 on page 24. 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 installed 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 section 12.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 242 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 Table 12-8.



**Table 12-8 IP Rating degrees of protection**

First digit	Second digit
Protection against contact and ingress of foreign bodies	Protection against ingress of water
0 No protection	0 No protection
1 Protection against large foreign bodies $\phi > 50\text{mm}$ (large area contact with the hand)	1 Protection against vertically falling drops of water
2 Protection against medium size foreign bodies $\phi > 12\text{mm}$ (finger)	2 Protection against spraywater (up to $15^\circ$ from the vertical)
3 Protection against small foreign bodies $\phi > 2.5\text{mm}$ (tools, wires)	3 Protection against spraywater (up to $60^\circ$ from the vertical)
4 Protection against granular foreign bodies $\phi > 1\text{mm}$ (tools, wires)	4 Protection against splashwater (from all directions)
5 Protection against dust deposit, complete protection against accidental contact.	5 Protection against heavy splash water (from all directions, at high pressure)
6 Protection against dust ingress, complete protection against accidental contact.	6 Protection against deckwater (e.g. in heavy seas)
7 -	7 Protection against immersion
8 -	8 Protection against submersion

**Table 12-9 UL enclosure ratings**

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

### 12.1.10 Corrosive gasses

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

- Table A2 of EN 50178
- Class 3C2 of IEC 60721-3-3

This corresponds to the levels typical of urban areas with industrial activities and/or heavy traffic, but not in the immediate neighbourhood of industrial sources with chemical emissions.

### 12.1.11 RoHS compliance

Unidrive SP SPz meets EU directive 2002-95-EC for RoHS compliance.

### 12.1.12 Vibration

Maximum recommended continuous vibration level 0.14 g r.m.s. broad-band 5 to 200 Hz.

#### NOTE

This is the limit for broad-band (random) vibration. Narrow-band vibration at this level which coincides with a structural resonance could result in premature failure.

#### Bump Test

Testing in each of three mutually perpendicular axes in turn.

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

Severity: 18g (size 1 to 3), 6ms, half sine

10g (size 4 to 6), 6ms, half sine

No. of Bumps: 600 (100 in each direction of each axis)

#### Random Vibration Test

Testing in each of three mutually perpendicular axes in turn.

Referenced standard: IEC 60068-2-64: Test Fh:

Severity:  $1.0 \text{ m}^2/\text{s}^3$  ( $0.01 \text{ g}^2/\text{Hz}$ ) ASD from 5 to 20 Hz

-3 dB/octave from 20 to 200 Hz

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

### Sinusoidal Vibration Test

Testing in each of three mutually perpendicular axes in turn.

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

Frequency range: 5 to 500 Hz

Severity: 3.5 mm peak displacement from 5 to 9 Hz

10  $\text{m/s}^2$  peak acceleration from 9 to 200 Hz

15  $\text{m/s}^2$  peak acceleration from 200 to 500 Hz

Sweep rate: 1 octave/minute

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

### 12.1.13 Starts per hour

By electronic control: unlimited

By interrupting the AC supply:  $\leq 20$  (equally spaced)

### 12.1.14 Start up time

This is the time taken from the moment of applying power to the drive, to the drive being ready to run the motor:

SPz and sizes 1 to 6: 4s

### 12.1.15 Output frequency / speed range

Open-loop frequency range: 0 to 3,000Hz

Closed-loop speed range: 0 to 40,000rpm

Closed-loop frequency range: 0 to 1,250Hz\*

\*(Limit to ~600Hz for good performance)

### 12.1.16 Accuracy and resolution

#### Speed:

The absolute frequency and speed accuracy depends on the accuracy of the crystal used with the drive microprocessor. The accuracy of the crystal is 100ppm, and so the absolute frequency/speed accuracy is 100ppm (0.01%) of the reference, when a preset speed is used. If an analog input is used the absolute accuracy is further limited by the absolute accuracy of the analog input.

The following data applies to the drive only; it does not include the performance of the source of the control signals.

Open loop resolution:

Preset frequency reference: 0.1Hz

Precision frequency reference: 0.001Hz

Closed loop resolution

Preset speed reference: 0.1rpm

Precision speed reference: 0.001rpm

Analog input 1: 16bit plus sign

Analog input 2: 10bit plus sign

#### Current:

The resolution of the current feedback is 10bit plus sign. The typical accuracy of the current feedback is 2%.

### 12.1.17 Acoustic noise

The heatsink fan generates the majority of the acoustic noise produced by the drive. The heatsink fan on SPz and sizes 1 and 2 is a dual speed fan and on size 3 to 6 it is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. On size 4 to 6 the minimum speed of the heatsink fan is 0 rpm. The size 3 to 6 is also installed with a variable speed fan to ventilate the capacitor bank.

Table 12-10 gives the acoustic noise produced by the drive for the heatsink fan running at the maximum and minimum speeds.

**Table 12-10 Acoustic noise data**

Size	< Date code M38		≥ Date code M38	
	Max speed dBA	Min speed dBA	Max speed dBA	Min speed dBA
SPz			65	53
1	48	41	48	28
2	54	45	54	35
3	56	43	56	43
4			53	
5			72	
6			72	

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 12-13.

**Table 12-13 Supply fault current used to calculate maximum input currents**

Model	Symmetrical fault level (kA)
All	100

### 12.1.18 Overall dimensions

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

**Table 12-11 Overall drive dimensions**

Size	Dimension				
	H	W	D	F	R
SPz	322mm (12.677in)	62mm (2.441in)	226mm (8.898in)		
1	386mm (15.197in)	100mm (3.937in)	219mm (8.622in)	139mm (5.472in)	≤80mm (3.150in)
2	389mm (15.315in)	155mm (6.102in)	260mm (10.236in)	140mm (5.512in)	≤120mm (4.724in)
3		250mm (9.843in)			
4	547mm (21.528in)	310mm (12.205in)	298mm (11.732in)	200mm (7.874in)	≤98mm (3.858in)
5	858mm (33.752in)				
6	1169mm (46.016in)				

### 12.1.19 Weights

**Table 12-12 Overall drive weights**

Size	Model	kg	lb
SPz	All	2.1	4.6
1	1.5TL to 3.5TL, 1.5T to 3.5T	5	11.0
	4.5T & 5.5T	5.8	12.8
2	All	7	15.4
3	All	15	33.1
4	All	30	66.1
5	All	55	121.3
6	All	75	165.3

### 12.1.20 Input current, fuse and cable size ratings

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

#### Typical input current

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

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

#### Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance.

**Table 12-14 SPz and size 1 to 3 input current, fuse and cable size ratings**

Model		Typical input current	Maximum continuous input current	European cable size EN60204			USA cable size UL508C		
				Fuse rating IEC gG	Input	Output	Fuse rating Class CC or J** <30A Class J >30A	Input	Output
LS	CT	A	A	A	mm <sup>2</sup>	mm <sup>2</sup>	A	AWG	AWG
SPz 1M/TL	SP0201	3.2 (5.0)*	3.6 (5.0)*	6	0.75	0.75	10	16	24
SPz 1.2M/TL	SP0202	4.8 (7.6)*	5.6 (7.6)*	10	1	0.75	10	16	22
SPz 1.5M/TL	SP0203	6.0 (9.6)*	6.9 (9.6)*	12	1.5	0.75	16	14	20
SPz 2M/TL	SP0204	7.9 (13.5)*	8.9 (13.5)*	16	2.5	0.75	20	12	18
SPz 2.5M/TL	SP0205	10.6 (17.4)*	12.3 (17.4)*	20	4	0.75	20	12	18
SP 1.5TL	SP1201	7.1	9.5	10	1.5	1.0	10	14	18
SP 2TL	SP1202	9.2	11.3	12	1.5	1.0	15	14	16
SP 2.5TL	SP1203	12.5	16.4	20	4.0	1.0	20	12	14
SP 3.5TL	SP1204	15.4	19.1	20	4.0	1.5	20	12	14
SP 4.5TL	SP2201	13.4	18.1	20	4.0	2.5	20	12	14
SP 5.5TL	SP2202	18.2	22.6	25	4.0	4.0	25	10	10
SP 8TL	SP2203	24.2	28.3	32	6.0	6.0	30	8	8
SP11TL	SP3201	35.4	43.1	50	16	16	45	6	6
SP 16TL	SP3202	46.8	54.3	63	25	25	60	4	4
SPz 1T	SP0401	2.0	2.3	4	0.75	0.75	10	16	24
SPz 1.2T	SP0402	2.6	2.8	4	0.75	0.75	10	16	24
SPz 1.5T	SP0403	3.2	3.3	6	0.75	0.75	10	16	24
SPz 2T	SP0404	4.3	4.4	6	0.75	0.75	10	16	22
SPz 2.5T	SP0405	5.6	5.7	8	0.75	0.75	10	16	20
SP 1.5T	SP1401	4.1	4.8	8	1.0	1.0	8	16	22
SP 2T	SP1402	5.1	5.8	8	1.0	1.0	8	16	20
SP 2.5T	SP1403	6.8	7.4	8	1.0	1.0	10	16	18
SP 3.5T	SP1404	9.3	10.6	12	1.5	1.0	15	14	16
SP 4.5T	SP1405	10	11	12	1.5	1.0	15	14	14
SP 5.5T	SP1406	12.6	13.4	16	2.5	1.5	15	14	14
SP 8T	SP2401	15.7	17	20	4.0	2.5	20	12	14
SP 11T	SP2402	20.2	21.4	25	4.0	4.0	25	10	10
SP 16T	SP2403	26.6	27.6	32	6.0	6.0	30	8	8
SP 20T	SP2404	26.6	27.6	32	6.0	6.0	30	8	8
SP 22T	SP3401	34.2	36.2	40	10	10	40	6	6
SP 27T	SP3402	40.2	42.7	50	16	16	45	6	6
SP 33T	SP3403	51.3	53.5	63	25	25	60	4	4
SP 3.5TM	SP3501	5.0	6.7	8	1.0	1.0	10	16	18
SP 4.5TM	SP3502	6.0	8.2	10	1.0	1.0	10	16	16
SP 5.5TM	SP3503	7.8	11.1	12	1.5	1.0	15	14	14
SP 8TM	SP3504	9.9	14.4	16	2.5	1.5	15	14	14
SP 11TM	SP3505	13.8	18.1	20	4.0	2.5	20	12	14
SP 16TM	SP3506	18.2	22.2	25	4.0	4.0	25	10	10
SP 22TM	SP3507	22.2	26.0	32	6.0	6.0	30	8.0	8.0

\*The value in the bracket is when the drive is used on a 1 phase supply.

\*\*Fast acting or high speed class J fuses only.

**NOTE**

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

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

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.

**Table 12-15 Size 4 and larger input current, fuse and cable size ratings**

Model		Typical input current	Maximum input current	Fuse option 1		Fuse option 2 semiconductor fuse in series with HRC fuse or breaker		Cable size			
				IEC class gR	North America: Ferraz HSJ	HRC IEC class gG UL class J	Semi-conductor IEC class aR	EN60204		UL508C	
LS	CT	A	A	A	A	A	A	Input mm <sup>2</sup>	Output mm <sup>2</sup>	Input AWG	Output AWG
SP 22TL	SP4201	62.1	68.9	100	90	90	160	25	25	3	3
SP 27TL	SP4202	72.1	78.1	100	100	100	160	35	35	3	3
SP 33TL	SP4203	94.5	99.9	125	125	125	200	70	70	1	1
SP 40TL	SP5201	116	142	200	175	160	200	95	95	2/0	2/0
SP 50TL	SP5202	137	165	250	225	200	250	120	120	4/0	4/0
SP 40T	SP4401	61.2	62.3	80	80	80	160	25	25	3	3
SP 50T	SP4402	76.3	79.6	110	110	100	200	35	35	2	2
SP 60T	SP4403	94.1	97.2	125	125	125	200	70	70	1	1
SP 75T	SP5401	126	131	200	175	160	200	95	95	2/0	2/0
SP 100T	SP5402	152	156	250	225	200	250	120	120	4/0	4/0
SP 120T	SP6401	224	241	315	300	250	315	2 x 70	2 x 70	2 x 2/0	2 x 2/0
SP 150T	SP6402	247	266	315	300	300	350	2 x 120	2 x 120	2 x 4/0	2 x 4/0
SP 22TH	SP4601	23	26.5	63	60	32	125	4	4	10	10
SP 27TH	SP4602	26.1	28.8	63	60	40	125	6	6	8	8
SP 33TH	SP4603	32.9	35.1	63	60	50	125	10	10	8	8
SP 40TH	SP4604	39	41	63	60	50	125	16	16	6	6
SP 50TH	SP4605	46.2	47.9	63	60	63	125	16	16	6	6
SP 60TH	SP4606	55.2	56.9	80	60	63	125	25	25	4	4
SP 75TH	SP5601	75.5	82.6	125	100	90	160	35	35	2	2
SP 100TH	SP5602	89.1	94.8	125	100	125	160	50	50	1	1
SP 120TH	SP6601	128	138	200	200	200	200	2 x 50	2 x 50	2 x 1	2 x 1
SP 150TH	SP6602	144	156	200	200	200	200	2 x 50	2 x 50	2 x 1	2 x 1

**NOTE**

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

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

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.

**Inrush current**

The drive will have an inrush current during power-up, the peak inrush is limited to the value shown below:

- SPz 1M/TL to 2.5M/TL 18 A peak
- SPz 1T to 2.5T 35 A peak
- 1.5TL to 3.5TL 18 A peak
- 1.5T to 5.5T 35 A peak
- 4.5TL to 8TL 12 A peak
- 8T to 20T 24 A peak
- 11TL to 16TL 8 A peak
- 22T to 33T 14 A peak
- 3.5TM to 22TM 18 A peak

For sizes 4 to 6, the inrush current is limited by a controlled rectifier to below the rated current of the drive.

**NOTE**

The inrush current for all drives after a brown-out can be larger than the power-up inrush.

**12.1.21 Maximum motor cable lengths**

**Table 12-16 Maximum motor cable lengths (200V drives)**

Model		200V Nominal AC supply voltage					
		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SPz 1M/TL	SP0201	50m (165ft)					
SPz 1.2M/TL	SP0202						
SPz 1.5M/TL	SP0203						
SPz 2M/TL	SP0204						
SPz 2.5M/TL	SP0205						
SP 1.5TL	SP1201	65m (210ft)				37m (120ft)	
SP 2TL	SP1202	100m (330ft)					
SP 2.5TL	SP1203	130m (425ft)		100m (330ft)	75m (245ft)	50m (165ft)	
SP 3.5TL	SP1204	200m (660ft)	150m (490ft)				
SP 4.5TL	SP2201						
SP 5.5TL	SP2202						
SP 8TL	SP2203						
SP11TL	SP3201	37m (120ft)					
SP 16TL	SP3202						
SP 22TL	SP4201						
SP 27TL	SP4202	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)	37m (120ft)	
SP 33TL	SP4203						
SP 40TL	SP5201						
SP 50TL	SP5202	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)	37m (120ft)	

**Table 12-17 Maximum motor cable lengths (400V drives)**

400V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SPz 1T	SP0401	50m (165ft)					
SPz 1.2T	SP0402						
SPz 1.5T	SP0403						
SPz 2T	SP0404						
SPz 2.5T	SP0405						
SP 1.5T	SP1401						
SP 2T	SP1402	100m (330ft)					
SP 2.5T	SP1403	130m (425ft)					
SP 3.5T	SP1404	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)	50m (165ft)	37m (120ft)
SP 4.5T	SP1405						
SP 5.5T	SP1406						
SP 8T	SP2401						
SP 11T	SP2402						
SP 16T	SP2403						
SP 20T	SP2404						
SP 22T	SP3401						
SP 27T	SP3402						
SP 33T	SP3403						
SP 40T	SP4401	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
SP 50T	SP4402						
SP 60T	SP4403						
SP 75T	SP5401						
SP 100T	SP5402						
SP 120T	SP6401						
SP 150T	SP6402						

**Table 12-18 Maximum motor cable lengths (575V drives)**

575V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP 3.5TM	SP3501	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)		
SP 4.5TM	SP3502						
SP 5.5TM	SP3503						
SP 8TM	SP3504						
SP 11TM	SP3505						
SP 16TM	SP3506						
SP 22TM	SP3507						

**Table 12-19 Maximum motor cable lengths (690V drives)**

690V Nominal AC supply voltage							
Model		Maximum permissible motor cable length for each of the following frequencies					
LS	CT	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP 22TH	SP4601	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
SP 27TH	SP4602						
SP 33TH	SP4603						
SP 40TH	SP4604						
SP 50TH	SP4605						
SP 60TH	SP4606						
SP 75TH	SP5601						
SP 100TH	SP5602						
SP 120TH	SP6601						
SP 150TH	SP6602						

- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
- The default switching frequency is 3kHz for Open-loop and Closed-loop vector, and 6kHz for Servo.

The maximum cable length is reduced from that shown in Table 12-16 and Table 12-17 if high capacitance motor cables are used. For further information, refer to section *High-capacitance cables* on page 67.

**12.1.22 Braking resistor values**

**Table 12-20 Minimum resistance values and peak power rating for the braking resistor at 40°C (104°F)**

Model		Minimum resistance* Ω	Instantaneous power rating kW
LS	CT		
SPz 1M/TL to 2.5M/TL	SP0201 to SP0205	35	4.35
1.5TL to 2.5TL	SP1201 to SP1203	43	3.5
3.5TL	SP1204	29	5.3
4.5TL to 8TL	SP2201 to SP2203	18	8.9
11TL & 16TL	SP3201 & SP3202	5	30.3
22TL to 33TL	SP4201 to SP4203	5	30.3
75T & 100T	SP5201 & SP5202	3.5	53
1T to 2.5T	SP0401 to SP0405	105	5.79
1.5T to 3.5T	SP1401 to SP1404	74	8.3
4.5T & 5.5T	SP1405 & SP1406	58	10.6
8T to 20T	SP2401 to SP2404	19	33.1
22T to 33T	SP3401 to SP3403	18	35.5
40T & 50T	SP4401 & SP4402	11	55.3
60T	SP4403	9	67.6
75T & 100T	SP5401 & SP5402	7	86.9
120T & 150T	SP6401 & SP6402	5	122
3.5TM to 22TM	SP3501 to SP3507	18	50.7
22TH to 60TH	SP4601 to SP4606	13	95
75TH & 100TH	SP5601 to SP5602	10	125
120TH & 150TH	SP6601 to SP6602	10	125

\* Resistor tolerance: ±10%

### 12.1.23 Torque settings

**Table 12-21 Drive control and relay terminal data**

Model	Connection type	Torque setting
All	Plug-in terminal block	0.5 N m 0.4 lb ft

**Table 12-22 Drive power terminal data**

Model size	AC terminals	High current DC and braking	Low voltage DC	Ground terminal
SPz	Terminal block 1.0 N m (0.73 b ft)			Screw (M6) 4.0 N m (2.9 lb ft)
1	Plug-in terminal block 1.5 N m (1.1 lb ft)	Terminal block (M4 screws) 1.5 N m (1.1 b ft)		Stud (M5) 4.0 N m 2.9 lb ft
2		Terminal block (M5 screws) 1.5 N m (1.1 lb ft)	Terminal block (M4 screws) 1.5 N m (1.1 b ft)	
3	Terminal block (M6 screws) 2.5 N m 1.8 lb ft			6.0 N m 4.4 lb ft
4	M10 stud 15 N m			M10 stud 15 N m
5	(11.1 lb ft)			(11.1 lb ft)
6				
Torque tolerance				±10%

**Table 12-23 Plug-in terminal block maximum cable sizes**

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm <sup>2</sup> (16 AWG)
All	2 way relay connector	2.5 mm <sup>2</sup> (12 AWG)
1 and 2	6 way AC power connector	8 mm <sup>2</sup> (8 AWG)
4, 5 and 6	Low Voltage DC Enable connector	1.5 mm <sup>2</sup> (16 AWG)
6	Heatsink fan supply connector	1.5 mm <sup>2</sup> (16 AWG)

### 12.1.24 Electromagnetic compatibility (EMC)

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

**Table 12-24 Immunity compliance**

Standard	Type of immunity	Test specification	Application	Level
IEC61000-4-2 EN61000-4-2	Electrostatic discharge	6kV contact discharge 8kV air discharge	Module enclosure	Level 3 (industrial)
IEC61000-4-3 EN61000-4-3	Radio frequency radiated field	10V/m prior to modulation 80 - 1000MHz 80% AM (1kHz) modulation	Module enclosure	Level 3 (industrial)
IEC61000-4-4 EN61000-4-4	Fast transient burst	5/50ns 2kV transient at 5kHz repetition frequency via coupling clamp	Control lines	Level 4 (industrial harsh)
		5/50ns 2kV transient at 5kHz repetition frequency by direct injection	Power lines	Level 3 (industrial)
IEC61000-4-5 EN61000-4-5	Surges	Common mode 4kV 1.2/50µs waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2kV 1.2/50µs waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground <sup>1</sup>	Level 2
IEC61000-4-6 EN61000-4-6	Conducted radio frequency	10V prior to modulation 0.15 - 80MHz 80% AM (1kHz) modulation	Control and power lines	Level 3 (industrial)
IEC61000-4-11 EN61000-4-11	Voltage dips and interruptions	-30% 10ms +60% 100ms -60% 1s <-95% 5s	AC power ports	
EN50082-1 IEC61000-6-1 EN61000-6-1	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
EN50082-2 IEC61000-6-2 EN61000-6-2	Generic immunity standard for the industrial environment			Complies
EN61800-3 IEC61800-3 EN61800-3	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

<sup>1</sup> See section *Surge immunity of control circuits - long cables and connections outside a building* on page 79 for control ports for possible requirements regarding grounding and external surge protection

### Emission

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

**Table 12-25 SPz (200V) emission compliance (single and three phase drives)**

Motor cable length (m)	Switching frequency (kHz)					
	3	4	6	8	12	16
Using internal filter:						
0 to 7	E2U					TBC
7 to 9	E2U				E2R	TBC
9 to 11	E2U		E2R			TBC
>11	E2R					TBC
Using external filter:						
0 to 20	R			I		
20 to 100	I					

**Table 12-26 SPz (400V) emission compliance**

Motor cable length (m)	Switching frequency (kHz)					
	3	4	6	8	12	16
Using internal filter:						
0 to 6	E2U		E2R		TBC	
6 to 12	E2U		E2R		TBC	
12 to 14	E2U	E2R		TBC		
>14	E2R			TBC		
Using external filter:						
0 to 20	R				I	
20 to 70				I		
70 to 100	I	Do not use				

**Table 12-27 Size 1 emission compliance**

Motor cable length (m)	Switching frequency (kHz)					
	3	4	6	8	12	16
Using internal filter:						
0 to 4	E2U	E2R				
>4	E2R					
Using internal filter and external ferrite ring:						
0 to 10	E2U		E2R			
> 10	E2R					
Using external filter:						
0 to 25	R				I	
25 to 75	I			Do not use		
75 to 100	I	Do not use				

**Table 12-28 Size 2 emission compliance**

Motor cable length (m)	Switching frequency (kHz)					
	3	4	6	8	12	16
Using internal filter:						
Any	E2R					
Using internal filter and external ferrite ring:						
0 to 4	E2U		E2R			
4 to 10	E2U	E2R				
> 10	E2R					
Using external filter:						
0 to 25	R				I	
25 to 75	I			Do not use		
75 to 100	I	Do not use				

**Table 12-29 Size 3 emission compliance**

Motor cable length (m)	Switching frequency (kHz)				
	3	4	6	8	12
Using internal filter:					
Any	E2R				
Using external filter:					
0 to 20	R				I
20 to 50					I
50 to 75	I				Do not use
75 to 100	I	Do not use			

**Table 12-30 Size 4 (200V & 400V) emission compliance**

Motor cable length (m)	Switching frequency (kHz)			
	3	4	6	8
Using internal filter:				
Any	E2R			
Using external filter:				
0 to 25	I			
25 to 50	I			
50 to 75	I	E2U		
75 to 100	I	E2U		

**Table 12-31 Size 4 (690V) emission compliance**

Motor cable length (m)	Switching frequency (kHz)			
	3	4	6	8
Using internal filter:				
Any	E2R			
Using external filter:				
0 to 25	I			
25 to 50	I	E2U		
50 to 75	I	E2U		
75 to 100	I	E2U		

**Table 12-32 Size 5 (400V) emission compliance**

Motor cable length (m)	Switching frequency (kHz)			
	3	4	6	8
Using internal filter:				
100	E2U			
Using external filter:				
0 to 100	I			

**Table 12-33 Size 5 (690V) emission compliance**

Motor cable length (m)	Switching frequency (kHz)			
	3	4	6	8
Using internal filter:				
100	E2R			
Using external filter:				
0 to 25	I			
0 to 100	I	Do not use		

**Table 12-34 Size 6 (400V only) emission compliance**

Motor cable length (m)	Switching frequency (kHz)		
	3	4	6
Using internal filter:			
0 to 100	E2U		
100 to max*	E2R		
Using external filter:			
0 to 100	I		

\*Refer to section 12.1.21 *Maximum motor cable lengths* on page 252.


**Table 12-35 Size 6 (690V only) emission compliance**

Motor cable length (m)	Switching frequency (kHz)		
	3	4	6
Using internal filter:			
0 to 100	E2U		
100 to max*	E2R		
Using external filter:			
0 to 25	I		
0 to 100	I	Do not use	

\*Refer to section 12.1.21 *Maximum motor cable lengths* on page 252.

**Key** (shown in decreasing order of permitted emission level):

- E2R EN 61800-3 second environment, restricted distribution  
(Additional measures may be required to prevent interference)
- E2U EN 61800-3 second environment, unrestricted distribution
- I Industrial generic standard EN 50081-2 (EN 61000-6-4)  
EN 61800-3 first environment restricted distribution (The following caution is required by EN 61800-3)

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

- R Residential generic standard EN 50081-1 (EN 61000-6-3)  
EN 61800-3 first environment unrestricted distribution

EN 61800-3 defines the following:

- The first environment is one that includes residential premises. It also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for residential purposes.
- The second environment is one that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for residential purposes.
- Restricted distribution is defined as a mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives.

#### IEC 61800-3:2004 and EN 61800-3:2004

The 2004 revision of the standard uses different terminology to align the requirements of the standard better with the EC EMC Directive.

Power drive systems are categorised C1 to C4:

Category	Definition	Corresponding code used above
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Rated at over 1000V or over 400A, intended for use in complex systems in the second environment	E2R

Note that category 4 is more restrictive than E2R, since the rated current of the PDS must exceed 400A or the supply voltage exceed 1000V, for the complete PDS.

## 12.2 Optional external EMC filters

**Table 12-36 EMC filter cross reference**

Drive		Schaffner	Epcos
LS	CT	Reference	Reference
SPz 1M/TL to 2.5M/TL (1 phase)	SP0201 to SP0205 (1 phase)	FS23072-19-07	
SPz 1M/TL to 2.5M/TL (3 phase)	SP0201 to SP0205 (3 phase)	FS23073-17-07	
1.5TL & 2TL	SP1201 & SP1202	FS6008-10-07	B84143-A10-R207
2.5TL & 3.5TL	SP1203 to SP1204	FS6008-16-07	B84143-A16-R207
4.5TL to 8TL	SP2201 to SP2203	FS6008-32-07	B84143-A32-R207
11TL & 16TL	SP3201 to SP3202	FS6008-75-07	B84143-A75-R207
22TL to 33TL	SP4201 to SP4203	FS6008-101-35	B84143-A101-R207
40TL & 50TL	SP5201 to SP5202	FS6008-164-40	B84143-A165-R207
1T to 2.5T	SP0401 to SP0405	FS23074-11-07	
1.5T to 3.5T	SP1401 to SP1404	FS6008-10-07	B84143-A10-R207
4.5T & 5.5T	SP1405 to SP1406	FS6008-16-07	B84143-A16-R207
8T to 20T	SP2401 to SP2404	FS6008-32-07	B84143-A32-R207
22T to 33T	SP3401 to SP3403	FS6008-62-07	B84143-A75-R207
40T to 60T	SP4401 to SP4403	FS6008-101-35	B84143-A101-R207
75T & 100T	SP5401 to SP5402	FS6008-164-40	B84143-A165-R207
120T & 150T	SP6401 to SP6402	FS6008-260-99	B84143-A260-S207
3.5TM to 22TM	SP3501 to SP3507	FS6008-30-07	B84143-A30-R207
22TH to 60TH	SP4601 to SP4606	FS6008-58-53	B84143-A58-R207
75TH & 100TH	SP5601 to SP5602	FS6008-95-35	B84143-A95-R207
120TH & 150TH	SP6601 to SP6602	FS6008-160-99	B84143-A0160-S207



## 12.2.1 EMC filter ratings

Table 12-37 Optional external EMC filter details

Reference	Manufacturer	Maximum continuous current		Voltage rating V	IP rating	Power dissipation at rated current W	Ground leakage		Discharge resistors	
		@ 40°C (104°F) A	@ 50°C (122°F) A				Balanced supply phase-to-phase and phase-to-ground mA	Worst case mA		
FS23072-19-07	Schaffner	19	17.3	240	20	11	29.5	56.9	See Note 6	
FS23073-17-07		17	15.5			13	8	50	See Note 1	
FS23074-11-07		11	10	480		10	16	90		
FS6008-10-07		10	10	480		6.9	29.4	153		
FS6008-16-07		16	16			9.2	38.8	277		
FS6008-32-07		32	28.2			11	38.0	206		
FS6008-62-07		62	56.6			23	66.0	357		
FS6008-75-07		75	68.5	240		29	24.0	170		
FS6008-30-07		30	30	575		15	102.0	557		See Note 3
FS6008-101-35		101	92.2	480		25	73.0	406		See Note 1
FS6008-58-53		58	52.8	690		31	66.0	344		See Note 4
FS6008-164-40		164	150	480		30	39.1	216		
FS6008-95-35		95	86.7	690		30	66.0	344	See Note 1	
FS6008-260-99		260	237	480		00	14.2	41.0		219
FS6008-160-99		160	146	690			5.4	88.5		296
B84143-A10-R207		Epcos	10	9.1		480	20	4.2	<30.0	186.5
B84143-A16-R207	16		14.6	10.8						
B84143-A32-R207	32		29.1	17.8						
B84143-A75-R207	75		68.3	19.4						
B84143-A30-R207	30		22.5	660	17.6	<35.0		230		
B84143-A101-R207	101		75	480	30	<30.0		180		
B84143-A58-R207	58		44	690	15	<40.0		<340	See Note 5	
B84143-A165-R207	165		125	480	27	<20.0		<120	See Note 2	
B84143-A95-R207	95		71	690	19	<55.0		<450	See Note 5	
B84143-A260-S207	260		195	480	00	13		<45.0		<375
B84143-A0160-S207	160		120	690		5		<60.0		<520

### NOTE

- 1MΩ in a Δ connection between phases, with the Δ point connected by a 680kΩ resistor to ground (i.e. line to line 2MΩ, line to ground 1.68MΩ)
- 1MΩ in a Δ connection between phases, with the Δ point connected by a 1.5MΩ resistor to ground (i.e. line to line 2MΩ, line to ground 2.5MΩ)
- 2MΩ between phases with each phase connected by a 660kΩ resistance to ground.
- 1.5MΩ in a Δ connection between phases, with the Δ point connected by a 680kΩ resistor to ground (i.e. line to line 3MΩ, line to ground 2.18MΩ)
- 1.8MΩ in a Δ connection between phases, with the Δ point connected by a 1.5MΩ resistor to ground (i.e. line to line 3.6MΩ, line to ground 3.3MΩ)
- 470kΩ between phases with each phase connected by a 2MΩ resistance to ground.

## 12.2.2 Overall EMC filter dimensions

Table 12-38 Optional external EMC filter dimensions

Reference	Manufacturer	Dimension			Weight	
		H	W	D	kg	lb
FS23072-19-07	Schaffner	359 mm (14.13 in)	61 mm (2.40 in)	29 mm (1.14 in)	1.2	2.64
FS23073-17-07						
FS23074-11-07						
FS6008-10-07		440 mm (17.323 in)	100 mm (3.937 in)	45 mm (1.772 in)	1.4	3.1
FS6008-16-07						
FS6008-32-07		428.5 mm (16.870 in)	155 mm (6.102 in)	55 mm (2.165 in)	2	4.4
FS6008-62-07		414 mm (16.299 in)	250 mm (9.842 in)	60 mm (2.362 in)	3.5	7.7
FS6008-75-07						
FS6008-30-07						
FS6008-101-35		300 mm (11.811 in)	225 mm (8.858 in)	100 mm (3.937 in)	4	8.8
FS6008-58-53			208 mm (8.189 in)		3.8	8.4
FS6008-164-40			249 mm (9.803 in)	120 mm (4.724 in)	6.8	15
FS6008-95-35			225 mm (8.858 in)	100 mm (3.937 in)	4.4	9.7
FS6008-260-99			295 mm (11.614 in)	230 mm (9.055 in)	136 mm (5.354 in)	5.25
FS6008-160-99		357 mm (14.055 in)				
B84143-A10-R207		Epcos	450 mm (17.717 in)	100 mm (3.937 in)	45 mm (1.772 in)	2.1
B84143-A16-R207	431.5 mm (16.988 in)		155 mm (6.102 in)	55 mm (2.165 in)	3.3	7.3
B84143-A32-R207						
B84143-A75-R207	425 mm (16.732 in)		250 mm (9.843 in)	60 mm (2.362 in)	5.1	11.2
B84143-A30-R207	300 mm (11.811 in)		207 mm (8.150 in)	90 mm (3.543 in)	7.8	17.2
B84143-A101-R207			205 mm (8.071 in)		8.0	17.6
B84143-A58-R207			249 mm (9.803 in)	120 mm (4.724 in)	12.0	26.5
B84143-A165-R207					10.0	22.0
B84143-A95-R207	364 mm (14.331 in)		230 mm (9.055 in)	147 mm (5.787 in)	8.6	19.0
B84143-A260-S207						
B84143-A0160-S207						

### 12.2.3 EMC filter torque settings


#### Optional external EMC Filter terminal data

Reference	Manufacturer	Power connections		Ground connections	
		Max cable size	Max torque	Ground stud size	Max torque
FS23072-19-07	Schaffner	4mm <sup>2</sup> 12AWG	0.8 N m (0.6 lb ft)	M5	3.5 N m (2.6 lb ft)
FS23073-17-07					
FS23074-11-07		10mm <sup>2</sup> 8AWG	2.0 N m (1.5 lb ft)	M6	3.9 N m (2.9 lb ft)
FS6008-10-07					
FS6008-16-07		16mm <sup>2</sup> 6AWG	2.2 N m (1.6 lb ft)	M10	25 N m (18.4 lb ft)
FS6008-32-07					
FS6008-62-07		50mm <sup>2</sup> 0AWG	8 N m (5.9 lb ft)	M6	3.9 N m (2.9 lb ft)
FS6008-75-07					
FS6008-30-07		25mm <sup>2</sup> 4AWG	2.3 N m (1.7 lb ft)	M10	25 N m (18.4 lb ft)
FS6008-101-35					
FS6008-58-53		95mm <sup>2</sup> 4/0AWG	20 N m (14.7 lb ft)	M10	25 N m (18.4 lb ft)
FS6008-164-40					
FS6008-95-35		50mm <sup>2</sup> 0AWG	8 N m (5.9 lb ft)	M5	3.0 N m (2.2 lb ft)
FS6008-260-99					
FS6008-160-99					
B84143-A16-R207	Epcos	4mm <sup>2</sup> 12AWG	0.6 N m (0.4 lb ft)	M6	5.1 N m (3.8 lb ft)
B84143-A10-R207					
B84143-A32-R207		10mm <sup>2</sup> 8AWG	1.35 N m (1.0 b ft)	M10	10 N m (7.4 lb ft)
B84143-A75-R207					
B84143-A30-R207		16mm <sup>2</sup> 6AWG	2.2 N m (1.6 lb ft)	M5	3.0 N m (2.2 lb ft)
B84143-A101-R207					
B84143-A58-R207		50mm <sup>2</sup> 0AWG	6.8 N m (5.0 lb ft)	M6	5.1 N m (3.8 lb ft)
B84143-A165-R207					
B84143-A95-R207		95mm <sup>2</sup> 4/0AWG	20 N m (14.7 lb ft)	M10	10 N m (7.4 lb ft)
B84143-A260-S207					
B84143-A0160-S207					

# 13 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 LEROY-SOMER distributor for repair.

## 13.1 Trip indications

If the drive trips, the output of the drive is disabled so that the drive stops controlling the motor. The upper display indicates that a trip has occurred and the lower display shows the trip. If this is a multi-module drive and a power module has indicated a trip, then the lower display will alternate between the trip string and the module number.

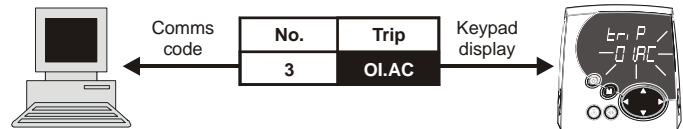
Trips are listed alphabetically in Table 13-1 based on the trip indication shown on the drive display. Refer to Figure 13-1.

If a display is not used, the drive LED Status indicator will flash if the drive has tripped. Refer to Figure 13-2.

The trip indication can be read in Pr 10.20 providing a trip number. Trip numbers are listed in numerical order in Table 13-2 so the trip indication can be cross referenced and then diagnosed using Table 13-1.

### Example

1. Trip code 3 is read from Pr 10.20 via serial communications.
2. Checking Table 13-2 shows Trip 3 is an OI.AC trip.



3. Look up OI.AC in Table 13-1.
4. Perform checks detailed under *Diagnosis*.

Figure 13-1 Keypad status modes

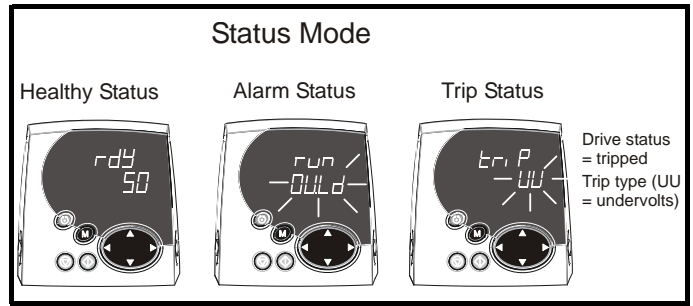
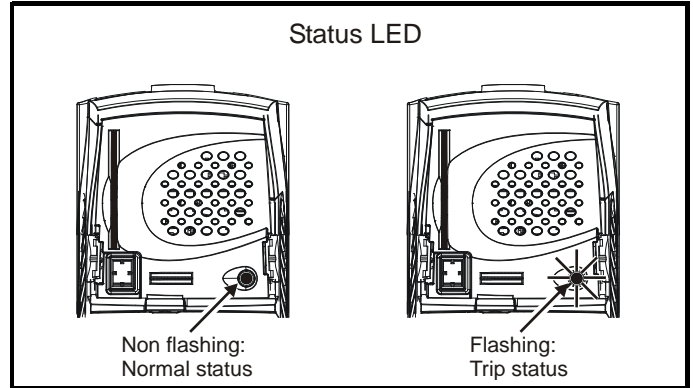




Figure 13-2 Location of the status LED



Trip	Diagnosis
OI.AC	<b>Instantaneous output over current detected: peak output current greater than 225%</b>
3	Acceleration / deceleration rate is too short. If seen during autotune reduce voltage boost Pr 5.15 Check for short circuit on output cabling Check integrity of motor insulation Check feedback device wiring Check feedback device mechanical coupling Check feedback signals are free from noise Is motor cable length within limits for that frame size? Reduce the values in speed loop gain parameters – Pr 3.10, Pr 3.11 and Pr 3.12 (closed loop vector and servo modes only) Has offset measurement test been completed? (servo mode only) Reduce the values in current loop gain parameters - Pr 4.13 and Pr 4.14 (closed loop vector and servo modes only)

**Table 13-1 Trip indications**

<b>Trip</b>	<b>Diagnosis</b>
<b>br.th</b>	<b>Internal braking resistor thermistor temperature monitoring fail (SPz only)</b>
<b>10</b>	If no internal brake resistor is installed, set Pr <b>0.51</b> (or Pr <b>10.37</b> ) to 8 to disable this trip. If an internal brake resistor is installed: <ul style="list-style-type: none"> <li>• Ensure that the internal braking resistor thermistor is connected correctly</li> <li>• Ensure that the fan in the drive is working correctly</li> <li>• Replace the internal braking resistor</li> </ul>
<b>C.Acc</b>	<b>SMARTCARD trip: SMARTCARD Read / Write fail</b>
<b>185</b>	Check SMARTCARD is installed / located correctly Ensure SMARTCARD is not writing data to data location 500 to 999 Replace SMARTCARD
<b>C.boot</b>	<b>SMARTCARD trip: The menu 0 parameter modification cannot be saved to the SMARTCARD because the necessary file has not been created on the SMARTCARD</b>
<b>177</b>	A write to a menu 0 parameter has been initiated via the keypad with Pr <b>11.42</b> set to auto(3) or boot(4), but the necessary file on the SMARTCARD has not been created Ensure that Pr <b>11.42</b> is correctly set and reset the drive to create the necessary file on the SMARTCARD Re-attempt the parameter write to the menu 0 parameter
<b>C.bUSY</b>	<b>SMARTCARD trip: SMARTCARD can not perform the required function as it is being accessed by a Solutions Module</b>
<b>178</b>	Wait for the Solutions Module to finish accessing the SMARTCARD and then re-attempt the required function
<b>C.Chg</b>	<b>SMARTCARD trip: Data location already contains data</b>
<b>179</b>	Erase data in data location Write data to an alternative data location
<b>C.cPr</b>	<b>SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different</b>
<b>188</b>	Press the red  reset button
<b>C.dAt</b>	<b>SMARTCARD trip: Data location specified does not contain any data</b>
<b>183</b>	Ensure data block number is correct
<b>C.Err</b>	<b>SMARTCARD trip: SMARTCARD data is corrupted</b>
<b>182</b>	Ensure the card is located correctly Erase data and retry Replace SMARTCARD
<b>C.Full</b>	<b>SMARTCARD trip: SMARTCARD full</b>
<b>184</b>	Delete a data block or use different SMARTCARD
<b>cL2</b>	<b>Analog input 2 current loss (current mode)</b>
<b>28</b>	Check analog input 2 (terminal 7) current signal is present (4-20mA, 20-4mA)
<b>cL3</b>	<b>Analog input 3 current loss (current mode)</b>
<b>29</b>	Check analog input 3 (terminal 8) current signal is present (4-20mA, 20-4mA)
<b>CL.bit</b>	<b>Trip initiated from the control word (Pr 6.42)</b>
<b>35</b>	Disable the control word by setting Pr <b>6.43</b> to 0 or check setting of Pr <b>6.42</b>
<b>ConFP</b>	<b>The number of power modules installed no longer matches the value stored in Pr 11.35</b>
<b>111</b>	Ensure that all power modules are correctly connected Ensure that all power modules have powered up correctly Ensure that the value in Pr <b>11.35</b> matches the number of power modules connected
<b>C.OPtn</b>	<b>SMARTCARD trip: Solutions Modules installed are different between source drive and destination drive</b>
<b>180</b>	Ensure correct Solutions Modules are installed Ensure Solutions Modules are in the same Solutions Module slot Press the red  reset button
<b>C.Prod</b>	<b>SMARTCARD trip: The data blocks on the SMARTCARD are not compatible with this product</b>
<b>175</b>	Erase all data on the SMARTCARD by setting Pr <b>xx.00</b> to 9999 and pressing the red  reset button Replace SMARTCARD
<b>C.rdo</b>	<b>SMARTCARD trip: SMARTCARD has the Read Only bit set</b>
<b>181</b>	Enter 9777 in Pr <b>xx.00</b> to allow SMARTCARD Read / Write access Ensure the drive is not writing to data locations 500 to 999 on the card

Trip	Diagnosis																												
<b>C.rtg</b>	<b>SMARTCARD trip: The voltage and/or current rating of the source and destination drives are different</b>																												
186	<p>Drive rating dependent parameters (parameters with the RA coding) are likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. However, with software V01.09.00 and later drive rating dependent parameters will be transferred if only the current rating is different and the file is a differences from default type file.</p> <p>Press the red  reset button</p> <p>Drive rating parameters are:</p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>2.08</td> <td>Standard ramp voltage</td> </tr> <tr> <td>4.05/6/7, 21.27/8/9</td> <td>Current limits</td> </tr> <tr> <td>4.24</td> <td>User current maximum scaling</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>5.10, 21.10</td> <td>Rated power factor</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> <tr> <td>6.48</td> <td>Line power supply loss ride through detection level</td> </tr> </tbody> </table> <p>The above parameters will be set to their default values.</p>	Parameter	Function	2.08	Standard ramp voltage	4.05/6/7, 21.27/8/9	Current limits	4.24	User current maximum scaling	5.07, 21.07	Motor rated current	5.09, 21.09	Motor rated voltage	5.10, 21.10	Rated power factor	5.17, 21.12	Stator resistance	5.18	Switching frequency	5.23, 21.13	Voltage offset	5.24, 21.14	Transient inductance	5.25, 21.24	Stator inductance	6.06	DC injection braking current	6.48	Line power supply loss ride through detection level
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2.08	Standard ramp voltage																												
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5.25, 21.24	Stator inductance																												
6.06	DC injection braking current																												
6.48	Line power supply loss ride through detection level																												
<b>C.TYP</b>	<b>SMARTCARD trip: SMARTCARD parameter set not compatible with drive</b>																												
187	<p>Press the reset button</p> <p>Ensure destination drive type is the same as the source parameter file drive type</p>																												
<b>dESt</b>	<b>Two or more parameters are writing to the same destination parameter</b>																												
199	Set Pr <b>xx.00</b> = 12001 check all visible parameters in the menus for duplication																												
<b>EEF</b>	<b>EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.</b>																												
31	This trip can only be cleared by loading default parameters and saving parameters																												
<b>EnC1</b>	<b>Drive encoder trip: Encoder power supply overload</b>																												
189	<p>Check encoder power supply wiring and encoder current requirement</p> <p>Maximum current = 200mA @ 15V, or 300mA @ 8V and 5V</p>																												
<b>EnC2</b>	<b>Drive encoder trip: Wire break (Drive encoder terminals 1 &amp; 2, 3 &amp; 4, 5 &amp; 6)</b>																												
190	<p>Check cable continuity</p> <p>Check wiring of feedback signals is correct</p> <p>Check encoder power supply is set correctly in Pr <b>3.36</b></p> <p>Replace feedback device</p> <p>If wire break detection on the main drive encoder input is not required, set Pr <b>3.40</b> = 0 to disable the Enc2 trip</p>																												
<b>EnC3</b>	<b>Drive encoder trip: Phase offset incorrect while running</b>																												
191	<p>Check the encoder signal for noise</p> <p>Check encoder shielding</p> <p>Check the integrity of the encoder mechanical mounting</p> <p>Repeat the offset measurement test</p>																												
<b>EnC4</b>	<b>Drive encoder trip: Feedback device comms failure</b>																												
192	<p>Ensure encoder power supply is correct</p> <p>Ensure baud rate is correct</p> <p>Check encoder wiring</p> <p>Replace feedback device</p>																												
<b>EnC5</b>	<b>Drive encoder trip: Checksum or CRC error</b>																												
193	<p>Check the encoder signal for noise</p> <p>Check the encoder cable shielding</p> <p>With EnDat encoders, check the comms resolution and/or carry out the auto-configuration Pr <b>3.41</b></p>																												
<b>EnC6</b>	<b>Drive encoder trip: Encoder has indicated an error</b>																												
194	<p>Replace feedback device</p> <p>With SSI encoders, check the wiring and encoder supply setting</p>																												

Trip	Diagnosis
<b>EnC7</b>	<b>Drive encoder trip: Initialisation failed</b>
195	Re-set the drive Check the correct encoder type is entered into Pr 3.38 Check encoder wiring Check encoder power supply is set correctly Carry out the auto-configuration Pr 3.41 Replace feedback device
<b>EnC8</b>	<b>Drive encoder trip: Auto configuration on power up has been requested and failed</b>
196	Change the setting of Pr 3.41 to 0 and manually enter the drive encoder turns (Pr 3.33) and the equivalent number of lines per revolution (Pr 3.34) Check the comms resolution
<b>EnC9</b>	<b>Drive encoder trip: Position feedback selected is selected from a Solutions Module slot which does not have a speed / position feedback Solutions Module installed</b>
197	Check setting of Pr 3.26 (or Pr 21.21 if the second motor parameters have been enabled)
<b>EnC10</b>	<b>Drive encoder trip: Servo mode phasing failure because encoder phase angle (Pr 3.25 or Pr 21.20) is incorrect</b>
198	Check the encoder wiring. Perform an autotune to measure the encoder phase angle or manually enter the correct phase angle into Pr 3.25 (or Pr 21.20). Spurious Enc10 trips can be seen in very dynamic applications. This trip can be disabled by setting the overspeed threshold in Pr 3.08 to a value greater than zero. Caution should be used in setting the over speed threshold level as a value which is too large may mean that an encoder fault will not be detected.
<b>Enc11</b>	<b>Drive encoder trip: A failure has occurred during the alignment of the analog signals of a SINCOS encoder with the digital count derived from the sine and cosine waveforms and the comms position (if applicable). This fault is usually due to noise on the sine and cosine signals.</b>
161	Check encoder cable shield. Examine sine and cosine signals for noise.
<b>Enc12</b>	<b>Drive encoder trip: Hiperface encoder - The encoder type could not be identified during auto-configuration</b>
162	Check encoder type can be auto-configured. Check encoder wiring. Enter parameters manually.
<b>Enc13</b>	<b>Drive encoder trip: EnDat encoder - The number of encoder turns read from the encoder during auto-configuration is not a power of 2</b>
163	Select a different type of encoder.
<b>Enc14</b>	<b>Drive encoder trip: EnDat encoder - The number of comms bits defining the encoder position within a turn read from the encoder during auto-configuration is too large.</b>
164	Select a different type of encoder. Faulty encoder.
<b>Enc15</b>	<b>Drive encoder trip: The number of periods per revolution calculated from encoder data during auto-configuration is either less than 2 or greater than 50,000.</b>
165	Linear motor pole pitch / encoder ppr set up is incorrect or out of parameter range i.e. Pr 5.36 = 0 or Pr 21.31 = 0. Faulty encoder.
<b>Enc16</b>	<b>Drive encoder trip: EnDat encoder - The number of comms bits per period for a linear encoder exceeds 255.</b>
166	Select a different type of encoder. Faulty encoder.
<b>Enc17</b>	<b>Drive encoder trip: The periods per revolution obtained during auto-configuration for a rotary SINCOS encoder is not a power of two.</b>
167	Select a different type of encoder. Faulty encoder.
<b>ENP.Er</b>	<b>Data error from electronic nameplate stored in selected position feedback device</b>
176	Replace feedback device
<b>Et</b>	<b>External trip</b>
6	Check terminal 31 signal Check value of Pr 10.32 Enter 12001 in Pr xx.00 and check for parameter controlling Pr 10.32 Ensure Pr 10.32 or Pr 10.38 (=6) are not being controlled by serial comms
<b>HF01</b>	<b>Data processing error: CPU address error</b>
	Hardware fault - return drive to supplier

Trip	Diagnosis
<b>HF02</b>	<b>Data processing error: DMAC address error</b>
	Hardware fault - return drive to supplier
<b>HF03</b>	<b>Data processing error: Illegal instruction</b>
	Hardware fault - return drive to supplier
<b>HF04</b>	<b>Data processing error: Illegal slot instruction</b>
	Hardware fault - return drive to supplier
<b>HF05</b>	<b>Data processing error: Undefined exception</b>
	Hardware fault - return drive to supplier
<b>HF06</b>	<b>Data processing error: Reserved exception</b>
	Hardware fault - return drive to supplier
<b>HF07</b>	<b>Data processing error: Watchdog failure</b>
	Hardware fault - return drive to supplier
<b>HF08</b>	<b>Data processing error: Level 4 crash</b>
	Hardware fault - return drive to supplier
<b>HF09</b>	<b>Data processing error: Heap overflow</b>
	Hardware fault - return drive to supplier
<b>HF10</b>	<b>Data processing error: Router error</b>
	Hardware fault - return drive to supplier
<b>HF11</b>	<b>Data processing error: Access to EEPROM failed</b>
	Hardware fault - return drive to supplier
<b>HF12</b>	<b>Data processing error: Main program stack overflow</b>
	Hardware fault - return drive to supplier
<b>HF13</b>	<b>Data processing error: Software incompatible with hardware</b>
	Hardware or software fault - return drive to supplier
<b>HF17</b>	<b>Multi-module system thermistor short circuit or open circuit</b>
<b>217</b>	Hardware fault - return drive to supplier
<b>HF18</b>	<b>Multi-module system interconnect cable error</b>
<b>218</b>	Hardware fault - return drive to supplier
<b>HF19</b>	<b>Temperature feedback multiplexing failure</b>
<b>219</b>	Hardware fault - return drive to supplier
<b>HF20</b>	<b>Power stage recognition: serial code error</b>
<b>220</b>	Hardware fault - return drive to supplier
<b>HF21</b>	<b>Power stage recognition: unrecognised frame size</b>
<b>221</b>	Hardware fault - return drive to supplier
<b>HF22</b>	<b>Power stage recognition: multi module frame size mismatch</b>
<b>222</b>	Hardware fault - return drive to supplier
<b>HF23</b>	<b>Power stage recognition: multi module voltage or current rating mismatch</b>
<b>223</b>	Hardware fault - return drive to supplier
<b>HF24</b>	<b>Power stage recognition: unrecognised drive size</b>
<b>224</b>	Hardware fault - return drive to supplier
<b>HF25</b>	<b>Current feedback offset error</b>
<b>225</b>	Hardware fault - return drive to supplier
<b>HF26</b>	<b>Soft start relay failed to close, soft start monitor failed or braking IGBT short circuit at power up</b>
<b>226</b>	Hardware fault - return drive to supplier
<b>HF27</b>	<b>Power stage thermistor 1 fault</b>
<b>227</b>	Hardware fault - return drive to supplier



Trip	Diagnosis
<b>HF28</b>	<b>Power stage thermistor 2 fault, or internal fan fault (size 3)</b>
<b>228</b>	Hardware fault - return drive to supplier
<b>HF29</b>	<b>Control board thermistor fault</b>
<b>229</b>	Hardware fault - return drive to supplier
<b>HF30</b>	<b>DCCT wire break trip from power module</b>
<b>230</b>	Hardware fault - return drive to supplier
<b>HF31</b>	<b>Internal capacitor bank fan failure (size 4 and larger) or a module has not powered up in a multi-module parallel drive</b>
<b>231</b>	Check the AC or DC power supply to all modules in a multi-module parallel drive If the AC or DC power supply is present, or if this is a single drive, then there is a hardware fault - return drive to the supplier
<b>HF32</b>	<b>Power stage - Identification and trip information serial code error</b>
<b>232</b>	Hardware fault - return drive to the supplier
<b>It.AC</b>	<b>Output current overload timed out (<math>I^2t</math>) - accumulator value can be seen in Pr 4.19</b>
<b>20</b>	Ensure the load is not jammed / sticking Check the load on the motor has not changed If seen during an autotune in servo mode, ensure that the motor rated current Pr <b>0.46</b> (Pr <b>5.07</b> ) or Pr <b>21.07</b> is $\leq$ Heavy Duty current rating of the drive Tune the rated speed parameter (closed loop vector only) Check feedback device signal for noise Check the feedback device mechanical coupling
<b>It.br</b>	<b>Braking resistor overload timed out (<math>I^2t</math>) – accumulator value can be seen in Pr 10.39</b>
<b>19</b>	Ensure the values entered in Pr <b>10.30</b> and Pr <b>10.31</b> are correct Increase the power rating of the braking resistor and change Pr <b>10.30</b> and Pr <b>10.31</b> If an external thermal protection device is being used and the braking resistor software overload is not required, set Pr <b>10.30</b> or Pr <b>10.31</b> to 0 to disable the trip
<b>L.SYnC</b>	<b>Drive failed to synchronize to the supply voltage in Regen mode</b>
<b>39</b>	Refer to the <i>Diagnostics</i> chapter in the <i>Unidrive SP Regen Installation Guide</i> .
<b>O.CtL</b>	<b>Drive control board over temperature</b>
<b>23</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Check ambient temperature Reduce drive switching frequency
<b>O.ht1</b>	<b>Power device over temperature based on thermal model</b>
<b>21</b>	Reduce drive switching frequency Reduce duty cycle Decrease acceleration / deceleration rates Reduce motor load
<b>O.ht2</b>	<b>Heatsink over temperature</b>
<b>22</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load
<b>Oht2.P</b>	<b>Power module heatsink over temperature</b>
<b>105</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load

Trip	Diagnosis
<b>O.ht3</b>	<b>Drive over-temperature based on thermal model</b>
27	The drive will attempt to stop the motor before tripping. If the motor does not stop in 10s the drive trips immediately. Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce duty cycle Reduce motor load
<b>Oht4.P</b>	<b>Power module rectifier over temperature or input snubber resistor over temperature (size 4 and above)</b>
102	Check for supply imbalance Check for supply disturbance such as notching from a DC drive Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load
<b>OI.AC</b>	<b>Instantaneous output over current detected: peak output current greater than 225%</b>
3	Acceleration /deceleration rate is too short. If seen during autotune reduce voltage boost Pr 5.15 Check for short circuit on output cabling Check integrity of motor insulation Check feedback device wiring Check feedback device mechanical coupling Check feedback signals are free from noise Is motor cable length within limits for that frame size? Reduce the values in speed loop gain parameters – Pr 3.10, Pr 3.11 and Pr 3.12 (closed loop vector and servo modes only) Has offset measurement test been completed? (servo mode only) Reduce the values in current loop gain parameters - Pr 4.13 and Pr 4.14 (closed loop vector and servo modes only)
<b>OIAC.P</b>	<b>Power module over current detected from the module output currents</b>
104	Acceleration /deceleration rate is too short. If seen during autotune reduce voltage boost Pr 5.15 Check for short circuit on output cabling Check integrity of motor insulation Check feedback device wiring Check feedback device mechanical coupling Check feedback signals are free from noise Is motor cable length within limits for that frame size? Reduce the values in speed loop gain parameters – Pr 3.10, Pr 3.11 and Pr 3.12 (closed loop vector and servo modes only) Has offset measurement test been completed? (servo mode only) Reduce the values in current loop gain parameters - Pr 4.13 and Pr 4.14 (closed loop vector and servo modes only)
<b>OI.br</b>	<b>Braking transistor over-current detected: short circuit protection for the braking transistor activated</b>
4	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
<b>OIbr.P</b>	<b>Power module braking IGBT over current</b>
103	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
<b>OldC.P</b>	<b>Power module over current detected from IGBT on state voltage monitoring</b>
109	Vce IGBT protection activated. Check motor and cable insulation.
<b>O.Ld1</b>	<b>Digital output overload: total current drawn from 24V supply and digital outputs exceeds 200mA</b>
26	Check total load on digital outputs (terminals 24,25,26)and +24V rail (terminal 22)
<b>O.SPd</b>	<b>Motor speed has exceeded the over speed threshold</b>
7	Increase the over speed trip threshold in Pr 3.08 (closed loop vector and servo modes only) Speed has exceeded 1.2 x Pr 1.06 or Pr 1.07 (open loop mode) Reduce the speed loop P gain (Pr 3.10) to reduce the speed overshoot (closed loop vector and servo modes only)

Trip	Diagnosis															
<b>OV</b>	<b>DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds</b>															
<b>2</b>	<p>Increase deceleration ramp (Pr <b>0.04</b>)            Decrease braking resistor value (staying above the minimum value)            Check nominal AC supply level            Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives            Check motor insulation</p> <table border="1"> <thead> <tr> <th>Drive voltage rating</th> <th>Peak voltage</th> <th>Maximum continuous voltage level (15s)</th> </tr> </thead> <tbody> <tr> <td>200</td> <td>415</td> <td>410</td> </tr> <tr> <td>400</td> <td>830</td> <td>815</td> </tr> <tr> <td>575</td> <td>990</td> <td>970</td> </tr> <tr> <td>690</td> <td>1190</td> <td>1175</td> </tr> </tbody> </table> <p>If the drive is operating in low voltage DC mode the overvoltage trip level is 1.45 x Pr <b>6.46</b>.</p>	Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)	200	415	410	400	830	815	575	990	970	690	1190	1175
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<b>OV.P</b>	<b>Power module DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds</b>															
<b>106</b>	<p>Increase deceleration ramp (Pr <b>0.04</b>)            Decrease braking resistor value (staying above the minimum value)            Check nominal AC supply level            Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives            Check motor insulation</p> <table border="1"> <thead> <tr> <th>Drive voltage rating</th> <th>Peak voltage</th> <th>Maximum continuous voltage level (15s)</th> </tr> </thead> <tbody> <tr> <td>200</td> <td>415</td> <td>410</td> </tr> <tr> <td>400</td> <td>830</td> <td>815</td> </tr> <tr> <td>575</td> <td>990</td> <td>970</td> </tr> <tr> <td>690</td> <td>1190</td> <td>1175</td> </tr> </tbody> </table> <p>If the drive is operating in low voltage DC mode the overvoltage trip level is 1.45 x Pr <b>6.46</b>.</p>	Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)	200	415	410	400	830	815	575	990	970	690	1190	1175
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<b>PAd</b>	<b>Keypad has been removed when the drive is receiving the speed reference from the keypad</b>															
<b>34</b>	<p>Install keypad and reset            Change speed reference selector to select speed reference from another source</p>															
<b>PH</b>	<b>AC voltage input phase loss or large supply imbalance detected</b>															
<b>32</b>	<p>Ensure all three phases are present and balanced            Check input voltage levels are correct (at full load)</p> <p><b>NOTE</b></p> <p>Load level must be between 50 and 100% for the drive to trip under phase loss conditions. The drive will attempt to stop the motor before this trip is initiated.</p>															
<b>PH.P</b>	<b>Power module phase loss detection</b>															
<b>107</b>	<p>Ensure all three phases are present and balanced            Check input voltage levels are correct (at full load)</p>															
<b>PS</b>	<b>Internal power supply fault</b>															
<b>5</b>	<p>Remove any Solutions Modules and reset            Hardware fault - return drive to supplier</p>															
<b>PS.10V</b>	<b>10V user power supply current greater than 10mA</b>															
<b>8</b>	<p>Check wiring to terminal 4            Reduce load on terminal 4</p>															
<b>PS.24V</b>	<b>24V internal power supply overload</b>															
<b>9</b>	<p>The total user load of the drive and Solutions Modules has exceeded the internal 24V power supply limit. The user load consists of the drive's digital outputs, the SM-I/O Plus digital outputs, the drive's main encoder supply and the SM-Universal Encoder Plus encoder supply.</p> <ul style="list-style-type: none"> <li>• Reduce load and reset</li> <li>• Provide an external 24V &gt;50W power supply</li> <li>• Remove any Solutions Modules and reset</li> </ul>															
<b>PS.P</b>	<b>Power module power supply fail</b>															
<b>108</b>	<p>Remove any Solutions Modules and reset            Hardware fault - return drive to supplier</p>															
<b>PSAVE.Er</b>	<b>Power down save parameters in the EEPROM are corrupt</b>															
<b>37</b>	<p>Indicates that the power was removed when power down save parameters were being saved. The drive will revert back to the power down parameter set that was last saved successfully. Perform a user save (Pr <b>xx.00</b> to 1000 or 1001 and reset the drive) or power down the drive normally to ensure this trip does or occur the next time the drive is powered up.</p>															

Trip	Diagnosis
<b>rS</b>	<b>Failure to measure resistance during autotune or when starting in open loop vector mode 0 or 3</b>
<b>33</b>	Check motor power connection continuity
<b>SAVE.Er</b>	<b>User save parameters in the EEPROM are corrupt</b>
<b>36</b>	Indicates that the power was removed when user parameters were being saved. The drive will revert back to the user parameter set that was last saved successfully. Perform a user save (Pr <b>xx.00</b> to 1000 or 1001 and reset the drive) to ensure this trip does or occur the next time the drive is powered up.
<b>SCL</b>	<b>Drive RS485 serial comms loss to remote keypad</b>
<b>30</b>	Reinstall the cable between the drive and keypad Check cable for damage Replace cable Replace keypad
<b>SLX.dF</b>	<b>Solutions Module slot X trip: Solutions Module type installed in slot X changed</b>
<b>204,209,214</b>	Save parameters and reset

Trip	Diagnosis			
<b>SLX.Er</b>	<b>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</b>			
<b>202,207,212</b>	<b>Feedback module category</b>			
	Check value in Pr <b>15/16/17.50</b> . The following table lists the possible error codes for the SM-Universal Encoder Plus, SM-Encoder Output Plus, SM-Encoder Plus and SM-Resolver. See the <i>Diagnostics</i> section in the relevant Solutions Module User Guide for more information.			
	Error code	Module	Trip Description	Diagnostic
	0	All	No trip	No fault detected
	1	SM-Universal Encoder Plus & SM-Encoder Output Plus	Encoder power supply overload	Check encoder power supply wiring and encoder current requirement Maximum current = 200mA @ 15V, or 300mA @ 8V and 5V
		SM-Resolver	Excitation output short circuit	Check the excitation output wiring.
	2	SM-Universal Encoder Plus & SM-Resolver	Wire break	Check cable continuity Check wiring of feedback signals is correct Check supply voltage or excitation output level Replace feedback device
	3	SM-Universal Encoder Plus	Phase offset incorrect while running	Check the encoder signal for noise Check encoder shielding Check the integrity of the encoder mechanical mounting Repeat the offset measurement test
	4	SM-Universal Encoder Plus	Feedback device communications failure	Ensure encoder power supply is correct Ensure baud rate is correct Check encoder wiring Replace feedback device
	5	SM-Universal Encoder Plus	Checksum or CRC error	Check the encoder signal for noise Check the encoder cable shielding
	6	SM-Universal Encoder Plus	Encoder has indicated an error	Replace encoder
	7	SM-Universal Encoder Plus	Initialisation failed	Check the correct encoder type is entered into Pr <b>15/16/17.15</b> Check encoder wiring Check supply voltage level Replace feedback device
	8	SM-Universal Encoder Plus	Auto configuration on power up has been requested and failed	Change the setting of Pr <b>15/16/17.18</b> and manually enter the number of turns bits (Pr <b>15/16/17.09</b> ) and the equivalent number of lines per revolution (Pr <b>15/16/17.10</b> ) and the single turn comms bits (Pr <b>15/16/17.11</b> )
	9	SM-Universal Encoder Plus	Motor thermistor trip	Check motor temperature Check thermistor continuity
	10	SM-Universal Encoder Plus	Motor thermistor short circuit	Check motor thermistor wiring Replace motor / motor thermistor
	11	SM-Universal Encoder Plus	Failure of the sincos analog position alignment during encoder initialisation	Check encoder cable shield. Examine sine and cosine signals for noise.
		SM-Resolver	Poles not compatible with motor	Check that the correct number of resolver poles has been set in Pr <b>15/16/17.15</b> .
	12	SM-Universal Encoder Plus	Encoder type could not be identified during auto-configuration	Check encoder type can be auto-configured. Check encoder wiring. Enter parameters manually.
	13	SM-Universal Encoder Plus	Number of encoder turns read from the encoder during auto-configuration is not a power of 2	Select a different type of encoder.
	14	SM-Universal Encoder Plus	Number of comms bits defining the encoder position within a turn read from the encoder during auto-configuration is too large.	Select a different type of encoder. Faulty encoder.
15	SM-Universal Encoder Plus	The number of periods per revolution calculated from encoder data during auto-configuration is either <2 or >50,000.	Linear motor pole pitch / encoder ppr set up is incorrect or out of parameter range i.e. Pr <b>5.36</b> = 0 or Pr <b>21.31</b> = 0. Faulty encoder.	
16	SM-Universal Encoder Plus	The number of comms bits per period for a linear encoder exceeds 255.	Select a different type of encoder. Faulty encoder.	
74	All	Solutions Module has overheated	Check ambient temperature Check enclosure ventilation	

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<b>SLX.Er</b>	<b>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</b>																																																																																								
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<b>SLX.Er</b>	<b>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</b>
<b>SLX.HF</b>	<b>Solutions Module slot X trip: Solutions Module X hardware fault</b>
<b>200,205,210</b>	Ensure Solutions Module is installed correctly Return Solutions Module to supplier
<b>SLX.nF</b>	<b>Solutions Module slot X trip: Solutions Module has been removed</b>
<b>203,208,213</b>	Ensure Solutions Module is installed correctly Reinstall Solutions Module Save parameters and reset drive
<b>SL.rtd</b>	<b>Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect</b>
<b>215</b>	Press reset. If the trip persists, contact the supplier of the drive.
<b>SLX.tO</b>	<b>Solutions Module slot X trip: Solutions Module watchdog timeout</b>
<b>201,206,211</b>	Press reset. If the trip persists, contact the supplier of the drive.
<b>t038</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>38</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t040 to t089</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>40 to 89</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t099</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>99</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t101</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>101</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t112 to t160</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>112 to 160</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t168 to t174</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>168 to 174</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>t216</b>	<b>User trip defined in 2<sup>nd</sup> processor Solutions Module code</b>
<b>216</b>	SM-Applications program must be interrogated to find the cause of this trip
<b>th</b>	<b>Motor thermistor trip</b>
<b>24</b>	Check motor temperature Check thermistor continuity Set Pr 7.15 = VOLt and reset the drive to disable this function
<b>thS</b>	<b>Motor thermistor short circuit</b>
<b>25</b>	Check motor thermistor wiring Replace motor / motor thermistor Set Pr 7.15 = VOLt and reset the drive to disable this function
<b>tunE*</b>	<b>Autotune stopped before completion</b>
<b>18</b>	The drive has tripped out during the autotune The red stop key has been pressed during the autotune The SAFE TORQUE OFF (SECURE DISABLE) signal (terminal 31) was active during the autotune procedure
<b>tunE1*</b>	<b>The position feedback did not change or required speed could not be reached during the inertia test (see Pr 5.12)</b>
<b>11</b>	Ensure the motor is free to turn i.e. brake was released Ensure Pr 3.26 and Pr 3.38 are set correctly Check feedback device wiring is correct Check encoder coupling to motor
<b>tunE2*</b>	<b>Position feedback direction incorrect or motor could not be stopped during the inertia test (see Pr 5.12)</b>
<b>12</b>	Check motor cable wiring is correct Check feedback device wiring is correct Swap any two motor phases
<b>tunE3*</b>	<b>Drive encoder commutation signals connected incorrectly or measured inertia out of range (see Pr 5.12)</b>
<b>13</b>	Check motor cable wiring is correct Check feedback device U,V and W commutation signal wiring is correct



Trip	Diagnosis												
<b>tunE4*</b>	<b>Drive encoder U commutation signal fail during an autotune</b>												
14	Check feedback device U phase commutation wires continuity Replace encoder												
<b>tunE5*</b>	<b>Drive encoder V commutation signal fail during an autotune</b>												
15	Check feedback device V phase commutation wires continuity Replace encoder												
<b>tunE6*</b>	<b>Drive encoder W commutation signal fail during an autotune</b>												
16	Check feedback device W phase commutation wires continuity Replace encoder												
<b>tunE7*</b>	<b>Motor number of poles set incorrectly</b>												
17	Check lines per revolution for feedback device Check the number of poles in Pr 5.11 is set correctly												
<b>Unid.P</b>	<b>Power module unidentified trip</b>												
110	Check all interconnecting cables between power modules Ensure cables are routed away from electrical noise sources												
<b>UP ACC</b>	<b>Onboard PLC program: cannot access Onboard PLC program file on drive</b>												
98	Disable drive - write access is not allowed when the drive is enabled Another source is already accessing Onboard PLC program - retry once other action is complete												
<b>UP div0</b>	<b>Onboard PLC program attempted divide by zero</b>												
90	Check program												
<b>UP OFL</b>	<b>Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)</b>												
95	Check program												
<b>UP ovr</b>	<b>Onboard PLC program attempted out of range parameter write</b>												
94	Check program												
<b>UP PAr</b>	<b>Onboard PLC program attempted access to a non-existent parameter</b>												
91	Check program												
<b>UP ro</b>	<b>Onboard PLC program attempted write to a read-only parameter</b>												
92	Check program												
<b>UP So</b>	<b>Onboard PLC program attempted read of a write-only parameter</b>												
93	Check program												
<b>UP udF</b>	<b>Onboard PLC program un-defined trip</b>												
97	Check program												
<b>UP uSEr</b>	<b>Onboard PLC program requested a trip</b>												
96	Check program												
<b>UV</b>	<b>DC bus under voltage threshold reached</b>												
1	Check AC supply voltage level <table border="1"> <thead> <tr> <th>Drive voltage rating (Vac)</th> <th>Under voltage threshold (Vdc)</th> <th>UV reset voltage (Vdc)</th> </tr> </thead> <tbody> <tr> <td>200</td> <td>175</td> <td>215V</td> </tr> <tr> <td>400</td> <td>330</td> <td>425V</td> </tr> <tr> <td>575 &amp; 690</td> <td>435</td> <td>590V</td> </tr> </tbody> </table>	Drive voltage rating (Vac)	Under voltage threshold (Vdc)	UV reset voltage (Vdc)	200	175	215V	400	330	425V	575 & 690	435	590V
Drive voltage rating (Vac)	Under voltage threshold (Vdc)	UV reset voltage (Vdc)											
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\*If a tunE through tunE 7 trip occurs, then after the drive is reset the drive cannot be made to run unless it is disabled via the SAFE TORQUE OFF (SECURE DISABLE) input (terminal 31), drive enable parameter (Pr 6.15) or the control word (Pr 6.42 and Pr 6.43).

Table 13-2 Serial communications look-up table

No.	Trip	No.	Trip	No.	Trip
1	UV	40 to 89	t040 to t089	182	C.Err
2	OV	90	UP div0	183	C.dAt
3	OI.AC	91	UP PAr	184	C.FULL
4	OI.br	92	UP ro	185	C.Acc
5	PS	93	UP So	186	C.rtg
6	Et	94	UP ovr	187	C.TyP
7	O.SPd	95	UP OFL	188	C.cPr
8	PS.10V	96	UP uSEr	189	EnC1
9	PS.24V	97	UP udF	190	EnC2
10	br.th	98	UP ACC	191	EnC3
11	tunE1	99	t099	192	EnC4
12	tunE2	100		193	EnC5
13	tunE3	101	t101	194	EnC6
14	tunE4	102	Oht4.P	195	EnC7
15	tunE5	103	OIbr.P	196	EnC8
16	tunE6	104	OIAC.P	197	EnC9
17	tunE7	105	Oht2.P	198	EnC10
18	tunE	106	OV.P	199	DESt
19	It.br	107	PH.P	200	SL1.HF
20	It.AC	108	PS.P	201	SL1.tO
21	O.ht1	109	OldC.P	202	SL1.Er
22	O.ht2	110	Unid.P	203	SL1.nF
23	O.CtL	111	ConF.P	204	SL1.dF
24	th	112 to 160	t112 to t160	205	SL2.HF
25	thS	161	Enc11	206	SL2.tO
26	O.Ld1	162	Enc12	207	SL2.Er
27	O.ht3	163	Enc13	208	SL2.nF
28	cL2	164	Enc14	209	SL2.dF
29	cL3	165	Enc15	210	SL3.HF
30	SCL	166	Enc16	211	SL3.tO
31	EEF	167	Enc17	212	SL3.Er
32	PH	168 to 174	t168 to t174	213	SL3.nF
33	rS	175	C.Prod	214	SL3.dF
34	PAd	176	EnP.Er	215	SL.rtd
35	CL.bit	177	C.boot	216	t216
36	SAVE.Er	178	C.bUSY	217 to 232	HF17 to HF32
37	PSAVE.Er	179	C.Chg		
38	t038	180	C.OPtn		
39	L.SYnC	181	C.RdO		

The trips can be grouped into the following categories. It should be noted that a trip can only occur when the drive is not tripped or is already tripped but with a trip with a lower priority number.

**Table 13-3 Trip categories**

Priority	Category	Trips	Comments
1	Hardware faults	HF01 to HF16	These indicate serious internal problems and cannot be reset. The drive is inactive after one of these trips and the display shows <b>HFxx</b> . The Drive OK relay opens and the serial comms will not function.
2	Non-resetable trips	HF17 to HF32, SL1.HF, SL2.HF, SL3.HF	Cannot be reset. Requires the drive to be powered down.
3	EEF trip	EEF	Cannot be reset unless a code to load defaults is first entered in Pr <b>xx.00</b> or Pr <b>11.43</b> .
4	SMARTCARD trips	C.boot, C.Busy, C.Chg, C.OPtn, C.RdO, C.Err, C.dat, C.FULL, C.Acc, C.rtg, C.TyP, C.cpr, C.Prod	Can be reset after 1.0s SMARTCARD trips have priority 5 during power-up
4	Encoder power supply trips	PS.24V, EnC1	Can be reset after 1.0s These trips can only override the following priority 5 trips: EnC2 to EnC8 or Enc11 to Enc17
5	Autotune	tunE, tunE1 to tunE7	Can be reset after 1.0s, but the drive cannot be made to run unless it is disabled via the SAFE TORQUE OFF (SECURE DISABLE) input (terminal 31), <i>Drive enable</i> (Pr <b>6.15</b> ) or the <i>Control word</i> (Pr <b>6.42</b> and Pr <b>6.43</b> ).
5	Normal trips with extended reset	OI.AC, OI.Br, OIAC.P, OIBr.P, OldC.P	Can be reset after 10.0s
5	Normal trips	All other trips not included in this table	Can be reset after 1.0s
5	Non-important trips	th, thS, Old1, cL2, cL3, SCL	If Pr <b>10.37</b> is 1 or 3 (i.e. bit 0 set to 1), the drive will stop before tripping
5	Phase loss	PH	The drive attempts to stop before tripping
5	Drive over-heat based on thermal model	O.ht3	The drive attempts to stop before tripping, but if it does not stop within 10s the drive will automatically trip
6	Self-resetting trips	UV	Under voltage trip cannot be reset by the user, but is automatically reset by the drive when the supply voltage is with specification

Although the UV trip operates in a similar way to all other trips, all drive functions can still operate but the drive cannot be enabled. The following differences apply to the UV trip:

1. Power-down save user parameters are saved when UV trip is activated except when the main high voltage supply is not active (i.e. operating in Low Voltage DC Supply Mode, Pr **6.44** = 1).
2. The UV trip is self-resetting when the DC bus voltage rises above the drive restart voltage level. If another trip is active instead of UV at this point, the trip is not reset.
3. The drive can change between using the main high voltage supply and low voltage DC supply only when the drive is in the under voltage condition (Pr **10.16** = 1). The UV trip can only be seen as active if another trip is not active in the under voltage condition.
4. When the drive is first powered up a UV trip is initiated if the supply voltage is below the restart voltage level and another trip is not active. This does not cause save power down save parameters to be saved at this point.

## 13.2 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", "Lt" and "PLC" the drive may eventually trip. Alarms flash once every 640ms except "PLC" which flashes once every 10s. Alarms are not displayed when a parameter is being edited.

**Table 13-4 Alarm indications**

Lower display	Description
<b>br.rS</b>	Braking resistor overload
	Braking resistor I <sup>2</sup> t accumulator (Pr 10.39) in the drive has reached 75.0% of the value at which the drive will trip and the braking IGBT is active.
<b>Hot</b>	Heatsink or control board or inverter IGBT over temperature alarms are active
	<ul style="list-style-type: none"> <li>The drive heatsink temperature has reached a threshold and the drive will trip O.ht2 if the temperature continues to rise (see the O.ht2 trip).</li> <li>Or</li> <li>The ambient temperature around the control PCB is approaching the over temperature threshold (see the O.CtL trip).</li> </ul>
<b>OVLd</b>	Motor overload
	The motor I <sup>2</sup> t accumulator (Pr 4.19) in the drive has reached 75% of the value at which the drive will be tripped and the load on the drive is >100%
<b>Auto tune</b>	Autotune in progress
	The autotune procedure has been initialised. 'Auto' and 'tunE' will flash alternatively on the display.
<b>Lt</b>	Limit switch is active
	Indicates that a limit switch is active and that it is causing the motor to be stopped (i.e. forward limit switch with forward reference etc.)
<b>PLC</b>	Onboard PLC program is running
	An Onboard PLC program is installed and running. The lower display will flash 'PLC' once every 10s.

## 13.3 Status indications

**Table 13-5 Status indications**

Upper display	Description	Drive output stage
<b>Act</b>	Regeneration mode active	Enabled
	The regen unit is enabled and synchronised to the supply.	
<b>ACUJ</b>	AC Supply loss	Enabled
	The drive has detected that the AC supply has been lost and is attempting to maintain the DC bus voltage by decelerating the motor.	
<b>dc</b>	DC applied to the motor	Enabled
	The drive is applying DC injection braking.	
<b>dEC</b>	Decelerating	Enabled
	The drive is decelerating the motor.	
<b>inh</b>	Inhibit	Disabled
	The drive is inhibited and cannot be run. The drive enable signal is not applied to terminal 31 or Pr 6.15 is set to 0.	
<b>POS</b>	Positioning	Enabled
	The drive is positioning/orientating the motor shaft.	
<b>rdY</b>	Ready	Disabled
	The drive is ready to be run.	
<b>run</b>	Running	Enabled
	The drive is running.	
<b>SCAN</b>	Scanning	Enabled
	Regen> The drive is enabled and is synchronising to the line.	
<b>StoP</b>	Stop or holding zero speed	Enabled
	The drive is holding zero speed. Regen> The drive is enabled but the AC voltage is too low, or the DC bus voltage is still rising or falling.	
<b>triP</b>	Trip condition	Disabled
	The drive has tripped and is no longer controlling the motor. The trip code appears on the lower display .	

**Table 13-6 Solutions Module and SMARTCARD status indications at power-up**

Lower display	Description
<b>boot</b>	A parameter set is being transferred from the SMARTCARD to the drive during power-up. For further information, please refer to section 9.2.4 <i>Booting up from the SMARTCARD on every power up (Pr 11.42 = boot (4))</i> on page 141.
<b>cArd</b>	The drive is writing a parameter set to the SMARTCARD during power-up. For further information, please refer to section 9.2.3 <i>Auto saving parameter changes (Pr 11.42 = Auto (3))</i> on page 141.
<b>loAding</b>	The drive is writing information to a Solutions Module.

## 13.4 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 multi-module drive module number (Pr 6.49 = 0) or the trip time (Pr 6.49 = 1) for each trip in Pr 10.41 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 module number or trip time stored in Pr 10.41 and Pr 10.42). Pr 10.29 is the oldest trip (with the module number or trip time 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 10.41 to Pr 10.42) 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 13-1 *Trip indications* on page 261 is the value transmitted.

## 13.5 Behaviour of the drive when tripped

If the drive trips, the output of the drive is disabled so that the drive stops controlling the motor. If any trip occurs (except the UV trip) the following read only parameters are frozen until the trip is cleared. This is to help in diagnosing the cause of the trip.

Parameter	Description
1.01	Frequency/speed reference
1.02	Pre-skip filter reference
1.03	Pre-ramp reference
2.01	Post-ramp reference
3.01	Frequency slaving demand/Final speed ref
3.02	Speed feedback
3.03	Speed error
3.04	Speed controller output
4.01	Current magnitude
4.02	Active current
4.17	Reactive current
5.01	Output frequency
5.02	Output voltage
5.03	Power
5.05	DC bus voltage
7.01	Analog input 1
7.02	Analog input 2
7.03	Analog input 3

### Analog and digital I/O

The analog and digital I/O on the drive continue to work correctly if a trip occurs, except the digital outputs will go low if one of the following trips occur: O.Ld1, PS.24V.

### Drive logic functions

The drive logic functions (i.e. PID, variable selectors, threshold detectors, etc.) continue to operate when the drive is tripped.

### Onboard PLC program

The Onboard PLC program continues to run if the drive is tripped, except if one of Onboard PLC program trips occur.

### Braking IGBT

The braking IGBT continues to operate even when the output of the drive is not enabled (except if the low voltage DC supply is being used), but is only disabled if any of the following trips occurs or would occur if another trip had not already become active: OI.Br, PS, It.Br, OV or any HFxx trip.

## 14 UL Listing Information

SPz drives have been assessed to meet UL requirements.

Size 1 to 6 drives have been assessed to meet both UL and cUL requirements.

### 14.1 Common UL information

#### Conformity

The drive conforms to UL listing requirements only when the following are observed:

- The drive is installed in a type 1 enclosure, or better, as defined by UL50
- The ambient temperature does not exceed 40°C (104°F) when the drive is operating
- The terminal tightening torques specified in section 3.12.2 *Terminal sizes and torque settings* on page 55
- If the drive control stage is supplied by an external power supply (+24V), the external power supply must be a UL Class 2 power supply

#### Motor overload protection

The drive provides motor overload protection. The default overload protection level is no higher than 150% of full-load current (FLC) of the drive in open loop mode and no higher than 175% of full-load current (FLC) of the drive in closed loop vector or servo modes. It is necessary for the motor rated current to be entered into Pr **0.46** (or Pr **5.07**) for the protection to operate correctly. The protection level may be adjusted below 150% if required. Refer to section 8.3 *Current limits* on page 136 for more information. The drive also provides motor thermal protection. Refer to section 8.4 *Motor thermal protection* on page 136.

#### Overspeed Protection

The drive provides overspeed protection. However, it does not provide the level of protection afforded by an independent high integrity overspeed protection device.

### 14.2 Power dependant UL information

#### Conformity

The drive conforms to to UL listing requirements only when the following is observed.

#### Fuses

##### SPz and sizes 1 to 3

- The correct UL-listed fast acting fuses (class CC or class J up to 30A and class J above 30A), e.g. Bussman Limitron KTK-R series, Ferraz Shawmut ATMR series or equivalent, are used in the AC supply. The drive does not comply with UL if MCBs are used in place of fuses.

For further details on fusing, refer to in Table 4-3 and Table 4-4 on page 64.

##### Sizes 4 to 6

- The UL-listed Ferraz HSJ (High speed J class) fuses are used in the AC supply. The drive does not comply with UL if any other fuses or MCBs are used in place of those stated.

For further details on fusing, refer to Table 4-5 on page 65.

#### Field wiring

##### SPz and sizes 1 to 4

- Class 1 60/75°C (140/167°F) copper wire only is used in the installation

##### Sizes 5 and 6

- Class 1 75°C (167°F) copper wire only is used in the installation

#### Field wiring connectors

##### Sizes 4 to 6

- UL listed wire connectors are used for terminating power circuit field wiring, e.g. IIsco TA series

### 14.3 AC supply specification

The drive is suitable for use in a circuit capable of delivering not more than 100,000rms symmetrical Amperes at 264Vac rms maximum (200V drives), 528Vac rms maximum (400V drives) or 600Vac rms maximum (575V and 690V drives).

### 14.4 Maximum continuous output current

The drive models are listed as having the maximum continuous output currents (FLC) shown in Table 14-1, Table 14-2, Table 14-3 and Table 14-4 (see Chapter 12 *Technical Data* on page 242 for details).

**Table 14-1 Maximum continuous output current (200V drives)**

Model		FLC (A)	Model		FLC (A)
LS	CT		LS	CT	
SPz 1M/TL	0201	2.2	SP 4.5TL	2201	15.5
SPz 1.2M/TL	0202	3.1	SP 5.5TL	2202	22
SPz 1.5M/TL	0203	4.0	SP 8TL	2203	28
SPz 2M/TL	0204	5.7	SP11TL	3201	42
SPz 2.5M/TL	0205	7.5	SP 16TL	3202	54
SP 1.5TL	1201	5.2	SP 22TL	4201	68
SP 2TL	1202	6.8	SP 27TL	4202	80
SP 2.5TL	1203	9.6	SP 33TL	4203	104
SP 3.5TL	1204	11	SP 40TL	5201	130
			SP 50TL	5202	154

**Table 14-2 Maximum continuous output current (400V drives)**

Model		FLC (A)	Model		FLC (A)
LS	CT		LS	CT	
SPz 1T	0401	1.3	SP 8T	2401	15.3
SPz 1.2T	0402	1.7	SP 11T	2402	21
SPz 1.5T	0403	2.1	SP 16T	2403	29
SPz 2T	0404	3.0	SP 22T	3401	35
SPz 2.5T	0405	4.2	SP 27T	3402	43
SP 1.5T	1401	2.8	SP 33T	3403	56
SP 2T	1402	3.8	SP 40T	4401	68
SP 2.5T	1403	5.0	SP 50T	4402	83
SP 3.5T	1404	6.9	SP 60T	4403	104
SP 4.5T	1405	8.8	SP 75T	5401	138
SP 5.5T	1406	11	SP 100T	5402	168
			SP 120T	6401	205
			SP 150T	6402	236

**Table 14-3 Maximum continuous output current (575V drives)**

Model		FLC (A)	Model		FLC (A)
LS	CT		LS	CT	
SP 3.5TM	3501	5.4	SP 11TM	3505	16
SP 4.5TM	3502	6.1	SP 16TM	3506	22
SP 5.5TM	3503	8.3	SP 22TM	3507	27
SP 8TM	3504	11			

**Table 14-4 Maximum continuous output current (690V drives)**

Model		FLC (A)	Model		FLC (A)
LS	CT		LS	CT	
SP 22TH	4601	22	SP 75TH	5601	84
SP 27TH	4602	27	SP 100TH	5602	99
SP 33TH	4603	36	SP 120TH	6601	125
SP 40TH	4604	43	SP 150TH	6602	144
SP 50TH	4605	52			
SP 60TH	4606	62			

## 14.5 Safety label

The safety label supplied with the connectors and mounting brackets must be placed on a fixed part inside the drive enclosure where it can be seen clearly by maintenance personnel for UL compliance.

The label clearly states "CAUTION Risk of Electric Shock Power down unit 10 minutes before removing cover".

## 14.6 UL listed accessories

- SM-Keypad
- SM-Keypad Plus
- SM-I/O Plus
- SM- Ethernet
- SM-CANopen
- SM-Universal Encoder Plus
- SM-Resolver
- SM-Encoder Plus
- SM-I/O Lite
- SM-LON
- SM-Applications Plus
- 15-way D-type converter
- SM-Encoder Output Plus
- SM-PROFIBUS-DP
- SM-DeviceNet
- SM-I/O Timer
- SM-INTERBUS
- SM-Applications Lite
- SM-Applications
- SM-I/O 32
- SM-SERCOS
- SM-I/O Timer

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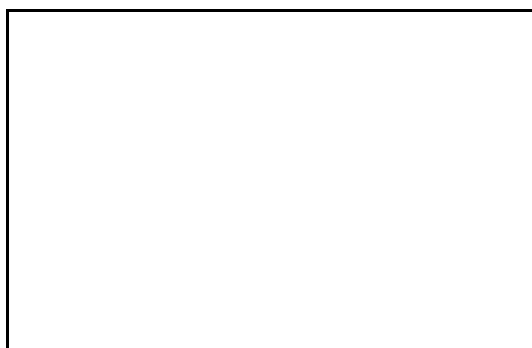
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