Advanced User Guide

Unidrive SP

Universal Variable Speed AC Drive for induction and servo motors

Part Number: 0471-0002-11
Issue: 11

Original Instructions

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

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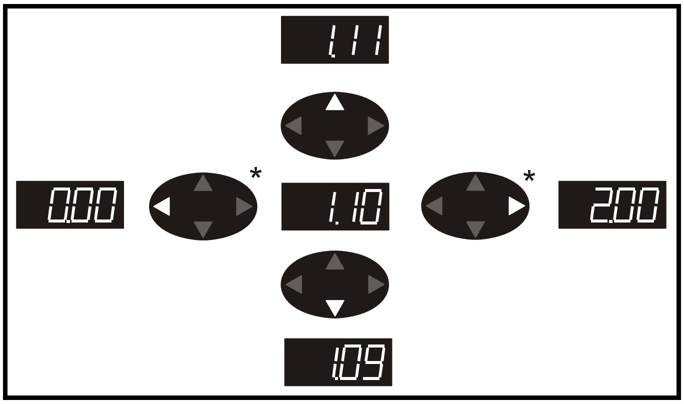
1 Parameter structure

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 in Pr **0.49**, and the left and right buttons are used to navigate between menus. For further information, see section 2.7 *Parameter access level and security* on page 13.

Figure 1-1 Parameter navigation

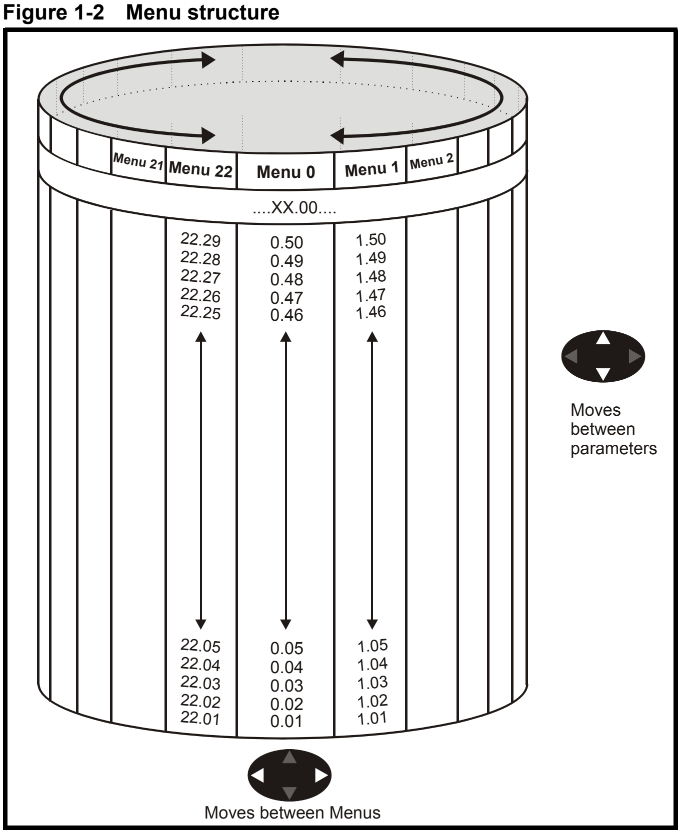


* can only be used to move between menus if L2 access has been enabled (Pr **0.49**).

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.

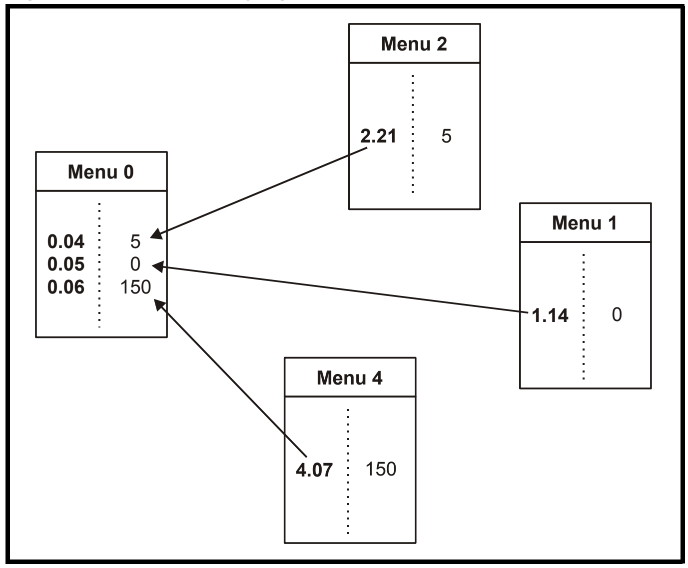
Figure 1-2 Menu structure



1.1 Menu 0

Menu 0 has up to 19 fixed parameters and 40 programmable parameters that are defined in menu 11 and menu 22. Menu 0 parameters are copies of advanced menu parameters, and although these parameters are accessible via drive serial comms, they are not accessible to any Solutions Modules. All menu 0 read/write parameters are saved on exiting the edit mode. Table 1-1 gives the default structure for each drive type setting. Where alternative parameters are selected with motor map 2 from menu 21 these are shown below the motor map 1 parameters.

Figure 1-3 Menu 0 copying



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.

Table 1-1 Menu 0 parameters

Parameter			Range(⇕) OL	Range(⇕) VT	Range(⇕) SV	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.00	**xx.00**	{**x.00**}	0 to 32,767			0			RW	Uni				
0.01	Minimum reference clamp	{**1.07**}	±3,000.0Hz	±SPEED_LIMIT_MAX Hz/rpm		0.0			RW	Bi			PT	US
0.02	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
0.03	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
0.04	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
0.05	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
0.06	Current limit	{**4.07**}	0 to Current_limit_max %			165.0	175.0		RW	Uni		RA		US
0.07	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^{-1}			0.0300	0.0100	RW	Uni				US
0.08	OL> Voltage boost	{**5.15**}	0.0 to 25.0% of motor rated voltage			Size 0 to 3: 3.0 Size 4 & 5: 2.0 Size 6 to 9: 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
0.09	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
0.10	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	
0.11	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^{16}ths of a revolution				RO	Uni	FI	NC	PT	
0.12	Total motor current	{**4.01**}	0 to Drive_current_max A						RO	Uni	FI	NC	PT	
0.13	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
0.14	Torque mode selector	{**4.11**}	0 to 1	0 to 4		Speed control mode (0)			RW	Uni				US
0.15	Ramp mode select	{**2.04**}	FASt (0) Std (1) Std.hV (2)	FASt (0) Std (1)		Std (1)			RW	Txt				US
0.16	OL> T28 and T29 auto-selection disable	{**8.39**}	OFF (0) or On (1)			0			RW	Bit				US
	CL> Ramp enable	{**2.02**}		OFF (0) or On (1)			On (1)		RW	Bit				US
0.17	OL> T29 digital input destination	{**8.26**}	Pr **0.00** to Pr **21.51**			Pr **6.31**			RW	Uni	DE		PT	US
	CL> Current demand filter time constant	{**4.12**}		0.0 to 25.0 ms			0.0		RW	Uni				US
0.18	Positive logic select	{**8.29**}	OFF (0) or On (1)			On (1)			RW	Bit			PT	US
0.19	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
0.20	Analog input 2 destination	{**7.14**}	Pr **0.00** to Pr **21.51**			Pr **1.37**			RW	Uni	DE		PT	US
0.21	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
0.22	Bipolar reference select	{**1.10**}	OFF (0) or On (1)			OFF (0)			RW	Bit				US
0.23	Jog reference	{**1.05**}	0 to 400.0 Hz	0 to 4000.0 rpm		0.0			RW	Uni				US
0.24	Pre-set reference 1	{**1.21**}	±Speed_limit_max rpm			0.0			RW	Bi				US
0.25	Pre-set reference 2	{**1.22**}	±Speed_limit_max rpm			0.0			RW	Bi				US
0.26	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
0.27	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
0.28	Keypad fwd/rev key enable	{**6.13**}	OFF (0) or On (1)			OFF (0)			RW	Bit				US

Parameter			Range(⇕) OL	Range(⇕) VT	Range(⇕) SV	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
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	Drive rated current	{**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	

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

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.

1.2 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. These are accessible via the keypad, drive serial comms and Solutions Modules. All advanced menu parameters are only saved by setting Pr **x.00** to 1000 and applying a reset (except parameters shown as power-down saved which are saved automatically at power-down). The advanced menus are accessible when the user selects L2 in Pr **11.44** (Pr **0.49** in menu 0). This can be done even if security is programmed. Pr **11.44** can be saved in EEPROM so that either Menu 0 only, or Menu 0 and the advanced menus are accessible at power-up.

Menu	Function
1	Speed reference selection, limits and filters
2	Ramps
3	Speed feedback and speed control
4	Current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
9	Programmable logic and motorized pot
10	Drive status and trip information
11	Miscellaneous
12	Programmable threshold, variable selector and brake control function
13	Position control
14	User PID controller
15	Slot 1 Solutions Module menu
16	Slot 2 Solutions Module menu
17	Slot 3 Solutions Module menu
18	User application menu 1 (saved in drive EEPROM)
19	User application menu 2 (saved in drive EEPROM)
20	User application menu 3 (not saved in drive EEPROM)
21	Second motor map
22	Additional menu 0 set-up

1.3 Solutions Modules

Any Solutions Module type is recognized with all drive types in any slots. The relevant template is used to define menu 15 for the module type installed in slot 1, menu 16 for slot 2, and menu 17 for slot 3.

1.4 Drive software version

This product is supplied with the latest software version. If this drive is to be connected to an existing system or machine, all drive software versions should be verified to confirm the same functionality as drives of the same model already present. This may also apply to drives returned from a Control Techniques Service Centre or Repair Centre. If there is any doubt please contact the supplier of the product.

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

2 Keypad and display

2.1 Understanding the display

There are two keypads available for the Unidrive SP. The SM-Keypad has an LED display and the SM-Keypad Plus has an LCD display. Both keypads can be installed to the drive but the SM-Keypad Plus can also be remotely mounted on an enclosure door.

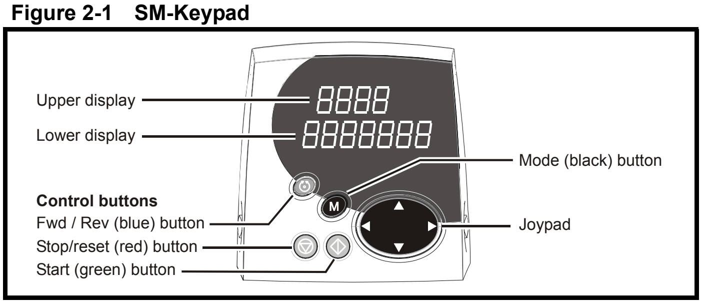
2.1.1 SM-Keypad / SP0-Keypad

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 2-1 SM-Keypad



2.1.2 SM-Keypad Plus

The display consists of three lines of text.

The top line shows the drive status or the current menu and parameter number being viewed on the left, and the parameter value or the specific trip type on the right.

The lower two lines show the parameter name or the help text.

Features :

- Parameter names displayed
- Units displayed (Hz, A, rpm, %)
- Parameter help text
- Diagnostics help text
- 5 language support: (English, French, German, Spanish and Italian)
- Displays SM-Applications virtual parameters: Menus 70 to 91
- Hardware key using the SM-Keypad Plus as a key to modify the drive set-up
- User defined parameter set
- Browsing filter
- Adjustable contrast

Figure 2-2 SP0 Keypad

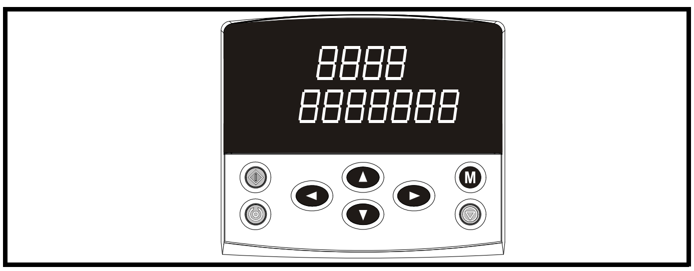
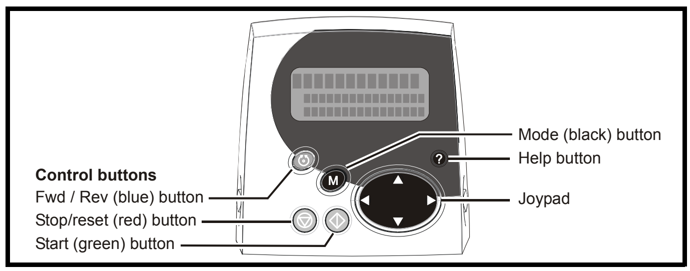


Figure 2-3 SM-Keypad Plus



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

2.2 Keypad operation

2.2.1 Control buttons

The keypad consists of:

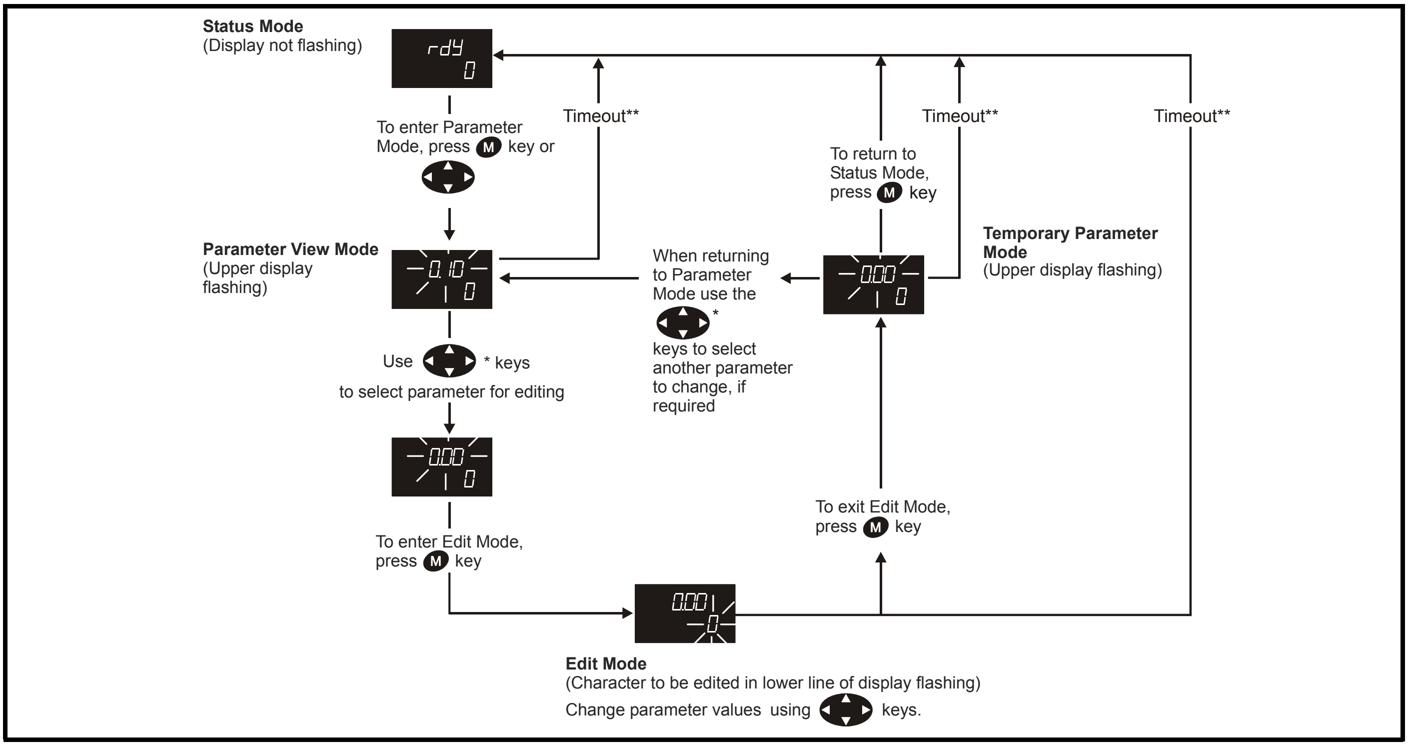
1. Joypad - used to navigate the parameter structure and change parameter values.
2. Mode button - used to change between the display modes – parameter view, parameter edit, status.
3. Three control buttons - used to control the drive if keypad mode is selected.
4. Help button (SM-Keypad Plus only) -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

The drive parameters are accessed as shown in Figure 2-4.

Figure 2-4 Display modes



2.3 Status mode

In status mode the 1st row shows a four letter mnemonic indicating the status of the drive. The second row show the parameter last viewed or edited.

State	Upper row
Inhibited: enable input is inactive	inh
Ready: enable closed, but inverter not active	rdY
Stopped: inverter active, but holding zero speed/frequency	StoP
Running: inverter active and motor running	run
Scanning: trying to synchronise in regen mode	SCAn
Mains loss: decelerating to zero in mains loss ride-through or stop modes	ACUU
Decelerating: speed/frequency is ramping to zero after a stop	dEC
DC injection: DC injection stop is active	dC
Position: position control active during orientation stop	POS
Tripped: drive is tripped	triP
Active: regen unit is synchronised and the inverter is active	ACt

2.4 Parameter view mode

In this mode the 1st row shows the menu.parameter number and the 2nd row the parameter value. The 2nd row gives a parameter value range of -999,999 to 9,999,999 with or without decimal points. (32 bit parameters can have values outside this range if written by an application module. If the value is outside this range "-------"is shown and the parameter value cannot be changed from the keypad). The Up and Down keys are used to select the parameter and the Left and Right keys are used to select the menu. In this mode the Up and Down keys are used to select the parameter within the selected menu. Holding the Up key will cause the parameter number to increment until the top of the menu is reached. A single Up key action when the last parameter in a menu is being displayed will cause the parameter number to roll over to Pr **x.00**.

Similarly holding the Down key will cause the parameter number to decrement until Pr **x.00** is reached and a single Down key action will cause the parameter number to roll under to the top of the menu. Pressing the Up and Down keys simultaneously will select Pr **x.00** in the currently selected menu.

The Left and Right keys are used to select the required menu (provided the security has been unlocked to allow access to menus other than 0). Holding the Right key will cause the menu number to increment until the Menu 22 is reached. A single Right key action when Menu 22 is being displayed will cause the menu number to roll over to 0. Similarly holding the Left key will cause the menu number to decrement to 0 and a single key action will cause the menu number to roll under to Menu 22. Pressing the Left and Right keys simultaneously will select Menu 0.

The drive remembers the parameter last accessed in each menu such that when a new menu is entered the last parameter viewed in that menu will re-appear.

2.5 Edit mode

Up and Down keys are used to increase and decrease parameter values respectively. If the maximum value of a parameter is greater than 9 and it is not represented by strings, then the Left and Right keys can be used to select a digit to adjust. The number of digits which can be independently selected for adjustment depends on the maximum value of the parameter. Pressing the Right key when the least significant digit is selected will cause the most significant digit to be selected, and vice-versa if the Left key is pressed when the most significant digit is selected. When a digit value is not being changed by the Up or Down keys the selected digit flashes to indicate which one is currently selected. For string type parameters the whole string flashes when adjustment is not occurring because there is no digit selection.

During adjustment of a parameter value with the Up or Down keys the display does not flash, providing the parameter value is in range, such that the user can see the value being edited without interruption. Adjustment of a numerical value can be done in one of two ways; firstly by using the Up and Down keys only, the selected digit remaining the least significant digit; and secondly by selecting each digit in turn and adjusting them to the required value.

Holding the Up or Down key in the first method will cause the parameters value to change more rapidly the longer the key is held, until such time that the parameters maximum or minimum is reached.

However with the second method an increasing rate of change does not take place when adjusting any other digit other than the least significant digit since a digit can only have one of 10 different values. Holding the Up or Down will cause an auto repeat and roll over to more significant digits but the rate of change is unaltered. If the maximum or minimum is exceeded when adjusting any other digit than the least significant one, the maximum value will flash on the display to warn the user that the maximum or minimum has been reached. If the user releases the Up or Down key before the flashing stops the last in range value will re-appear on the display. If the Up or Down key is held the display will stop flashing after three seconds and the maximum value will be written to the parameter.

Parameters can be set to 0 by pressing the Up and Down keys simultaneously.

2.6 SM-Keypad Plus

All SM-Keypad Plus displays built after data code N10 have software version 4.02.00 programmed and support 5 languages (English, French, German, Spanish and Italian) in addition to a user defined parameter set. This software also gives the user access to two menus for SM-Keypad Plus. Menu 40 is for SM-Keypad Plus set up, menu 41 selects commonly used parameters for quick browsing.

Keypads built prior to N10 only support one user defined extra parameter set only.

The SM-Keypad Plus contains two menus, menu 40 and menu 41. The parameters in these menus are listed below.

Table 2-1 Menu 40 parameter descriptions

Parameter		Range(⇕)	Default(⇨)	Type					
40.00	Parameter 0	0 to 32767	0	RW	Uni				
40.01	Language selection	English (0), Custom (1), French (2), German (3), Spanish (4), Italian (5)	English (0)	RW	Txt				US
40.02	Software version	999999		RO	Uni			PT	
40.03	Save to flash	Idle (0), Save (1), Restore (2), Default (3)	Idle (0)	RW	Txt				
40.04	LCD contrast	0 to 31	16	RW	Uni				US
40.05	Drive and attribute database upload was bypassed	Updated (0), Bypass (1)		RO	Txt			PT	
40.06	Browsing favourites control	Normal (0), Filter (1)	Normal (0)	RW	Txt				
40.07	Keypad security code	0 to 999	0	RW	Uni				US
40.08	Communication channel selection	Disable (0), Slot1 (1), Slot2 (2), Slot3 (3), Slave (4), Direct (5)	Disable (0)	RW	Txt				US
40.09	Hardware key code	0 to 999	0	RW	Uni				US
40.10	Drive node ID (Address)	0 to 255	1	RW	Uni				US
40.11	Flash ROM memory size	4Mbit (0), 8Mbit (1)		RO	Txt			PT	US
40.19	String database version number	0 to 999999		RO	Uni			PT	
40.20	Screen saver strings and enable	None (0), Default (1), User (2)	Default (1)	RW	Txt				US
40.21	Screen saver interval	0 to 600	120	RW	Uni				US
40.22	Turbo browse time interval	0 to 200ms	50ms	RW	Uni				US

Table 2-2 Menu 41 parameter descriptions

Parameter		Range(⇕)	Default(⇨)	Type					
41.00	Parameter 0	0 to 32767	0	RW	Uni				
41.01 to 41.50	Browsing filter source F01 to F50	Pr **0.00** to Pr **391.51**	0	RW	Uni				
41.51	Browsing favourites control	Normal (0), Filter (1)	Normal (0)	RW	Txt				

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 about the SM-Keypad Plus, see the *SM-Keypad Plus User Guide*.

2.7 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.

2.7.1 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**

2.7.2 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.

2.7.3 User Security

The User Security, when set, prevents write access to any of the parameters (other than Pr. **0.49** 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.

2.8 Alarm and trip display

An alarm can flash alternately with the data displayed on the 2nd row when one of the following conditions occur. If action is not taken to eliminate the alarm, except "Auto tune", "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.

Alarm string	Alarm condition
br.rS	Braking resistor (Pr **10.39** > 75.0% and the braking IGBT is active)
OVLd	Motor overload (Pr **4.20** > 75% and the drive output current > Pr **5.07**)
hot	Heatsink or control board alarms are active
Auto tunE	Auto tune in progress
Lt	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).
PLC	On-board PLC program is running

When a trip occurs the drive switches to status mode and "trip" is shown on the 1st row and the trip string flashes on the 2nd row. If the trip is a power module trip and the drive is a multi-module drive, the number of the power module that initiated the trip flashes alternately with the trip string. The read only parameters listed below are frozen with any trip except UV trip until the trip is cleared. For a list of the possible trip strings see Pr **10.20**. Pressing any of the parameter keys changes the mode to the parameter view mode. If the trip is HF01 to HF16 then no key action is recognized.

Parameter	Description
1.01	Frequency reference/Speed reference
1.02	Frequency reference/Speed reference
1.03	Pre-ramp reference
2.01	Post-ramp reference
3.01	Frequency slaving demand/ Final speed reference/ Reactive power
3.02	Speed feedback
3.03	Speed error
3.04	Speed controller output
4.01	Current magnitude
4.02	Active current
4.17	Magnetising 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

2.9 Keypad control mode

The drive can be controlled from the keypad if Pr **1.14** is set to 4. The Stop and Run keys automatically become active (the Reverse key may be optionally enabled with Pr **6.13**). The frequency/speed reference is defined by Pr **1.17**. This is a read only parameter that can only be adjusted in status mode by pressing the Up or Down keys. If keypad control mode is selected, then pressing the Up or Down keys in status mode will cause the drive to automatically display the keypad reference and adjust it in the relevant direction. This can be done whether the drive is disabled or running. If the Up or Down keys are held the rate of change of keypad reference increases with time.

The units used for to display the keypad reference for different modes are given below.

Mode	Unit
Open loop	Hz
Closed loop	rpm
Servo	rpm

2.10 Drive reset

A drive reset is required to: reset the drive from a trip (except some “HFxx” trips which cannot be reset); and other functions as defined in section 3 *Parameter x.00* on page 16. A reset can be performed in four ways:

1. Stop key: If the drive has been set up such that the stop key is not operative then the key has a drive reset function only. When the stop function of the stop key is enabled, a reset is initiated while the drive is running by holding the Run key and then pressing the Stop key. When the drive is not running the Stop key will always reset the drive.
2. The drive resets after a 0 to 1 transition of the Drive Reset parameter (Pr **10.33**). A digital input can be programmed to change this parameter.
3. Serial comms, fieldbus or applications Solutions Module: Drive reset is triggered by a value of 100 being written to the User trip parameter (Pr **10.38**).
4. Auto reset: Pr **10.34** can be used to provide an auto-reset function.

If the drive trips EEF (internal EEPROM error) then it is not possible to reset the drive using the normal reset methods described above. 1233 or 1244 must be entered into Pr **x.00** before the drive can be reset. Default parameters are loaded after an EEF trip, and so the parameters should be reprogrammed as required and saved in EEPROM.

If the drive is reset after a trip from any source other than the Stop key, the drive restarts immediately, if:

1. A non-latching sequencer is used with the enable active and one of run forward, run reverse or run active
2. A latching sequencer is used if the enable and not stop are active and one of run forward, run reverse or run is active.

If the drive is reset with the Stop key the drive does not restart until a not active to active edge occurs on run forward, run reverse or run.

2.11 Second motor parameters

An alternative set of motor parameters are held in menu 21 which can be selected by Pr **11.45**. When the alternative parameter set is being used by the drive the decimal point after the right hand digit in the 1st row is on.

2.12 Special display functions

The following special display functions are used.

1. If the second motor map is being used the decimal point second from the right of the first row is on.
2. When parameters are saved to a SMARTCARD the right-most decimal point on the first row flashes for 2 seconds.

During power up one or more of the following actions may be required. Each action may take several seconds, and so special display strings are shown.

Display string	Action
boot	If a SMARTCARD is present with Pr **11.42** set to boot the parameters from the card must be transferred to the drive EEPROM.
card	If the drive is in auto or boot mode (Pr **11.42** set to 3 or 4) the drive ensures that the data on the card is consistent with the drive by writing to the card.
loading	It may be necessary for a Solutions Module to transfer parameter information from the drive. This is only carried out if the parameter information held by the Solutions Module is for a different drive software version. The drive allows up to five seconds for this process.

3 Parameter x.00

Parameter **x.00** is available in all menus and has the following functions.

Value	Action
1000	Save parameters when under voltage is not active (Pr **10.16** = 0) and 48V supply is not active (Pr **6.44** = 0).
1001	Save parameters under all conditions
1070	Reset all Solutions 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 parameter to a card and create a bootable difference from default SMART card block with data block number 1 and clear Pr **11.42**. If data block 1 exists it is over written.
3yyy	Transfer drive EEPROM data to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive ladder program to SMARTCARD block number yyy
6yyy	Transfer SMARTCARD data block yyy to the drive
7yyy	Erase SMARTCARD data block yyy
8yyy	Compare drive parameters with block yyy
9555	Clear SMART card warning suppression flag
9666	Set SMART card warning suppression flag
9777	Clear SMARTCARD read-only flag
9888	Set SMARTCARD read-only flag
9999	Erase SMARTCARD
110zy	Transfer electronic nameplate parameters to/from drive from/to encoder
*12000	Display non-default values only
*12001	Display destination parameters only

*These functions do not require a drive reset to become active. All other functions require a drive reset.

3.1 Parameter x.00 reset

When an action is started by setting Pr **x.00** to one of the above values and initiating a drive reset this parameter is cleared when the action is completed successfully. If the action is not started, e.g. because the drive is enabled and an attempt is made to load defaults, etc., Pr **x.00** is not cleared and no trip is produced. If the action is started and then fails for some reason a trip is always produced and Pr **x.00** is not cleared. It should be noted that parameter saves etc. can also be initiated with the copying parameter (Pr **11.42**). If actions that can be initiated by either parameter are started and then completed successfully Pr **x.00** is cleared and Pr **11.42** is cleared if it has a value of less than 3.

It should be noted that there could be some conflict between the actions of Pr **x.00** and Pr **11.42** (Parameter copying) when the drive is reset. If Pr **11.42** has a value of 1 or 2 and a valid action is required from the value of Pr **x.00** then only the action required by Pr **x.00** is performed. Pr **x.00** and Pr **11.42** are then reset to zero. If Pr **11.42** has a value of 3 or 4 it will operate correctly causing parameters to be save to a smart card each time a parameter save is performed.

3.2 Saving parameters in drive EEPROM

Drive parameters are saved to drive EEPROM by setting Pr **x.00** to 1000 or 1001 and initiating a drive reset. In addition to user save parameters, power down save parameters are also saved by these actions and by changing drive mode, but not by any other actions that result in parameters being saved to drive EEPROM (i.e. loading defaults). Power down save parameters are not saved at power down unless the drive is supplied from a normal mains supply, and so this gives the user the option of saving these parameters when required. When the parameter save is complete Pr **x.00** is reset to zero by the drive. Care should be taken when saving parameters because this action can take between 400ms and several seconds depending on how many changes are stored in the EEPROM. If the drive is powered down during a parameter save it is possible that data may be lost. When the drive is operating from a normal mains supply then it will stay active for a short time after the power is removed, however, if the drive is being powered from a 24V control supply, or it is being operated from a low voltage battery supply, the drive will power down very quickly after the supply is removed. The drive provides two features to reduce the risk of data loss when the drive is powered down.

1. If Pr **x.00** is set to 1000 a parameter save is only initiated on drive reset if the drive is supplied from a normal mains supply (Pr **10.16** = 0 and Pr **6.44** = 0). 1001 must be used to initiate a save if the drive is not supplied from a normal mains supply.
2. Two banks of arrays are provided in EEPROM to store the data. When a parameter save is initiated the data is stored in a new bank and only when the data store is complete does the new bank become active. If the power is removed before the parameter save is complete a SAVE.Er trip (user save parameter save error) or PSAVE.Er trip (power down save parameter save error) will be produced when the drive is powered up again indicating that the drive has reverted to the data that was saved prior to the last parameter save.

The second feature will significantly reduce the possibility of completely invalidating all saved data, which would result in an EEF trip on the next power-up. However the following points should be noted:

1. If the power is removed during a parameter save the current data that is being saved to the EEPROM that is different from the last data saved in the EEPROM will be lost and SAVE.Er or PSAVE.Er trip will occur on power-up.
2. This feature does not apply when user save parameters are saved automatically by adjusting the values in menu 0 with an LED keypad. However, the time taken to save parameters in this way is very short, and is unlikely to cause data loss if the power is removed after the parameter has been changed. It should be noted that any parameter changes made in this way are included in the currently active bank in the EEPROM, so that if the power is removed during a subsequent save initiated via Pr **x.00** that results in an SAVE.Er trip, the changes made via menu 0 will be retained and not lost.
3. User save parameters are saved to drive EEPROM after a transfer of data from an electronic nameplate in an encoder.
4. User save parameters are saved to drive EEPROM after a transfer of data from a SMART card.
5. This feature is not provided for data saved to a SMART card, and so it is possible to corrupt the data files on a SMART card if the power is removed when data is being transferred to the card.
6. User save parameters are saved to drive EEPROM after defaults are loaded.

7. When the drive mode is changed all data in the EEPROM is deleted and then restored with the defaults for the new mode. If the power is removed during a change of drive mode, an EEF trip is likely to occur on the next power-up. After a change of drive mode the power down save parameters are also saved. As these parameters are not saved if the power is removed unless the drive is supplied with a normal mains supply, this ensures that the power down save parameters are always stored correctly for the new drive mode. The first time parameters are saved after the change of drive mode the save will take slightly longer than a normal parameter save.
8. When a Solutions Module is changed for a different type in a slot, or a module is inserted when one was not present previously or a module is removed the EEPROM is forced to re-initialise itself on the next parameter saves. On the first parameter save one bank is cleared and then written and on the next parameter save the other bank is cleared and rewritten. Each of these parameter saves takes slightly longer than a normal parameter save.
9. The new system has been introduced for user save parameter in V01.07.00 software, and power down save parameters in V01.08.00 software. When the firmware is updated from an earlier version the drive will automatically update the EEPROM correctly. If the software is changed back to an earlier version defaults should be loaded after the change. If it is subsequently changed back to V01.07.00/ V01.08.00 or later defaults should be loaded after the change.

3.3 Loading defaults

When defaults are loaded the user save parameters are automatically saved to the drive EEPROM in all modes. Standard defaults are loaded by setting 1233 in Pr **x.00** performing a drive reset.

The following differences from standard defaults are available when different values are set in Pr **x.00**.

US Default Differences (Pr **x.00** = 1244 and perform a drive reset)

Pr	Description	Default	Modes	Voltage rating
1.06	Max reference clamp	60.0Hz	Open-loop	All
1.06	Max reference clamp	1800rpm	Closed-loop vector	All
2.08	Standard ramp volts	775V	Open-loop, Closed-loop vector, Servo	400V
5.06	Rated frequency	60.0Hz	Open-loop	All
5.08	Rated load rpm	1800rpm	Open-loop	All
5.08	Rated load rpm	1770rpm	Closed-loop vector	All
5.09	Rated voltage	460V	Open-loop, Closed-loop vector, Servo	400V
21.01	M2 Max reference clamp	60.0Hz	Open-loop	All
21.01	M2 Max reference clamp	1800rpm	Closed-loop vector	All
21.06	M2 Rated frequency	60.0Hz	Open-loop	All
21.09	M2 Rated voltage	460V	Open-loop, Closed-loop vector, Servo	400V

3.4 SMARTCARD transfers

Drive parameters, set-up macros and internal ladder programs can be transferred to/from SMARTCARDs. See Pr **11.36** to Pr **11.40**.

3.5 Electronic nameplate transfers

Some encoders using Stegmann Hiperface or EnDat comms can hold motor data. The data can be transferred to/from the encoder by writing 110zy to parameter x.00 and resetting the drive where z is 0 for the drive or 1, 2 or 3 for Solutions Module slots 1, 2 or 3 respectively. See Chapter 8 *Electronic nameplate* on page 408 for details.

3.6 Display non-default values or destination parameters

If a value of 12000 is written to Pr **x.00**, then only parameters that are different from the last defaults loaded and Pr **x.00** are displayed. If a value of 12001 is written to Pr **x.00**, then only destination parameters are displayed. This function is provided to aid locating destination clashes if a dESt trip occurs.

4 Parameter description format

In the following sections descriptions are given for the advanced parameter set. With each parameter the following information block is given.

5.11	Number of motor poles															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 60 (Auto to 120 POLE)														
Default	Open-loop, Closed-loop vector Servo	0 (Auto) 3 (6 POLE)														
Second motor parameter	Open-loop, Closed-loop vector, Servo	Pr **21.11**														
Update rate	Background read															

The top row gives the menu parameter number and name. The other rows provide the following information.

Drive modes
The drive modes are the modes in which this parameter is accessible. If the parameter is not present the parameter is skipped when accessing from the keypad. The following types are possible.

Open-loop - The control strategy is V/F mode with fixed boost or open-loop vector control.

Closed-loop vector - The control strategy is rotor flux oriented vector control with closed-loop current operation for induction motors. The drive can be operated with or without position feedback.

Servo - The control strategy is rotor flux oriented vector control with closed-loop current operation for permanent magnet synchronous motors. The drive must be operated with position feedback.

Regen - The drive operates as a PWM rectifier.

Coding

NOTE

This guide will show all bit parameters (with the Bit coding), as having a parameter range of "0 to 1", and a default value of either "0" or "1". This reflects the value seen through serial communications. The bit parameters will be displayed on the SM-Keypad or SM-Keypad Plus (if used) as being "OFF" or "On" ("OFF"= 0, "On" = 1).

The coding defines the attributes of the parameter as follows:

Coding	Attribute
Bit	1 bit parameter
SP	Spare: not used
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: indicates that this parameter can be a destination parameter.
Txt	Text: the parameter uses text strings instead of numbers.
VM	Variable maximum: the maximum of this parameter can vary.
DP	Decimal place: indicates the number of decimal places used by this parameter.
ND	No default: when defaults are loaded (except when the drive is manufactured or on EEPROM failure) this parameter is not modified.
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.
NV	Not visible: not visible on the keypad.
PT	Protected: cannot be used as a destination.
US	User save: saved in drive EEPROM when the user initiates a parameter save.
RW	Read/write: can be written by the user.
BU	Bit default one/unsigned: Bit parameters with this flag set to one have a default of one (all other bit parameters have a default of zero. Non-bit parameters are unipolar if this flag is one.
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.

4.1 Parameter ranges and variable maximums:

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

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

The values given in Table 4-1 are the variable maximums used in the drive.

Table 4-1 Definition of parameter ranges & variable maximums

Maximum	Definition
SPEED_FREQ_MAX [Open-loop 3000.0Hz, Closed-loop vector and Servo 40000.0rpm]	**Maximum speed (closed-loop mode) reference or frequency (open-loop mode) reference** 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]	**Maximum applied to speed reference limits** 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 = 3.0×10^7 / ELPR subject to an absolute maximum of 40,000 rpm. It should be noted that this limit makes no allowance for controller overshoot, and that the maximum encoder frequency should not exceed 500kHz even under overshoot conditions. 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. If a resolver is used as speed feedback from a Solutions Module the calculation is different (see Pr **15/16/17.10** for the SM-Resolver module). With closed-loop vector mode it is possible to disable this limit via parameter 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. SPEED_LIMIT_MAX is defined as above when Pr **3.24** = 0 or 1, and is 40,000rpm when Pr **3.24** = 2 or 3.
SPEED_MAX [40000.0rpm]	**Maximum speed** 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]	**Maximum motor rated current or maximum normal duty current rating** RATED_CURRENT_MAX ≤ 1.36 x Kc The rated current can be increased above the current scaling level (Kc) up to a level not exceeding 1.36 x Kc. The actual level varies from one drive size to another. (Maximum motor rated current is the maximum normal duty current rating). Refer to Table 4-2
DRIVE_CURRENT_MAX [9999.99A]	**Maximum drive current** The maximum drive current is the current at the over current trip level and is given by: DRIVE_CURRENT_MAX = Kc / 0.45 where Kc is the current scaling factor

<table>
<tr><th>Maximum</th><th>Definition</th></tr>
<tr><td>MOTOR1_CURRENT_LIMIT_MAX
[1000.0%]</td><td>Maximum current limit settings for motor map 1
This maximum current limit setting is the maximum applied to the current limit parameters in motor map 1.
Open Loop
$$\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + PF^2 - 1\right]}}{PF} \times 100\%$$
Where:
The Maximum current is either (1.5 x Kc) when the 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
Closed Loop Vector
$$\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + \cos(\varphi_1)^2 - 1\right]}}{\cos(\varphi_1)} \times 100\%$$
Where:
The Maximum current is either (1.75 x Kc) when the 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
$\varphi 1$ = cos-1(PF) - $\varphi 2$. This is measured by the drive during an autotune. See section 5.6.2 Closed-loop vector on page 90 for more information regarding $\varphi 2$.
PF is motor rated power factor given by Pr 5.10
Servo
$$\text{Maximum current limit} = \left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right] \times 100\%$$
Where:
Maximum current is drive rated current (Pr 11.32) x 1.75
Motor rated current is given by Pr 5.07</td></tr>
<tr><td>MOTOR2_CURRENT_LIMIT_MAX
[1000.0%]</td><td>Maximum current limit settings for motor map 2
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.</td></tr>
<tr><td>TORQUE_PROD_CURRENT_MAX
[1000.0%]</td><td>Maximum torque producing current
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.</td></tr>
<tr><td>USER_CURRENT_MAX
[1000.0%]</td><td>Current parameter limit selected by the user
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</td></tr>
<tr><td>REGEN_REACTIVE_MAX</td><td>Reactive current limit in regen mode
The drive applies a limit to the reactive current reference in regen mode to limit the total current to DRIVE_CURRENT_MAX.
$$\mathbf{REGEN\_REACTIVE\_MAX} = \sqrt{\left(\left(\frac{\mathbf{Kc \times 1.75}}{\mathbf{Regen\ unit\ rated\ current}}\right)^2 - \left[\frac{\mathbf{Pr\ 4.07}}{\mathbf{100}}\right]^2\right)} \times \mathbf{100\%}$$
Where:
Kc is given in Table 4-2 on page 22.
Regen unit rated current is given by Pr 5.07</td></tr>
<tr><td>AC_VOLTAGE_SET_MAX
[690V]</td><td>Maximum output voltage set-point
Defines the maximum motor voltage that can be selected.
200V drives: 240V, 400V drives: 480V
575V drives: 575V, 690V drives: 690V</td></tr>
</table>

Maximum	Definition
AC_VOLTAGE_MAX [930V]	**Maximum AC output voltage** 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]	**Maximum DC voltage set-point** 200V rating drive: 0 to 400V, 400V rating drive: 0 to 800V 575V rating drive: 0 to 950V, 690V rating drive: 0 to 1150V
DC_VOLTAGE_MAX [1190V]	**Maximum DC bus voltage** The maximum measurable DC bus voltage. 200V drives: 415V, 400V drives: 830V 575V drives: 995V, 690V drives: 1190V
POWER_MAX [9999.99kW]	**Maximum power in kW** The maximum power has been chosen to allow for the maximum power that can be output by the drive with maximum AC output voltage, maximum controlled current and unity power factor. Therefore, Software V01.07.01 and earlier: POWER_MAX = √3 x AC_VOLTAGE_MAX x Kc x 1.75 Software V01.08.00 and later: POWER_MAX = √3 x AC_VOLTAGE_MAX x DRIVE_CURRENT_MAX

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

Table 4-2 Maximum motor rated current (sizes 0 to 6)

Model	Kc A	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

Table 4-3 Maximum motor rated current (sizes 6 to 9 Free Standing drives)

Model	Kc A	Pr 11.32 A	Heavy Duty current rating A	Normal Duty current rating A
SP6411	154.2	180	180	205
SP6412	180	210	210	236
SP7411	205.7	246	238	290
SP7412	248.5	290	290	350
SP8411	293	342	335	389
SP8412	342	399	389	450
SP8413	391	467.4	450	545
SP8414	472	551	620	545
SP9410	513	598.5	593	690
SP9411	585	684	620	690
SP9412	586	701.1	690	790
SP9413	684	798	790	900
SP9414	782	934.8	900	1010
SP9415	944	1102	1010	1164

Table 4-4 Maximum motor rated current (SPM modular drives)

Model	Kc A	Maximum Heavy Duty current rating (Pr 11.32) A	Maximum Normal Duty current rating A
SPMD1201	133.7	156	192
SPMD1202	164.5	192	248
SPMD1203	214.2	250	312
SPMD1204	248.5	290	350
SPMA1401	154.2	180	205
SPMA1402	180.0	210	236
SPMD1401	154.2	180	205
SPMD1402	180.0	210	246
SPMD1403	205.7	246	290
SPMD1404	248.5	290	350
SPMA1601	85.7	100	125
SPMA1602	107.1	125	144
SPMD1601	85.7	100	125
SPMD1602	107.1	125	144
SPMD1603	123.4	144	168
SPMD1604	144.0	168	192

4.1.1 Default

The default values given are the standard drive defaults which are loaded after a drive reset with 1233 in Pr **x.00**.

4.1.2 Second motor parameter

Some parameters have an equivalent second motor value that can be used as an alternative when the second motor is selected with Pr **11.45**. Menu 21 contains all the second motor parameters. In this menu the parameter specifications include the location of the normal motor parameter which is being duplicated.

4.1.3 Update rate

Defines the rate at which the parameter data is written by the drive (write) or read and acted upon by the drive (read). Where background update rate is specified, the update time depends on the drive processor load.

Generally the update time is between 2ms and 30ms, however, the update time is significantly extended when loading defaults, changing drive mode, transferring data to/from a SMARTCARD, or transferring blocks of parameters or communications messages to/from the drive (not a Solutions Module) via the drive serial comms port.

4.2 Sources and destinations

4.2.1 Sources

Some functions have source pointer parameters, i.e. drive outputs, PID controller etc.. The source pointer parameter range is Pr **0.00** to Pr **21.51**. The source pointer is set up to point to a parameter, which supplies the information to control the source and this is referred to as the source data parameter. For example, Pr **7.19** is the source pointer parameter for analog output 1. If Pr **7.19** is set to a value of 18.11, then Pr **18.11** is the source data parameter, and as the value of Pr **18.11** is modified the analog output level is changed.

1. If the parameter number in the source pointer parameter does not exist the input is taken as zero.
2. If the source is not a bit type source (i.e. not a digital output etc). then the source level is defined by (source data value x 100%) / source data parameter maximum. Generally the result is rounded down to the nearest unit, but other rounding effects may occur depending on the internal scaling of the particular source function.
3. If the source is a bit, i.e. a digital output, and the source data parameter is a bit parameter then the input to the source function follows the value of the source data parameter.
4. If the source is a bit, i.e. a digital output, and the source data parameter is not a bit parameter the source input is zero if the source data value is less than source data parameter maximum / 2 rounded down to the nearest unit. The source input is one if the source data value is greater than or equal to source data parameter maximum / 2 rounded down to the nearest unit. For example if the source pointer parameter is set to Pr **18.11**, which has a maximum of 32767, the source input is zero if the source data value is less than 16383 and one if it is greater than this.

4.2.2 Destinations

Some functions have destination pointer parameters, i.e. drive inputs, etc.. The destination pointer parameter range is P **0.00** to Pr **21.51**. The destination pointer parameter is set up to point to a parameter, which receives information from the function referred to as the destination parameter.

1. If the parameter number in the destination pointer parameter does not exist then the output value has no effect.
2. If the destination parameter is protected then the output value has no effect.
3. If the function output is a bit value (i.e. a digital input) the destination parameter value does not operate in the same way as a source described above, but is always either 0 or 1 depending on the state of the function output whether the destination parameter is a bit parameter or not.
4. If the function output is not a bit value (i.e. analog input) and the destination parameter is not a bit parameter, the destination value is given by (function output x destination parameter maximum) / 100%. Generally the result is rounded down to the nearest unit, but other rounding effects may occur depending on the internal scaling of the particular source function (rounded down to nearest unit). Pr **1.36** and Pr **1.37** are a special case. The scaling shown in the description of parameter Pr **1.08** is used when any non-bit type quantity is routed to these parameters.
5. If the function output is not a bit value and the destination parameter is a bit value, the destination value is 0 if the function output is less than 50% of its maximum value, otherwise it is 1.
6. If more than one destination selector is routed to the same destination, the value of the destination parameter is undefined. The drive checks for this condition where the destinations are defined in any menu except menus 15 to 17. If a conflict occurs a dESt trip occurs that cannot be reset until the conflict is resolved.

4.2.3 Sources and destinations

1. Bit and non-bit parameters may be connected to each other as sources or destinations. The scaling is as described previously.
2. All new source and destination routing only changes to new set-up locations when the drive is reset.
3. When a destination pointer parameter within the drive or a dumb Solutions Module (SM-Resolver, SM-Encoder Plus, SM-Encoder Output Plus, SM-I/O plus) is changed the old destination is written to zero, unless the destination change is the result of loading defaults or transferring parameters from a SMARTCARD. When defaults are loaded the old destination is set to its default value. When parameters are loaded from a SMARTCARD the old destination retains its old value unless a SMARTCARD value is written to it.

4.3 Update rates

Update rates are given for every parameter in the header table as shown below.

3.03	**Speed error**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Closed-loop vector, Servo							±SPEED_MAX rpm								
Update rate	4ms write															

Some parameters have an increased update in special circumstances.

4.3.1 Speed reference update rate

The normal update rate for the speed references (via menu 1) is 4ms, however it is possible to reduce the sample time to 250µs by selecting the reference from particular sources. The fast update rate is only possible provided the conditions given below are met. (Note: high speed updating is not provided for frequency references - i.e. Open-loop mode).

Analog input references (not including I/O expansion Solutions Module)

1. The reference must be derived via Pr **1.36** or Pr **1.37**
2. The analog inputs must be in voltage mode with zero offset
3. Bipolar mode must be used or unipolar mode with the minimum speed (Pr **1.07**) set to zero
4. No skip bands are enabled, i.e. Pr **1.29**, Pr **1.31** and Pr **1.33** must be zero.
5. The jog and velocity feed-forward references must not be enabled.

Applications and fieldbus Solutions Modules

Pr **91.02** must be used to define the speed reference (this parameter is only visible from the Solutions Modules). Any value written to Pr **91.02** should be automatically mapped into preset Pr **1.21** by the Solutions Module.

In fast update mode the references are sampled every 250µs. A sliding window filter may be applied to analog input 1 (see Pr **7.26**) in normal or high speed updating modes. The default value for this filter is 4ms, therefore Pr **7.26** must be set to zero to obtain the fastest possible update rate.

When fast updating is used the scaling is performed by a simple multiplication. This minimizes software execution time, but also ensures that there is no loss of resolution from the v to f converter used to implement analog input 1. Therefore the speed of the motor may be controlled with infinite resolution from analog input 1 except for deadband effects around zero reference. The scale factor used for the multiplication cannot exactly duplicate the scaling for the two stage conversion (i.e. conversion in menu 7 to a percentage of full scale, and conversion to 0.1rpm units) used when high speed updating is not in operation. Therefore the absolute scaling of the analog inputs varies slightly between normal and high speed updating.

The amount of difference depends on the maximum speed, user scaling in menu 7, and the analog input 1 the filter time.

The worst case difference for analog input 1 is 0.12 % of full scale, and for analog inputs 2 and 3 the difference is less than 0.12 % with a maximum speed of 50 rpm or more. Typical differences (1500 rpm maximum speed, menu 7 scaling of 1.000, analog input 1 filter of 4 ms) are 0.015% for analog input 1 and 0.004 % for analog inputs 2 and 3.

4.3.2 Hard speed reference update rate

The normal update rate for the hard speed reference is 4ms, however it is possible to reduce the sample time to 250 µs by selecting the reference from particular sources. The fast update rate is only possible provided the conditions given below are met.

Analog inputs (not including I/O expansion Solutions Module)

The analog inputs must be in voltage mode with zero offset

Limitations are the same as for the references via menu 1 described above.

Applications and fieldbus Solutions Modules

For faster update rate Pr **91.03** must be used (this parameter is only visible from the Solutions Modules). Any value written to Pr **91.03** is automatically mapped into the hard speed reference Pr **3.22**.

Encoder reference

It is possible to use the drive encoder as the source for the hard speed reference. To do this the drive encoder reference destination (Pr **3.46**) should be routed to the hard speed reference parameter. If, and only if, the maximum drive encoder reference (Pr **3.43**) is set to the same value as the maximum reference value (SPEED_FREQ_MAX), and the scaling (Pr **3.44**) is 1.000, the drive takes the encoder pulses directly. This gives a form of reference slaving where the integral term in the speed controller accumulates all pulses from the reference and tries to match them to the feedback from the motor encoder. Pulses are lost if the reference reaches a minimum or maximum limit including zero speed in unipolar mode. The reference is sampled every 250 µs. It is possible to apply scaling even in this high speed update mode by changing the number of encoder lines per revolution. It is also possible to use this high speed update mode with some position feedback category Solutions Modules (see description for the appropriate Solutions Module).

4.3.3 Torque reference update rate

The normal update rate for the torque reference (Pr **4.08**) is 4 ms, however it is possible to reduce the sample time to 250 μs by selecting the reference from particular sources, but only in closed-loop vector or servo modes. The fast update rate is only possible provided the conditions given below are met.

Analog inputs 2 or 3 on the drive

The analog inputs must be in voltage mode with zero offset.

5 Advanced parameter descriptions

5.1 Overview

Table 5-1 Menu descriptions

Menu no.	Description
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, variable selectors and brake control
13	Position control
14	User PID controller
15, 16, 17	Solutions Module slots
18	Application menu 1
19	Application menu 2
20	Application menu 3
21	Second motor parameters
22	Additional menu 0 set-up

Table 5-2 gives a full key of the coding which appears in the following parameter tables.

Table 5-2 Key to parameter coding

Coding	Attribute
Bit	1 bit parameter
SP	Spare: not used
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: indicates that this parameter can be a destination parameter.
Txt	Text: the parameter uses text strings instead of numbers.
VM	Variable maximum: the maximum of this parameter can vary.
DP	Decimal place: indicates the number of decimal places used by this parameter.
ND	No default: when defaults are loaded (except when the drive is manufactured or on EEPROM failure) this parameter is not modified.
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.
NV	Not visible: not visible on the keypad.
PT	Protected: cannot be used as a destination.
US	User save: saved in drive EEPROM when the user initiates a parameter save.
RW	Read/write: can be written by the user.
BU	Bit default one/unsigned: Bit parameters with this flag set to one have a default of one (all other bit parameters have a default of zero. Non-bit parameters are unipolar if this flag is one.
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.

5.2 Feature look-up table

Feature	Parameter number (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												
Copying	11.42	11.36 to 11.40											
Coast to stop	6.01												
Comms	11.23 to 11.26												
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	2.09
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	6.29									
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											
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				

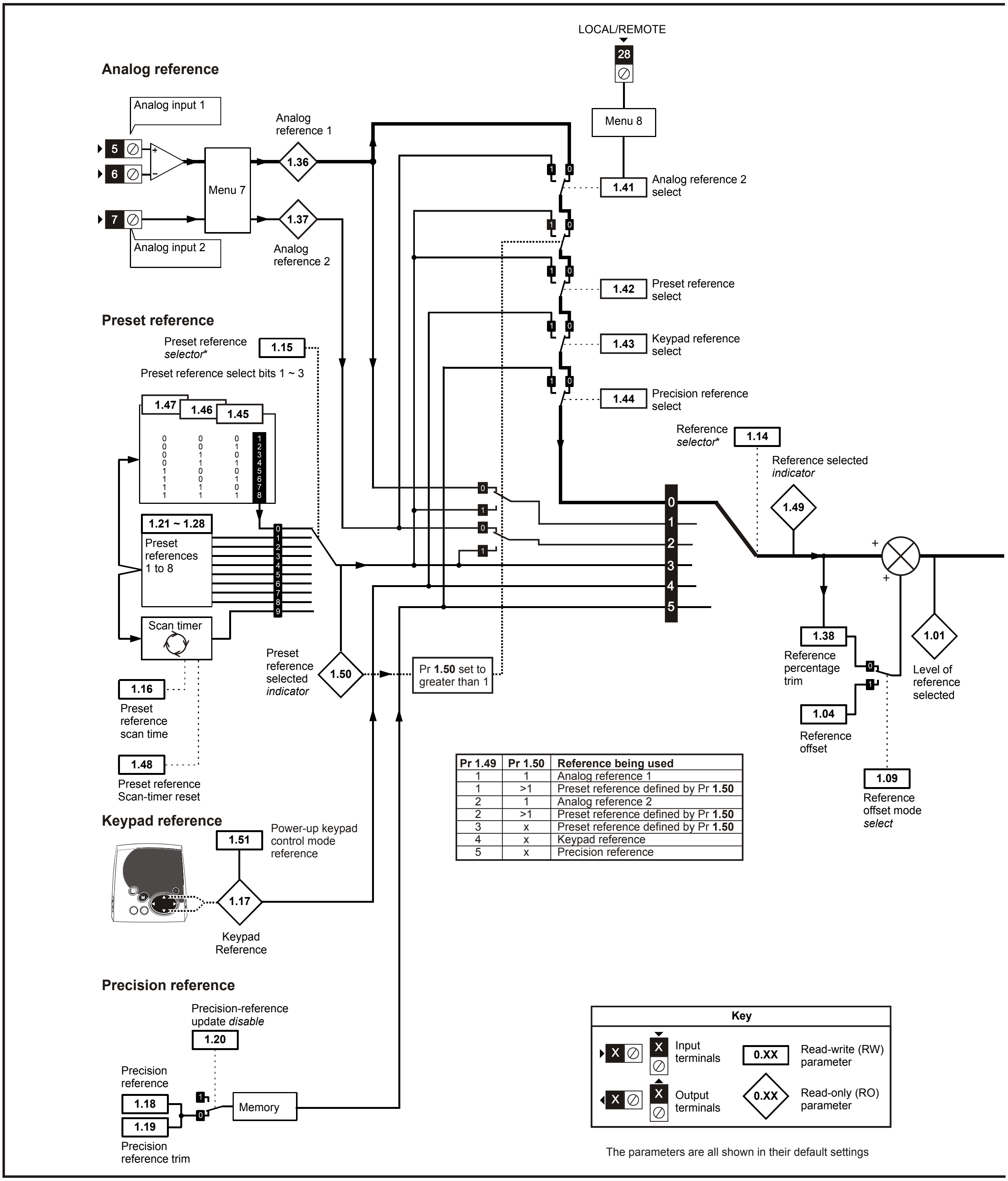
Feature	Parameter number (Pr)												
Inertia compensation	2.38	5.12	4.22	3.18									
Jog reference	1.05	2.19	2.29										
Ke	5.33												
Keypad reference	1.17	1.14	1.43	1.51	6.12	6.13							
Kt	5.32												
Limit switches	6.35	6.36											
Local position reference	13.20 to 13.23												
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											
Mains loss	6.03	10.15	10.16	5.05									
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	3.24	5.14	11.31									
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											
Regen mode	3.01 to 3.11		4.08	5.01	5.02	5.03	5.07						
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 Closed-Loop Vector mode)	3.24	3.42	4.12	5.40									
S ramp	2.06	2.07											
Sample rates	5.18												
Safe Torque Off 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	Parameter number (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											

5.3 Menu 1: Frequency/speed reference

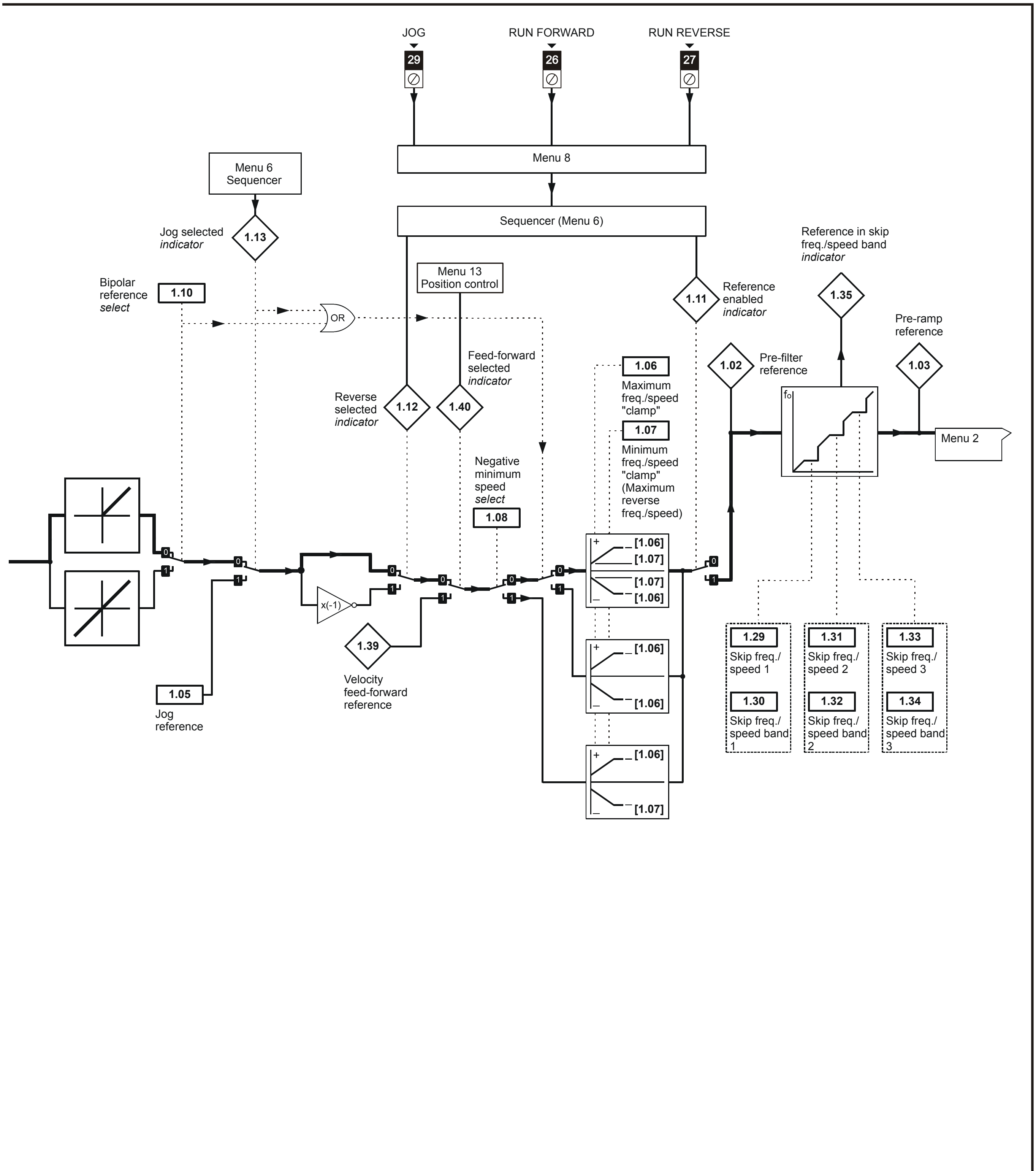
Menu 1 controls the main reference selection. When the drive operates in open-loop mode a frequency reference is produced, and when the drive operates in closed-loop vector or servo modes a speed reference is produced.

Figure 5-1 Menu 1 logic diagram



Pr 1.49	Pr 1.50	Reference being used
1	1	Analog reference 1
1	>1	Preset reference defined by Pr **1.50**
2	1	Analog reference 2
2	>1	Preset reference defined by Pr **1.50**
3	x	Preset reference defined by Pr **1.50**
4	x	Keypad reference
5	x	Precision reference

*Refer to Pr **1.14** on page 35.


JOG
RUN FORWARD
RUN REVERSE
29
26
27
Menu 8
Menu 6 Sequencer
Sequencer (Menu 6)
Jog selected indicator
1.13
Bipolar reference select
1.10
OR
Menu 13 Position control
1.11
Reference enabled indicator
Reference in skip freq./speed band indicator
1.35
Pre-ramp reference
1.03
Feed-forward selected indicator
1.06
Maximum freq./speed "clamp"
1.02
Pre-filter reference
Reverse selected indicator
1.12
1.40
1.07
Minimum freq./speed "clamp" (Maximum reverse freq./speed)
Menu 2
Negative minimum speed select
1.08
x(-1)
[1.06]
[1.07]
1.39
Velocity feed-forward reference
1.05
Jog reference
1.29
Skip freq./ speed 1
1.30
Skip freq./ speed band 1
1.31
Skip freq./ speed 2
1.32
Skip freq./ speed band 2
1.33
Skip freq./ speed 3
1.34
Skip freq./ speed band 3

1.01	**Frequency/speed reference selected**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo							±SPEED_FREQ_MAX Hz/rpm								
Update rate	4ms write															

1.02	**Pre-skip filter reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo							±SPEED_FREQ_MAX Hz/rpm								
Update rate	4ms write															

1.03	**Pre-ramp reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo							±SPEED_FREQ_MAX Hz/rpm								
Update rate	4ms write															

1.04	**Reference offset**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Open-loop Closed-loop vector, Servo							±3,000.0 Hz ±40,000.0 rpm								
Default	Open-loop, Closed-loop vector. Servo							0								
Update rate	Background read when precision reference is active 4ms write otherwise															

See Pr **1.09** on page 34.

1.05	**Jog reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop Closed-loop vector, Servo							0 to 400.0 Hz 0 to 4,000.0 rpm								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Update rate	4ms read															

Reference used for jogging. See section 5.8 *Menu 6: Sequencer and clock* on page 134 for details on when the jog mode can be activated. The jog reference can be used for relative jogging in digital lock mode (see section 5.15 *Menu 13: Position control* on page 232).

1.06	Maximum reference clamp															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector and servo: VM = 1															
Range	Open-loop Closed-loop vector and Servo							0 to 3,000.0 Hz ±SPEED_LIMIT_MAX rpm								
Default	Open-loop Closed-loop vector Servo							EUR: 50.0, USA: 60.0 EUR: 1,500.0, USA: 1,800.0 3,000.0								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.01**								
Update rate	Background read															

See below.

1.07	Minimum reference clamp															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1					1	1	1		
	Closed-loop vector and Servo: VM = 1															
Range	Open-loop Closed-loop vector and Servo							±3,000.0 Hz* ±SPEED_LIMIT_MAX rpm*								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.02**								
Update rate	Background read															

*The range shown for Pr **1.07** shows the range used for scaling purposes (i.e. for routing to an analog output etc). Further range restrictions are applied as given below.

Pr 1.08 (Neg min ref enable)	Pr 1.10 (Bipolar mode enable)	Open-loop	Closed-loop vector and Servo
0	0	0 to Pr **1.06**	0 to Pr **1.06**
0	1	0	0
1	0	-3,000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm
1	1	-3,000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm

The same limits are applied to Pr **21.02**, but based on the value of Pr **21.01**.

(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**)

1.08	Negative minimum reference clamp enable															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

The effects of the reference clamps (Pr **1.06** and **1.07**), the negative minimum clamp enable (Pr **1.08**) and the bipolar reference enable parameters are defined below.

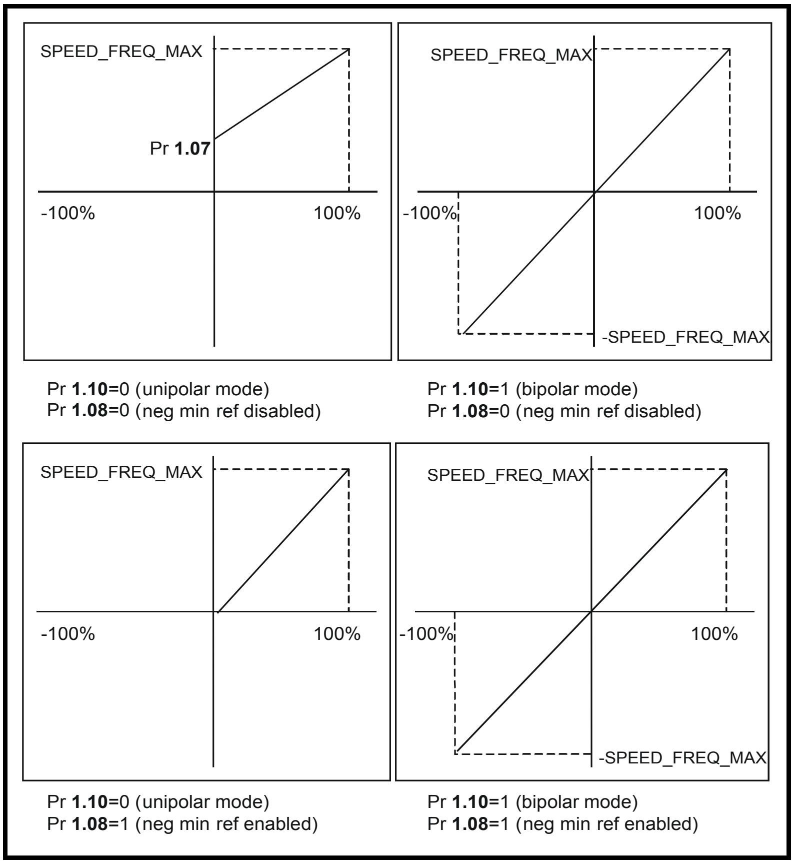
The variable maximum limit for reference parameters, SPEED_FREQ_MAX, is defined as:

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**)

Analog input scaling

The following diagrams show the scaling applied when analog inputs are used to define the reference and are routed via Pr **1.36** or Pr **1.37**.



Reference limits

With reference to the block diagram for Menu 1 (Figure 5-1 on page 30) the following table shows the limits applied to the reference by various blocks in the reference system. It should be noted that the minimum limit in the main reference limits block changes when either the jog reference or velocity feedforward references are active. When one of these is active: if Pr **1.08** = 0 the minimum = -Pr **1.06** [-Pr **21.01** for motor map2], if Pr **1.08** = 1 the minimum = -Pr **1.07** [-Pr **21.02** for motor map 2].

	Minimum	Maximum
Keypad control reference (Pr **1.17**)	Unipolar mode: Pr **1.07**, or 0 if Pr **1.07** < 0 Bipolar mode: -SPEED_FREQ_MAX	SPEED_FREQ_MAX
Bipolar/unipolar selector	Unipolar mode: Pr **1.07**, or 0 if Pr **1.07** < 0 Bipolar mode: no limit applied	No maximum limit applied
Main reference limits	Neg minimum ref disabled: -Pr **1.06** Neg minimum ref enabled: Pr **1.07**	Pr **1.06**

1.09	**Reference offset select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read when precision reference is active 4ms read otherwise															

When this parameter is 0 the reference is given by

Pr **1.01** = selected reference x (100 + Pr **1.38**) / 100

and when this parameter is 1 the reference is given by

Pr **1.01** = selected reference + Pr **1.04**

1.10	**Bipolar reference enable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

See Pr **1.08** on page 33.

1.11	**Reference enabled indicator**															
1.12	**Reverse selected indicator**															
1.13	**Jog selected indicator**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1		1				
Update rate	4ms read															

These parameters are controlled by the drive sequencer as defined in Menu 6. They select the appropriate reference as commanded by the drive logic. Pr **1.11** will be active if a run command is given, the drive is enabled and the drive is ok. This parameter can be used as an interlock in a Onboard PLC or SM-Applications program to show that the drive is able to respond to a speed or torque demand.

1.14	**Reference selector**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 5								
Default	Open-loop, Closed-loop vector, Servo							0 (A1.A2)								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.03**								
Update rate	4ms read															

Pr **1.14** defines how the value of Pr **1.49** is derived as follows:

Value of Pr 1.14	Display String	Pr 1.49
0	A1.A2 (Analog ref 1. Analog ref 2)	*Selected by terminal input
1	A1.Pr (Analog ref 1. Preset speeds)	1
2	A2.Pr (Analog ref 2. Preset speeds)	2
3	Pr (Preset speeds)	3
4	Pad (Keypad reference)	4
5	Prc (Precision reference)	5

*Pr **1.41** to Pr **1.44** can be controlled by digital inputs to force the value of Pr **1.49**:

all bits equal to zero gives 1,

Pr **1.41** = 1 then Pr **1.49** = 2
Pr **1.42** = 1 then Pr **1.49** = 3
Pr **1.43** = 1 then Pr **1.49** = 4
Pr **1.44** = 1 then Pr **1.49** = 5

The bit parameters with lower numbers have priority over those with higher numbers.

Pr **1.49** and Pr **1.50** then define the reference as follows:

Pr 1.49	Pr 1.50	Reference
1	1	Analog reference 1 (Pr **1.36**)
1	>1	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
2	1	Analog reference 2 (Pr **1.37**)
2	>1	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
3	x**	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
4	x**	Keypad reference (Pr **1.17**)
5	x**	Precision reference (Pr **1.18** and Pr **1.19**)

** x = any value

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**, have no effect and jog is disabled.

1.15	**Preset selector**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 9														
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

Pr **1.15** defines how the value of Pr **1.50** is derived as follows:

Value of Pr 1.15	Pr 1.50
0	Selected by terminal input*
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	Selected by timer**

*Pr **1.45** to Pr **1.47** can be controlled by digital inputs to define the value of Pr **1.50** as follows:

The presets are selected automatically in turn. Pr **1.16 defines the time between each change.

Pr 1.47	Pr 1.46	Pr 1.45	Pr 1.50
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

Pr **1.49** and Pr **1.50** then define the reference as follows:

Pr 1.49	Pr 1.50	Reference
1	1	Analog reference 1 (Pr **1.36**)
1	>1	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
2	1	Analog reference 2 (Pr **1.37**)
2	>1	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
3	x	Preset defined by Pr **1.50** (Pr **1.21** to Pr **1.28**)
4	x	Keypad reference (Pr **1.17**)
5	x	Precision reference (Pr **1.18** and Pr **1.19**)

1.16	**Preset reference selector timer**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 400.0 s														
Default	Open-loop, Closed-loop vector, Servo	10.0														
Update rate	Background read															

This parameter defines the time between preset reference changes when Pr **1.15** is set to 9. If Pr **1.48** is set to 1 then the preset counter and timer are reset and preset 1 will be selected.

1.17	**Keypad control mode reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1			1		1				1
Range	Open-loop, Closed-loop vector, Servo							±SPEED_FREQ_MAX Hz/rpm								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Update rate	4ms read															

The drive can be controlled from the keypad if Pr **1.14** is set to 4. The Stop and Run keys automatically become active (the Reverse key may be optionally enabled with Pr **6.13**). The frequency/speed reference is defined by Pr **1.17**. This is a read only parameter that can only be adjusted in status mode by pressing the Up or Down keys. If keypad control mode is selected, then pressing the Up or Down keys in status mode will cause the drive to automatically display the keypad reference and adjust it in the relevant direction. This can be done whether the drive is disabled or running. If the Up or Down keys are held the rate of change of keypad reference increases with time. The units used for to display the keypad reference for different modes are given below.

Mode	Unit
Open loop	Hz
Closed loop	rpm
Servo	rpm

See also Pr **1.51** on page 41 (*Power-up keypad control mode reference*).

1.18	**Precision reference coarse**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1		
Range	Open-loop, Closed-loop vector, Servo							±SPEED_FREQ_MAX Hz/rpm								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Update rate	Background read															

See below.

1.19	**Precision reference fine**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop Closed-loop vector, Servo							0.000 to 0.099 Hz 0.000 to 0.099 rpm								
Default	Open-loop, Closed-loop vector, Servo							0.000								
Update rate	Background read															

Open loop

The frequency reference resolution is restricted to 0.1Hz from normal parameters, but the resolution can be improved by using the precision reference. Pr **1.18** defines the coarse part of reference (either positive or negative) with a resolution of 0.1Hz and Pr **1.19** defines the fine part of the reference (always positive) with a resolution of 0.001Hz. The final reference is given by Pr **1.18** + Pr **1.19.** Therefore Pr **1.19** increases positive references away from zero, and decreases negative references towards zero.

Closed loop

As with open-loop a higher resolution speed reference can be programmed by selecting these parameters. In this case the speed will have a resolution of 0.001 rpm.

1.20	Precision reference update disable	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	(see below)	
Default	Open-loop, Closed-loop vector, Servo	0
Update rate	Background read	

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

When this bit is at 0 the precision reference parameters are read and stored in internal memory. Because the precision reference has to be set in two parameters, this bit is provided to prevent the drive reading the parameters while the reference is being updated. Instead, the drive uses the value stored in memory preventing the possibility of data skew.

1.21	Preset reference 1	
1.22	Preset reference 2	
1.23	Preset reference 3	
1.24	Preset reference 4	
1.25	Preset reference 5	
1.26	Preset reference 6	
1.27	Preset reference 7	
1.28	Preset reference 8	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	(see below)	
Range	Open-loop, Closed-loop vector, Servo	±SPEED_FREQ_MAX Hz/rpm
Default	Open-loop, Closed-loop vector, Servo	0.0
Update rate	4ms read	

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

1.29	Skip reference 1	
1.31	Skip reference 2	
1.33	Skip reference 3	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	(see below)	
	Closed-loop vector and servo DP = 0	
Range	Open-loop Closed-loop vector, Servo	0.0 to 3,000.0 Hz 0 to 40,000 rpm
Default	Open-loop Closed-loop vector, Servo	0.0 0
Update rate	Background read	

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

See below.

1.30	**Skip reference band 1**															
1.32	**Skip reference band 2**															
1.34	**Skip reference band 3**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector and servo DP = 0															
Range	Open-loop Closed-loop vector, Servo								0.0 to 25.0 Hz 0 to 250 rpm							
Default	Open-loop Closed-loop vector, Servo								0.5 5							
Update rate	Background read															

Three skip references are available to prevent continuous operation at a speed that would cause mechanical resonance. When a skip reference parameter is set to 0 that filter is disabled. The skip reference band parameters define the frequency or speed range either side of the programmed skip reference, over which references are rejected. The actual reject band is therefore twice that programmed in these parameters, the skip reference parameters defining the centre of the band. When the selected reference is within a band the lower limit of the band is passed through to the ramps such that reference is always less than demanded.

1.35	**Reference in rejection zone**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

This parameter indicates that the selected reference is within one of the skip reference zones such that the motor speed is not as demanded.

1.36	**Analog reference 1**															
1.37	**Analog reference 2**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1						
Range	Open-loop, Closed-loop vector, Servo								±SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	4ms write															

Although most parameters can be controlled from analog inputs, these two parameters are a special case in that if an analog input is directed to one of these parameters, the scan rate of that analog input is increased to 250μs as long as:

1. The reference must be derived via Pr **1.36** or Pr **1.37**
2. The analog inputs must be in voltage mode with zero offset
3. Bipolar mode must be used or unipolar mode with the minimum speed (Pr **1.07**) set to zero
4. No skip bands are enabled, i.e. Pr **1.29**, Pr **1.31** and Pr **1.33** must be zero.
5. The jog and velocity feed-forward references must not be enabled.

These are special parameters when a non-bit type quantity uses these parameters as a destination (not just from analog inputs). The scaling and limiting applied is as described with Pr **1.08** on page 33.

1.38	**Percentage trim**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2			1				1		
Range	Open-loop Closed-loop vector, Servo								±100.00 %							
Default	Open-loop Closed-loop vector, Servo								0.00							
Update rate	4ms read															

See Pr **1.09** on page 34.

1.39	**Velocity feed forward**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				
Range	Open-loop Closed-loop vector, Servo							±3,000.0 Hz ±40,000.0 rpm								
Update rate	4ms read															

This parameter indicates the velocity feed forward reference when position control is used (see section 5.15 *Menu 13: Position control* on page 232).

1.40	**Velocity feed forward select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

This bit indicates that the position controller has selected the velocity feed forward as a reference for the drive

1.41	**Analog reference 2 select**															
1.42	**Preset reference select**															
1.43	**Keypad reference select**															
1.44	**Precision reference select**															
1.45	**Preset reference 1 select**															
1.46	**Preset reference 2 select**															
1.47	**Preset reference 3 select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

Pr **1.41** to Pr **1.44** control Pr **1.49**. The priority order is Pr **1.44** (highest), Pr **1.43**, Pr **1.42**, Pr **1.41** (lowest). If more than one parameter is active, the highest priority takes precedence.

Pr **1.41** = 1 forces Pr **1.49** = 2 (see table in Pr **1.14** on page 35 and Pr **1.15** on page 36)
Pr **1.42** = 1 forces Pr **1.49** = 3 (always selects preset references)
Pr **1.43** = 1 forces Pr **1.49** = 4 (always selects keypad control mode)
Pr **1.44** = 1 forces Pr **1.49** = 5 (always selects precision reference)

Pr **1.45** to Pr **1.47** control Pr **1.50.**

Pr **1.45** controls Pr **1.50** bit 0*
Pr **1.46** controls Pr **1.50** bit 1*
Pr **1.47** controls Pr **1.50** bit 2*

*See the description with Pr **1.14** and Pr **1.15** on page 36 for more information.

1.48	**Reference timer reset flag**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

When this flag is set the preset timer for auto preset timer mode (Pr **01.15** = 9) is reset and preset 1 is selected. This can be used to start a new sequence of reference selection by a programmable input terminal or function. When this bit is zero the preset selection will follow the timer even when the drive is disabled.

1.49	**Reference selected indicator**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo	1 to 5														
Update rate	4ms write															

Indicates the reference currently selected

1.50	**Preset reference selected indicator**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo	1 to 8														
Update rate	4ms write															

Indicates the preset reference currently being selected

1.51	**Power-up keypad control mode reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 2														
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	N/A															

Selects the value of the keypad control mode (Pr **1.17**) at power-up as follows:

0 rESEt zero

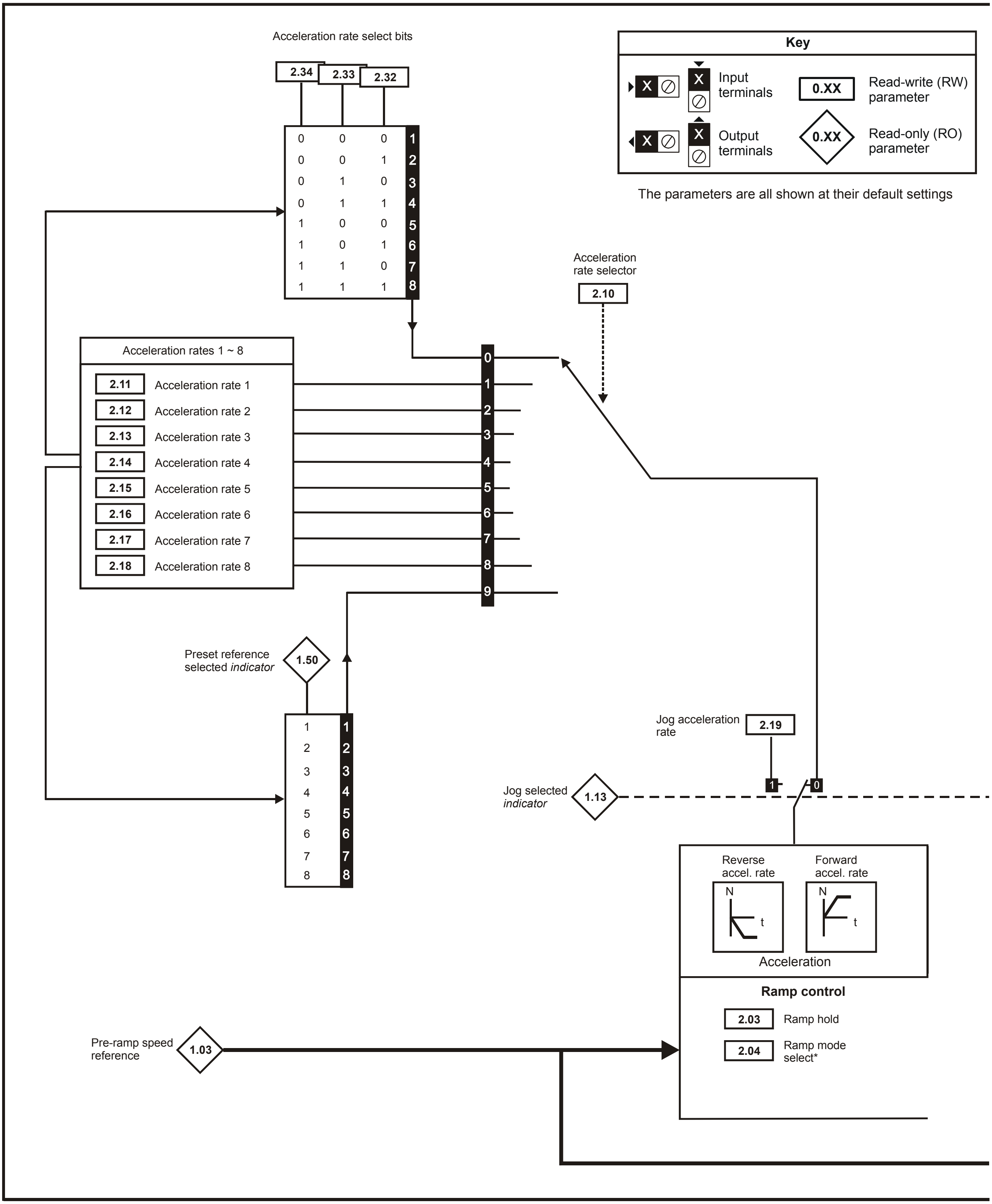
1 LASt last value used before power-down

2 PrS1 Preset 1, Pr **1.21**, before power-down

5.4 Menu 2: Ramps

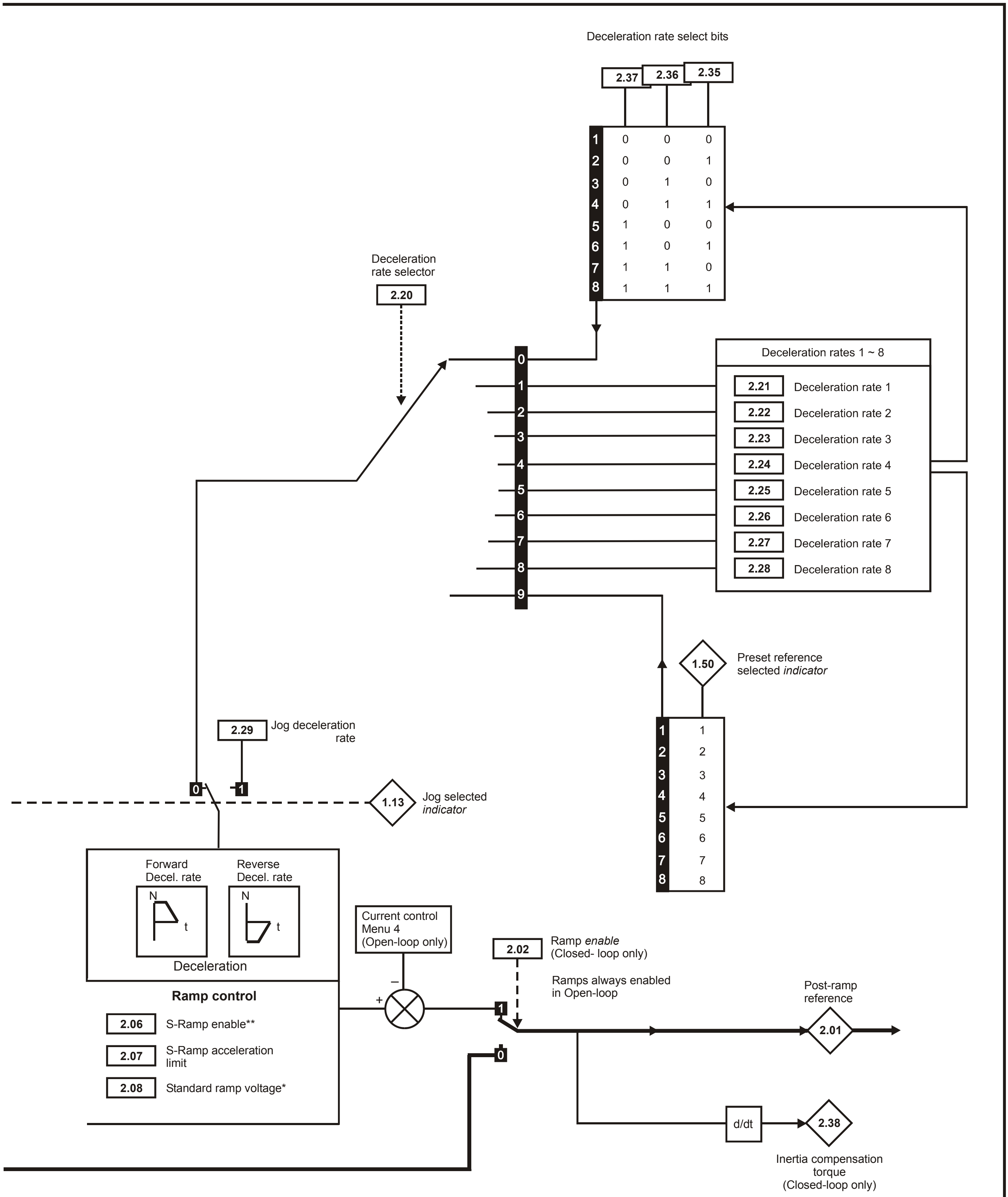
The pre-ramp frequency or speed reference passes through the ramp block controlled by menu 2 before being used by the drive to produce the basic output frequency (Open-loop modes), or as an input to the speed controller (Closed-loop vector or Servo modes). The ramp block includes: linear ramps, an S ramp function for ramped acceleration and deceleration, deceleration ramp control to prevent rises in the DC bus voltage within the drive that would cause an over-voltage trip if no braking resistor is installed.

Figure 5-2 Menu 2 logic diagram



* For more information refer to Pr **2.04** on page 44.

** For more information refer to Pr **2.06** on page 45.



2.01	**Post ramp reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo								±SPEED_FREQ_MAX Hz/rpm							
Update rate	4ms write															

2.02	**Ramp enable**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Coding	RW, Bit, US															
Default	Closed-loop vector and Servo								1							
Update rate	4ms read															

2.03	**Ramp hold**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	4ms read															

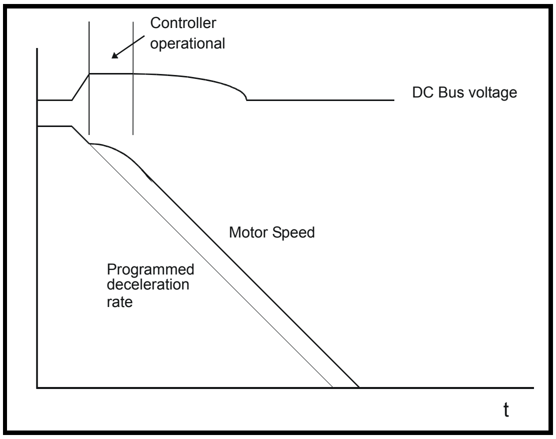
If this bit is set the ramp will be held. If S ramp is enabled the acceleration will ramp towards zero causing the ramp output to curve towards a constant speed. If a drive stop is demanded the ramp hold function is disabled.

2.04	**Ramp mode select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop Closed-loop vector, Servo								0 to 2 0 to 1							
Default	Open-loop, Closed-loop vector, Servo								1							
Update rate	4ms read															

This parameter does not affect the acceleration ramp, and 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. If the speed or frequency reference is just set to zero with an overhauling or very high inertia load, then the drive may not decelerate.

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 DC bus 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 mode) 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.

2.06	**S ramp enable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	4ms read															

Setting this parameter enables the S ramp function. S ramp is disabled during deceleration when the standard ramp voltage controller is active. 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**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector and Servo DP = 3															
Range	Open-loop Closed-loop vector and servo								0.0 to 300.0 s^2/100Hz 0.000 to 100.000 s^2/1,000rpm							
Default	Open-loop Closed-loop vector Servo								3.1 1.500 0.030							
Update rate	Background read															

This parameter defines the maximum rate of change of acceleration/deceleration. If the S ramp is disabled (Pr **2.06** = 0) a linear ramp is used and the time in seconds taken for the ramp output to change by frequency (Δ f*) or speed (Δ w*) is given by:

Frequency (Open-loop mode)

$T_{Ramp} = \Delta f^* \times A / 100$

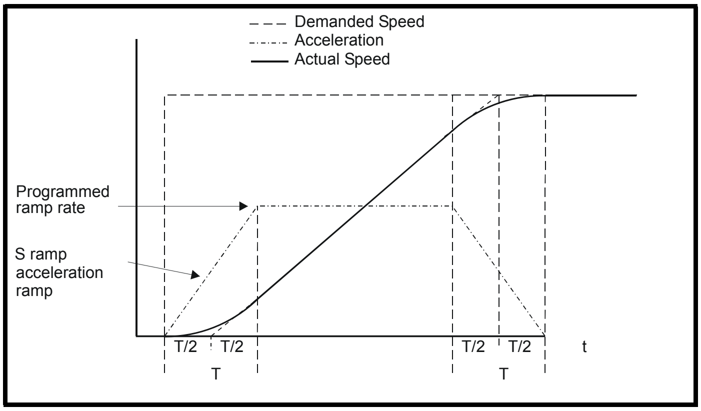
where A is the selected ramp rate in s / 100Hz

Speed (Closed-loop vector and servo)

$T_{Ramp} = \Delta w^* \times A / 1000$

Where A is the selected ramp rate in s / 1000rpm

If the S ramp is enabled (Pr **2.06** = 1) then the ramp time is extended as shown in the diagram below.



The time taken in seconds for the ramp output to change by frequency (Δf^*) or speed (Δw^*) is given below. Two cases are given because the total ramp time must be calculated with a different equation depending on whether the acceleration is able to reach the selected ramp rate (A) or not. If the required change is small the selected ramp rate is not reached and the ramp does not include the central linear ramp region. If the required change is larger the ramp does include the central linear region as shown in the diagram above.

Frequency (Open-loop mode)

$\Delta f^*_{linear} = 100 \times J / A^2$

where:

A is the selected ramp rate in s / 100Hz

J is parameter Pr **2.07**, the S ramp acceleration limit in s^2 / 100Hz

If the required change is less than Δf^*_{linear} then T_{Ramp1} should be used, but if the speed change is greater or equal to Δf^*_{linear} T_{Ramp2} should be used.

$T_{Ramp1} = 2 \sqrt{} (\Delta f^* \times J / 100)$

$T_{Ramp2} = (\Delta f^* \times A / 100) + (J / A)$

Speed (Closed-loop vector and servo)

$\Delta w^*_{linear} = 1000 \times J / A^2$

where:

A is the selected ramp rate in s / 1000rpm

J is Pr **2.07**, the S ramp acceleration limit in s^2 / 1000rpm

If the required change is less than Δw^*_{linear} then T_{Ramp1} should be used, but if the speed change is greater or equal to Δw^*_{linear} T_{Ramp1} should be used.

$T_{Ramp1} = 2 \sqrt{} (\Delta w^* \times J / 1000)$

$T_{Ramp2} = (\Delta w^* \times A / 1000) + (J / A)$

The default values for the ramp rate and S ramp acceleration limit have been chosen such that for the default maximum speed, the curved parts of the S ramp are 25% of the original ramp if S ramp is enabled. Therefore the ramp time is increased by a factor of 1.5.

2.08	Standard ramp voltage															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to DC_VOLTAGE_SET_MAX V							
Default	Open-loop, Closed-loop vector, Servo								200V rating drive: 375 400V rating drive: EUR: 750 / USA: 775 575V rating drive: 895 690V rating drive: 1,075							
Update rate	Background read															

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 OU 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 √2.

02.09	**Deceleration failure detection**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

Deceleration failure detection is provided to force the drive to change from the decelerating state to the appropriate stop state if the motor frequency or speed is held at a constant level for 10s or more when the standard ramp voltage controller is active. When the drive is connected to a highly inductive supply it is possible for the d.c. link voltage to rise as the motor frequency/speed falls. This rise in d.c. link voltage causes the standard ramp d.c. link voltage controller to prevent any further deceleration.

In some applications with very high inertia, the motor frequency/speed must fall very slowly or else the power fed into the d.c. link will cause an over-voltage trip. In these applications it may be necessary to disable the deceleration failure detection system by setting this parameter to 1.

2.10	**Acceleration rate selector**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 9								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

The acceleration rate is selected as follows.

0	Ramp rate selection by terminal input
1 - 8	Ramp rate defined by parameter number, i.e. 1 = Pr **2.11**, 2 = Pr **2.12**, etc.
9	Ramp rate selection by Pr **1.50**

When Pr **2.10** is set to 0 the acceleration ramp rate selected depends on the state of bit Pr **2.32** to Pr **2.34**. These bits are for control by digital inputs such that ramp rates can be selected by external control. The ramp rate selected depends on the binary code generated by these bits as follows:

Pr 2.34	Pr 2.33	Pr 2.32	Ramp defined by
0	0	0	Pr **2.11**
0	0	1	Pr **2.12**
0	1	0	Pr **2.13**
0	1	1	Pr **2.14**
1	0	0	Pr **2.15**
1	0	1	Pr **2.16**
1	1	0	Pr **2.17**
1	1	1	Pr **2.18**

When Pr **2.10** is set to 9 the appropriate acceleration rate is automatically selected depending on the value of Pr **1.50**, and so an acceleration rate can be programmed to operate with each reference. Since the new ramp rate is selected with the new reference, the acceleration applies towards the selected preset if the motor needs to accelerate to reach the preset.

<table>
<tr><td>2.11</td><td colspan="16">Acceleration rate 1</td></tr>
<tr><td>2.12</td><td colspan="16">Acceleration rate 2</td></tr>
<tr><td>2.13</td><td colspan="16">Acceleration rate 3</td></tr>
<tr><td>2.14</td><td colspan="16">Acceleration rate 4</td></tr>
<tr><td>2.15</td><td colspan="16">Acceleration rate 5</td></tr>
<tr><td>2.16</td><td colspan="16">Acceleration rate 6</td></tr>
<tr><td>2.17</td><td colspan="16">Acceleration rate 7</td></tr>
<tr><td>2.18</td><td colspan="16">Acceleration rate 8</td></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="3">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td colspan="16">Closed-loop vector and Servo DP = 3</td></tr>
<tr><td>Range</td><td colspan="8">Open-loop
Closed-loop vector, Servo</td><td colspan="8">0.0 to 3,200.0 s/100Hz
0.000 to 3,200.000 s/1000rpm</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop
Closed-loop vector
Servo</td><td colspan="8">5.0
2.000
0.200</td></tr>
<tr><td>Second motor parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">Pr 21.04 for Pr 2.11 only</td></tr>
<tr><td>Update rate</td><td colspan="16">4ms read</td></tr>
</table>

Closed-loop vector and servo

If an acceleration rate is selected where the parameter is set to 0.000 the acceleration ramp is disabled and the reference changes instantly to its new value during acceleration.

Open-loop

If either an acceleration or deceleration rate is selected where the parameter is set to 0.0 in open-loop mode, the ramps are disabled (for both acceleration and deceleration). This disables the voltage controller, used for standard ramp and mains loss ride through, and the frequency based current limits.

<table>
<tr><td>2.19</td><td colspan="16">Jog acceleration rate</td></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="3">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td colspan="16">Closed-loop vector and Servo DP = 3</td></tr>
<tr><td>Range</td><td colspan="8">Open-loop
Closed-loop vector and Servo</td><td colspan="8">0.0 to 3200.0 s/100Hz
0.000 to 3200.000 s/1000rpm</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop
Closed-loop vector, Servo</td><td colspan="8">0.2
0.000</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

The jog acceleration rate is only used when accelerating towards the jog reference and when changing the jog reference.

<table>
<tr><td>2.20</td><td colspan="16">Deceleration rate selector</td></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0 to 9</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0</td></tr>
<tr><td>Update rate</td><td colspan="16">4ms read</td></tr>
</table>

The acceleration rate is selected as follows:

0 Ramp rate selection by terminal input
1 - 8 Ramp rate defined by parameter number, i.e. 1 = Pr **2.21**, 2 = Pr **2.22**, etc.
9 Ramp rate selection by Pr **1.50**

When Pr **2.20** is set to 0 the deceleration ramp rate selected depends on the state of bit Pr **2.35** to Pr **2.37**. These bits are for control by digital inputs such that ramp rates can be selected by external control. The ramp rate selected depends on the binary code generated by these bits as follows:

02.37	02.36	02.35	Ramp defined by
0	0	0	Pr **2.21**
0	0	1	Pr **2.22**
0	1	0	Pr **2.23**
0	1	1	Pr **2.24**
1	0	0	Pr **2.25**
1	0	1	Pr **2.26**
1	1	0	Pr **2.27**
1	1	1	Pr **2.28**

When Pr **2.20** is set to 9 the appropriate deceleration rate is automatically selected depending on the value of Pr **1.50**, and so a deceleration rate can be programmed to operate with each reference. Since the new ramp rate is selected with the new reference, the deceleration applies towards the selected preset if the motor needs to decelerate to reach the preset.

2.21	**Deceleration rate 1**															
2.22	**Deceleration rate 2**															
2.23	**Deceleration rate 3**															
2.24	**Deceleration rate 4**															
2.25	**Deceleration rate 5**															
2.26	**Deceleration rate 6**															
2.27	**Deceleration rate 7**															
2.28	**Deceleration rate 8**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector and Servo DP = 3															
Range	Open-loop Closed-loop vector, Servo	0.0 to 3,200.0 s/100Hz 0.000 to 3,200.000 s/1000rpm														
Default	Open-loop Closed-loop vector Servo	10.0 2.000 0.200														
Second motor parameter	Open-loop, Closed-loop vector, Servo	Pr **21.05** for Pr **2.21** only														
Update rate	4ms read															

Closed-loop vector and servo

If an deceleration rate is selected where the parameter is set to 0.000 the deceleration ramp is disabled and the reference changes instantly to its new value during deceleration.

Open-loop

If either an acceleration or deceleration rate is selected where the parameter is set to 0.0 in open-loop mode, the ramps are disabled (for both acceleration and deceleration). This disables the voltage controller, used for standard ramp and mains loss ride through, and the frequency based current limits.

2.29	**Jog deceleration rate**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector and Servo DP = 3															
Range	Open-loop Closed-loop vector and servo	0.0 to 3,200.0 s/100Hz 0.000 to 3,200.000 s/1000rpm														
Default	Open-loop Closed-loop vector, Servo	0.2 0.000														
Update rate	Background read															

The jog deceleration rate is only used when the drive is changing speed because the jog reference has changed or to stop from the jog reference. It is not used to go from the jog to the run state. This prevents the fast ramps normally used with jog from being used when changing between running and jogging.

2.32	**Acceleration select bit 0**															
2.33	**Acceleration select bit 1**															
2.34	**Acceleration select bit 2**															
2.35	**Deceleration select bit 0**															
2.36	**Deceleration select bit 1**															
2.37	**Deceleration select bit 2**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Update rate	4ms read															

These bits are provided for control by logic input terminals for external ramp selection (see Pr **2.10** and Pr **2.20**).

2.38	**Inertia compensation torque**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				
Range	Closed-loop vector, Servo								±1,000.0 %							
Update rate	4ms write															

The motor and load inertia (Pr **3.18**), motor torque per amp (Pr **5.32**) and the rate of change of the ramp output (Pr **2.01**) are used to produce a torque feed forward value that should accelerate or decelerate the load at the required rate. This value can be used as a feed forward term that is added to the speed controller output if Pr **4.22** is set to one. Pr **2.38** shows the torque value as a percentage of rated active current.

5.5 Menu 3: Slave frequency, speed feedback, speed control and regen operation

Menu 3 relates to different functions depending on the drive mode selected as shown in the table below. The menus for some drive modes are significantly different and therefore the complete menu is covered in different sections. Open-loop is different from Closed-loop vector and Servo except that it shares a common block of parameters for the drive encoder. The drive encoder parameters are only described in the Closed-loop vector and Servo section.

Drive mode section	Menu 3 functions
Open-loop	Frequency slaving "Zero speed" and "at speed" detectors
Closed-loop vector and servo	Speed feedback, speed controller "Zero speed", "at speed" and overspeed detectors, drive encoder
Regen	Regen control and monitoring functions

Frequency/Speed accuracy and resolution

Digital reference resolution

When a preset frequency/speed is used the reference resolution is 0.1Hz or 0.1rpm. Improved resolution can be obtained by using the precision reference (0.001Hz or 0.001rpm).

Analog reference resolution

In Open-loop modes the frequency reference controlled by an analog input has a maximum resolution of 12bits plus sign, but this is reduced if the window filter time for this input controller by Pr **7.26** is reduced below the default value of 4.0ms. The resolution of the frequency reference from analog inputs 2 or 3 is 10bits plus sign.

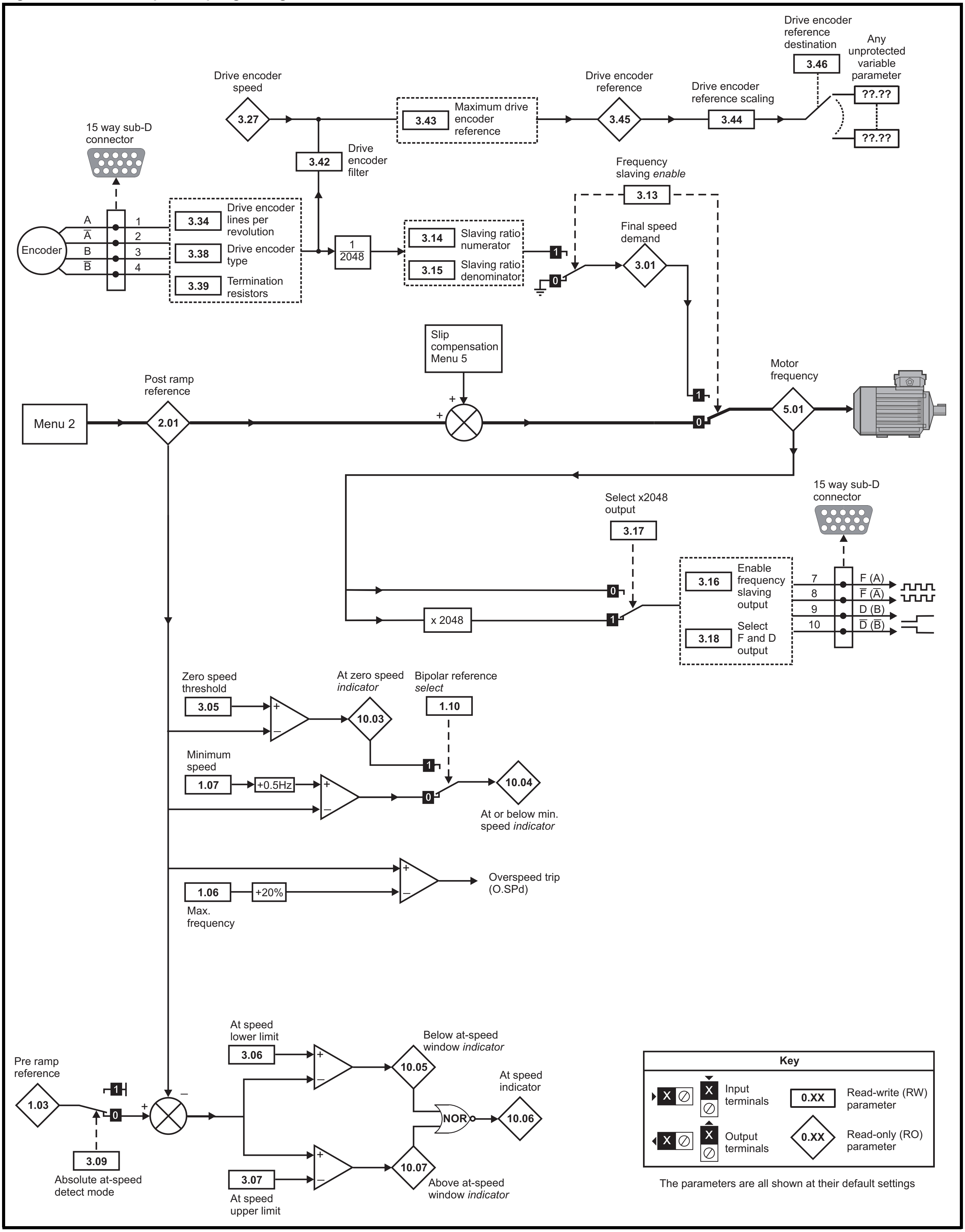
In Closed-loop vector or Servo mode the resolution from analog input 1 is better than 16bits plus sign provided the speed reference is routed via Pr **1.36**, Pr **1.37** or Pr **3.22** in high speed update mode. The resolution from analog inputs 2 or 3 is 10bits plus sign.

Accuracy

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 and non-linearity of the analog input.

Parameter descriptions: Open-loop

Figure 5-3 Menu 3 Open-loop logic diagram



3.01	**Frequency slaving demand**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1				1	1		1		1				
Range	Open-loop								±1000.0 Hz							
Update rate	4ms write															

The slave frequency demand is only relevant if the drive is operating in frequency slaving mode, in other modes this parameter reads as 0.0. The value shown in slaving mode is the fundamental drive output frequency. Frequency slaving mode is used to lock the fundamental frequency produced by the drive with an external frequency applied to the main drive encoder input. This could be used for example to keep the shafts of two synchronous machines in lock, by feeding the frequency slaving output from the master drive into the encoder input of the slave drive. Alternatively the two machines could be operated so that the shafts rotate with an exact ratio, i.e. as though the shafts were connected by gears (see Pr **3.14** and Pr **3.15** on page 54).

The source for frequency slaving mode may be quadrature A/B encoder signals or Frequency and Direction. With the latter care must be taken to ensure that the D set-up time (10μs) is observed or pulses may be lost. The frequency slaving input must be selected as F and D or quadrature to match the source mode. The input mode is selected by Pr **3.38** which defines the encoder type. The default for source and destination drives is quadrature A/B mode, unlike previous products which used F and D only.

The drive will not count pulses while it is disabled (this parameter will show 0.0), but will maintain lock once enabled even if the direction of rotation reverses. In frequency slaving mode the drive current limits are not active, however, the drive peak limit is active and will try and limit the drive current to the magnitude limit by modifying the output voltage away from the defined V to F (Voltage to Frequency) characteristic. If synchronous machines are used and the current required exceeds the drive magnitude limit the slave machine will pole slip.

3.05	**Zero speed threshold**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 20.0 Hz							
Default	Open-loop								1.0							
Update rate	Background read															

If the post ramp reference (Pr **2.01**) is at or below the level defined by this parameter in either direction the Zero speed flag (Pr **10.03**) is 1, otherwise the flag is 0.

3.06	**At speed lower limit**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 3,000.0 Hz							
Default	Open-loop								1.0							
Update rate	Background read															

3.07	**At speed upper limit**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 3,000.0 Hz							
Default	Open-loop								1.0							
Update rate	Background read															

3.09	**Absolute "at speed" select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop								0							
Update rate	Background read															

"At speed" flag (Pr **10.06**) is set if the post-ramp reference (Pr **2.01**) is on the boundaries or within the at speed window. Flags Pr **10.07** and Pr **10.05** are set if the reference is above or below the window respectively.

If Pr **3.09** = 0 reference window mode is used and the "at speed" condition is true if

(|Pr **1.03**| - Pr **3.06**) ≤ |Pr **2.01**| ≤ (|Pr **1.03**| + Pr **3.07**)

(If the lower limit is less than zero then zero is used as the lower limit).

If Pr **3.09** = 1 absolute window mode is used and the "at speed" condition is true if

Pr **3.06** ≤ |Pr **2.01**| ≤ Pr **3.07**

The speed detector system also includes an overspeed trip in open-loop mode. The level cannot be set by the user, but the drive produces an overspeed trip if the final frequency (Pr **5.01**) exceeds 1.2 x SPEED_FREQ_MAX.

3.13	**Enable frequency slaving**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop								0							
Update rate	4ms read															

Frequency slaving as described in Pr **3.01** is enabled by this parameter. Frequency slaving can be enabled or disabled even when the drive is enabled. The change from slaving to normal operation will result in the frequency ramping from the slaving frequency to the demanded frequency using whichever ramp rate that is applicable to normal operation. The change from normal operation to slaving will result in an instantaneous change to the slaving frequency. Therefore the slaving frequency should be similar to the demanded frequency before the change is made.

3.14	**Slaving ratio numerator**															
3.15	**Slaving ratio denominator**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop								0.000 to 1.000							
Default	Open-loop								1.000							
Update rate	4ms read															

The slave frequency input can be scaled before it defines the slave frequency demand (Pr **3.01**) using Pr **3.14** and Pr **3.15**. The numerator and denominator can be adjusted while the drive is running without causing jumps in angle. However if the change in ratio causes a large change in frequency the transient current could activate the peak limit or trip the drive. Although Pr **3.15** can be set to zero the drive uses a value of 0.001 if this parameter is zero.

3.16	**Enable frequency slaving output**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop								0							
Update rate	Background read															

3.17	**Select x2048 output**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop								1							
Update rate	Background read															

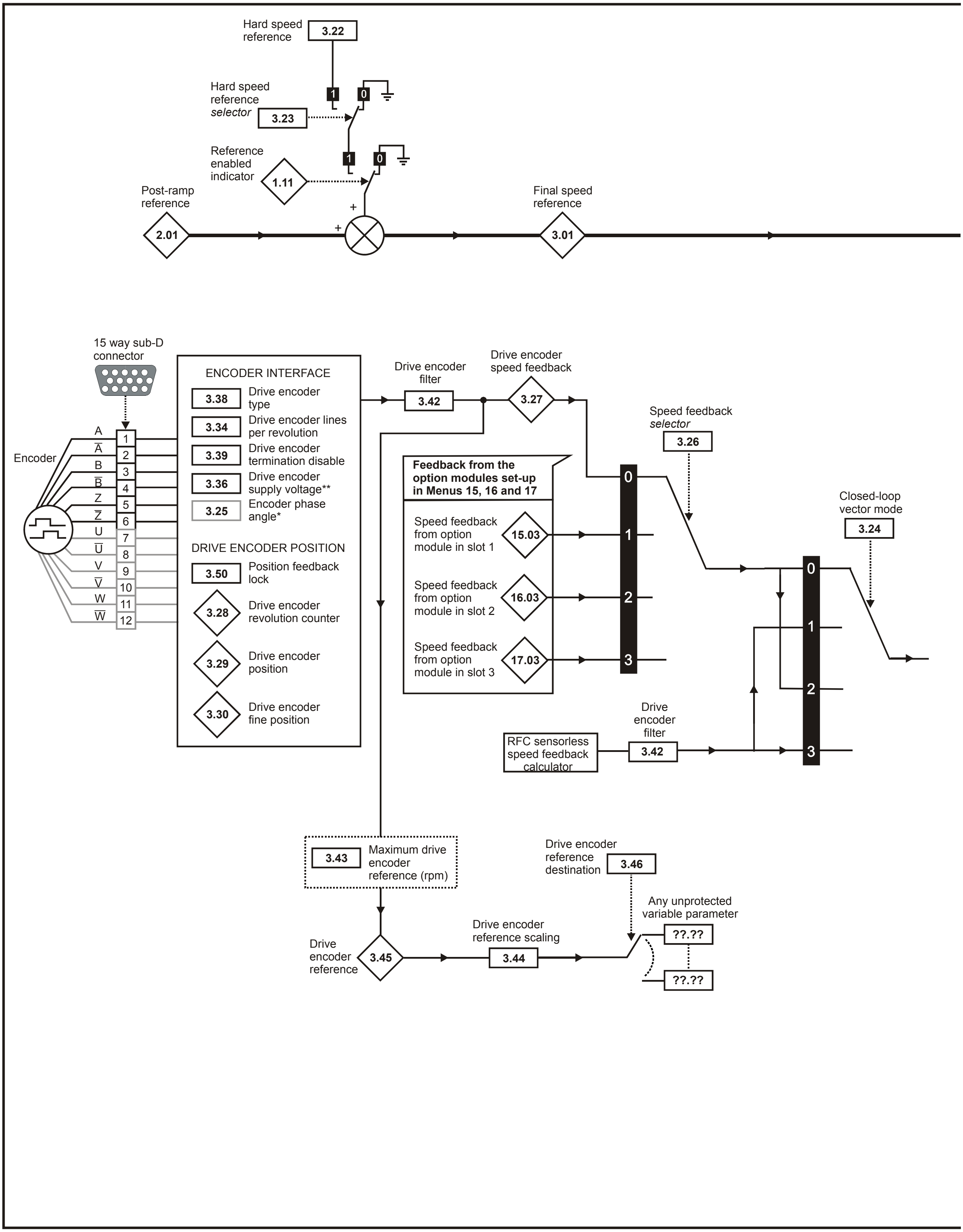
3.18	**F and D frequency slaving output**														
Drive modes	Open-loop														
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop							0								
Update rate	Background read															

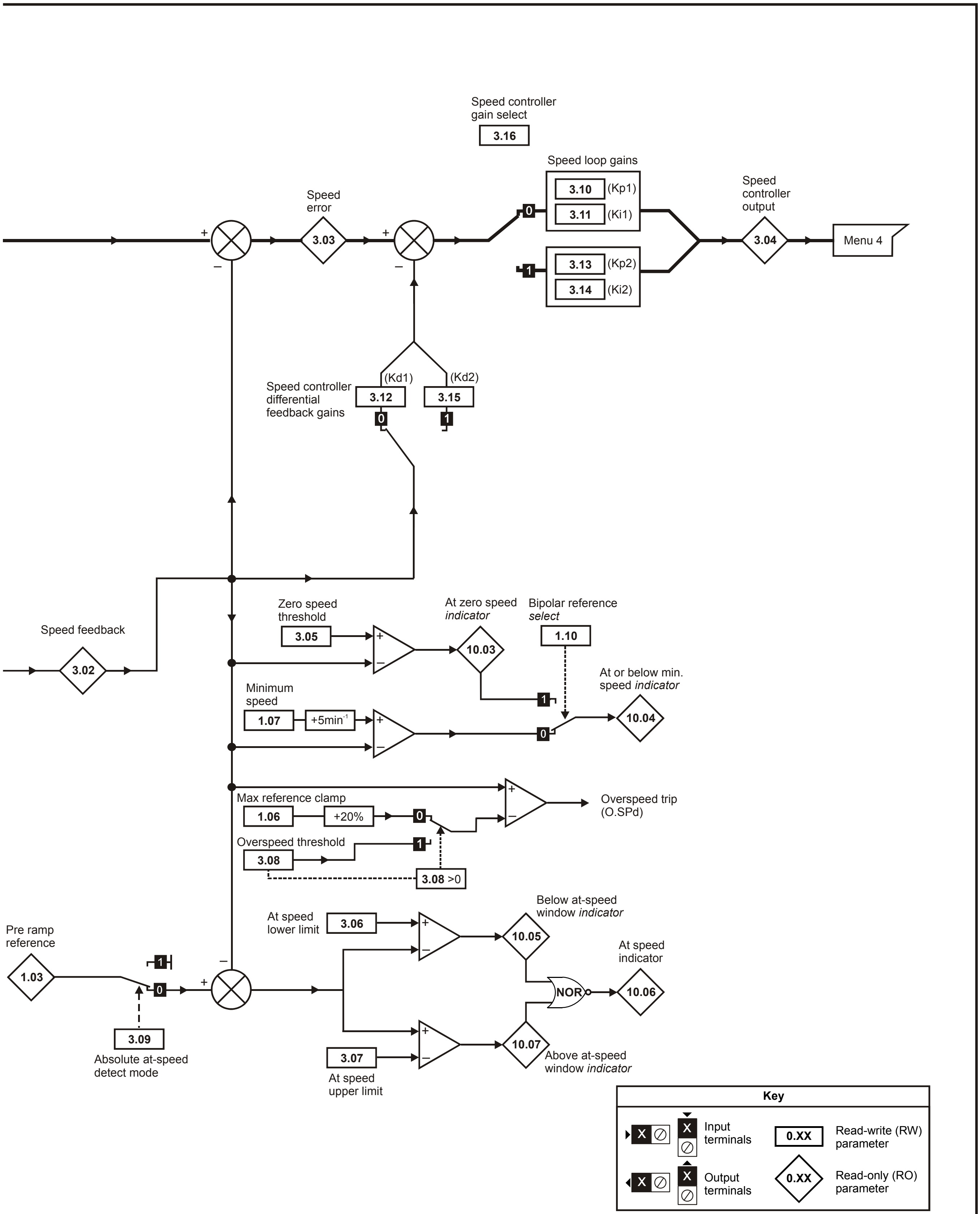
The frequency slaving output is in the form of F and D or quadrature A/B signals (Pr **3.18** = 0 gives quadrature, Pr **3.18** = 1 gives F and D). When F and D is used the output frequency is either 1 or 2048 times the drive fundamental output frequency (selected by Pr **3.17**). When quadrature A/B signals are used, the slaving output frequency is effectively divided by 2 giving either 0.5 or 1024 times the drive fundamental output frequency. When the drive output frequency changes direction there is always a period of 250μs where no pulses are produced. This ensures that with an F and D output there is a set-up time of 250μs for the direction signal before an edge occurs on the frequency signal. The frequency slaving output operates up to 1000Hz, above this frequency the outputs could be undefined.

For further Menu 3 Open-loop parameters, refer to Pr 3.27 on page 67.

Parameter descriptions: Closed-loop vector and Servo

Figure 5-4 Menu 3 Closed-loop logic diagram





The parameters are all shown at their default settings

3.01	Final speed reference															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Closed-loop vector, Servo								±SPEED_MAX rpm							
Update rate	4ms write															

This is the final speed demand at the input to the speed regulator formed by the sum of the ramp output and the hard speed reference (if the hard speed reference is enabled). If the drive is disabled this parameter will show 0.0.

3.02	Speed Feedback															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Closed-loop vector, Servo								±SPEED_MAX rpm							
Update rate	4ms write															

The speed feedback can be taken from the drive encoder port or a position feedback module installed in any slot as selected with Pr **3.26**. Pr **3.02** shows the level of the speed feedback selected for the speed controller. The FI attribute is set for this parameter, so display filtering is active when this parameter is viewed with one of the drive keypads. The value held in the drive parameter (accessible via comms or a Solutions Module) does not include this filter, but is a value that is obtained over a sliding 16ms period to limit the ripple seen in this parameter value. The speed feedback value includes encoder quantization ripple given by the following equation:

Ripple in Pr **3.02** = 60 / 16ms / (ELPR x 4)

where ELPR is the equivalent encoder lines per revolution as defined below.

Position feedback device	ELPR
Ab, Ab.Servo	number of lines per revolution
Fd, Fr, Fd.Servo, Fr.Servo	number of lines per revolution / 2
SC.Hiper, SC.EnDat, SC, SC.SSI	number of sine waves per revolution

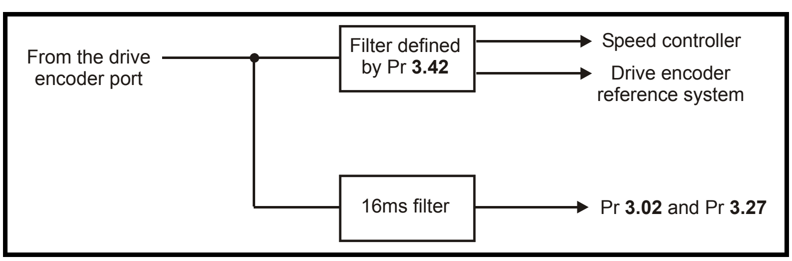
For example a 4096 line Ab type encoder gives a ripple level of 0.23rpm.

The 16ms sliding window filter is always applied to the value shown in Pr **3.02**, but this sliding window filter is not normally applied to the actual speed feedback used by the speed controller or the drive encoder reference system (Pr **3.43** to Pr **3.46**).The user may apply a filter to the speed controller input and the drive encoder reference system input if required by setting Pr **3.42** to the required filter time. The encoder ripple seen by the speed controller is given by:

Encoder speed ripple = 60 / Filter time / (ELPR x 4)

If Pr **3.42** is set to zero (no filter) the ripple seen by the speed controller and drive encoder reference system is given by:

Encoder speed ripple = 60 / 250μs / (ELPR x 4)



The diagram above shows the filter arrangement. It should be noted that the same filtering is provided at the speed controller input and for Pr **3.02** when the feedback is obtained from a Solutions Module, but the variable length window filter is controlled by Pr **x.19**.

It is not advisable to use the speed feedback filter unless it is specifically required for high inertia applications with high controller gains, or if a commutation signal only encoder is used, because the filter has a non-linear transfer function. It is preferable to use the current demand filters (see Pr **4.12** or **4.23**) as these are linear first order filters that provide filtering on noise generated from both the speed reference and the speed feedback. It should be noted that any filtering included within the speed controller feedback loop, either on the speed feedback or the current demand, introduces a delay and limits the maximum bandwidth of the controller for stable operation.

The speed ripple can be quite high, for example with a 4096 line encoder the speed ripple is 14.6rpm, but this does not define the resolution of the speed feedback which is normally much better and depends on the length of the measuring period used to obtain the feedback. This is shown in the improved resolution of the value accessible in Pr **3.02** which is measured over 16ms, i.e. a resolution of 0.23rpm with a 4096 line encoder. The speed controller itself accumulates all pulses from the encoder, and so the speed controller resolution is not limited by the feedback, but by the resolution of the speed reference. If a SINCOS encoder is used the encoder speed ripple is reduced by a factor of $2^{(2 - \text{INTERPOLATION BITS})}$ For example with the nominal 10 bits of interpolation information, the speed ripple is reduced by a factor of 256. This shows how a SINCOS encoder can reduce noise caused by encoder quantization without any filtering in the speed feedback or the current demand, so that high gains may be used to give high dynamic performance and a very stiff system.

3.03	**Speed error**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Closed-loop vector, Servo							±SPEED_MAX rpm								
Update rate	4ms write															

The speed error is the difference between the final speed demand and the speed feedback in rpm. This does not include the effect of the D term in the speed controller feedback branch.

3.04	**Speed controller output**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Closed-loop vector, Servo							±TORQUE_PROD_CURRENT_MAX %								
Update rate	4ms write															

The output of the speed regulator is a torque demand given as a percentage of rated motor torque. This is then modified to account for changes in motor flux if field weakening is active, and then used as the torque producing current reference.

3.05	**Zero speed threshold**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 200 rpm								
Default	Closed-loop vector, Servo							5								
Update rate	Background read															

If the speed feedback (Pr **3.02**) is at or below the level defined by this parameter in either direction the Zero speed flag (Pr **10.03**) is 1, otherwise the flag is 0.

3.06	**At speed lower limit**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 40,000 rpm								
Default	Closed-loop vector, Servo							5								
Update rate	Background read															

3.07	**At speed upper limit**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 40,000 rpm								
Default	Closed-loop vector, Servo							5								
Update rate	Background read															

"At speed" flag (Pr **10.06**) is set if the speed feedback (Pr **3.02**) is on the boundaries or within the at speed window. Flags Pr **10.07** and Pr **10.05** are set if the reference is above or below the window respectively.

If Pr **3.09** = 0 reference window mode is used and the "at speed" condition is true if

(|Pr **1.03**| - Pr **3.06**) ≤ |Pr **3.02**| ≤ (|Pr **1.03**| + Pr **3.07**)

(If the lower limit is less than zero then zero is used as the lower limit).

If Pr **3.09** = 1 absolute window mode is used and the "at speed" condition is true if

Pr **3.06** ≤ |Pr **3.02**| ≤ Pr **3.07**

3.08	**Overspeed threshold**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo	0 to 40,0000 rpm														
Default	Closed-loop vector, Servo	0														
Update rate	Background read															

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 1.2 x SPEED_FREQ_MAX.

In servo mode the motor speed and the motor voltage can be monitored to detect that the motor is accelerating in an uncontrolled way because the motor phasing angle has not been set up correctly in Pr **3.25** (Pr **21.20** if motor map 2 is selected). If the overspeed threshold is set to zero phasing angle error monitoring is enabled. If the overspeed threshold is set to any other value this feature is disabled.

3.09	**Absolute “at speed” detect**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo	0														
Update rate	Background read															

See Pr **3.06** and Pr **3.07** on page 59.

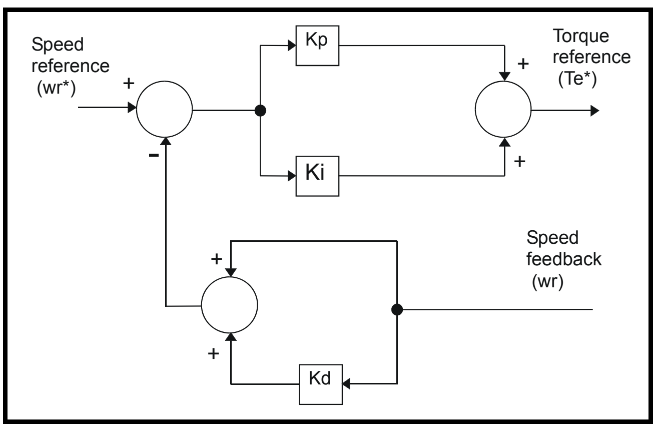
3.10	**Speed controller proportional gain (Kp1)**															
3.13	**Speed controller proportional gain (Kp2)**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							4						1	1	1	
Range	Closed-loop vector, Servo	0.0000 to 6.5535 (1/ rad s^{-1})														
Default	Closed-loop vector Servo	0.0300 0.0100														
Second motor parameter	Closed-loop vector, Servo	Pr **21.17**														
Update rate	Background read															

3.11	**Speed controller integral gain (Ki1)**															
3.14	**Speed controller integral gain (Ki2)**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Closed-loop vector, Servo	0.00 to 655.35 s/rad s^{-1}														
Default	Closed-loop vector Servo	0.10 1.00														
Second motor parameter	Closed-loop vector, Servo	Pr **21.18**														
Update rate	Background read															

3.12	**Speed controller differential feedback gain (Kd1)**															
3.15	**Speed controller differential feedback gain (Kd2)**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5						1	1	1	
Range	Closed-loop vector, Servo							0.00000 to 0.65535 s^{-1}/rad s^{-1}								
Default	Closed-loop vector, Servo							0.00000								
Second motor parameter	Closed-loop vector, Servo							Pr **21.19**								
Update rate	Background read															

3.16	**Speed controller gain select**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo							0								
Update rate	4ms read															

The following diagram shows a generalised representation of the speed controller. The 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 are used, if Pr **3.16** = 1, gains Kp2, Ki2 and Kd2 are used. Pr **3.16** may be changed when the drive is enabled or disabled.

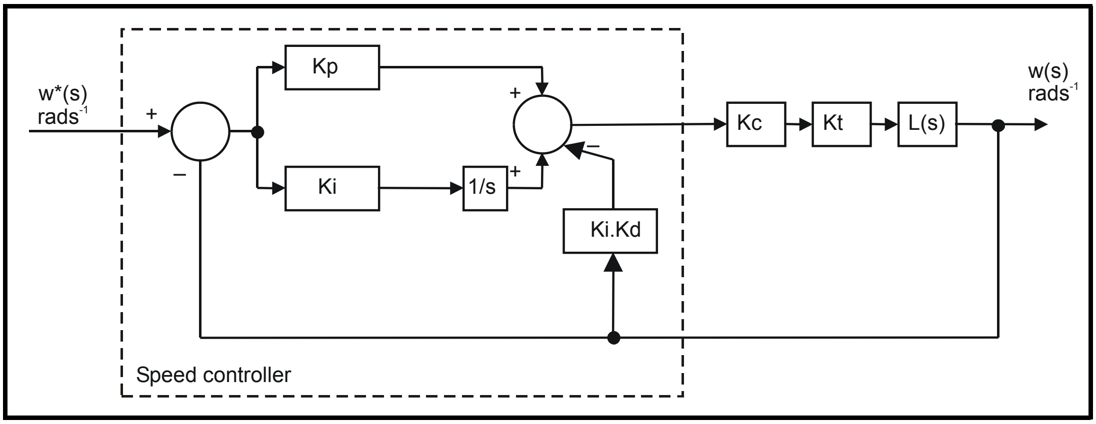


Proportional gain (Kp)
If Kp has a value and Ki is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called 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 quantisation (using digital encoders, resolvers, etc). becomes unacceptable, or the closed-loop stability limit is reached (using SINCOS encoders).

Integral gain (Ki)
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. The integral term is implemented in the form of $\sum$(Ki x error), and so the integral gain can be changed when the controller is active without causing large torque demand transients.

Differential gain (Kd)
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. It should be noted that the differential term is limited internally so that it is ineffective if speed in rpm x Kd x Ki is greater than 170.

To analyze the performance of the speed controller it may be represented as an s-domain model as shown below.



Where:

Kc is the conversion between the speed controller output and the torque producing current. A value of unity at the output of the speed controller gives a torque producing current equal to Kc. The drive automatically compensates the torque producing current for flux variations in field weakening, and so Kc can be assumed to have a constant value even in field weakening. See menu 4 for the value of Kc each drive size).

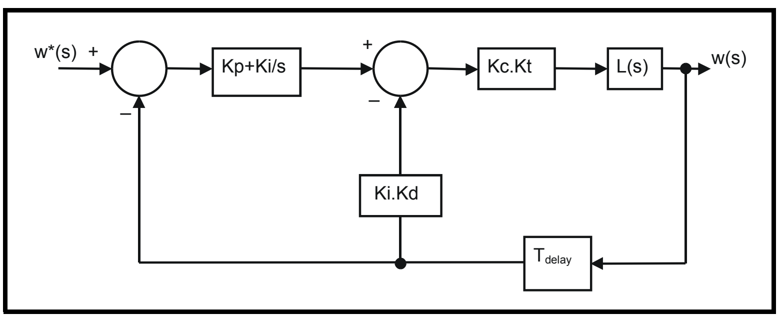
Kt is the torque constant of the motor (i.e. torque in Nm per amp of torque producing current). This value is normally available for a servo motor from the manufacturer, however for induction motors the value must be calculated from

Kt = Motor rated torque / Motor rated torque producing current

= Motor rated torque / $\sqrt{}$(Motor rated current^2 - No load current^2)

L(s) is the transfer function of the load.

The s-domain system above may be used to determine the performance of systems with a relatively low bandwidth. However, the real drive system also includes non-ideal delays due to the torque controller response, and speed measurement and control delays. These delays, which can be approximated with a simple unity gain transport delay (T_{delay}) as shown below, should be taken into account for more accurate results.



The speed controller gains used in previous Unidrive products were in internal drive units. Conversion between the previous internal units and the SI units used in this product are given in the table below.

Gain	Conversion from previous internal units to new SI units
Kp	Kp_old / 17103
Ki	Ki_old / 94.41
Kd	Kd_old / 46376

3.17	Speed controller set-up method															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo								0 to 3							
Default	Closed-loop vector, Servo								0							
Update rate	Background (1s) read															

The user may enter the required speed controller gains into Pr **3.10** to Pr **3.15.** However, if the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains, provided a value of motor plus load inertia (Pr **3.18**) and the motor torque per amp (Pr **5.32**) are set-up correctly. The gain values are calculated to give a required compliance angle or bandwidth. The calculated values for Kp and Ki are written to Pr **3.10** and Pr **3.11** once per second when one of these set-up methods is selected (i.e. Pr **3.17** = 1 or 2). The values are calculated from a linear model assuming a pure inertia load, not including unwanted delays in the speed and current controllers. The Kd gain is not affected. If Pr **3.17** is set to 3 automatic gain set up is not active, but Kp is boosted by a factor of 16.

0: user set-up

With the default value the user should enter the required speed controller gains.

1: Bandwidth set-up

If bandwidth based set-up is required the following parameters must be set correctly: Pr **3.20** = required bandwidth, Pr **3.21** = required damping factor, Pr **3.18** = motor + load inertia (it is possible to measure the load inertia as part of the auto-tuning process, see Pr **5.12** on page 117), Pr **5.32** = motor torque per amp.

$Ki = J / (Kc \times Kt) \times (2\pi \times Bandwidth / Kbw)^2$ = Pr **3.18** / (Kc x Pr **5.32**) x (2π x Pr **3.20** / Kbw)^2

Where: $Kbw = \sqrt{[(2\xi^2 + 1) + \sqrt{((2\xi^2 + 1)^2 + 1)}]}$

$Kp = 2 \xi \sqrt{[(Ki \times J) / (Kc \times Kt)]}$ = 2 ξ √ [(Pr **3.11** x Pr **3.18**) / (Kc x Pr **5.32**)]

2: Compliance angle set-up

If compliance angle based set-up is required the following parameters must be set correctly: Pr **3.19** = required compliance angle, Pr **3.21** = required damping factor, Pr **3.18** = motor + load inertia (it is possible to measure the load inertia as part of the auto-tuning process, see Pr **5.12** on page 117), Pr **5.32** = motor torque per amp.

Ki = 1 / Compliance angle (rad s^{-1})

$Kp = 2 \xi \sqrt{[(Ki \times J) / (Kc \times Kt)]}$ = 2 ξ √ [(Pr **3.11** x Pr **3.18**) / (Kc x Pr **5.32**)]

3: Kp gain times 16

If this parameter is set to 3 the Kp gain (from whichever source) is multiplied by 16. This is intended to boost the range of Kp for applications with very high inertia. It should be noted that if high values of Kp are used it is likely that the speed controller output will need to be filtered (see Pr **4.12**) or the speed feedback will need to be filtered (see Pr **3.42**). If the feedback is not filtered it is possible the output of the speed controller will be a square wave that changes between the current limits causing the integral term saturation system to malfunction.

3.18	**Motor and load inertia**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5						1	1	1	
Range	Closed-loop vector, Servo							0.00000 to 90.00000 kg m^2								
Default	Closed-loop vector, Servo							0.00000								
Update rate	Background (1s) read															

The motor and load inertia represents the total inertia driven by the motor. This is used to set the speed controller gains (see Pr **3.13** on page 60) and to provide torque feed-forwards during acceleration when required. (see Pr **4.11** on page 100) (It is possible to measure the inertia as part of the auto-tune process, see Pr **5.12** on page 117.

3.19	**Compliance angle**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Closed-loop vector, Servo							0.0 to 359.9 °mechanical								
Default	Closed-loop vector, Servo							4.0								
Update rate	Background (1s) read															

The compliance angle is the required angular displacement when the drive delivers a torque producing current equivalent to the current scaling (Kc) with no field weakening.

3.20	**Bandwidth**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 255 Hz								
Default	Closed-loop vector, Servo							10 Hz								
Update rate	Background (1s) read															

The bandwidth is defined as the theoretical 3dB point on the closed-loop gain characteristic of the speed controller as a second order system. At this point the phase shift is approximately 60°. This parameter is used to define the bandwidth used for setting up the speed loop gain parameters automatically when Pr **3.17** = 1.

3.21	**Damping factor**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Closed-loop vector, Servo								0.0 to 10.0							
Default	Closed-loop vector, Servo								1.0							
Update rate	Background (1s) read															

This is the damping factor related to the response of the system to a torque transient, and so if the damping factor is unity the response to a load torque transient is critically damped. The step response of the speed controller gives approximately 10% overshoot with unity damping factor.
This parameter is used to define the damping factor used for setting up the speed loop gain parameters automatically when Pr **3.17** = 1 or 2.

3.22	**Hard speed reference**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1	1	
Range	Closed-loop vector, Servo								±SPEED_FREQ_MAX rpm							
Default	Closed-loop vector, Servo								0.0							
Update rate	4ms read															

3.23	**Hard speed reference selector**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo								0							
Update rate	4ms read															

The hard speed reference is a reference value which does not pass through the ramp system (Menu 2). It is added to the normal post ramp speed reference. Its value may be written from the keypad, via serial comms, from an analog input or from an encoder input. This parameter can also be used by the position controller (Menu 13) as the speed reference input. The hard speed reference is selected when Pr **3.23** = 1.

3.24	**Closed-loop vector mode**															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector								0 to 3							
Default	Closed-loop vector								0							
Update rate	Background read															

0: Closed-loop vector mode with position feedback

The drive uses the closed-loop vector algorithm with the selected position feedback.

1: RFC mode - Closed-loop vector mode without position feedback

The drive uses the closed-loop vector algorithm and derives the position feedback internally.

2: Closed-loop vector mode with no maximum speed limit

3: RFC mode - Closed-loop vector mode without position feedback with no maximum speed limit

In some applications using closed-loop vector control the maximum speed of the system is above the speed at which the encoder feedback frequency is too high to be used by the drive. For these type of applications Pr **3.24** should be set to 2 for low speed operation and 3 for high speed operation. It should be noted that the drive no longer checks that the maximum encoder frequency cannot be exceeded in closed-loop vector control, and so the user must ensure that Pr **3.24** is set to 3 before the encoder frequency limit is reached.

If the drive encoder lines per rev (Pr **3.34**) is set to a value that is not a power of 2 and the drive encoder type (Pr **3.38**) is used to select any type of SINCOS encoder this parameter is forced to zero. This is because the extra processing time required to support the feedback device would not allow enough time for the closed-loop vector algorithm without position feedback to be executed. It should be noted that if the algorithm without position feedback is active that the sample rate for 6 and 12kHz operation is reduced from 12kHz to 6kHz. Also operation at 4kHz, 8kHz or 16kHz is not possible and if these frequencies are selected the actual switching frequency is switched down to the next lower frequency. Pr **5.37** displays the actual switching frequency being used.

When closed-loop vector mode without position feedback is used a filter with a 4ms time constant is automatically included in the speed feedback as this is required for this system to operate correctly. This will reduce the possible bandwidth of the speed controller compared with the bandwidth possible when position feedback is used. Particularly when operating above rated speed it may be necessary to include further filtering (Pr **4.12** set to a value between 1.0 and 5.0ms) to achieve stable operation.

3.25	**Encoder phase angle**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1					1	1	1	
Range	Servo								0.0 to 359.9 ° electrical							
Second motor parameter	Servo								Pr **21.20**							
Update rate	Background read															

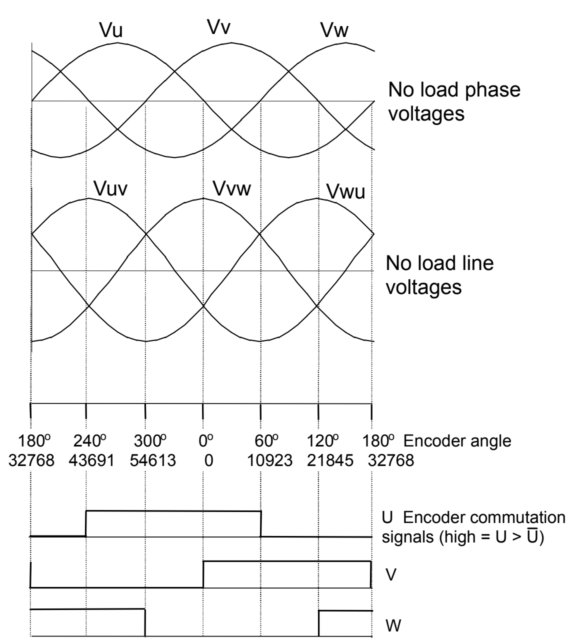
The phase angle between the rotor flux in a servo motor and the encoder position is required for the motor to operated correctly. If the phase angle is known it can be set in this parameter by the user. Alternatively the drive can automatically measure the phase angle by performing a phasing test (see Pr **5.12** on page 117). 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.

The alignment required for zero encoder phase angle (i.e. Pr **3.25** = 0.0) is given below for different feedback devices. Forward rotation of the motor is produced when Vu leads Vv leads Vw. Although it is not essential, forward rotation of a motor is normally defined as clockwise when looking at the motor shaft end. When the motor is rotating forwards the motor speed is shown as positive and the position increases.

Encoder with commutation signals (Ab.Servo, Fd.Servo, Fr.Servo)

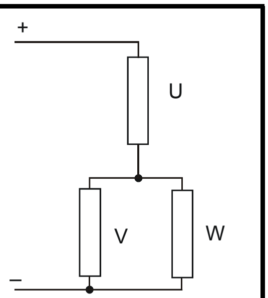
The alignment required between the no-load motor voltages and the commutation signals for Pr **3.25** = 0 is shown in the following diagram below:

It should be noted that if the encoder is advanced (i.e. the UVW signals are moved to the right with respect to the voltages) the phasing angle in Pr **3.25** is increased from zero. If the encoder is retarded the phasing angle changes to 359.9° and then reduces towards zero.



Encoder alignment for zero encoder phase angle

The encoder can be aligned statically by connecting the motor to a DC power supply as shown:



The motor will move to one of a number of positions defined by the number of motor pole pairs (i.e. 3 positions for a six pole motor, etc). The encoder should be adjusted so that the U commutation signal is high, W is low and V is toggling in one of these positions.

Any other feedback device

The alignment required between the no-load motor voltages and the commutation signals for Pr **3.25** = 0 is shown in the diagram below for a 2 or 4 pole motor. For higher numbers of poles 0° should still be aligned as shown, but one electrical cycle shown corresponds to 360°/ (Number of poles / 2). The encoder can be aligned statically by connecting the motor to a DC power supply as already shown. The motor will move to one of a number of positions defined by the number of motor pole pairs (i.e. 3 positions for a six pole motor, etc). The encoder should be adjusted so that the position displayed by the drive is n x 65536 / (Number of poles / 2), where n = 0, 1, ... (Number of poles / 2)

It should be noted that if the encoder is advanced (i.e. the encoder is moved so that the angle moves to the right with respect to the voltages) the phasing angle in Pr **3.25** is increased from zero. If the encoder is retarded the phasing angle changes to 359.9° and then reduces towards zero.

3.26	**Speed feedback selector**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Closed-loop vector, Servo								0 to 3							
Default	Closed-loop vector, Servo								0							
Second motor parameter	Closed-loop vector, Servo								Pr **21.21**							
Update rate	Background read (Only has any effect when the drive is disabled)															

0, drv: Drive encoder

The position feedback from the encoder connected to the drive itself is used to derive the speed feedback for the speed controller and to calculate the motor rotor flux position.

1, Slot1: Solutions Module in slot 1

The position feedback from the Solutions Module in Solutions Module slot 1 is used to derive the speed feedback for the speed controller and to calculate the motor rotor flux position. If a position feedback category Solutions Module is not installed in slot 1 the drive produces an EnC9 trip.

2, Slot2: Solutions Module in slot 2

3, Slot3: Solutions Module in slot 3

Parameters common to open-loop and closed-loop modes

3.27	**Drive encoder speed feedback**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1				1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo							±40,000.0 rpm								
Update rate	4ms write															

Provided the set-up parameters for the drive encoder are correct this parameter shows the encoder speed in rpm.

It should be noted that the value shown by this parameter is measured over a 16ms sliding window period (in the same way as Pr **3.02**), and so the ripple in this parameter accessible via comms or by a Solutions Module is as defined for Pr **3.02**. The FI attribute for this parameter is set, and so further filtering is applied when this parameter is viewed with one of the drive keypads.

3.28	**Drive encoder revolution counter**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535 revolutions								
Update rate	4ms write															

3.29	**Drive encoder position**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535 ($1/2^{16}$ths of a revolution)								
Update rate	4ms write															

3.30	**Drive encoder fine position**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535 ($1/2^{32}$ths of a revolution)								
Update rate	4ms write															

These parameters effectively give the encoder position with a resolution of $1/2^{32}$ths of a revolution as a 48 bit number as shown below.

47 — 32	31 — 16	15 — 0
Revolutions	Position	Fine position

Provided the encoder set-up parameters are correct, the position is always converted to units of $1/2^{32}$ths of a revolution, but some parts of the value may not be relevant depending on the resolution of the feedback device. For example a 1024 line digital encoder produces 4096 counts per revolution, and so the position is represented by the bits in the shaded area only.

47 — 32	31 — 20	19 — 16	15 — 0
Revolutions	**Position**		Fine position

When the encoder rotates by more than one revolution, the revolutions in Pr **3.28** increment or decrement in the form of a sixteen bit roll-over counter. If an absolute position feedback device (except an encoder with commutation signals) is used the position is initialized at power-up with the absolute position. If a multi-turn absolute encoder is used the revolution counter is also initialized with the absolute revolutions at power-up.

If a linear encoder is used the turns information is used to represent movement by the number of poles defined by Pr **5.11** (or 21.11 for motor map 2). Therefore if the number of poles is set to two, one revolution is the movement by one pole pitch.

3.31	**Drive encoder marker position reset disable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

3.32	**Drive encoder marker flag**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	250μs write															

An incremental digital encoder or a SINCOS encoder without communications may have a marker channel. When this channel becomes active it may be used to reset the encoder position and set the marker flag (Pr **3.31** = 0), or just to set the marker flag (Pr **3.31** = 1). The marker flag is set each time the marker input becomes active, but it is not reset by the drive, and so it must be cleared by the user.

If Pr **3.35** is set to zero the marker system operates in a conventional manner and only resets the position (Pr **3.29** and Pr **3.30**) and not the turns (Pr **3.28**) on a marker event. If Pr **3.35** is set to one the whole position (Pr **3.28** to Pr **3.30**) are reset on a marker event. The full reset mode allows the marker to give a form of registration where the marker event defines zero position.
The marker function only operates when Ab, Fd, Fr, SC, Ab.Servo, Fd.Servo, Fr.Servo type encoders are selected with Pr **3.38**.

3.33	**Drive encoder turns bits / Linear encoder comms to sine wave ratio**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 255								
Default	Open-loop, Closed-loop vector, Servo							16								
Update rate	Background read (Only has any effect when the drive is disabled)															

This parameter has a different function depending on the type of encoder selected with Pr **3.38** and Pr **3.39.**

Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo, SC
It is sometimes desirable to mask off the most significant bits of the revolution counter with these types of encoders. This does not have to be done for the drive to function correctly. If Pr **3.33** is zero the revolution counter (Pr **3.28**) is held at zero. If Pr **3.33** has any other value it defines the maximum number of the revolution counter before it is reset to zero. For example, if Pr **3.33** = 5, then Pr **3.28** counts up to 31 before being reset. If Pr **3.33** is greater than 16, the number of turns bits is 16 and the Pr **3.28** counts up to 65535 before being reset.

SC.Hiper, SC.EnDat, SC.SSI and 03.39 = 1 or 2 (Rotary encoder)
Pr **3.33** must contain the number of bits in the comms message used to give the multi-turn information. For a single turn comms encoder, Pr **3.33** must be set to zero. As well as setting the number of comms turns bits this parameter also sets up a mask on the turns displayed in Pr **3.28** as described above. With SC.Hiper or SC.EnDat encoders it is possible for this parameter to be obtained automatically from the encoder (see Pr **3.41**). If Pr **3.33** is greater than 16 the number of turns bits is 16.

SC.Hiper, SC.EnDat, SC.SSI and 03.39 = 0 (Linear encoder)
When a linear encoder is selected no mask is placed on the turns information displayed in Pr **3.28**, and so this parameter always displays the turns information as a full 16 bit value with a maximum of 65535. Linear SINCOS encoders with comms are normally specified with a length for each sine wave period and the length for the least significant bit of the position in the comms message. Pr **3.33** should be set up with the ratio between these two lengths so that the drive can determine the drive encoder position during initialization. The Linear encoder comms to sine wave ratio is defined as follows:

$$\text{Linear encoder comms to sine wave ratio} = \frac{\text{Length for a sine wave period}}{\text{Length representing the LS bit of the position in the comms message}}$$

With SC.Hiper or SC.EnDat encoders it is possible for this parameter to be obtained automatically from the encoder (see Pr **3.41**).

This ratio can be greater than 255 for some EnDat encoders. If this is the case it is possible to use auto-configuration to set up the correct value provided the ratio is less than or equal to 65535. The value cannot be stored in Pr **3.33** because it will be too large, and so Pr **3.33** is set to 255. Auto-configuration must be enabled (Pr **3.41**=1) and this setting must be saved, so that auto-configuration is carried out at power-up and each time the drive encoder is initialized. Once auto-configuration has been carried out so that the internally stored value (not visible to the user) is larger than 255, this value cannot be changed via Pr **3.33**. The internal value can be reset to re-enable the function of Pr **3.33** by powering down and then powering up again, or by auto-configuration with an alternative encoder where the corresponding value for Pr **3.33** is less than or equal to 255.

EnDat, SSI
Pr **3.33** must contain the number of bits in the comms message used to give the multi-turn information. If the encoder gives no turns information, for example a single turn comms encoder, Pr **3.33** must be set to zero. As well as setting the number of comms turns bits that the drive will attempt to obtain from the encoder, this parameter also sets up a mask on the turns displayed in Pr **3.28** as described above. With an EnDat encoder it is possible for this parameter to be obtained automatically from the encoder (see Pr **3.41**). If Pr **3.33** is greater than 16 the number of turns bit is 16.
It should be noted that some SSI encoders include leading zeros before the turns information. In this case the number of turns bits should include the leading zeros.

3.34	Drive encoder lines per revolution															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0* to 50,000							
Default	Open-loop, Closed-loop vector Servo								1,024 4,096							
Update rate	Background read (Only has any effect when the drive is disabled)															

*Limited to a minimum of 1 except for Ab.Servo, Fd.Servo and Fr.Servo encoders in servo mode and EnDat and SSI encoders in all modes.

NOTE

Support for non power of 2 encoders was added as follows :

From software version 1.06.00 onwards - SC and SC.Endat type encoders
From software version 01.06.01 onwards - SC.Hiper, SC.SSI, Ab.servo, Fr.servo and Fd.servo type encoders.

For example - a Unidrive SP with software prior to 1.06.01 in servo mode does not store the phase offset if used with a 2000PPR quadrature encoder

When Ab, Fd, Fr, AbServo, Fd.Servo, Fr.Servo, SC, SC.Hiper, SC.EnDat or SC.SSI encoder are used the equivalent number of encoder lines per revolution must be set-up correctly in Pr **3.34** to give the correct speed and position feedback. This is particularly important if the encoder is selected for speed feedback with Pr **3.26**. The equivalent number of encoder lines per revolution (ELPR) is defined as follows.

Position feedback device	ELPR
Ab, Ab.Servo	number of lines per revolution
Fd, Fr, Fd.Servo, Fr.Servo	number of lines per revolution / 2
SC.Hiper, SC.EnDat, SC, SC.SSI	number of sine wave periods per revolution

For any type of linear encoder one revolution is the motor pole pitch multiplied by the number of poles set up in Pr **5.11** or Pr **21.11**.

Ab.Servo, Fd.Servo, Fr.Servo
The incremental (A/B) signal frequency should not exceed 500kHz.

It should be noted that if this parameter is set to zero the incremental signals are ignored and only the UVW commutation signals are used to define the motor position. See Pr **3.38.** If Pr **3.34** or the motor pole pairs defined by either Pr **5.11** or Pr **21.11** (depending on the motor map selected) are modified and the encoder type is Ab.Servo, Fd.Servo or Fr.Servo then encoder is re-initialized. This ensures that the control position used by the drive to determine the flux axis of the motor is re-aligned with the commutation signals when the encoder moves again and prevents possible errors.

SC.Hiper, SC.EnDat, SC, SC.SSI
The sine wave signal frequency can be up to 500kHz, but the resolution is reduced at higher frequencies. The table below 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.

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

If the position feedback device is a rotary SINCOS encoder with comms the position supplied via comms gives a number of counts per revolution that is a power of two and the resolution is defined by the single turns comms bit (Pr **3.35**). It is assumed therefore that the number of periods per revolution is also a power of two, and so if a SC.Hiper, SC.EnDat or SC.SSI type devices is selected and Pr **3.39** is 1 or 2 to select a rotary encoder = 1 or 2, Pr **3.34** is forced to be a power of two between 2 and 32768.

When Pr **3.34** is adjusted an Enc7 trip is produced, because the encoder requires re-initialization. If this parameter is set to a value that is not a power of two and the encoder is set up as a linear encoder (Pr **3.39** = 0) the sample rate for the current controllers is reduced to 6kHz for 6 or 12kHz switching frequency. All other switching frequencies are unaffected. See Pr **5.37** on page 132.

If the position feedback device is SC.Hiper or SC.EnDat it is possible for the drive to set up this parameter automatically from information obtained from the encoder (see Pr **3.41** on page 76).

EnDat, SSI
Where encoder comms alone is used as position feedback, the equivalent lines per revolution (Pr **3.34**) is not used in setting up the encoder interface. If auto-configuration is used (see Pr **3.41** on page 76 for details), then Pr **3.34** is set to zero if this is successful.

Linear motors
The value entered in this parameter for a linear motor should be calculated as follows:

$$\textbf{Pr 3.34 PPR setting} = \frac{\textbf{Motor pole pitch}}{(\textbf{Encoder pitch} \times \textbf{4})}$$

If this value is not an integer then an SM-Universal Encoder Plus is required.

3.35	Drive encoder single turn comms bits / Linear encoder comms bits/Marker mode															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to 32 bits							
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	Background read (Only has any effect when the drive is disabled)															

Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo, SC
Pr **3.35** defines the marker mode. If this parameter is zero the marker system operates in a conventional manner, but if this parameter is non-zero the marker causes a full position reset.

SC.Hiper, SC.EnDat, SC.SSI and 03.39 = 1 or 2 (Rotary encoder)
Pr **3.35** must be set to the number of comms bits used to represent one revolution of the encoder. The single turn comms resolution may be higher than the resolution of the sine waves per revolution.

SC.Hiper, SC.EnDat, SC.SSI and 03.39 = 0 (Linear encoder)
Pr **3.35** must be set up to the total number of bits representing the whole encoder position in the comms message. This parameter is not used with linear SC.Hiper encoders as the number of bits used to represent the whole position is always 32.

EnDat, SSI
Pr **3.35** must be set to the number of bits used to represent one revolution of the encoder.

Although Pr **3.35** can be set to any value from 0 to 32, if the value is less than 1, the resolution is 1 bit. Some SSI encoders (SC.SSI or SSI) include a power supply monitor alarm using the least significant bit of the position. It is possible for the drive to monitor this bit and produce an Enc6 trip if the power supply is too low (see Pr **3.40**). If the encoder gives this information the comms resolution should be set up to include this bit whether it is being monitored by the drive or not. It should be noted that some SSI encoders include trailing zeros after the position. This parameter should be set up to include the trailing zero bits.

It is possible for the drive to set up this parameter automatically from information obtained from the encoder via Hiperface or EnDat interfaces (see Pr **3.41**).

3.36	Drive encoder supply voltage															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to 2							
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	Background read															

The encoder supply voltage present on the drive encoder connector is defined by this parameter as 0 (5V), 1 (8V), or 2 (15V).

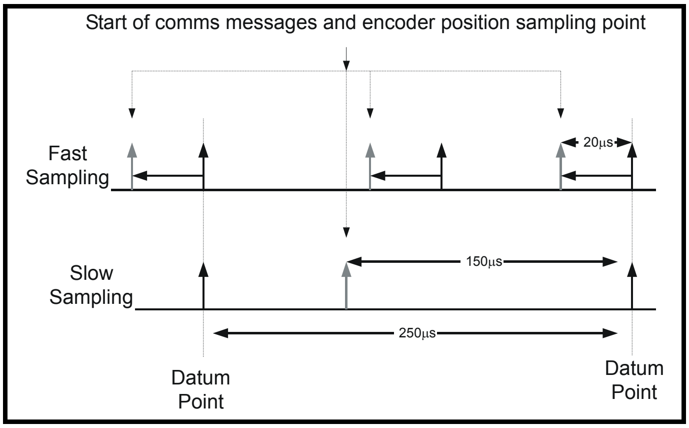
3.37	Drive encoder comms baud rate															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to 7							
Default	Open-loop, Closed-loop vector, Servo								2							
Update rate	Background read (Only has any effect when the drive is disabled)															

This parameter defines the baud rate for the encoder comms when using SSI or EnDat encoders. However, a fixed baud rate of 9600 baud is used with HIPERFACE encoders and this parameter has no effect.

Parameter value	Parameter string	Baud rate
0	100	100k
1	200	200k
2	300	300k
3	400	400k
4	500	500k
5	1000	1M
6	1500	1.5M
7	2000	2M

Any baud rate can be used when encoder comms is used with a SINCOS encoder to obtain the absolute position during initialization. When encoder comms is used alone(EnDat or SSI selected with Pr **3.38**) the time taken to obtain the comms position must be 160µs or less, otherwise the drive initiates an Enc4 trip.

There is a delay obtaining the position from an encoder using comms alone. The length of this delay affects the sample rate and timing of the position used by the drive for control and the position passed to Solutions Modules. If for an EnDat encoder the position within one turn can be obtained in 30µs and the whole comms message including CRC can be obtained in 60µs then fast sampling is used, otherwise slow sampling is used as shown below. If for an SSI encoder the whole position can be obtained in 30µs fast sampling is used. In each case the position is sampled within the encoder at the start of the comms message from the drive.



In the example the current/torque sampling rate is 4kHz, but this will change if a different switching frequency is selected. If fast sampling is used the control position used to define the drive reference frame is obtained every current/torque control sample and the position passed to Solutions Modules is obtained 20µs before the datum point where other types of encoders are sampled. If slow sampling is used both the control position and the position passed to Solutions Modules is obtained 150µs before the datum. When fast sampling is used the delay introduced into the control system by the encoder is less, and so a higher control system bandwidth will be possible. So that the position values from the encoder can be used in a position control system compensation is provided for the delay in obtaining the position before it is made available to Solutions Modules or in the drive position parameters so that it appears to have been sampled at the datum. This compensation is based on the delay (i.e. 20µs or 150µs) and the change of position over the previous sample.

EnDat comms

The following equations are used by the drive to determine the time taken to obtain the position information from an EnDat encoder. These are based on $t_{cal} \leq 5\mu s$, where t_{cal} is the time from the first clock edge of the position command message from the drive to the first clock edge when the encoder responds as defined in the EnDat specification. This limit of 5µs may exclude a small number of EnDat encoders from being used by the drive as a comms only feedback device. It is also assumed that $t_D \leq 1.25\mu s$ where t_D is the data delay from the encoder as defined by the EnDat specification for 105m of cable. Although with higher clock rates shorter cables must be used, and t_D will be less than 1.25µs, the calculation performed by the drive always assumes t_D=1.25µs. It should be noted that all values are rounded up to the nearest microsecond.

Command message time = $t_{command}$ = 10T or t_{cal} whichever is the longest

Where: T = 1/Baud Rate, t_{cal} = 5µs

Time for single turn position = $t_{command}$ + t_D + (2 + Single turn resolution) x T

= $t_{command}$ + t_D + (2 + Pr **3.35**) x T

Where: t_D = 1.25µs

Time for whole message including CRC = Time for single turn position + (Number of turns bits + 5) x T

= Time for single turn position + (Pr **3.33** + 5) x T

For example an encoder with 12 turns bits, 13 bit single turn resolution and a baud rate of 2M would give the following times:

Time for single turn position = 14µs (13.75µs rounded up)

Time for the whole message including CRC = 23µs (22.25µs rounded up)

A recovery time (tm) is specified for EnDat encoders, that is the time required between the end of one data transfer and the beginning of the next one. If this time is not allowed between messages that transfer the position from the encoder, the encoder operates in continuous mode and the data from the encoder will be incorrect and cause CRC errors. tm is nominally 20µs, but may vary from 10µs to 30µs (EnDat 2.1 specification). If tm is greater than 23µs and 6 or 12kHz switching is used, which have a fast sample rate of 83µs, it is possible for the time allowed for tm to be too short. Therefore if 6 or 12kHz switching are used the total message transfer time should not exceed 53µs unless tm can be guaranteed to be less than 30µs by a suitable margin.

SSI comms

The whole position must be obtained from an SSI encoder before it can be used by the drive, therefore the time for the single turn position and the time for the whole message are the same.

Time to obtain the position= (Number of turns bits + Single turn resolution + 1) x T
= t_D + (Pr **3.33** + Pr **3.35** + 1) x T

For example an encoder with 12 turns bits, 13 bit single turn resolution and a baud rate of 1M would give the following time:

Time to obtain the position data = 28μs (27.25μs rounded up)

The drive does not include the recovery time of the encoder in these calculations, therefore the user must ensure that there is sufficient time after the data transfer before the next transfer begins. If the encoder does not recover in time its output will be low just before the new transfer beings and will cause an Enc5 trip.

3.38	Drive encoder type															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 11								
Default	Open-loop, Closed-loop vector Servo							0 3								
Update rate	Background read (Only has any effect when the drive is disabled)															

The following encoders can be connected to the drive encoder port.

0, Ab: Quadrature incremental encoder, with or without marker pulse

1, Fd: Incremental encoder with frequency and direction outputs, with or without marker pulse

2, Fr: Incremental encoder with forward and reverse outputs, with or without marker pulse

This type of encoder can be used for motor control in closed-loop vector mode or servo mode. In servo mode a phasing test must be performed after every drive power-up or encoder trip.

3, Ab.Servo: Quadrature incremental encoder with commutation outputs, with or without marker pulse

4, Fd.Servo: Incremental encoder with frequency, direction and commutation outputs, with or without marker pulse

5, Fr.Servo: Incremental encoder with forward, reverse and commutation outputs, with or without marker pulse

This type of encoder is normally only used in servo mode. If it is used in closed-loop vector mode the UVW signals are ignored. 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 initialised. If the Drive encoder lines per rev (Pr **3.34**) is set to zero the incremental signals are ignored and the drive can run with commutation signals alone. A phase locked loop is used to smooth the feedback, but particularly at low speeds the motor movement includes a significant ripple. Low speed loop gains should be used and the drive encoder filter (Pr **3.42**) should be set to 16ms.

6, SC: SinCos: Encoder with no serial communications

This type of encoder can be used for motor control in closed-loop vector mode or servo mode. In servo mode a phasing test must be performed after every drive power-up or encoder trip.

7, SC.Hiper: Absolute SinCos encoder using Stegmann 485 comms protocol (HiperFace).

This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. The drive can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the drive initiates a trip. An applications or fieldbus Solutions Module can communicate with the encoder via parameters that are not visible from the keypad or drive 485 comms.

8, EnDAt: Absolute EnDat only encoder

This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. Additional communications with the encoder from an applications or fieldbus module is not possible

9, SC.Endat: Absolute SinCos encoder using EnDat comms protocol

This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. The drive can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the drive initiates a trip. An applications or fieldbus Solutions Module can communicate with the encoder via parameters that are not visible from the keypad or drive 485 comms.

10, SSI: Absolute SSI only encoder

This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. Additional communications with the encoder from an applications or fieldbus module is not possible. SSI encoders use either gray code or binary format which can be selected with Pr **3.41**.

11, SC.SSI: SinCos encoder using SSI comms protocol

This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. The drive can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the drive initiates a trip.

All SINCOS encoders and encoders using communications must be initialized before their position data can be used. The encoder is automatically initialized at power-up, after trips Enc1 to Enc8 or Enc11 to Enc17 are reset, and when the initialization (Pr **3.47**) is set to 1. If the encoder is not initialized or the initialisation is invalid the drive initiates trip Enc7.

3.39	**Drive encoder termination select / Rotary encoder select / Comms only encoder mode**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, Closed-loop vector, Servo							0 to 2								
Default	Open-loop, Closed-loop vector, Servo							1								
Update rate	Background read															

Ab, Fd, Fr, Ab Servo, Fd Servo, Fr Servo - Drive encoder termination select

The terminations may be enabled/disabled by this parameter as follows:

Encoder input	Pr 3.39=0	Pr 3.39=1	Pr 3.39=2
A-A\	Disabled	Enabled	Enabled
B-B\	Disabled	Enabled	Enabled
Z-Z\	Disabled	Disabled	Enabled
U-U\, V-V\, W-W\	Enabled	Enabled	Enabled

SC - Drive encoder termination select

The terminations may be enabled/disabled by this parameter as follows:

Encoder input	Pr 3.39=0	Pr 3.39=1	Pr 3.39=2
A-A\	Disabled	Enabled	Enabled
B-B\	Disabled	Enabled	Enabled
Z-Z\	Disabled	Disabled	Enabled

SC.Hiper, SC.EnDat, SC.SSI - Rotary encoder select

If Pr **3.39** is set to 1 or 2 the encoder is a rotary encoder and the following apply:

1. Pr **3.33** defines the number of turns bits in the comms message from the encoder and a mask is applied to Pr **3.28** to remove turns bits in excess of those provided in the encoder comms position.
2. The number of encoder lines per revolution defined by Pr **3.34** is forced to a power of two between 2 and 32768.
3. Pr **3.35** defines the number of comms bits used to define a single turn.

If Pr **3.39** is set to 0 the encoder is a linear encoder and the following apply:

1. Pr **3.33** defines the ratio between the length of a sine wave period and the length of the least significant comms bit.
2. No mask is applied to the turns displayed in Pr **3.28.**
3. Pr **3.35** defines the number of comms bits used to give the whole position value.

If the position feedback device is SC.Hiper or SC.EnDat it is possible for the drive to set up this parameter automatically from information obtained from the encoder (see Pr **3.41**).

EnDat, SSI - Comms only encoder mode

If this parameter is set to 1 or 2 the drive always takes the complete absolute position for these comms only type encoders. The turns (Pr **3.28**), position (Pr **3.29**) and fine position (Pr **3.30**) will be an exact representation of the position from the encoder. If the encoder does not provide 16bits of turns information, the internal representation of the turns used by the position controller in Menu 13 and functions within the SM-Applications Module such as the Advanced Position Controller, rolls over at the maximum position value from the encoder. This jump in position is likely to cause unwanted effects. As the SSI format does not include any error checking it is not possible for the drive to detect if the position data has been corrupted by noise on the encoder signals. The benefit of using the absolute position directly from an SSI encoder is that even if the encoder communications are disturbed by noise and position errors occur, the position will always recover the correct position after the disturbance has ceased. The EnDat format includes a CRC that is used by the drive to detect corrupted data, and so if the position data has been corrupted the drive uses the previous correct data until new uncorrupted data is received.

It should be noted that if the encoder does not provide at least 6 bits of turns information the speed feedback used to generate the drive over speed trip is incorrect when the position rolls over or under the maximum value. Therefore this mode should not be used with encoders that do not provide this turns information unless the encoder is not going to pass through the maximum position.

If this parameter is set to 0 the drive only takes the absolute position directly from the encoder during initialization. The change of position over each sample is then used to determine the current position. This method always gives 16 bits of turns information that can be used without jumps in position by the position controller in Menu13 and SM-Applications modules etc. This method will only operate correctly if the change of position over any 250μs period is less than 0.5 of a turn, or else the turns information will be incorrect. The turns can then only be corrected by re-initializing the encoder. Under normal operating conditions and at a maximum speed of 40,000rpm the maximum change of position is less than 0.5 turns, however, if noise corrupts the data from an SSI encoder it is possible to have apparent large change of position, and this can result in the turns information becoming and remaining corrupted until the encoder is re-initialized.

This problem should not occur with EnDat encoders because three consecutive corrupted messages at the slowest sample rate (i.e. 25μs) would be required even at the maximum speed of 40,000rpm before the change of position would be the required 0.5 turns to give possible corruption of the turns information. If three consecutive messages with CRC errors occur this will cause the drive to produce an Enc5 trip. The drive can only be re-enabled after the trip is reset which will re-initialize the encoder and correct the absolute turns.

If an SSI encoder is used, but is not powered from the drive, and the encoder is powered up after the drive, it is possible that the first change of position detected could be large enough to cause the problem described above. This can be avoided if the encoder interface is initialized via Pr **3.47** after the encoder has powered up. If the encoder includes a bit that indicates the status of the power supply the power supply monitor should be enabled (see Pr **3.40**). This will ensure that the drive remains tripped until the encoder is powered up and the action of resetting the trip will reinitialise the encoder interface.

If the position feedback device is EnDat it is possible for the drive to set up this parameter automatically from information obtained from the encoder (see Pr **3.41**).

3.40	**Drive encoder error detection level**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo						0 to 7									
Default	Open-loop Closed-loop vector, Servo						0 1									
Update rate	Background read															

Trips can be enabled/disabled using Pr **3.40** as follows.

Bit	Function
0	Wire break detect
1	Phase error detect
2	SSI power supply bit monitor

Encoder trips

The following table shows trips that can be initiated that are related to the drive encoder feedback and whether they can be enabled and disabled by Pr **3.40**.

Encoders	Reason for error	Drive trip
All	Power supply short circuit	Enc1
Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo, SC, SC.Hiper, SC.EnDat, SC.SSI	+Hardware wire-break detect on A, B and Z inputs(1) Software wire break detection on sine wave signals There is no wire break detection on the U, V and W commutation inputs	Enc2
Ab.Servo, Fd.Servo, Fr.Servo SC.Hiper, SC.EnDat, SC.SSI	+Phase error(2) +Sine/cosine phase error(3)	Enc3
SC.Hiper, SC.EnDat, SC.SSI EnDat SSI	Comms failure (timeout)(5) Comms transfer time is too long	Enc4
SC.Hiper, SC.EnDat, EnDat	Checksum/CRC error or SSI not ready at start of position transfer (i.e. data input not one)	Enc5
SC.Hiper, SC.EnDat, EnDat SSI, SC.SSI	The encoder has indicated an error +Power supply failure	Enc6
SC, SC.Hiper, SC.EnDat, SC.SSI, EnDat, SSI	Initialisation has failed due to a comms error.	Enc7
SC.Hiper, SC.EnDat, EnDat	Auto-configuration has been requested by changing Pr **3.41**, but an initialisation has not occurred to perform auto-configuration.	Enc8
All	Speed feedback selected from an option slot that does not have a position feedback category Solutions Module installed	Enc9
All (Servo mode only)	Incorrect encoder phasing(4)	Enc10
SC, SC.Hiper, SC.EnDat, SC.SSI	Failure of analog position alignment during encoder initialisation	Enc11
SC.Hiper	The encoder type could not be identified during auto-configuration	Enc12

Encoders	Reason for error	Drive trip
SC.EnDat, EnDat	The number of encoder turns read from the encoder during auto-configuration is not a power of 2	Enc13
SC.EnDat, EnDat	The number of bits defining the encoder position within a turn read from the encoder during auto-configuration is too large.	Enc14
SC.Hiper, SC.EnDat, EnDat	The number of periods per revolution is either less than 1 or greater than 50000 when read or calculated from the encoder data during auto-configuration.	Enc15
SC.EnDat, EnDat	The number of comms bits per period are larger than 255.	Enc 16
SC.Hiper, SC.EnDat, EnDat	This is a rotary encoder (Pr **3.39**=1 or 2) and the lines per revolution read from this encoder are not a power of two.	Enc 17

+These trips can be enabled/disabled by Pr **3.40**

1. If the terminations are not enabled on the A, B or Z inputs the wire break system will not operate. (Note that as default the Z input terminations are disabled to disable wire break detection on this input).
2. Phase error for a servo type encoder is to detect that the incremental pulses have been counted incorrectly. The error is detected if the incremental position moves by 10° with respect to the position defined by the UVW commutation signals. The trip is initiated if the error is detected for 10 consecutive samples.
3. Phase error for SinCos encoders with comms is detected by interrogating the encoder every second via comms to compare the incremental position determined from the sine waves with the incremental position via comms. If the error is greater than 10° for 10 consecutive samples the trip is initiated. It should be noted that this system should not be used where 180 x Pr **5.11** (or Pr **21.11** for motor map 2) / Pr **3.34** is greater than 10° or else incorrect EnC3 trips will occur.
4. Incorrect encoder phasing is detected if the motor reaches half of the speed defined by SPEED_FREQ_MAX and the phasing error is larger enough for the motor to accelerate uncontrollably. It can be disabled by setting Pr **3.08** to any value greater than zero.
5. This trip can also be caused when data is transferred between the encoder and a Solutions Module, such as an SM-Applications module, and an error other than those covered by EnC5 or EnC6 occurs.

Wire-break detection

It may be important to detect a break in the connections between the drive and the position feedback device. This feature is provided for most encoder types either directly or indirectly as listed below.

Device	Detection method	Drive Trip
Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo	Hardware detectors on the A(F), B(D,R) and Z signal detect a wire break.	Enc2
SC, SC.Hiper, SC.EnData, SC.SSI	The differential levels of the sine and cosine waveforms are available to the drive. The drive detects wire break if $Sine^2$+$Cosine^2$ is less than the value produced by two valid waveforms with a differential peak to peak magnitude of 0.25V (1/4 of the nominal level). This detects wire break in the sine and cosine connections.	Enc2
SC.Hiper, SC.EnDat, EnDat	Wire break in the comms link is detected by a CRC or timeout error.	Enc4, Enc5
SSI	Wire break detection is difficult with these devices. However, if power supply monitoring is enabled the drive will be looking for a one at the start of the message and a zero to indicate that the power supply is okay. If the clock stops or the data line is disconnected the data input to the drive may stay in one state or the other and cause a trip.	Enc5, Enc6

Encoder initialisation

Encoder initialisation will occur as follows: at drive power-up, when requested by the user via Pr **3.47**, when trips PS.24V or Enc1 to Enc8 or Enc11 to Enc17 are reset. Initialisation causes an encoder with comms to be re-initialized 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 120deg (electrical) of rotation when the motor is restarted.

A delay is provided during initialisation for some encoders to allow the encoder to be ready to provide position information after it has powered up. The delay is provided during initialisation because this occurs during drive power-up and after encoder power supply trips are reset. The delays are as follows:

Encoder type	Initialisation delay
Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo	None
SC.Hiper	150ms, then encoder reset, then 150ms
SC.EnDat, EnDat	1.0s
All other types	1.2s

Encoder power supply trips

The encoder power supply from the drive can be switched off by the drive either because the encoder power supply is overloaded (Enc1 trip) or because the internal 24V supply within the drive is overloaded (PS.24V trip). The internal 24V supply provides power for the encoder power supply, user 24V output, digital I/O, Solutions Modules etc.

To ensure that an Enc1 trip is not initiated when the internal 24V is overloaded, and subsequently switched off by the drive, there is a delay of 40ms in the detection of Enc1 trip. It is possible for other encoder trips such as wire break detection (Enc2) to occur when the power supply is removed from the encoder. Therefore overloading the internal 24V supply or the encoder supply could result in an immediate Enc2 trip. To ensure that the correct reason for the trip is given PS.24V and Enc1 trips override an existing Enc2 to Enc8 or Enc11 trip. This means that both the original trip (Enc2 to Enc8 or Enc11) and then the new trip (PS.24V or Enc1) are stored in the trip log.

3.41	**Drive encoder auto configuration enable / SSI binary format select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

SC.Hiper, SC.EnDat, EnDat

When a SC.Hiper, SC.EnDat or EnDat encoder is being used, the drive will interrogate the encoder on power-up. If Pr **3.41** is set to one and the encoder type is recognized based on the information provided by the encoder, the drive will set the encoder turns / linear encoder comms to sine wave ratio (Pr **3.33**), the equivalent lines per revolution (Pr **3.34**) and the encoder comms resolution / linear encoder comms bits (Pr **3.35**). For SC.Hiper or SC.EnDat encoders the rotary encoder select (Pr **3.39**) is also set up. If the encoder is not recognized, there is a comms error or the resulting parameter values are out of range the drive initiates an Enc7 or Enc12 to Enc17 trip to prompt the user to enter the information. The drive can auto-configure with any of the following devices.

Rotary EnDat encoders

The encoder turns, comms resolution and equivalent lines per rev are set up directly using the data read from the encoder.

Linear EnDat encoders

The comms resolution is set to the number of bits required for the whole position within the position data messages from the encoder. The linear encoder comms to sine wave ratio is calculated from the sine wave period and LS comms bit length. The encoder does not give the equivalent lines per rev directly, but gives the length of a sinewave period in nm. Therefore the drive uses the pole pitch (Pr **5.36** or **21.31**) and the number of motor poles (Pr **5.11** or **21.11**) for the current active motor (defined by Pr **11.45**) to calculate the equivalent lines per revolution.

ELPR = Pole pitch x Number of motor pole pairs / Length of a sinewave

Normally the Number of motor poles will be set to 2, and so

ELPR = Pole pitch / Length of a sinewave

It should be noted that the equivalent lines per rev parameter is only updated when auto-configuration occurs, i.e. when the encoder is initialized, and that it uses the pole pitch for the currently active motor. The value for Pole pitch x Number of motor pole pairs is limited to 655.35mm by the drive. If the pole pitch is left at its default value of zero which would give ELPR = 0, or the result of the calculation is over 50000, the drive will initiate an Enc15 trip.

Rotary hiperface encoders

The drive can recognize any of the following devices: SCS 60/70, SCM 60/70, SRS 50/60, SRM 50/60, SHS 170, SCS-KIT 101, SKS36, SKM36. If the drive cannot recognize the encoder type it will initiate Enc12 trip.

Linear Hiperface encoders

The drive can recognize the LINCODER. The calculations used for linear EnDat encoders are also used to determine the equivalent lines per revolution. However, the length of a sine wave is fixed at 5mm.

EnDat encoders

If the encoder type is EnDat comms only then after auto-configuration parameter 03.39 is set to zero if the number of turns bits is less than 6. This automatically selects absolute mode and prevents over speed trips at the encoder roll-over points which would otherwise occur.

SSI, SC.SSI

SSI encoders normally use gray code data format. However, some encoders use binary format which may be selected by setting this parameter to one.

3.42	**Drive encoder filter**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 5 (0 to16 ms)								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

0 = 0ms, 1 = 1ms, 2 = 2ms, 3 = 4ms, 4 = 8ms, 5 = 16ms

A sliding window filter may be applied to the feedback taken from the drive encoder. This is particularly useful in applications where the drive encoder is used to give speed feedback for the speed controller and where the load includes a high inertia, and so the speed controller gains are very high. Under these conditions, without a filter on the feedback, it is possible for the speed loop output to change constantly from one current limit to the other and lock the integral term of the speed controller.

In closed-loop vector mode, if Pr **3.24** is set to 1 or 3 so that the drive is operating without position feedback, this parameter also 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.

3.43	**Maximum drive encoder reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 40,000 rpm														
Default	Open-loop, Closed-loop vector Servo	1,500 3,000														
Update rate	Background read															

3.44	**Drive encoder reference scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo	1.000														
Update rate	Background read															

3.45	**Drive encoder reference**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1				1			1		1				
Range	Open-loop, Closed-loop vector, Servo	±100.0%														
Update rate	4ms write															

3.46	**Drive encoder reference destination**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo	Pr **0.00** to Pr **21.50**														
Default	Open-loop, Closed-loop vector, Servo	Pr **0.00**														
Update rate	Read on reset															

The drive encoder input can be used as a reference to control a drive parameter. The drive encoder reference parameter (Pr **3.45**) gives the speed of the encoder input as a percentage of the maximum drive encoder reference provided that the number of encoder lines per revolution (Pr **3.34**) has been set up correctly. This may then be scaled and routed to any non-protected drive parameter.

3.47	**Re-initialise position feedback**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Update rate	Background read															

3.48	**Position feedback initialised**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

At power-up Pr **3.48** is initially zero, but is set to one when the drive encoder and any encoders connected to position category modules have been initialized. The drive cannot be enabled until this parameter is one.

If any trips occur that could indicate that the encoder system is no longer initialized correctly (i.e. Enc2-Enc8 and Enc11-Enc17), or the internal 24V or encoder power supplies are overloaded (i.e. Enc1 or PS.24V), Pr **3.48** is set to zero and the drive cannot be enabled until the encoder is re-initialized. It is likely that the failure of either of these supplies will cause one of the other encoder trips and it should be noted that Enc1 or PS.24V trips can override Enc2-Enc8 and Enc11-Enc17 trips so that the power supply overload is not mistaken for an encoder error.

3.49	**Full motor object electronic nameplate transfer**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Read on reset															

When this parameter is set to one, additional information for the motor object can be transferred from Pr **18.11** to Pr **18.17** as shown below.

User parameter	Motor object parameter
Pr **18.11**	Motor object version number
Pr **18.12**	Motor type (MSW)
Pr **18.13**	Motor type (LSW)
Pr **18.14**	Motor manufacturer
Pr **18.15**	Motor serial number (MSW)
Pr **18.16**	Motor serial number
Pr **18.17**	Motor serial number (LSW)

3.50	**Position feedback lock**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

If Pr **3.50** is set to one Pr **3.28**, Pr **3.29** and Pr **3.30** are not updated. If this parameter is set to zero these parameters are updated normally.

5.5.1 Communication with Hiperface and EnDat encoders

It is possible to use the communications channel between the drive and a Hiperface or EnDat encoder. This allows access to the encoder functions including reading the encoder position and, reading and writing to encoder memory. The system can be used to communicate with SC.Hiper and SC.EnDat type encoders provided that the position checking system has been disabled, by setting Pr **90.21** to one.

To send a message to the encoder the required message must be written to the transmit register (Pr **90.22**). To read the response from the encoder the data is read from the receive register (Pr **90.23**).

Bits 13-15 of the registers are used to indicate the following:

Register	Bit	Function
Transmit	15	Must be set for the drive to transfer the LS byte to the comms buffer.
Transmit	14	The LS byte is the last byte of the message and this byte should be put in the comms buffer and be transferred to the encoder.
Transmit	13	The LS byte is the first byte of the message. (If this is used the buffer pointer is reset to the start of the buffer).
Receive	15	Indicates data from the last transfer can be read from the receive buffer.
Receive	14	The byte in the LS byte is the last byte of the receive message
Receive	13	There is no data in the receive buffer and the LS byte is the comms system status. If there was an error in the received message this will always be set and one of the status error bits will be set until the comms is used again by this system or by the drive.

Data should be written to the transmit register (Pr **90.22**) when the register has been reset to zero by the drive. The data will be transferred to the comms buffer and the transmit register will be cleared.

Data can be read from the receive register (Pr **90.23**) at any time. If there is receive data in the buffer bit 15 will be set. Once the data has been read the register should be cleared and the drive will then transfer more data.

The actual encoder comms buffer is 16 bytes long and any messages that exceed this length (including the checksum added for Hiperface) will cause an error. The status flags are defined as follows:

Bit	Meaning
0	The number of bytes put into the transmit buffer is not consistent with the expected message length. (Hiperface only)
1	The number of bytes written to the transmit buffer, or the expected length of the store data transmit message, or the expected length of a read data message have exceed the length of the buffer. (Hiperface only)
2	The command code is not supported.
3	The encoder has signalled an error.
4	There was an error in the checksum/CRC of the received message.
5	A timeout occurred.

SC.Hiper type encoders

The Stegmann Hiperface comms protocol is an asynchronous byte based system. Up to 15 bytes of data can be written to the buffer. The first byte should be the encoder address. The checksum will be calculated by the drive and added to the end of the message before the message is transmitted to the encoder. The drive checks the checksum of the received message. If successfully received, the receive message can be read via the receive register (Pr **90.23**) including the address and the checksum received from the encoder. It should be noted that the encoder must be set up for 9600 baud, 1 start bit, 1 stop bit and even parity (default set-up) for the encoder comms to operate with the drive. Also the data block security should not be enabled in the encoder if the drive encoder nameplate system is to operate correctly.

The following commands are supported:

Code	Command
0x42	Read position
0x43	Set position
0x44	Read analog value
0x46	Read counter
0x47	Increment counter
0x49	Clear counter
0x4a	Read data (maximum of 10 bytes)
0x4b	Store data (maximum of 9 bytes)
0x4c	Data field status
0x4d	Create a data field
0x4e	Available memory
0x50	Read encoder status
0x52	Read type
0x53	Reset encoder

Example of a Hiperface transfer: read position

Disable drive encoder position check by setting Pr **90.21** to one. This should be set back to zero at the end of the transfer if encoder position checking is required.

Transfer the "read position" message to the encoder comms buffer by writing the sequence of words shown in the table below to Pr **90.22**. A check should be carried out before each word is written to ensure that the parameter is zero (i.e. the drive has taken any previous data).

	Bit 15	Bit 14	Bit 13	Data	
0xa0ff	1	0	1	0xff	Broadcast message so address = 0xff
0xc042	1	1	0	0x42	Read position command

As bit 14 of the second word is set to one the drive will add the checksum and transfer this message to the encoder. When the encoder response has been received by the drive the first byte of the message will be placed in the least significant byte of Pr **90.23** and bit 15 will be set to one. This data should be read and the parameter cleared so that the drive will put the next byte into this parameter. The sequence of data that should appear in Pr **90.23** for an encoder with an address of 0x40 and a position of 0x03, 0x59, 0x63, 0x97 is shown in the table below.

	Bit 15	Bit 14	Bit 13	Data	
0x8040	1	0	0	0x40	Encoder address
0x8042	1	0	0	0x42	Read position command
0x8003	1	0	0	0x03	Position byte 0 (MS byte)
0x8059	1	0	0	0x59	Position byte 1
0x8063	1	0	0	0x63	Position byte 2
0x8097	1	0	0	0x97	Position byte 3 (LS byte)
0xc0ac	1	1	0	0xac	Checksum

Example of Hiperface transfer: Delete data field

Transfer the "delete data field" message to the encoder comms buffer by writing the sequence of words shown in the table below to Pr **90.22.** A check should be carried out before each word is written to ensure that the parameter is zero (i.e. the drive has taken any previous data).

	Bit 15	Bit 14	Bit 13	Data	
0xa0ff	1	0	1	0xff	Broadcast message so address = 0xff
0x804d	1	0	0	0x4d	Create data field command
0x8002	1	0	0	0x02	Data field 2
0x8065	1	0	0	0x65	Status of data existing data field 2 with bit 7 set to zero
0x8055	1	1	0	0x55	Code for data field at default of 0x55

The response from the encoder is a follows.

	Bit 15	Bit 14	Bit 13	Data	
0x8040	1	0	0	0x40	Encoder address
0x8042	1	0	0	0x4d	Create data field command
0x8003	1	0	0	0x02	Data field 2
0x8059	1	0	0	0x65	Status of the data field before delete
0x8063	1	1	0	0x78	Checksum

SC.EnDat

The Heidenhain EnDat protocol is a synchronous protocol using the following command message format (drive to encoder).

Command	1st byte
Address	
Data (LSB)	
Data (MSB)	4th byte

The following commands are supported:

Code	Command	Address	Data
0x00	Encoder to send position	Don't care	Don't care
0x01	Selection of memory area	MRS code	Don't care
0x03	Encoder to receive parameter	Address	Data
0x04	Encoder to send parameter	Address	Don't care
0x05	Encoder to receive reset	Don't care	Don't care

The following is an example of the response when the Encoder to send position command is used (encoder to drive).

LS byte	1st byte	Bits 7-0 = 0
		Bits 7-0 = 0
		Bits 7-0 = 0
		Bits 7-0 = 0
		Bits 5-0 = 0 Bit 6 = Alarm bit Bit 7 = Bit 0 of position
		Bits 7-0 = Bits 8-1 of position
		Bits 3-0 = Bits 12-9 of position Bits 7-4 = Bits 3-0 of turns
MS byte	8th byte	Bits 7-0 = Bits 11-4 of turns

The example shown above is for an encoder with 12 bits representing the turns and 13 bits representing the position within a turn. The position command only requires one byte to be sent to the encoder. Bits 14 and 13 can both be set in the transmit register if required to indicate that this is both the first and last byte of the message.

If any other command is used then the response is as follows (encoder to drive).

Address	1st byte
Data (LSB)	
Data (MSB)	3rd byte

Example of EnDat transfer: Read position

Disable drive encoder position check by setting Pr **90.21** to one. This should be set back to zero at the end of the transfer if encoder position checking is required.

Transfer the "read position" message to the encoder comms buffer by writing the sequence of words shown in the table below to Pr **90.22**. A check should be carried out before each word is written to ensure that the parameter is zero (i.e. the drive has taken any previous data).

	Bit 15	Bit 14	Bit 13	Data	
0xa000	1	0	1	0x00	Read position command
0xc000	1	1	0	0x00	Address

The second word contains the address which is not required for the command, but has been passed to the drive so that a word with bit 14 set to one is received by the drive to initiate the data transfer to the encoder. When the encoder response has been received by the drive the first byte of the message will be placed in the least significant byte of Pr **90.23** and bit 15 will be set to one. This data should be read and the parameter cleared so that the drive will put the next byte into this parameter. The sequence of data that could appear in Pr **90.23** for an encoder with 12 turns bits and 13 position bits is shown in the table below.

	Bit 15	Bit 14	Bit 13	Data	
0x8000	1	0	0	0x00	
0x8000	1	0	0	0x00	
0x8000	1	0	0	0x00	
0x8000	1	0	0	0x00	
0x8000	1	0	0	0x00	Bit7 = bit 0 of position, Bit6 = alarm bit
0x809f	1	0	0	0x9f	Bits 8-1 of position
0x804e	1	0	0	0x4e	Bits 3-0 of turns and 12-9 of position
0xc074	1	1	0	0x74	Bits 11-4 of turns

Turns = 0111 0100 0100 = 0x744

Position = 1 1101 0011 1110 = 0x1d3e

Alarm bit = 0

Example of EnDat transfer: Encoder send parameter

Data written to Pr **90.22**

	Bit 15	Bit 14	Bit 13	Data	
0xa004	1	0	1	0x04	Encoder to send parameter command
0x8000	1	0	0	0x00	Address zero
0x8000	1	0	0	0x00	Data (not required)
0xc000	1	1	0	0x00	Data (not required)

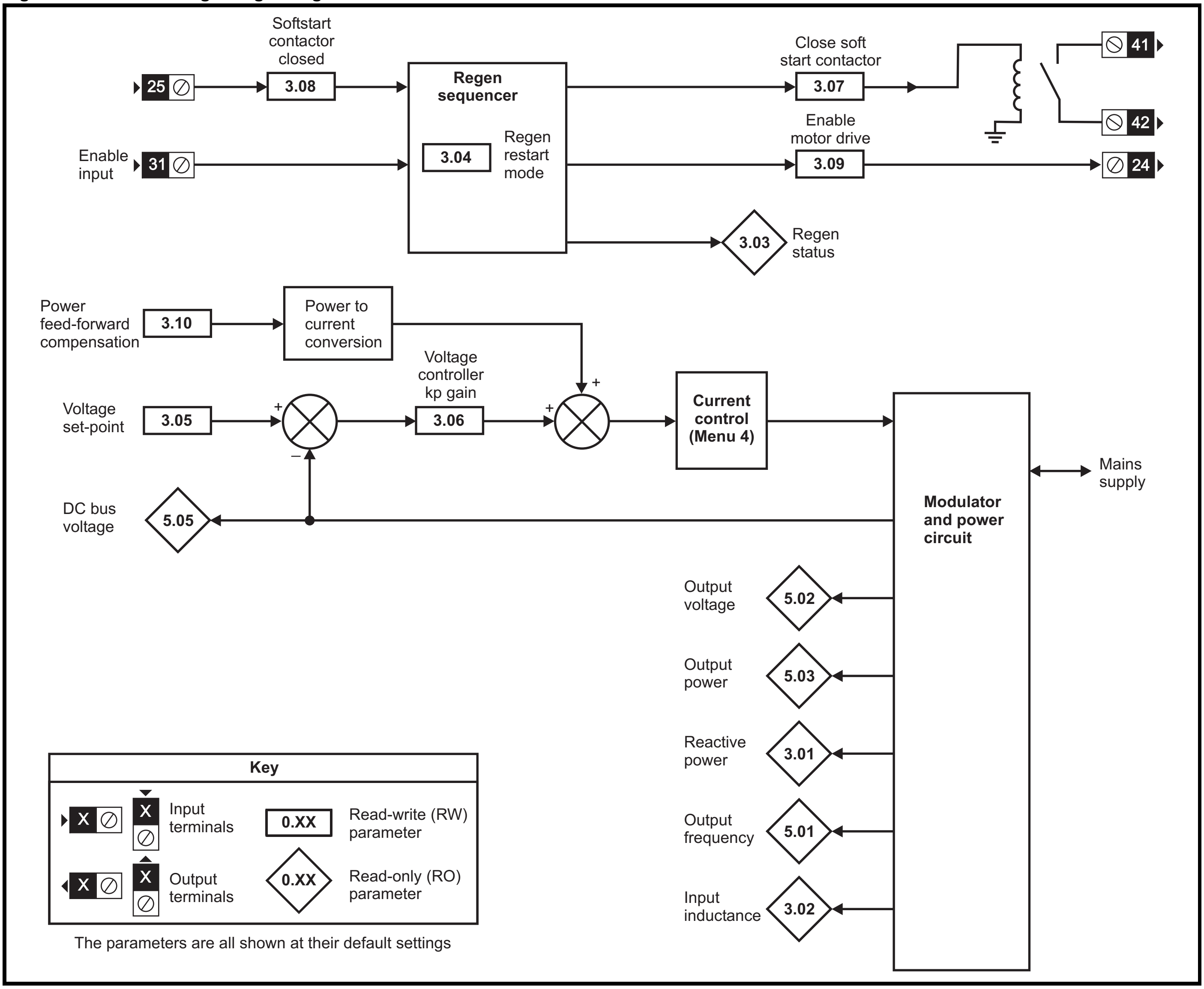
Data read from Pr **90.23**

	Bit 15	Bit 14	Bit 13	Data	
0x8000	1	0	0	0x00	Address
0x8012	1	0	0	0x12	Data
0x8034	1	1	0	0x34	Data

The data in the parameter at address zero is 0x1234.

Parameter descriptions: Regen

Figure 5-5 Menu 3 Regen logic diagram



In Regen mode some form of charging system must be used to limit the current taken from the supply to charge the d.c. link capacitors when the supply is first connected to the drive inverter terminals (i.e. UVW). Either an external soft start resistor or the charging system in the drive may be used. See Unidrive SP Regen Installation Guide for details. When the d.c. link capacitors are charged a contactor, controlled by the drive, is closed to either short out the external charging resistor, or to disconnect the charging system and connect the drive inverter terminals directly to the supply. This contactor is controlled by Pr **3.07** which is normally used as the source for the drive relay. An auxiliary contact on this contactor is monitored in Pr **3.08** which normally follows the state of digital I/O 2.

A current feedback trimming routine runs before the drive is enabled to minimize offsets in the current feedback. Unnecessary offsets can be caused by the current taken from the supply to power the drive control electronics or by current pulses due to noise on the supply during the current trimming period. If an external charging resistor is used and the shorting contactor is open the additional supply resistance can reduce the peak level of these currents. If the charge system in the drive is used and the contactor is open the drive inverter terminals are not connected to the supply, and so there is no current flowing into the drive inverter terminals. Therefore the drive will always ensure that the contactor is open while the current trimming system is active. Two alternative strategies can be selected with Pr **3.11**:

1. The first strategy (Pr **3.11**=0) activates current trimming immediately after the supply is applied to the drive before the contactor is closed. Current trimming is not carried out again unless the drive is powered down and powered up again.
2. The second strategy (Pr **3.11**=1) activates current trimming after power up before the contactor is closed and again each time just before the drive is enabled. Because the contactor must be open during current trimming the contactor is opened when the drive enable is applied, the current trimming is performed, the contactor is closed and then the drive is enabled. If the enable is active during power-up with this strategy, current trimming is only carried out once before the contactor is closed.

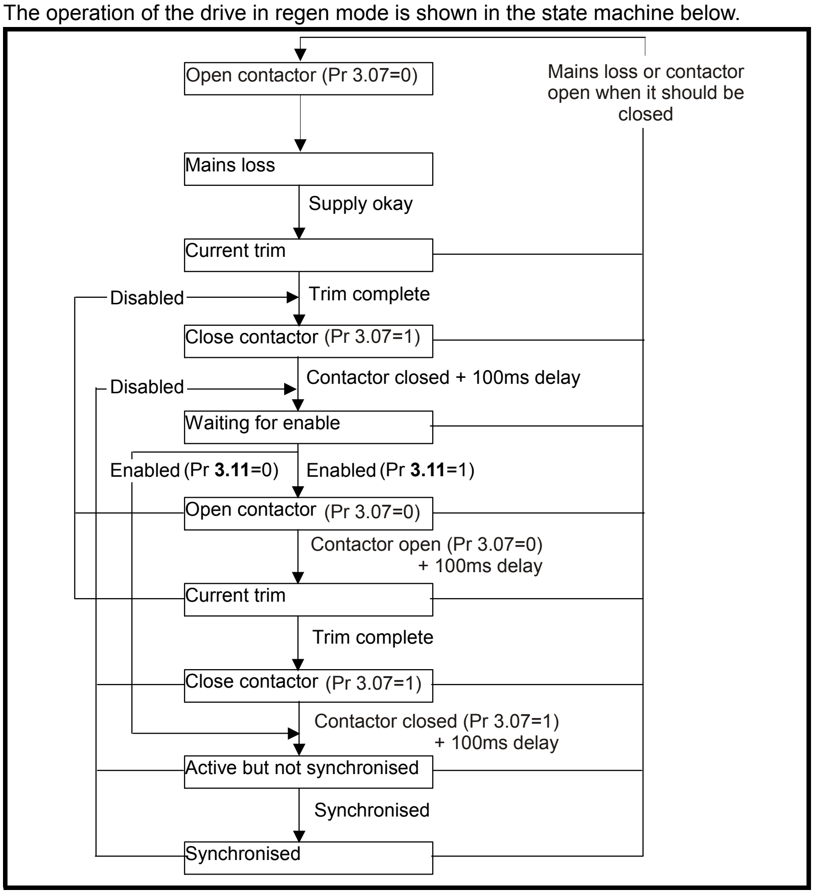
The drive checks for mains loss either by monitoring the d.c. link or additionally when the inverter is active by an internal estimate of the a.c. supply level. The detection levels used for different drive voltage ratings are given in the following table.

Voltage rating V	DC voltage mains loss detection level V dc	AC voltage mains loss detection level V ac
200	205	75
400	410	150
575	540	225
690	540	225

During power-up the supply is considered okay and the drive can operate if the d.c. link voltage is above the levels given in the table below.

Drive voltage rating V	dc voltage for supply okay V dc
200	215
400	430
575	565
690	565

The operation of the drive in regen mode is shown in the state machine below.



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

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

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

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

3.03	**Regen status**															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 31								
Update rate	4ms write															

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

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

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

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

0, rESYnC: Continuously attempt to re-synchronize

1, del.triP: delayed trip

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

2, triP: immediate trip

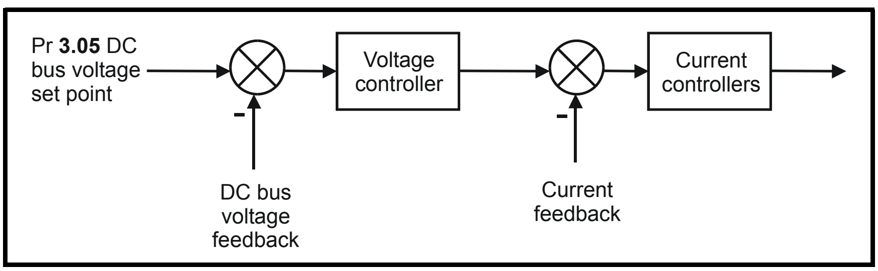
Attempt to synchronize for 30s. If unsuccessful after this time then give a LI.SYnC trip. After a failure during running, trip immediately.

3.05	Voltage set-point															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Regen								0 to DC_VOLTAGE_SET_MAX V							
Default	Regen								200V rating drive: 350 400V rating drive: 700 575V rating drive: 835 690V rating drive: 1100							
Update rate	Background read															

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

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

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



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

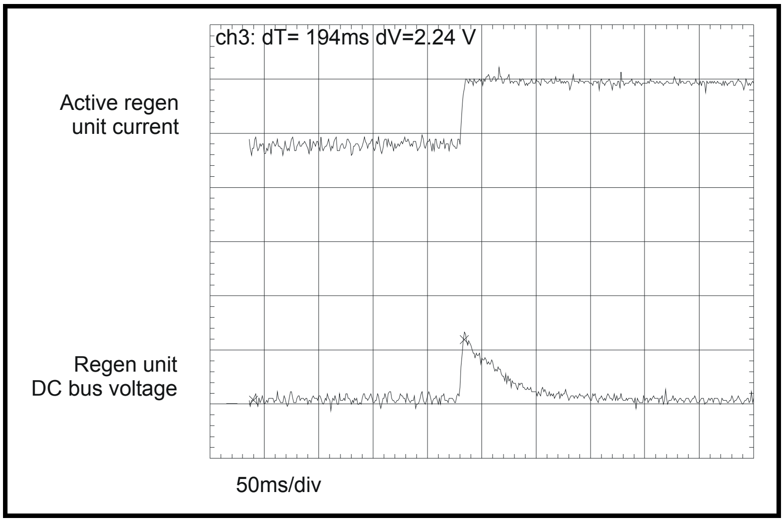
Setting the current controller gains

The most critical parameter for stability is the current controller proportional gain (Pr **4.13**). The required value for this is dependent on the regen unit input inductance. If the inductance of the supply is a significant proportion of the recommended regen inductor (i.e. $60/I_{DR}$ mH per phase, where I_{DR} is equivalent to Kc), then the proportional gain may need to be increased. The supply inductance is likely to be negligible compared to the regen inductor value with small drives, but is likely to be significant with larger drives. The proportional gain should be adjusted as described for Pr **4.13** (closed-loop modes) using the total inductance per phase. The current controller integral gain is not so critical, and in a majority of cases the default value is suitable. However, if it is necessary to adjust this parameter it should be set up as described for Pr **4.14** (closed-loop modes) using the supply resistance for one phase.

Setting the voltage controller gain

Even when the gains are set correctly there will be a transient change of DC bus voltage when there is a change in the load on any drive connected to the regen unit. This can be reduced substantially by using an analog input for power feed forward compensation (see Pr **3.10**). The following discussion relates to a system without power feed-forward compensation.

If the power flow from the supply is increased (i.e. more power is taken from the supply or less power is fed back into the supply) the DC bus voltage will fall, but the minimum level will be limited to just below the peak rectified level of the supply provided the maximum rating of the unit is not exceeded. If the power flow from the supply is reduced (i.e. less power is taken from the supply or more power is fed back into the supply) the DC bus voltage will rise. During a rapid transient the bus will rise and then fall as shown below.



The example shown is for a very rapid load change where the torque reference of the motor drive has been changed instantly from one value to another. The proportional gain of the voltage controller defines the voltage transient because the integral term is too slow to have an effect. (In applications where the motor drive is operating under speed control, the speed controller may only require a limited rate of change of torque demand, and so the transient voltage may be less than covered in the discussion below). If the set point voltage (Pr **3.05**) plus the transient rise exceed the over-voltage trip level the regen unit will trip.

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

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

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

Where:

K_L = load change / 200%
K_{RAT} = Drive voltage rating / 400
K_{MV} = Motor voltage / 400
K_{SP} = 700 / DC bus voltage set point

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

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

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

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

The contactor should be controlled by this parameter. When regen mode is selected this bit is routed to digital I/O7 (T41/42 - relay output) as default. This output, or an alternative output, should be used to control the contactor.

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

When regen mode is selected Pr **3.08** is the destination from digital I/O2 (T25) with the I/O set up as an input as default. This input, or an alternative input, should be connected to an auxiliary contact on the contactor so that it follows the state of the contactor..

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

When the unit has been enabled and successfully synchronized this bit will become active. If the regen unit attempts to re-synchronize or trips, this bit becomes inactive. When regen mode is selected this bit is routed to a digital I/O1 (T24) with the I/O set up as an output as default. The output, or an alternative output, should be used to enable the motor drive(s) connected to the DC Bus link of the regen unit.

3.10	**Power feed-forward compensation**															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1			1				1		
Range	Regen							±100.0%								
Default	Regen							0.0								
Update rate	4ms read															

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

3.11	**Current trimming mode**															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen							0 to 1								
Default	Regen							0								
Update rate	4ms read															

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

5.6 Menu 4: Torque and current control

The scaling of the current feedback is based on the rating of the drive as follows:

Level	x current scaling (Kc)
Over-current trip	1/0.45 = 2.22
Open-loop peak limit	1.75
Closed-loop vector, Servo and Regen maximum standard operating current	1.75
Open-loop maximum standard operating current	1.5
Current scaling (Kc)	1.0
Maximum Normal Duty current rating	≤1.36
Maximum motor rated current	≤1.36

Current scaling (Kc) is 1 per unit current and is related to the scaling of the drive current feedback. For most drive sizes Kc is the same as the Maximum heavy duty current rating defined by Pr **11.32**. The Maximum heavy duty current rating is the maximum value of rated motor current (defined by Pr **5.07** or Pr **21.07**) that can be set for operation with the force vented motor protection characteristic - Pr **4.25** = 0 (see Pr **4.16** for more details). If the Kc and Maximum heavy duty current rating are the same then the drive uses 1.75 x Maximum heavy duty current rating for the open-loop peak limit and the maximum standard operating current for closed-loop modes. This is the limit up to which the drive can control current normally. The current range above this is allowed for current controller overshoot and for additional current feedback pulses associated with long cable operation. For some drive sizes the Maximum heavy duty current rating is larger than Kc, therefore the potential overload is reduced below 1.75 x Kc.

The motor rated current (defined by Pr **5.07** or Pr **21.07**) may be increased above the maximum Heavy Duty current rating up to the maximum Normal Duty rated current . When the motor rated current is above the maximum Heavy Duty current rating the drive always provides motor protection scheme that is intended for variable torque applications (see Pr **4.16** on page 105 for more details). The maximum rated current is the maximum rated current allowed for Normal Duty operation.

Table below gives the current scaling (Kc), Maximum heavy duty current rating and Maximum normal duty rated current for all drive sizes and voltage ratings.

Table 5-3 Current ratings

200V				400V				575V				690V			
Model	Current scaling (Kc)	Max Heavy Duty current rating	Max Normal Duty rated current	Model	Current scaling (Kc)	Max Heavy Duty current rating	Max Normal Duty rated current	Model	Current scaling (Kc)	Max Heavy Duty current rating	Max Normal Duty rated current	Model	Current scaling (Kc)	Max Heavy Duty current rating	Max Normal Duty rated current
SP0201	2.2	2.2	2.2	SP0401	1.3	1.3	1.3	SP3501	4.1	4.1	5.4	SP4601	18	18	22
SP0202	3.1	3.1	3.1	SP0402	1.7	1.7	1.7	SP3502	5.4	5.4	6.1	SP4602	22	22	27
SP0203	4.0	4.0	4.0	SP0403	2.1	2.1	2.1	SP3503	6.1	6.1	8.4	SP4603	27	27	36
SP0204	5.7	5.7	5.7	SP0404	3.0	3.0	3.0	SP3504	9.5	9.5	11	SP4604	36	36	43
SP0205	7.5	7.5	7.5	SP0405	4.2	4.2	4.2	SP3505	12	12	16	SP4605	43	43	52
SP1201	4.3	4.3	5.2	SP1401	2.1	2.1	2.8	SP3506	18	18	22	SP4606	52	52	62
SP1202	5.8	5.8	6.8	SP1402	3.0	3.0	3.8	SP3507	22	22	27	SP5601	62	62	84
SP1203	7.5	7.5	9.6	SP1403	4.2	4.2	5.0					SP5602	84	84	99
SP1204	10.6	10.6	11	SP1404	5.8	5.8	6.9					SP6601	85.7	100	125
SP2201	12.6	12.6	15.5	SP1405	7.6	7.6	8.8					SP6602	107.1	125	144
SP2202	17	17	22	SP1406	9.5	9.5	11					SPMA1601	85.7	100	125
SP2203	25	25	28	SP2401	13	13	15.3					SPMA1602	107.1	125	144
SP3201	31	31	42	SP2402	16.5	16.5	21					SPMD1601	85.7	100	125
SP3202	42	42	54	SP2403	23	25	29					SPMD1602	107.1	125	144
SP4201	56	56	68	SP2404	29	29	29					SPMD1603	123.4	144	168
SP4202	68	68	80	SP3401	32	32	35					SPMD1604	144.0	168	192
SP4203	80	80	104	SP3402	40	40	43								
SP5201	105	105	130	SP3403	46	46	56								
SP5202	130	130	154	SP4401	60	60	68								
SPMD1201	133.7	156	192	SP4402	74	74	83								
SPMD1202	164.5	192	248	SP4403	96	96	104								
SPMD1203	214.2	250	312	SP5401	124	124	138								
SPMD1204	248.5	290	350	SP5402	156	156	168								
				SP6401	154.2	180	205								
				SP6402	180	210	236								
				SPMA1401	154.2	180	205								
				SPMA1402	180	210	236								
				SPMD1401	154.2	180	205								
				SPMD1402	180	210	246								
				SPMD1403	205.7	246	290								
				SPMD1404	248.5	290	350								

SPMAxxxx and SPMDxxxx drive modules can be connected in parallel provided all power modules have the same voltage and current rating to make a larger drive. The currents are then defined as follows:

Current scaling (Kc)
Kc is the sum of Kc for all the modules..

Maximum heavy duty current rating
Maximum heavy duty current rating = 0.95 x Sum of maximum heavy duty current rating for all the modules

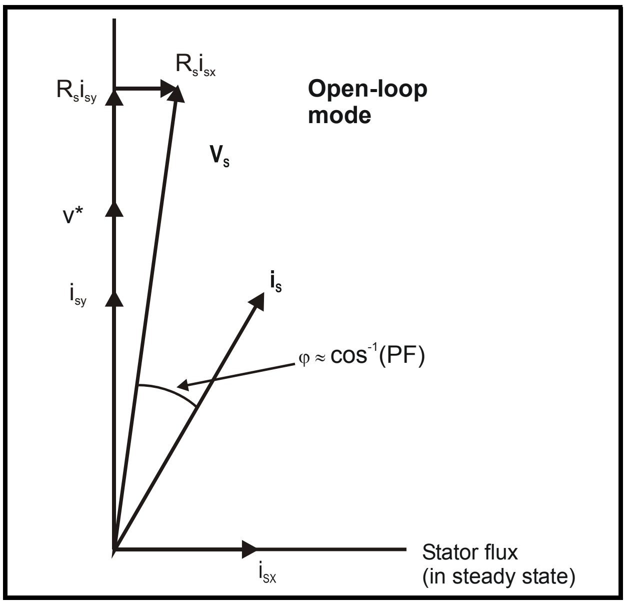
Maximum rated current
Maximum rated current = 0.95 x Sum of maximum normal duty rated current for all the modules

5.6.1 Open-loop

In this mode the drive operates in the stator flux reference frame under steady state conditions. The absolute maximum controlled motor current is defined by the peak limit system as 1.75 x Kc. However, the drive does not normally operate at this level, but uses the peak limit system as protection against over-current trips. Under normal operation the motor current is limited to 1.50 x Kc, allowing a safety margin between the maximum normal operating current and the peak limit level. Therefore a motor with the same current rating as the drive can produce at least 150% torque when the drive operates in current limit.

DRIVE_CURRENT_MAX is full scale current feedback, i.e. Kc / 0.45.

The relationship between the voltage and current for open-loop operation is shown in the following vector diagram.



Definitions:

- $\mathbf{v_s}$ = motor terminal voltage vector
- $\mathbf{i_s}$ = motor current vector
- i_{sy} = y axis component of current
- i_{sx} = x axis component of current
- v* = no load y axis voltage reference

MOTOR1_CURRENT_LIMIT_MAX is used as the maximum for some parameters such as the user current limits. This is defined in the vector diagram as follows (with a maximum of 1000%):

$$\textbf{MOTOR1\_CURRENT\_LIMIT\_MAX} = \frac{\sqrt{\left[\left[\frac{\textbf{Maximum current}}{\textbf{Motor rated current}}\right]^2 + (\textbf{PF})^2 - \textbf{1}\right]}}{\textbf{PF}} \times \textbf{100\%}$$

Where

Motor rated current is given by Pr **5.07**
PF is motor rated power factor given by Pr **5.10**
(MOTOR2_CURRENT_LIMIT_MAX is calculated from the motor map 2 parameters)
The Maximum current is either (1.5 x Kc) when the rated current set by Pr **5.07** (or Pr **21.07** if motor map 2 is selected) is less than or equal to the Maximum Heavy Duty current rating, otherwise it is (1.1 x Maximum Normal Duty rated current).

For example, with a motor of the same rating as the drive and a power factor of 0.85, the maximum current limit is 165.2% for Heavy Duty operation.

The above calculation is based on the assumption that the flux producing current (Pr **4.17**) in the stator flux reference frame does not vary with load and remains at the level for rated load. This is not the case and the flux producing current will vary as the load is increased. Therefore the maximum current limit may not be reached before the drive reduces the current limit to prevent the peak limit from becoming active.

The rated active and rated magnetising currents are calculated from the power factor (Pr **5.10**) and motor rated current (Pr **5.07**) as:

rated active current = power factor x motor rated current

rated magnetising current = √(1 - power factor^2) x motor rated current

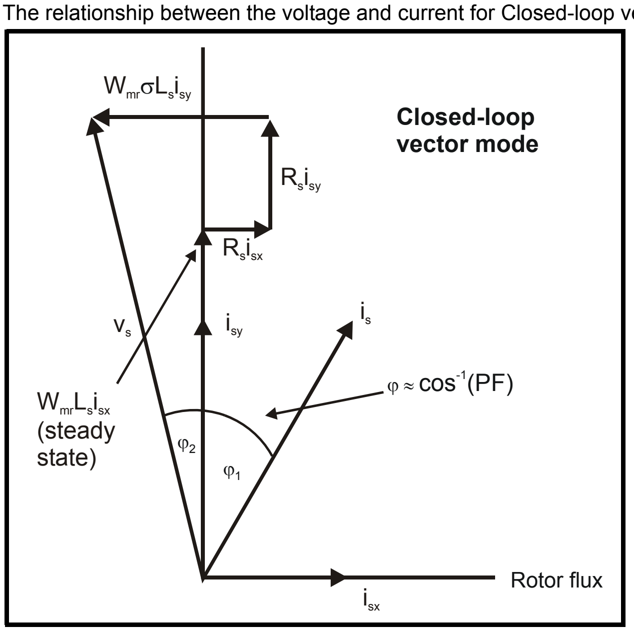
In this mode of operation the drive only requires the motor rated current and the power factor at rated load to set up the maximum current limits, scale the current limits correctly and calculate the rated active and magnetizing currents. The user may enter the nameplate values in Pr **5.07** and Pr **5.10** respectively and the drive will operate satisfactorily. Alternatively the drive can perform an auto-tune test on the motor to measure the power factor at rated load by measuring Rs (stationary test), σL_s (stationary test), and L_s (rotating test). See Pr **5.12** on page 117 for details.

5.6.2 Closed-loop vector

In this mode the drive operates in the rotor flux reference frame. The maximum normal operating current is controlled by the current limits.

DRIVE_CURRENT_MAX is full scale current feedback, i.e. Kc / 0.45.

The relationship between the voltage and current for Closed-loop vector operation is shown in the following vector diagram.



Definitions:

v_s = motor terminal voltage vector

i_s = motor current vector

i_{sy} = y axis component of current

i_{sx} = x axis component of current

MOTOR1_CURRENT_LIMIT_MAX is used as the maximum for some parameters such as the user current limits. The magnetizing current (isx) remains constant except in field weakening where it is reduced to control the motor voltage. The maximum current limit is defined as follows (with a maximum of 1000%):

$$\textbf{MOTOR1\_CURRENT\_LIMIT\_MAX} = \frac{\sqrt{\left[\left[\dfrac{\textbf{Maximum current}}{\textbf{Motor rated current}}\right]^2 + \cos(\varphi_1)^2 - 1\right]}}{\cos(\varphi_1)} \times \textbf{100\%}$$

Where:

Motor rated current is given by Pr **5.07**

$\varphi_1 = \cos^{-1}(PF) - \varphi_2$

PF is motor rated power factor given by Pr **5.10**

(MOTOR2_CURRENT_LIMIT_MAX is calculated from the motor map 2 parameters)

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

φ_1 can be derived directly by the drive auto-tune. However, if the auto-tune is not carried out φ_1 is derived from φ_2 and the power factor. It should be noted that the drive autotune would make the total y axis voltage under rated load conditions equal to the rated voltage (V_R), therefore φ_2 is given by the following equation.

$$\varphi_2 = -\tan^{-1}\left[\frac{R_s I_{sxR} - 2\pi f_R \sigma L_s I_{syR}}{V_R}\right]$$

Where:

R_s is the motor stator resistance (Pr **5.17**)

f_R is the rated frequency (Pr **5.06**)

σL_S is the transient inductance (H) (Pr **5.24** / 1000)

V_R is the rated voltage (Pr **5.09**)

I_{sxR} and I_{syR} are the currents in the x and y axes of the rotor flux reference frame under rated load

I_{sxR} and I_{syR} are derived as I_{sxR} = Pr **5.07** x $\sqrt{(1 - \text{Pr } \mathbf{5.10}^2)}$ and I_{syR} = Pr **5.07** x Pr **5.10** for the purposes of calculating φ_2. This calculation gives a result that is reasonably accurate for most purposes.

rated active current = $\cos(\varphi_1)$ x motor rated current

rated magnetising current = $\sqrt{(1 - \cos(\varphi_1)^2)}$ x motor rated current

In this mode of operation the drive requires the following parameters to set the maximum current limits, scale the current limits correctly and calculate the rated active and magnetising currents.

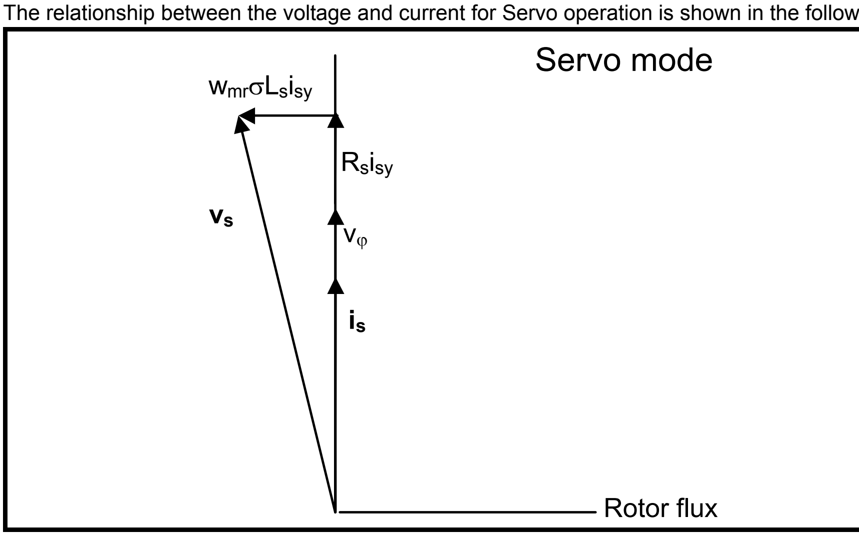
Parameters	Current limit accuracy
Motor rated current, power factor at rated load (R_s and σL_s are zero)	Moderate accuracy
Motor rated current, power factor at rated load, measured values of R_s and σL_s	Good accuracy
Motor rated current, power factor at rated load, measured values of R_s, σL_s and L_s	Exact current limits based on all measured values

5.6.3 Servo

In this mode the drive operates in the rotor flux reference frame. The maximum normal operating current is controlled by the current limits.

DRIVE_CURRENT_MAX is full scale current feedback, i.e. Kc / 0.45.

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



Definitions:

$\mathbf{v_s}$ = motor terminal voltage vector

$\mathbf{i_s}$ = motor current vector

$V\varphi$ = voltage produced by the rotor magnets

MOTOR1_CURRENT_LIMIT_MAX is used as the maximum for some parameters such as the user current limits. The current maximum current limit is defined as follows (with a maximum of 1000%):

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

Where:

Motor rated current is given by Pr **5.07**

(MOTOR2_CURRENT_LIMIT_MAX is calculated from the motor map 2 parameters)

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

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

rated active current = motor rated current
rated magnetising current = 0

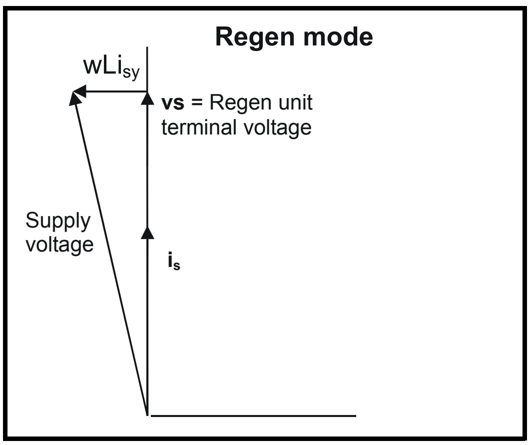
In this mode the drive only requires the motor rated current to set the maximum current limit correctly and scale the current limits, and so no auto-tuning is required to set these accurately.

5.6.4 Regen

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

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

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



Definitions:

$\mathbf{i_s}$ = regen drive terminal voltage vector

vs = regen drive current vector

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

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

Where:

Regen unit rated current is given by Pr **5.07**

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

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

rated active current = regen mode rated current
rated magnetising current = 0

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

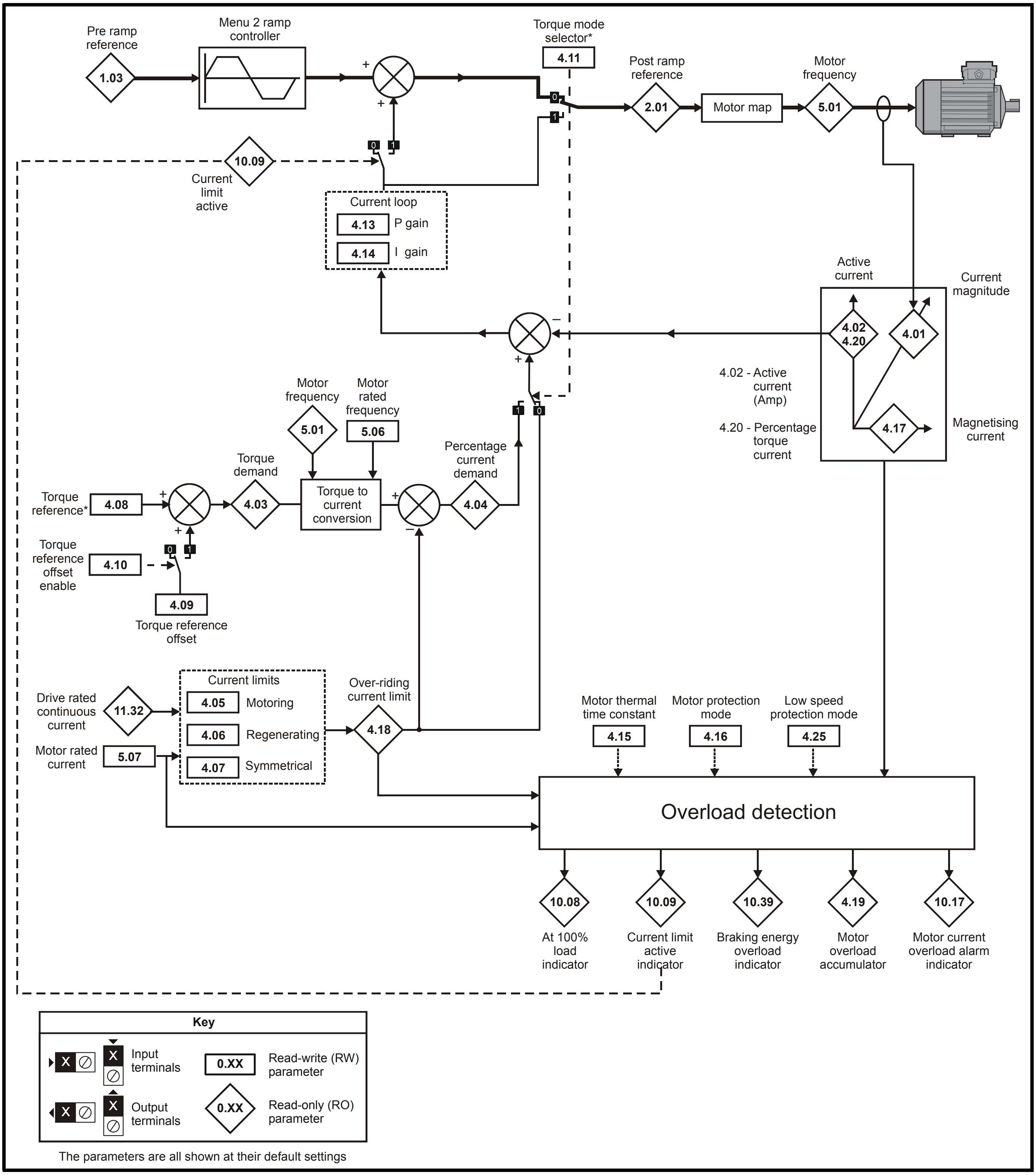
It is possible to set a level of reactive current with Pr **4.08** in regen mode. This parameter has a limit defined as REGEN_REACTIVE_MAX that is provided to limit the total current to DRIVE_CURRENT_MAX.

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

5.6.5 Parameter descriptions

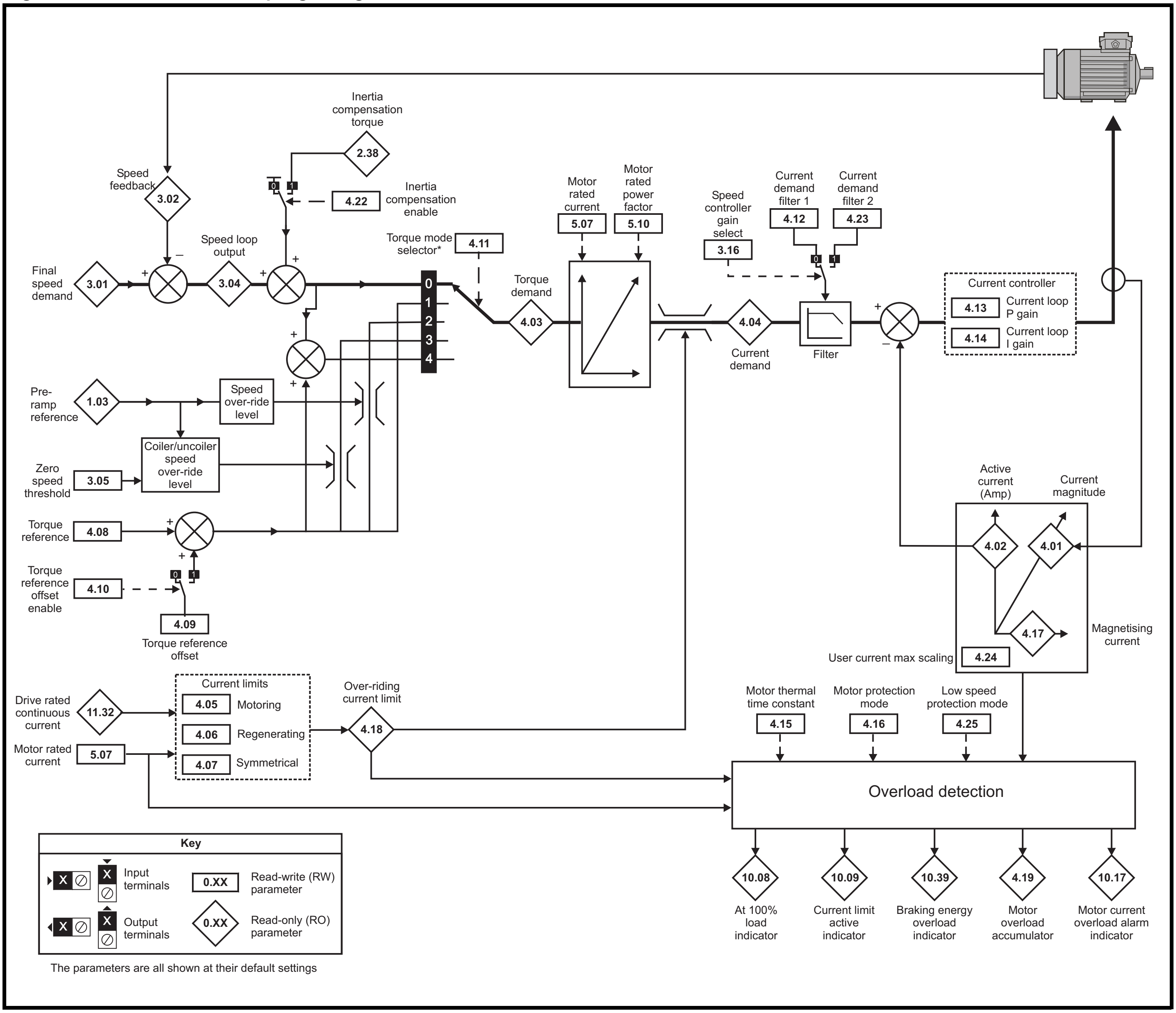
Parameter descriptions: Open-loop

Figure 5-6 Menu 4 Open-loop logic diagram



Parameter descriptions: Closed-loop vector

Figure 5-7 Menu 4 Closed-loop logic diagram



Parameter descriptions: Servo

Figure 5-8 Menu 4 Servo logic diagram

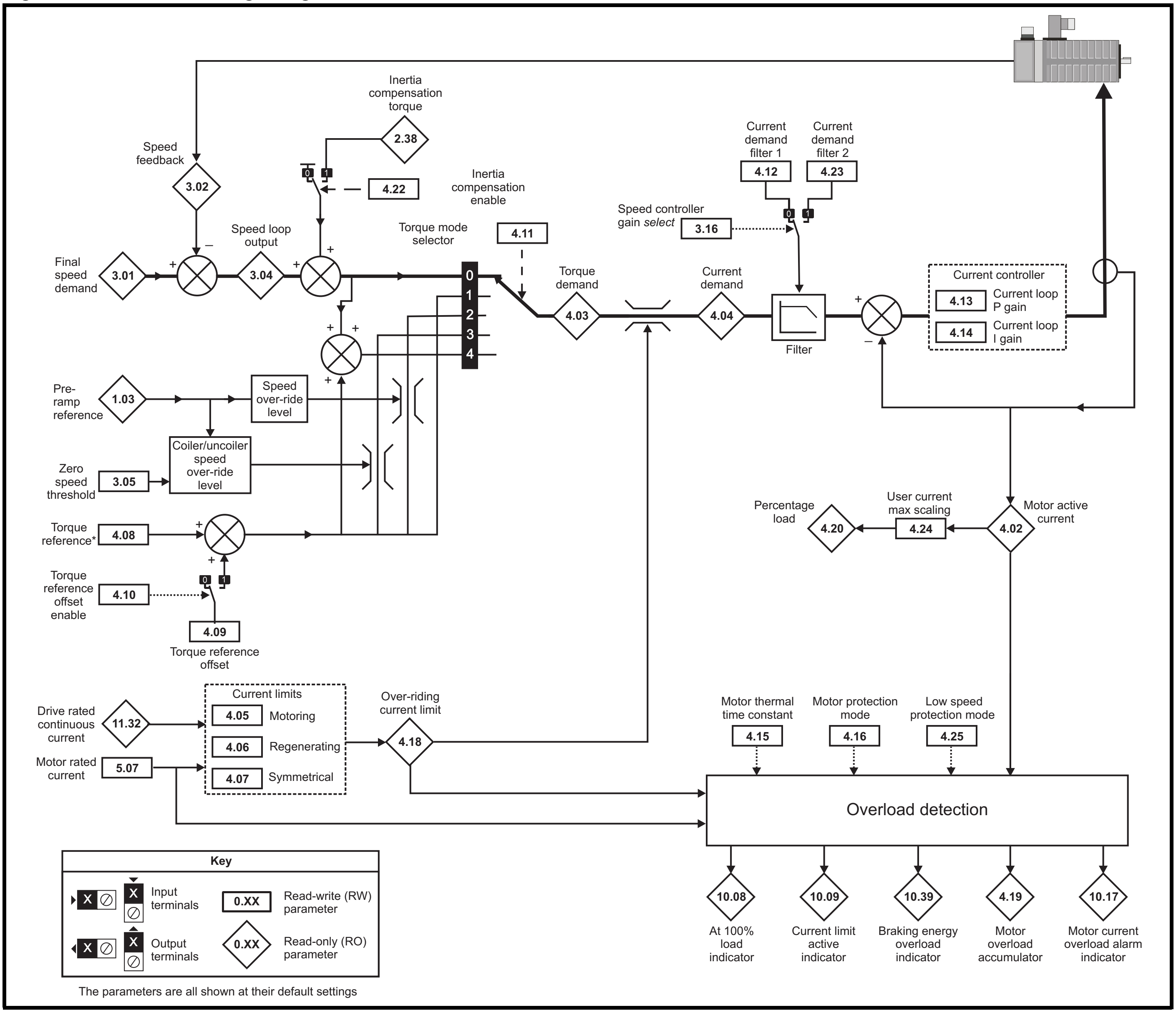
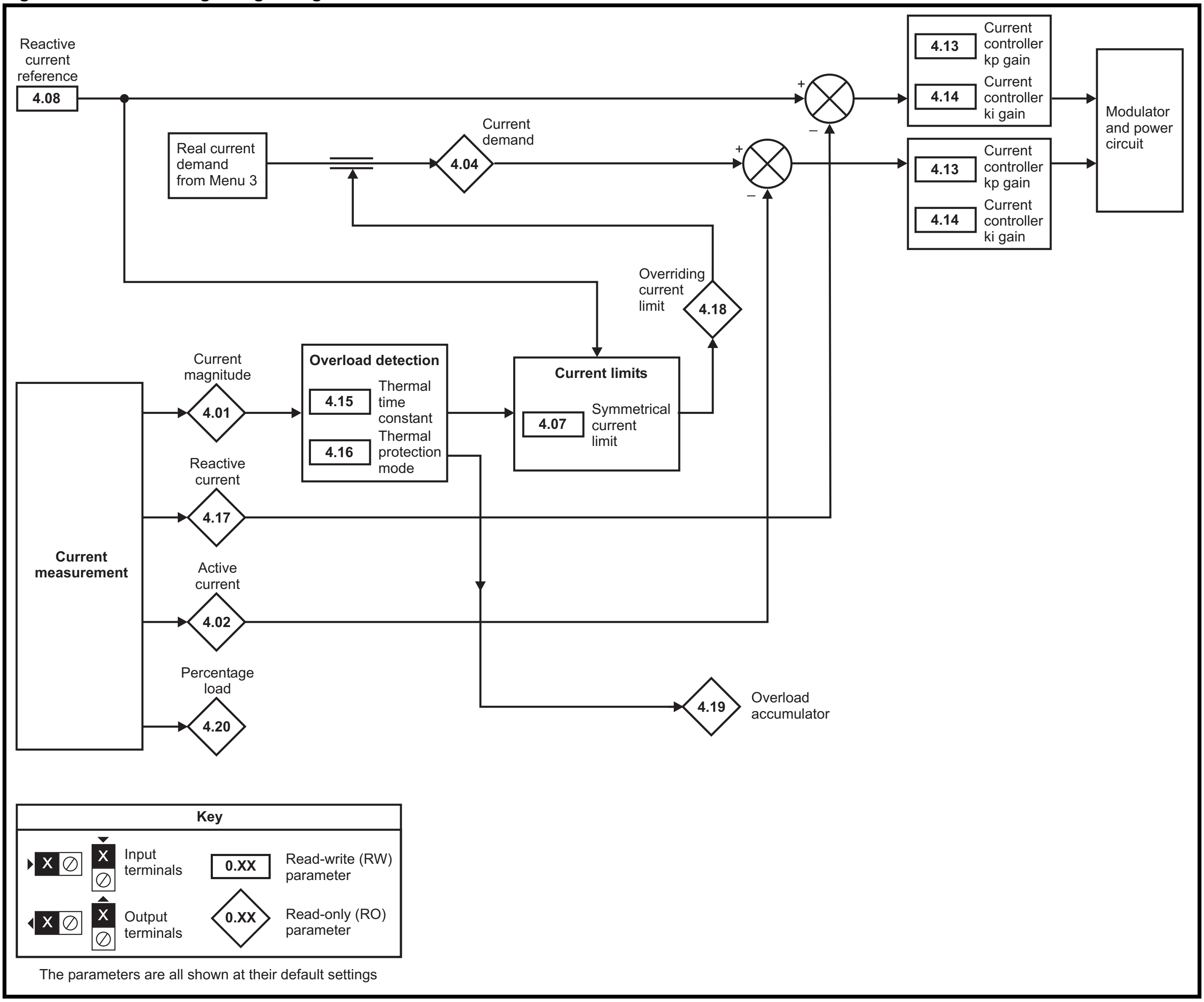
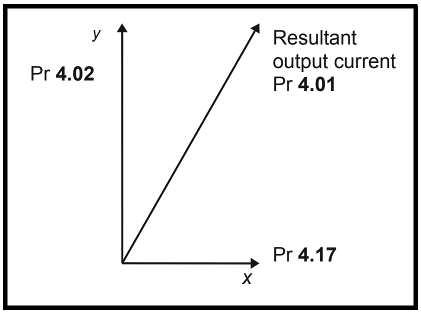


Figure 5-9 Menu 4 Regen logic diagram



4.01	**Current magnitude**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to DRIVE_CURRENT_MAX A								
Update rate	4ms write															

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



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

4.02	**Active current**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±DRIVE_CURRENT_MAX A								
Update rate	4ms write															

Open-loop, Closed-loop vector and Servo

The active current is the torque producing current in a motor drive.

Direction of active current	Direction of rotation	Torque direction
+	+	Forward (accelerating)
-	+	Reverse (decelerating)
+	-	Forward (decelerating)
-	-	Reverse (accelerating)

The active current is aligned with the y axis of the reference frame. In open-loop mode the x axis of the reference frame is aligned with the stator flux vector. In Closed-loop vector and Servo modes the x axis of the reference frame is aligned with the rotor flux vector. The motor torque is proportional to the torque producing current when field weakening is not active. Once field weakening is active the torque producing current is boosted to compensate for the reduction in motor flux.

Regen

The active current is the real current in a regen unit.

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

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

4.03	**Torque demand**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo								±TORQUE_PROD_CURRENT_MAX %							
Update rate	4ms write															

Open-loop
The torque demand is the sum of the torque reference (Pr **4.08**) and the torque offset (Pr **4.09**), if enabled. The units of the torque demand are % of rated torque. 100% rated torque is defined as the torque produced by 100% rated active current.

Closed-loop vector
The torque demand can be derived from the speed controller and/or the torque reference and offset. The units of the torque demand are % of rated torque. 100% rated torque is defined as the torque produced by 100% rated active current.

4.04	**Current demand**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen								±TORQUE_PROD_CURRENT_MAX %							
Update rate	4ms write															

Open-loop
The current demand is derived from the torque demand. Provided the motor is not field weakened the torque and current demands are the same. In field weakening the current demand is increased with reduced flux:

Pr **4.04** = Pr **4.03** x frequency / rated frequency

The current demand is subject to the current limits.

Closed-loop vector and Servo
The current demand is derived from the torque demand. Provided the motor is not field weakened the torque and current demands are the same. In the field weakening range the current demand is increased with reduced flux unless Pr **5.28** = 1. The level of flux is derived from the motor model within the drive controllers.

Pr **4.04** = Pr **4.03** x flux / rated flux

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

4.05	**Motoring current limit**															
Drive modes	Open-loop, Closed-loop vector, Servo,Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo,Regen								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Open-loop Closed-loop vector, Servo,Regen								165.0* 175.0*							
Second motor parameter	Open-loop, Closed-loop vector, Servo,Regen								Pr **21.27**							
Update rate	Background read															

4.06	**Regen current limit**															
Drive modes	Open-loop, Closed-loop vector, Servo,Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Open-loop Closed-loop vector, Servo,Regen								165.0* 175.0*							
Second motor parameter	Open-loop, Closed-loop vector, Servo,Regen								Pr **21.28**							
Update rate	Background read															

4.07	Symmetrical current limit	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to MOTOR1_CURRENT_LIMIT_MAX %
Default	Open-loop Closed-loop vector, Servo, Regen	165.0* 175.0*
Second motor parameter	Open-loop, Closed-loop vector, Servo,Regen	Pr **21.29**
Update rate	Background read	

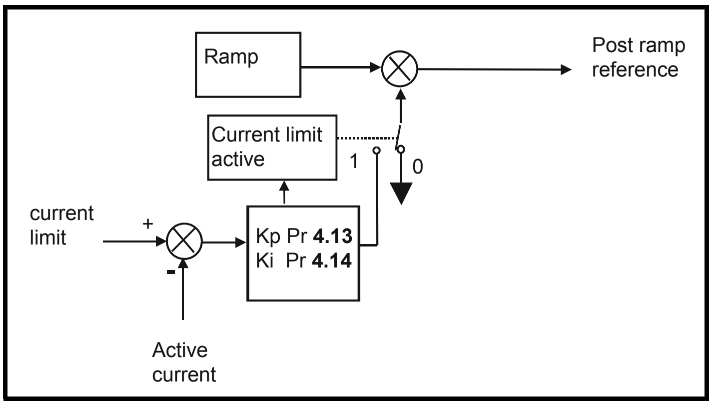
Coding

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

* These are the maximum default values. If the variable maximum of this parameter (MOTOR1_CURRENT_LIMIT_MAX) gives a lower value with the default value of Motor rated current (Pr **5.07**) the default of this parameter is at the lower value.

Open-loop

The motoring current limit applies in either direction of rotation when the machine is producing motoring torque. Similarly the regen current limit applies in either direction when the machine is producing regenerating torque. The symmetrical current limit can override either motoring or regenerating current limit if it is set at a lower value than either limit.



The current limits are compared with the active current and if the current exceeds a limit the error value passes through the PI controller to give a frequency component which is used to modify the ramp output. The direction of the modification is always to reduce the frequency to zero if the active current is over the motoring limit, or to increase the frequency towards the maximum if the current is over the regenerating limit. Even when the current limit is active the ramp still operates, therefore the proportional and integral gains (Pr **4.13** and Pr **4.14**) must be high enough to counter the effects of the ramp. See Pr **4.13** and Pr **4.14** on page 103 for gain setting.

Closed-loop vector and Servo

The motoring current limit applies in either direction of rotation when the machine is producing motoring torque. Similarly the regen current limit applies in either direction when the machine is producing regenerating torque. The symmetrical current limit can override either motoring or regenerating current limit if it is set at a lower value than either limit.

Regen

Current limits are provided in regen mode, however, if the current limits are active the DC bus voltage can no longer be controlled. The motoring current limit applies with either phase rotation at the input when power is being taken from the supply. Similarly the regen current limit applies with either phase rotation at the input when power is being fed back into the supply. The symmetrical current limit can override either motoring or regenerating current limit if it is set at a lower value than either limit.

4.08	Torque reference	
Drive modes	Open-loop, Closed-loop vector, Servo	
Range	Open-loop, Closed-loop vector, Servo	±USER_CURRENT_MAX %
Default	Open-loop, Closed-loop vector, Servo	0.00
Update rate	4ms read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1	2						1	1		

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

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

4.09	**Torque offset**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1		
Range	Open-loop, Closed-loop vector, Servo							±USER_CURRENT_MAX %								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Update rate	4ms read															

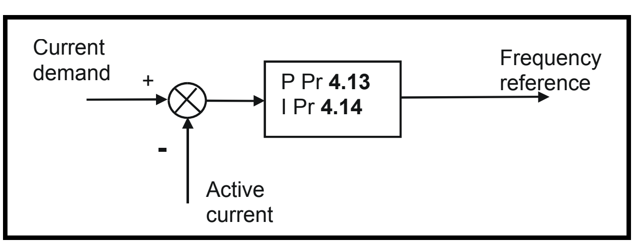
4.10	**Torque offset select**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

The torque offset is added to the torque reference when Pr **4.10** is one. The torque offset is updated every 4ms when connected to an analog input, and so Pr **4.08** should be used for fast updating if required.

4.11	**Torque mode selector**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop Closed-loop vector and Servo							0 to 1 0 to 4								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

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 .



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

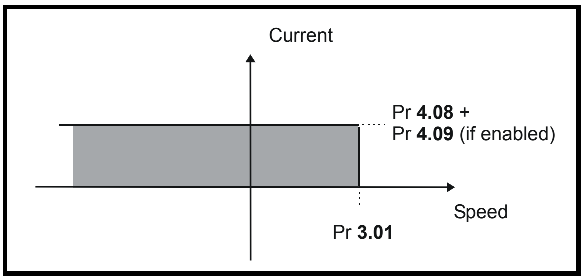
The torque demand is equal to the speed loop output.

1: Torque control

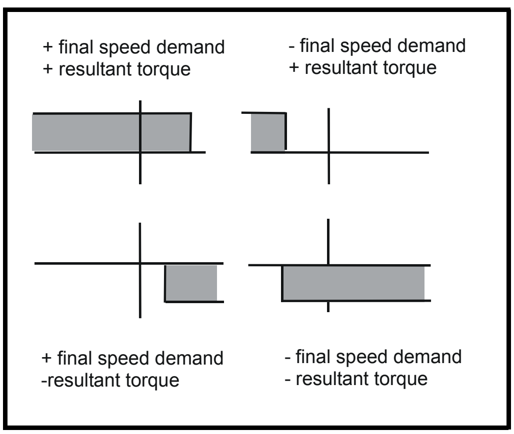
The torque demand is given by the sum of the torque reference and the torque offset, if enabled. The speed is not limited in any way, however, the drive will trip at the overspeed threshold if runaway occurs.

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** + 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

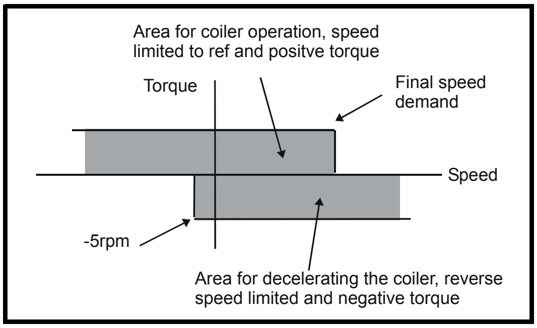
Positive final speed demand: a positive resultant torque will give torque control with a positive speed limit defined by the final speed demand. A negative resultant torque will give torque control with a negative speed limit of -5rpm.

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:

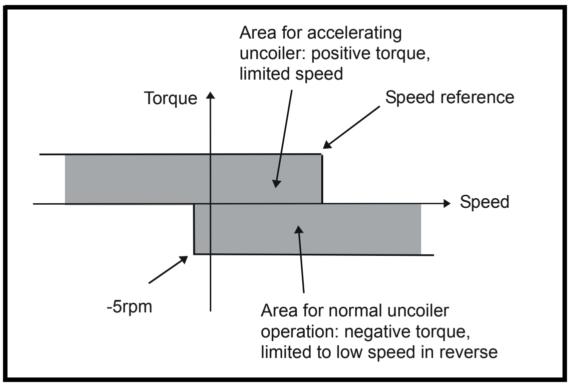
This is an example of a coiler operating in the positive direction. The final speed demand is set to a positive value just above the coiler reference speed. If the resultant torque demand is positive the coiler operates with a limited speed, so that if the material breaks the speed does not exceed a 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.

4.12	**Current demand filter 1**	
Drive modes	Closed-loop vector, Servo	
Range	Closed-loop vector, Servo	0.0 to 25.0 ms
Default	Closed-loop vector, Servo	0.0
Update rate	Background read	

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

A first order filter, with a time constant defined by this parameter, 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. Alternative time constants can be selected depending on the value of the speed controller gain selector (Pr **3.16**). If Pr **3.16** = 0 Pr **4.12** is used, if Pr **3.16** = 1 Pr **4.23** is used.

4.13	**Current controller Kp gain**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 30,000
Default	Drive voltage rating: Open-loop, Closed-loop vector, Servo Regen	200V 400V 575V 690V 20 20 20 20 75 150 180 215 45 90 110 130
	Closed-loop vector, Servo	Pr **21.22**
Update rate	Background read	

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

4.14	**Current controller Ki gain**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 30,000								
Default	Drive voltage rating: Open-loop, Closed-loop vector, Servo, Regen							200V 400V 575V 690V 40 40 40 40 1,000 2,000 2,400 3,000								
Second motor parameter	Closed-loop vector, Servo							Pr **21.23**								
Update rate	Background read															

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 mains 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

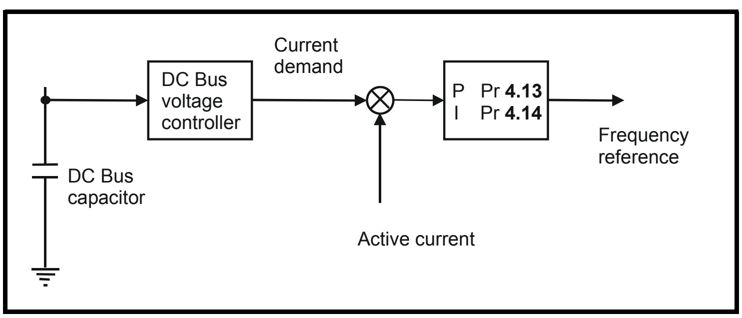
The current limits will normally operate with an integral term only, particularly below the point where field weakening begins. The proportional term is inherent in the loop. The integral term must be increased enough to counter the effect of the ramp which is still active even in current limit. For 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.

Mains loss and controlled standard ramp

The DC bus voltage controller becomes active if mains 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 proportional gain Kp (Pr **4.13**) is the most critical value in controlling the performance of the current controllers. Either the value can be set by auto-tuning (see Pr **5.12**), or it can be set by the user so that

Kp = (L / T) x (Ifs / Vfs) x (256 / 5)

Where:

T is the sample time of the current controllers. The drive compensates for any change of sample time, and so it should be assumed that the sample time is equivalent to the lowest sample rate of 167μs.
L is the 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 (σLs). This is the inductance value stored in Pr **5.24** after the auto-tune test is carried out.
I_{fs} is the peak full scale current feedback = Kc x √2 / 0.45. Where Kc is the current scaling for each size of drive.

V_{fs} is the maximum DC bus voltage.

Therefore:

Kp = (L / 167us) x (Kc x √2 / 0.45 / Vfs) x (256 / 5)
= K x L x Kc

Where:

K = √2 / (0.45 x V_{fs} x 167μs) x (256 / 5)

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

Drive voltage rating	V_{fs}	K
200V	415V	2,322
400V	830V	1,161
575V	990V	973
690V	1190V	809

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

Ki = Kp x 256 x T / τ_m

where

τ_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

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

The above equations give the gain values that are calculated by the auto-tune system and these should give the best response at all switching frequencies with minimal overshoot. If required the gains can be adjusted to improve performance as follows:

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

As already stated, the drive compensates for changes of switching frequency to give similar performance as the switching frequency changes. The following table gives the relationship between the user gain values and the values actually used by the drive for Unidrive and Unidrive SP. Although other scaling values are included in the current controller these values can be used to make a relative comparison between switching frequencies and a relative comparison between Unidrive and Unidrive SP. For example: the amount of acoustic noise produced in the motor from encoder speed ripple is generally related to the product of the speed controller and current controller proportional gains. The values in this table can be used in conjunction with the speed loop proportional gain to assess the amount of acoustic noise that is likely to be produced from the encoder speed ripple for each product and with different switching frequencies.

Unidrive			Unidrive SP		
Switching freq	**Proportional gain**	**Integral gain**	**Switching freq**	**Proportional gain**	**Integral gain**
3kHz	Pr **4.13** x 0.5	Pr **4.14**	3kHz	Pr **4.13**	Pr **4.14**
4.5kHz	Pr **4.13** x 0.75	Pr **4.14**	4kHz	Pr **4.13** x 1.5	Pr **4.14**
6kHz	Pr **4.13**	Pr **4.14**	6kHz	Pr **4.13** x 2	Pr **4.14**
9kHz	Pr **4.13** x 0.75	Pr **4.14**	8kHz	Pr **4.13** x 2	Pr **4.14** x 1.3
12kHz	Pr **4.13**	Pr **4.14**	12kHz	Pr **4.13** x 2.6	Pr **4.14** x 1.3
			16kHz	Pr **4.13** x 2	Pr **4.14** x 1.3

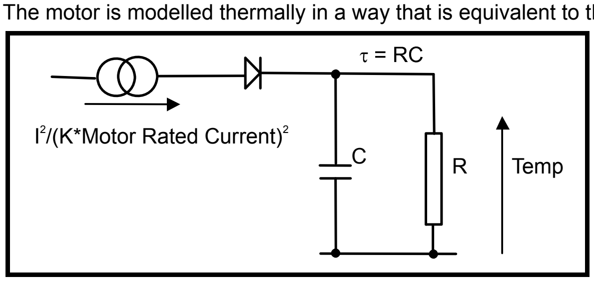
Regen

The defaults Kp and Ki gains should be suitable for the standard regen inductors. If the input inductance is significantly higher the gains should be adjusted as described for the Closed-loop vector and Servo modes. See Pr **3.06** on page 85 for guidelines on setting the regen unit current controller gains. The table given for the relative levels of current controller gains for closed-loop vector and servo modes also applies to regen mode.

4.15	**Thermal time constant**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to 3000.0								
Default	Open-loop, Closed-loop vector, Regen Servo							89.0 20.0								
Second motor parameter	Open-loop, Closed-loop vector, Servo, Regen							Pr **21.16**								
Update rate	Background read															

4.16	**Thermal protection mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 1								
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	Background read															

The motor is modelled thermally in a way that is equivalent to the electrical circuit shown as follows.

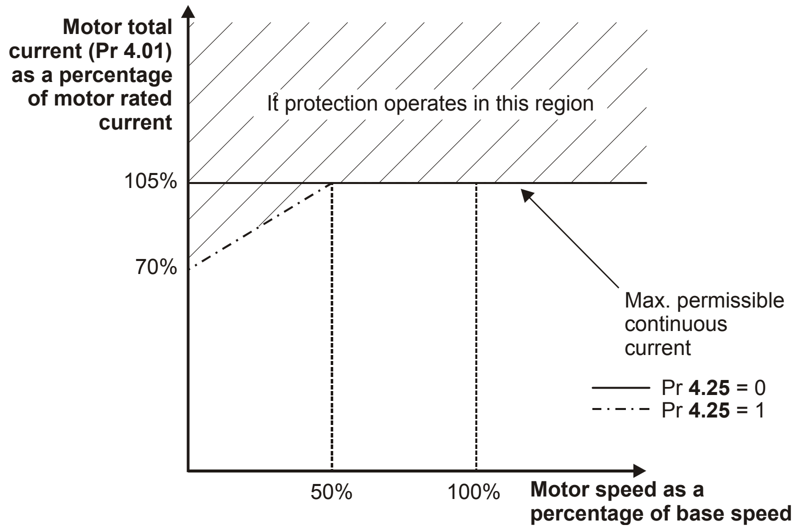


The temperature of the motor as a percentage of maximum temperature, with a constant current magnitude of I, constant value of K and constant value of motor rated current (set by Pr **5.07** or Pr **21.07**) after time t is given by

$$\text{Temp} = [I^2 / (K \times \text{Motor rated current})^2] (1 - e^{-t/\tau}) \times 100\%$$

This assumes that the maximum allowed motor temperature is produced by K x Motor rated current and that τ is the thermal time constant of the point in the motor that reaches its maximum allowed temperature first. τ is defined by Pr **4.15.** The estimated motor temperature is given by Pr **4.19** as a percentage of maximum temperature. If Pr **4.15** has a value between 0.0 and 1.0 the thermal time constant is taken as 1.0.

If the rated current (defined by Pr **5.07** or Pr **21.07** depending on which motor is selected) is less or equal to the maximum Heavy Duty rating then Pr **4.25** can be used to select 2 alternative protection characteristics (see diagram below). 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 half of rated speed. 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. (In Regen mode K = 1.05 over the whole operating frequency range).

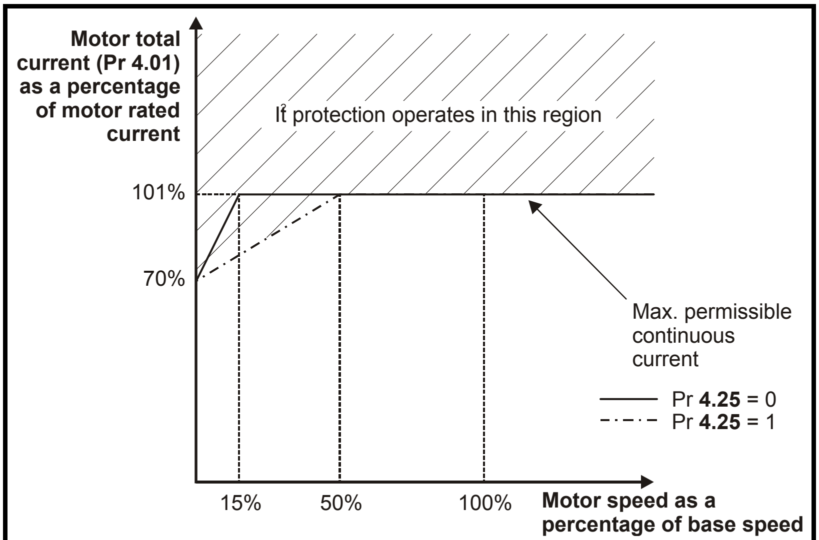


Open loop: Proportion of rated frequency Pr **5.06**.

Closed loop: Proportion of rated speed Pr **5.08**.

Rated current (Pr **5.07** or Pr **21.07**) ≤ maximum Heavy Duty rating.

If the rated current is above the maximum Heavy Duty rating then Pr **4.25** can also be used to select 2 alternative protection characteristics. Both characteristics 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. 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. (In Regen mode K = 1.01 over the whole operating frequency range).



Open loop: Proportion of rated frequency Pr **5.06**.

Closed loop: Proportion of rated speed Pr **5.08**.

Rated current (Pr **5.07** or Pr **21.07**) > maximum Heavy Duty rating.

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

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

T_{trip} = -(Pr **4.15**) x ln(1 - (K x Pr **5.07** / 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 / Overload)^2)

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

Pr **4.15** = -60 / ln(1 - (1.05 / 1.50)^2) = 89

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

The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the motor while the drive remains powered-up. Each time Pr **11.45** is changed to select a new motor, or the rated current defined by Pr **5.07** or Pr **21.07** (depending on the motor selected) is altered, the accumulator is reset to zero.

4.17	**Reactive current**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±DRIVE_CURRENT_MAX A								
Update rate	4ms write															

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

4.18	**Overriding current limit**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen								0 to TORQUE_PROD_CURRENT_MAX %							
Update rate	Background write															

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

4.19	**Overload accumulator**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen								0 to 100.0 %							
Update rate	Background write															

See Pr **4.16** on page 105.

4.20	**Percentage load**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo Regen								±USER_CURRENT_MAX %							
Update rate	Background write															

Open-loop, Closed-loop vector, Servo

This parameter displays the actual torque producing current (Pr **4.02**) as a percentage of rated active current. Positive values indicate motoring and negative values indicate regenerating.

Regen

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

4.22	**Inertia compensation enable**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo							0								
Update rate	Background read															

If this parameter is set to one, the drive calculates a torque reference from the motor and load inertia (Pr **3.18**) and the rate of change of speed reference. The torque reference is added to the speed controller output to provide inertia compensation. This can be used in speed or torque control applications to produce the torque required to accelerate or decelerate the load inertia.

4.23	**Current demand filter 2**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Closed-loop vector, Servo							0.0 to 25.0 ms								
Default	Closed-loop vector, Servo							0.0								
Update rate	Background read															

The current demand filter time constant is defined by this parameter if the speed gain select (Pr **3.16**) is one.

4.24	**User current maximum scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to TORQUE_PROD_CURRENT_MAX %								
Default	Open-loop, Closed-loop vector, Servo, Regen							165.0* 175.0*								
Update rate	Background read															

* These are the maximum default values. If the variable maximum of this parameter (TORQUE_PROD_CURRENT_MAX which is defined by MOTOR1_CURRENT_LIMIT_MAX or MOTOR2_CURRENT_LIMIT_MAX depending on which motor map is active) gives a lower value with the default value of Motor rated current (Pr **5.07** or Pr **21.07**) default of this parameter is at the lower value.

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

4.25	**Low speed thermal protection mode**															
Drive modes	Open-loop, Closed-loop, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop, Servo							0								
Update rate	Background read															

See Pr **4.16** on page 105.

4.26	**Percentage torque**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Default	Open-loop							±USER_CURRENT_MAX %								
Update rate	Background read															

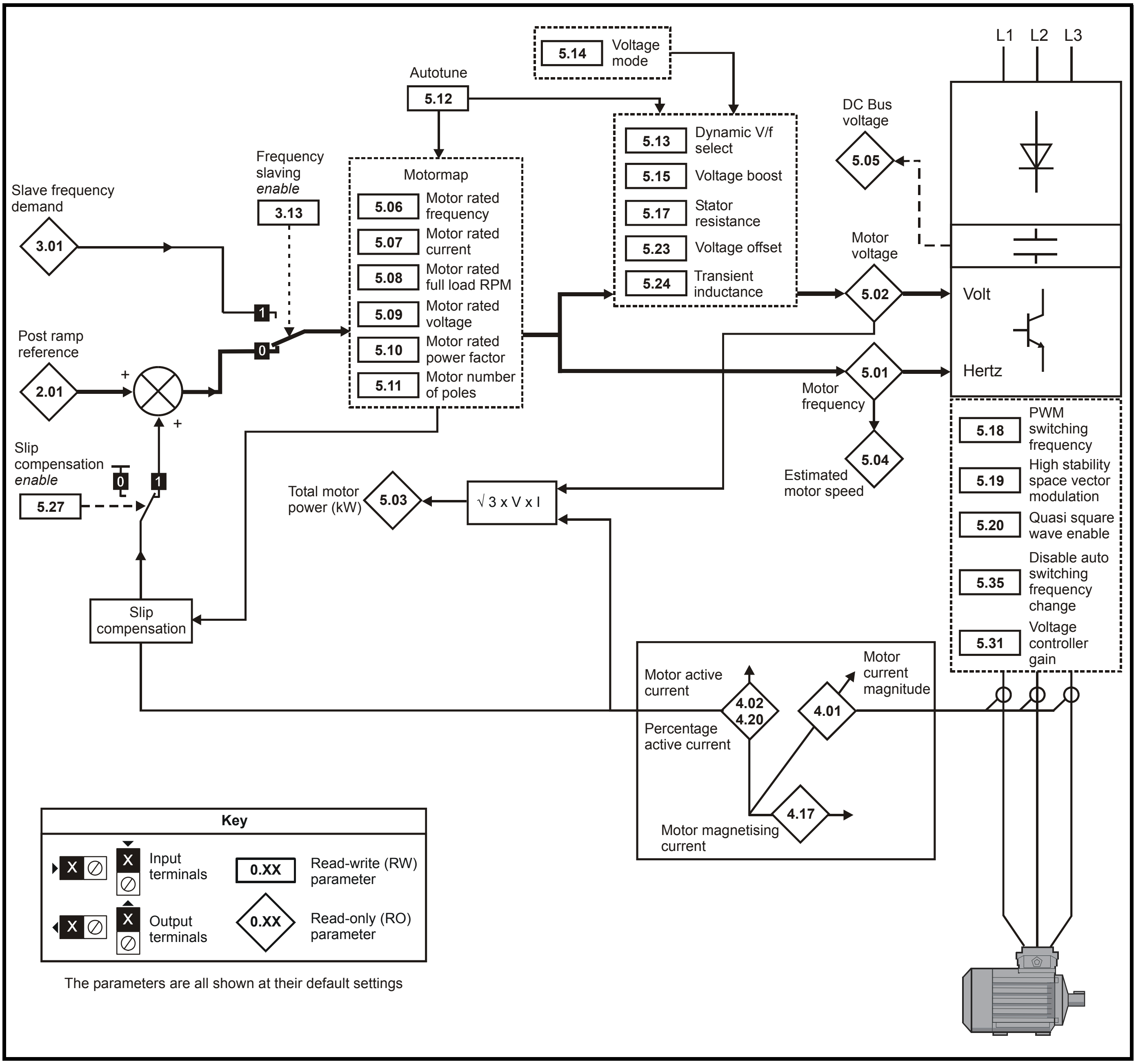
Pr **4.26** shows the torque producing current (Pr **4.02**) as a percentage of the active torque producing current, but with an additional adjustment above base speed so that this parameter shows percentage torque. Below base speed Pr **4.26** is equal to Pr **4.20**. Above base speed the percentage torque producing current (shown in Pr **4.20**) is adjusted as follows:

Pr **4.26** = Pr **4.20** x rated frequency / frequency

5.7 Menu 5: Motor control

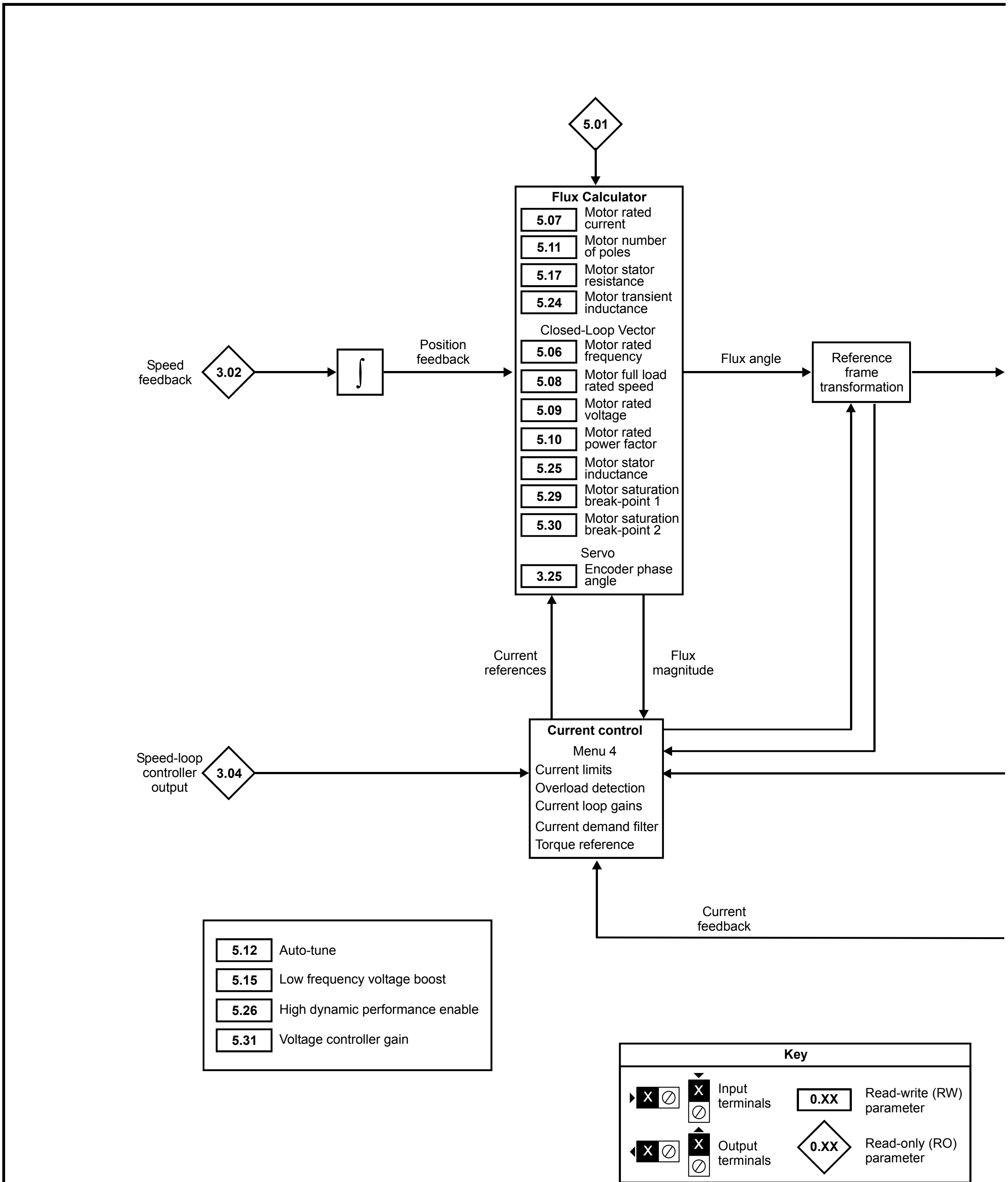
Open loop

Figure 5-10 Menu 5 Open-loop logic diagram

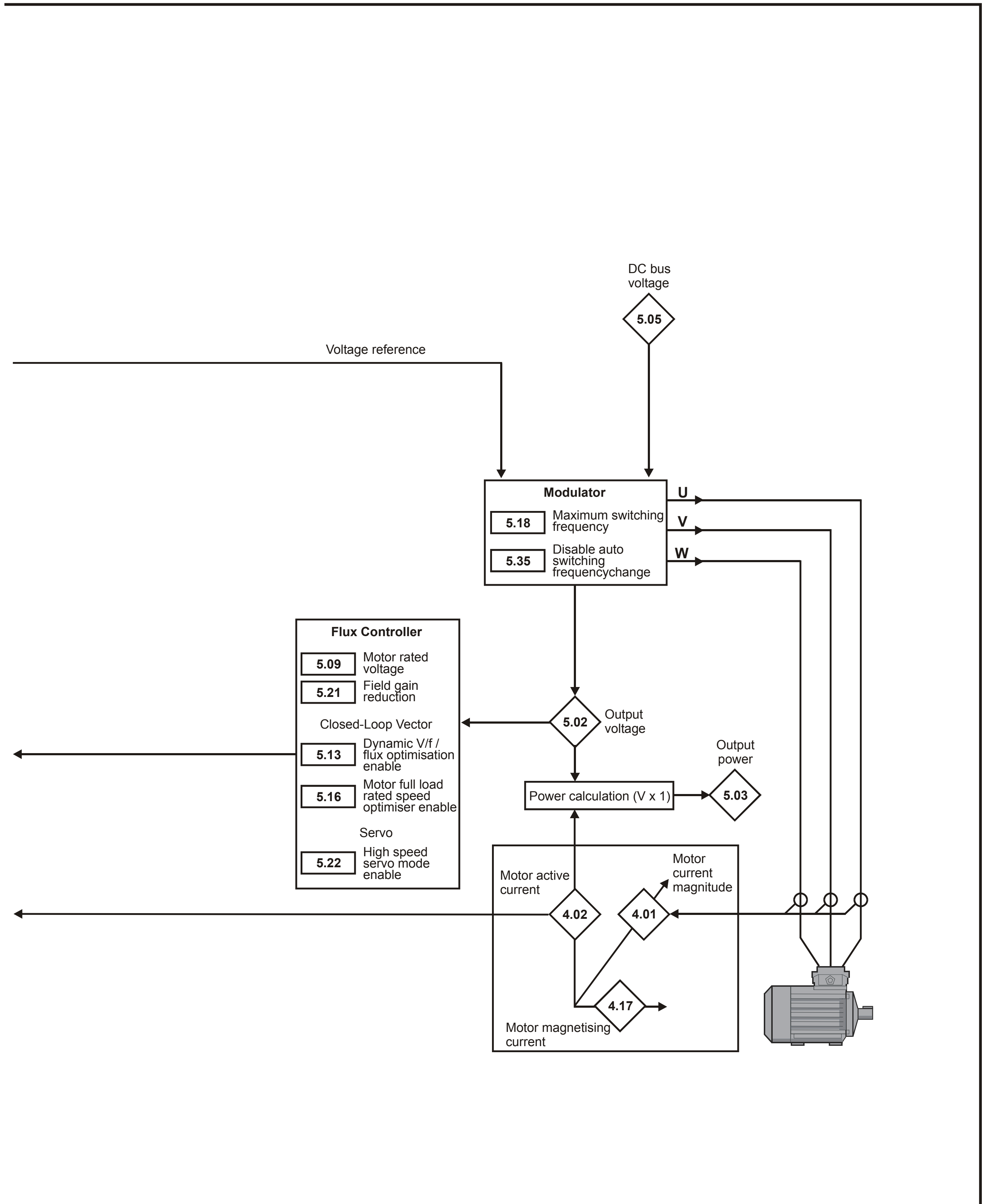


Closed-loop vector and Servo

Figure 5-11 Menu 5 Closed-loop logic diagram

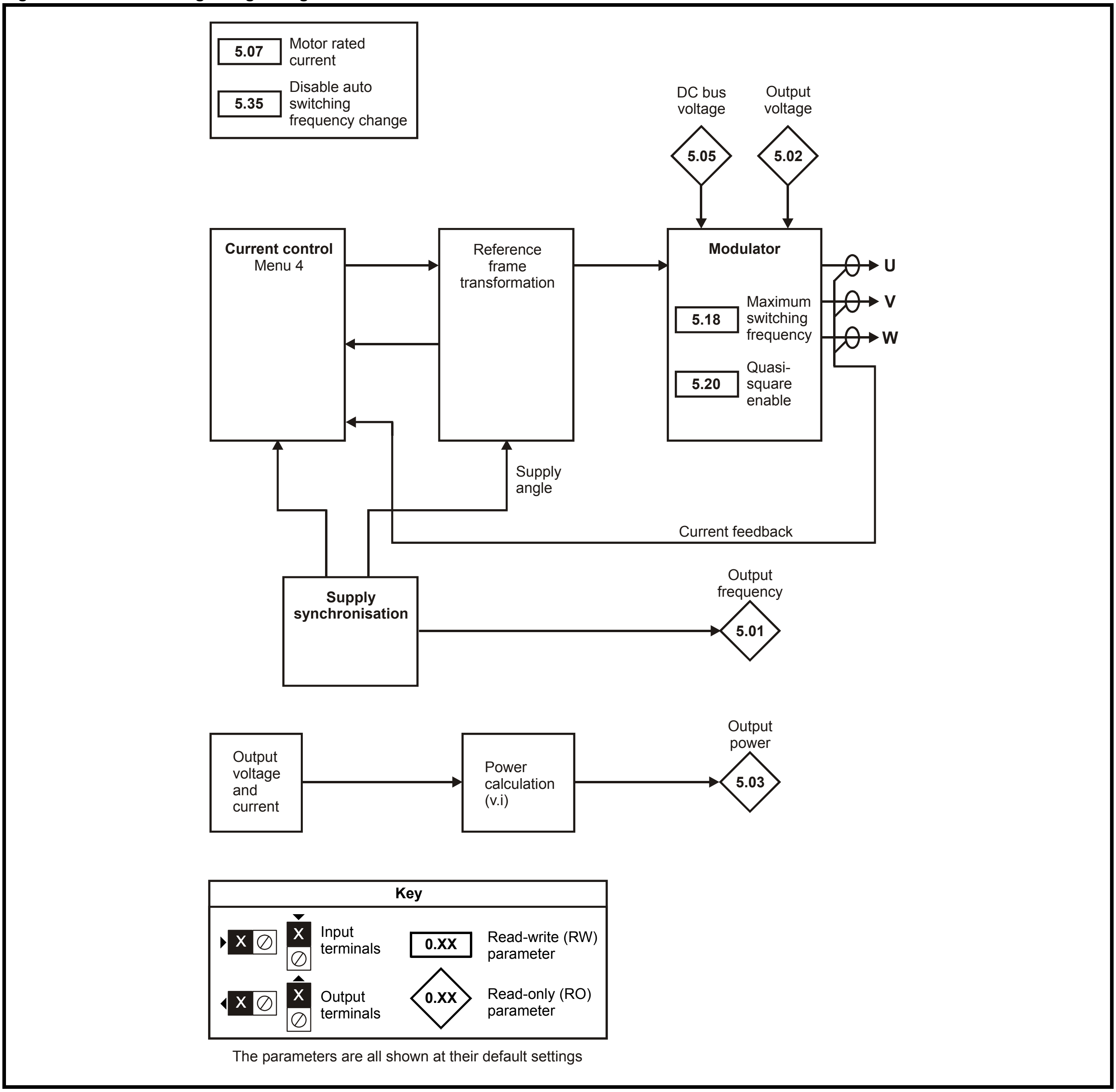


The parameters are all shown at their default settings


DC bus voltage
5.05
Voltage reference
Modulator
5.18
Maximum switching frequency
5.35
Disable auto switching frequencychange
U
V
W
Flux Controller
5.09
Motor rated voltage
5.21
Field gain reduction
Closed-Loop Vector
5.13
Dynamic V/f / flux optimisation enable
5.16
Motor full load rated speed optimiser enable
Servo
5.22
High speed servo mode enable
5.02
Output voltage
Output power
Power calculation (V x 1)
5.03
Motor active current
Motor current magnitude
4.02
4.01
4.17
Motor magnetising current

Regen

Figure 5-12 Menu 5 Regen logic diagram



5.01	**Output frequency**															
Drive modes	Open-loop, Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
	RFC: VM = 0															
Range	Open-loop RFC							±SPEED_FREQ_MAX Hz ±1250.0 Hz								
Update rate	250µs write															

Open-loop

Although the range for scaling purposes is ±SPEED_FREQ_MAX, the actual parameter value can be increased beyond this range by slip compensation. This parameter gives the output frequency of the drive, i.e. the sum of the post ramp reference and the slip compensation.

Closed-loop vector and Servo

In these modes the output frequency is not controlled directly, and so the output frequency displayed in this parameter is calculated by measuring the frequency of the controller reference frame.

Regen

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

5.02	**Output voltage**															
Drive modes	Open-loop, Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1		1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to AC_VOLTAGE_MAX V								
Update rate	Background write															

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

5.03	**Output power**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±POWER_MAX kW								
Update rate	Background write															

Open-loop, Closed-loop vector and Servo modes

The output power is the dot product of the output voltage and current vectors. Positive power indicates power flowing from the drive to the motor (motoring) and negative power indicates power flowing from the motor to the drive (regen).

Regen mode

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

5.04	**Motor rpm**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1				
Range	Open-loop							±180,000 rpm								
Update rate	Background write															

The motor rpm is calculated from the post ramp reference (Pr **2.01**) for normal operation, or the slave frequency demand (Pr **3.01**) if frequency slaving is being used. The speed of rotation is calculated as follows:

rpm = 60 x frequency / no. of pole pairs

This calculation relies on the number of motor poles being set up correctly in Pr **5.11**, or if auto mode is selected (Pr **5.11** = 0) then it relies on a reasonably accurate value of motor rated speed being set in Pr **5.08** to allow correct calculation of the motor poles. If frequency slaving is being used there will be an error due to the slip frequency. However, in normal operation the result will be reasonably accurate provided that the slip compensation has been set up correctly in the rated full load rpm parameter (Pr **5.08**).

5.05	**DC bus voltage**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to +DC_VOLTAGE_MAX V
Update rate	Background write	

Coding

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

Voltage across the internal DC bus of the drive.

5.06	**Rated frequency**	
Drive modes	Open-loop, Closed-loop vector	
Range	Open-loop Closed-loop vector	0 to 3000.0 Hz 0 to 1250.0 Hz
Default	Open-loop, Closed-loop vector	EUR: 50.0 Hz, USA: 60.0 Hz
Second motor parameter	Open-loop, Closed-loop vector	Pr **21.06**
Update rate	Background read	

Coding

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

Open loop

The motor rated frequency and the motor rated voltage (Pr **5.09**) are used to define the voltage to frequency characteristic applied to the motor (see Pr **5.09** on page 115). The motor rated frequency is also used in conjunction with the motor full load rpm to calculate the rated slip for slip compensation (see Pr **5.08** on page 115).

Closed loop vector

The motor rated frequency is used in conjunction with the motor full load rpm to calculate the rated slip of the machine for the vector control algorithm (see Pr **5.08** on page 115). The test frequency used for the rotating auto-tune test is $^2/_3$ x Pr **5.06**.

5.07	**Motor rated current (Regen mode: Regen unit rated current)**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop, Servo, Regen	0 to RATED_CURRENT_MAX A
Default	Open-loop, Closed-loop vector, Servo, Regen	Maximum heavy duty current (i.e. the value of Pr **11.32**)
Second motor parameter	Open-loop, Closed-loop vector, Servo, Regen	Pr **21.07**
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1	2		1				1	1	1	

The rated current should be set at the motor nameplate value for rated current. The value of this parameter is used as follows:

Open-loop	Current limits Motor thermal protection Vector mode voltage control Slip compensation Dynamic V to F control
Closed-loop vector	Current limits Motor thermal protection Vector control algorithm
Servo	Current limits Motor thermal protection
Regen	Thermal protection

5.08	**Rated load rpm / Rated speed**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
	Closed-loop vector and Servo DP=2															
Range	Open-loop, Closed-loop								0 to 180,000 rpm 0.00 to 40,000.00 rpm							
Default	Open-loop, Closed-loop vector Servo								EUR: 1,500, USA: 1,800 EUR: 1450.00, USA: 1,770.00 3,000.00							
Second motor parameter	Open-loop, Closed-loop vector, Servo								Pr **21.08**							
Update rate	Background read															

Open loop

The rated load rpm is used with the motor rated frequency and No. of poles to calculate the rated slip of induction machines in Hz.

rated slip (Hz) = rated motor frequency - (no. of pole pairs x motor full load rpm / 60)
= Pr **5.06** - ((Pr **5.11** / 2) x Pr **5.08** / 60)

If Pr **5.08** 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 droop as load is applied. 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 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 machine, 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 the drive rated speed optimization system may be used to automatically adjust this parameter (see Pr **5.16** on page 123). It should be noted that the optimization system does not operate when closed-loop vector mode is used with no position feedback (see Pr **3.24** on page 64).

Servo

The Rated load rpm defines the rated speed of the motor and is only used in the motor thermal protection scheme (see Pr **4.16** on page 105). and to determine the speed used in the auto tuning inertia test (see Pr **5.12** on page 117).

5.09	**Rated voltage**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Open-loop, Closed-loop, Servo								0 to AC_VOLTAGE_SET_MAX V							
Default	Open-loop, Closed-loop vector, Servo								200V rating drive: 230V 400V rating drive: EUR: 400V, USA: 480V 600V rating drive: 575V 690V rating drive: 690V							
Second motor parameter	Open-loop, Closed-loop vector, Servo								Pr **21.09**							
Update rate	Level 4 read															

Open loop

The rated voltage is used in conjunction with the motor rated frequency (Pr **5.06**) to define the voltage to frequency characteristic applied to the motor. The following operating methods selected by Pr **5.14** are used to define the drive frequency to voltage characteristic.

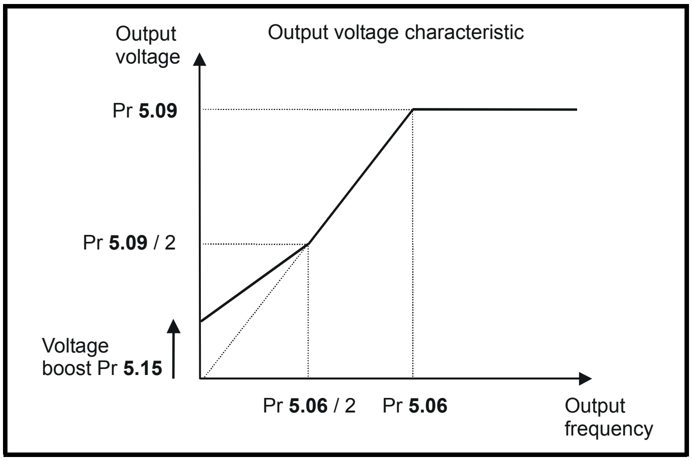
Open-loop vector mode: Ur_S, Ur or Ur_I

A linear characteristic is used from 0Hz to rated frequency, and then a constant voltage above rated frequency. When the drive operates between rated frequency/50 and rated frequency/4, full vector based stator resistance (Rs) compensation is applied. However there is a delay of 0.5s when the drive is enabled during which only partial vector based compensation is applied to allow the machine flux to build up.

When the drive operates between rated frequency/4 and rated frequency/2 the Rs compensation is gradually reduced to zero as the frequency increases. For the vector modes to operate correctly the stator resistance (Pr **5.17**), motor rated power factor (Pr **5.10**) and voltage offset (Pr **5.23**) are all required to be set up accurately.

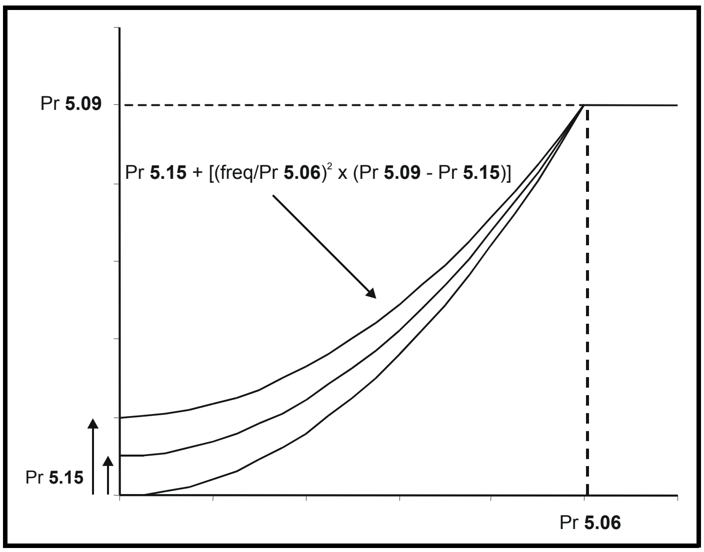
Fixed boost mode: Fd

A linear characteristic is used from 0Hz to rated frequency, and then constant voltage above rated frequency. Low frequency voltage boost as defined by Pr **5.15** is applied as shown below.



Square law mode: SrE

A square law characteristic is used from 0Hz to rated frequency, and then constant voltage above rated frequency. Low frequency voltage boost raises the start point of the square law characteristic as shown below.



Closed loop vector

The rated voltage is used by the field controller to limit the voltage applied to the motor. Normally this is set to the nameplate value. So that current control can be maintained it is necessary for the drive to leave some 'headroom' between the machine terminal voltage and the maximum available drive output voltage. The drive allows over-modulation of the PWM inverter which can produce a fundamental voltage that is higher than the drive input voltage, but would cause substantial odd harmonic distortion if used in steady state operation. Therefore the drive uses a headroom limit which allows the inverter to give a steady state output voltage equivalent to the input voltage minus voltage drops inside the drive. This gives enough headroom for the current controllers to operate satisfactorily. However, for good transient performance at high speed the rated voltage should be set below 95% of the minimum supply voltage to the drive.

The rated voltage is also used in conjunction with the motor rated frequency (Pr **5.06**) during the rotating auto-tune test (see Pr **5.12** on page 117) and in the calculations required for automatic optimization of the rated motor slip. It is important, therefore that the correct rated voltage for the motor is used. In some applications it may be necessary to restrict the voltage applied to the motor to a level lower than the nameplate rated voltage of the motor. In this case the rated frequency (Pr **5.06**) must be adjusted to maintain the ratio of rated voltage and frequency given on the motor nameplate. The rated frequency will then be different to the nameplate value, and so the rated speed must be changed from the nameplate value to give the correct rated slip.

Servo

The rated voltage is used by the field controller to limit the voltage applied to the motor if high speed operation is required. As in closed-loop vector mode some headroom must be left for the current controllers to operate, and so the drive will use the voltage level set by this parameter or the headroom limit whichever is the lower.

5.10	Rated power factor	
Drive modes	Open-loop, Closed-loop vector	
Range	Open-loop, Closed-loop	0.000 to 1.000
Default	Open-loop, Closed-loop vector	0.850
Second motor parameter	Open-loop, Closed-loop vector	Pr **21.10**
Update rate	Background read	

Coding:

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						3		1				1	1	1	

Open loop

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 **5.07**) 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.

Closed loop vector

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 and other motor parameters to calculate the rated active and magnetising currents 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

5.11	Number of motor poles	
Drive modes	Open-loop, Closed-loop vector, Servo	
Range	Open-loop, Closed-loop vector, Servo	0 to 60 (Auto to 120 POLE)
Default	Open-loop, Closed-loop vector Servo	0 (Auto) 3 (6 POLE)
Second motor parameter	Open-loop, Closed-loop vector, Servo	Pr **21.11**
Update rate	Background read	

Coding:

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

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 **5.06**) and the rated load rpm (Pr **5.08**). The number of poles = 120 * rated frequency / 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 **5.06**) and the rated load rpm (Pr **5.08**). The number of poles = 120 * rated frequency / 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.

5.12	Autotune	
Drive modes	Open-loop, Closed-loop vector, Servo	
Range	Open-loop, Closed-loop vector, Servo	0 to 2 0 to 4 0 to 6
Default	Open-loop, Closed-loop vector, Servo	0
Update rate	Background read	

Coding:

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

If this parameter is set to a non-zero value, the drive is enabled and a run command is applied in either direction the drive performs an auto-tune test for the drive modes listed below. All tests that rotate the motor are carried out in the forward direction if Pr **1.12** = 0 or the reverse direction if Pr **1.12** = 1. For example, if the test is initiated by applying run reverse (Pr **6.32** = 1) the test is performed in the reverse direction. It should be noted however that the motor may jump in either direction by up to half an electrical revolution at the start of the phasing test and then move in the required direction for the remainder of the test. The test will not start unless the drive is disabled before the test is initiated by applying the enable or run, i.e. it will not start if the drive is in the stop state. In closed-loop modes it is not possible to go into the stop state if Pr **5.12** has a non-zero value.

(If Pr **5.12** is set to 4 in closed-loop vector mode or 6 in servo mode then no test is carried out, but the current loop gains are re-calculated. For these actions the drive does not need to be enabled).

It is important that the motor is at standstill before the auto-tune test is performed if the correct results are to be obtained. The parameters modified by the auto-tune tests are defined below when the second motor parameters are not selected (i.e. Pr **11.45** = 0). If the second motor is selected for the duration of the tests (i.e. Pr **11.45** = 1), the second motor parameters in menu 21 are modified instead and not the parameters described below. When the test is completed successfully the drive is disabled and will enter the inhibit state. The motor can only be restarted if the enable is removed either from the enable input, or Pr **6.15** is set to zero or from the control word (Pr **6.42**). As the tests progresses the calculated parameters are saved to EEPROM as indicated. If for any reason the test fails, and the drive trips, no further parameters are calculated or stored in EEPROM. (If the drive is in Auto or Boot copying modes (Pr **11.42** = 3 or 4) the parameters are also saved to the SMARTCARD where it is indicated that parameters are saved to EEPROM).

Open-loop

In this mode the following parameters are used in the vector control algorithm.

	Parameter	Basic algorithm	Slip compensation
Rated frequency	Pr **5.06**	✓	✓
Rated current	Pr **5.07**	✓	✓
Rated load rpm	Pr **5.08**		✓
Rated voltage	Pr **5.09**	✓	
Power factor	Pr **5.10**	✓	
No. of poles	Pr **5.11**		✓
Stator resistance (R_s)	Pr **5.17**	✓	
Transient inductance (σL_s)	Pr **5.24**		

All these parameters can be set by the user. The auto-tune test can be used to overwrite the user or default settings as described below. Accurate values of stator resistance and voltage offset are required even for moderate performance in vector mode (an accurate value of power factor is less critical).

1: Stationary test

- A stationary test is performed to measure the stator resistance (Pr **5.17**) and voltage offset (Pr **5.23**). The power factor (Pr **5.10**) is not affected.
- Pr **5.17** and Pr **5.23** are saved to EEPROM.

2: Rotating test

- The stationary test is performed and the parameters saved to EEPROM as described above.
- A stationary test is performed to measure the transient inductance (Pr **5.24**). The transient inductance is not used directly by the drive, but is an intermediate value in determining the power factor after the rotating test.
- Pr **5.24** is saved to EEPROM.
- A rotating test is performed in which the motor is accelerated with the currently selected ramps to $^2/_3$ of rated speed and held at this speed for several seconds. Once the test is complete the power factor (Pr **5.10**) is updated and the motor coasts to a stop. The motor should be unloaded for this test to produce correct results.
- Pr **5.10** is saved to EEPROM.

Closed-loop vector

In this mode the following parameters are used in the vector control algorithm.

	Parameter	If L_s is zero	If L_s is not zero	Required for good performance	Required for excellent performance
Rated frequency	Pr **5.06**	✓	✓	✓	✓
Rated current	Pr **5.07**	✓	✓	✓	✓
Rated load rpm	Pr **5.08**	✓	✓	✓	✓
Rated Voltage	Pr **5.09**	✓	✓	✓	✓
Power factor	Pr **5.10**	✓		✓	
No. of poles	Pr **5.11**	✓	✓	✓	✓
Stator resistance (R_s)	Pr **5.17**	✓	✓	✓	✓
Transient inductance (σL_s)	Pr **5.24**	✓	✓	✓	✓
Stator inductance (L_s)	Pr **5.25**		✓		✓
Motor saturation breakpoint 1	Pr **5.29**	✓	✓		✓
Motor saturation breakpoint 2	Pr **5.30**	✓	✓		✓

All these parameters can be set by the user. The motor set-up is constantly recalculated in the background task, therefore modifying these parameters even after auto-tune will affect the performance of the drive. The auto-tune test can be used to overwrite the user or default settings as described below. It should be noted that the current loop gains (Pr **4.13** and **4.14**) are not updated as part of any test if either the stator resistance or the transient inductance for the active motor map are zero.

1. **Stationary test**

- A stationary test is performed to measure the stator resistance (Pr **5.17**)
- Pr **5.17** is saved to EEPROM.
- A stationary test is performed to measure the transient inductance (Pr **5.24**). When this test is complete the current loop gains (Pr **4.13** and Pr **4.14**) are over-written with the correct values based on the calculations given in Menu 4. A moderately accurate value of φ_1 as described in menu 4 can be obtained from the measured stator resistance and transient inductance to set the correct current limits and flux level in the motor.
- Pr **4.13**, Pr **4.14** and Pr **5.24** are saved to EEPROM.

2. Rotating test

- The stationary tests are performed and the parameters saved to EEPROM as described above.
- A rotating test is performed in which the motor is accelerated using the ramp rate defined by Pr **2.11** (or Pr **21.04** if motor 2 is selected) to $^2/_3$ of rated frequency and held at this frequency for up to 36 seconds. During the rotating test the stator inductance (Pr **5.25**), and the motor saturation breakpoints (Pr **5.29** and Pr **5.30**) are calculated. The power factor is also modified for user information only, and is not used after this point because the stator inductance will have a non-zero value. When the test is complete the motor coasts to a stop. The motor should be unloaded for this test to produce correct results.
- Pr **5.25**, Pr **5.29** and Pr **5.30** are saved to EEPROM.

3. **Inertia measurement**

- The drive attempts to accelerate the motor in the forward direction up to $^3/_4$ x rated load rpm and then back to standstill. Several attempts may be made, starting with rated torque/16, and then increasing the torque progressively to x$^1/_8$, x$^1/_4$, x$^1/_2$ and x1 rated torque if the motor cannot be accelerated to the required speed. 5s acceleration time is allowed during the first four attempts and 60s on the final attempt. 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 written to Pr **3.18**. (If closed-loop vector control without position feedback is used the first attempt is made with x$^1/_4$ because the torque control at very low speeds is not as accurate as when position feedback is used. Using a higher level of torque ensures that the motor starts).
- Pr **3.18** is saved to EEPROM.

The calculated value of inertia is dependant on the value of the motor torque per amp parameter (Pr **5.32**) which is calculated by the drive using an efficiency of 0.9. Therefore the inertia may be inaccurate if the motor efficiency is substantially different from 0.9. However, if the inertia is used for automatic speed loop gain set up the calculated gains will not be affected because Kt is also used in these calculations and any inaccuracy cancels out.

The test algorithm attempts to remove the effect of any load on the motor other than the torque required to accelerate and decelerate the motor, i.e. friction and windage losses, static torque load etc. Provided the average torque during acceleration and the average torque during deceleration are the same the effect of the additional torque is removed and the inertia value is calculated correctly.

4. Current controller gain calculation only

- No current is applied to the motor.
- The current loop gains are calculated based on the value of the motor inductance (Pr **5.24**) and resistance (Pr **5.17**) and written to Pr **4.13** and Pr **4.14**.
- Pr **4.13** and Pr **4.14** are saved to EEPROM.

This is intended to be used as a method of setting up the current loop gains from user defined values of motor inductance and resistance. The drive should not be enabled to perform these calculations. If the parameter is set to 4 it is automatically cleared by the drive once the calculation is complete. It should be noted that the value changes back to zero within a few hundred milliseconds of being set to 4 by the user.

Servo

In this mode the following parameters are used in the vector control algorithm.

	Parameter	Required for good performance	Required for excellent performance
Encoder phase angle	Pr **3.25**	✓	✓
No. of poles	Pr **5.11**	✓	✓
Transient inductance (σL_S)	Pr **5.24**		✓
Stator resistance (Rs)	Pr **5.17**		✓

All these parameters can be set by the user. The motor set-up is constantly recalculated in the background task, therefore modifying these parameters even after auto-tune will affect the performance of the drive. The auto-tune test can be used to overwrite the user or default settings as described below. It should be noted that the current loop gains (Pr **4.13** and Pr **4.14**) are not updated as part of any test if either the stator resistance or the transient inductance for the active motor map are zero.

1: Short low speed test

- The motor is rotated by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the forward direction. The drive applies rated current to the motor during the test and measures the encoder phase angle (Pr **3.25**) only. 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.
- Pr **3.25** is saved to EEPROM.

2. Normal low speed test

- The motor is rotated by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the forward direction. The drive applies rated current to the motor during the test and measures the encoder phase angle (Pr **3.25**). 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.
- Pr **3.25** is saved to EEPROM.
- A stationary test is performed to measure the motor resistance (Pr **5.17**).
- Pr **5.17** is saved to EEPROM.
- A stationary test is performed to measure the motor inductance (Pr **5.24**). When this test is complete the current loop gains (Pr **4.13** and Pr **4.14**) are over-written with the correct values based on the calculations given in Menu 4. It should be noted that the inductance measured is the inductance in the flux axis. For many motors this will be 20 to 30% less that the inductance in the other axis. The inductance for the other axis could be used to calculate the current controller proportional gain if required because there are no transient changes of current reference flux axis. Therefore the gain can be increased by the user if required. The inductance for the other axis should be used to obtain optimal cross coupling cancellation (see Pr **5.26** on page 128), and so the inductance parameter (Pr **5.24**) could also be increased by the user if required.
- Pr **4.13**, Pr **4.14** and Pr **5.24** are saved to EEPROM.

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 **5.07** or Pr **21.07**). 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.

Either the short or normal low speed tests could be used with a servo motor that does not have an absolute encoder (i.e. incremental without UVW commutation signals, SINCOS without comms etc). to control a servo motor. A phasing test would need to be performed after each power-up, or loss of encoder power supply if the motor rotates while the supply is not present before the motor could be controlled by the drive. If this method of control is used the drive cannot do any error checking to ensure that the absolute position has not been lost due to unwanted encoder counts due to noise.

Either the short or the normal low speed tests can be used with a servo type encoder (Ab.Servo, Fd.Servo or Fr.Servo) that has only commutation signals, i.e. the lines per revolution has been set to zero. When these tests are performed with this type of encoder the motor will continue to move in the same direction after the first two electrical revolutions. It will then stop for either 0.8s (short test) or 4s (normal test) and then continue to move again for part of an electrical revolution.

3: Inertia measurement

See inertia test for closed-loop vector mode. The calculated inertia depends on the value of motor torque per amp entered in Pr **5.32**. If this parameter is incorrect the inertia value will be incorrect. However, as explained in the inertia test description for closed-loop vector mode, this will not affect the accuracy of automatic speed loop gain set up.

4. Stationary test to set up current controller gains only

- A stationary test is performed to measure the motor resistance (Pr **5.17**).
- Pr **5.17** is saved to EEPROM.
- A stationary test is performed to measure the motor inductance (Pr **5.24**). When this test is complete the current loop gains (Pr **4.13** and Pr **4.14**) are overwritten with the correct values based on the calculations given in Menu 4.
- Pr **4.13**, Pr **4.14** and Pr **5.24** are saved to EEPROM.

This test can only be used with a motor when the correct phasing angle has been set in Pr **3.25**, because rated current is applied in the flux axis during the resistance measurement. If the phasing angle is not correct the motor may move and the results may be incorrect.

5. Minimal movement phasing test

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 rated current defined by Pr **5.07**) until the movement is approximately at the level defined by Pr **5.38** electrical degrees.. The resulting movements are used to estimate the phase angle. The test is carried out as follows:

- Current pulses are applied to determine the phasing angle
- An additional test is performed to ensure that the phasing angle is correct. If the test fails there is a delay and then test recommences. This is repeated twice after which a tunE2 trip is initiated. The delay before recommencing the test is 200ms and then 400ms. These delays allow the motor to stop moving if the test has initiated movement due to cogging torque.
- A test is performed to ensure that the feedback device direction is correct
- Pr **3.25** (phasing angle) is updated and saved to EEPROM.

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. The test can only be used where the total inertia is less than 0.715 x T_{rated} / Pr **5.38** kgm^2, assuming no additional stictional load, where Trated is the torque produced by rated current as defined by Pr **5.07** or Pr **21.07**. In most cases the motor only moves by the required angle, however, it is possible for the test to initiate additional movement due to cogging torque. The amount of movement depends on the design of the motor and is similar to the movement produced by cogging torque when the drive is disabled. If the motor is moving at a speed that is higher than the zero speed threshold (Pr **3.05**) when the test is initiated a tunE3 trip is initiated.

This test can be used with any type of encoder except a commutation only encoder i.e. Ab.Servo, Fd.Servo or Fr.Servo encoders with the lines per rev set to zero. However, it is also not recommended with Ab.Servo, Fd.Servo or Fr.Servo encoders because the absolute position is not defined until two valid changes of the commutation signals have occurred after power-up or an encoder trip. Therefore if the test is carried out before two valid changes have occurred, the movement produced during the test may be quite large and the result may be slightly inaccurate. Once two valid changes have occurred the test operates in the same way as for other encoder types.

The current controllers are used to perform this test, however, the default gains may be too high. It is not possible to carry out the necessary test to set up the current controllers before the phasing angle is known. If the gains are too high the minimal movement phasing test may cause an OI.AC trip. If this happens the current controller gains should be reduced progressively until the test is successful. Once the phasing angle is known, the stationary test to set up the current controller gains only (Pr **5.12** = 4) may be used to obtain the correct gain values for the current controllers.

6. Current controller gain calculation only

- No current is applied to the motor.
- The current loop gains are calculated based on the value of the motor inductance (Pr **5.24**) and resistance (Pr **5.17**) and written to Pr **4.13** and Pr **4.14**.
- Pr **4.13** and Pr **4.14** are saved to EEPROM.

This is intended to be used as a method of setting up the current loop gains from user defined values of motor inductance and resistance. The drive should not be enabled to perform these calculations. If the parameter is set to 6 it is automatically cleared by the drive once the calculation is complete. It should be noted that the value changes back to zero within a few hundred milliseconds of being set to 6 by the user.

Open-loop, Closed-loop vector and Servo

The auto-tune tests may be aborted by removing the run command or the enable or if a trip occurs. During the auto-tune tests the following trips can occur in addition to the other drive trips.

Trip code	Reason	Test which can cause trip
tunE1	The position feedback did not change (i.e. motor did not turn or feedback failed)	Closed-loop vector 2 Servo 1,2,5
	The motor did not reach the required speed	Closed-loop vector 3 Servo 3
tunE2	Position feedback direction incorrect	Closed-loop vector 2 Servo 1,2
	The motor could not be stopped	Closed-loop vector 3 Servo 3
	Minimal movement phasing test failed	Servo 5
tunE3	Drive encoder commutation signals connected incorrectly, i.e. direction incorrect. (Drive encoder only).	Servo 1,2
	The motor was moving when the minimal movement phasing test was initiated	Servo 5
	The calculated inertia is out of range	Closed-loop vector 3 Servo 3
tunE4	Drive encoder U commutation signal fail (Drive encoder only).	Servo 1,2
tunE5	Drive encoder V commutation signal fail (Drive encoder only).	Servo 1,2
tunE6	Drive encoder W commutation signal fail (Drive encoder only).	Servo 1,2
tunE7	Motor poles or encoder lines set up incorrectly.A trip is initiated if the speed is not within ±6.25% of the expected no load speed just after the motor has ramped up to speed. This trip will not occur if the motor poles are set to more than 12.	Closed-loop vector 2 Servo 1,2
tunE	Auto-tune stopped before completion	All
rS*	Stator resistance too high	Open-loop 1, 2 Closed-loop vector 1 Servo 2

*The rS trip is produced if the drive cannot achieve the necessary current levels to measure the stator resistance during the test (i.e. there is no motor connected to the drive), or if the necessary current level can be achieved, but the calculated resistance exceeds the maximum values for the particular drive size or it exceeds the maximum of Pr **5.17**. The maximum measurable value for a particular drive size can be calculated from the following formula.

Rs_{max} = DC_VOLTAGE_MAX x 0.45 / (Kc x $\sqrt{}^{2}$)
where Kc is the current scaling factor for the drive

5.13	**Dynamic V to F / flux optimise select**														
Drive modes	Open-loop, Closed-loop vector														
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector							0								
Update rate	Background read															

Open-loop

Setting this bit enables dynamic V to f mode which is intended for applications where power loss should be kept to a minimum under low load conditions. The rated frequency used to derive the voltage to frequency characteristic of the drive is varied with load:

if |active current| < 0.7 x rated active current
motor rated frequency = Pr **5.06** x (2 - (active current / (0.7 x rated active current)))

else if |active current| ≥ 0.7 x rated active current
motor rated frequency = Pr **5.06**

Although the rated frequency varies the value shown as Pr **5.06** does not vary from that set by the user.

Closed-loop vector

At light load the losses in the motor can be reduced by reducing the motor flux. When flux optimization is selected the flux producing current in the motor is reduced under light load conditions so that it is equal to the torque producing current with a minimum limit of half the rated flux producing current. This optimizes the copper losses in the motor and reduces the iron losses.Flux optimization is disabled if closed-loop vector mode is used without position feedback (i.e. Pr **3.24** is set to 1 or 3).

5.14	**Voltage mode select**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop								0 to 5							
Default	Open-loop								4							
Update rate	Background read															

0: Ur_S, Stator resistance and voltage offset measured at each start

The stator resistance (Pr **5.17**) and the voltage offset (Pr **5.23**) are measured and the parameters over-written each time the drive is started. This test can only be done with a stationary machine where the flux has decayed to zero. Therefore this mode should only be used if the machine is guaranteed to be stationary each time the drive is enabled. 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 re-started. In this case, previously measured values are used. The new values of stator resistance and voltage offset are not automatically saved to EEPROM or the SMARTCARD.

1: Ur, No measurements

The stator resistance and voltage offset are not measured. The user can enter the motor and cabling resistance into the stator resistance parameter. However this will not include resistance effects within the drive inverter. Therefore if this mode is to be used, it is best to use the auto-tuning stationary test initially to measure the stator resistance.

2: Fd, Fixed boost mode.

Neither the stator resistance nor the voltage offset are used, instead a fixed characteristic with boost applied as defined by Pr **5.15** is used.

3: Ur_Auto, Stator resistance and voltage offset measured at first drive enable

The stator resistance and voltage offset are measured once, the first time the drive is enabled. After the test has been completed successfully the mode is changed to Ur mode. The stator resistance and voltage offset are written to the parameters for the currently selected motor map and these parameters along with this parameter are saved in the EEPROM (and the SMARTCARD if Pr **11.42** = 3 or 4). If the test fails the stator resistance and voltage offset are not updated, the mode is changed to Ur, but no parameters are saved.

4: Ur_I, Stator resistance and voltage offset measured at each power-up

The stator resistance and voltage offset are measured when the drive is first enabled and at each subsequent power-up. The new values of stator resistance and voltage offset are not automatically saved to EEPROM or the SMARTCARD.

5: SrE, Square law characteristic

Neither the stator resistance nor the voltage offset are used, instead a fixed square law characteristic with boost applied as defined by Pr **5.15** is used.

5.14	**Action on enable**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Servo								0 to 2							
Default	Servo								0							
Update rate	Background read															

This parameter defines the action taken on enable as follows:

0: nonE
No action.

1: Ph Enl
A minimal movement phasing test is performed each time the drive is enabled (i.e. changes from the inhibit state to either the stop or run state). The test can be used to determine the phasing angle for an absolute or non-absolute type encoder. If the test is completed successfully the drive changes to the stop or run state as appropriate. The phasing angle parameter is updated to the correct value, but it is not saved to EEPROM or the SMART card.

2: Ph Init
A minimal movement phasing test is performed the first time the drive is enabled after power-up. The test will only be performed again on enable if the position feedback device(s) have been re-initialized. Re-initialization occurs for example after a trip specifically related to an encoder where position information may have been lost. Initialization occurs when parameter 03.48 changes from zero to one. The phasing angle parameter is updated to the correct value, but it is not saved to EEPROM or the SMART card.

5.15	**Low frequency voltage boost**															
Drive modes	Open-loop, Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector								0.0 to 25.0 % of motor rated voltage							
Default	Open-loop, Closed-loop vector								See below							
Update rate	Background read															

The voltage boost is used in fixed boost mode and square law mode for Open-loop mode, and during the rotating auto-tune test in Closed-loop vector mode.In open-loop mode the default is dependant on the frame size as given in the table below.

Drive sizes	Default
SP0xxx,SP1xxx, SP2xxx, SP3xxx	3.0%
SP4xxx, SP5xxx	2.0%
SP6xxx to SP9xxx, SPMxxxxx	1.0%

5.16	**Rated rpm auto-tune**															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Closed-loop vector								0 to 2							
Default	Closed-loop vector								0							
Update rate	Background read															

The motor rated full load rpm parameter (Pr **5.08**) in conjunction with the motor rated frequency parameter (Pr **5.06**) 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 this parameter is set to 1 or 2 the drive can automatically sense if the value of slip defined by Pr **5.06** and Pr **5.08** has been set incorrectly or has varied with motor temperature. If the value is incorrect Pr **5.08** is automatically adjusted. Pr **5.08** is not saved at power-down, and so when the drive is powered-down and up again it will return to the last value saved by the user. 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 frequency is above rated frequency/8, and when the load on the motor load rises above $^{5}/_{8}$ rated load. Optimization is disabled again if the load falls below half 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** and Pr **5.30**) should be stored in the relevant parameters. Rated rpm auto-tune is not available if the drive is not using external position/speed feedback (RFC mode).

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.

The rated rpm optimizer is automatically disabled when closed-loop vector RFC mode is selected (Pr **3.24**=1 or 3).

5.17	Stator resistance															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0.000 to 65.000														
Default	Open-loop, Closed-loop vector, Servo	0.000														
Second motor parameter	Open-loop, Closed-loop vector, Servo	Pr **21.12**														
Update rate	Background read															

Pr **5.17** shows the stator resistance of the motor. The units vary with the drive size to ensure that the full range of likely resistances can be represented with suitable resolution. The table below shows the units. Therefore 1.000 in the parameter represents the resistance shown in the units column.

Drive size	Units
SP0xxx	10 Ohms
SP1xxx to SP5xxx	1 Ohm
SP6xxx toSP9xxx and SPMxxxxx	0.01 Ohms

NOTE

From software version 1.07.00 onwards the maximum value of this parameter increased from 30 to 65 ohms to allow use of the autotune with very small motors. rS trips will be seen with small motors with a higher resistance than 30 ohms per phase with earlier software versions.

5.18	Maximum switching frequency															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1				1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 5 (3, 4, 6, 8, 12, 16 kHz)*														
Default	Open-loop, Closed-loop vector, Regen Servo	0 (3 kHz) 2 (6 kHz)														
Update rate	Background read															

*The maximum switching frequency available is limited for some drive sizes as shown in the table below.

200V	kHz	400V	kHz	575V	kHz	690V	kHz
SP0201	16	SP0401	16	SP3501	8	SP4601	8
SP0202	16	SP0402	16	SP3502	8	SP4602	8
SP0203	16	SP0403	16	SP3503	8	SP4603	8
SP0204	16	SP0404	16	SP3504	8	SP4604	8
SP0205	16	SP0405	16	SP3505	8	SP4605	8
SP1201	16	SP1401	16	SP3506	8	SP4606	8
SP1202	16	SP1402	16	SP3507	8	SP5601	8
SP1203	16	SP1403	16			SP5602	8
SP1204	16	SP1404	16			SP6601	6
SP2201	16	SP1405	16			SP6602	6
SP2202	16	SP1406	16			SPMA1601	6
SP2203	16	SP2401	16			SPMA1602	6
SP3201	12	SP2402	16			SPMD1601	6
SP3202	12	SP2403	16			SPMD1602	6
SP4201	8	SP2404	16			SPMD1603	6
SP4202	8	SP3401	16			SPMD1604	6
SP4203	8	SP3402	16				
SP5201	8	SP3403	12				
SP5202	8	SP4401	8				
SPMD1201	6	SP4402	8				
SPMD1202	6	SP4403	8				
SPMD1203	6	SP5401	8				
SPMD1204	6	SP5402	8				
		SP6401	6				
		SP6402	6				
		SPMA1401	6				
		SPMA1402	6				
		SPMD1401	6				
		SPMD1402	6				
		SPMD1403	6				
		SPMD1404	6				

This parameter defines the required switching frequency. The drive may automatically reduce the actual switching frequency (without changing this parameter) if the power stage becomes too hot. The switching frequency can reduce from 12kHz to 6kHz to 3kHz, or 16kHz to 8kHz to 4kHz. An estimate of the IGBT junction temperature is made based on the heatsink temperature and an instantaneous temperature drop using the drive output current and switching frequency. The estimated IGBT junction temperature is displayed in Pr **7.34**. If the temperature exceeds 135°C the switching frequency is reduced if this is possible (i.e >4kHz) and this mode is enabled (see Pr **5.35** on page 131). Reducing the switching frequency reduces the drive losses and the junction temperature displayed in Pr **7.34** also reduces. If the load condition persists the junction temperature may continue to rise. If the temperature exceeds 145°C and the switching frequency cannot be reduced the drive will initiate an O.ht1 trip. Every 20ms the drive will attempt to restore the switching frequency if the higher switching frequency will not take the IGBT temperature above 135°C.

The following table gives the sampling rate for different sections of the control system for different switching frequencies.

	3, 6, 12kHz	4, 8, 16kHz	Open-loop	Closed-loop vector	Servo	Regen
Level 1	3 = 167µs 6 = 83µs 12 = 83µs	125µs	Peak limit	Current controllers		
Level 2	250µs		Current limit and ramps	Speed controller and ramps		Sequencing and Synchronization
Level 3	1ms		Voltage controller			
Level 4	4ms		Time critical user interface			
Background	N/A		Non-time critical user interface			

5.19	High stability space vector modulation															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop,							0								
Update rate	Background read															

Normally the drive will use space vector modulation to produce the IGBT control signals. High stability space vector modulation offers three advantages in an open loop drive, but the acoustic noise produced by the motor may increase slightly.

- It is possible for instability to occur around motor rated frequency/2 on light load. The drive uses dead-time compensation to reduce this effect, however, it is still possible that some machines will be unstable. To prevent this, high stability space vector modulation should be enabled by setting this parameter.
- As the output voltage approaches the maximum available from the drive pulse deletion occurs. This can cause unstable operation with a lightly or fully loaded machine. High stability space vector modulation will reduce this effect.
- High stability space vector modulation also gives a small reduction in drive heat loss.

5.20	Quasi-square enable															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop							0								
Update rate	Background read															

Open loop

The maximum modulation level of the drive is normally limited to unity giving an output voltage equivalent to the drive input voltage minus voltage drops within the drive. 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** 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. 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.

As the rated voltage parameter is increased for a given d.c. link voltage the modulation depth is also increased. Therefore if the rated voltage is set to a level higher than the supply voltage the point at which pulse dropping, over-modulation and quasi-square operation each begin may occur at a frequencies below the rated frequency.

5.21	Field gain reduction															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo							0								
Update rate	Background read															

A suitable field controller gain is automatically set by the drive from the motor parameters. However it is possible by setting this parameter to a 1 to reduce this gain by a factor of 2 if instability problems occur above base speed.

5.22	**Enable high speed servo mode**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Servo							0								
Update rate	Background read															

High speed servo mode is not enabled as default. 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 x 1000 / (Ke x √2)	400 / √2
400	800 x 1000 / (Ke x √2)	800 / √2
575	955 x 1000 / (Ke x √2)	955 / √2
690	1145 x 1000 / (Ke x √2)	1145 / √2

Ke 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 de-magnetize the motor. The motor manufacturer should always be consulted before using this mode.

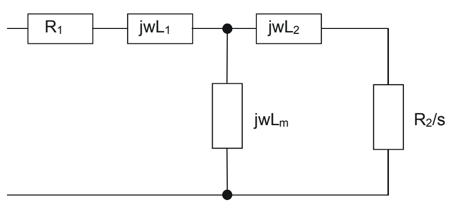
5.23	**Voltage offset**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1		1				1	1	1	
Range	Open-loop							0.0 to 25.0 V								
Default	Open-loop							0.0								
Second motor parameter	Open-loop							Pr **21.13**								
Update rate	Background read															

Due to various effects in the drive inverter a voltage offset must be produced before any current flows. To obtain good performance at low frequencies where the machine terminal voltage is small this offset must be taken into account. The value shown in Pr **5.23** is this offset given in line to line rms volts. It is not possible for the user to measure this voltage easily, and so the automatic measurement procedure should be used (see Pr **5.14** on page 122).

5.24	**Transient inductance (σL_s)**																
Drive modes	Open-loop, Closed-loop vector, Servo																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
							3		1				1	1	1		
Range	Open-loop, Closed-loop vector, Servo								0.000 to 500.000 mH								
Default	Open-loop, Closed-loop vector, Servo								0.000								
Second motor parameter	Open-loop, Closed-loop vector, Servo								Pr **21.14**								
Update rate	Background read																

Open-loop, Closed-loop vector
With reference to the diagram below, the transient inductance is defined as

$$\sigma \mathbf{L_s = L_1 + (L_2.L_m / (L_2 + L_m))}$$



Steady state per phase equivalent circuit
of an induction motor

Based on the parameters normally used for the motor equivalent circuit for transient analysis, i.e. $L_s = L_1 + L_m$, $L_r = L_2 + L_m$, the transient inductance is given by

$$\sigma \mathbf{L_s = L_s - (L_m^2 / L_r)}$$

The transient inductance is used as an intermediate variable to calculate the power factor in open-loop mode. It is used in the vector algorithm, for cross-coupling compensation and to set the current controller gains in closed-loop vector mode.

Servo
The transient inductance is the phase inductance for a servo motor. This is half the inductance measured from phase to phase. This value is used for cross-coupling compensation and to set the current controller gains.

5.25	**Stator inductance (L_s)**																
Drive modes	Closed-loop vector																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
							2		1				1	1	1		
Range	Closed-loop vector								0.00 to 5000.00 mH								
Default	Closed-loop vector								0.00								
Second motor parameter	Closed-loop vector								Pr **21.24**								
Update rate	Background read																

This parameter holds the stator inductance of the motor with rated flux. If the motor flux is reduced the value of stator inductance used by the vector control algorithm is modified using the motor saturation breakpoints (Pr **5.29** and Pr **5.30**). Stator inductance (L_s) = $L_1 + L_m$ from the steady state equivalent circuit. It should be noted that if this parameter is changed from a non-zero value to zero the power factor (Pr **5.10**) is automatically set to 0.850. The same applies to the motor map 2 stator inductance (Pr **21.24**) and motor map 2 power factor (Pr **21.10**).

5.26	**High dynamic performance enable**																
Drive modes	Closed-loop vector, Servo																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
	1												1	1			
Default	Closed-loop vector, Servo								0								
Update rate	Background read																

When this bit is set the drive provides a cross-coupling feed forward voltage as produced by the transient inductance and a frequency based voltage feed forward term. These voltages improve the transient performance of the current controllers

5.27	Enable slip compensation															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Open-loop								1							
Update rate	Background read															

The level of slip compensation is set by the rated frequency and rated speed parameters. Slip compensation is only enabled when this parameter is set to 1 and Pr **5.08** is set to a value other than zero or synchronous speed.

5.28	Field weakening compensation disable															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector								0							
Update rate	Background read															

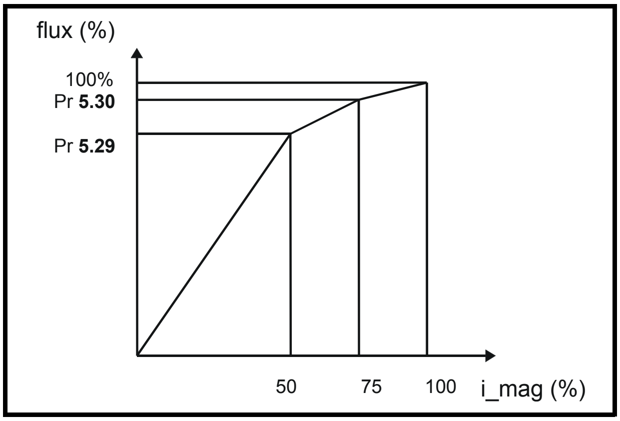
When the flux in the motor is reduced below its rated level the level of torque producing current required for a given amount of shaft torque is higher than the rated level. In speed control the compensation prevents gain reduction at higher speeds. In torque control the compensation maintains the torque at the correct level for a given torque demand. In some applications using speed control it may be desirable to have a reduction of gain as the motor flux is reduced to maintain stability. If this is required Pr **5.28** should be set to one. It should be noted that although field weakening is possible in servo mode, gain compensation is not applied in this mode.

5.29	Motor saturation breakpoint 1															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector								0 to 100 % of rated flux							
Default	Closed-loop vector								50							
Second motor parameter	Closed-loop vector								Pr **21.25**							
Update rate	Background read															

5.30	Motor saturation breakpoint 2															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector								0 to 100 % of rated flux							
Default	Closed-loop vector								75							
Second motor parameter	Closed-loop vector								Pr **21.26**							
Update rate	Background read															

The rated level of flux in most induction motors causes saturation. Therefore the flux against flux producing current characteristic is non-linear. The effects of saturation are to cause a step increase in torque when operating in torque mode as the speed increases into the field weakening region.

The drive can include the effects of saturation by representing the flux producing current to flux characteristic as a series of three lines as shown below:



If Pr **5.29** and Pr **5.30** have their default values of 50 and 75, the characteristic becomes one line and there will be a linear relationship between the drive estimate of flux and the flux producing current. If Pr **5.29** and Pr **5.30** are increased above 50 and 75 the drive estimate of flux can include the effect of saturation. It is unlikely that information will be available to set up these parameters, and so the values are determined during the rotating auto-tune test.

5.31	**Voltage controller gain**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 30								
Default	Open-loop, Closed-loop vector, Servo							1								
Update rate	Background read															

This parameter controls the gain of the voltage controller used for mains loss and standard ramp control. If the parameter is set to 1 the gain used is suitable for applications where the drive is used alone. Higher values are intended for applications where the DC bus of each drive is connected in parallel and the drive is used as a master for mains loss control. This is intended for use in applications where each drive is locked together using open-loop frequency slaving. (If motors are locked together using digital-locking, using a master for mains loss control, it is unlikely that the system will be stable during mains loss unless the power rating of the master is much higher than the combined rating of the slaves. This is due to the lag created by the master motor inertia).

5.32	**Motor torque per amp (Kt)**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
CLV							2	1							1	
SV							2						1	1	1	
Range	Closed-loop vector, Servo							0.00 to 500.00 NmA^{-1}								
Default	Servo							1.60								
Update rate	Background (1s) read															

This parameter shows the motor torque per amp of active (torque producing) current used to calculate the speed controller gains when the automatic set-up methods are active (i.e. Pr **3.17** = 1 or 2).

Closed-loop vector

The drive calculates the motor torque per amp of active current using the motor parameters as shown below assuming a motor efficiency of 90%.

$$\mathbf{Kt} = \frac{\mathbf{\sqrt{3} \text{ x Vrated x Irated x Rated power factor x Efficiency}}}{\mathbf{\text{Rated speed (rad } s^{-1}\text{) x Rated active current}}}$$

$$\mathbf{Kt} = \frac{\mathbf{\sqrt{3} \text{ x Pr 5.09 x Pr 5.07 x Pr 5.10 x 0.9}}}{\mathbf{(2\pi \text{ x Pr 5.08 / 60) x Rated active current}}}$$

Rated active current is the active current when the motor current is equal to the rated motor current and is defined at the start of the description of menu 4.

Servo

The motor torque per amp (Kt) must be entered in this parameter by the user for the automatic gain calculation system to operate correctly, and to allow the drive to calculate the correct inertia during an inertia auto-tune.

5.33	**Motor volts per 1000rpm (Ke)**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Servo							0 to 10,000								
Default	Servo							98								
Second motor parameter	Servo							Pr **21.30**								
Update rate	Background read															

This parameter is used to set up the current controller integral terms when the drive is disabled to prevent current transients when the drive is enabled with a spinning motor. It is also used to provide a voltage feed forward term if high dynamic performance is selected with Pr **5.26**.

5.35	**Disable auto-switching frequency change**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	Background read															

The drive thermal protection scheme (see Pr **5.18** on page 124) reduces the switching frequency automatically when necessary to prevent the drive from overheating. It is possible to disable this feature by setting this bit parameter to one. If the feature is disabled the drive trips immediately when the IGBT temperature is too high.

5.36	**Motor pole pitch**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 655.35mm								
Default	Open-loop, Closed-loop vector, Servo							0.00mm								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.31**								
Update rate	Background read															

This parameter should be set up to give the pole pitch of a linear motor, i.e. the movement of the motor for one cycle of the drive power output waveforms, if auto-configuration with a linear EnDat encoder is required.

5.37	**Actual switching frequency**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo								0 to 7							
Update rate	Background write															

Pr **5.37** shows the actual switching frequency used by the inverter. The maximum switching frequency is set with parameter Pr **5.18**, but this may be reduced by the drive if automatic switching frequency changes are allowed (Pr **5.35**=1). Pr **5.37** also indicates if the sample time for the current controllers have been reduced to allow for SINCOS encoders with lines per revolution that are not a power of two, or closed-loop vector mode operation without an encoder.

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

5.38	**Minimal movement phasing test angle**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Servo								0 to 25.5 degrees							
Default	Servo								5.0 degrees							
Update rate	Background read															

5.39	**Minimal movement phasing test pulse length**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Servo								0 to 3							
Default	Servo								0							
Update rate	Background read															

By applying short current pulses to the motor and using the resulting movement the drive can calculate the phasing angle (Pr **3.25** or Pr **21.20**). These begin at as short low level pulses, which are increased in magnitude and length until the required electrical movement define by Pr **5.38** is achieved. The actual movement may be larger because motor cogging may cause additional unwanted movement. The required movement should only be reduced if this is necessary as the results become less accurate with less movement. Care should be taken to ensure that the minimum movement is large enough so that the change of position given by the feedback device can be registered by the drive. For example a 4096 line incremental device on a 6 pole motor will give a change of position count of 75 for a 5°electrical movement. It is suggested that this test should not be used with a change of position count of less than 50. Although Pr **5.38** can be reduced to zero the lowest value used by the drive is 1.0 degrees.

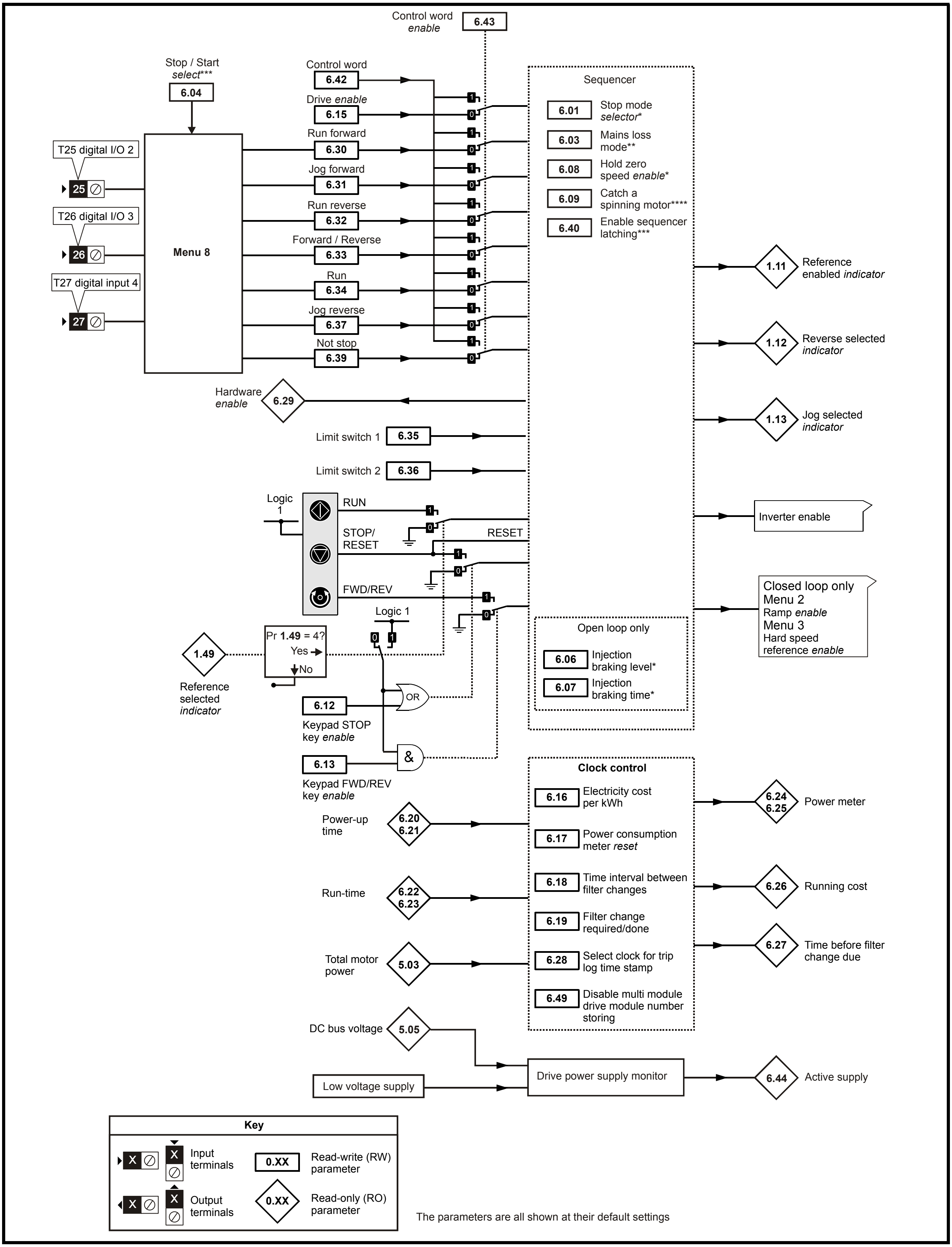
The necessary movement can be produced with a lower torque level if the test pulses are extended. If the pulses of torque are smaller then the acceleration is less, and so the noise and vibration produced by the test are less. The pulse length can be modified with Pr **5.39** (1 = pulse lengths x 2, 2 = x 3, and 3 = x 4). Longer pulses should only be used if noise and vibration are a problem and the motor has low friction and low cogging torque. As the torque level is reduced the measurement is likely to be affected by cogging and the results may not be accurate.

5.40	**Spin start boost**															
Drive modes	Open-loop, Closed-loop vector															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector							0.0 to 10.0								
Default	Open-loop, Closed-loop vector							1.0								
Update rate	Background read															

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 (RFC mode) (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.

5.8 Menu 6: Sequencer and clock

Figure 5-13 Menu 6 logic diagram



6.01	**Stop mode**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop Closed-loop vector, Servo								0 to 5 0 to 2							
Default	Open-loop, Closed-loop vector Servo								1 1 2							
Update rate	Background read															

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**.	No phase 2.	
5:Disable	Inverter disabled	No phase 2.	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 5 (Disable stopping mode) the disable stopping mode is used when the run command is removed and will allow the drive to be started immediately by reapplying the run command. However, if the drive is disabled by removing the drive enable (i.e. via the Safe Torque Off input or the drive enable (Pr **6.15**)) then the drive cannot be re-enabled for 1s.

Closed-loop vector and Servo

Only one stopping phase exists and the ready state is entered as soon as the single stopping action is complete. It should be noted that the stop condition is detected when the speed feedback is below the zero speed threshold (Pr **3.05**) for at least 16ms. If the speed is not stable it is possible that the stop condition is not detected. In this case the system should be made more stable or the zero speed threshold should be raised.

Stopping Mode	Action
0: Coast	Inhibits the inverter
1: Ramp	Stop with ramp
2: No ramp	Stop with no ramp

If coast stop is selected the inverter is inhibited immediately when the run command is removed. If however, hold zero speed is also selected (Pr **6.08** = 1), then the inverter will be re-enabled to hold zero speed. The result is that the inverter is disabled for one sample and then enabled to ramp the motor to a stop. Therefore is coast stop is required Pr **6.08** should be set to zero to disable hold zero speed.

If stop with ramp is selected the relevant ramp rate is used to stop the motor even if Pr **2.02** is set to zero to disable ramps.

The motor can be stopped with position orientation after stopping. This mode is selected with the position controller mode (Pr **13.10**). When this mode is selected Pr **6.01** has no effect.

6.03	**Mains loss mode**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to 2							
Default	Open-loop, Closed-loop vector, Servo								0							
Update rate	Background read															

0: dis
There is no mains 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 a UU trip occurs and this will reset itself if the voltage rises again above VuuRestart shown 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 mains 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. If the main is reapplied the drive restarts after it reaches the ready state provided the necessary controls are still active to initiate a start.

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 mains 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 at a very low level the drive may trip UU before the motor has stopped. If the mains is reapplied the drive restarts after it reaches the ready state provided the necessary controls are still active to initiate a start.

2: ride.th

The drive detects mains loss when the DC bus voltage falls below Vml_1. The drive then enters a mode where a closed-loop controller attempts to hold the DC bus level at Vml_2. This causes the motor to decelerate at a rate that increases as the speed falls. If the mains is re-applied it will force the DC bus voltage above the detection threshold Vml_3 and the drive will continue to operate normally. The output of the mains loss controller is a current demand that is fed into the current control system and therefore the gain parameters Pr **4.13** and Pr **4.14** must be set up for optimum control. See Pr **4.13** and Pr **4.14** on page 103 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	435
Vml_1	205*	410*	540*	540*
Vml_2	Vml_1 - 10V	Vml_1 - 20V	Vml_1 - 25V	Vml_1 - 25V
Vml_3	Vml_1 + 10	Vml_1 + 15	Vml_1 + 50	Vml_1 + 50
Vuu Restart	215	425	590	590

* Vml_1 is defined by Pr **6.48**. The values given in the table are the default values.

<table>
<tr><th>6.04</th><th colspan="16">Start/stop logic select</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>TE</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0 to 4</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">4</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

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. (Note any changes made to the destination parameters only become active after a drive reset).

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 in the *Unidrive SP User Guide* 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.

Pr 6.04	T25 (Pr 8.22)	T26 (Pr 8.23)	T27 (Pr 8.24)	Pr 6.40
0	Pr **6.29***	Pr **6.30** Run Forward	Pr **6.32** Run Reverse	0 (non latching)
1	Pr **6.39** Not stop	Pr **6.30** Run Forward	Pr **6.32** Run Reverse	1 (latching)
2	Pr **6.29***	Pr **6.34** Run	Pr **6.33** Fwd /Rev	0 (non latching)
3	Pr **6.39** Not stop	Pr **6.34** Run	Pr **6.33** Fwd/Rev	1 (latching)
4	User prog	User prog	User prog	User prog

* With software version V01.10.00 and later, Pr **6.29** can be used as a fast disable parameter. See Pr **6.29** on page 142 for more information.

Pr **6.29** reflects the state of the Safe Torque Off input and so it is not necessary to control this with a digital input, but the set up here is provided for older products. Routing a digital input can be used for fast disabling, see Pr **6.29** for more details.

6.06	Injection braking level															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1		1				1	1	1	
Range	Open-loop								0 to 150.0 %							
Default	Open-loop								100.0 %							
Update rate	Background read															

Defines the current level used during DC injection braking as a percentage of motor rated current as defined by Pr **5.07**.

6.07	Injection braking time															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 25.0 s							
Default	Open-loop								1.0							
Update rate	Background read															

Defines the time of injection braking during phase 1 with stopping modes 3 and 4 (see Pr **6.01** on page 135) for injection braking stop.

6.08	Hold zero speed															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector Servo								0 1							
Update rate	4ms read															

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.

NOTE

Pr **6.08** may be changed by the brake control in menu 12.

6.09	Catch a spinning motor															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop Closed-loop vector, Servo							3 1								
Default	Open-loop Closed-loop vector, Servo							0 1								
Update rate	Background read															

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 the run command is given when the drive is in the stop state, or when the drive is first enabled after power-up with Ur_I voltage mode, or when the run command is given with Ur_S voltage mode. With default parameters the length of the test is approximately 200ms, however, if the motor has a short rotor time constant (usually small motors) the time may be shorter. The drive will set the test time 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**, Pr **21.12**) is set up correctly. This applies even if fixed boost (Fd) or square law (SrE) voltage mode is being used. The test uses the rated magnetizing 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 may 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 parameter at one, the post ramp reference is set to the motor speed. When closed-loop vector mode is used without position feedback (RFC mode), 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 (RFC mode) 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.

6.12	Enable stop key															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

This parameter permanently enables the Stop key on the drive such that the drive will always stop when the Stop key is pressed. If keypad mode is selected this has no effect because the Stop key is automatically enabled.

The sequencer logic has been designed so that pressing the Stop key, whether the Stop key is enabled or not, does not make the drive change from a stopped to a running condition. As the Stop key is also used to reset trips this means that if the Stop key is pressed when the drive is tripped, the trip will be reset, but the drive does not start. (This does not apply to the UU trip which cannot be reset by the user, but is automatically reset when the d.c. link voltage is high enough). Preventing the drive from starting when the stop key is pressed is implemented as follows.

Sequencer latching not enabled (Pr 6.40=0)

If the Stop key is pressed when the Stop key is enabled (Pr **6.12**=1) or when the drive is tripped the sequencer run is removed, and so the drive stops or remains stopped respectively. The sequencer run can only then be reapplied after at least one of the following conditions occurs.

1. Run forward, Run reverse and Run sequencing bits all zero
2. OR the drive is disabled via Pr **6.15** or Pr **6.29**
3. OR Run forward and Run reverse are both active and have been for 60ms.
4. The drive is in the UU state.

The drive can then be restarted by activating the necessary bits to give a normal start.

Sequencer latching enabled (Pr 6.40=1)

If the Stop key is pressed when the stop key is enabled (Pr **6.12=**1) or when the drive is tripped the sequencer run is removed, and so the drive stops or remains stopped respectively. The sequencer run can only then be reapplied after at least one of the following conditions occurs.

1. Run forward, Run reverse and Run sequencing bits all zero after the latches
2. OR Not stop sequencing bit is zero
3. OR the drive is disabled via Pr **6.15** or Pr **6.29**
4. OR Run forward and Run reverse are both active and have been for 60ms.
5. The drive is in the UU state.

The drive can then be restarted by activating the necessary bits to give a normal start. Note that Run forward and Run reverse together will reset the stop key condition, but the latches associated with Run forward and Run reverse must then be reset before the drive can be restarted. It should be noted holding the Run key and pressing the Stop key to reset the drive without stopping does not apply unless keypad reference mode is selected.

6.13	**Enable forward/reverse key**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

This parameter enables the Fwd/Rev key on the drive in keypad mode.

6.15	**Drive enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Open-loop, Closed-loop vector, Servo, Regen							1								
Update rate	4ms read															

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

6.16	**Electricity cost per kWh**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to 600.0 currency units per kWh								
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	Background read															

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

6.17	**Reset energy meter**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	Background read															

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

6.18	**Time between filter changes**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1			1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 30,000 hrs														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

6.19	**Filter change required / change done**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1		1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read/write															

To enable the feature that indicates to the user when a filter change is due Pr **6.18** should be set to the time between filter changes. When the drive is running, Pr **6.27** is reduced each time the runtime timer hour increments (Pr **6.23**) until Pr **6.27** reaches 0, at which point Pr **6.19** is set to 1 to inform the user that a filter change is required. When the user has changed the filter, resetting Pr **6.19** to 0 will indicate to the drive that the change has been done and Pr **6.27** will be reloaded with the value of Pr **6.18**. Pr **6.27** can be updated with the value of Pr **6.18** at any time by setting and clearing this parameter manually. If Pr **6.18** = 0, then Pr **6.27** is held at zero and so parameters should be saved after Pr **6.18** has been setup so that this system will function correctly after the drive is powered down and powered up again.

6.20	**Powered-up time: years.days**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1		1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 9.364 Years.Days														
Update rate	Background write															

6.21	**Powered-up time: hours.minutes**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1		1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 23.59 Hours.Minutes														
Update rate	Background write															

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

6.22	**Run time: years.days**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 9.364 Years.Days														
Update rate	Background write															

6.23	**Run time: hours.minutes**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 23.59 Hours.Minutes								
Update rate	Background write															

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

6.24	**Energy meter: MWh**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				1
Range	Open-loop, Closed-loop vector, Servo, Regen							±999.9 MWh								
Update rate	Background write															

6.25	**Energy meter: kWh**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				1
Range	Open-loop, Closed-loop vector, Servo, Regen							±99.99 kWh								
Update rate	Background write															

Pr **6.24** and Pr **6.25** form the energy meter that indicates the net energy supplied to/from the drive in kWh (i.e. energy supplied by the drive - energy fed back to the drive). For motor control modes a positive value indicates net transfer of energy from the drive to the motor. For Regen mode a positive value indicates a net transfer of energy from the supply to the drive. The energy meter is reset and held at zero when Pr **6.17** is one.

If the maximum or minimum of Pr **6.24** is reached, the parameter does not roll over, but is instead clamped at the maximum or minimum value.

6.26	**Running cost**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±32,000								
Update rate	Background write															

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

6.27	**Time before filter change due**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 30,000 hrs								
Update rate	Background read															

See Pr **6.18** on page 140.

6.28	**Select clock for trip log time stamping**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	Background read															

The trip log includes time stamping for individual trips provided Pr **6.49** is set to one. If Pr **6.28** is zero, the powered-up clock is used for time stamping. If Pr **6.28** is one, the run time clock is used for time stamping. It should be noted that changing this parameter clears the trip and trip time logs.

6.29	**Hardware enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1		1				
Update rate	4ms write															

This bit shows whether the drive is in the enable state or not.
Generally this will reflect the state of the enable input and shows the same value as Pr **8.09**. However the disabled state can be forced by other functions within the drive. Pr **8.09** will always follow the enable input state but the Pr **6.29** will be held at zero, indicating that the drive is forced into the disable state by the following:

1. A digital input is routed to this parameter as described below to provide a fast disable and the input forces this parameter to zero.
2. Any of the following trips are active: OI.AC, PS.10V, PS.24V, OI.Br, OV.

Software V01.10.00 onwards
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 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 input there can be a delay of up to 20ms. However, if a digital I/O is set up to provide the fast disable function it is possible to disable the drive within 600us of de-activating the input. To do this the enable signal should be connected to both the Safe Torque Off (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 to enable the drive.

If the safety function of the Safe Torque Off input is required then there must not be a direct connection between the Safe Torque Off input (T31) and any other digital I/O on the drive. If the safety function of the Safe Torque Off 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 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 input to be forced high, including the case where a component such as a blocking diode has failed.

6.30	**Sequencing bit: Run forward**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

6.31	**Sequencing bit: Jog**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

6.32	**Sequencing bit: Run reverse**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

6.33	**Sequencing bit: Forward/reverse**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

6.34	**Sequencing bit: Run**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

In normal operation the sequencer has been designed to operate with Run forward / Run reverse controls, or with a Run control and a forward reverse selector. If Run forward / Run reverse control is required then bits Pr **6.30** and Pr **6.32** should be used to control the drive (digital inputs should not be routed to bits Pr **6.33** and Pr **6.34**). If Run control with a forward reverse selector is required then bits Pr **6.33** and Pr **6.34** should be used to control the drive (digital inputs should not be routed to bits Pr **6.30** and Pr **6.32**).

The Run forward and Run reverse, or Run sequencing bits can be made latching by setting bit Pr **6.40**. The Not stop bit (Pr **6.39**) should be one to allow the sequencing bit to be latched. If the Not stop bit is zero all latches are cleared and held at zero. The jog or jog reverse sequencing bits can also cause the drive to run provided the motor is stopped when these bits are activated and the normal run sequencing bits are not providing a run signal.

6.35	**Forward limit switch**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	250μs read															

6.36	**Reverse limit switch**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	250µs read															

Digital inputs connected to limit switches should be routed to these parameters if fast stopping is required at a limit. In Open-loop mode the drive will respond in 4.5ms (500µs digital input filter delay + 4ms software delay) and stop the motor using the currently selected ramp rate. In Closed-loop vector and Servo modes the drive will respond in 750µs (500µs digital input filter delay + 250µs software delay) and stop the motor with zero ramp rate (i.e. in current limit). The limit switches are direction dependant so that the motor can rotate in a direction that allows the system to move away from the limit switch. (In open-loop frequency slaving mode both limit switches are active).

Open-loop

Pre-ramp reference > 0Hz	Forward limit switch active
Pre-ramp reference < 0Hz	Reverse limit switch active
Pre-ramp reference = 0Hz	Both limit switches active

Closed-loop and Servo

Pre-ramp reference+hard speed reference > 0rpm	Forward limit switch active
Pre-ramp reference+hard speed reference < 0rpm	Reverse limit switch active
Pre-ramp reference+hard speed reference = 0rpm	Both limit switches active

6.37	**Sequencing bit: Jog reverse**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

6.39	**Sequencing bit: Not stop**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

6.40	**Enable sequencer latching**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

6.41	**Drive event flags**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 65535														
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	Background write															

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

Defaults loaded (Bit 0)

The drive sets bit 0 when defaults have been loaded and the associated parameter save has been completed. The drive does not reset this flag except at power-up. This flag is intended to be used by SM-Applications Solutions Module programs to determine when the default loading process is complete. For example an application may require defaults that are different from the standard drive defaults. These may be loaded and another parameter save initiated by the SM-Applications module when this flag is set. The flag should then be cleared so that the next event can be detected.

Drive mode changed (Bit 1)

The drive sets bit 1 when the drive mode has changed and the associated parameter save has been completed. The drive does not reset this flag except at power-up. This flag is intended to be used in a similar way as bit 0.

6.42	**Control word**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Bits 0 –7: 4ms read, Bits 8-15: Background read															

6.43	**Control word enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Related to bits 0-7: 4ms read, related to bits 8-15: Background read															

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

Bits marked with * have no effect in Regen mode.

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

Bits 0-7 and bit 9: sequencing control

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

Bit 8: Analog/preset reference

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

Bit12: Trip drive

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

Bit 13: Reset drive

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

Bit 14: Keypad watchdog

When the control word is enabled (Pr **6.43**) bit 14 of the control word becomes active. (Bit 7 of the control word has no effect on this function). A watchdog is provided for an external keypad or other device where a break in the communication link must be detected. The watchdog system can be enabled and/or serviced if bit 14 of the control word is changed from zero to one with the control word enabled. Once the watchdog is enabled it must be serviced at least once every second or an "SCL" trip occurs. The watchdog is disabled when an "SCL" trip occurs, and so it must be re-enabled when the trip is reset. It should be noted that when data is transferred from a SMART card to the drive there may be a delay of up to 1.5s for the comms to respond. Once the comms starts to respond again normally the watchdog will not time out for a further 2s even if it is not serviced. This period is allowed for the system connected to the comms port to recover if required and to begin servicing the watchdog again.

6.44	**Active supply**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

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

0: Normal high voltage supply

The drive is operating in normal high voltage supply mode.

SP1xxx, SP2xxx, SP3xxx:

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

SP4xxx, SP5xxx, SP6xxx, SPMxxx:

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

1: Low voltage battery supply

The drive is operating in low voltage battery supply mode.

SP1xxx, SP2xxx, SP3xxx:

The drive is using the low voltage auxiliary power input to derive the power circuit supplies (i.e. gate drives, fans, etc). The main power terminals can be connected to a different supply of any voltage up to the maximum normal supply level. All parameters voltage based parameters are calculated from the auxiliary supply level and not the supply from the main power terminals. If the auxiliary supply and the main supply are different then these parameters will not be correct. Parameters that are saved at power-down are not saved when the power is removed in this mode.

SP4xxx and larger:

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

For all sizes of drive in low voltage battery mode, 24V must also be supplied via the 24V control board power supply input. The drive will operate normally except that mains loss detection is disabled, the braking IGBT will only operate when the drive is enabled, and the voltage levels contained in the following table are used instead of the normal high voltage levels whatever the voltage rating of the drive.

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

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

6.45	**Force cooling fan to run at full speed**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Update rate	Background read															

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 when the drive is in the UU state, the fan always runs at minimum speed.

6.46	**Nominal low voltage battery supply**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	48 to 72 for SP0xxx drives 48 to 48 for SP1xxx drives 48 to 72 for SP2xxx and SP3xxx drives 48 to 72 for all other 200V drives 48 to 96 for all other 400V and 690V drives															
Default	Open-loop, Closed-loop vector, Servo, Regen	48														
Update rate	Background read															

This parameter defines the nominal supply voltage when operating in low voltage mode. The parameter is used to define the braking IGBT switching threshold and the over voltage trip level for low voltage battery mode (see Pr **6.44**).

6.47	**Disable mains/phase loss detection from input rectifier**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	Background read															

SP0xxx, SP1xxx, SP2xxx and SP3xxx

Drives in these sizes ranges have a diode rectifier input stage with no direct monitoring system. Mains loss and phase loss detection is derived from the DC bus voltage. This parameter has no effect.

SP4xxx, SP5xxx and SP6xxx

Drives in these sizes ranges have an active rectifier input stage that is used to control DC bus charging. Mains loss and phase loss detection is derived from the DC bus voltage. The only status information taken from the input rectifier stage is an over temperature indication which gives an Oht4 trip if active. This parameter has no effect on this feature. When the control system is leaving the mains loss ride through condition (ACUU) it is important that no load is applied to the input rectifier until it is fully active. This feature can be disabled by setting this parameter to one.

SPMxxxx

Drives in this size range can use an active rectifier input stage that is used to control DC bus charging. These drives can be operated as a single power module or the power modules can be operated in parallel. Mains and phase loss detection is derived from the DC bus voltage, but additional monitoring is provided by the input rectifier controller as follows:

1. An over temperature indication from a single module or any module operating in parallel causes an Oht4.P trip if it is present for more than 0.5s. This feature is not affected by this parameter.
2. A phase loss indication from a single module or any module operating in parallel causes a PH.P trip if it is present for more than 0.5s. If this parameter is set to one, the drive is operating in regen mode or the drive is operating from a low voltage supply this feature is disabled.
3. A mains loss indication from any, but not all modules operating in parallel causes a PH.P trip if this condition is present for more than 0.5s. If this parameter is set to one, the drive is operating in regen mode or the drive is operating from a low voltage supply this feature is disabled.

When the control system is leaving the mains loss ride through condition (ACUU) it is important that no load is applied to the input rectifier until it is fully active. This feature can be disabled by setting this parameter to one.

The active rectifier status signals are monitored in one of the following ways:

1. When SPMAxxx drives are connected in parallel the status of the individual rectifiers is monitored through the parallel module control interface system.
2. When SPMDxxx drives are connected in parallel the status of the individual rectifiers is combined and is monitored when the combined status signals are connected to power module one.
3. When an external rectifier is used, these monitoring features are provided via digital I/O terminals using the rectifier monitoring feature of the variable selector blocks (see menu 12).

6.48	**Mains loss ride through detection level**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Open-loop,Closed-loop vector, Servo								0 to DC_VOLTAGE_SET_MAX V							
Default	Open-loop,Closed-loop vector, Servo								200V rated drive 205 400V rated drive 410 575V rated drive 540 690V rated drive 540							
Update rate	Background read															

The mains 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 mains loss detection becomes active under normal operating conditions the motor will coast to a stop.

6.49	**Disable multi-module drive module number storing on trip**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	Background read															

When power modules are connected in parallel various trips can be initiated from the power modules themselves. To aid identification of the source of the trip the module number of the source can be stored in the module number and trip time log (Pr **10.41** to Pr **10.51**). If the drive is a single module drive (Sp1xxx to SP6xxx) the module number that is stored is normally zero.

However, a SPMAxxxx or SPMDxxxx drive is installed with the interface circuits normally intended for parallel operation, so if a SPMAxxxx or SPMDxxxx drive is used as a single module then a module number of 1 is stored. If Pr **6.49** is zero the module number is stored in the module number and trip time log. If this parameter is one, either the powered-up clock or run time clock is stored in the module number and trip time log as defined by Pr **6.28**. It should be noted that changing this parameter clears the trip, and module number and trip time logs.

6.50	**Drive comms state**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Default	Open-loop,Closed-loop vector, Servo, Regen								0 to 3							
Update rate	Background write															

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

1. Comms messages via the 485 port are limited to a maximum of 32 bytes
2. The 6 pin keypad port will operate correctly with an LED keypad, but it will no longer operate with an LCD keypad
3. Modbus messages using the CMP protocol can only route messages to nodes within the drive. It will not be possible for these to be routed further, i.e. via CT Net on an SM Applications module.

6.51	**External rectifier not active**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1													1		
Default	Open-loop,Closed-loop vector, Servo, Regen	0														
Update rate	1ms read															

When a drive with an internal rectifier is used this parameter should be left at zero. For a drive with an active external rectifier (used to control DC Bus charging) this parameter should be the destination of the output of a variable selector set up for external rectifier monitoring. This allows the monitoring block to prevent the drive from leaving the main loss ride through mode until the rectifier is fully active and phased forwards. If this feature is not used the mains loss ride through mode ends as soon as the DC Bus voltage is above the mains loss detection level. The rectifier may still be phasing forwards and the application of load at this point may cause the DC Bus voltage to fall back below the mains loss detection level again.

5.9 Menu 7: Analog I/O

Hardware

The drive has three analog inputs (AI1 to AI3) and two analog outputs (AO1 and AO2). Each input has a similar parameter structure and each output has a similar parameter structure. The nominal full scale level for inputs in voltage mode is 9.8V. This ensures that when the input is driven from a voltage produced from the drive's own 10V supply, the input can reach full scale.

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

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

Update rate

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

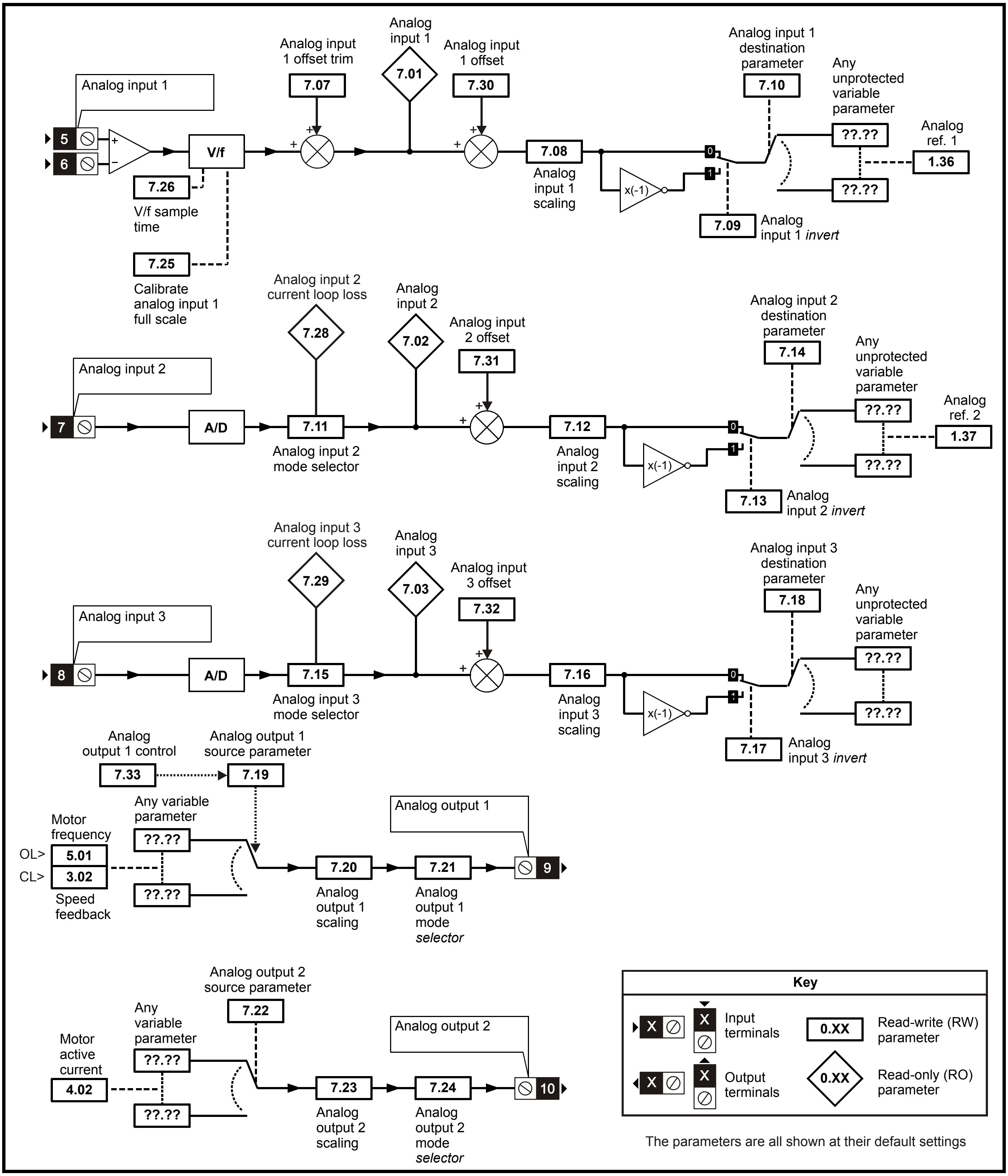
Input destination	Closed-loop vector or Servo mode sample rate	Regen mode sample rate
Pr **1.36** - Analog reference	250µs (AI1 subject to window filter. See Pr **7.26** on page 159)	
Pr **1.37** - Analog reference	250µs (AI1 subject to window filter. See Pr **7.26** on page 159)	
Pr **3.10** - Power feed forward compensation		AI1 - 4ms AI2 or 3 - 1ms
Pr **3.22** - Hard speed reference	250µs (AI1 subject to window filter. See Pr **7.26** on page 159)	
Pr **4.08** - Torque reference	AI1 – 4ms AI2 or 3 – 250µs	

It should be noted that the analog inputs are always sampled every 4ms in Open-loop mode. However, the window filter applied to analog input 1 (see Pr **7.26**) can be set to a time that is shorter than 4ms. There is no advantage in doing this, as it simply reduces the resolution of the input data, which is still only sampled and routed to its destination parameter every 4ms.

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

Output source	Scaling
Pr **3.02** – speed	(Closed-loop vector and servo modes only) 10.0V = SPEED_MAX
Pr **4.02** - torque prod current	10.0V = Kc / 0.45 where Kc is the current scaling factor for the drive
Pr **4.17** - magnetising current	10.0V = Kc / 0.45
Pr **5.03** - output power	(Closed-loop vector and servo modes only) The output is the product of the active current and the voltage component in phase with the active current (vsy x isy). 10V would be produced when: Active current = Kc / 0.45 Peak phase voltage in phase with the active current = DC_VOLTAGE_MAX / 2

Figure 5-14 Menu 7 logic diagram



7.01	**T5/6 analog input 1 level**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.00 %								
Update rate	4ms write															

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

7.02	**T7 analog input 2 level**															
7.03	**T8 analog input 3 level**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.0 %								
Update rate	4ms write															

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

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

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

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

7.04	**Power circuit temperature 1**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							-128 to 127°C								
Update rate	Background write															

7.05	**Power circuit temperature 2**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							-128 to 127°C								
Update rate	Background write															

7.06	**Control board temperature**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							-128 to 127°C								
Update rate	Background write															

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

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

Table 5-4 Power stage temperature 1 (Pr 7.04) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	77	72	75
SP1xxx	110	105	100
SP2xxx	115	110	100
SP3xxx	120	115	100
SP4xxx	72	67	68
SP5xxx	72	67	68
SP6xxx	92	87	85
SPMAxxxx	92	87	85
SPMDxxxx	96	91	88

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

Drive size	Trip temperature
SP6xxx	67
SPMAxxxx	67
SPMDxxxx	71

Table 5-5 Power stack temperature 2 (Pr 7.05) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	83	78	80
SP1xxx	92	87	85
SP2xxx	100	95	95
SP3xxx	98	93	94
SP4xxx	78	73	72
SP5xxx	78	73	72
SP6xxx	78	73	72
SPMAxxxx	78	73	72
SPMDxxxx	78	73	72

Table 5-6 Power stack temperature 3 (Pr 7.36) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	105	100	100
SP1xxx	N/A	N/A	N/A
SP2xxx	N/A	N/A	N/A
SP3xxx	N/A	N/A	N/A
SP4xxx	N/A	N/A	N/A
SP5xxx	N/A	N/A	N/A
SP6xxx	85	80	80
SPMAxxxx	85	80	80
SPMDxxxx	N/A	N/A	N/A

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

Drive cooling fan

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

1. If Pr **6.45** = 1 the fan is at full speed for at least 10s.
2. If a Solutions Module indicates that it is too hot the fan is at full speed for at least 10s.
3. For drive sizes SP1xxx to SP2xxx the fan is at full speed if the drive is enabled and the highest power circuit temperature (Pr **7.04** or Pr **7.05**) or the temperature calculated for the case of the IGBT package exceed the threshold for the drive. The fan is at its low speed if this temperature falls 5°C below the threshold or the drive is disabled and the temperature is below the alarm level for Pr **7.04** and Pr **7.05**.
4. For drive sizes SP3xxx to SPMAxxxx or SPMDxxx the fan speed is controlled above its minimum level if the drive is enabled and the highest power circuit temperature (Pr **7.04**, Pr **7.05** or Pr **7.36**) or the temperature calculated for the case of the IGBT package exceed the lower threshold for the drive. The maximum fan speed is reached when the highest of these temperatures exceeds the upper threshold. The fan is at its minimum speed if the drive is disabled and the temperature is below the alarm level for Pr **7.04**, Pr **7.05** and Pr **7.36**.
5. For drive size SP0xxx the fan is always on when the drive or the braking IGBT are enabled and remains on for 10s after the drive or braking IGBT is disabled.

The thresholds are given in the table below in °C :

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

7.07	T5/6 analog input 1 offset trim															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen								±10.000 %							
Default	Open-loop, Closed-loop vector, Servo, Regen								0.000							
Update rate	Background read															

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

7.08	T5/6 analog input 1 scaling															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								0.000 to 4.000							
Default	Open-loop, Closed-loop vector, Servo, Regen								1.000							
Update rate	Background read															

7.09	T5/6 analog input 1 invert															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	Background read															

7.10	T5/6 analog input 1 destination															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								Pr **0.00** to Pr **21.51**							
Default	Open-loop, Closed-loop vector, Servo Regen								Pr **1.36** Pr **0.00**							
Update rate	Read on drive reset															

7.11	**T7 analog input 2 mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 6														
Default	Open-loop, Closed-loop vector, Servo, Regen	6														
Update rate	Background read															

The following modes are available for the analog input 2. In modes 2 & 3 a current loop loss trip is generated if the input current falls below 3mA.

Parameter value	Parameter string	Mode	Comments
0	0-20	0 - 20mA	
1	20-0	20 - 0mA	
2	4-20.tr	4 -20mA with trip on loss	Trip if I < 3mA, Pr **7.02** = 0.0% if I < 4mA
3	20-4.tr	20 - 4mA with trip on loss	Trip if I < 3mA, Pr **7.02** = 100.0% if I < 4mA
4	4-20	4 - 20mA with no trip on loss	Pr **7.02** = 0.0% if I < 4mA
5	20-4	20 - 4mA with no trip on loss	Pr **7.02** = 100.0% if I < 4mA
6	VOLt	Voltage mode	

In modes 2 and 4 the destination parameter is at a value equivalent to 0.0% when the input current is less than 4mA. In modes 3 and 5 the destination parameter is at a value equivalent to 100.0% when the input current is less than 4mA.

7.12	**T7 analog input 2 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

7.13	**T7 analog input 2 invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

7.14	**T7 analog input 2 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo Regen	Pr **1.37** Pr **3.10**														
Update rate	Read on drive reset															

7.15	**T8 analog input 3 mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 9														
Default	Open-loop, Closed-loop vector, Servo Regen	8 6														
Update rate	Background read															

The following modes are available for the analog input 3. In modes 2 & 3 a current loop loss trip is generated if the input current falls below 3mA.

Parameter value	Parameter string	Mode	Comments
0	0-20	0 - 20mA	
1	20-0	20 - 0mA	
2	4-20.tr	4 -20mA with trip on loss	Trip if I < 3mA, Pr **7.03** = 0.0% if I < 4mA
3	20-4.tr	20 - 4mA with trip on loss	Trip if I < 3mA, Pr **7.03** = 100.0% if I < 4mA
4	4-20	4 - 20mA with no trip on loss	Pr **7.03** = 0.0% if I < 4mA
5	20-4	20 - 4mA with no trip on loss	Pr **7.03** = 100.0% if I < 4mA
6	VOLt	Voltage mode	
7	th.SC	Thermistor with short circuit detection	TH trip if R > 3k3 TH reset if R < 1k8 THS trip if R < 50R
8	th	Thermistor without short circuit detection	TH trip if R > 3k3 TH reset if R < 1k8
9	th.diSp	Thermistor display only with no trip	

In modes 2 and 4 the destination parameter is at a value equivalent to 0.0% when the input current is less than 4mA. In modes 3 and 5 the destination parameter is at a value equivalent to 100.0% when the input current is less than 4mA.

7.16	**T8 analog input 3 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

7.17	**T8 analog input 3 invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

7.18	**T8 analog input 3 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on drive reset															

7.19	**T9 analog output 1 source**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop Closed-loop vector, Servo Regen	Pr **5.01** Pr **3.02** Pr **4.01**														
Update rate	Background read															

7.20	**T9 analog output 1 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

7.21	**T9 analog output 1 mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 3														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

The following modes are available for the analog outputs.

Parameter value	Parameter string	Mode
0	VOLt	Voltage mode
1	0-20	0 - 20mA
2	4-20	4 - 20mA
3	H.SPd	High speed update mode

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

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

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

7.22	**T10 analog output 2 source**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**
Default	Open-loop, Closed-loop vector, Servo Regen	Pr **4.02** Pr **5.05**
Update rate	Read on drive reset	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						2					1	1	1	1	

7.23	**T10 analog output 2 scaling**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						3						1	1	1	

7.24	**T10 analog output 2 mode**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 3
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	Background read	

Coding

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

The following modes are available for the analog outputs.

Parameter value	Parameter string	Mode
0	VOLt	Voltage mode
1	0-20	0 - 20mA
2	4-20	4 - 20mA
3	H.SPd	High speed update mode

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

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

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

7.25	**Calibrate T5/6 analog input 1 full scale**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	Background read	

Coding

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

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

7.26	**T5/6 analog input 1 sample time**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 8.0 ms
Default	Open-loop, Closed-loop vector, Servo, Regen	4.0
Update rate	Background read	

Coding

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

Analog input 1 is filtered using a window filter to remove quantization noise and adjust the resolution of this input. The length of the window can be adjusted with this parameter. The shortest possible window is 250μs. It should be noted that if this input is not used as a speed reference (Pr **1.36**, Pr **1.37**) or as a hard speed reference (Pr **3.22**) the sample time affects the resolution. The nominal resolution is given by Pr **7.26** x 500 x 10, therefore the default setting gives approximately 11 bit resolution.

7.28	**T7 analog input 2 current loop loss**
7.29	**T8 analog input 3 current loop loss**
Drive modes	Open-loop, Closed-loop vector, Servo, Regen
Update rate	Background write

Coding

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

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

7.30	**T5/6 analog input 1 offset**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.00 %
Default	Open-loop, Closed-loop vector, Servo, Regen	0.00
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						2						1	1		

7.31	**T7 analog input 2 offset**															
7.32	**T8 analog input 3 offset**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.0 %														
Default	Open-loop, Closed-loop vector, Servo, Regen	0.0														
Update rate	Background read															

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

7.33	**T9 analog output 1 control**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 2														
Default	Open-loop, Closed-loop vector, Servo, Regen	2														
Update rate	Background read															

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

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

7.34	**IGBT junction temperature**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen	±200 °C														
Update rate	Background write															

The IGBT junction temperature displayed in this parameter is the sum of the power circuit 1 temperature (Pr **7.04**) and a thermal model of the drive power stage. The calculated IGBT junction temperature is used to modify the drive switching frequency to reduce losses if the devices become too hot (see Pr **5.18** on page 124).

If the temperature exceeds 135°C, the switching frequency is reduced provided that this feature has not been reached. The switching frequency can be reduced from 12kHz to 6kHz to 3kHz, or from 16kHz to 8kHz to 4kHz. If at any time the calculated IGBT junction temperature exceeds 145°C, the drive initiates an Ohtl.trip. Once the switching frequency has been reduced, the drive will attempt to restore the switching frequency every 20ms provided the higher switching frequency does not raise the IGBT temperature above 135°C.

7.35	**Drive thermal protection accumulator**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 100 %														
Update rate	Background write															

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

7.36	**Power circuit temperature 3**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen	-128 to 127 °C														
Update rate	Background write															

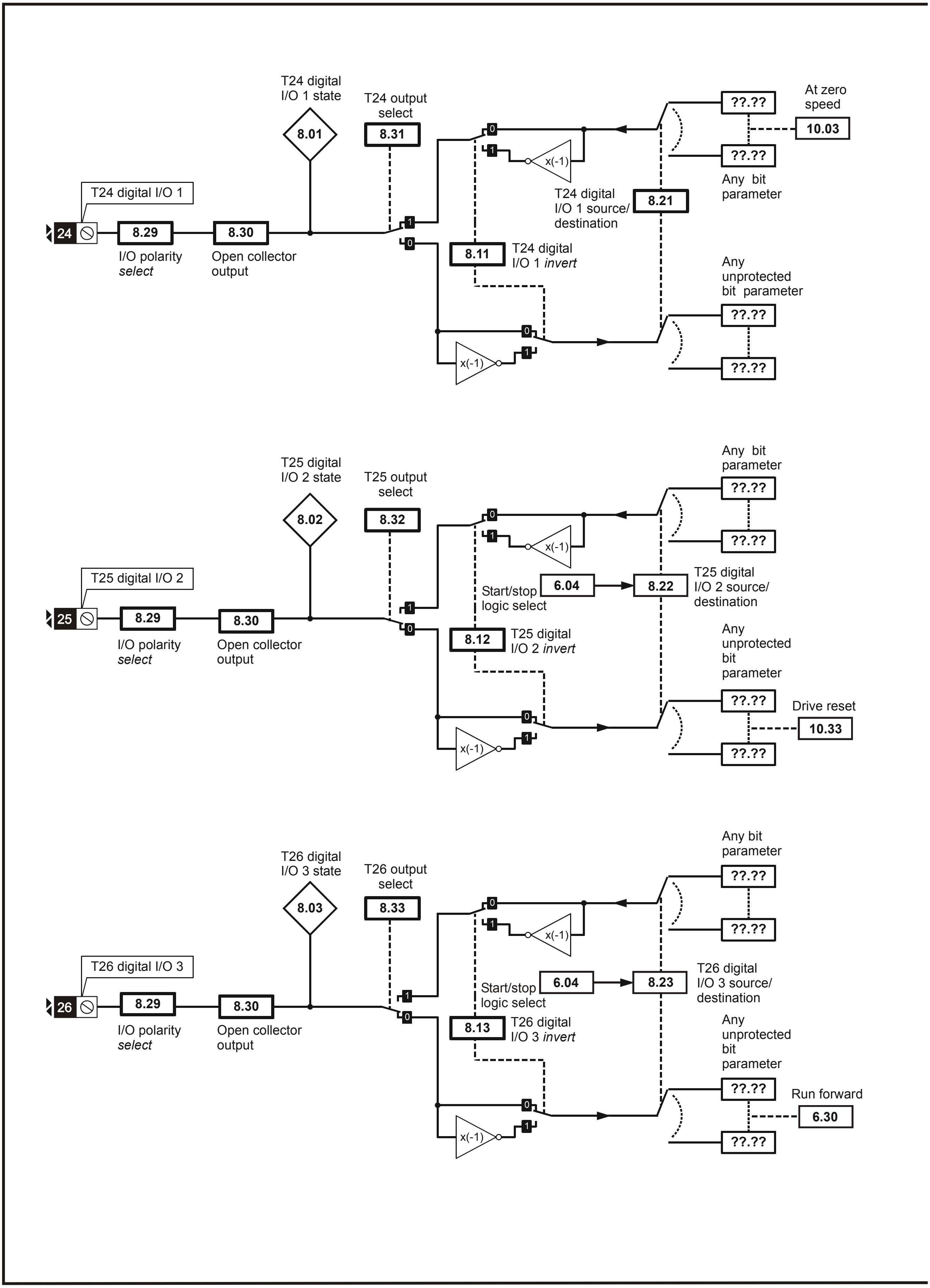
An additional thermal monitoring point is provided in SP6xxx and SPMxxxxx drives. The temperature is displayed in this parameter in degrees C. See Pr **7.04** to Pr **7.06** for more details.

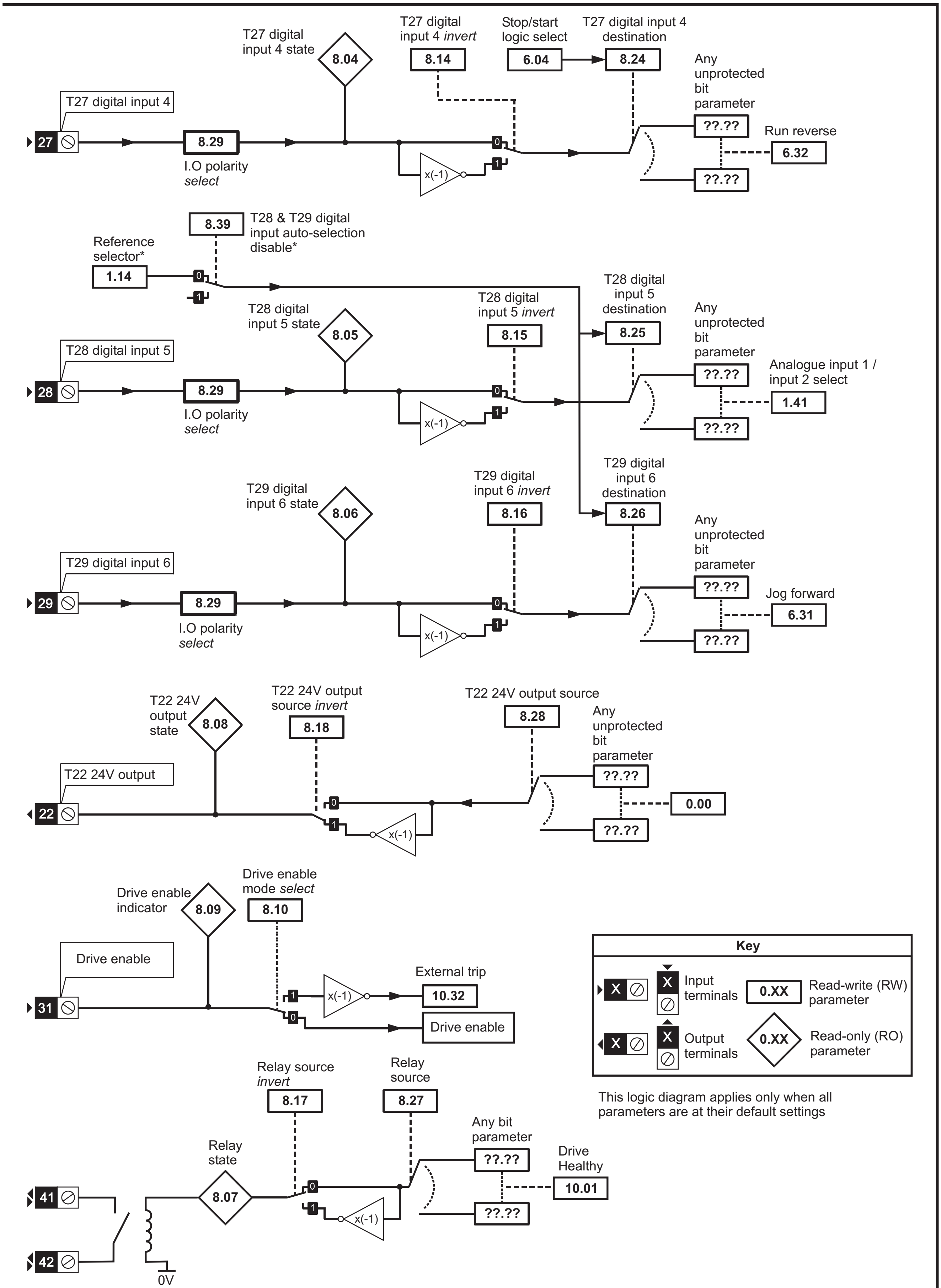
5.10 Menu 8: Digital I/O

The drive has eight digital I/O terminals (T22, T24 to T29 and the relay) and an enable input. Each input has the same parameter structure. The digital inputs are sampled every 4ms, except when inputs are routed to the limit switches Pr **6.35** and Pr **6.36** when the sample time is reduced to 250μs. The digital input hardware (excluding the Safe Torque Off input) introduces a further 100us delay. The Safe Torque Off input hardware gives a typical delay of 8ms (maximum 20ms). The digital outputs are updated every 4ms. Any changes to the source/destination parameters only become effective after drive reset is activated.

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

Figure 5-15 Menu 8 logic diagram





This logic diagram applies only when all parameters are at their default settings

Open-loop, closed-loop vector and servo
Table 5-7

Terminal + type	I/O state	Invert		Source / destination		Output select	
	Pr	Pr	Default	Pr	Default	Pr	Default
T24 input / output 1	Pr **8.01**	Pr **8.11**	0	Pr **8.21**	Pr **10.03** - Zero speed	Pr **8.31**	1
T25 input / output 2	Pr **8.02**	Pr **8.12**	0	Pr **8.22**	Pr **10.33** - Drive reset	Pr **8.32**	0
T26 input / output 3	Pr **8.03**	Pr **8.13**	0	Pr **8.23**	Pr **6.30** - Run forward	Pr **8.33**	0
T27 input 4	Pr **8.04**	Pr **8.14**	0	Pr **8.24**	Pr **6.32** - Run reverse		
T28 input 5	Pr **8.05**	Pr **8.15**	0	Pr **8.25**	Pr **1.41** – Local/remote		
T29 input 6	Pr **8.06**	Pr **8.16**	0	Pr **8.26**	Pr **6.31** – Jog		
T41 / 42 Relay	Pr **8.07**	Pr **8.17**	0	Pr **8.27**	Pr **10.01** – Drive ok		
T22 24V output	Pr **8.08**	Pr **8.18**	1	Pr **8.28**	Pr **0.00**		
T31 Safe Torque Off	Pr **8.09**						

Regen
Table 5-8

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

8.01	**T24 digital I/O 1 state**
8.02	**T25 digital I/O 2 state**
8.03	**T26 digital I/O 3 state**
8.04	**T27 digital input 4 state**
8.05	**T28 digital input 5 state**
8.06	**T29 digital input 6 state**
8.07	**Relay status**
8.08	**T22 24V output state**
8.09	**Drive enable indicator**
Drive modes	Open-loop, Closed-loop vector, Servo, Regen

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

Default	Open-loop, Closed-loop vector, Servo, Regen	See table
Update rate	4ms write	

OFF (0) = Terminal inactive

On (1) = Terminal active

8.10	**Drive enable mode select**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen							OFF (0)								
Update rate	Background read															

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

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

OFF (0) = Non-inverted

On (1) = Inverted

8.20	**Digital I/O read word**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 511								
Update rate	Background write															

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

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

8.21	**T24 digital I/O 1 source/destination**															
8.22	**T25 digital I/O 2 source/destination**															
8.23	**T26 digital I/O 3 source/destination**															
8.24	**T27 digital input 4 destination**															
8.25	**T28 digital input 5 destination**															
8.26	**T29 digital input 6 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Default	Open-loop, Closed-loop vector, Servo Regen	See Table 5-7 on page 166 See Table 5-8 on page 166														
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Update rate	Read on drive reset															

8.27	**Relay source**															
8.28	**T22 24V output source**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Default	Open-loop, Closed-loop vector, Servo Regen	See Table 5-7 on page 166 See Table 5-8 on page 166														
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Update rate	Read on drive reset															

8.29	**Positive logic select**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1	1	1	1	
Default	Open-loop, Closed-loop vector, Servo, Regen	On (1)														
Update rate	Background read															

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

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

8.30	**Open collector output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	OFF (0)														
Update rate	Background read															

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

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

OFF (0) = Terminal is an input
On (1) = Terminal is an output

8.39	**T28 & T29 digital input auto-selection disable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo								OFF (0)							
Update rate	Background read															

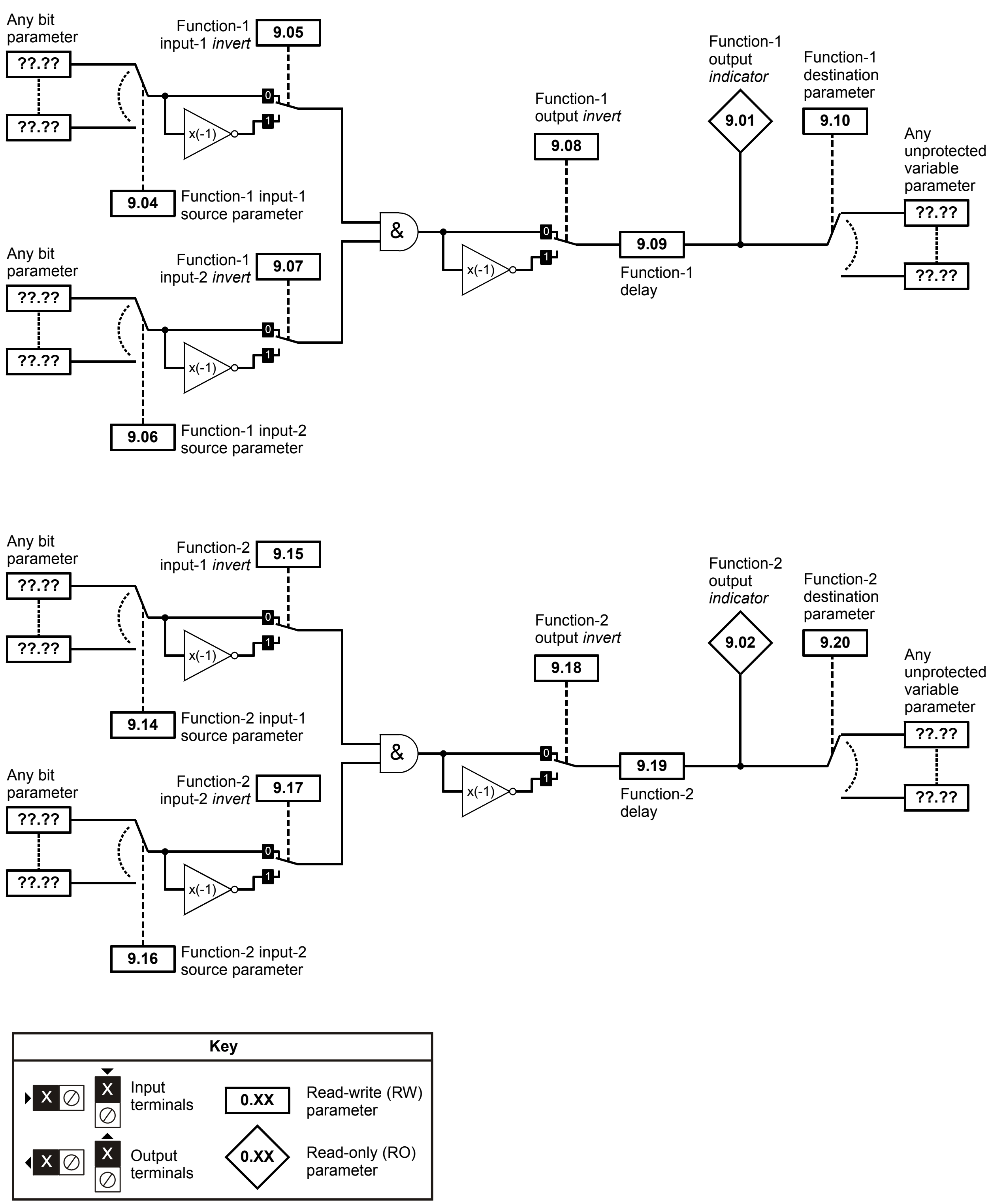
When this parameter is 0, Pr **8.25** and Pr **8.26** are set up automatically according to the setting of the reference select Pr **1.14**. Setting this parameter to 1 disables this function.

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

This parameter has no effect in Regen mode.

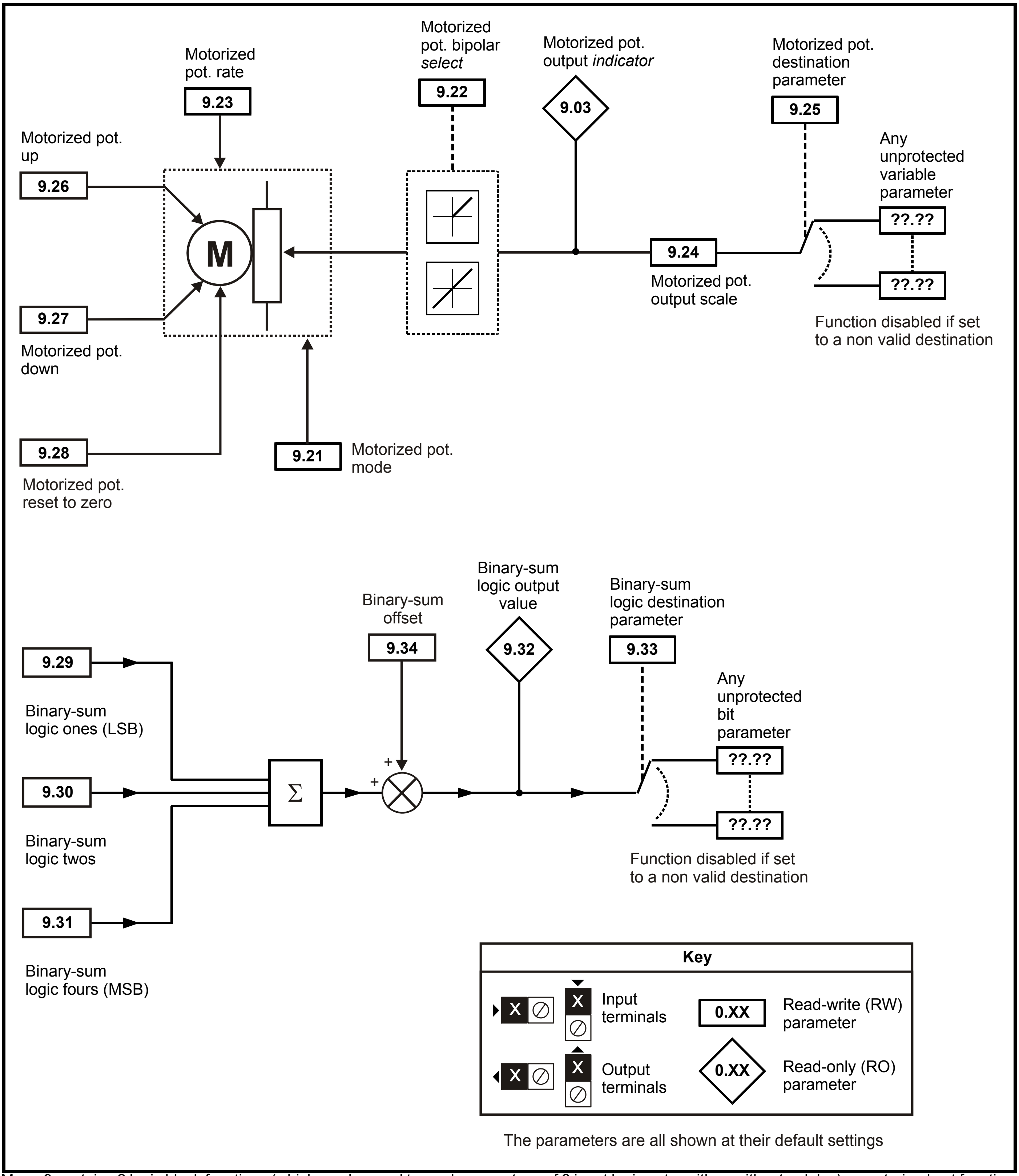
5.11 Menu 9: Programmable logic, motorized pot and binary sum

Figure 5-16 Menu 9 logic diagram: Programmable logic



The parameters are all shown at their default settings

Figure 5-17 Menu 9 logic diagram: Motorized pot and binary sum



Menu 9 contains 2 logic block functions (which can be used to produce any type of 2 input logic gate, with or without a delay), a motorized pot function and a binary sum block. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. The logic functions are active if one or both the sources are routed to a valid parameter. The other functions are active if the output destination is routed to a valid unprotected parameter.

9.01	**Logic function 1 output**															
9.02	**Logic function 2 output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms x number of menu 9 or 12 functions active write															

9.03	**Motorized pot output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				1
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.00 %								
Update rate	4ms x number of menu 9 or 12 functions active write															

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

9.04	**Logic function 1 source 1**															
9.14	**Logic function 2 source 1**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00** to Pr **21.51**								
Default	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00**								
Update rate	Read on reset															

9.05	**Logic function 1 source 1 invert**															
9.15	**Logic function 2 source 1 invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	4ms x number of menu 9 or 12 functions active read															

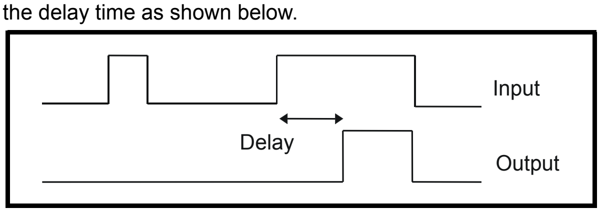
9.06	**Logic function 1 source 2**															
9.16	**Logic function 2 source 2**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00** to Pr **21.51**								
Default	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00**								
Update rate	Read on reset															

9.07	**Logic function 1 source 2 invert**															
9.17	**Logic function 2 source 2 invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

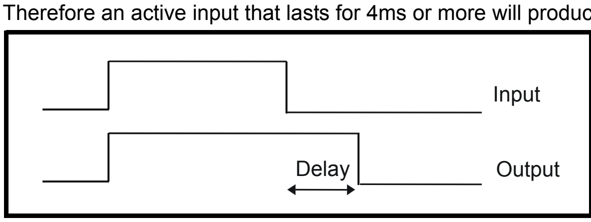
9.08	**Logic function 1 output invert**															
9.18	**Logic function 2 output invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Coding	RW, Bit, US															
Default	Open-loop,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

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

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



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



9.10	**Logic function 1 destination**															
9.20	**Logic function 2 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

9.21	**Motorized pot mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 3														
Default	Open-loop, Closed-loop vector, Servo, Regen	2														
Update rate	Background read															

The motorized pot modes are given in the following table.

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

9.22	**Motorized pot bipolar select**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

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

9.23	**Motorized pot rate**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 250 s														
Default	Open-loop, Closed-loop vector, Servo, Regen	20														
Update rate	Background read															

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

9.24	**Motorized pot scale factor**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	4ms x number of menu 9 or 12 functions active read															

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

9.25	**Motorized pot destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

9.26	**Motorized pot up**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

9.27	**Motorized pot down**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

9.28	**Motorized pot reset**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

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

9.29	**Binary sum ones input**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	4ms x number of menu 9 or 12 functions active read	

Coding

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

9.30	**Binary sum twos input**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	4ms x number of menu 9 or 12 functions active read	

Coding

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

9.31	**Binary sum fours input**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	4ms x number of menu 9 or 12 functions active read	

Coding

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

9.32	**Binary sum output**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 255
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	4ms x number of menu 9 or 12 functions active write	

Coding

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

9.33	**Binary sum destination**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**
Update rate	Read on reset	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			2					1	1	1	1	

<table>
<tr><td>9.34</td><td colspan="16">Binary sum offset</td></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo, Regen</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">0 to 248</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">0</td></tr>
<tr><td>Update rate</td><td colspan="16">4ms x number of menu 9 or 12 functions active write</td></tr>
</table>

The binary sum output is given by:

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

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

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

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

5.12 Menu 10: Status and trips

10.01	Drive ok														
Drive modes	Open-loop, Closed-loop vector, Servo, Regen														
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write														

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

10.02	Drive active															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

Indicates that the drive inverter is active.

10.03	Zero speed															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

Open-loop
Indicates that the absolute value of the ramp output (|Pr **2.01**|) is at or below the zero speed threshold defined by Pr **3.05**.

Closed-loop and Servo
Indicates that the absolute value of speed feedback (|Pr **3.02**|) is at or below the zero speed threshold defined by Pr **3.05**.

10.04	Running at or below min speed															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

In bipolar mode (Pr **1.10** = 1) this parameter is the same as zero speed (Pr **10.03**). In unipolar mode this parameter is set if the absolute value of the ramp output (Pr **2.01**) or speed feedback (Pr **3.02**) is at or below (minimum speed + 0.5Hz), or (minimum speed + 5rpm). Minimum speed is defined by Pr **1.07**. The parameter is only set if the drive is running.

10.05	Below set speed															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

10.06	At speed															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

10.07	**Above set speed**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

These flags are set by the speed detector in menu 3.

See Pr **3.06**, Pr **3.07** on page 59 and Pr **3.09** on page 60.

10.08	**Load reached**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

Indicates that the modulus of the active current is greater or equal to the rated active current as defined in menu 4.

10.09	**Drive output is at current limit**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

Indicates that the current limits are active.

10.10	**Regenerating**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

Open-loop, Closed-loop vector, Servo
Indicates that power is being transferred from the motor to the drive.

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

10.11	**Braking IGBT active**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

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

10.12	**Braking resistor alarm**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

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

10.13	Direction commanded															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

This parameter is one if the pre-ramp reference (Pr **1.03**) is negative, and zero if the pre-ramp reference is zero or positive.

10.14	Direction running															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

Open-loop
This parameter is one if the post-ramp reference (Pr **2.01**) is negative, or zero if the post-ramp reference is zero or positive.

Closed-loop vector and Servo
This parameter is one if the speed feedback (Pr **3.02**) is negative, or zero if the speed feedback is zero or positive.

10.15	Mains loss															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

Open-loop, Closed-loop vector and Servo
Indicates that the drive has detected mains loss from the level of the DC bus voltage. This parameter can only become active if mains loss ride through or mains loss stop modes are selected (see Pr **6.03** on page 135).

Regen
This parameter is the inverse of Pr **3.07**.

10.16	Under voltage active															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

This parameter indicates that the under voltage condition is active. Normally this condition exists when the UU trip is also active. However, when the drive first powers up it remains in the under voltage state (i.e. this parameter is active) until the DC bus voltage exceeds the under voltage restart level (see Pr **6.03** on page 135). As the UU trip voltage level is lower than the under voltage restart level this parameter is active, but a UU trip is not active at power up until the DC bus voltage exceeds the under voltage restart level.

10.17	Overload alarm															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

This parameter is set if the drive output current is larger than 105% of rated current (Pr **5.07**) and the overload accumulator is greater than 75% to warn that if the motor current is not reduced the drive will trip on an Ixt overload. (If the rated current (Pr **5.07**) is set to a level above the maximum heavy duty current (Pr **11.32**) the overload alarm is given when the current is higher than 101% of rated current).

10.18	Drive over temperature alarm															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

Indicates that any of the heat sink temperatures (Pr **7.04** or Pr **7.05**) or the control board temperature (Pr **7.06**) are above their alarm level.

10.19	**Drive warning**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

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

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

Contains the last 10 drive trips. Pr **10.20** is the most recent trip and Pr **10.29** the oldest. When a new trip occurs all the parameters move down one, the current trip is put in Pr **10.20** and the oldest trip is lost off the bottom of the log. Descriptions of the trips are given in the table below. A time stamp can be stored for each trip (see Pr **10.41** to Pr **10.51**). All trips are stored, including HF trips numbered from 17 to 32. (HF trips with numbers from 1 to 16 are not stored in the trip log). UU trips are not stored unless the drive is running when the trip occurs. Any trip can be initiated by the actions described or by writing the relevant trip number to Pr **10.38**. If any trips shown as user trips are initiated the trip string is "txxx", where xxx is the trip number.

For drives SP4xxx and larger some trips are detected and initiated by the power module hardware (trips 101 -109). These are indicated by ".P" at the end of the trip string. If the drive is a multi-module drive the number of the module that has caused the trip can be stored (see Pr **10.41** to Pr **10.51**).

Table 5-9 Trip indications

Trip	Diagnosis
br.th	**Internal braking resistor thermistor temperature monitoring fail (size 0 only)**
10	If no internal brake resistor is installed, set Pr **0.51** (or Pr **10.37**) to 8 to disable this trip. If an internal brake resistor is installed: • Ensure that the internal braking resistor thermistor is connected correctly • Ensure that the fan in the drive is working correctly • Replace the internal braking resistor
C.Acc	**SMARTCARD trip: SMARTCARD Read / Write fail**
185	Check SMARTCARD is installed / located correctly Ensure SMARTCARD is not writing data to data location 500 to 999 Replace SMARTCARD
C.boot	**SMARTCARD trip: The menu 0 parameter modification cannot be saved to the SMARTCARD because the necessary file has not been created on the SMARTCARD**
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 bee 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
C.bUSY	**SMARTCARD trip: SMARTCARD can not perform the required function as it is being accessed by a Solutions Module**
178	Wait for the Solutions Module to finish accessing the SMARTCARD and then re-attempt the required function

Trip	Diagnosis
C.Chg	**SMARTCARD trip: Data location already contains data**
179	Erase data in data location Write data to an alternative data location
C.cPr	**SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different**
188	Press the red reset button
C.dAt	**SMARTCARD trip: Data location specified does not contain any data**
183	Ensure data block number is correct
C.Err	**SMARTCARD trip: SMARTCARD data is corrupted**
182	Ensure the card is located correctly Erase data and retry Replace SMARTCARD
C.Full	**SMARTCARD trip: SMARTCARD full**
184	Delete a data block or use different SMARTCARD
cL2	**Analog input 2 current loss (current mode)**
28	Check analog input 2 (terminal 7) current signal is present (4-20mA, 20-4mA)
cL3	**Analog input 3 current loss (current mode)**
29	Check analog input 3 (terminal 8) current signal is present (4-20mA, 20-4mA)
CL.bit	**Trip initiated from the control word (Pr 6.42)**
35	Disable the control word by setting Pr **6.43** to 0 or check setting of Pr **6.42**
ConF.P	**The number of power modules installed no longer matches the value stored in Pr 11.35**
111	Ensure that all power modules are correctly connected Ensure that all power modules have powered up correctly Ensure that the value in Pr **11.35** matches the number of power modules connected
C.OPtn	**SMARTCARD trip: Solutions Modules installed are different between source drive and destination drive**
180	Ensure correct Solutions Modules are installed Ensure Solutions Modules are in the same Solutions Module slot Press the red reset button
C.Prod	**SMARTCARD trip: The data blocks on the SMARTCARD are not compatible with this product**
175	Erase all data on the SMARTCARD by setting Pr **xx.00** to 9999 and pressing the red reset button Replace SMARTCARD
C.rdo	**SMARTCARD trip: SMARTCARD has the Read Only bit set**
181	Enter 9777 in Pr **xx.00** to allow SMARTCARD Read / Write access Ensure the drive is not writing to data locations 500 to 999 on the card

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>C.rtg</td><td>SMARTCARD trip: The voltage and/or current rating of the source and destination drives are different</td></tr>
<tr><td>186</td><td>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.
Press the red reset button
Drive rating parameters are:
<table>
<tr><th>Parameter</th><th>Function</th></tr>
<tr><td>2.08</td><td>Standard ramp voltage</td></tr>
<tr><td>4.05/6/7, 21.27/8/9</td><td>Current limits</td></tr>
<tr><td>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>
</table>
The above parameters will be set to their default values.</td></tr>
<tr><td>C.TyP</td><td>SMARTCARD trip: SMARTCARD parameter set not compatible with drive</td></tr>
<tr><td>187</td><td>Press the reset button
Ensure destination drive type is the same as the source parameter file drive type</td></tr>
<tr><td>dESt</td><td>Two or more parameters are writing to the same destination parameter</td></tr>
<tr><td>199</td><td>Set Pr xx.00 = 12001 check all visible parameters in the menus for duplication</td></tr>
<tr><td>EEF</td><td>EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.</td></tr>
<tr><td>31</td><td>This trip can only be cleared by loading default parameters and saving parameters</td></tr>
<tr><td>EnC1</td><td>Drive encoder trip: Encoder power supply overload</td></tr>
<tr><td>189</td><td>Check encoder power supply wiring and encoder current requirement
Maximum current = 200mA @ 15V, or 300mA @ 8V and 5V</td></tr>
<tr><td>EnC2</td><td>Drive encoder trip: Wire break (Drive encoder terminals 1 & 2, 3 & 4, 5 & 6)</td></tr>
<tr><td>190</td><td>Check cable continuity
Check wiring of feedback signals is correct
Check encoder power supply is set correctly in Pr 3.36
Replace feedback device
If wire break detection on the main drive encoder input is not required, set Pr 3.40 = 0 to disable the Enc2 trip</td></tr>
<tr><td>EnC3</td><td>Drive encoder trip: Phase offset incorrect while running</td></tr>
<tr><td>191</td><td>Check the encoder signal for noise
Check encoder shielding
Check the integrity of the encoder mechanical mounting
Repeat the offset measurement test</td></tr>
<tr><td>EnC4</td><td>Drive encoder trip: Feedback device comms failure</td></tr>
<tr><td>192</td><td>Ensure encoder power supply is correct
Ensure baud rate is correct
Check encoder wiring
Replace feedback device</td></tr>
<tr><td>EnC5</td><td>Drive encoder trip: Checksum or CRC error</td></tr>
<tr><td>193</td><td>Check the encoder signal for noise
Check the encoder cable shielding
With EnDat encoders, check the comms resolution and/or carry out the auto-configuration Pr 3.41
Checksum / CRC error or SSI not ready at start of position transfer (i.e. data input not one)</td></tr>
</table>

Trip	Diagnosis
EnC6	**Drive encoder trip: Encoder has indicated an error**
194	Replace feedback device With SSI encoders, check the wiring and encoder supply setting
EnC7	**Drive encoder trip: Initialisation failed**
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
EnC8	**Drive encoder trip: Auto configuration on power up has been requested and failed**
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
EnC9	**Drive encoder trip: Position feedback selected is selected from a Solutions Module slot which does not have a speed / position feedback Solutions Module installed**
197	Check setting of Pr **3.26** (or Pr **21.21** if the second motor parameters have been enabled)
EnC10	**Drive encoder trip: Servo mode phasing failure because encoder phase angle (Pr 3.25 or Pr 21.20) is incorrect**
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.
Enc11	**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.**
161	Check encoder cable shield. Examine sine and cosine signals for noise.
Enc12	**Drive encoder trip: Hiperface encoder - The encoder type could not be identified during auto-configuration**
162	Check encoder type can be auto-configured. Check encoder wiring. Enter parameters manually.
Enc13	**Drive encoder trip: EnDat encoder - The number of encoder turns read from the encoder during auto-configuration is not a power of 2**
163	Select a different type of encoder.
Enc14	**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.**
164	Select a different type of encoder. Faulty encoder.
Enc15	**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.**
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.
Enc16	**Drive encoder trip: EnDat encoder - The number of comms bits per period for a linear encoder exceeds 255.**
166	Select a different type of encoder. Faulty encoder.
Enc17	**Drive encoder trip: The periods per revolution obtained during auto-configuration for a rotary SINCOS encoder is not a power of two.**
167	Select a different type of encoder. Faulty encoder.
EnP.Er	**Data error from electronic nameplate stored in selected position feedback device**
176	Replace feedback device

Trip	Diagnosis
Et	**External trip from input on terminal 31**
6	Check terminal 31 signal Check value of Pr **10.32** Enter 12001 in Pr **xx.00** and check for parameter controlling Pr **10.32** Ensure Pr **10.32** or Pr **10.38** (=6) are not being controlled by serial comms
HF01	**Data processing error: CPU address error**
	Hardware fault - return drive to supplier
HF02	**Data processing error: DMAC address error**
	Hardware fault - return drive to supplier
HF03	**Data processing error: Illegal instruction**
	Hardware fault - return drive to supplier
HF04	**Data processing error: Illegal slot instruction**
	Hardware fault - return drive to supplier
HF05	**Data processing error: Undefined exception**
	Hardware fault - return drive to supplier
HF06	**Data processing error: Reserved exception**
	Hardware fault - return drive to supplier
HF07	**Data processing error: Watchdog failure**
	Hardware fault - return drive to supplier
HF08	**Data processing error: Level 4 crash**
	Hardware fault - return drive to supplier
HF09	**Data processing error: Heap overflow**
	Hardware fault - return drive to supplier
HF10	**Data processing error: Router error**
	Hardware fault - return drive to supplier
HF11	**Data processing error: Access to EEPROM failed**
	Hardware fault - return drive to supplier
HF12	**Data processing error: Main program stack overflow**
	Hardware fault - return drive to supplier
HF13	**Data processing error: Software incompatible with hardware**
	Hardware or software fault - return drive to supplier
HF17	**Multi-module system thermistor short circuit or open circuit**
217	Hardware fault - return drive to supplier
HF18	**Multi-module system interconnect cable error**
218	Parallel cable in wrong port. (Note in multi module systems, the drive with the trip code displayed indicates that the next drive in the sequence has the physical fault) Hardware fault - return drive to supplier
HF19	**Temperature feedback multiplexing failure**
219	Hardware fault - return drive to supplier
HF20	**Power stage recognition: serial code error**
220	Hardware fault - return drive to supplier
HF21	**Power stage recognition: unrecognised frame size**
221	Hardware fault - return drive to supplier
HF22	**Power stage recognition: multi module frame size mismatch**
222	Hardware fault - return drive to supplier
HF23	**Power stage recognition: multi module voltage or current rating mismatch**
223	Hardware fault - return drive to supplier
HF24	**Power stage recognition: unrecognised drive size**
224	Hardware fault - return drive to supplier

Trip	Diagnosis
HF25	**Current feedback offset error**
225	Hardware fault - return drive to supplier
HF26	**Soft start relay failed to close, soft start monitor failed or braking IGBT short circuit at power up**
226	Hardware fault - return drive to supplier
HF27	**Power stage thermistor 1 fault**
227	Hardware fault - return drive to supplier
HF28	**Power stage thermistor 2 fault, or internal fan fault (size 3)**
228	Hardware fault - return drive to supplier
HF29	**Control board thermistor fault**
229	Hardware fault - return drive to supplier
HF30	**DCCT wire break trip from power module**
230	Hardware fault - return drive to supplier
HF31	**Internal capacitor bank fan failure (size 4 and larger) or a module has not powered up in a multi-module parallel drive**
231	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
HF32	**Power stage - Identification and trip information serial code error**
232	Hardware fault - return drive to the supplier
It.AC	**Output current overload timed out (I^2t) - accumulator value can be seen in Pr 4.19**
20	Ensure the load is not jammed / sticking Ensure that the motor rated current is not set to zero Check the load on the motor has not changed Ensure rated speed parameter is correct (RFC) If seen during an autotune in servo mode, ensure that the motor rated current Pr **0.46** (Pr **5.07**) or Pr **21.07** is ≤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
It.br	**Braking resistor overload timed out (I^2t) – accumulator value can be seen in Pr 10.39**
19	Ensure the values entered in Pr **10.30** and Pr **10.31** are correct Increase the power rating of the braking resistor and change Pr **10.30** and Pr **10.31** If an external thermal protection device is being used and the braking resistor software overload is not required, set Pr **10.30** or Pr **10.31** to 0 to disable the trip
L.SYnC	**Drive failed to synchronize to the supply voltage in Regen mode**
39	Refer to the *Diagnostics* chapter in the *Unidrive SP Regen Installation Guide*.
O.CtL	**Drive control board over temperature**
23	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Check ambient temperature Reduce drive switching frequency
O.ht1	**Power device over temperature based on thermal model**
21	Reduce drive switching frequency Reduce duty cycle Decrease acceleration / deceleration rates Reduce motor load
O.ht2	**Heatsink over temperature**
22	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
Oht2.P	**Power module heatsink over temperature**
105	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
O.ht3	**Drive over-temperature based on thermal model**
27	The drive will attempt to stop the motor before tripping. If the motor does not stop in 10s the drive trips immediately. Check DC bus ripple Reduce duty cycle Reduce motor load
Oht4.P	**Power module rectifier over temperature or input snubber resistor over temperature (size 4 and above)**
102	Check for supply imbalance Check for supply disturbance such as notching from a DC drive Check 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
OI.AC	**Instantaneous output over current detected: peak output current greater than 222%**
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)
OIAC.P	**Power module over current detected from the module output currents**
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)
OI.br	**Braking transistor over-current detected: short circuit protection for the braking transistor activated**
4	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
OIbr.P	**Power module braking IGBT over current**
103	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
OIdC.P	**Power module over current detected from IGBT on state voltage monitoring**
109	Vce IGBT protection activated. Check motor and cable insulation.

Trip	Diagnosis
O.Ld1	**Digital output overload: total current drawn from 24V supply and digital outputs exceeds 200mA**
26	Check total load on digital outputs (terminals 24,25,26)and +24V rail (terminal 22)
O.SPd	**Motor speed has exceeded the over speed threshold**
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)
OV	**DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds**
2	Increase deceleration ramp (Pr **0.04**) 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 **Drive voltage rating** / **Peak voltage** / **Maximum continuous voltage level (15s)** 200 / 415 / 410 400 / 830 / 815 575 / 990 / 970 690 / 1190 / 1175 If the drive is operating in low voltage DC mode the overvoltage trip level is 1.45 x Pr **6.46**.
OV.P	**Power module DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds**
106	Increase deceleration ramp (Pr **0.04**) 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 **Drive voltage rating** / **Peak voltage** / **Maximum continuous voltage level (15s)** 200 / 415 / 410 400 / 830 / 815 575 / 990 / 970 690 / 1190 / 1175 If the drive is operating in low voltage DC mode the overvoltage trip level is 1.45 x Pr **6.46**.
PAd	**Keypad has been removed when the drive is receiving the speed reference from the keypad**
34	Install keypad and reset Change speed reference selector to select speed reference from another source
PH	**AC voltage input phase loss or large supply imbalance detected**
32	Ensure all three phases are present and balanced Check input voltage levels are correct (at full load) **NOTE** 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.
PH.P	**Power module phase loss detection**
107	Ensure all three phases are present and balanced Check input voltage levels are correct (at full load)
PS	**Internal power supply fault**
5	Remove any Solutions Modules and reset Hardware fault - return drive to supplier
PS.10V	**10V user power supply current greater than 10mA**
8	Check wiring to terminal 4 Reduce load on terminal 4
PS.24V	**24V internal power supply overload**
9	The total user load of the drive and Solutions Modules has exceeded the internal 24V power supply limit. The user load consists of the drive's digital outputs, the SM-I/O Plus digital outputs, the drive's main encoder supply, the SM-Universal Encoder Plus encoder supply and the SM-Encoder Output Plus encoder supply. • Reduce load and reset • Provide an external 24V >50W power supply • Remove any Solutions Modules and reset

Trip	Diagnosis
PS.P	**Power module power supply fail**
108	Remove any Solutions Modules and reset Hardware fault - return drive to supplier
PSAVE.Er	**Power down save parameters in the EEPROM are corrupt**
37	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 **xx.00** 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.
rS	**Failure to measure resistance during autotune or when starting in open loop vector mode 0 or 3**
33	Check motor power connection continuity
SAVE.Er	**User save parameters in the EEPROM are corrupt**
36	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 **xx.00** to 1000 or 1001 and reset the drive) to ensure this trip does or occur the next time the drive is powered up.
SCL	**Drive RS485 serial comms loss to remote keypad**
30	Reinstall the cable between the drive and keypad Check cable for damage Replace cable Replace keypad
SLX.dF	**Solutions Module slot X trip: Solutions Module type installed in slot X changed**
204,209,214	Save parameters and reset

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**Feedback module category** Check value in Pr **15**/**16**/**17.50**. 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 *Diagnostics* 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 **15**/**16**/**17.15** 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 **15**/**16**/**17.18** and manually enter the number of turns bits (Pr **15**/**16**/**17.09**) and the equivalent number of lines per revolution (Pr **15**/**16**/**17.10**) and the single turn comms bits (Pr **15**/**16**/**17.11**)
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 **15**/**16**/**17.15**.
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 **5.36** = 0 or Pr **21.31** = 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	SM-Universal Encoder Plus & SM-Resolver	Solutions Module has overheated	Check ambient temperature Check enclosure ventilation

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**Automation (Applications) module category** Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the SM-Applications and SM-Applications Lite. See the *Diagnostics* section in the relevant Solutions Module User Guide for more information.

Error Code	Trip Description
39	User program stack overflow
40	Unknown error - please contact supplier
41	Parameter does not exist
42	Attempt to write to a read-only parameter
43	Attempt to read from a write-only parameter
44	Parameter value out of range
45	Invalid synchronisation modes
46	Unused
47	Synchronisation lost with CTSync Master
48	RS485 not in user mode
49	Invalid RS485 configuration
50	Maths error - divide by zero or overflow
51	Array index out of range
52	Control word user trip
53	DPL program incompatible with target
54	DPL task overrun
55	Unused
56	Invalid timer unit configuration
57	Function block does not exist
58	Flash PLC Storage corrupt
59	Drive rejected application module as Sync master
60	CTNet hardware failure. Please contact your supplier
61	CTNet invalid configuration
62	CTNet invalid baud-rate
63	CTNet invalid node ID
64	Digital Output overload
65	Invalid function block parameter(s)
66	User heap too large
67	RAM file does not exist or a non-RAM file id has been specified
68	The RAM file specified is not associated to an array
69	Failed to update drive parameter database cache in Flash memory
70	User program downloaded while drive enabled
71	Failed to change drive mode
72	Invalid CTNet buffer operation
73	Fast parameter initialisation failure
74	Over-temperature
75	Hardware unavailable
76	Module type cannot be resolved. Module is not recognised.
77	Inter-Solutions Module comms error with module in slot 1
78	Inter-Solutions Module comms error with module in slot 2
79	Inter-Solutions Module comms error with module in slot 3
80	Inter-Solutions Module comms error with module unknown slot
81	APC internal error
82	Communications to drive faulty

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**Automation (I/O Expansion) module category** Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the SM-I/O Plus, SM-I/O Lite, SM-I/O Timer, SM-I/O PELV, SM-I/O 120V, SM-I/O 32 and SM-I/O 24V Protected. See the *Diagnostics* section in the relevant Solutions Module User Guide for more information.

Error code	Module	Reason for fault
0	All	No errors
1	All	Digital output overload
2	SM-I/O Lite, SM-I/O Timer	Analog input 1 current input too high (>22mA) or too low (<3mA)
	SM-I/O PELV, SM-I/O 24V Protected	Digital input overload
3	SM-I/O PELV, SM-I/O 24V Protected	Analog input 1 current input too low (<3mA)
	SM-I/O 24V Protected	Communications error
4	SM-I/O PELV	User power supply absent
5	SM-I/O Timer	Real time clock communication error
74	All	Module over temperature

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**Fieldbus module category** Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the Fieldbus modules. See the *Diagnostics* section in the relevant Solutions Module User Guide for more information.

Error code	Module	Trip Description
0	All	No trip
1	SM-EtherCAT	No fieldbus mode has been selected
2	SM-EtherCAT	Critical task over-run
52	SM-PROFIBUS-DP, SM-INTERBUS, SM-DeviceNet, SM-CANOpen	User control word trip
58	SM-LON	Incorrect non-volatile storage
61	SM-PROFIBUS-DP, SM-INTERBUS, SM-DeviceNet, SM-CANOpen, SM-SERCOS, SM-LON	Configuration error
62	SM-EtherCAT	Database initialization error
63	SM-EtherCAT	File system initialization error
64	SM-DeviceNet	Expected packet rate timeout
65	SM-PROFIBUS-DP, SM-INTERBUS, SM-DeviceNet, SM-CANOpen, SM-SERCOS, SM-LON	Network loss
66	SM-PROFIBUS-DP	Critical link failure
	SM-CAN, SM-DeviceNet, SM-CANOpen	Bus off error
69	SM-CAN, SM-EtherCAT	No acknowledgement
70	All (except SM-Ethernet and SM-LON)	Flash transfer error
	SM-Ethernet, SM-LON	No valid menu data available for the module from the drive
74	All	Solutions module over temperature
75	SM-Ethernet, SM-EtherCAT	The drive is not responding
76	SM-Ethernet, SM-EtherCAT	The Modbus connection has timed out
80	All (except SM-SERCOS)	Inter-option communications error
81	All (except SM-SERCOS)	Communications error to slot 1
82	All (except SM-SERCOS)	Communications error to slot 2
83	All (except SM-SERCOS)	Communications error to slot 3
84	SM-Ethernet, SM-EtherCAT	Memory allocation error
85	SM-Ethernet, SM-EtherCAT	File system error
86	SM-Ethernet, SM-EtherCAT	Configuration file error
87	SM-Ethernet	Language file error
97	SM-Ethernet	Timed event over-run
98	All	Internal watchdog error
99	All	Internal software error

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**SLM module category** Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the SM-SLM. See the *Diagnostics* section in the *SM-SLM User Guide* for more information.

Error Code	Trip Description
0	No fault detected
1	Power supply overloaded
2	SLM version is too low
3	DriveLink error
4	Incorrect switching frequency selected
5	Feedback source selection incorrect
6	Encoder error
7	Motor object number of instances error
8	Motor object list version error
9	Performance object number of instances error
10	Parameter channel error
11	Drive operating mode incompatible
12	Error writing to the SLM EEPROM
13	Motor object type incorrect
14	Unidrive SP object error
15	Encoder object CRC error
16	Motor object CRC error
17	Performance object CRC error
18	Unidrive SP object CRC error
19	Sequencer timeout
74	Solutions module over temperature

Trip	Diagnosis
SLX.HF	**Solutions Module slot X trip: Solutions Module X hardware fault**
200,205,210	Ensure Solutions Module is installed correctly Return Solutions Module to supplier
SLX.nF	**Solutions Module slot X trip: Solutions Module has been removed**
203,208,213	Ensure Solutions Module is installed correctly Reinstall Solutions Module Save parameters and reset drive
SL.rtd	**Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect**
215	Press reset. If the trip persists, contact the supplier of the drive.
SLX.tO	**Solutions Module slot X trip: Solutions Module watchdog timeout**
201,206,211	Press reset. If the trip persists, contact the supplier of the drive.
t038	**User defined trip**
38	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
t040 to t089	**User defined trip**
40 to 89	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
t099	**User defined trip**
99	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
t101	**User defined trip**
101	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
t112 to t160	**User defined trip**
112 to 160	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
t168 to t174	**User defined trip**
168 to 174	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip

Trip	Diagnosis
t216	**User defined trip**
216	Onboard PLC and/or SM-Applications program must be interrogated to find the cause of this trip
th	**Motor thermistor trip**
24	Check motor temperature Check thermistor continuity Set Pr **7.15** = VOLt and reset the drive to disable this function
thS	**Motor thermistor short circuit**
25	Check motor thermistor wiring Replace motor / motor thermistor Set Pr **7.15** = VOLt and reset the drive to disable this function
tunE*	**Autotune stopped before completion**
18	The drive has tripped out during the autotune The red stop key has been pressed during the autotune The SAFE TORQUE OFF signal (terminal 31) was active during the autotune procedure
tunE1*	**The position feedback did not change or required speed could not be reached during the inertia test (see Pr 5.12)**
11	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 feedback parameters are set correctly Check encoder coupling to motor
tunE2*	**Position feedback direction incorrect or motor could not be stopped during the inertia test (see Pr 5.12)**
12	Check motor cable wiring is correct Check feedback device wiring is correct Swap any two motor phases (closed loop vector only)
tunE3*	**Drive encoder commutation signals connected incorrectly or measured inertia out of range (see Pr 5.12)**
13	Check motor cable wiring is correct Check feedback device U,V and W commutation signal wiring is correct
tunE4*	**Drive encoder U commutation signal fail during an autotune**
14	Check feedback device U phase commutation wires continuity Replace encoder
tunE5*	**Drive encoder V commutation signal fail during an autotune**
15	Check feedback device V phase commutation wires continuity Replace encoder
tunE6*	**Drive encoder W commutation signal fail during an autotune**
16	Check feedback device W phase commutation wires continuity Replace encoder
tunE7*	**Motor number of poles set incorrectly**
17	Check lines per revolution for feedback device Check the number of poles in Pr **5.11** is set correctly
Unid.P	**Power module unidentified trip**
110	Check all interconnecting cables between power modules Ensure cables are routed away from electrical noise sources
UP ACC	**Onboard PLC program: cannot access Onboard PLC program file on drive**
98	Disable drive - write access is not allowed when the drive is enabled Another source is already accessing Onboard PLC program - retry once other action is complete
UP div0	**Onboard PLC program attempted divide by zero**
90	Check program
UP OFL	**Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)**
95	Check program
UP ovr	**Onboard PLC program attempted out of range parameter write**
94	Check program
UP PAr	**Onboard PLC program attempted access to a non-existent parameter**
91	Check program

Trip	Diagnosis
UP ro	**Onboard PLC program attempted write to a read-only parameter**
92	Check program
UP So	**Onboard PLC program attempted read of a write-only parameter**
93	Check program
UP udF	**Onboard PLC program un-defined trip**
97	Check program
UP uSEr	**Onboard PLC program requested a trip**
96	Check program
UV	**DC bus under voltage threshold reached**
1	Check AC supply voltage level **Drive voltage rating (Vac)** / **Under voltage threshold (Vdc)** / **UV reset voltage (Vdc)** 200 / 175 / 215V 400 / 330 / 425V 575 & 690 / 435 / 590V

*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 input (terminal 31), drive enable parameter (Pr **6.15**) or the control word (Pr **6.42** and Pr **6.43**).

Table 5-10 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	OIdC.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	HF17
37	PSAVE.Er	179	C.Chg	218	HF18
38	t038	180	C.OPtn	219	HF19
39	L.SYnC	181	C.RdO	220 to 232	HF20 to HF32

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.

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 HFxx.
2	Non-resetable trips	HF17 to HF32, SL1.HF, SL2.HF, SL3.HF	Cannot be reset.
3	EEF trip	EEF	Cannot be reset unless a code to load defaults is first entered in Pr **x.00** or Pr **11.43**.
4	SMART card 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	SMART card trips have priority 5 during power up.
4	Encoder power supply trips	PS.24V, Enc1	These trips can only override the following priority 5 trips: Enc2 - Enc8 or Enc11 - En17
5	Normal trips with extended reset	OI.AC, OI.br, OIAC.P, OIbr.P, OidC.P	Can be reset after 10.0s
5	Normal trips	All other trips not included in this table	
5	Non-important trips	Old1, cL2, cL3, SCL	If bit 0 of Pr **10.37** is 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 reseting trips	UU	Under voltage trip cannot be reset by the user, but is automatically reset by the drive when the supply voltage is with specification.

Unless otherwise stated trips cannot be reset until 1.0s after the trip has been accepted by the drive.

Power module trips

Trips 101 to 110 are power module trips that are initiated by the drive power electronics module, or modules for a multi-module parallel drive. The trip identifier for each of these trips is in the form "xxxx.P". If the drive is a single module drive, and does not use the power interface intended for parallel operation, (SP4xxx to SP6xxx only) OIdC.P, Oht4.P and Unid.P power module trip are possible. When the trip string is displayed the trip source module number is not displayed and the module number stored in the "module number and trip time log" is zero. If the drive is a multi-module parallel drive or a single module drive using the power interface intended for parallel operation (SPMAxxxx and SPMDxxxx) all the power module trips are possible, the trip source module is displayed with the trip string and the module number is stored in the log. A PH.P trip is initiated if some, but not all parallel modules detect mains loss via their input stage to ensure that the input stages of the remaining modules are not overloaded. If mains loss is detected by all modules then the normal mains loss system based on DC bus monitoring is used. A PH.P trip occurs if any modules detect phase loss via their input stage.The normal phase loss system which detects phase loss from DC bus voltage ripple cannot be used in case different phases have been lost by different modules or if the system is a 12 pulse or higher system.

Braking IGBT control

The braking IGBT continues to operate even when the drive is not enabled (except if the active supply is a low voltage supply, see Pr **6.44**), 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 or OV or any HFxx trip.

UU trip

It should be noted that although the UU 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 UU trip:

1. Power down save user parameters are saved when UU trip is activated except when the main high voltage supply is not active (Pr **6.44** = 1).
2. The UU trip is self-resetting when the DC bus voltage rises above the drive restart voltage level. If another trip is active instead of UU at this point, the trip is not reset.
3. The drive can change between using the main high voltage supply and low voltage battery supply only when the drive is in the under voltage condition (Pr **10.16** = 1). The UU 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 UU 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.

Table 5-11 Hardware fault trips

HF fault code	Reason for trip
01	CPU address error
02	DMAC address error
03	Illegal instruction
04	Illegal slot instruction
05	Undefined exception
06	Reserved exception
07	Watchdog failure
08	Level 4 crash
09	Heap overflow
10	Router error
11	Access to the EEPROM failed or incorrect EEPROMs installed.
12	Main program stack overflow
13	The drive firmware is not compatible with the drive hardware
14-16	Not used
17	Power circuit - Multi-module system thermistor short circuit
18	Power circuit - Multi-module system interconnect cable error
19	Power circuit - temperature feedback multiplexer failure
20	Power circuit - identification code error
21	Power circuit - unrecognised frame size
22	Power circuit - multi-module frame size mismatch
23	Power circuit - multi-module voltage rating mismatch
24	Power circuit - unrecognised drive size
25	Current feedback offset error
26	Soft start relay failed to close, or soft start monitor failed, or braking IGBT short circuit at power-up
27	Power circuit thermistor 1 fault
28	Power circuit thermistor 2 or 3 fault / Internal fan fault for some drive sizes.
29	Control board thermistor fault
30	DCCT wired break trip from power module
31	Aux fan failure from power module or a module in a multi module system that has not powered up
32	Power stage - identification and trip information serial code error

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

For SP0xxx, SP1xxx and SP2xxx drives the default value is a suitable value for standard braking resistors that can be mounted within the drive heatsink as given in the table below. For larger drives the default is 0.00.

Drive voltage rating	Parameter default		
	SP0xxx	SP1xxx and SP2xxx	All other sizes
200V	0.06s	0.09s	0.00s
400V	0.01s	0.02s	0.00s
575V and 690V	N/A	N/A	0.00s

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

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

10.31	Full power braking period															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.0 to 1500.0 s														
Default	Open-loop, Closed-loop vector, Servo, Regen	See below														
Update rate	Background read															

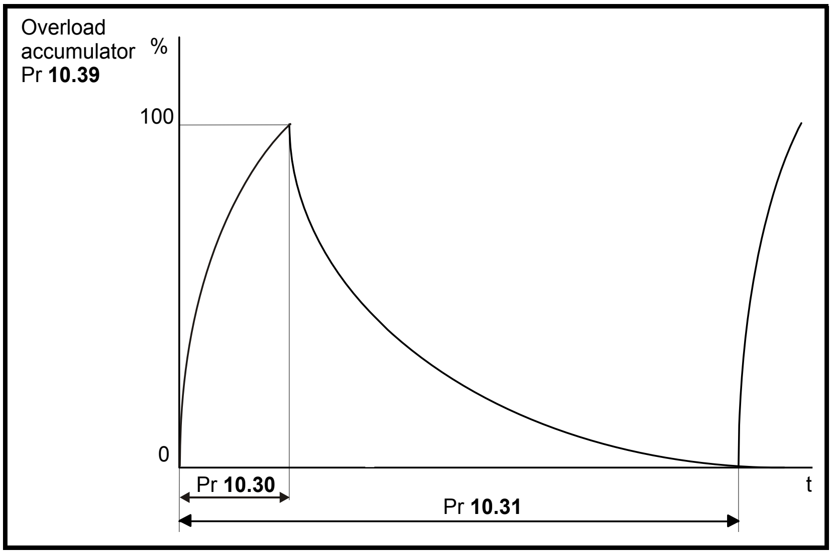
This parameter defines the time between periods when the braking IGBT is on for the full power braking time so that the average power in the resistor does not exceed the rating of the resistor.

For SP0xxx, SP1xxx and SP2xxx drives the default value is a suitable value for standard braking resistors that can be mounted within the drive as given in the table below.

Drive voltage rating	Parameter default		
	SP0xxx	**SP1xxx, SP2xxx**	**All other sizes**
200V	2.6s	3.3s	0.00s
400V	1.7s	3.3s	0.00s
575V and 690V	N/A	N/A	0.00s

If Pr **10.31** is set to zero then the braking resistor thermal protection system is disabled.

The braking resistor temperature is modelled by the drive as shown below. The temperature rises in proportion to the power flowing into the resistor and falls in proportion to the difference between the resistor temperature and ambient. Under the conditions shown the resistor is heating up just to 100% of its rated temperature during each braking period.



Assuming that the full power braking time is much shorter than the full power braking period i.e. Pr **10.30** < Pr **10.31** /10 (which is normally the case) the values for Pr **10.30** and Pr **10.31** can be calculated as follows:

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

Where:

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

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

Where:

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

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

If the average power rating of the resistor is not to be exceeded in the cycle shown in the diagram above, the average power in the resistor is given by

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

Where:

Tp is the full power braking period

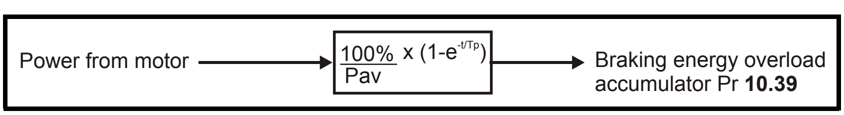
$P_{on} = E / T_{on}$

Therefore $P_{av} = E / Tp$

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

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

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



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

10.32	**External trip**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

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

10.33	**Drive reset**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

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

10.34	**No. of auto-reset attempts**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 5														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

10.35	**Auto-reset delay**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.0 to 25.0 s														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.0														
Update rate	Background read															

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

10.36	**Hold drive ok until last attempt**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

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

10.37	Action on trip detection															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 15														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

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 (size 0 only)
3	Disable braking resistor temperature monitoring failure detection (size 0 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 (size 0 only)

The user can disable the phase loss trip in 200V size 0 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 size 0 drives only.

Disable braking resistor temperature monitoring failure detection

Size 0 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 size 0 drives.

10.38	User trip															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 255														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

When a value other than zero is written to the user trip parameter the actions described in the following table are performed. The drive immediately writes the value back to zero. If the value is not included in the table a trip is initiated with the same trip number as the value provided the drive is not already tripped.

Action	Values written to 10.38	Trip code
No action	1 31 200 205 210 217-245	UU EEF SL1.HF SL2.HF SL3.HF HFx
Drive reset	100	
Clear trip and trip time logs	255	

10.39	**Braking energy overload accumulator**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to 100.0 %								
Update rate	Background read															

This parameter gives an indication of braking resistor temperature based on a simple thermal model, see Pr **10.30** and Pr **10.31** on page 198. Zero indicates the resistor is close to ambient and 100% is the maximum temperature (trip level). A br.rS warning is given if this parameter is above 75% and the braking IGBT active.

10.40	**Status word**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 32,767								
Update rate	Background write															

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

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

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

10.41	**Trip 0 time: years.days**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							0.000 to 9.364 Years.Days								
Update rate	Background write															

10.42	**Module number for trip 0, or Trip 0 time: hours.minutes**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
		1					2	1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							00.00 to 23.59 Hours.Minutes								
Update rate	Background write															

10.43	**Module number for trip 1, or Trip 1 time**															
10.44	**Module number for trip 2, or Trip 2 time**															
10.45	**Module number for trip 3, or Trip 3 time**															
10.46	**Module number for trip 4, or Trip 4 time**															
10.47	**Module number for trip 5, or Trip 5 time**															
10.48	**Module number for trip 6, or Trip 6 time**															
10.49	**Module number for trip 7, or Trip 7 time**															
10.50	**Module number for trip 8, or Trip 8 time**															
10.51	**Module number for trip 9, or Trip 9 time**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 600.00 Hours.Minutes								
Update rate	Background write															

Pr 6.49 = 0

These parameters are used to store the module number if the trip has been initiated by the power module hardware (trips numbers 101 to 110, HF30 and HF31). Pr **10.42** is used to store the module number related to the latest trip stored in Pr **10.20**, and Pr **10.43** to Pr **10.51** store the module numbers related to the trips stored in Pr **10.21** to Pr **10.29**. If the drive has only one power module and this module is not using the power interface intended for parallel operation (SP1xxx to SP6xxx) then Pr **10.42** to Pr **10.51** are always zero. If the drive has more than one parallel power module or is a single module drive using the power interface intended for parallel operation (SPMAxxxx and SPMDxxxx) then the values in Pr **10.42** to Pr **10.51** can be used to identify the power module that initiated the trip. As these parameters are also used to show Hours.Minutes the module number is shown with 2 decimal places, i.e. module 1 is shown as 0.01, etc.. Pr **10.41** is always zero.

Pr 6.49 = 1

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

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

5.13 Menu 11: General drive set-up

11.01	**Parameter 0.11 set-up**
11.02	**Parameter 0.12 set-up**
11.03	**Parameter 0.13 set-up**
11.04	**Parameter 0.14 set-up**
11.05	**Parameter 0.15 set-up**
11.06	**Parameter 0.16 set-up**
11.07	**Parameter 0.17 set-up**
11.08	**Parameter 0.18 set-up**
11.09	**Parameter 0.19 set-up**
11.10	**Parameter 0.20 set-up**
11.11	**Parameter 0.21 set-up**
11.12	**Parameter 0.22 set-up**
11.13	**Parameter 0.23 set-up**
11.14	**Parameter 0.24 set-up**
11.15	**Parameter 0.25 set-up**
11.16	**Parameter 0.26 set-up**
11.17	**Parameter 0.27 set-up**
11.18	**Parameter 0.28 set-up**
11.19	**Parameter 0.29 set-up**
11.20	**Parameter 0.30 set-up**
Drive modes	Open-loop, Closed-loop vector, Servo, Regen

Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	

Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **1.00** to Pr **21.51**
Default	Open-loop, Closed-loop vector, Servo, Regen	See Table 5-12
Update rate	Background read	

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

Table 5-12 Default settings:

Parameter	Menu 0	Open-loop	Closed-loop vector	Servo	Regen
Pr **11.01**	Pr **0.11**	Pr **5.01**	Pr **5.01**	Pr **3.29**	Pr **5.01**
Pr **11.02**	Pr **0.12**	Pr **4.01**	Pr **4.01**	Pr **4.01**	Pr **4.01**
Pr **11.03**	Pr **0.13**	Pr **4.02**	Pr **4.02**	Pr **7.07**	Pr **4.02**
Pr **11.04**	Pr **0.14**	Pr **4.11**	Pr **4.11**	Pr **4.11**	Pr **5.03**
Pr **11.05**	Pr **0.15**	Pr **2.04**	Pr **2.04**	Pr **2.04**	Pr **3.01**
Pr **11.06**	Pr **0.16**	Pr **8.39**	Pr **2.02**	Pr **2.02**	Pr **3.02**
Pr **11.07**	Pr **0.17**	Pr **8.26**	Pr **4.12**	Pr **4.12**	Pr **4.08**
Pr **11.08**	Pr **0.18**	Pr **8.29**	Pr **8.29**	Pr **8.29**	Pr **8.29**
Pr **11.09**	Pr **0.19**	Pr **7.11**	Pr **7.11**	Pr **7.11**	Pr **7.11**
Pr **11.10**	Pr **0.20**	Pr **7.14**	Pr **7.14**	Pr **7.14**	Pr **7.14**
Pr **11.11**	Pr **0.21**	Pr **7.15**	Pr **7.15**	Pr **7.15**	Pr **7.15**
Pr **11.12**	Pr **0.22**	Pr **1.10**	Pr **1.10**	Pr **1.10**	Pr **0.00**
Pr **11.13**	Pr **0.23**	Pr **1.05**	Pr **1.05**	Pr **1.05**	Pr **0.00**
Pr **11.14**	Pr **0.24**	Pr **1.21**	Pr **1.21**	Pr **1.21**	Pr **0.00**
Pr **11.15**	Pr **0.25**	Pr **1.22**	Pr **1.22**	Pr **1.22**	Pr **0.00**
Pr **11.16**	Pr **0.26**	Pr **1.23**	Pr **3.08**	Pr **3.08**	Pr **0.00**
Pr **11.17**	Pr **0.27**	Pr **1.24**	Pr **3.34**	Pr **3.34**	Pr **0.00**
Pr **11.18**	Pr **0.28**	Pr **6.13**	Pr **6.13**	Pr **6.13**	Pr **0.00**
Pr **11.19**	Pr **0.29**	Pr **11.36**	Pr **11.36**	Pr **11.36**	Pr **11.36**
Pr **11.20**	Pr **0.30**	Pr **11.42**	Pr **11.42**	Pr **11.42**	Pr **11.42**

11.21	**Parameter 0.30 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 9.999														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

This parameter may be used to scale the value of Pr **0.30** seen via the LED keypad (not via serial comms). Any parameter routed to Pr **0.30** may be scaled. Scaling is only applied in the status and view modes. If the parameter is edited via the keypad it reverts to its un-scaled value during editing.

11.22	**Parameter displayed at power-up**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **0.59**														
Default	Open-loop, Closed-loop vector, Servo Regen	Pr **0.10** Pr **0.11**														
Update rate	Background read															

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

11.23	**Serial address**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	00 to 247														
Default	Open-loop, Closed-loop vector, Servo, Regen	1														
Update rate	Background read															

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

ANSI

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

Modbus RTU

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

11.24	**Serial mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 2														
Default	Open-loop, Closed-loop vector, Servo, Regen	1														
Update rate	Background read															

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

Parameter value	String	Comms mode
0	AnSI	ANSIx3.28 protocol
1	rtU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but only with an LCD keypad

ANSIx3.28 protocol

Full details of the CT implementation of ANSIx3.28 are given in Chapter 7 *Serial communications protocol* on page 402.

Modbus RTU protocol

Full details of the CT implementation of Modbus RTU are given in Chapter 7 *Serial communications protocol* on page 402.

The protocol provides the following facilities:

- Drive parameter access with basic Modbus RTU
- The protocol supports access to 32 bit floating point parameters

The following product specific limitations apply:

- Maximum slave response time when accessing the drive is 100ms
- Maximum number of 16 bit registers that can be written to, or read from, the drive itself is limited to 16
- Maximum number of 16 bit registers that can be written to, or read from, a Solutions Module or via a Solutions Module - see Solutions Module User Guide
- The communications buffer can hold a maximum of 128bytes

Modbus RTU protocol, but with SM-Keypad Plus only

This setting is used for disabling comms access when the SM-Keypad Plus is used as a hardware key. See the SM-Keypad Plus User Guide for more information.

11.25	Baud rate															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 9														
Default	Open-loop, Closed-loop vector, Servo, Regen	6														
Update rate	Background read															

Used in all comms modes to define the baud rate.

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

*Modbus RTU only

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

11.26	**Minimum comms transmit delay**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 250 ms														
Default	Open-loop, Closed-loop vector, Servo, Regen	2														
Update rate	Background read															

There will always be a finite delay between the end of a message from the host (master) and the time at which the host is ready to receive the response from the drive (slave). The drive does not respond until at least 1ms after the message has been received from the host allowing 1ms for the host to change from transmit to receive mode. This initial delay can be extended using Pr **11.26** if required for both ANSI and Modbus RTU protocols.

Pr 11.26	Action
0	The transmit buffers are turned on and data transmission begins immediately after the initial delay (≥ 1ms)
1	The transmit buffers are turned on after the initial delay (≥ 1ms) and data transmission begins after 1ms.
2 or more	The transmit buffers are turned on after the initial delay (≥ 1ms) a delay of at least the time specified in Pr **11.26** and data transmission begins 1ms later.

Note that the drive holds its own transmitters active for up to 1ms after it has transmitted data before switching to the receive mode, the host should not send any data during this time.

Modbus RTU uses a silent period detection system to detect the end of a message. This silent period is either the length of time for 3.5 characters at the present baud rate or the length of time set in Pr **11.26**, whichever is the longest.

11.28	**Drive derivative**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 16														
Update rate	Write at power-up															

If this parameter is zero the drive is a standard Unidrive SP product. If this parameter is non-zero then the product is a derivative product. Derivatives can have different defaults from the standard product and restrictions on the values allowed for some parameters.

11.29	**Software version**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	1.00 to 99.99														
Update rate	Write at power-up															

The drive software version consists of three numbers xx.yy.zz. Pr **11.29** displays xx.yy and zz is displayed in Pr **11.34**. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation.

11.30	**User security code**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1		1	1	1
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 999														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

If any number other than 0 is programmed into this parameter user security is applied so that no parameters except Pr **11.44** can be adjusted with the LED keypad. When this parameter is read via an LED keypad and security is locked it appears as zero. The security code can be modified via serial comms etc. by setting this parameter to the required value, setting Pr **11.44** to 2 and initiating a reset by setting Pr **10.38** to 100. However security can only be cleared via the LED keypad.

11.31	**User drive mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1		1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	1 to 4														
Default	Open-loop Closed-loop vector Servo Regen	1 2 3 4														
Update rate	Background read															

This parameter defines the drive mode. If this parameter is changed from the current drive mode, Pr **x.00** is set to 1253, 1254, 1255 or 1256, and then the drive is reset the drive mode is changed to the mode defined by this parameter. After the mode change the default settings of all parameters will be set according to drive mode. The drive mode will not be changed if the drive is running. If the parameter value is changed and a reset is initiated, but Pr **x.00** is not equal to 1253, 1254, 1255 or 1256, or the drive is running, this parameter is set back to the value for the current drive mode and the drive mode is not changed.

Parameter value	String	Drive mode
1	OPEn LP	Open-loop
2	CL VECt	Closed-loop vector
3	serVO	Servo
4	REGEn	Regen

11.32	**Maximum Heavy Duty current rating**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.00 to 9999.99 A														
Update rate	Write at power-up															

This parameter indicates the continuous current rating of the drive for Heavy Duty operation. See section 5.6 *Menu 4: Torque and current control* on page 88 for more details.

11.33	**Drive voltage rating**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 (200) to 3 (690)														
Update rate	Write at power-up															

This parameter has four possible values (200, 400, 575, 690) and indicates the voltage rating of the drive.

11.34	**Software sub-version**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 99														
Update rate	Write at power-up															

The drive software version consists of three numbers xx.yy.zz. Pr **11.29** displays xx.yy and zz is displayed in Pr **11.34**. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation.

11.35	**Number of modules**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 10														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

This parameter can be used to initiate a ConF.P trip if the number of power modules actually connected together in a multi-module drive is different from the expected number. This can be used for example to detect if the control connection between modules has been disconnected. If Pr **11.35** is set to the default value of zero, this feature is disabled and ConF.P trips will not occur. If the feature is required, Pr **11.35** should be set to the actual number of power modules and parameters should be saved. When the drive subsequently powers up the number of power modules is checked and if the actual number of modules is different from Pr **11.35** a ConF.P trip is initiated.

V01.09.01 and earlier

This parameter indicates the number of modules installed in a system. If the drive cannot be used in a multi-module system the value is always 1.

11.36	**SMARTCARD parameter data previously loaded**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1		1	1		1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 999														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background write															

This parameter shows the number of the data block last parameter or difference from default data block transferred from a SMARTCARD to the drive.

11.37	**SMARTCARD data number**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 1003														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

Data blocks are stored on a SMARTCARD with header information including a number to identify the block .The header information also includes the type of data stored in the block (i.e. the file type), the drive mode if this is parameter or difference from default data, the version number and a checksum. This data can be viewed through Pr **11.38** to Pr **11.40** by increasing or decreasing Pr **11.37**. This parameter jumps between the data numbers of the data blocks present on the card.

If this parameter is increased above the highest data block on the card it can have the special values given below:

1000 - shows the space left on the card for data blocks in 16 byte pages

1001 - shows the total space available on the card for data blocks in 16 byte pages

1002 - shows the state of the read-only (bit 0) and warning suppression flags (bit 1)

1003 - shows the product identifier

It should be noted that 16 bytes are reserved at the beginning and the end of the card that cannot be used to hold data. Therefore a 4096 byte card has 4064 bytes (254 x 16 byte pages) available to hold data. Compatible cards from 4Kbytes to 512Kbytes may be used with the drive. The first 16 bytes on the card hold the card header information including the read-only flag, which can be set to make the whole card read-only, and the warning suppression flag, which can be set to prevent C.rtg and C.Optn trips when data is transferred to the drive from a card. The card header also contains the product identifier which is described later.

The actions of erasing a card, erasing a file, creating a new file, changing a menu 0 parameter, or inserting a new card will set Pr **11.37** to 0.

Various SMART card actions can be initiated via Pr **x.00** or the copying (Pr **11.42**) and reseting the drive as given in the table below:

Code	Action
Pr **x.00** = 2001	Transfer drive parameters as difference from defaults to a bootable SMART card block with block number 1. (This will clear data block 1 on the card if it already exists).
Pr **x.00** = 3yyy	Transfer drive parameters to a SMART card block number yyy as a parameter file
Pr **x.00** = 4yyy	Transfer drive data to a SMART card block number yyy as difference from defaults file
Pr **x.00** = 5yyy	Transfer drive user program to SMART card block number yyy
Pr **x.00** = 6yyy	Transfer SMART card data block yyy to the drive
Pr **x.00** = 7yyy	Erase SMART card data block yyy
Pr **x.00** = 8yyy	Compare drive parameters with block yyy
Pr **x.00** = 9555	Clear SMART card warning suppression flag
Pr **x.00** = 9666	Set SMART card warning suppression flag
Pr **x.00** = 9777	Clear smart card read-only flag
Pr **x.00** = 9888	Set smart card read-only flag
Pr **x.00** = 9999	Erase SMART card
Pr **11.42** = Read	Transfer SMART card data block 1 to the drive provided it is a parameter file
Pr **11.42** = Prog	Transfer drive parameters to a SMART card block number one as a parameter file
Pr **11.42** = Auto Pr **11.42** = boot	Transfer drive parameters to a SMART card block with data block number 1 as a parameter file provided Pr **11.42** has been changed since power-up.

The data, and the format of the data, is different depending on the method used to store it on a SMART card. The different formats are described below. In addition to data transfers a compare function is provided.

If 8yyy is entered in Pr **x.00** and the drive is reset data block yyy on the SMARTCARD is compared with the data in the drive. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a trip is initiated and parameter x.00 is not cleared. This function can be used with all data block types except the option type (18).

Parameter file type data block

This type of data block is created when 3xxx in Pr **x.00**, the copying parameter (Pr **11.42**) or auto/boot mode is used to initiate the transfer. The data block (referred to as a parameter file) contains the complete data from all user save (US) parameters except those with the NC coding bit set. Parameter RAM is used as the source of this information. Power-down save (PS) are not saved to the SMART card. When the data is transferred back to a drive, it is transferred to the drive RAM and then the drive EEPROM. A parameter save is not required to retain the data after power-down. Before the data is taken from the card, defaults are loaded in the destination drive using the same default code as was last used in the source drive.

Difference from defaults type data block

This type of data block is created when 4xxx in Pr **x.00** is used to initiate the transfer. This data block format (referred to a difference from defaults file) is different depending on the software version. The data held in the data block has changed between different software versions as follows:

Before V01.07.00

Parameters that are different from the last defaults loaded. The parameter must have the following attributes: NC=0 (clonable), ND=0 (has a default) and US=1 (user save).

V01.07.xx

Parameters that are different from the last defaults loaded. The parameter must have the following attributes: NC=0 (clonable), ND=0 (has a default) and US=1 (user save). In addition to these parameters all menu 20 parameters except Pr **20.00** if they are different from their default value.

V01.08.00 onwards

Parameters with the following attributes: NC=0 (clonable) and US=1 (user save), and menu 20 parameters except Pr **20.00** if they are different from their default value. If a parameter is user save (US), but has no default (ND) it is saved on the card whatever its value.

It is possible to transfer parameters between drives with each of the software version dependant formats, however, the data block compare function does not work with data produced by the different formats.

The data density is not as high as a parameter file type data block, 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 example, for creating drive macros. Parameter RAM is used as the source of this information.

When the data is transferred back to a drive, using 6yyy in Pr **x.00**, it is transferred to the drive RAM and then to the drive EEPROM. A parameter save is not required to retain the data after power-down.

Onboard Application Lite user program data blocks

This type of data block is created when 5xxx in Pr **x.00** is used to initiate the transfer. The Onboard Application Lite user program from a drive may be transferred to/from internal flash memory from/to a SMART card. If the user program is transferred from a drive with no program loaded the block is still created on the card, but contains no data. If this is then transferred to a drive the drive will then have no user program.

When transferring data between drives the following should be noted:

Parameter transfer failure

When parameter or default difference data is transferred to the drive the parameters are automatically saved to drive EEPROM. If the transfer from the card fails for any reason the drive produces the appropriate trip. If the failure occurs after the transfer has begun, it is possible that some, but not all the parameters will have been updated with the card data. However, if the transfer fails the parameters are not saved to drive EEPROM, therefore only the RAM values will be incorrect. If the drive is powered down and then powered up again the original drive parameters will be restored.

Read-only function

Data blocks with numbers from 1 to 499 can be created or erased by the user. Data block with numbers 500 and above are read-only and cannot be created or erased by the user. The whole card may also be protected from writing or erasing by setting the read-only flag. If the card or a data block on the card is read-only, then the operation to erase the whole card is disabled.

Changing the drive mode

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 only exception is that the mode cannot be changed to a mode that is not allowed for the particular derivative of drive, e.g. Regen mode is not allowed with the Unidrive ES derivative. If an attempt is made to change to a disallowed mode the drive produces a C.Typ trip.

Different voltage ratings

If the voltage rating of the source and destination drive are different then the parameters are transferred with the exception of rating dependent parameters (RA attribute set, see table below), which are left at their default values. In this case a C.rtg trip is given as a warning that this has happened. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

Parameter number	Function
Pr **2.08**	Standard ramp voltage
Pr **3.05**	Regen unit voltage setpoint
Pr **4.05** - Pr **4.07**, Pr **21.27**- 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**	D.C. injection braking current
Pr **6.48**	Mains loss ride through detection level

Different Solutions Modules installed

If the categories of the Solutions Modules installed to the source drive are different to the destination drive then the parameters are transferred with the exception of the parameters in the menus of the modules that are different. These parameters are left at their default values. In this case a C.Optn trip is given as a warning. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

Different current rating with a parameter file type data block

If the current ratings of the source and destination drive are different and the parameters stored as a parameter file (not differences from default) then rating dependant parameters are set to their defaults and a C.rtg trip is produced as described above where the voltage ratings are different. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

Different current rating with difference from defaults type data block

If the current ratings of the source and destination drives are different, but the parameters are stored as a difference from defaults file, the rating dependant parameters are transferred from the card to the drive and the appropriate maximums are applied. The C.rtg is still produced unless it is suppressed. To ensure that the performance of the destination drive is similar to that of the source drive, the speed controller gains and current controller gains are scaled as shown in the table below. Note that the gain scaling is only applied when the data block number is less than 500.

Drive modes	Gains	Scaling applied
Closed-loop vector Servo	Speed controller gains	x Source Pr **11.32** / Destination Pr **11.32**
Closed-loop vector Servo Regen	Current controller gains	x Destination Pr **11.32** / Source Pr **11.32**

Effects of variable maximums if ratings or options are different

It should be noted that if ratings of the source and destination drives are different, or the Solutions Modules installed to the source and destination drives are different, it is possible that some parameters with variable maximums may be limited and not have the same values as on the card. For example the user current maximum scaling (Pr **4.24**) is rating dependent and could be set to its default value when it is transferred between drives of different ratings, but this could also affect the torque reference (Pr **4.08**) as this uses Pr **4.24** as its maximum. Also different position feedback Solutions Modules can apply different limits on the speed references, therefore these can be affected when parameters are transferred between drives with different position feedback Solutions Modules installed where the Solutions Module is being used for the drive position feedback.

Unexpected rating changes

Some drive ratings may change between software versions, for example the derating factor for multi-module drives has changed between versions V01.08.01 and V01.09.00. These changes will cause a C.rtg trip when parameters are transferred between drives of different software versions where the rating has changed.

Product identifier

When a SMART card is used with software version V01.11.00 onwards it must have the correct product identifier in the card header to give full functionality with the drive. The product identifier is written to the card when the whole card is erased.

Product	Product Identifier
Unidrive SP (standard)	255
Commander GP20	1
Digitax ST	2
Affinity	3
Mentor MP	4

If the identifier does not match the drive product and the card contains any data blocks a C.Prod trip is produced. Also if the following functions are initiated a C.Acc trip is produced and the card or drive data is not affected: erase file, transfer data block from card to drive, or transfer data block from drive to card. It is still possible to use Pr **11.37** to browse information about the whole card (i.e. Pr **11.37** = 1000 to 1003), but it is not possible to see the data block information (i.e. Pr **11.37** < 1000). It is also possible to change the card header information (i.e. read-only flag and warning suppression flag). This feature allows the read-only flag to be cleared so that a card can be erased to be used with the product that performs the card erase.

If the card does not contain any data blocks (i.e. an erased card) and the identifier does not match that of the drive then the drive will automatically change the identifier on the card to match when it is first inserted.

11.38	**SMARTCARD data type/mode**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Open-loop, Closed-loop, Servo, Regen							0 to 18								
Update rate	Background write															

Gives the type/mode of the data block selected with Pr **11.37** as shown below.

Pr 11.38	String	Type/mode
0	FrEE	Value when Pr **11.37** = 0
1	3C.SE	Commander SE mode parameter file (not used)
2	3OPEn.LP	Open-loop mode parameter file
3	3CL.VECt	Closed-loop vector mode parameter file
4	3SErVO	Servo mode parameter file
5	3REGEn	Regen mode parameter file
6-8	3Un	Unused
9	4C.SE	Commander SE mode difference from default file (not used)
10	4OPEn.LP	Open-loop mode difference from default file
11	4CL.VECt	Closed-loop vector mode difference from default file
12	4SErVO	Servo mode difference from default file
13	4REGEn	Regen mode difference from default file
14-16	4Un	Unused
17	LAddEr	Onboard Application Lite user program file
18	Option	A file containing user defined data (normally created by an SM-Applications Solutions Module)

11.39	**SMARTCARD data version**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop, Servo, Regen	0 to 9,999														
Default	Open-loop, Closed-loop, Servo, Regen	0														
Update rate	Background read/write															

Gives the version number of the data block. This is intended to be used when data blocks are used as drive macros. If a version number is to be stored with a data block this parameter should be set to the required version number before the data is transferred. Each time Pr **11.37** is changed by the user the drive puts the version number of the currently viewed data block in this parameter.

11.40	**SMARTCARD data checksum**															
Drive modes	Open-loop, Closed-loop, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop, Servo, Regen	0 to 65,335														
Update rate	Background write															

Gives the checksum of the data block, space left on the card, the total space on the card for the card flags see Pr **11.37** for details.

11.41	**Status mode time-out**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 250 s														
Default	Open-loop, Closed-loop vector, Servo, Regen	240														
Update rate	Background read															

Sets the timeout for the drive display to revert to status mode from edit mode following no key presses. Although this parameter can be set to less than 2s, the minimum timeout is 2s.

11.42	**Parameter copying**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1					1			*	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								0 to 4							
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	Background read															

* Modes 1 and 2 are not US (i.e. not saved when drive parameters are saved), mode 3 and 4 are US.

Therefore this parameter can only be saved to EEPROM if it has a value of 0, 3 or 4.

Reading (1)

Setting Pr **11.42** to 1 and resetting the drive will transfer the data from the card into the drive parameters and then the drive EEPROM, provided data block 1 exists and is a parameter file for the current drive mode. All smart card trips apply. When the action is complete this parameter is automatically reset to zero.

Programming (2)

Setting Pr **11.42** to 2 and resetting the drive will save the parameters to a card, i.e. equivalent to writing 3001 to Pr **x.00**. If the data block already exists it is automatically over-written. When the action is complete this parameter is automatically reset to zero.

Auto (3)

Changing Pr **11.42** to 3 and resetting the drive will save the complete parameter set from the drive parameters to the card, i.e. equivalent to writing 3001 to Pr **x.00**. If the data block already exists it is automatically overwritten. If the card is removed when Pr **11.42** is set to 3, Pr **11.42** will be set to 0. The action of setting Pr **11.42** to 0 when a card is removed forces the user to change Pr **11.42** back to 3 if auto mode is still required. The user will need to set Pr **11.42** to 3 and reset the drive to write the complete parameter set to the new card.

When a parameter in menu zero is changed via the keypad and a card is installed the parameter is saved both to the drive EEPROM and the card. Only the new value of the modified parameter is written to the EEPROM and the card. If Pr **11.42** was not cleared automatically when a card is removed, then when a new card is inserted that contains data block 1 the modified parameter would be written to the existing data block 1 on the new card and the rest of the parameters in this data block may not be the same as those in the drive.

When Pr **11.42** is equal to 3 and the parameters in the drive are saved, the card is also updated, therefore the card becomes a copy of the drive parameters. At power up, if Pr **11.42** is set to 3, the drive will save the complete parameter set to the card. This is done to ensure that if a card is inserted while the drive is powered down the new card will have the correct data after the drive is powered up again.

Boot (4)

When Pr **11.42** is set to 4 the drive operates in the same way as with Pr **11.42** set to 3 and automatically creates a copy of it parameters on a SMART card. Pr **11.42** has the NC (not clonable) attribute, and so it does not have a value stored on a SMART card in the normal way. However, when data is transferred to a card from the source drive the value of this parameter is held in the header of parameter or difference from default file type data blocks so that the destination drive can detect when boot transfer is required on power-up (i.e. the source drive had this parameter set to 4). If a card is present at power up, and it has Pr **11.42** stored as 4 in the header of a parameter file or difference from default file as data block 1 then the following actions are taken.

1. The parameters from data block 1 are transferred to the drive and then saved in drive EEPROM.
2. If data block 2 exists and is type 17 the user program from this data block is transferred to the drive.
3. Parameter Pr **11.42** is set to zero after the data transfer is complete.

It is possible to create a difference from default bootable file by setting parameter Pr **x.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 default file has the added advantage of including menu 20 parameters. A bootable difference from default file can only be created in one operation and parameters cannot be added as they are saved via menu zero.

When the drive is powered up it detects which Solutions Modules are installed before loading parameters from a SMART card which has been set up for boot mode. If a new Solutions Module has been installed since the last time the drive was powered up, the drive produces a SLx.dF trip and then proceeds to transfer the parameters from the SMART card. If the parameter data in the card includes the parameters for the newly installed Solutions Module then these are also transferred to the drive. Once the transfer is complete the drive parameters are automatically saved to the drive EEPROM. The SLx.dF trip can be reset either by resting the drive or powering down and then powering up again. Because the parameters are transferred to the drive after detecting the Solutions Modules it is possible to fit the required Solutions Modules to a drive (corresponding to the modules installed when the SMART card data was stored) and transfer the parameters to the drive including those for the Solutions Modules.

11.43	**Load defaults**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 2
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	Background read	

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

Setting this parameter to a non-zero value and resetting the drive loads defaults as follows. This parameter is automatically reset to zero when the action is complete.

Parameter value	Equivalent Pr x.00 value	Defaults loaded
1 (Eur)	1233	Normal defaults
2 (USA)	1244	US defaults

11.44	**Security status**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop, Servo, Regen	0 to 2
Update rate	Background read	

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

This parameter controls access via the 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.

11.45	**Motor 2 parameters select**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	Background read	

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

When this bit is set to one the motor 2 parameters in menu 21 become active instead of the equivalent parameters in other menus. Changes will only be implemented when the drive is disabled. When the motor 2 parameters are active the decimal point that is second from the right on the 1st row of the display is lit. If this parameter is one when an auto-tune is carried out (Pr **5.12** = 1), the results of the auto-tune are written to the equivalent second motor parameters instead of the normal parameters. Each time this parameter is changed the accumulator for motor thermal protection is reset to zero.

11.46	**Defaults previously loaded**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 2,000
Default	Open-loop, Closed-loop vector, Servo, Regen	Number of defaults loaded, i.e. 1,233 etc.
Update rate	Background write	

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

Displays the number of the last set of defaults loaded, i.e. 1233, 1244, etc.

11.47	**Drive Onboard Application Lite Ladder Program Enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 2								
Default	Open-loop, Closed-loop vector, Servo, Regen							2								
Update rate	Background read															

This parameter is used to start and stop the drive Onboard PLC program.

Value	Description
0	Halt the Drive Onboard Application Lite ladder Program.
1	Run the Drive Onboard Application Lite ladder 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 Application Lite ladder Program (if installed). Any out-of-range parameter writes attempted will cause a drive trip.

11.48	**Drive Onboard PLC program status**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							-128 to +127								
Update rate	Background write															

The Drive Onboard Application Lite Ladder Program Status parameter indicates to the user the actual state of the drive Onboard Application Lite Ladder Program. (not installed / running / stopped / tripped).

Value	Description
-n	Onboard Application Lite Ladder 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 Application Lite Ladder Program is not installed.
1	Onboard Application Lite Ladder Program is installed but stopped.
2	Onboard Application Lite Ladder Program is installed and running.

11.49	**Drive Onboard Application Lite Ladder Programming Events**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	1
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 65,535								
Update rate	Background write															

The Drive Onboard Application Lite Ladder Programming Events parameter holds the number of times a Onboard Application Lite Ladder program download has taken place and is 0 on dispatch from the factory. If the Drive Onboard Application Lite Ladder Programming Events is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value. This parameter is not altered when defaults are loaded.

11.50	Drive Onboard Application Lite Ladder Program Average Scan Time															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 65,535 ms								
Update rate	Onboard Application Lite Ladder program execution period															

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 Application Lite Ladder Program first run															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							0 or 1								
Update rate	Onboard Application Lite Ladder program execution period															

The Drive Onboard Application Lite Ladder Program first run parameter is set for the duration of the first ladder diagram scan from the ladder diagram stopped state. This enables the user to perform any required initialisation every time the ladder diagram is run. This parameter is set every time the ladder is stopped.

5.14 Menu 12: Threshold detectors, variable selectors and brake control function

Menu 12 includes two threshold detectors which produce logic signals depending on the level of a variable value with respect to a threshold, and two variable selectors which allow two input parameters to be selected or combined to produce a variable output. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. A function is active if one or more sources are routed to a valid parameter.

Figure 5-18 Menu 12 logic diagram

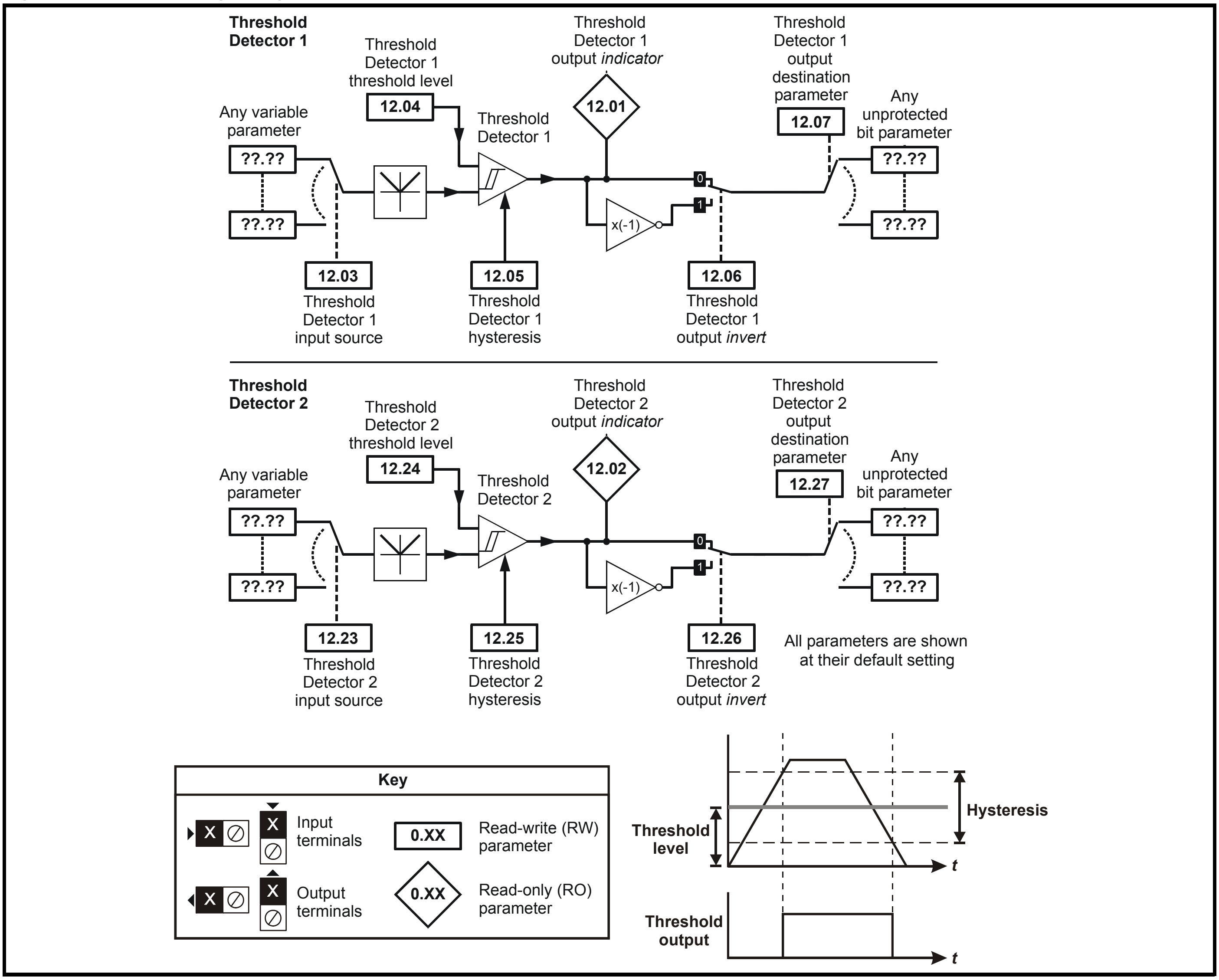
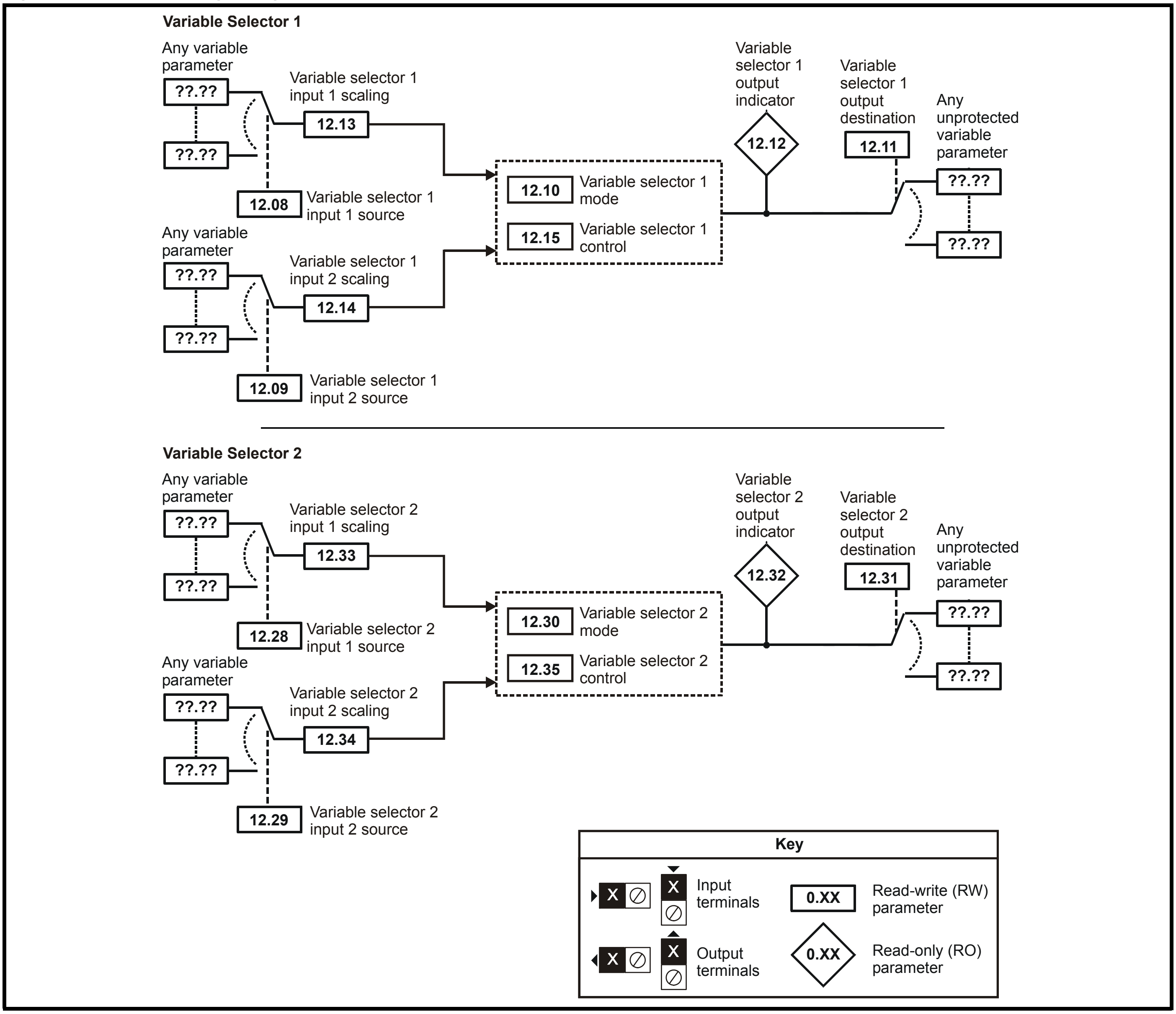


Figure 5-19 Menu 12 Logic diagram (continued)



12.01	**Threshold detector 1 output**															
12.02	**Threshold detector 2 output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms x number of menu 9 or 12 functions active write															

12.03	**Threshold detector 1 source**															
12.23	**Threshold detector 2 source**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00** to Pr **21.51**								
Default	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00**								
Update rate	Read on reset															

12.04	**Threshold detector 1 level**															
12.24	**Threshold detector 2 level**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.00 to 100.00 %														
Default	Open-loop, Closed-loop vector, Servo, Regen	0.00														
Update rate	4ms x number of menu 9 or 12 functions active read															

12.05	**Threshold detector 1 hysteresis**															
12.25	**Threshold detector 2 hysteresis**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.00 to 25.00 %														
Default	Open-loop, Closed-loop vector, Servo, Regen	0.00														
Update rate	4ms x number of menu 9 or 12 functions active read															

12.06	**Threshold detector 1 output invert**															
12.26	**Threshold detector 2 output invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

12.07	**Threshold detector 1 destination**															
12.27	**Threshold detector 2 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

The threshold detector compares the modulus of the source input value (defined by Pr **12.03**, Pr **12.23**), converted to a percentage of its maximum value, with the threshold level (Pr **12.04**, Pr **12.24**). If the value is greater or equal to the threshold plus half the hysteresis band (Pr **12.05**, Pr **12.25**) the output becomes active, or if the value is less than the threshold minus half the hysteresis band the output becomes inactive. The output may be inverted if required by setting the invert flag (Pr **12.06**, Pr **12.26**). The result is routed to the destination (defined by Pr **12.07**, Pr **12.27**).

12.08	**Variable selector 1 source 1**															
12.28	**Variable selector 2 source 1**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

12.09	**Variable selector 1 source 2**															
12.29	**Variable selector 2 source 2**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

12.10	**Variable selector 1 mode**															
12.30	**Variable selector 2 mode**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 11														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms x number of menu 9 or 12 functions active read															

12.11	**Variable selector 1 destination**															
12.31	**Variable selector 2 destination**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

12.12	**Variable selector 1 output**															
12.32	**Variable selector 2 output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.00 %														
Update rate	4ms x number of menu 9 or 12 functions active write															

12.13	**Variable selector 1 source 1 scaling**															
12.33	**Variable selector 2 source 1 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen							±4.000								
Default	Open-loop, Closed-loop vector, Servo, Regen							1.000								
Update rate	4ms x number of menu 9 or 12 functions active read															

12.14	**Variable selector 1 source 2 scaling**															
12.34	**Variable selector 2 source 2 scaling**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen							±4.000								
Default	Open-loop, Closed-loop vector, Servo, Regen							1.000								
Update rate	4ms x number of menu 9 or 12 functions active read															

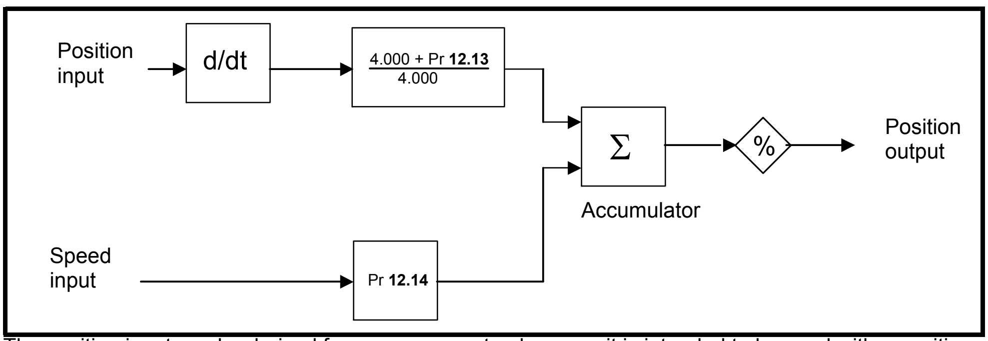
12.15	**Variable selector 1 control**															
12.35	**Variable selector 2 control**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.00 to 100.00								
Default	Open-loop, Closed-loop vector, Servo, Regen							0.00								
Update rate	Background															

The variable selectors allow two source values (defined by Pr **12.08**, Pr **12.28** and Pr **12.09**, Pr **12.29**) to be combined as defined by the mode (Pr **12.10**, Pr **12.30**) to produce an output (Pr **12.12**, Pr **12.32**) which can be routed to the destination parameter (defined by Pr **12.11**, Pr **12.31**). The actions of the variable selector are defined by the mode parameter as given below. If the mode parameter is changed or the variable selector is disabled because neither source is routed to a valid parameter all the internal state variables (i.e. time constant accumulator, etc). within the selector are reset. When the Sectional control mode is selected the function is also reset, and the output is held at zero, when the control (Pr **12.15** or Pr **12.35**) is zero. It is active when the control has a non-zero value.

Mode value	Action	Result
0	Select input 1	output = input1
1	Select input 2	output = input2
2	Add	output = input1 + input2
3	Subtract	output = input1 - input 2
4	Multiply	output = (input1 x input2) / 100.0
5	Divide	output = (input1 x 100.0) / input2
6	Time constant	output = input1 / ((control param)s + 1)
7	Linear ramp	output = input1 via a ramp with a ramp time of (control param) seconds from 0 to 100%
8	Modulus	output = | input1 |
9	Powers	control = 0.02: output = $input1^2$ / 100.0 control = 0.03: output = $input1^3$ / 100.0^2 control has any other value: output = input1
10	Sectional control	control = 0.00: disabled, accumulator reset and output zero control <> 0.00: output as defined below
11	External rectifier monitor	See below

Sectional control

The sectional control function is intended to apply scaling and a speed offset to a 16 bit position value to generate a new 16 bit position value. The output can be used as an input to the position controller (menu 13) or to generate an encoder simulation output via the SM-Universal encoder plus module. This function can be selected for either variable selector, but the description below relates to variable selector 1.



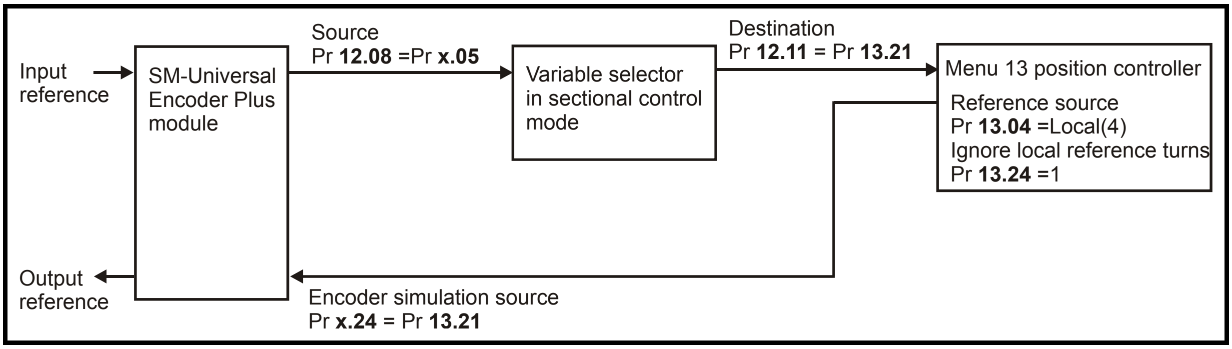
The position input can be derived from any parameter, however it is intended to be used with a position value that has a range from 0 to 65535. The input is scaled so that as Pr **12.13** is varied between -4.000 and 4.000, the proportion of the input position change added to the accumulator varies from 0.000 to 2.000 (the change of position input value is added without scaling if Pr **12.13** is 0.000). The remainder from the scaling division is stored and then added at the next sample to maintain an exact ratio between the position input and the position output, provided the speed input is zero. The controller only takes the change of position from the input source parameter, and not the absolute value, so that when the controller is first made active the output does not jump to the source position, but only moves with any changes of source position after that point in time.

The range of the output of the accumulator is 0.00% and 100.00%. Unlike other functions the value is not simply limited, but rolls under or over respectively. Although the output destination can be any parameter it is intended to be used with a position value that has a range from 0 to 65535.

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

This sample time for this function is 4ms x number of menu 9 and 12 functions active. Extending the sample time does not cause any overflow errors within the function, however, care must be taken to ensure that the input or output positions do not change by more than half a revolution within the sample time, i.e for a sample time of 4ms the input or output speed should not exceed 7500rpm, for a sample time of 8ms the speed should not exceed 3750rpm, etc. If the output of this function is to supply a reference to the position controller in menu 13 it must be the only user function in menu 9 or 12 enabled. **If another function is enabled the input to the position controller will only change every 8ms (i.e. every 2 samples of the position controller) and the speed reference applied to the drive could be very noisy.**

The diagram below shows how the variable selector in Sectional control mode can be used to provide a position reference for the drive and act as a source for encoder simulation to give the position reference for the next drive in the system.



The input reference is provided by the previous drive in the system via the SM-Universal Encoder Plus module and is used as the position source (Pr **12.08**) for the variable selector. The destination of the variable selector is the local position reference for the menu 13 position controller (Pr **13.21**). Pr **13.21** counts up or down based on the delta position from the variable selector and rolls over or under at 65535 or 0. If the controller is set up to ignore the local reference turns then Pr **13.21** can be used as the position controller reference. If Pr **13.21** is also used as the encoder simulation source the local reference can also be used to give the reference for the next drive in the system. With this arrangement a ratio is provided between the input reference and output reference within the variable selector. An addition ratio can be provided within the position controller between the position in Pr **13.21** and the position reference used by the position controller. The variable selector speed reference can be used to move the position reference forwards or backwards with respect to the input reference.

11. External Rectifier (SPMC/U) Monitor

This mode is intended to monitor an external rectifier system (SPMC/U) to provide over temperature monitoring, phase loss detection and mains loss detection. The variable selector inputs should be routed to digital inputs on the drive or a Solutions Module, which are connected to the (SPMC/U) rectifier status outputs. The external rectifier monitor produces a number of actions depending on the state of the inputs as given in the table below. The OK/healthy state becomes active immediately both inputs are high, but the other states only become active when the required inputs have been active for at least 0.5s. The high state is defined as a value greater than or equal to half the source maximum and the low state is defined as a value less than half the source maximum (with the scaling parameters set to 1.000). If digital inputs are used as the sources and the scaling parameters are 1.000, high is therefore defined as 1, and low is defined as 0. The variable selector output gives 0% if the rectifier is OK/healthy, otherwise it gives 100%. The output should be routed to Pr **6.51** (rectifier not active) so that the drive is not allowed to leave the main loss condition if the rectifier is not fully phased forwards.

Input 1 (Pr **12.08,** Pr **12.28**)	**Input 2** (Pr **12.09,** Pr **12.29**)	**State**	**Trip**	**Output** (Pr **12.12,** Pr **12.32**)
High	High	Healthy	None	0%
High	Low	Over temperature	Oht4.P trip	100%
Low	High	Phase loss	PH.P trip	100%
Low	Low	Mains Loss	None	100%

For more information about Oht4.P and PH.P trips, refer to the *Unidrive SPM User Guide*.

5.14.1 Brake control function

The brake control function can be used to control an electro-mechanical brake via the drive digital I/O. A brake control function is provided for open-loop operation of induction motors (Open-loop mode) and an alternative brake control function is provided for closed-loop operation of induction motors or servo motors (Closed-loop vector and Servo modes). The parameters that are common to both brake control functions (Pr **12.40** and Pr **12.41**) are described below. The other parameters used by each of the brake control functions are then described in the section for the appropriate function.

12.40	**Brake release**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background read															

This parameter should be used as a source for a digital output to control an electro-mechanical brake. This parameter is one to release the brake and zero to apply the brake. Digital I/O can be automatically configured to use this parameter as a source (see Pr **12.41**).

12.41	Brake controller enable															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 3								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Read on drive reset															

WARNING

The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

0 = dis

The brake controller is disabled and no other drive parameters are affected by the brake controller. When this parameter is changed from a non-zero value to zero the following parameters are set to zero: Pr **2.03** (all modes), Pr **6.08** (Closed-loop vector and Servo modes), Pr **13.04** and Pr **13.10** (Closed-loop vector and Servo modes if Pr **12.49** = 1).

1 = rel

The brake controller is enabled with I/O set up to control the brake via the relay output T41/42. Drive ok is re-routed to digital I/O 2 (T25).

2 = d IO

The brake controller is enabled with I/O set up to control the brake via digital I/O 2 (T25).

3 = User

The brake controller is enabled, but no parameters are set to select the brake output.

The following tables show the automatic parameter changes that occur to set up digital I/O2 (T25) and the relay output (T41/42) after drive reset when Pr **12.41** has been changed. The changes are done in two stages: the first stage restores the I/O used as defined by the initial setting of Pr **12.41** and the second stage sets up the I/O as defined by the new setting of Pr **12.41**.

Stage 1: Restore I/O

Initial setting in Pr 12.41	Pr 8.12 (Invert)	Pr 8.22 (Source / destination)	Pr 8.32 (Input/ output)	Pr 8.17 (Invert)	Pr 8.27 (Source)
0	No action				
1	0	Pr **10.33**	0	0	Pr **10.01**
2	0	Pr **10.33**	0	No action	
3	No action				

Stage 2: Set-up I/O

New setting in Pr 12.41	Pr 8.12 (Invert)	Pr 8.22 (Source / destination)	Pr 8.32 (Input/ output)	Pr 8.17 (Invert)	Pr 8.27 (Source)
0	No action				
1	0	Pr **10.01**	1	0	Pr **12.40**
2	0	Pr **12.40**	1	No action	
3	No action				

WARNING

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.

Open-loop

WARNING

The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

Figure 5-20 Open-loop brake function

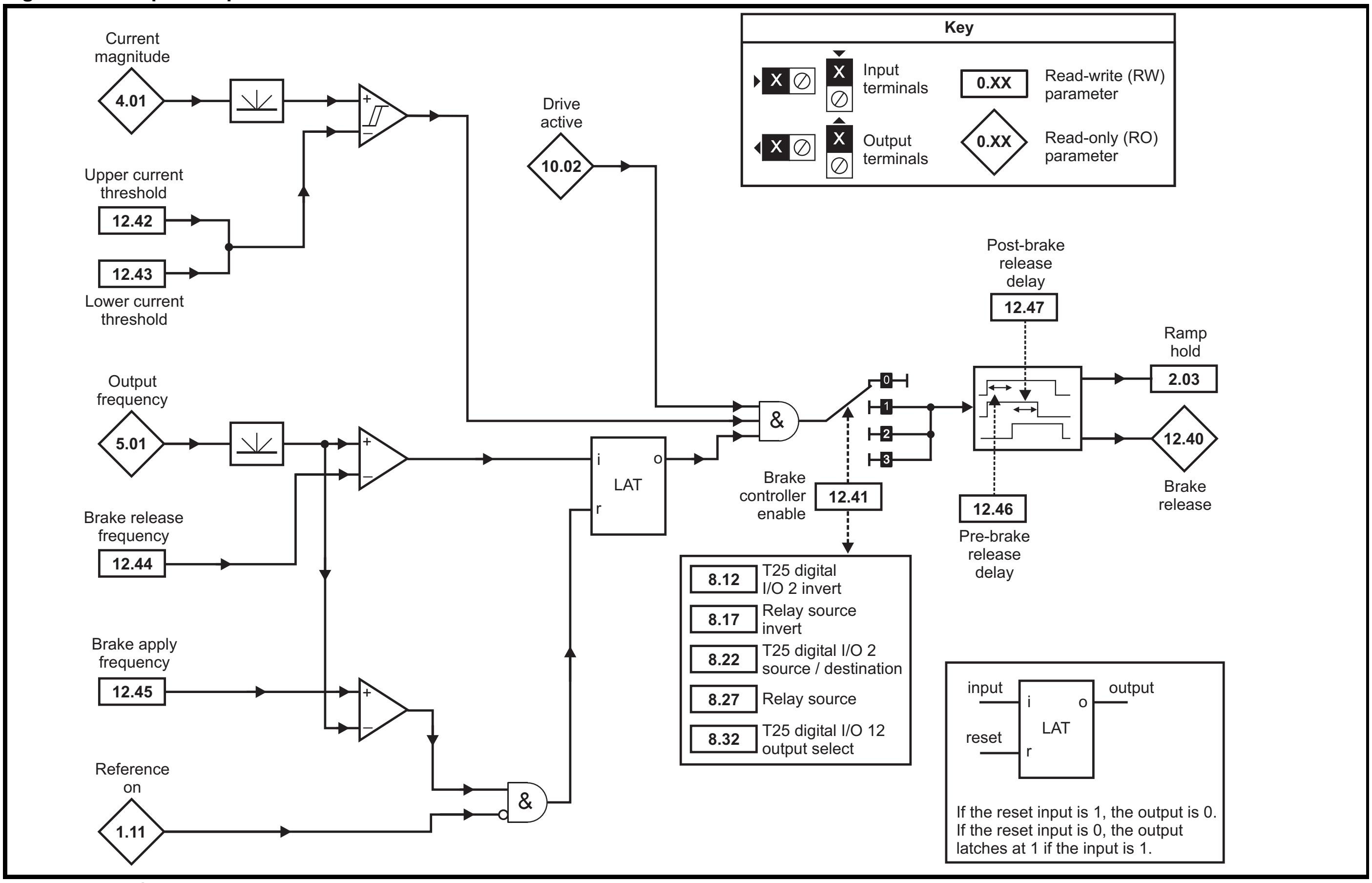
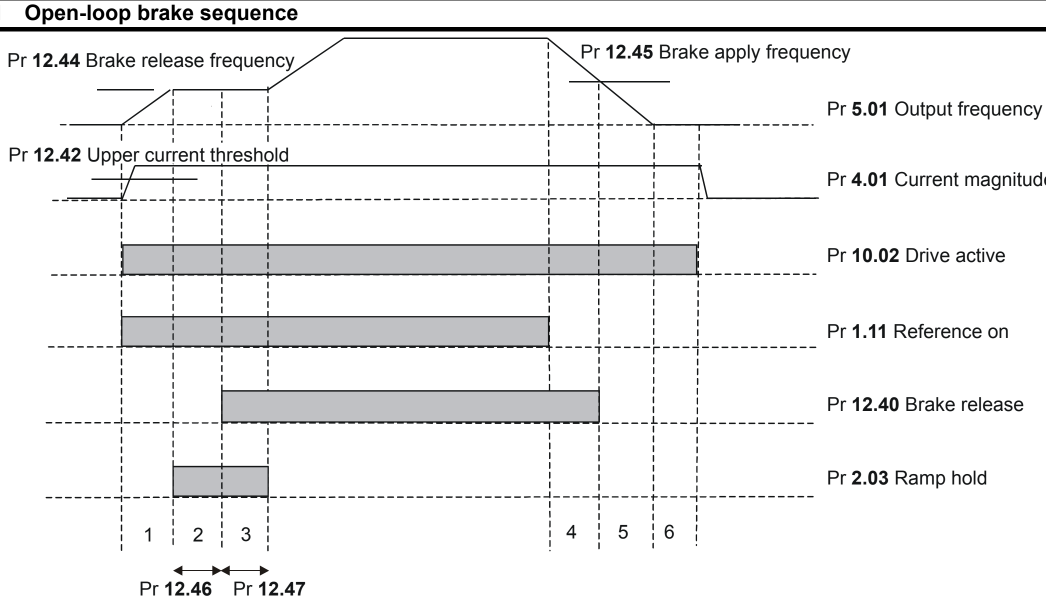


Figure 5-21 Open-loop brake sequence



1. Wait for upper current threshold and brake release frequency
2. Pre-brake release delay
3. Post-brake release delay
4. Wait for brake apply frequency
5. Wait for zero frequency
6. 1s delay as phase 2 of stopping sequence (Pr **6.01**=1,2 or 3)

12.42	Upper current threshold															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop								0 to 200 %							
Default	Open-loop								50							
Update rate	Background read															

12.43	Lower current threshold															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop								0 to 200 %							
Default	Open-loop								10							
Update rate	Background read															

The current magnitude is compared to an upper and lower threshold by a comparator with hysteresis to give torque present and drive output open detection functions respectively. The upper and lower threshold currents are given as a percentage of motor current defined by Pr **5.07** (or Pr **21.07** if motor map 2 is selected). The upper threshold should be set to the current level that indicates that there is magnetizing current and sufficient torque producing current in the motor to deliver the required amount of torque when the brake is released. The output of the comparator remains active after this level has been reached unless the current subsequently falls below the lower threshold which should be set to the required level to detect the condition where the motor has been disconnected from the drive. If the lower threshold is set greater or equal to the upper threshold, the upper threshold applies with a hysteresis band of zero. If Pr **12.42** and Pr **12.43** are both set to zero then the output of the comparator is always one.

12.44	Brake release frequency															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 20.0 Hz							
Default	Open-loop								1.0							
Update rate	Background read															

The frequency comparator can be used to detect when the motor frequency has reached a level where the motor can produce the required amount of torque to ensure that the motor rotates in the demanded direction when the brake is released. This parameter should be set to a level slightly above the motor slip frequency that is likely to occur under the highest expected load that is applied to the motor when the brake is released.

12.45	Brake apply frequency															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 20.0 Hz							
Default	Open-loop								2.0							
Update rate	Background read															

The brake apply frequency threshold is used to ensure that the brake is applied before the motor frequency reaches zero and to prevent the motor rotating (in the reverse direction due to an overhauling load for example) during the brake apply time. If the frequency falls below this threshold, but the motor is not required to stop (i.e. reversing direction without stopping), provided the Reference on parameter (Pr **1.11**) remains at one, the brake is not applied. This prevents the brake from activating and de-activating as the motor passes through zero speed.

12.46	**Pre-brake release delay**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 25.0 s							
Default	Open-loop								1.0							
Update rate	Background read															

The pre-brake release delay is used to allow time for the motor torque to reach the required level before the brake is released. This time should allow for the motor flux to reach a significant proportion of the rated level (2 or 3 times the rotor time constant of the motor), and the time for slip compensation to become fully active (at least 0.5s). During the Pre-brake delay period the frequency reference is held constant (Pr **2.03** = 1).

12.47	**Post-brake release delay**															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop								0.0 to 25.0 s							
Default	Open-loop								1.0							
Update rate	Background read															

The post-brake release delay is used to allow for the brake release time. During this period the frequency reference is held constant (Pr **2.03** = 1), so that there is no sudden increase in motor speed when the brake actually releases.

Closed loop vector and Servo

WARNING

The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

Figure 5-22 Closed-loop vector and Servo brake function

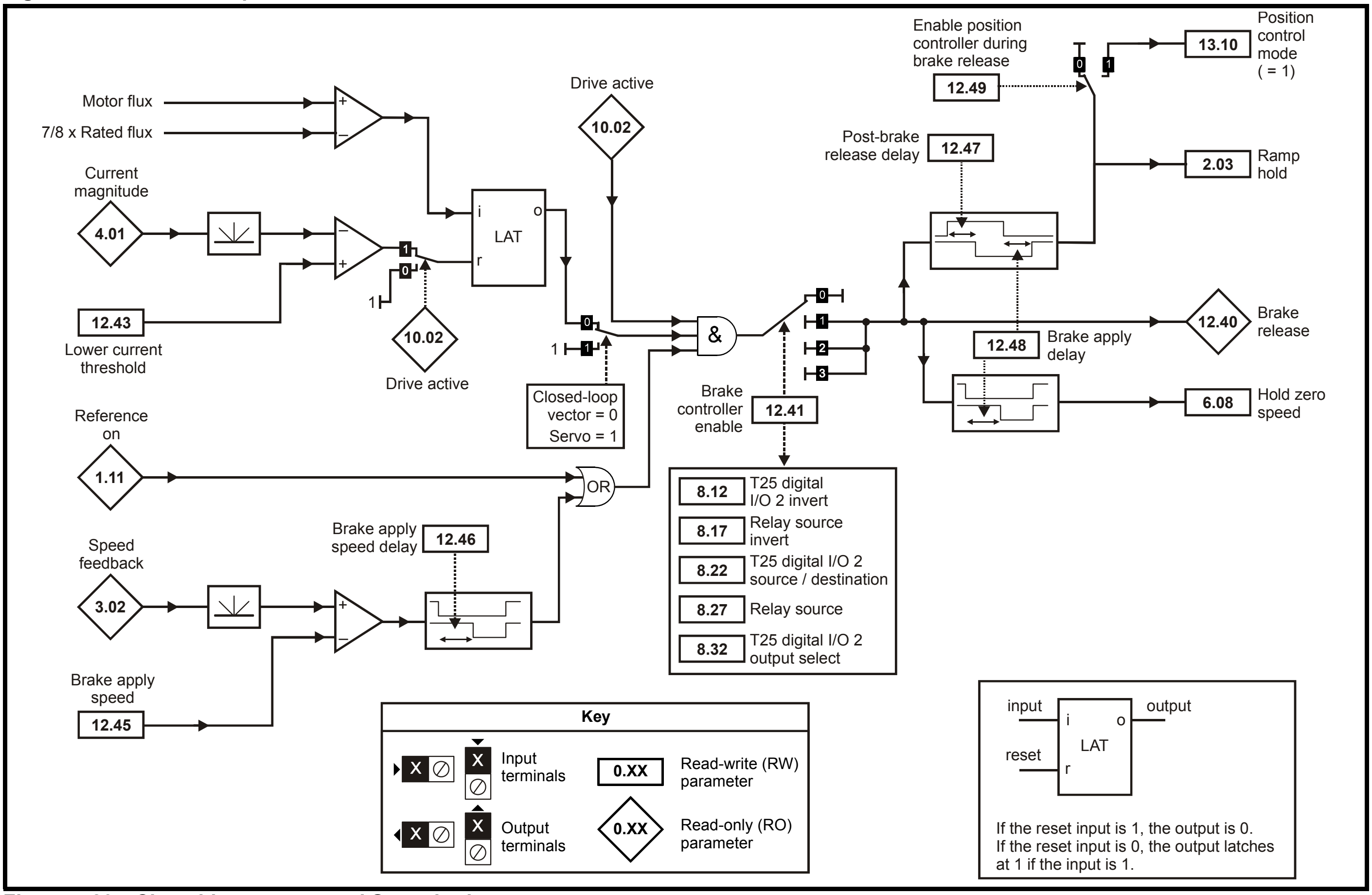
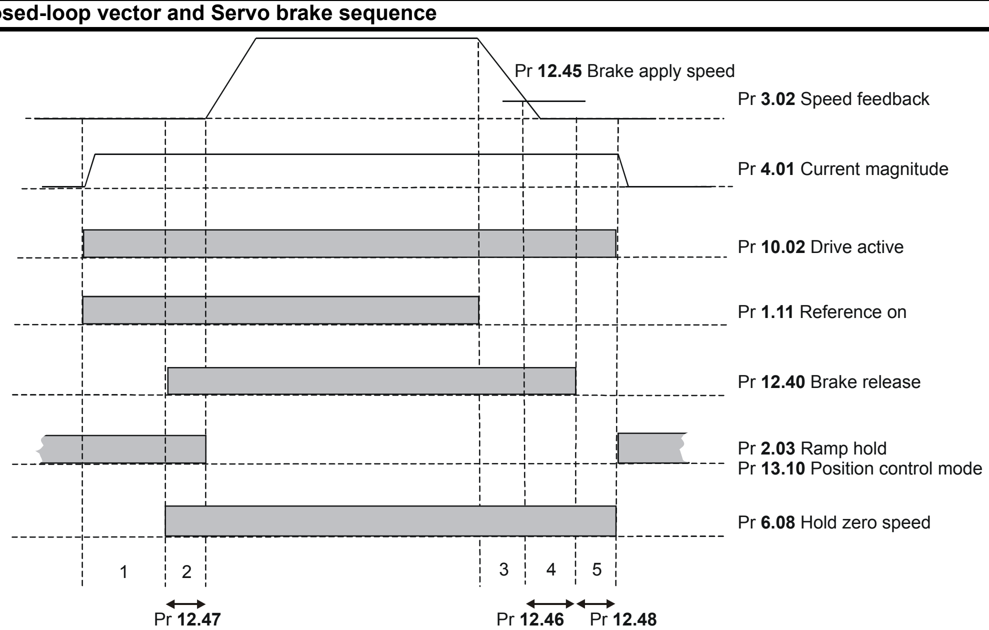


Figure 5-23 Closed-loop vector and Servo brake sequence



1. Wait for motor fluxed (closed-loop vector only)
2. Post-brake release delay
3. Wait for speed threshold
4. Wait for brake apply speed delay
5. Brake apply delay

12.43	Low current threshold															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 200 %								
Default	Open-loop, Closed-loop vector, Servo							10								
Update rate	Background read															

If the current magnitude falls below the lower current threshold the brake is applied immediately. The lower threshold should be set to the required level to detect the condition where the motor has been disconnected from the drive. If this parameter is set to zero the loss of current will not cause the brake to be applied. However, the flux detection and current threshold latch will be reset when the drive is disabled.

12.45	Brake apply speed															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 200 rpm								
Default	Closed-loop vector, Servo							5								
Update rate	Background read															

When stopping, the drive reference can be removed (i.e. Pr **1.11** = 0), but the brake will remain energized (open) until the motor has remained at a speed below the brake apply speed for the delay defined by Pr **12.46**. The delay prevents rapid activation and de-activation of the brake when fine control of a motor is required close to zero speed.

12.46	Brake apply speed delay															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Closed-loop vector, Servo							0.0 to 25.0 s								
Default	Closed-loop vector, Servo							1.0								
Update rate	Background read															

See Pr **12.45**.

12.47	Post-brake release delay															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Closed-loop vector, Servo							0.0 to 25.0 s								
Default	Closed-loop vector, Servo							1.0								
Update rate	Background read															

The post-brake release time is used to allow for the brake release time. From the time that the drive is enabled and then during this period the speed reference is held constant at zero, so that there is no sudden increase in motor speed when the brake actually releases.

12.48	Brake-apply delay															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Closed-loop vector, Servo							0.0 to 25.0 s								
Default	Closed-loop vector, Servo							1.0								
Update rate	Background read															

The brake apply delay is used to allow for the brake application time. During this period the Hold zero speed parameter (Pr **6.08**) is one, and so the drive is enabled with zero speed reference. This ensures that the motor remains stationary while the brake is being applied.

12.49	**Enable position controller during brake release**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector, Servo								0							
Update rate	Background read															

If this parameter is zero then ramp hold only is applied when the drive is not active and until the end of the post-brake release delay to ensure that the speed reference remains at zero until the brake has released. If this parameter is set to one the position controller (see menu 13) is also enabled (Pr **13.10** = 1) and the local position reference source is selected (Pr **13.04** = 4(LocAL)) during the period when ramp hold is active. Provided the default, non-absolute mode, is selected the position controller can help to limit the movement of the motor when the brake is released. When Pr **12.49** is changed from one to zero Pr **13.04** and Pr **13.10** are automatically set to zero.

5.15 Menu 13: Position control

Menu 13 provides a position control system for the drive in open-loop mode and closed-loop modes (closed-loop vector and servo). The position reference can be taken from the drive encoder, from a position feedback module or from a local reference defined in this menu. The reference includes a relative jog function that can be used to advance or retard the position reference at a defined speed and a ratio that can scale the reference. The feedback position can be taken from the drive encoder or from a position feedback module. As well as giving position control the controller can provide shaft orientation within one revolution in conjunction with the drive sequencer (see section 5.8 *Menu 6: Sequencer and clock* on page 134). The sample time for the position controller is 4ms and the output is supplied to the speed or frequency reference every 4ms.

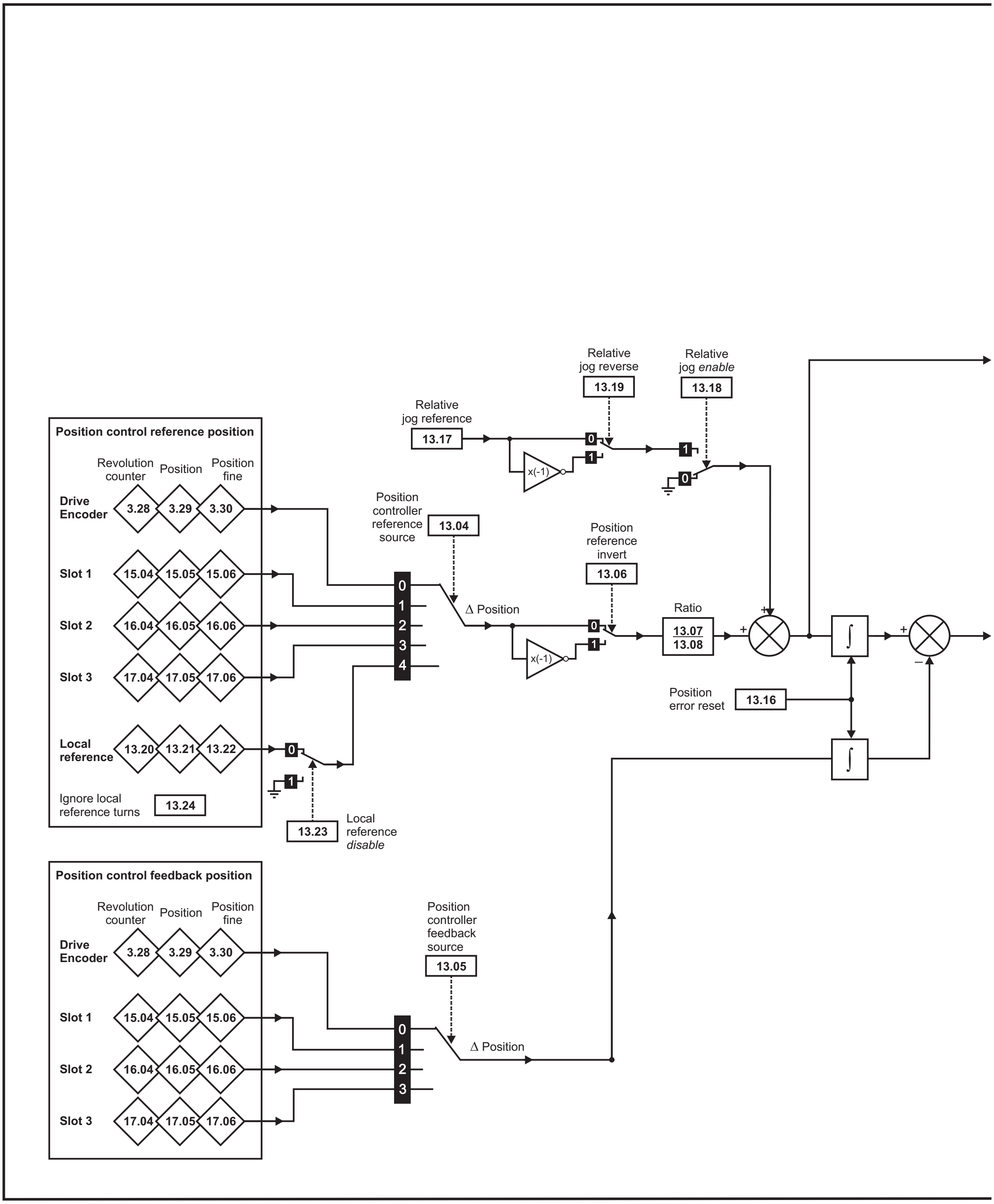
Open–loop mode

The position controller outputs are a velocity feed forward and a speed reference (both in 0.1rpm units). When the position controller is selected (i.e. Pr **13.10** is non-zero) these values are converted to 0.1Hz units and combined as shown below, before being written to the velocity feed forward parameter (Pr **1.39**). The velocity feed forward select (Pr **1.40**) is always one when the position controller is selected. When the position controller is de-selected (i.e. Pr **13.10** is changed to zero) Pr **1.39** and Pr **1.40** are set to zero. In open-loop mode the motor control must pass through the drive ramp system, and so for stable operation short ramp times are normally required.

Closed-loop modes

The position controller outputs are a velocity feed forward and a speed reference (both in 0.1rpm units). When the position controller is selected (i.e. Pr **13.10** is non-zero) these values are written directly to the velocity feed forward (Pr **1.39**) and hard speed reference (Pr **3.22**) respectively. Also the hard speed reference select (Pr **3.23**) is forced to a one and the velocity feed forward select (Pr **1.40**) is set to one when a controller mode giving velocity feed forward is selected. When the position controller is de-selected (i.e. Pr **13.10** is changed to zero) Pr **1.39**, Pr **1.40**, Pr **3.22** and Pr **3.23** are set to zero.

Figure 5-24 Menu 13 Open-loop logic diagram



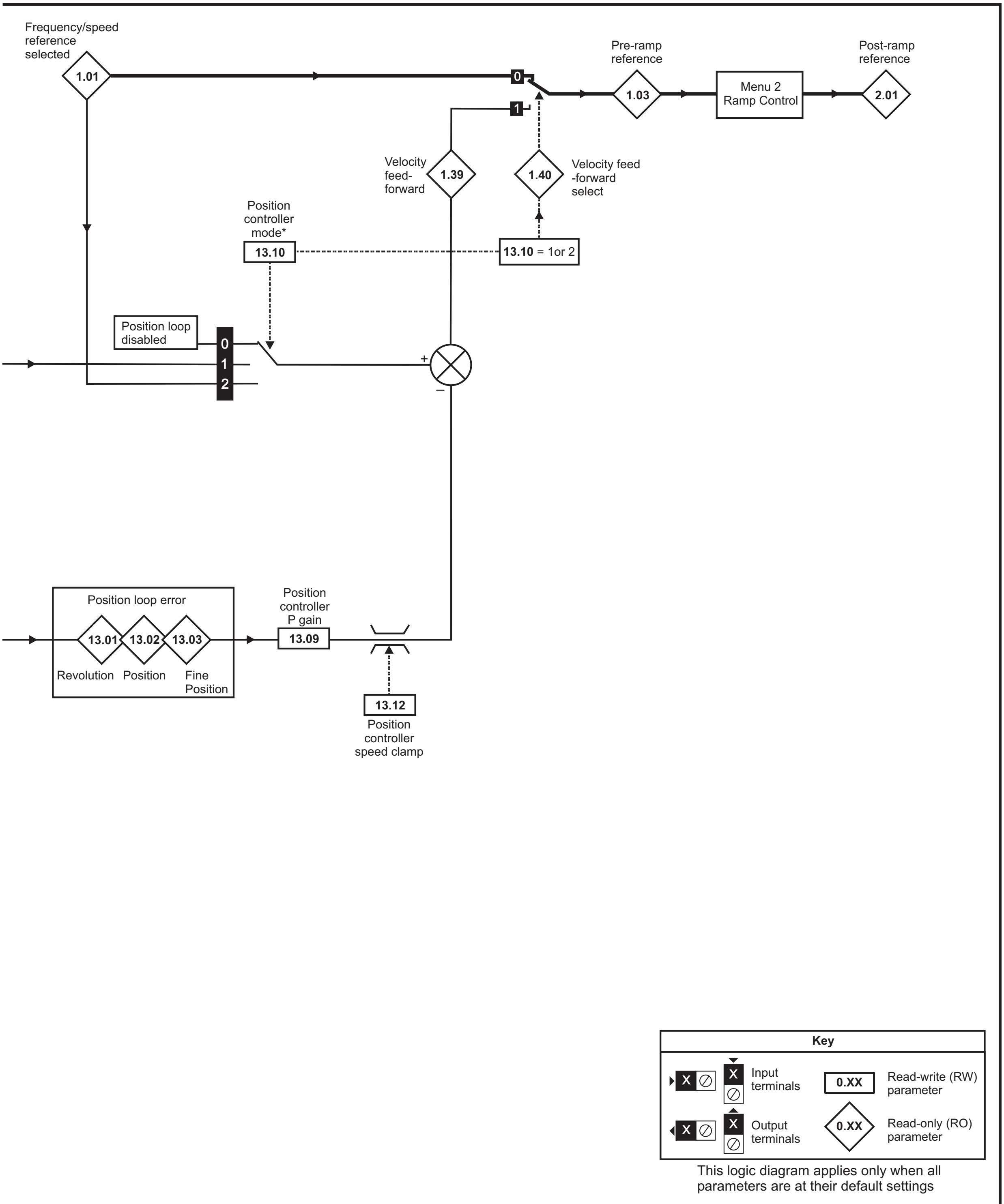
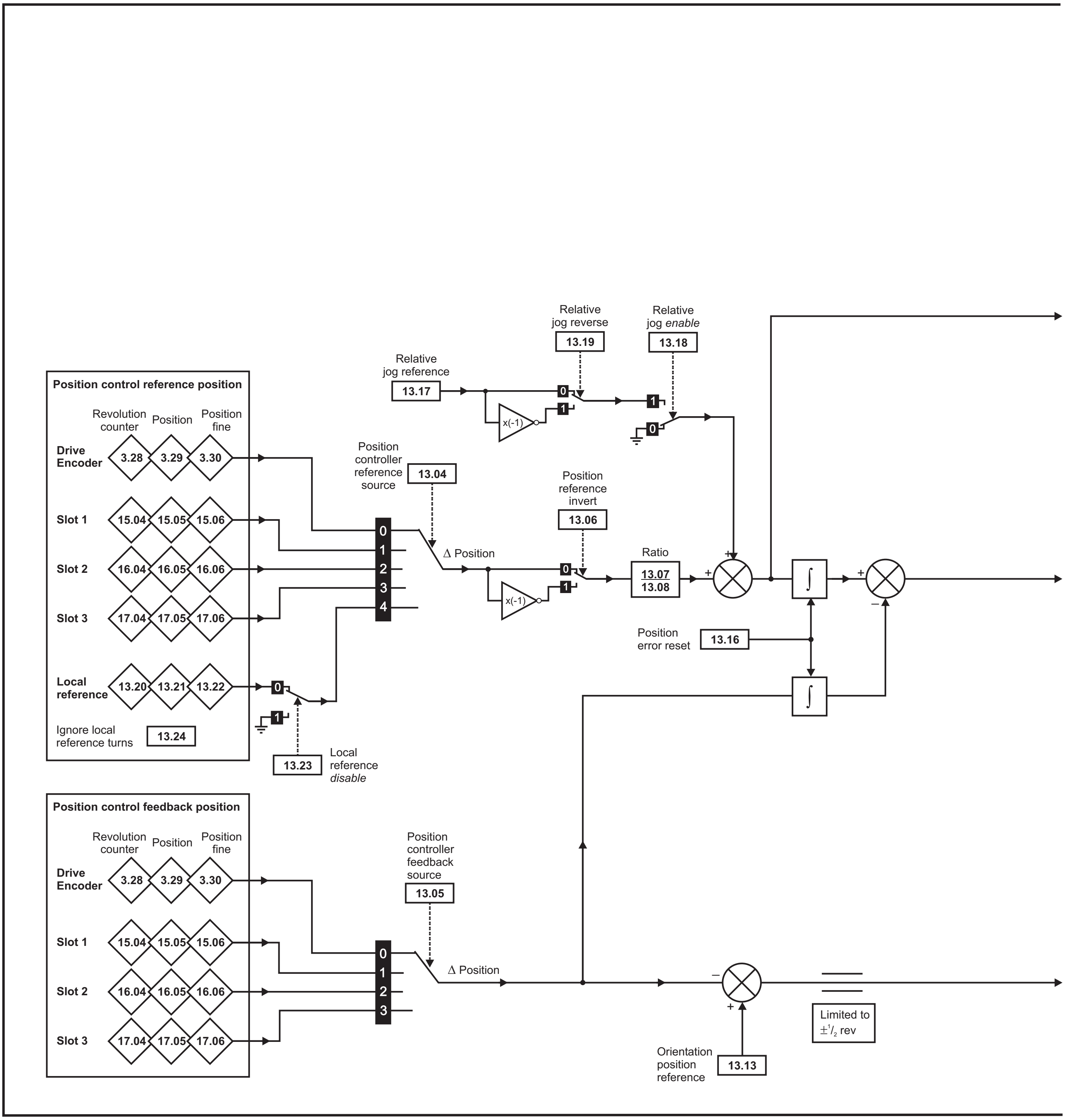
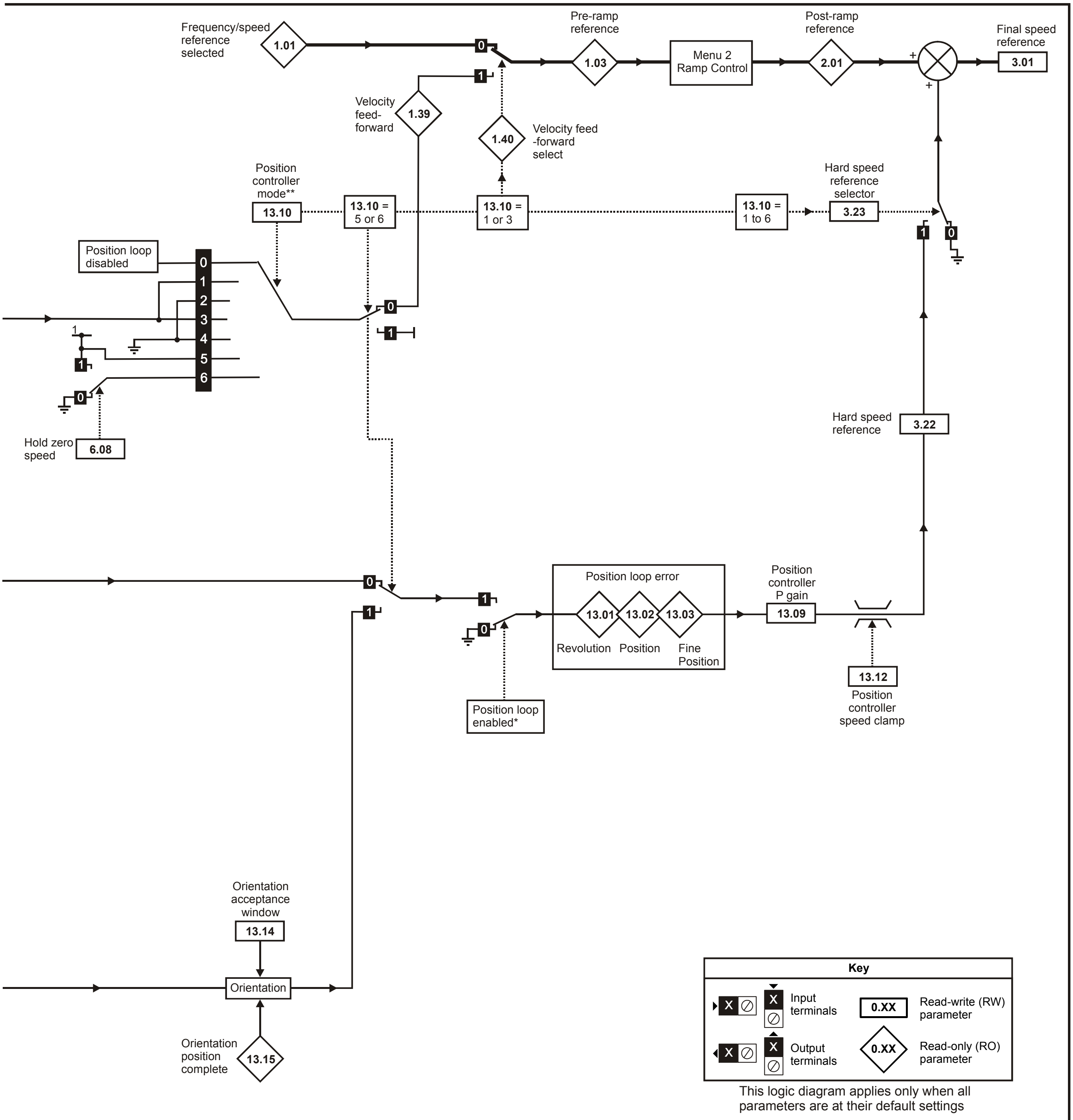

Frequency/speed reference selected
1.01
Pre-ramp reference
1.03
Menu 2 Ramp Control
Post-ramp reference
2.01
0
1
Velocity feed-forward
1.39
1.40
Velocity feed -forward select
Position controller mode*
13.10
13.10 = 1or 2
Position loop disabled
0
1
2
+
_
Position loop error
13.01
13.02
13.03
Revolution
Position
Fine Position
Position controller P gain
13.09
13.12
Position controller speed clamp
Key
X
Input terminals
0.XX
Read-write (RW) parameter
X
Output terminals
0.XX
Read-only (RO) parameter
This logic diagram applies only when all parameters are at their default settings

Figure 5-25 Menu 13 Closed-loop logic diagram





* 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.

The position feedback initialised parameter (Pr **3.48**) is zero.

13.01	**Revolutions error**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo	-32,768 to 32,767														
Update rate	4ms write															

13.02	**Position error**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo	-32,768 to 32,767														
Update rate	4ms write															

13.03	**Fine position error**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, Closed-loop vector, Servo	-32,768 to 32,767														
Update rate	4ms write															

For normal position control the position changes from the reference and the feedback are accumulated in an integrator during each sample. The integrator is large enough to guarantee that the position controller will operate with a position error within the range -32,768 revolutions to +32,767 revolutions before rolling over. The position error is displayed in Pr **13.01**, Pr **13.02** and Pr **13.03**. Pr **13.01** shows the turns error, Pr **13.02** shows the error within a revolution in $1/2^{16}$ counts per revolution units and Pr **13.03** shows the fine position error in $1/2^{32}$ counts per revolution units. These values are both positive and negative and so they can be used to show the following error with different levels of resolution.

For orientation mode the error between the orientation position and the position feedback source is shown in Pr **13.02**.

13.04	**Position controller reference source**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 4														
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	Background read															

13.05	**Position controller feedback source**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to 3														
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	Background read															

Source parameter	**Source**
0 (drv)	Drive encoder
1 (slot1)	Slot 1
2 (slot2)	Slot 2
3 (slot3)	Slot 3
4 (locAl)	Local reference

The reference and feedback positions can be taken from the drive encoder or a position feedback Solutions Module in one of the Solutions Module slots. The reference can also be taken from the local reference parameters. If the reference and feedback sources are the same the position controller cannot be enabled. If a Solutions Module slot is selected as a source, but the module is not a position feedback category Solutions Module the position controller cannot be enabled. Orientation mode can always be enabled in closed-loop modes.

13.06	**Position reference invert**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

13.07	**Ratio numerator**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0.000 to 4.000								
Default	Open-loop, Closed-loop vector, Servo							1.000								
Update rate	Background read															

13.08	**Ratio denominator**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0.000 to 1.000								
Default	Open-loop, Closed-loop vector, Servo							1.000								
Update rate	Background read															

An exact ratio can be applied to the position reference with these two parameters. The ratio cannot be changed when the drive is enabled without causing abrupt changes of position. Although it is possible to set up ratios with a high gain or even with a denominator of zero, the drive limits the resultant gain of the ratio block to 4.000.

13.09	**Position controller P gain**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0.00 to 100.00 rads $^{-1}$/rad								
Default	Open-loop, Closed-loop vector, Servo							25.00								
Update rate	Background read															

The gain of the position controller is controlled with this parameter. The standard units within the drive for position are in 2^{32} counts per revolution and the standard units for speed are 0.1rpm, however the position controller gain is given in rads^{-1}/rad. These units are consistent with units such as mms^{-1}/mm or ms^{-1}/m often used for linear control applications. An error of 1 radian (10430 counts in the position error (Pr **13.02**)) gives a speed reference of 1rads^{-1} (9.5rpm) when this gain is 1.00.

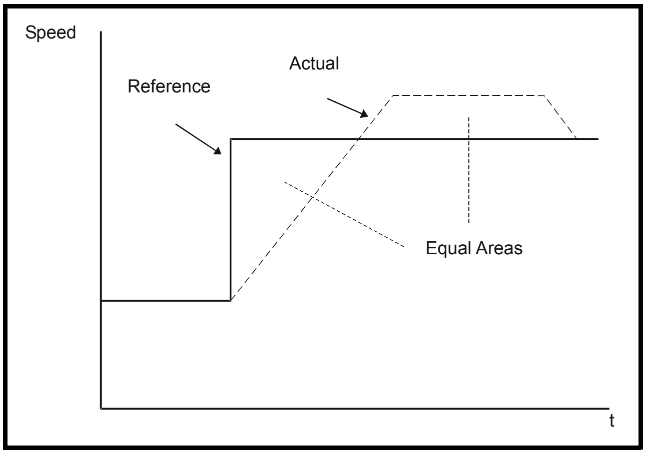
13.10	**Position controller mode**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop Closed-loop vector, Servo							0 to 2 0 to 6								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

This parameter is used to set the position controller mode as shown in the following table.

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	

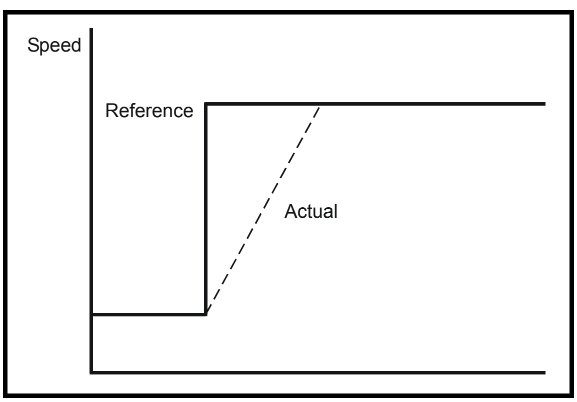
Rigid position control

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** on page 53). This allows slippage to occur while the speed error is high. It may be necessary to increase the ‘At Speed’ window in Pr **3.06** and Pr **3.07** with some lower resolution feedback devices.



Velocity feed forward

The position controller can generate a velocity feed forward value from the speed of the reference encoder. The feed-forward value is passed to menu 1, and so ramps may be included if required. Because the position controller only has a proportional gain, it is necessary to use velocity feed-forward 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 to 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 holds 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 held 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.

Orientation is only possible with a suitable feedback device such as an absolute encoder (sincos encoder with communications or communications only encoder), incremental encoder with a marker pulse or a 2 pole resolver.

13.11	**Absolute mode enable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

When this parameter is set to one and the position controller mode (Pr **13.10**) is 1 or 2, the position error integrator is loaded with the absolute position error defined by the position sources when the position controller is disabled. (The position controller is disabled under the following conditions: when the drive is in the inhibit, ready or tripped states; either the reference or feedback position sources from Solutions Modules are invalid; the position feedback is not correctly initialized (Pr **3.48** = 0); the position control mode (Pr **13.10**) is changed; this parameter (Pr **13.11**) is changed; or the position error reset (Pr **13.16**) is set to one). Therefore when this parameter is one the position controller operates on the absolute position from the reference and feedback. If the feedback device is not absolute then the absolute position is the change of position since the drive was powered-up.

When this parameter is zero or the position control mode is not 1 or 2 the error integrator is loaded with zero when the position controller is disabled therefore the position controller operates on the relative position changes of the reference and feedback from the point when the position controller is re-enabled.

It should be noted that the value of this parameter does not affect the operation of the marker reset for any position source. If the marker position reset disable (Pr **3.31** for the drive encoder, or similar for Solutions Modules) is zero, the position controller takes the position source including the effect of the marker. When a marker event occurs the position and fine position are reset to zero, but the turns are not affected. If the marker position reset disable is one then the marker events have no effect on the position source used by the position controller.

13.12	**Position controller speed clamp**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 250 rpm								
Default	Open-loop, Closed-loop vector, Servo							150								
Update rate	Background read															

This parameter limits the velocity correction applied by the position controller. In closed-loop modes this value is also used as the reference during orientation.

13.13	**Orientation position reference**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo							0 to 65,535								
Default	Closed-loop vector, Servo							0								
Update rate	Background read															

13.14	Orientation acceptance window															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Closed-loop vector, Servo	0 to 4,096														
Default	Closed-loop vector, Servo	256														
Update rate	Background read															

13.15	Orientation position complete															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms write															

Pr **13.13** defines the position as a $1/2^{16}$ of a revolution for orientation. Pr **13.14** defines the position acceptance window either side of the position reference for orientation in $1/2^{16}$ of a revolution. When the position is within the window defined by Pr **13.14**, Pr **13.15** indicates orientation is complete.

13.16	Position error reset															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

The position error integrator is preset to the absolute error (Pr **13.10** is 1 or 2, and Pr **13.11** is one) otherwise it is set to zero when this parameter is set to one.

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 (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 (Pr **3.48**) is zero.

13.17	Relative jog reference															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0.0 to 4,000.0rpm														
Default	Open-loop, Closed-loop vector, Servo	0.0														
Update rate	Background read															

13.18	Relative jog enable															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

13.19	**Relative jog reverse**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

Relative jog can be used to move the feedback position relative to the reference position at a speed defined by Pr **13.17**.

13.20	**Local reference turns**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

13.21	**Local reference position**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

13.22	**Local reference fine position**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 65,535								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

13.23	**Local reference disable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

The local reference can be used to control the position of the motor shaft. If the local reference disable parameter is one the previously written value is used. This allows all three parts of the local reference position to be changed without data skew problems.

13.24	**Ignore local reference turns**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

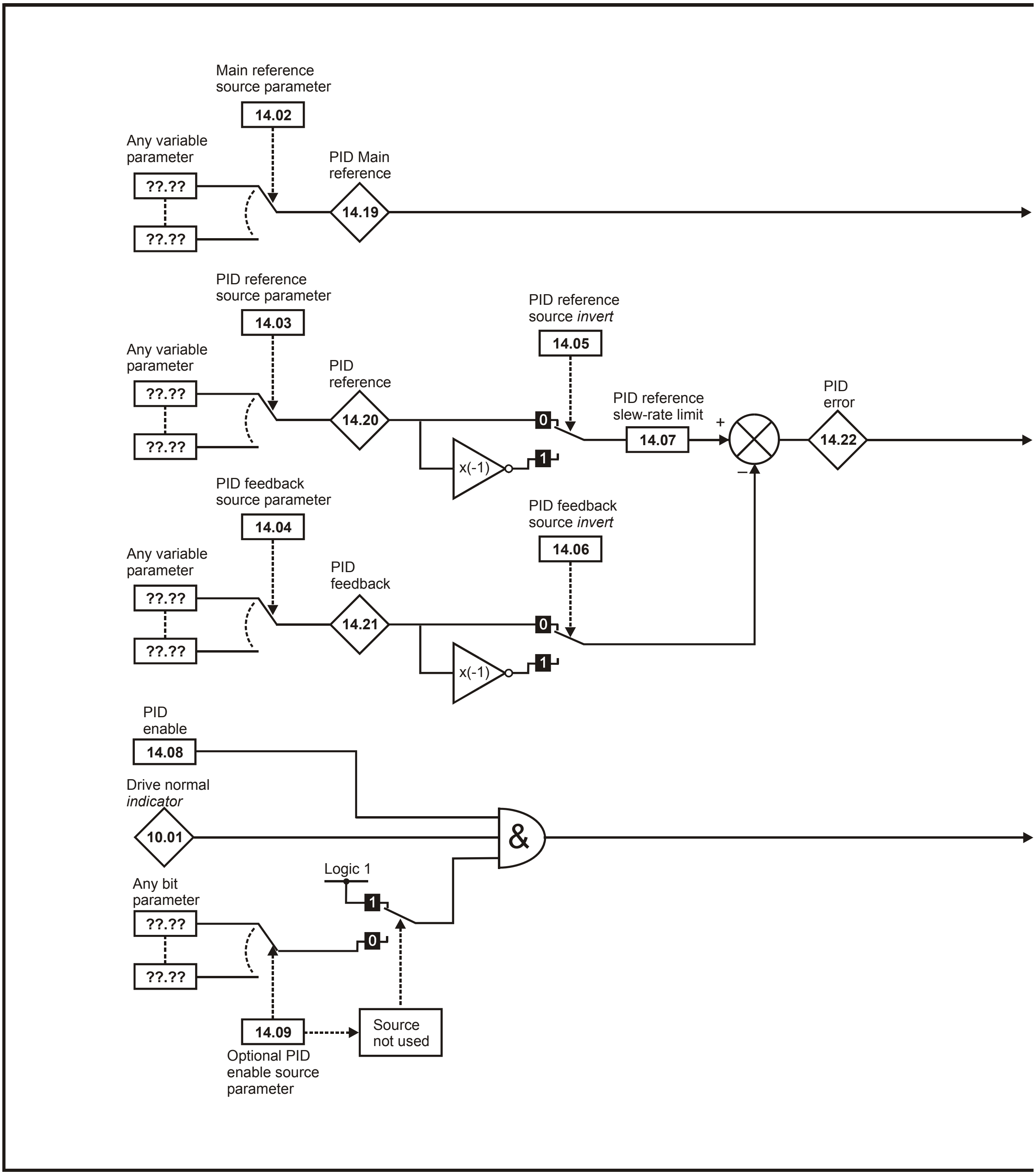
The local reference consists of a turns, a position and a fine position value. When Pr **13.24** is zero the reference is a 48bit position made from these three values.

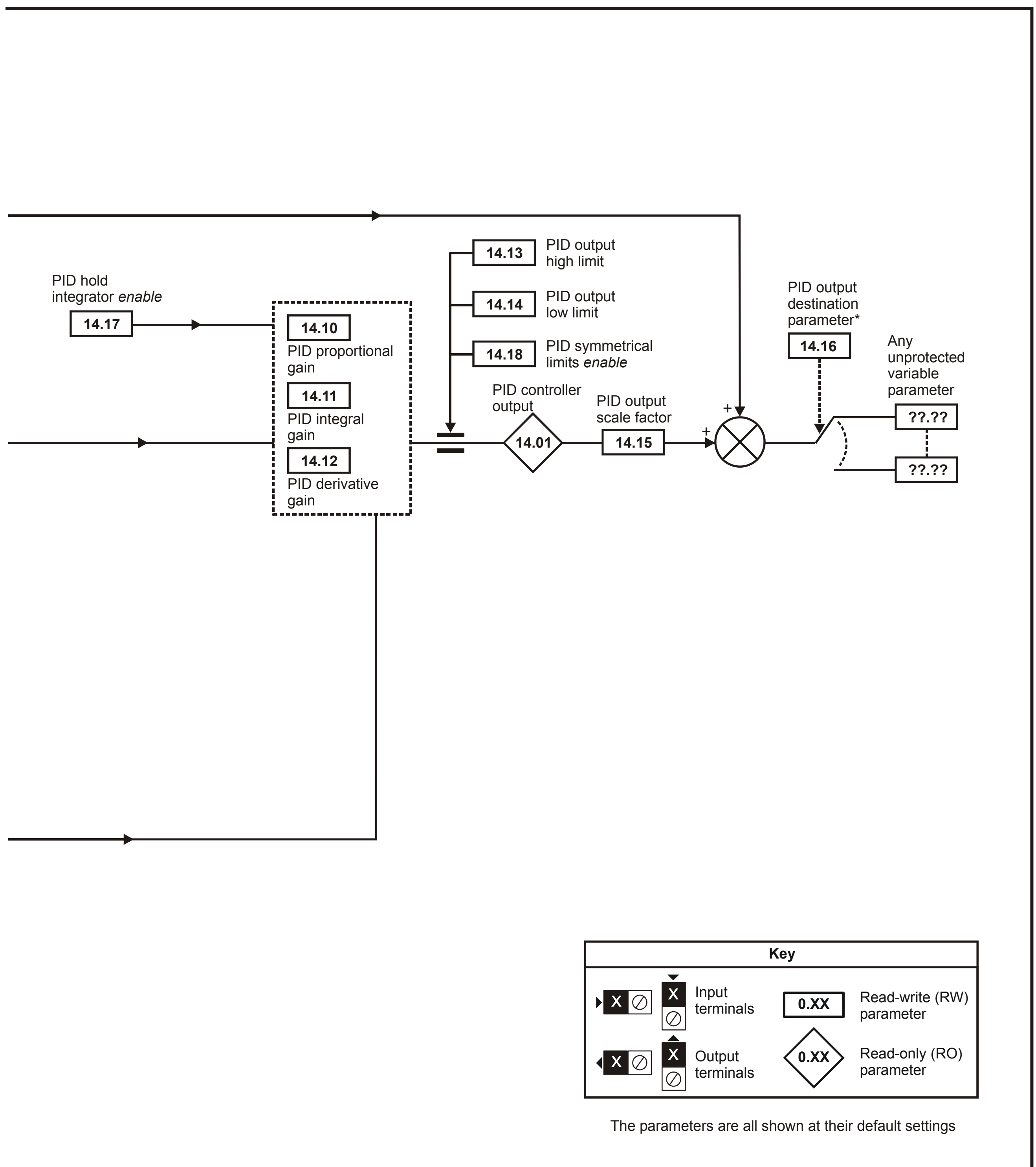
If Pr **13.24** is set to one the local reference is a 32bit position made from the position and fine position values. The position delta, used as the input to the position controller, is calculated correctly even when the turns are ignored as the 32bit position is treated as a roll-over/roll-under counter. This feature can be used, for example, with the local reference when only the position (and not the turns or fine position) is available. This feature is not available when absolute mode is selected (Pr **13.11** = 1).

5.16 Menu 14: User PID controller

This menu contains a PID controller which has programmable reference and feedback inputs, programmable enable bit, reference slew rate limiting, variable clamp levels and programmable destination. The sample rate of the PID controller is 4ms.

Figure 5-26 Menu 14 logic diagram





*The PID controller is only enabled if Pr **14.16** is set to a non Pr **xx.00** and unprotected destination parameter.

14.01	**PID output**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.00 %								
Update rate	4ms write															

Subject to the limits the PID controller output is given by

output = error x [P + I/s + Ds/(0.064s + 1)]

Where:

error = reference - feedback
P = proportional gain = Pr **14.10**
I = integral gain = Pr **14.11**
D = differential gain = Pr **14.12**

Therefore with an error of 100% and P = 1.000 the output produced by the proportional term is 100%. With an error of 100% and I = 1.000 the output produced by the integral term will increase linearly by 100% every second. With an error that is increasing by 100% per second and D = 1.000 the output produced by the D term will be 100%.

14.02	**PID main reference source**															
14.03	**PID reference source**															
14.04	**PID feedback source**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00** to Pr **21.51**								
Default	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00**								
Update rate	Read on reset															

14.05	**PID reference source invert**															
14.06	**PID feedback source invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	4ms read															

14.07	**PID reference slew rate limit**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to 3,200.0 s								
Default	Open-loop, Closed-loop vector, Servo, Regen							0.0								
Update rate	Background read															

This parameter defines the time taken for the reference input to ramp from 0 to 100.0% following a 0 to 100% step change in input.

14.08	**PID enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	4ms read															

14.09	**PID optional enable source**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**														
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**														
Update rate	Read on reset															

To enable the PID controller the drive must be OK/healthy (Pr **10.01** = 1) and the PID enable (Pr **14.08**) must be one. If the option enable source (Pr **14.09**) is 00.00 or routed to a non-existent parameter the PID controller is still enabled provided Pr **10.01** = 1 and Pr **14.08** = 1. If the optional enable source (Pr **14.09**) is routed to an existing parameter the source parameter must be one before the PID controller can be enabled. If the PID controller is disabled the output is zero and the integrator is set to zero.

14.10	**PID P gain**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

14.11	**PID I gain**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	0.500														
Update rate	Background read															

14.12	**PID D gain**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	0.000														
Update rate	Background read															

14.13	**PID upper limit**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.00 to 100.00 %
Default	Open-loop, Closed-loop vector, Servo, Regen	100.00
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						2						1	1	1	

14.14	**PID lower limit**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.00 %
Default	Open-loop, Closed-loop vector, Servo, Regen	-100.00
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						2						1	1		

If Pr **14.18** = 0, the upper limit (Pr **14.13**) defines the maximum positive output for the PID controller and the lower limit (Pr **14.14**) defines the minimum positive or maximum negative output. If Pr **14.18** = 1, the upper limit defines the maximum positive or negative magnitude for the PID controller output. When any of the limits are active the integrator is held.

14.15	**PID scaling**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.000 to 4.000
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000
Update rate	4ms read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						3						1	1	1	

14.16	**PID destination**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **21.51**
Default	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00**
Update rate	Read on reset	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			2					1	1	1	1	

The value written to the destination parameter is (PID controller output x scaling) + PID main reference.

14.17	**PID hold integrator**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Default	Open-loop, Closed-loop vector, Servo, Regen	0
Update rate	4ms read	

Coding

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

When this parameter is set to 0 the integrator operates normally. Setting this parameter to 1 will cause the integrator value to be held. Setting this parameter does not prevent the integrator from being reset to zero if the PID controller is disabled.

14.18	**PID symmetrical limit enable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	Background read															

See Pr **14.13** and Pr **14.14**.

14.19	**PID main reference**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen								±100.00 %							
Update rate	4ms write															

14.20	**PID reference**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen								±100.00 %							
Update rate	4ms write															

14.21	**PID feedback**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen								±100.00 %							
Update rate	4ms write															

14.22	**PID error**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen								±100.00 %							
Update rate	4ms write															

5.17 Menus 15, 16 and 17: Solutions Module slots

Pr **x.00** and Pr **x.01** are always present in menus 15, 16 and 17. Pr **x.01** indicates which type of module is present (0 = no module installed). When a module is installed the drive provides the relevant menu (menu 15 for slot 1, 16 for slot 2 and 17 for slot 3) depending on the Solutions Module installed. The possible categories are shown below.

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	
204	SM-I/O PELV	
205	SM-I/O 24V Protected	
206	SM-I/O120V	
207	SM-I/O Lite	
208	SM-I/O 32	
301	SM-Applications	Automation (Applications)
302	SM-Applications Lite	
303	SM-EZMotion	
304	SM-Applications Plus	
305	SM-Applications Lite V2	
306	SM-Register	
401	SM-LON	Fieldbus
403	SM-PROFIBUS-DP	
404	SM-INTERBUS	
406	SM-CAN	
407	SM-DeviceNet	
408	SM-CANopen	
409	SM-SERCOS	
410	SM-Ethernet	
421	SM-EtherCAT	
501	SM-SLM	SLM

Most modules include a processor and parameters are updated by the processor in the Solutions Module. However, dumb modules do not contain a processor and all parameters are updated by the drive processor. Dumb Solutions Modules are SM-Encoder Plus, SM-Encoder Output Plus, SM-Resolver and SM-I/O Plus.

Dumb Solutions Module parameters are read/written by the drive background task or at the combined update time for time critical parameters. The combined update time depends on the number and type of dumb Solutions Modules installed to the drive. For each Solutions Module the update rate of these parameters is specified as 4ms, 8ms, etc. The combined update time is the total of the update times for all dumb Solutions Modules installed.

For example, if a module with 4ms update time and a module with 8ms are installed to the drive, then the combined update time for the time critical parameters of each module is 12ms.

In the parameter tables the update time added by the type of module is given, for example 4ms for the SM-Encoder Plus or 8ms for the SM-I/O Plus.

When parameters are saved by the user in the drive EEPROM the option code of the currently installed module is saved in EEPROM. If the drive is subsequently powered-up with a different module installed, or no module installed where a module was previously installed, the drive gives a Slot.dF trip. The menu for the relevant slot appears for the new module category with the default parameter values for the new category. The new parameters values are not stored in EEPROM until the user performs a parameter save.

Parameters common to all categories

Parameter		Range	Default	Type					
x.**01**	Solutions Module ID	0 to 599		RO	Uni			PT	US
x.**50**	Solutions Module error status	0 to 255		RO	Uni		NC	PT	

5.17.1 SM-Universal Encoder Plus

The Solutions Module checks for various errors as shown below.

Table 5-13 Solutions Module error status values for SM-Universal Encoder Plus

Error code	Encoders	Fault description
1	All	Power supply short circuit
2	Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo, SC.SErvo	+Hardware wire-break detect on A, B and Z inputs(1)
	SC, SC.HiPEr, SC.EndAt, SSC.SSI, SC.SErvo	Software wire break detection on sine wave signals
3	Ab.SErvo, Fd.SErvo, Fr.SErvo, SC.SErvo	+Phase error(2)
	SC.SErvo (both methods), SC.HiPEr, SC.EndAt, SC.SSI, SC.SErvo	+Sine/cosine phase error(3)
4	SC.HiPEr, SC.EndAt, SC.SSI	Comms failure (timeout)
	EndAt	Comms failure (timeout) or transfer time too long
	SSI	Comms transfer time is too long
5	SC.HiPEr, SC.EndAt, EndAt	Checksum / CRC error or SSI not ready at start of position transfer (i.e. data input not one)
6	SC.HiPEr, SC.EndAt, EndAt	The encoder has indicated an error
	SC.SSI, SSI	+Power supply failure
7	SC, SC.HiPEr, SC.EndAt, SC.SSI, EndAt, SSI	Initialisation has failed due to a comms error.
8	SC.HiPEr, SC.EndAt, EndAt	Auto-configuration has been requested by changing Pr **x.18**. An initialisation will occur to perform auto-configuration.
9	All	Thermistor trip, Over-temperature
10	All	Thermistor trip, Short circuit
11	SC, SC.HiPEr, SC.EndAt, SC.SSI, SC.SErvo	Failure of analog position alignment during encoder initialisation
12	SC.HiPEr	The encoder type could not be identified during auto-configuration
13	SC.EndAt, EndAt	The number of encoder turns read from the encoder during auto-configuration is not a power of 2
14	SC.EndAt, EndAt	The number of bits defining the encoder position within a turn read from the encoder during auto-configuration is too large.
15	SC.HiPEr, SC.EndAt, EndAt	The number of periods per revolution is either less than 2 or greater than 50000 when read or calculated from the encoder data during auto-configuration.
16	SC.EndAt, EndAt	The number of comms bits per period are larger than 255.
74	All	The Solutions Module has overheated.

+These trips can be enabled/disabled by Pr **x.17**

1. If the terminations are not enabled on the A, B or Z inputs the wire break system will not operate. (Note that as default the Z input terminations are disabled to disable wire break detection on this input).
2. Phase error for a servo type encoder is to detect that the incremental pulses have been counted incorrectly. The error is detected if the incremental position moves by 10°C with respect to the position defined by the UVW commutation signals. The trip is initiated if the error is detected for 10 consecutive samples.
3. Phase error for SINCOS encoders with comms is detected by interrogating the encoder every second via comms to compare the incremental position determined from the sine waves with the incremental position via comms. If the error is Š 10×C for 10 consecutive samples the trip is initiated.

Encoder initialisation will occur when trips 1 to 8 are reset. This causes an encoder with comms to be re-initialized and auto-configuration to be performed if selected.

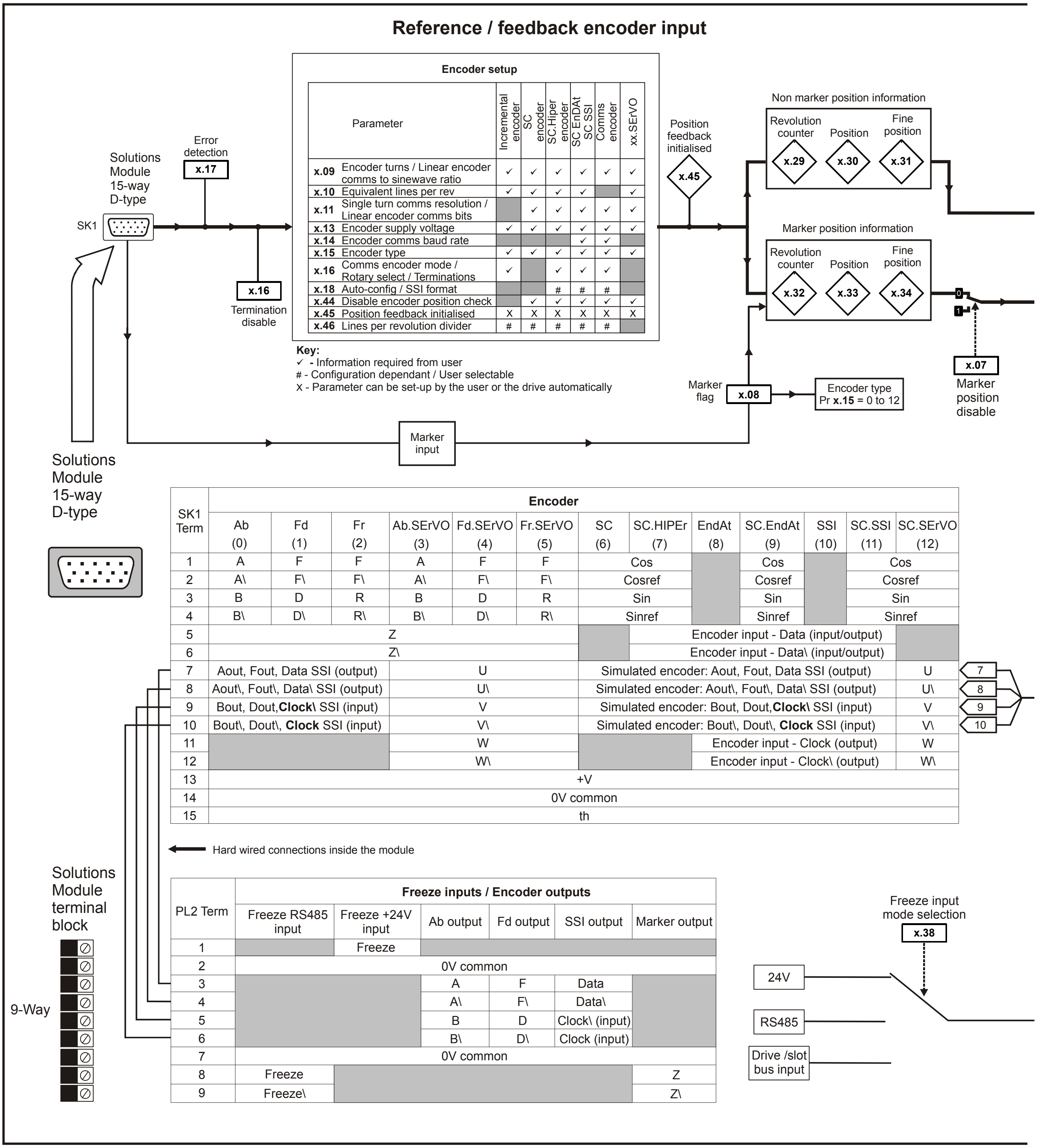
It is important that a break in the connections between the drive and the position feedback device can be detected. This feature is provided either directly or indirectly as listed.
When the drive is reset this parameter is cleared for the relevant Solutions Module

Wire-break detection

It may be important to detect a break in the connections between the drive and the position feedback device. This feature is provided for most encoder types either directly or indirectly as listed below.

Pr x.50	Encoders	Fault description
2	Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo, SC.SErvo	Hardware detectors on the A(F), B(D,R) and Z signal detect a wire break.
2	SC, SC.HiPEr, SC.EndAt, SC.SSI SC.SErvo	The differential levels of the sine and cosine waveforms are available to the drive, from this the drive detects wire break if $Sine^2+Cosine^2$ are less than the value produced by two valid waveforms with a differential peak to peak magnitude of 0.25V (1/4 of the nominal level). This detects wire break in the sine and cosine connections.
4, 5	SC.HiPEr, SC.EndAt, EndAt	Wire break in the comms link is detected by a CRC or timeout error.
5, 6	SSI	Wire break detection is difficult with these devices. However, if power supply monitoring is enabled the drive will be looking for a one at the start of the message and a zero to indicate that the power supply is okay. If the clock stops or the data line is disconnected the data input to the drive may stay in one state or the other and cause a trip.

Figure 5-27 SM-Universal Encoder Plus logic diagram



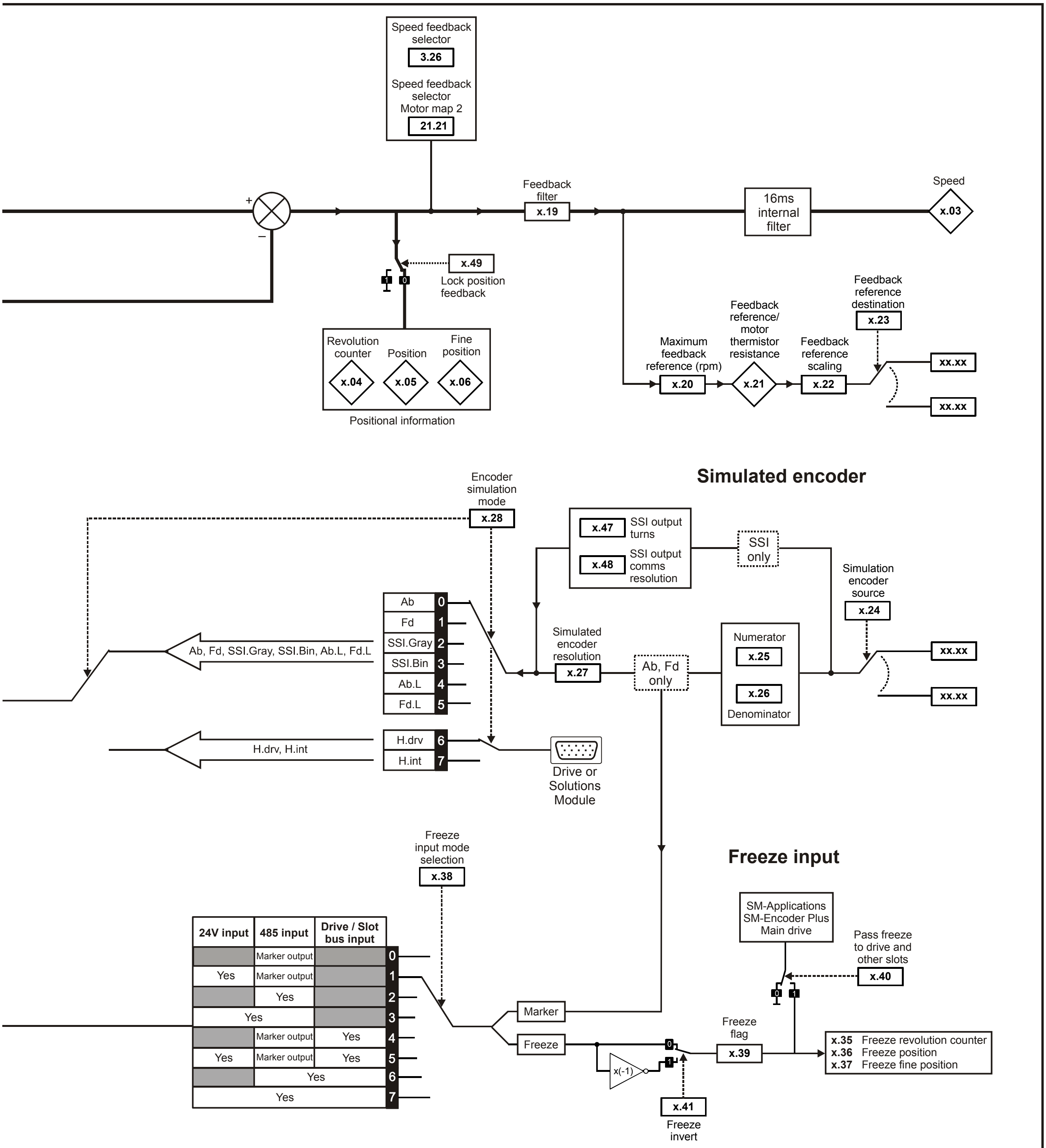
Encoder setup

Parameter		Incremental encoder	SC encoder	SC.Hiper encoder	SC EnDAt SC SSI	Comms encoder	xx.SErVO
x.09	Encoder turns / Linear encoder comms to sinewave ratio	✓	✓	✓	✓	✓	✓
x.10	Equivalent lines per rev	✓	✓	✓	✓		✓
x.11	Single turn comms resolution / Linear encoder comms bits		✓	✓	✓	✓	✓
x.13	Encoder supply voltage	✓	✓	✓	✓	✓	✓
x.14	Encoder comms baud rate				✓	✓	
x.15	Encoder type	✓	✓	✓	✓	✓	✓
x.16	Comms encoder mode / Rotary select / Terminations	✓		✓	✓	✓	
x.18	Auto-config / SSI format			#	#	#	
x.44	Disable encoder position check		✓	✓	✓	✓	✓
x.45	Position feedback initialised	X	X	X	X	X	X
x.46	Lines per revolution divider	#	#	#	#	#	

Key:
✓ - Information required from user
\# - Configuration dependant / User selectable
X - Parameter can be set-up by the user or the drive automatically

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												

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\


Speed feedback selector
3.26
Speed feedback selector Motor map 2
21.21
Feedback filter
x.19
16ms internal filter
Speed
x.03
x.49
Lock position feedback
Revolution counter
Position
Fine position
x.04
x.05
x.06
Positional information
Feedback reference destination
x.23
Feedback reference/ motor thermistor resistance
Maximum feedback reference (rpm)
Feedback reference scaling
x.20
x.21
x.22
xx.xx
xx.xx
Simulated encoder
Encoder simulation mode
x.28
x.47
SSI output turns
x.48
SSI output comms resolution
SSI only
Simulation encoder source
x.24
Ab
Fd
SSI.Gray
SSI.Bin
Ab.L
Fd.L
Ab, Fd, SSI.Gray, SSI.Bin, Ab.L, Fd.L
Simulated encoder resolution
x.27
Ab, Fd only
Numerator
x.25
x.26
Denominator
xx.xx
xx.xx
H.drv
H.int
H.drv, H.int
Drive or Solutions Module
Freeze input
Freeze input mode selection
x.38
24V input
485 input
Drive / Slot bus input
Marker output
Yes
Yes
Freeze
Marker
SM-Applications SM-Encoder Plus Main drive
Pass freeze to drive and other slots
x.40
Freeze flag
x.39
x(-1)
x.41
Freeze invert
x.35 Freeze revolution counter
x.36 Freeze position
x.37 Freeze fine position

x.01	Solutions Module ID code							
RO	Uni						PT	US
⇕	0 to 599				⇨			
Update rate: Write on power-up								

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

102: SM-Universal Encoder Plus

The new parameters values are not stored in EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a Slot.dF trip

x.02	Solutions Module software version								
RO	Uni					NC	PT		
⇕	00.00 to 99.99				⇨				
Update rate: Write on power-up									

NOTE

When operating with an Issue 3 SM-Universal Encoder Plus, the software must be of version **03.xx.xx**. When operating with an Issue 4 SM-Universal Encoder Plus, the software must be of version **04.xx.xx**.
Failure to comply with the above can result in Solutions Module failure.

x.03	Speed								
RO	Bi	FI				NC	PT		
⇕	±40,000.0 rpm				⇨				
Update rate: 4ms write									

Provided the set-up parameters for the position feedback are correct this parameter shows the speed in rpm, this parameter is filtered to give a readable indication of speed.

x.04	Revolution counter								
RO	Uni	FI				NC	PT		
⇕	0 to 65535 revolutions				⇨				
Update rate: 4ms write									

x.05	Position								
RO	Uni	FI				NC	PT		
⇕	0 to 65535 ($1/2^{16}$ths of a revolution)				⇨				
Update rate: 4ms write									

Standard source for simulated encoder output with feedback position being updated every 250µs for the simulated encoder output. Pr **x.05** display value is updated every 4ms.

x.06	Fine position								
RO	Uni	FI				NC	PT		
⇕	0 to 65535 ($1/2^{32}$nds of a revolution)				⇨				
Update rate: 4ms write									

These parameters give the position with a resolution of $1/2^{32}$ths of a revolution as a 48 bit number as shown below.

47 — 32	31 — 16	15 — 0
Revolutions	Position	Fine position

Provided the set-up parameters are correct, the position is always converted to units of $1/2^{32}$ths of a revolution, but some parts of the value may not be relevant depending on the resolution of the feedback device.

Example:

A 1024 line digital encoder produces 4096 counts per revolution, and so the position is represented by the bits in the shaded area only.

47 32	31 20	19 16	15 0
Revolutions	Position		Fine position

When the feedback device rotates by more than one revolution, the revolutions in Pr **x.04** increment or decrement in the form of a sixteen bit roll-over counter. If an absolute position feedback is used the position is initialized at power-up with the absolute position.

If a linear encoder is used the turns information is used to represent the movement by the number of poles defined by Pr **5.11**. Therefore if the number of poles is set to two, one revolution is the movement by one pole pitch.

NOTE

It may be required that Pr **x.04**, Pr **x.05** and Pr **x.06** are reset to zero this can be carried out by changing the encoder type Pr **x.15** with all counters being reset.

x.07	**Marker position reset disable**								
RW	Bit							US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

x.08	**Marker flag**								
RW	Bit					NC			
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: 4ms write									

An incremental digital encoder may have a marker channel and when this channel becomes active (rising edge in the forward direction and falling edge in reverse) it may be used to reset the encoder position and set the marker flag (Pr **x.07** = 0), or just to set the marker flag (Pr **x.07** = 1). When the position is reset by the marker, Pr **x.05** and Pr **x.06** are reset to zero.

The marker flag is set each time the marker input becomes active, but it is not reset by the Solutions Module, and so this must be done by the user. The marker function only operates when Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo, SC.SErvo type encoders are selected with Pr **x.15.**

x.09	**Encoder turns/ linear encoder comms to sine wave ratio**								
RW	Uni					NC		US	
⇕	0 to 255				⇨	16			
Update rate: Background read									

This parameter has a different function depending on the type of encoder selected with Pr **x.15** and Pr **x.16**.

Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo, SC, SC.SErvo
It is sometimes desirable to mask off the most significant bits of the revolution counter with these types of encoders. This does not have to be done for the drive to function correctly. If Pr **x.09** is zero the revolution counter (Pr **x.04**) is held at zero. If Pr **x.09** has any other value it defines the maximum number of the revolution counter before it is reset to zero.

Example, if Pr **x.09**=5, then Pr **x.04** counts up to 31 before being reset. If Pr **x.09** is greater than 16 the number of turns bits is 16 and Pr **x.04** counts up to 65535 before being reset.

SC.HiPEr, SC.EndAt, SC.SSI and Pr x.16 = 1 or 2 (Rotary encoder)
Pr x.09 must contain the number of bits in the comms message used to give the multi-turn information. For a single turn comms encoder, Pr **x.09** must be set to zero. As well as setting the number of comms turns bits this parameter also sets up a mask on the turns displayed in Pr **x.04** as described above.
With SC.HiPEr or SC.EndAt encoders it is possible for this parameter to be obtained automatically from the encoder (see Pr **x.18**). If Pr **x.09** is greater than 16 the number of turns bits is 16.

SC.HiPEr, SC.EndAt, SC.SSI and x.16 = 0 (Linear encoder)
When a linear encoder is selected no mask is placed on the turns information displayed in Pr **x.09**, and so this parameter always displays the turns information as a full 16 bit value with a maximum of 65535. Linear SINCOS encoders with comms are normally specified with a length for each sine wave period and the length for the least significant bit of the position in the comms message. Pr **x.09** should be set up with the ratio between these two lengths so that the Solutions Module can determine the encoder position during initialisation.

The Linear encoder comms to sine wave ratio is defined as follows:

$$\textbf{Linear encoder comms to sine wave ratio} = \frac{\textbf{Length for sine wave period}}{\textbf{Length representing the LS bit of the position in the comms message}}$$

With SC.HiPEr or SC.EndAt encoders it is possible for this parameter to be obtained automatically from the encoder (see Pr **x.18**).

EndAt, SSI
Pr **x.09** must contain the number of bits in the comms message used to give the multi-turn information. For a single turn comms encoder, Pr **x.09** must be set to zero. As well as setting the number of comms turns bits this parameter also sets up a mask on the turns displayed in Pr **x.04** as described above. It is possible for this parameter to be obtained automatically from the encoder (see Pr **x.18**). If Pr **x.09** is greater than 16 the number of turns bit is 16.

NOTE

It should be noted that if the Pr **x.19** the Feedback Filter is used where, the speed feedback is provided by either an EndAt or SSI encoder connected directly to the module, it is necessary for the encoder to provide at least 6 bits of turns information. This is not a problem when the position is defined by the absolute position from the encoder at initialisation and then accumulated delta positions (Pr **x.16** = 0), however, if the absolute position is taken directly from the encoder (Pr **x.16** > 0) the encoder must provide at least 6 bits of turns information.

If the Feedback filter Pr **x.19** is not used turns information from the encoder is not required.

x.10	Equivalent lines per revolution								
RW	Uni							US	
⇕	0 to 50000				⇨	4096			
Update rate: Background read									

When Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo or SINCOS signals are used the equivalent number of encoder lines per revolution must be set-up correctly in Pr **x.10** to give the correct speed and position feedback. This is particularly important if the encoder is selected for speed feedback with Pr **3.26**. The equivalent number of encoder lines per revolution (ELPR) is defined as follows.

Position feedback device	ELPR
Ab, Ab.SErvo	number of lines per revolution
Fd, Fr, Fd.SErvo, Fr.SErvo	number of lines per revolution / 2
SC.HiPEr, SC.EndAt, SC, SC.SErvo	number of sine waves per revolution

For any type of linear encoder one revolution is the motor pole pitch multiplied by the number of poles set up in Pr **5.11**.

Ab, Fd, Fr, Ab.SErvo, Fd.SErvo and Fr.SErvo

The incremental signal frequency should not exceed 500kHz.

SC.HiPEr, SC.EndAt, SC.SErvo, SC and SC.SSI

NOTE

The absolute maximum sine wave signal frequency is 166kHz (version **3.x.x**) 250kHz (version **4.x.x**).

The encoder port is designed to give 10 bits of interpolation resolution at 115kHz. The resolution is reduced at frequencies higher than 115kHz and at peak to peak differential voltages less than 1 volt. The total resolution in bits per revolution is the ELPR plus the number of bits of interpolated information.

The table below shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port.

Volt/Freq	1,000	5,000	50,000	100,000	150,000	200,000	250,000
1.2	11	11	11	10	10	9	9
1.0	11	11	10	10	9	9	8
0.8	10	10	10	10	9	8	8
0.6	10	10	10	9	9	8	7
0.4	9	9	9	9	8	7	7

NOTE

200kHz and 250kHz are not available with hardware versions less than **4.x.x**

If the position feedback device is a rotary SINCOS encoder with comms the position supplied via comms gives a number of counts per revolution that is a power of two and the resolution is defined by the single turns comms bit (Pr **x.11**).

When Pr **x.11** is adjusted an "Initialisation failed - 7" trip is produced, because the encoder requires re-initialisation.

EndAt, SSI

Where encoder comms alone is used as position feedback, the equivalent lines per revolution (Pr **x.10**) is not used in setting up the encoder interface. It is possible for the drive to set up this parameter automatically from information obtained from an EndAt encoder (see Pr **x.18**).

The equivalent lines per revolution in Pr **x.10** can be divided where required using Pr **x.46** line per revolution divider.

Example 128.123 lines per revolution would be set as 128123 in Pr **x.10** and 100 in Pr **x.46** giving 128123 / 1000 = 128.123

x.11	Single turns comms bits/ linear encoder comms bits								
RW	Uni							US	
⇕	0 to 32 bits				⇨	0			
Update rate: Background read									

Where encoder comms is used for initial setting of absolute position (SC.HiPEr or SC.EndAt), the comms resolution in bits must be set correctly, either by the user or the drive (see Pr **x.18**), in Pr **x.11**. The comms resolution may be higher than the resolution of the sine waves per revolution.

Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo, SC, SC.SErvo

Pr **x.11** has no effect.

SC.HiPEr, SC.EndAt, SC.SSI and x.16 = 1 or 2 (Rotary encoder)

Pr **x.11** must be set to the number of comms bits used to represent one revolution of the encoder. The single turn comms resolution may be higher than the resolution of the sine waves per revolution.

SC.HiPEr, SC.EndAt, SC.SSI and x.16 = 0 (Linear encoder)
Pr **x.11** must be set up to the total number of bits representing the whole encoder position in the comms message.

This parameter is not used with linear SC.HiPEr encoders as the number of bits used to represent the whole position is always 32.

EndAt, SSI
Pr **x.11** must be set to the number of bits used to represent one revolution of the encoder.

Although Pr **x.11** can be set to any value from 0 to 32, if the value is less than 1, the resolution is 1 bit. Some SSI encoders (SC.SSI or SSI) include a power supply monitor alarm using the least significant bit of the position. It is possible for the drive to monitor this bit and produce a trip 6 if the power supply is too low (see Pr **x.17**). If the encoder gives this information the comms resolution should be set up to include this bit whether it is being monitored by the Solutions Module or not.

It is possible for the drive to set up this parameter automatically from encoder information via Hiperface or EndAt interfaces (see Pr **x.18**).

x.12	Motor thermistor check enable							
RW	Bit						US	
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

The motor thermistor if connected to the Solutions Module for temperature monitoring is enabled through this parameter.

Refer to the *SM-Universal Encoder Plus User Guide* for full details.

x.13	Encoder supply voltage							
RW	Uni						US	
⇳	0 to 2			⇨	0			
Update rate: Background read								

The encoder supply voltage present on the SM-Universal Encoder is defined by this parameter as 0(5V), 1(8V), or 2(15V).

x.14	Encoder comms baud rate							
RW	Txt						US	
⇳	0 to 7			⇨	2			
Update rate: Background read								

This parameter defines the baud rate for the encoder comms when using encoders with either SSI or EndAt interfaces. A fixed baud rate of 9600 is used with Hiperface encoders and this parameter has no effect. Any baud rate can be used when encoder comms is used with a SINCOS encoder to obtain the absolution position during initialisation.

Pr value	Pr string	Baud rate
0	100	100k
1	200	200k
2	300	300k
3	400	400k
4	500	500k
5	1000	1M
6	1500	1.5M
7	2000	2M

When the encoder comms is used and the position within one turn can be obtained in 30μs and the rest of the message including CRC within a further 30μs (60μs total) the encoder position for control is taken during each level 1 interrupt (fast sampling).

If either of these conditions is not met the position is taken every 250μs. The position feedback used for speed control is taken every 250μs irrespective of the encoder message time. The comms message must not be longer than 200μs otherwise position feedback errors will occur. Compensation based on the speed over the previous 250μs is applied to correct the position so that it appears to have been taken at the encoder datum used by all other encoder types.

If fast sampling is used the control position used to define the drive reference frame is obtained every current/torque control sample (switching frequency selected dependant). If slow sampling is used the control position is obtained every 200μs.

When fast sampling is used the delay introduced into the control system by the encoder is less, and so a higher control system bandwidth will be possible (position values from the encoder could be used in a position control system).

NOTE

Also refer to the *SM-Universal Encoder Plus User Guide*, for further detailed information on operation with encoder serial comms.

x.15	Encoder type								
RW	Uni							US	
⇕	0 to 12			⇨	0				
Update rate: Background read									

The following encoders can be connected to the SM-Universal Encoder Plus.

0, Ab: Quadrature incremental encoder, with or without marker pulse
1, Fd: Incremental encoder with frequency and direction outputs, with or without marker pulse
2, Fr: Incremental encoder with forward and reverse outputs, with or without marker pulse
3, Ab.SErvo: Quadrature incremental encoder with commutation outputs, with or without marker pulse
4, Fd.SErvo: Incremental encoder with frequency, direction and commutation outputs, with or without marker pulse
5, Fr.SErvo: Incremental encoder with forward, reverse and commutation outputs, with or without marker pulse
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.

6, SC: SinCos encoder with no serial communications
This type of encoder can be used for motor control in closed-loop vector mode or servo mode. In servo mode a phasing test must be performed after every drive power-up or encoder trip.

7, SC.HiPEr: Absolute SinCos encoder using Stegmann 485 comms protocol (HiperFace).
This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. The Solutions Module can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the Solutions Module trips the drive. Additional communications with the encoder is possible.

8, EndAt: Absolute EndAt only encoder
This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. Additional communications with the encoder is not possible.

9, SC.EndAt: Absolute SinCos encoder using EndAt comms protocol
This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. The Solutions Module can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the drive trips. Additional communications with the encoder is possible.

10, SSI: Absolute SSI only encoder
This type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. Additional communications with the encoder is not possible. SSI encoders use either gray code or binary format which can be selected with Pr **x.18**. Most SSI encoders use 13 bit single turn position information, and so Pr **x.11** should normally be set to 13. If the single turn resolution of the encoder is lower then the least significant bits of the data are always zero. Some SSI encoders use the least significant bit to show the status of the encoder power supply. In this case the single turn position resolution should be set to include this bit, but the Solutions Module should be set up to monitor it via Pr **x.17**. Some SSI encoders use a right shifted format where the unused single turn position bits are removed instead of being set to zero. For these encoders the single turn position resolution should be set to the number of bits used for the single turn position.

NOTE

If an Absolute SSI only encoder is used with a data transfer rate of >30μs timing problems may occur, resulting in speed feedback instability.

11, SC.SSI: SinCos encoder using SSI comms protocol
This type of encoder gives absolute position and can be used for motor control in Closed-loop vector or Servo modes. The drive can check the position from the sine and cosine waveforms against the internal encoder position using serial communications and if an error occurs the drive trips.

12, SC.SErvo: SinCos encoder with UVW communication outputs
The type of encoder gives absolute position and can be used for motor control in closed-loop vector or servo modes. U, V, W commutation outputs are required with a SinCos type encoder when used with a servo motor. The U, V, W commutation outputs are used to define the motor position during the first 120° electrical rotation after the drive is powered-up or the encoder is initialized.

The following should be noted:
It should be noted that all SINCOS encoders and encoders using communications must be initialized before their position data can be used. The encoder is automatically initialized at power-up or when the initialisation parameter (Pr **3.47**) is set to 1.

In addition to using all the above encoders types as position feedback from a motor, they may be used as a position reference for the drive position controller or a position controller application in an Solutions Module etc. When a comms only encoder interface is used, it is possible to instantly change the position by a large number of turns. This can cause a position error in the drive if the change over a 250μs period appears to produce a speed of greater than 40,000rpm. Therefore if the EndAt or SSI interface is used to provide a reference the change over each 250μs sample must not exceed 0.16 turns. If the position is incorrect because the change is too large this can be corrected by re-initializing the encoder interface, Pr **3.47**.

If an SSI encoder is used, but is not powered from the drive, and the encoder is powered up after the drive it is possible that the first change of position detected could be big enough to cause the problem described above. This can be avoided if the encoder interface is initialized via Pr **3.47** after the encoder has powered up. If the encoder includes a bit that indicates the status of the power supply the power supply monitor should be enabled, Pr **3.40**.

Trips can be enabled/disabled using Pr **3.40** as follows.

Bit	Function
0	Wire break detect
1	Phase error detect
2	SSI power supply bit monitor

This will ensure that the drive remains tripped until the encoder is powered up and the action of resetting the trip will re-initialize the encoder interface.

x.16	Encoder termination/rotary encoder select/comms only encoder mode								
RW	Txt							US	
⇳	0 to 2			⇨	1				
Update rate: Background read									

Encoder termination select

Ab, Fd, Fr, Ab.SErvo, Fd.SErvo, Fr.SErvo.

The terminations may be enabled/disabled by this parameter as follows:

Encoder input	Pr x.16=0	Pr x.16=1	Pr x.16=2
A-A\	Disabled	Enabled	Enabled
B-B\	Disabled	Enabled	Enabled
Z-Z\	Disabled	Disabled	Enabled
U-U\, V-V\, W-W\	Enabled	Enabled	Enabled

SC- Not used
Pr **x.16** has no effect

SC.SErvo

U-U\, V-V\, W-W\ and Sin and Cos signals are terminated and cannot be disabled.

SC.HiPEr, SC.EndAt, SC.SSI - Rotary encoder select

If Pr **x.16** is set to 1 or 2 the encoder is a rotary encoder and the following applies

1. Pr **x.09** defines the number of turns bits in the comms message from the encoder and a mask is applied to Pr **x.04** to remove turns bits in excess of those provided in the encoder comms position.
2. Pr **x.11** defines the number of comms bits used to define a single turn.

If Pr **x.16** is set to 0 the encoder is a linear encoder and the following apply:

1. Pr **x.09** defines the ratio between the length of a sine wave period and the length of the least significant comms bit.
2. No mask is applied to the turns displayed in Pr **x.04**.
3. Pr **x.11** defines the number of comms bits used to give the whole position value.

If the position feedback device is SC.HiPEr or SC.EndAt it is possible for the drive to set up this parameter automatically from information obtained from the encoder (see Pr **x.18**).

EndAt, SSI - Comms only encoder mode

If this parameter is set to 1 or 2 the drive always takes the complete absolute position for these comms only type encoders. The turns (Pr **x.04**), position (Pr **x.05**) and fine position (Pr **x.06**) will be an exact representation of the position from the encoder.

If the encoder does not provide 16bits of turns information, the internal representation of the turns used by the position controller in Menu 13 and functions within the SM-Applications Module such as the Advanced Position Controller, rolls over at the maximum position value from the encoder. This jump in position is likely to cause unwanted effects.

EndAt
The EndAt format includes a CRC that is used by the drive to detect corrupted data, and so if the position data has been corrupted the drive uses the previous correct data until new uncorrupted data is received.

If this parameter is set to 0 the drive only takes the absolute position directly from the encoder during initialisation. The change of position over each sample is then used to determine the current position. This method always gives 16 bits of turns information that can be used without jumps in position by the position controller in Menu13 and SM-applications modules etc. This method will only operate correctly if the change of position over any 250μs period is less than 0.5 of a turn, or else the turns information will be incorrect. The turns can then only be corrected by re-initializing the encoder.This problem should not occur with EndAt encoders because three consecutive corrupted messages at the slowest sample rate (i.e. 250μs) would be required even at the maximum speed of 40,000rpm before the change of position would be the required 0.5 turns to give possible corruption of the turns information. If three consecutive messages with CRC errors occur this will cause the drive to produce an EnC5 trip. The drive can only be re-enabled after the trip is reset which will re-initialize the encoder and correct the absolute turns

SSI
As the SSI format does not include any error checking and it is not possible for the drive to detect if the position data has been corrupted. The benefit of using the absolute position directly from an SSI encoder is that even if the encoder communications are disturbed by noise and position errors occur, the position will always recover the correct position after the disturbance has ceased.

Under normal operating conditions and at a maximum speed of 40,000rpm the maximum change of position is less than 0.5 turns, however, if noise corrupts the data from an SSI encoder it is possible to have apparent large change of position, and this can result in the turns information becoming and remaining corrupted until the encoder is re-initialized.

If an SSI encoder is used, but is not powered from the drive, and the encoder is powered up after the drive, it is possible that the first change of position detected could be large enough to cause the problem described above. This can be avoided if the encoder interface is initialized via Pr **3.47** after the encoder has powered up. If the encoder includes a bit that indicates the status of the power supply the power supply monitor should be enabled (see Pr **x.17**). This will ensure that the drive remains tripped until the encoder is powered up and the action of resetting the trip will reinitialise the encoder interface.

x.17	Error detection level							
RW	Uni						US	
⇕	0 to 15			⇨	0			
Update rate: Background read								

Trips can be enabled/disabled using Pr **x.17** as follows:

Bit	Function
0	Wire break detect
1	Phase error detect
2	SSI power supply monitor
3	Suppress trips 1 to 6 if not used as feedback

The binary sum defines the level of error detection as below:

Bit 3	Bit 2	Bit 1	Bit 0	Error detection level	Pr x.17
0	0	0	0	Error detection disabled	0
0	0	0	1	Wire break detect	1
0	0	1	0	Phase error detect	2
0	0	1	1	Wire break + phase error detect	3
0	1	0	0	SSI power supply bit monitor	4
0	1	0	1	Wire break + SSI power supply bit monitor	5
0	1	1	0	Phase error detect + SSI power supply bit monitor	6
0	1	1	1	Wire break detect + phase error detect + SSI power supply bit monitor	7
1	0	0	0	Error detection disabled + trips suppressed	8
1	0	0	1	Wire break detect suppressed	9
1	0	1	0	Phase error detect suppressed	10
1	0	1	1	Wire break suppressed + phase error detect suppressed	11
1	1	0	0	SSI power supply bit suppressed	12
1	1	0	1	Wire break suppressed + SSI power supply bit suppressed	13
1	1	1	0	Phase error detect suppressed + SSI power supply bit suppressed	14
1	1	1	1	Wire break detect suppressed + phase error detect suppressed + SSI power supply bit suppressed	15

NOTE

If the SSI power supply bit monitor feature is enabled, ensure that this has been configured for an encoder setup Pr **x.09**, Pr **x.11**.

NOTE

In order for the phase error detection to function correctly the LPR of the SC.HiPEr, SC.EndAt and SC.SSI encoder must be greater than 9 x number of motor poles (e.g 54 for a 6 pole servo motor).

Trip suppression mode

If bit 3 is set and #3.26 does not select this option module as the feedback device, trips 1 to 6 (encoder trips during normal running) will not trip the drive. They will still be serviced locally, for example the power supply will be turned off if an overload condition occurs.

When this mode is active and a trip occurs, the option module will set x.49 (freeze encoder position) to alert the user that a trip has been suppressed. The trip number will still be written to x.50, but a drive trip request will not be made (SIx.Er). The action of resetting the drive resets the flag (x.49) and the trip (x.50).

x.18	Auto configuration enable / SSI binary format select							
RW	Bit						US	
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

SC.HiPEr, SC.EndAt, EndAt

When an SC.HiPEr, SC.EndAt or EndAt encoder is being used, the Solutions Module will interrogate the encoder on power-up. If Pr x.18 is set to one and the encoder type is recognized based on the information provided by the encoder, the Solutions Module will set-up.

1. The encoder turns / linear encoder comms to sine wave ratio (Pr **x.09**)
2. The equivalent lines per revolution (Pr **x.10**)
3. The encoder comms resolution / linear encoder comms bits (Pr **x.11**)

For SC.HiPEr or SC.EndAt encoders the rotary encoder select (Pr **x.16**) is also set up. If the encoder is not recognized, there is a comms error or the resulting parameter values are out of range the Solutions Module initiates a trip 7 or 12 to 16 trip to prompt the user to enter the information. The Solutions Module can auto-configure with any of the following devices.

Rotary EndAt encoders

The encoder turns, comms resolution and equivalent lines per rev are set up directly using the data read from the encoder.

Linear EndAt encoders

The comms resolution is set to the number of bits required for the whole position within the position data messages from the encoder. The linear encoder comms to sine wave ratio is calculated from the sine wave period and LS comms bit length. The encoder does not give the equivalent lines per rev directly, but gives the length of a sinewave period in mm. Therefore the Solutions Module uses the pole pitch (Pr **5.36**) and the number of motor poles (Pr **5.11**) for the motor to calculate the equivalent lines per revolution.

ELPR = Pole pitch x Number of motor pole pairs / Length of a sinewave

Normally the Number of motor poles will be set to 2, and so:

ELPR = Pole pitch / Length of a sinewave

It should be noted that the equivalent lines per revolution parameter is only updated when auto-configuration occurs, i.e. when the encoder is initialized, and that it uses the pole pitch for the active motor. The value for Pole pitch x Number of motor pole pairs is limited to 655.35mm by the drive. If the pole pitch is left at its default value of zero which would give ELPR = 0, or the result of the calculation is over 50000, the drive will initiate an Enc15 trip.

NOTE

The ELPR divider (Pr **x.46**) is returned to 1 if auto-configuration completes correctly.

Hiperface encoders

The Solutions Module can recognize any of the following devices: SCS 60/70, SCM 60/70, SRS 50/60, SRM 50/60, SHS 170, LINCODER, SCS-KIT 101, SKS36, SKM36, SEK52 and SEK53. If the Solutions Module cannot recognize the encoder type it will initiate 12 trip.

NOTE

The ELPR divider (Pr **x.46**) is returned to 1 if auto-configuration completes correctly.

SC.SSI, SSI

SSI encoders normally use gray code data format. However, some encoders use binary format that may be selected by setting this parameter to one.

x.19	**Feedback filter**							
RW	Uni						US	
⇕	0 (0), 1 (1), 2 (2), 4 (3), 8 (4), 16 (5) ms			⇨	0 (0)			
Update rate: Background read								

0 = 0ms, 1 = 1ms, 2 = 2ms, 3 = 4ms, 4 = 8ms, 5 = 16ms

A sliding window filter may be applied to the feedback. This is particularly useful in applications where the feedback is used to give speed feedback for the speed controller and where the load includes a high inertia, and so the speed controller gains are very high. Under these conditions, without a filter on the feedback, it is possible for the speed loop output to change constantly from one current limit to the other and lock the integral term of the speed controller.

It should be noted that if this filter is used where the speed feedback is provided by an EndAt or SSI encoder connected directly to the module, it is necessary for the encoder to provide at least 6 bits of turns information. This is not a problem when the position is defined by the absolute position from the encoder at initialisation and then accumulated delta positions (Pr **x.16**=0), however, if the absolute position is taken directly from the encoder (Pr **x.16** > 0) the encoder must provide at least 6 bits of turns information. If this filter is not used (i.e. Pr **x.19**=0) turns information from the encoder is not required.

The speed filter can be used to reduce resolution "stepping" problems with low line per revolution encoder inputs when used through the feedback reference router also.

x.20	**Maximum feedback reference**							
RW	Uni						US	
⇕	0.0 to 40,000.0rpm			⇨				
Update rate: Background read								

x.21	**Feedback reference/ Motor thermistor resistance**							
RO	Bi				NC	PT		
⇕	-100.0 to +100.00%			⇨				
Update rate: 4ms write								

The resistance value of the thermistor input can be seen in Pr **x.21**. The motor thermistor resistance value shown in Pr **x.21** is shown in 0.1% of 10kΩ units. The position feedback when used as a reference can be viewed here.

x.22	Feedback reference scaling							
RW	Uni						US	
⇳	0.000 to 4.000			⇨	1.000			
Update rate: Background read								

The feedback reference scaling is applied as follows:

3000rpm Motor							
Parameter		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Pr **x.20**	Max f/b ref	3000.0	1500.0	6000.0	3000.0	1500.0	6000.0
Pr **x.21**	F/b ref	100.0	100.0	50.0	100.0	100.0	50.0
Pr **x.22**	F/b ref scaling	1.000	1.000	1.000	0.500	0.500	0.500
Pr **x.23**	Destination	Pr **1.21**	Pr **1.21**	Pr **1.21**	Pr **1.21**	Pr **1.21**	Pr **1.21**
Pr **1.21**	Preset speed	3000.0	3000.0	1500.0	1500.0	1500.0	750.0

x.23	Feedback reference destination							
RW	Uni			DE			US	
⇳	00.00 to 21.51			⇨	00.00			
Update rate: Read on reset								

The position feedback can be used as a reference for any unprotected parameter and is the output from the speed filter (Pr **x.19**). This value is also displayed in Pr **x.03** after further filtering to aid readability.

The filtered reference is converted to percentage of the maximum position feedback reference (Pr **x.20**) and displayed via the feedback reference (Pr **x.21**). This value is to the nearest tenth of a percent and is limited to ± 100.0%. The limited percentage value is then scaled by the feedback reference scaling (Pr **x.22**). This scaled value is also to the nearest tenth of a percent and is also limited to ± 100.0%. The value written to the destination parameter is converted to a percentage of the full-scale value of the destination (Pr **x.23**) to the nearest tenth of a percent.

The destination is updated every 4ms.

If the destination for the feedback is the hard speed reference (Pr **3.22**), a shortcut facility is provided in the drive. In order to invoke this facility, the maximum feedback reference (Pr **x.20**) must be set to the maximum currently used for the hard speed reference and the scaling parameter (Pr **x.22**) must be set to 1.0000. The destination is updated every 250μs and a value in rpm is written to Pr **3.22** every 4ms for indication only.

NOTE

If the destination is default or invalid (non-existent or protected) Pr **x.21** displays the motor thermistor resistance in 0.1% of 10kΩ units. This operates even if Pr **x.12** (thermistor enable) is not enabled allowing the user to design their own characteristic without trips using the threshold detector.

Example

Speed is 200rpm Pr **x.20** is 400rpm so Pr **x.21** shows 50%. Pr **x.22** is 0.500 so the final percentage value is 25%. The destination is a 16 bit bipolar parameter which therefore will have 25% * (2^15) = 8192 written to it.

Effect of encoder resolution

A 1024 line encoder as the input produces 4096 counts per revolution. The resolution is one count per 250μs. As one count is 1/4096th of a revolution, the speed resolution is actually 58.8rpm.

A 4096 line encoder as the input produces 16384 counts per revolution. As one count is 1/16384th of a revolution, the speed resolution is actually 14.6rpm.

To compensate for the resolution of one count per 250μs the speed filter can be used. For example a filter of 4ms divides the resolution by 16, but could affect the performance of any control loop.

Effect of percentage resolution

Destinations other than the hard speed reference (Pr **3.22**) will be rounded to the nearest tenth of a percent. This would give a minimum resolution of 1 rpm if the destination maximum were 1000.0rpm for example.

x.24	Encoder simulation source							
RW	Uni					PT	US	
⇳	00.00 to 21.51			⇨	00.00			
Update rate: Read on reset								

x.25	Encoder simulation ratio numerator							
RW	Uni						US	
⇳	0.0000 to 3.0000			⇨	0.2500			
Update rate: Background read								

The simulated encoder output (incremental), Ab, Ab.L, Fd, Fd.L can be scaled using the above parameter.

x.26	**Encoder simulation ratio denominator**								
RW	Uni							US	
⇳	0.0000 to 3.0000			⇨	1.0000				
Update rate: Background read									

The simulated encoder output (incremental), Ab, Ab.L, Fd, Fd.L can be scaled using the above parameter.

x.27	**Encoder simulation resolution select**								
RW	Bit					NC		US	
⇳	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: Background read									

The simulated encoder output (incremental), Ab, Ab.L, Fd, Fd.L can be scaled using the above parameter.
An encoder simulation output can be generated from any parameter as a source as defined by Pr **x.24** (00.00 disables encoder simulation). Although any parameter can be used, the source parameter is assumed to be a 16 bit position value in the form of a roll-over counter. Therefore only parameters with a range of -32768 to 32767 or 0 to 65535 are normally used. The marker is simulated when the source rolls over or under.

The sources update rate should be considered when setting up a simulated encoder output, for example with Pr **x.05** as the source this has an update rate of 250μs (shortcut in software) with Pr **x.30** this has an update rate of 4ms (averaging is applied for the simulated encoder output in this example to prevent “stepping effects” being seen on the simulated encoder output).

When the Solutions Module is connected to a high precision encoder (i.e. SinCos) and the source has been selected as the internal position (Pr **x.05**), the resolution can be increase to a 24 bit position value by setting Pr **x.27** to a one.

x.28	**Encoder simulation mode**								
RW	Txt							US	
⇳	0 to 7			⇨	0				
Update rate: Background read									

Pr **x.28** defines the output mode for simulated encoder output as follows.

Pr x.28	String	Mode
0	Ab	Quadrature
1	Fd	Frequency and direction
2	SSI.Gray	SSI output (Gray code)
3	SSI.Bin	SSI output (Binary format)
4	Ab.L	Quadrature with marker LOCK
5	Fd.L	Frequency and direction with marker LOCK
6	H.drv	Drive ABZ input signals routed through Hardware
7	H.int	Solutions Module ABZ input signals routed through Hardware

NOTE

Modes 6 and 7 are only available with the drive software versions **01.07.00** onwards, and issue 4 SM-Universal Encoder Plus.

NOTE

If the source is not the feedback device, the simulator waits until all feedback devices are initialized before the starting to output. The wait for initialisation does not occur if the drive software version is less than **V01.08.00**.

NOTE

Also refer to the *SM-Universal Encoder Plus User Guide* for further detailed information.

x.29	**Non-marker reset revolution counter**								
RO	Uni					NC	PT		
⇳	0 to 65535 revolutions			⇨					
Update rate: 4ms write									

x.30	**Non-marker reset position**								
RO	Uni					NC	PT		
⇳	0 to 65535 ($1/2^{16}$ths of a revolution)			⇨					
Update rate: 4ms write									

x.31	Non-marker reset fine position						
RO	Uni				NC	PT	
⇳	0 to 65535 (1/2^{32}nds of a revolution)	⇨					
Update rate: 4ms write							

This position is taken from the position feedback device and is not affected by the marker or the freeze inputs.

x.32	Marker revolution counter						
RO	Uni				NC	PT	
⇳	0 to 65535 revolutions	⇨					
Update rate: 4ms write							

x.33	Marker position						
RO	Uni				NC	PT	
⇳	0 to 65535 (1/2^{16}ths of a revolution)	⇨					
Update rate: 4ms write							

x.34	Marker fine position						
RO	Uni				NC	PT	
⇳	0 to 65535 (1/2^{32}nds of a revolution)	⇨					
Update rate: 4ms write							

Each time the marker becomes active the non-marker position values (Pr **x.29** to Pr **x.31**) are sampled and stored in Pr **x.32** to Pr **x.34**.

x.35	Freeze revolution counter						
RO	Uni				NC	PT	
⇳	0 to 65535 revolutions	⇨					
Update rate: 250µs write							

x.36	Freeze position						
RO	Uni				NC	PT	
⇳	0 to 65535 (1/2^{16}ths of a revolution)	⇨					
Update rate: 250µs write							

x.37	Freeze fine position						
RO	Uni				NC	PT	
⇳	0 to 65535 (1/2^{32}nds of a revolution)	⇨					
Update rate: 250µs write							

x.38	Freeze input mode/ Marker output select							
RW	Uni						US	
⇳	0 to 7	⇨	1					
Update rate: Background read								

The freeze input to the SM Universal Encoder Plus can take the following forms

- A 485 signal through the encoder marker simulation output pins
- A 24V signal on the freeze 24V input
- A signal on the internal drive and slot freeze line generated by another Solutions Module.

The selection of which mode used is dependent on the value of Pr **x.38**. The default is 1 that corresponds to only the 24V input to this Solutions Module. The values correspond to the modes as described in the table below:

Value in Pr x.38	24V input	485 input	Drive/slot bus input
0	No	No	No
1	Yes	No	No
2	No	Yes	No
3	Yes	Yes	No
4	No	No	Yes
5	Yes	No	Yes
6	No	Yes	Yes
7	Yes	Yes	Yes

NOTE

Modes 4 to 7 are only available with the drive software versions **01.07.00** onwards and issue 4 SM-Universal Encoder Plus.

x.39	**Freeze flag**								
RW	Bit					NC			
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: 250µs write									

Each time the freeze input on the Solutions Module becomes active the non-marker position (Pr **x.29** to Pr **x.31**) is stored in Pr **x.35** to Pr **x.37** and the freeze flag (Pr **x.39**) is set. The freeze flag is not reset by the module and must be reset by the user. No other freeze conditions will be trapped if the flag is set.

x.40	**Pass freeze to drive and other slots**								
RW	Bit					NC		US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

This parameter enables the Solutions Module to pass the freeze signal internally to the drive and other slots so that when a freeze occurs on the Solutions Module the main drive position and/or other slots can also be frozen.

x.41	**Freeze invert**								
RW	Bit							US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

When Pr **x.41** = 0 freeze occurs on the rising edge of the freeze input. When Pr **x.41** = 1 freeze occurs on the falling edge of the freeze input.

x.42	**Encoder comms transmit register/Sin signal value/ commutation signal level**								
RW	Uni					NC			
⇕	0 to 65535				⇨	0			
Update rate: Background read									

In SINCOS mode (6) ONLY with no comms or commutation inputs, the internal differential Sin signal value is written to Pr **x.42** as an unsigned number.
A value greater then 32768 in Pr **x.42** requires the user to minus 65536 to get the negative result. 0.675V approximate differential input produces 16384 (the maximum). The value given is quantized to 32 as the ADC produces a 10bit value with the outputs most significant bit in bit14 of the value in Pr **x.42**.

0.5V gives approximately 12192 and 0.25V gives approximately 6112.

In AB.SErvo (3), FD.SErvo (4) or FR.SErvo (5) mode, the value in Pr **x. 42** is obtained from the rules below. This permits the user to determine the current segment and status of the commutation inputs (U high equals logic 1, U low equals logic 0):

Pr **x.42** = 1000 * segment + 100 * U state + 10 * V state + W state

Example

If the commutation inputs equalled 110 (which is the 2nd segment) then Pr **x.42** would be set to 2110.

Segment 9 means that the current commutation input is invalid.

All other modes follow the description for Pr **x.44**.

NOTE

This parameter has no effect for SC.SErvo encoders.

x.43	**Encoder comms receive register/Cos signal value**							
RW	Uni				NC			
⇳	0 to 65535			⇨	0			
Update rate: Background write								

In SINCOS mode (6) ONLY with no comms or commutation inputs, the internal differential Cos signal is written to this parameter as an unsigned number.

A value greater then 32768 in Pr **x.42** requires the user to minus 65536 to get the negative result.
In AB.SErvo (3), FD.SErvo (4) or FR.SErvo (5) mode, Pr **x.43** equals zero.
All other modes follow the description for Pr **x.44**.

NOTE
This parameter has no effect for SC.SErvo encoders.

x.44	**Disable encoder position check**							
RW	Bit				NC	PT		
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

If Pr **x.44** is zero the drive can check the position derived with the sine and cosine waveforms from a SinCos encoder via serial communications.

If Pr **x.44** is set to one the checking is disabled and encoder comms is available via the transmit and receive registers. The transmission system can be used to communicate with encoders provided the mode is either SC.HiPEr or SC.EndAt.

NOTE
For further detailed information refer to the *SM-Universal Encoder Plus User Guide*.

x.45	**Position feedback initialised**							
RO	Bit				NC	PT		
⇳				⇨				
Update rate: Background write								

At power-up Pr **x.45** is initially zero, but is set to one when the encoder connected to position module has been initialized. The drive cannot be enabled until this parameter is one.

If the encoder power-supply is lost, or the encoder type parameter is changed for an encoder connected to a Solutions Module, and the encoder type is SC, SC.HiPEr, SC.EndAt or EndAt the encoder will no longer be initialized. When an encoder is no longer initialized Pr **x.45** is reset to zero and the drive cannot be enabled. The encoder may be re-initialized, provided the drive is not active, by setting Pr **3.47** to one. Pr **x.45** is automatically reset to zero when the initialization is complete.

x.46	**Line per revolution divider**							
RW	Uni						US	
⇳	1 to 1024			⇨	1			
Update rate: Background read								

The LPR divider Pr **x.46** is used to scale the equivalent lines per revolution in Pr **x.10** of incremental and SinCos encoders, without comms, on rotary motors, and all but comms only encoders on linear motors. (Servo encoders must have the same number and pitch of poles as the motor).

The equivalent line per revolution parameter (Pr **x.10**) is divided by the value in Pr **x.46**. This can be used when an encoder is used with a linear motor where the number of counts or sine waves per pole is not an integer.

Example

128.123 lines per revolution would be set as 128123 in Pr **x.10** and 1000 in Pr **x.46** giving:

128123 / 1000 = 128.123. If the value is less than 1, the value used will be 1.

When using SinCos encoders with comms, the comms and SinCos positions must be aligned. The comms position resolution may be a multiple of the analog position resolution. When a linear encoder type has been selected (Pr **x.16** = 0) the value in Pr **x.09** is this multiple.

The motor pole pitch used to configure EndAt and Hiperface encoders is that of the currently selected motor map.

NOTE
When setting larger values in Pr **x.10** when the Solutions Module is the main feedback device, the drive will limit the maximum speed, which in turn limits the maximum of some of the drive parameters such as Pr **1.06** and Pr **1.21**. If the overall value of the LPR after division is low once more, the parameters that have been limited will not return to their original values and may need to be increased. An ELPR of 10,000 gives a maximum speed of 3000rpm.

NOTE
When operating with an Incremental plus commutation (absolute encoder), Ab.SErvo, Fd.SErvo, Fr.SErvo or SC.SErvo this parameter should remain at default (Pr **x.46** = 1).

x.47	**SSI output turns**								
RW	Uni							US	
⇳	0 to 16			⇨	16				
Update rate: Background read									

Used to define the simulated encoder output in SSI mode, refer to the *SM-Universal Encoder Plus User Guide*.

x.48	**SSI output comms resolution**								
RW	Uni							US	
⇳	0 to 32 bits			⇨	0				
Update rate: Background read									

Used to define the simulated encoder output in SSI mode, refer to the *SM-Universal Encoder Plus User Guide*.

x.49	**Lock position feedback**								
RW	Bit								
⇳	OFF (0) or On (1)			⇨					
Update rate: Background write									

If Pr **x.49** is set to one, Pr **x.04**, Pr **x.05** and Pr **x.06** are not updated. If this parameter is zero, Pr **x.04**, Pr **x.05** and Pr **x.06** are updated normally.

x.50	**Solutions Module error status**								
RO	Uni					NC	PT		
⇳	0 to 255			⇨					
Update rate: Background write									

The error status is provided so that the only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a 'SLX.Er' trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-13 on page 253 for the meaning of the values in this parameter for the SM-Universal Encoder Plus). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C (94°C **V03.02.00** or later), the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C (94°C **V03.02.00** or later), the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

x.51	**Solutions Module software sub-version**								
RO	Uni					NC	PT		
⇳	0 to 99			⇨					
Update rate: Write on power-up									

The SM-Universal Encoder Plus includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz.

Where:

xx specifies a change that affects hardware compatibility
yy specifies a change that affects product documentation
zz specifies a change that does not affect the product documentation

When a Solutions Module is installed that does not contain software, both Pr **x.02** and Pr **x.51** appear as zero.

NOTE

When operating with an Issue 3 SM-Universal Encoder Plus Solutions Module, the software must be **V.03.xx.xx**. When operating with an Issue 4 SM-Universal Encoder Plus Solutions Module, the software must be **V.04.xx.xx**
Failure to comply with the above can result in Solutions Module failure.

5.17.2 SM-Resolver

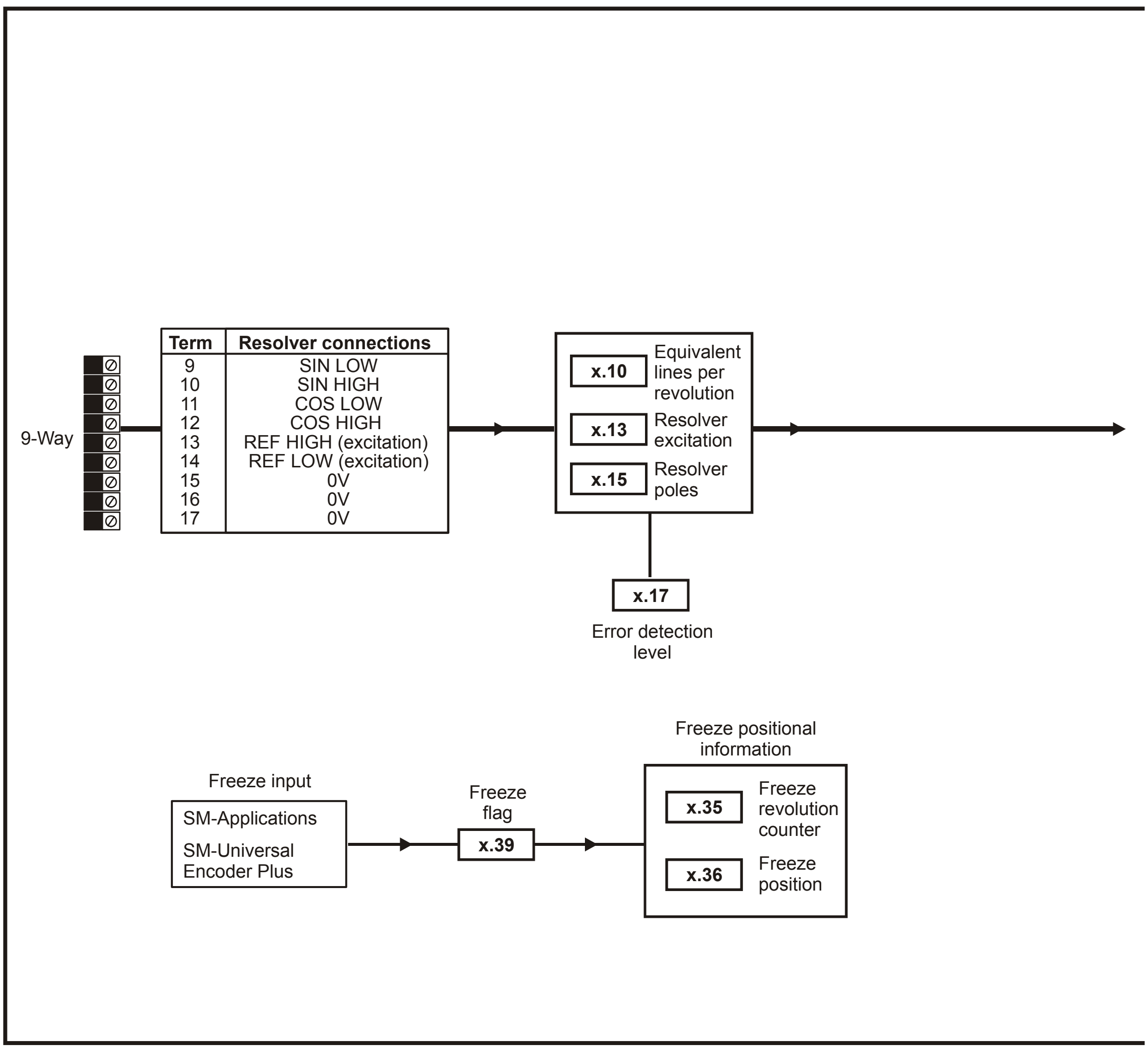
The Solutions Module checks for various errors as shown below.

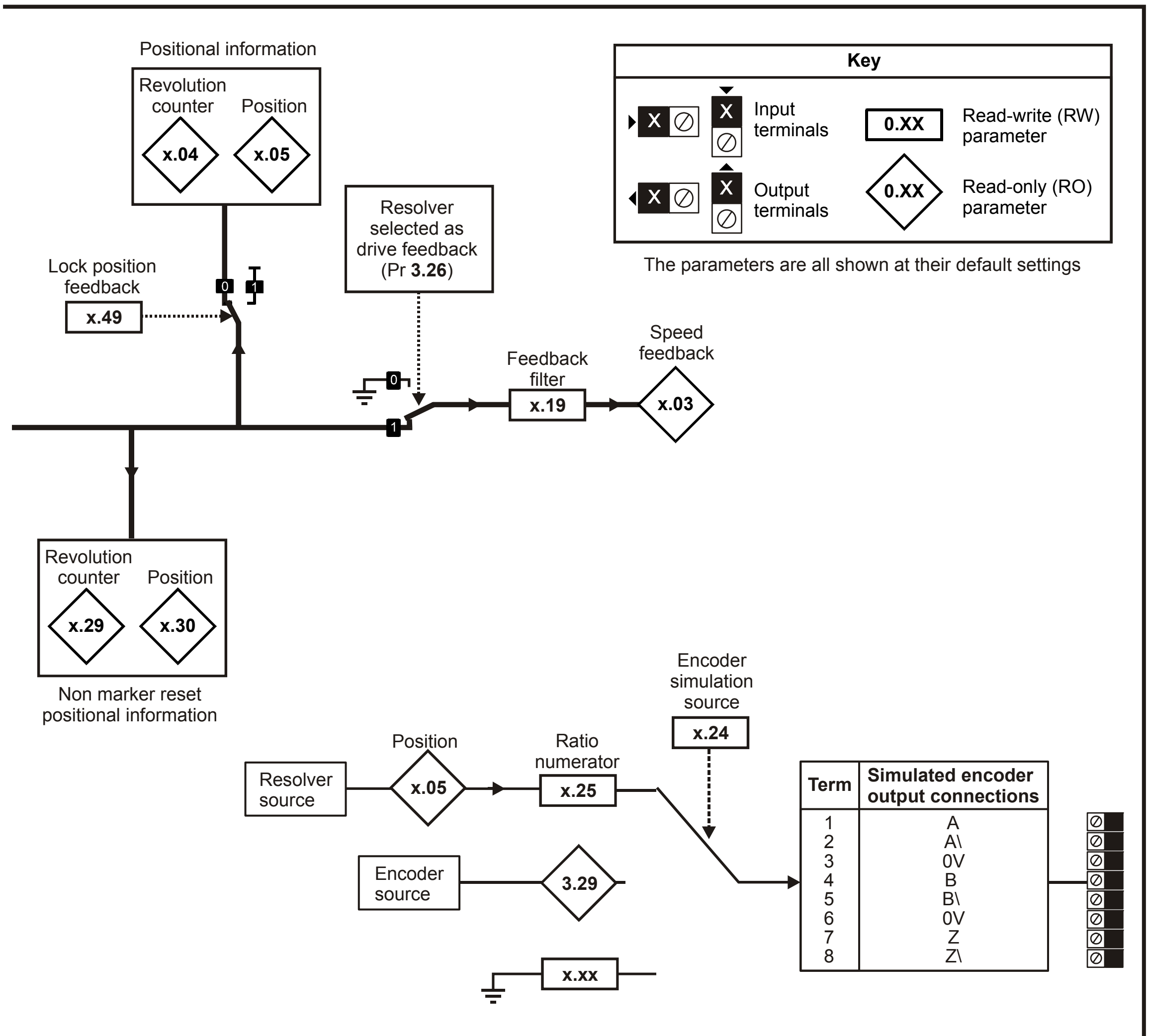
Table 5-14 Solutions Module error status values for the SM-Resolver

Error code	Reason for error
0	No fault detected
1	Excitation supply short circuit
2	+Wire-break detect
74	The Solutions Module has overheated.

+ This trip can be enabled/disabled by Pr **x.17**.

Figure 5-28 SM-Resolver logic diagram





Positional information
Revolution counter
Position
x.04
x.05
Lock position feedback
x.49
Resolver selected as drive feedback (Pr 3.26)
Feedback filter
x.19
Speed feedback
x.03
Key
Input terminals
Output terminals
0.XX
Read-write (RW) parameter
0.XX
Read-only (RO) parameter
The parameters are all shown at their default settings
Revolution counter
Position
x.29
x.30
Non marker reset positional information
Encoder simulation source
x.24
Resolver source
Position
x.05
Ratio numerator
x.25
Encoder source
3.29
x.xx
Term
Simulated encoder output connections
1 A
2 A\
3 0V
4 B
5 B\
6 0V
7 Z
8 Z\

When an SM-Resolver is installed the user parameter menu for the module contains all the parameters for a position feedback category Solutions Module. However, all parameters are not used by this Solutions Module. In the descriptions below only the parameters used by the module are described.

The update time for some functions are affected by the number of dumb Solutions Modules installed to the drive. The update time for these functions is the sum of the update times for all dumb Solutions Modules installed to the drive, called the combined update time. The update time for the SM-Encoder plus and SM-Resolver modules is 4ms, and the update time for the SM-I/O plus is 8ms.

For example, if a module with 4ms update time and a module with 8ms are installed to the drive, then the combined update time for the time critical parameters of each module is 12ms.

If the module is selected for motor control the position feedback can be used as the reference or feedback source for the position controller within the drive or with any application within a SM-Applications module. However, if the module is not selected for motor control the speed (Pr **x.03** is always zero), and the maximum speed must be limited depending on the Solutions Module combined update time so that the resolver position does not change by more than half an electrical revolution within the sample period. Therefore

Maximum speed (rpm) <0.5 x 60 / Combined update time / (Resolver poles / 2)

e.g with a combined update time of 4ms and a 2 pole resolver the maximum speed is 7500rpm. If this maximum speed is exceeded the resolver position and freeze position will be incorrect.

Position/speed feedback update rate

If the module is selected for motor control position feedback then the position and speed parameters are updated as defined with each parameter, but are available within the drive at a faster rate as shown below.

Control position	Current controller sample rate
Control speed	250μs
Position controller position (menu 13)	4ms
Position for SM-Applications module, etc.	250μs

If the module is not selected for motor control position feedback the position and speed are updated as defined with the appropriate parameters.

x.01	Solutions Module ID code							
RO	Uni					PT	US	
⇕	0 to 599			⇨	101			
Update rate: Write on power-up								

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

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The new parameters values are not stored in EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a Slot.dF or SLot.nf trip.

x.03	Speed feedback							
RO	Bi	FI			NC	PT		
⇕	±40,000.0 rpm			⇨				
Update rate: 4ms x number of dumb modules								

Provided the set-up parameters for the position feedback are correct this parameter shows the speed in rpm.

x.04	Revolution counter							
RO	Uni	FI			NC	PT		
⇕	0 to 65,535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.05	Position							
RO	Uni	FI			NC	PT		
⇕	0 to 65,535 ($1/2^{16}$ths revolutions)			⇨				
Update rate: 4ms x number of dumb modules								

Pr **x.04** and Pr **x.05** give the position with a resolution of 1/2^{16}ths of a revolution as a 32 bit number as shown below.

31 16	15 0
Revolutions	Position

Provided the set-up parameters are correct, the position is always converted to units of 1/2^{16}ths of a revolution, but some parts of the value may not be relevant depending on the resolution of the feedback device. For example if 10 bit resolution is selected the resolver produces 4,096 counts per revolution, and so the position is represented by the bits in the shaded area only.

31 16	15 4	3 0
Revolutions	Position	

When the feedback device rotates by more than one revolution, the revolutions in Pr **x.04** increment or decrement in the form of a sixteen bit roll-over counter.

NOTE

The internal update time for the position Pr **x.05** when used as feedback runs at level 1, this being switching frequency dependant as follows.

Update time	Switching frequency	Level
167µs	3kHz	1
125µs	4kHz, 8kHz, 16kHz	1
83µs	6kHz, 12kHz	1

NOTE

The internal update time for the speed Pr **x.03** when used as feedback runs at level 2 as follows.

Update time	Switching frequency	Level
250µs	3kHz, 4kHz, 6kHz, 8kHz, 12kHz, 16kHz	2

x.10	**Equivalent lines per revolution**								
RW	Uni							US	
⇕	0 to 50,000				⇨	4,096			
Update rate: Background read									

This parameter relates to the equivalent lines per revolution of a quadrature encoder that would provide same resolution of feedback. This parameter should only be set to 256 (10 bit resolution), 1,024 (12 bit resolution) or 4,096 (14 bit resolution). If the parameter is set to any other value the drive assumes the following: 32 to 256 = 256; 257 to 1,024 = 1,024; 1,025 to 50,000 = 4,096. If the drive is operating in Closed-loop vector or Servo modes and the resolver is selected to provide speed feedback for the drive (see Pr **3.26**) then variable maximum SPEED_LIMIT_MAX is defined in the following table.

Resolver poles (Pr x.15)	Equivalent lines per revolution (Pr x.10)	Operating resolution (bit)	SPEED_LIMIT_MAX
2	4,096	14	3,300.0
2	1,024	12	13,200.0
2	256	10	40,000.0
4	4,096	14	1,650.0
4	1,024	12	6,600.0
4	256	10	26,400.0
6	4,096	14	1,100.0
6	1,024	12	4,400.0
6	256	10	17,600.0
8	4,096	14	825.0
8	1,024	12	3,300.0
8	256	10	13,200.0

It should be noted that for a 2 pole resolver that this parameter defines the resolution over one mechanical revolution, but for a resolver with 4, 6 or 8 poles the resolution defines the resolution over an electrical revolution of the motor. For example with a 6 pole resolver (and 6 pole motor) the resolution is over $^1/_3$ of a mechanical revolution.

x.13	Resolver excitation							
RW	Uni						US	
⇳	3:1 (0), 2:1 (1 or 2)			⇨	3:1 (0)			
Update rate: Background read								

The excitation level can be controlled for use with 3:1 ratio resolvers (Pr **x.13** = 0), or 2:1 ratio resolvers (Pr **x.13** = 1 or 2).

x.15	Resolver poles							
RW	Uni						US	
⇳	2POLE (0), 4POLE (1), 6POLE (2), 8POLE (3 to 12)			⇨	2POLE (0)			
Update rate: Background read								

Resolvers with the following numbers of poles can be used with the Solutions Module.

0: 2POLE

1: 4POLE

2: 6POLE

3 to 12: 8POLE

A 2 pole resolver can be selected as drive speed feedback with a motor with any number of poles. A resolver with a number of poles greater than 2 can only be used with a motor where the number of revolver poles divides exactly into the number of motor poles i.e. a 4 pole resolver with an 8 pole motor.

x.17	Error detection level							
RW	Uni						US	
⇳	0 to 7			⇨	1			
Update rate: Background read								

Trips can be enabled/disabled using Pr **x.17** as follows:

Bit	Function
0	Wire break detect
1	Not used
2	Not used

The binary sum defines the level of error detection as below:

Bit 2	Bit 1	Bit 0	Error detection level	Value in Pr x.17
0	0	0	Error detection disabled	0
0	0	1	Wire break detect	1
0	1	0	Error detection disabled	2
0	1	1	Wire break detect	3
1	0	0	Error detection disabled	4
1	0	1	Wire break detect	5
1	1	0	Error detection disabled	6
1	1	1	Wire break detect	7

NOTE

The wire break trip is not activated provided one signal is >1.5Vrms or both are >0.2Vrms approximately.

x.19	**Feedback filter**								
RW	Uni							US	
⇕	0 to 5 (0 to 16 ms)				⇨	0			
Update rate: Background read									

A sliding window filter may be applied to the feedback. This is particularly useful in applications where the feedback is used to give speed feedback for the speed controller and where the load includes a high inertia, and so the speed controller gains are very high. Under these conditions, without a filter on the feedback, it is possible for the speed loop output to change constantly from one current limit to the other and lock the integral term of the speed controller. The filter is not active if the parameter value is 0 or 1ms, but operates over the defined window for parameter values of 2, 4, 8 and 16ms.

Value in Pr x.19	Filter window
0	Not active
1	Not active
2	2ms
3	4ms
4	8ms
5	16ms

x.24	**Encoder simulation source**								
RW	Uni						PT	US	
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Background read									

x.25	**Encoder simulation ratio numerator**								
RW	Uni							US	
⇕	0.0000 to 3.0000				⇨	1.0000			
Update rate: Background read									

Pr x.24 = Pr x.05

Encoder simulation output is derived from the resolver input via hardware. The resolution multiplier can be set up using Pr **x.25** as shown in the table below. The marker output is active when the resolver position is zero, therefore the marker pulse width is equivalent to one encoder count if the ratio is 1, but is reduced if the ratio is less than 1.

NOTE

Some ratios are not possible when the resolver resolution is reduced below 14 bits as shown in the table below.

Pr x.25	Resolver resolution		
	14 bit	**12 bit**	**10 bit**
0.0000 to 0.0312	1/32	1/8	1/2
0.0313 to 0.0625	1/16	1/8	1/2
0.0626 to 0.1250	1/8	1/8	1/2
0.1251 to 0.2500	1/4	1/4	1/2
0.2501 to 0.5000	1/2	1/2	1/2
0.5001 to 3.0000	1	1	1

Pr x.24 = Pr 3.29

Encoder simulation output is derived from the drive encoder port via hardware from the A, B and Z inputs. The drive encoder signals must be digital and not SINCOS. No ratio is possible, therefore Pr **x.25** has no effect.

If Pr **x.24** has any value than those above the encoder simulation outputs are not active.

x.29	**Non-marker reset revolution counter**								
RO	Uni					NC	PT		
⇕	0 to 65,535 revolutions				⇨				
Update rate: 4ms x number of dumb modules									

x.30	Non-marker reset position							
RO	Uni				NC	PT		
⇳	0 to 65,535 (1/2^{16}ths of a revolution)			⇨				
Update rate: 4ms x number of dumb modules								

Pr **x.29** and Pr **x.30** are duplicates of Pr **x.04** and Pr **x.05** respectively.

x.35	Freeze revolution counter							
RO	Uni				NC	PT		
⇳	0 to 65535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.36	Freeze position							
RO	Uni				NC	PT		
⇳	0 to 65535 (1/2^{16}ths of a revolution)			⇨				
Update rate: 4ms x number of dumb modules								

x.39	Freeze flag							
RW	Bit				NC			
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: 4ms x number of dumb modules								

This Solutions Module does not have its own freeze input, therefore the freeze input must come from a SM-Applications or SM-Universal Encoder Plus. The freeze data is processed every 4ms x number of dumb modules installed. If a freeze has occurred and the freeze flag (Pr **x.39**) is zero, the position is stored in Pr **x.36** and the freeze flag is set. The freeze flag must be reset by the user before the next freeze event is stored. This function is only active with 2 pole resolvers.

x.45	Position feedback initialised							
RO	Bit				NC	PT		
⇳	OFF (0) or On (1)			⇨				
Update rate: Background write								

At power-up Pr **x.45** is initially OFF (0), but is set to On (1) when the SM-Resolver can provide position feedback. Pr **x.45** then remains at On (1) while the drive is powered-up.

x.49	Lock position feedback							
RW	Bit							
⇳	OFF (0) or On (1)			⇨				
Update rate: Background write								

If Pr **x.49** is set to one, Pr **x.04** and Pr **x.05** are not updated. If this parameter is zero, Pr **x.04** and Pr **x.05** are updated normally.

x.50	Solutions Module error status							
RO	Uni				NC	PT		
⇳	0 to 255			⇨				
Update rate: Background write								

The error status is provided so that the only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a 'SLX.Er' trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-14 on page 272 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

5.17.3 SM-Encoder Plus / SM-Encoder Output Plus

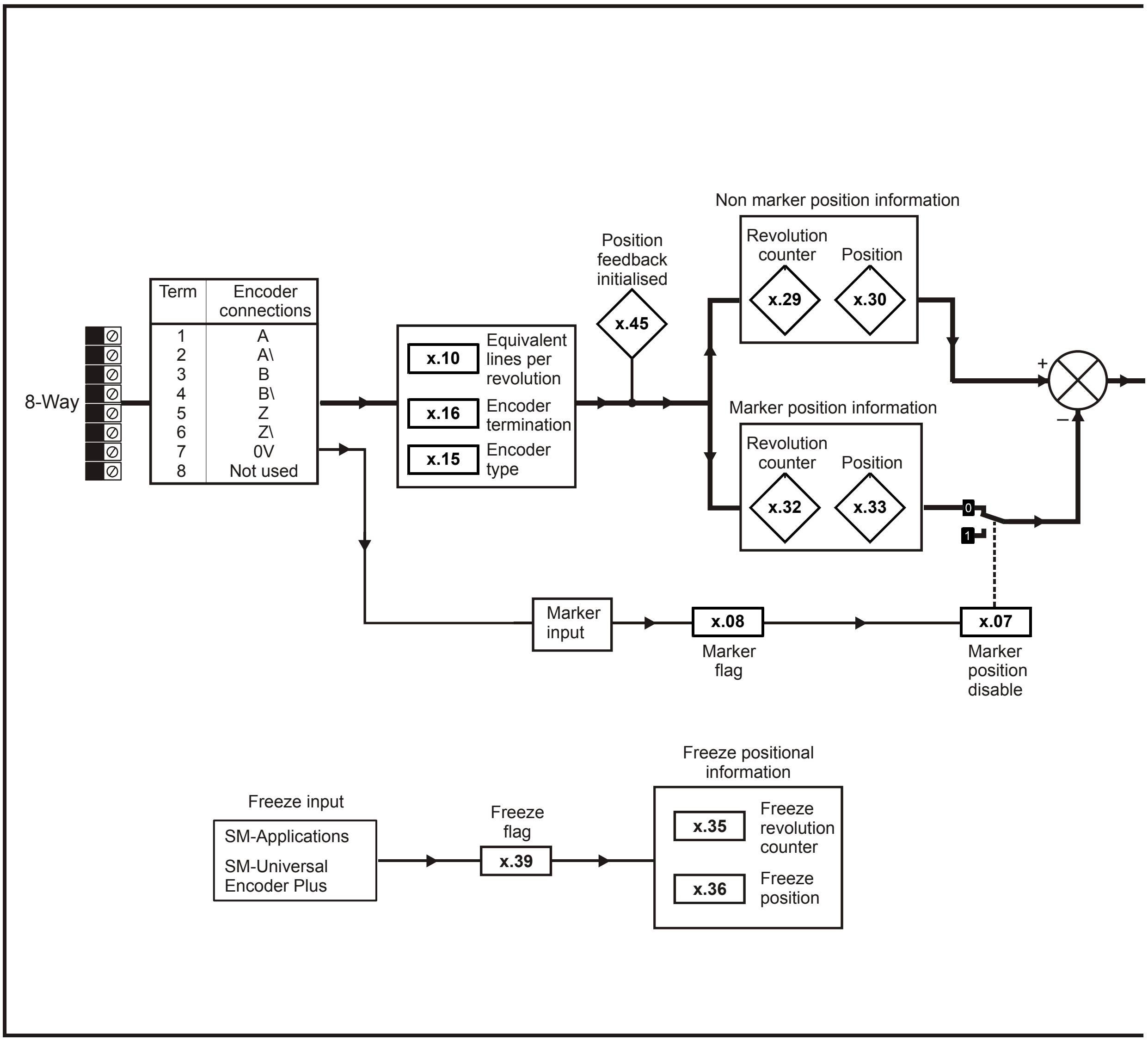
The Solutions Modules checks for various errors as shown below.

Table 5-15 Solutions Module error status values for the SM-Encoder Plus and SM-Encoder Output Plus

Error code	Reason for error
0	No fault detected
1	Power supply overloaded (SM-Encoder Output Plus only)

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.

Figure 5-29 SM-Encoder Plus logic diagram



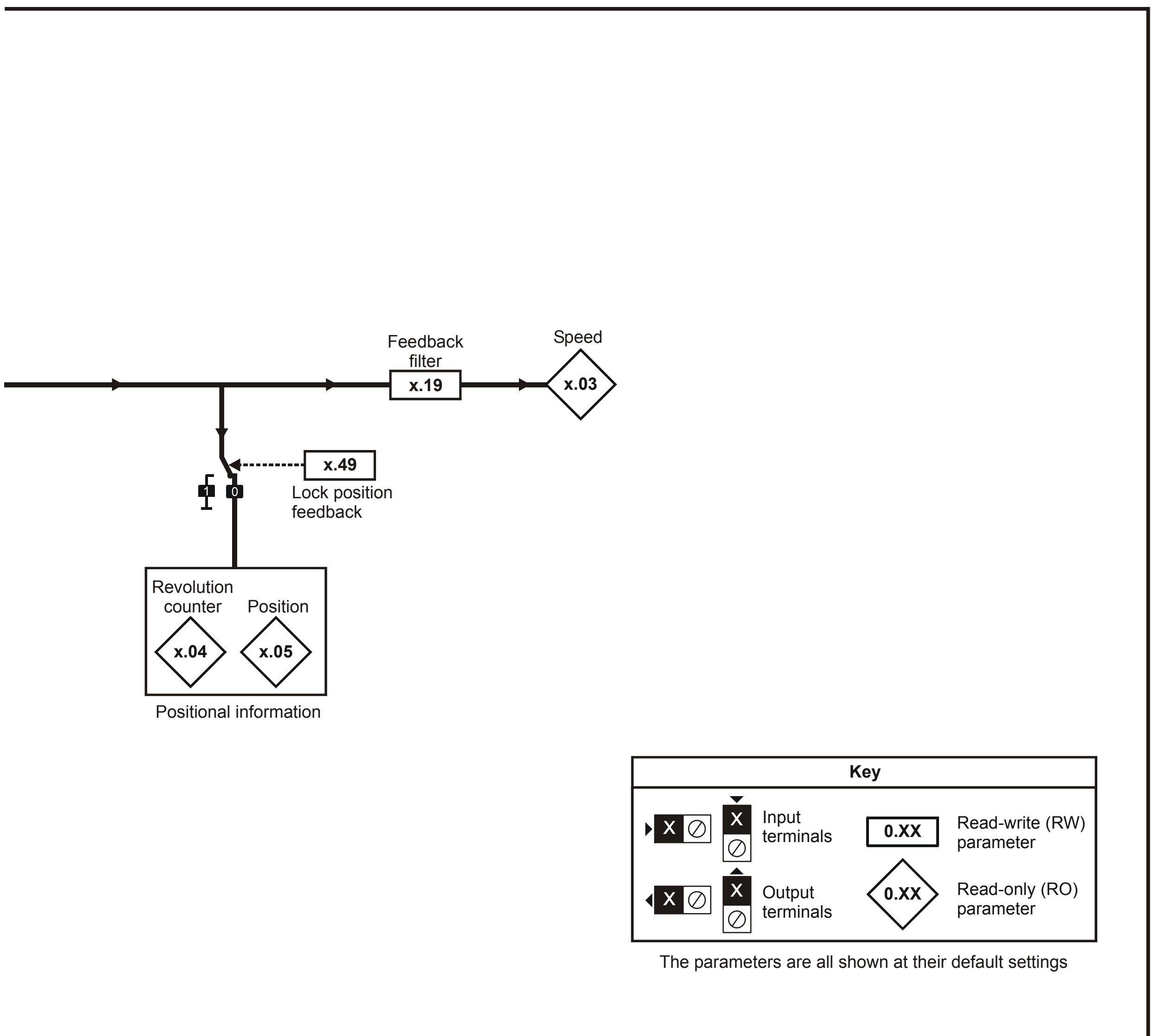
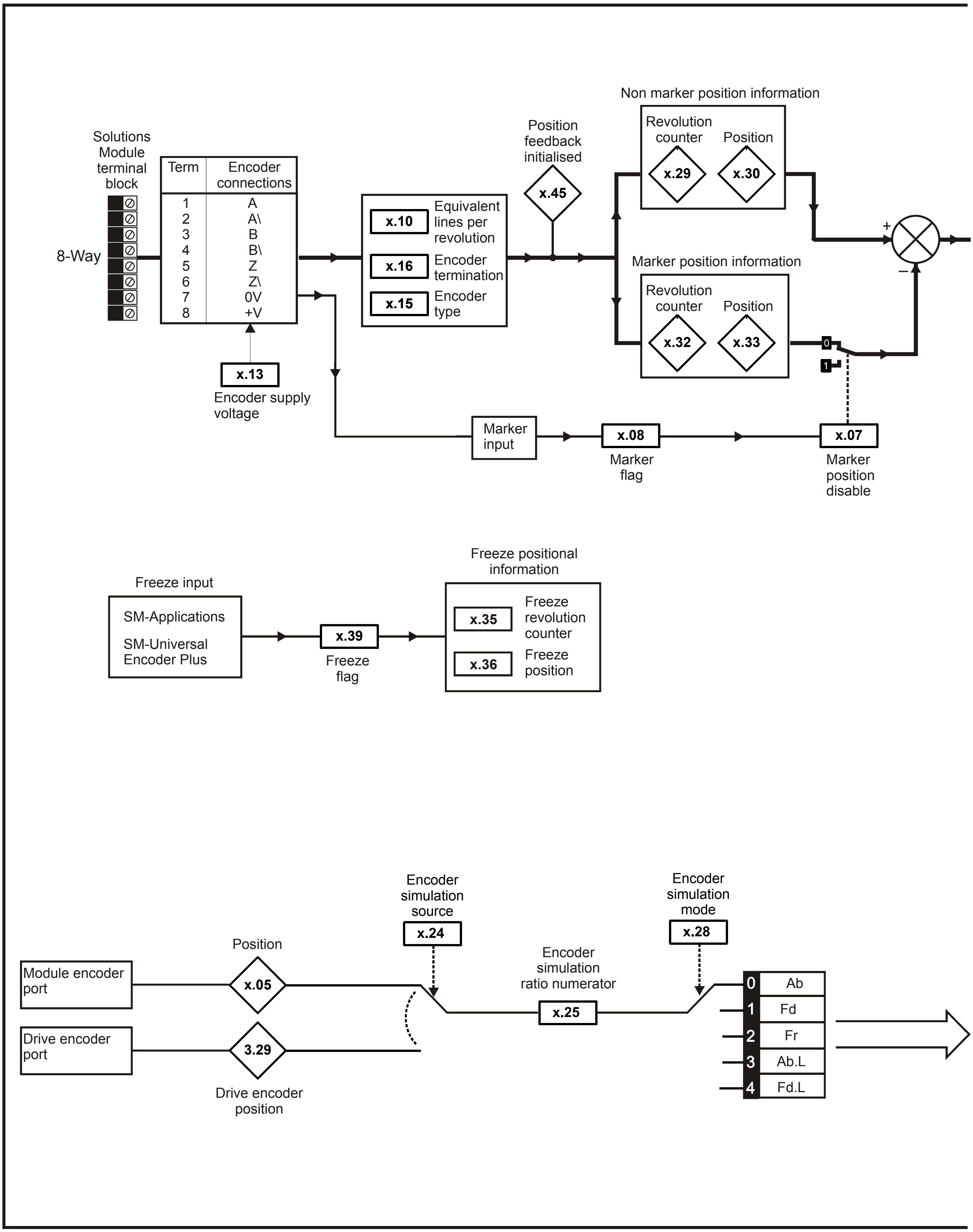
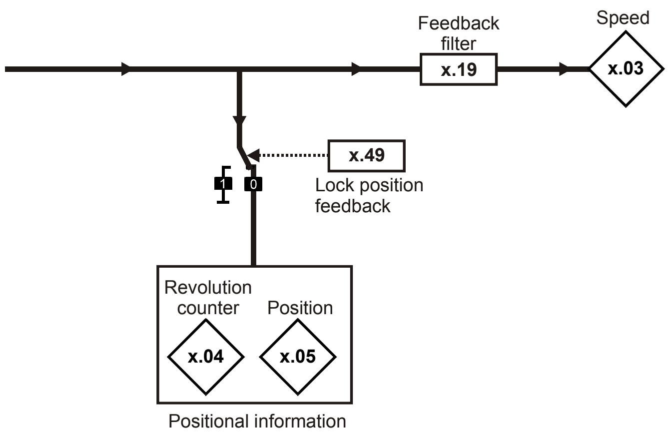
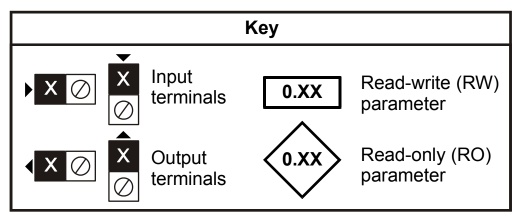

Feedback filter
x.19
Speed
x.03
x.49
Lock position feedback
1
0
Revolution counter
Position
x.04
x.05
Positional information
Key
X
Input terminals
Output terminals
0.XX
Read-write (RW) parameter
0.XX
Read-only (RO) parameter
The parameters are all shown at their default settings

Figure 5-30 SM-Encoder Output Plus Encoder logic diagram

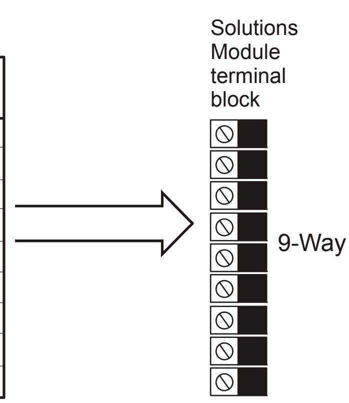






The parameters are all shown at their default settings

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



The update time for some functions are affected by the number of dumb Solutions Modules installed to the drive. The update time for these functions is the sum of the update times for all dumb Solutions Modules installed to the drive, called the combined update time. The update time for the SM-Encoder Plus, SM-Encoder Output Plus and SM-Resolver modules is 4ms, and the update time for the SM-I/O Plus is 8ms.

For example, if a module with 4ms update time and a module with 8ms are installed to the drive, then the combined update time for the time critical parameters of each module is 12ms.

Some functions with the SM-Encoder plus and SM-Encoder Output Plus modules do not function correctly if the update time is too long. The input frequency should not exceed 500kHz, but in addition the number of encoder counts seen over one sample period should not exceed 32768. Provided the frequency is within the 500kHz limit, the maximum count cannot be exceeded with Fd and Fr encoders with any sample time, or with Ab encoders if the sample time is 16ms or less. If the sample time is 20ms then the maximum allowed frequency with Ab encoders is 409.6kHz.

Position/speed feedback update rate

If the module is selected for motor control position feedback then the position and speed parameters are updated as defined with each parameter, but are available within the drive at a faster rate as shown below.

Control position	Current controller sample rate
Control speed	250μs
Position controller position (menu 13)	4ms
Position for SM-Applications module, etc.	250μs

If the module is not selected for motor control position feedback the position and speed are updated as defined with the appropriate parameters.

x.01	Solutions Module ID code							
RO	Uni					PT	US	
⇕	0 to 599			⇨	104			
Update rate: Write on power-up								

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

104: SM-Encoder Plus / SM-Encoder Output Plus

The new parameters values are not stored in EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a Slot.dF or SLot.nf trip.

x.03	Speed feedback							
RO	Bi	FI				NC	PT	
⇕	±40,000.0 rpm			⇨				
Update rate: 4ms x number of dumb modules								

Provided the set-up parameters for the position feedback are correct this parameter shows the speed in rpm.

x.04	Revolution counter							
RO	Uni	FI				NC	PT	
⇕	0 to 65,535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.05	Position							
RO	Uni	FI				NC	PT	
⇕	0 to 65,535 ($1/2^{16}$ths revolutions)			⇨				
Update rate: 4ms x number of dumb modules								

Pr **x.04** and Pr **x.05** give the position with a resolution of $1/2^{16}$ths of a revolution as a 32 bit number as shown below.

31 ... 16	15 ... 0
Revolutions	Position

Provided the set-up parameters are correct, the position is always converted to units of $1/2^{16}$ths of a revolution, but some parts of the value may not be relevant depending on the resolution of the feedback device. For example if 10 bit resolution is selected the resolver produces 4,096 counts per revolution, and so the position is represented by the bits in the shaded area only.

31 ... 16	15 ... 4	3 ... 0
Revolutions	Position	

When the feedback device rotates by more than one revolution, the revolutions in Pr **x.04** increment or decrement in the form of a sixteen bit roll-over counter.

x.07	Marker position reset disable							
RW	Bit						US	
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

x.08	Marker flag							
RW	Bit				NC			
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: 4ms x number of dumb modules								

An incremental digital encoder may have a marker channel and when this channel becomes active (rising edge in the forward direction and falling edge in reverse) it may be used to reset the encoder position and set the marker flag (Pr **x.07** = 0), or just to set the marker flag (Pr **x.07** = 1). When the position is reset by the marker, Pr **x.05** is reset to zero.

The marker flag is set each time the marker input becomes active, but it is not reset by the drive, and so this must be done by the user.

x.10	Equivalent lines per revolution							
RW	Uni						US	
⇕	0 to 50,000			⇨	4,096			
Update rate: Background read (only has any effect when the drive is disabled)								

When Ab, Fd, or Fr signals are used the equivalent number of encoder lines per revolution must be set-up correctly in Pr **x.10** to give the correct speed and position feedback. The equivalent number of encoder lines per revolution (ELPR) is defined as follows:

Position feedback device	ELPR
Ab	**number of lines per revolution**
Fd, Fr	**number of lines per revolution / 2**

Although Pr **x.10** can be set to any value from 0 to 50,000, there are restrictions on the values actually used as follows:

If Pr **x.10** < 2, ELPR = 2. If Pr **x.10** > 16,384, ELPR = 16,384. Otherwise, Pr **x.10** is rounded down to the nearest value that is a power of 2, e.g. if 5,000 is set in Pr **x.10**, the drive actually uses 4,096

x.13	Encoder supply voltage							
RW		Uni					US	
⇕	0 to 2				0			
Update rate: Background read								

The encoder supply voltage for this Solutions Module is defined by this parameter as 0(5V), 1(8V), or 2(15V).

x.15	Encoder type							
RW	Uni						US	
⇕	Ab (0), Fd (1), Fr (2)			⇨	Ab (0)			
Update rate: 4ms x number of dumb modules								

The following encoders can be connected to the SM-Encoder Plus.

0, Ab: Quadrature incremental encoder, with or without marker pulse

1, Fd: Incremental encoder with frequency and direction outputs, with or without marker pulse

2, Fr: Incremental encoder with forward and reverse outputs, with or without marker pulse

x.16	Encoder termination							
RW	Txt						US	
⇕	0 to 2			⇨	1			
Update rate: Background read								

The terminations may be enabled/disabled by this parameter as follows:

Encoder input	x.16=0	x.16=1	x.16=2
A-A\	Disabled	Enabled	Enabled
B-B\	Disabled	Enabled	Enabled
Z-Z\	Disabled	Disabled	Enabled

x.19	Feedback filter								
RW	Uni							US	
⇳	0 to 5 (0 to 16 ms)			⇨	0				
Update rate: Background read									

A sliding window filter may be applied to the feedback. This is particularly useful in applications where the feedback is used to give speed feedback for the speed controller and where the load includes a high inertia, and so the speed controller gains are very high. Under these conditions, without a filter on the feedback, it is possible for the speed loop output to change constantly from one current limit to the other and lock the integral term of the speed controller. The filter is not active if the parameter value is 0 or 1ms, but operates over the defined window for parameter values of 2, 4, 8 and 16ms.

Value in Pr x.19	Filter window
0	Not active
1	Not active
2	2ms
4	4ms
8	8ms
16	16ms

x.24	Encoder simulation source								
RW		Uni					PT	US	
⇳	0.00 to 21.51				0.00				
Update rate: Background read									

x.25	Encoder simulation ratio numerator								
RW		Uni						US	
⇳	0.00 to 3.00				0.25				
Update rate: Background read									

The encoder simulation system provides an encoder output with minimal delay from either the drive encoder (Pr **x.24** = 3.29) or the encoder connected to this option module (Pr **x.24** equal to any other value). The drive encoder can be an incremental encoder (Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo) or it can be a SINCOS encoder (SC, SC.Hiper, SC.EnDat or SC.SSI). If any other encoder types are selected the output is undefined. If a SINCOS encoder is being used the encoder simulation is derived from the sine waves and does not include interpolation information. The ratio between the change of encoder position and the change of encoder simulation output position is defined by Pr **x.25**. The table below shows the possible ratios.

Pr x.25	Ratio
0.0000 to 0.0312	1/32
0.0313 to 0.0625	1/16
0.0626 to 0.1250	1/8
0.1251 to 0.2500	1/4
0.2501 to 0.5000	1/2
0.5001 to 3.0000	1

x.28	Encoder simulation mode							
RW	Txt						US	
⇳	0 to 7				0			
Update rate: Background read								

Pr **x.28** selects the format of the encoder simulation output as shown in the table below.

Pr x.28	Mode
0	Quadrature outputs
1	Frequency and direction outputs
2	Forward and reverse outputs
3	Quadrature outputs with marker lock
4 to 7	Frequency and direction outputs with marker lock

The marker output is derived directly from the encoder simulation input source marker. The width of the marker pulse is not adjusted with the encoder simulation ratio, but remains the same width as the input marker. If a mode without marker lock is selected then the relationship between the marker position and the incremental signals is undefined. If a mode with marker lock is selected the incremental position is shifted when the first input marker occurs so that with Ab mode the marker is aligned with A high and B high, and with Fd mode the marker is aligned with F high. Marker lock is required when the system that is receiving the encoder simulation signals requires a defined relationship between the marker and the incremental signals. Marker lock should not be used if the drive encoder equivalent lines per revolution (ELPR) is not a power of 2 or the ELPR of the encoder simulation output is less than 1 after the divide ratio has been applied.

x.29	Non-marker reset revolution counter							
RO	Uni				NC	PT		
⇳	0 to 65,535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.30	Non-marker reset position							
RO	Uni				NC	PT		
⇳	0 to 65,535 (1/2^{16}ths of a revolution)			⇨				
Update rate: 4ms x number of dumb modules								

Pr **x.29** and Pr **x.30** are duplicates of Pr **x.04** and Pr **x.05** respectively and not affected by the marker or freeze inputs.

x.32	Marker revolution counter							
RO	Uni				NC	PT		
⇳	0 to 65,535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.33	Marker position							
RO	Uni				NC	PT		
⇳	0 to 65,535 (1/2^{16}ths of a revolution)			⇨				
Update rate: 4ms x number of dumb modules								

Each time the marker becomes active, the non-marker position values (Pr **x.29** and Pr **x.30**) are sampled and stored in Pr **x.32** and Pr **x.33**.

x.35	Freeze revolution counter							
RO	Uni				NC	PT		
⇳	0 to 65535 revolutions			⇨				
Update rate: 4ms x number of dumb modules								

x.36	Freeze position							
RO	Uni				NC	PT		
⇳	0 to 65535 (1/2^{16}ths of a revolution)			⇨				
Update rate: 4ms x number of dumb modules								

x.39	Freeze flag								
RW	Bit					NC			
⇳	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: 4ms x number of dumb modules									

This Solutions Module does not have its own freeze input, therefore the freeze input must come from a SM-Applications or SM-Universal Encoder Plus. The freeze data is processed every 4ms x number of dumb modules installed. If a freeze has occurred and the freeze flag (Pr **x.39**) is zero, the position data is stored in Pr **x.35** and Pr **x.36** and the freeze flag is set. The freeze flag must be reset by the user before the next freeze event is stored.

x.45	Position feedback initialised								
RO	Bit					NC	PT		
⇳	OFF (0) or On (1)				⇨				
Update rate: 4ms x number of dumb modules									

At power-up Pr **x.45** is initially OFF (0), but is set to On (1) when the SM-Encoder Plus can provide position feedback. Pr **x.45** then remains at On (1) while the drive is powered-up.

x.49	Lock position feedback								
RW	Bit								
⇳	OFF (0) or On (1)				⇨				
Update rate: Background write									

If Pr **x.49** is set to one, Pr **x.04** and Pr **x.05** are not updated. If this parameter is zero, Pr **x.04** and Pr **x.05** are updated normally.

x.50	Solutions Module error status								
RO	Uni					NC	PT		
⇳	0 to 255				⇨				

The error status is provided so that the only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a 'SLX.er' trip, where X is the slot number. A value of zero indicates the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-15 on page 280 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared.

The Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

5.17.4 SM-IO Plus

Table 5-16 Solutions Module error status values for the SM-I/O Plus

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

Figure 5-31 SM I/O Plus Digital Input/Output logic diagram 1

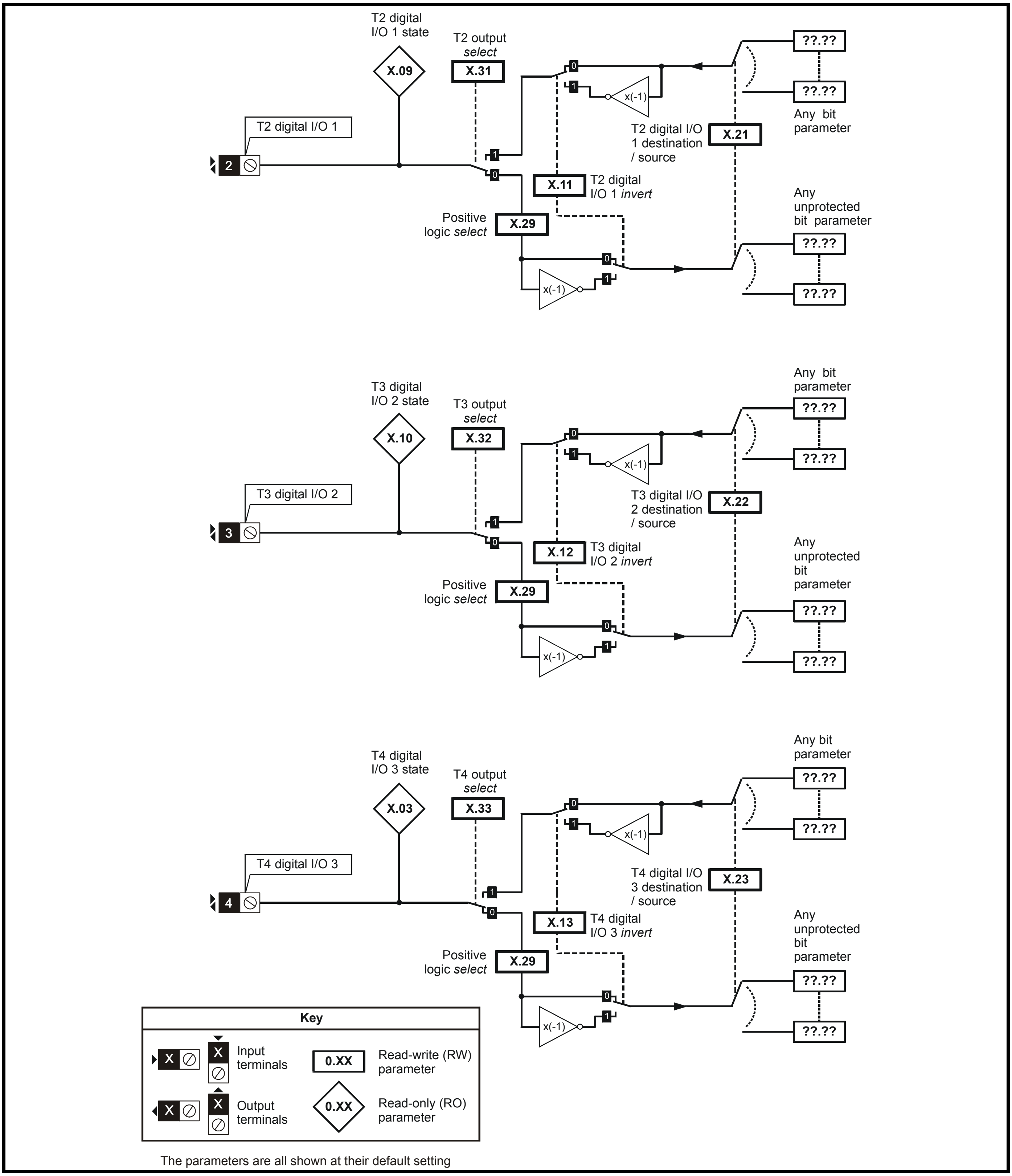
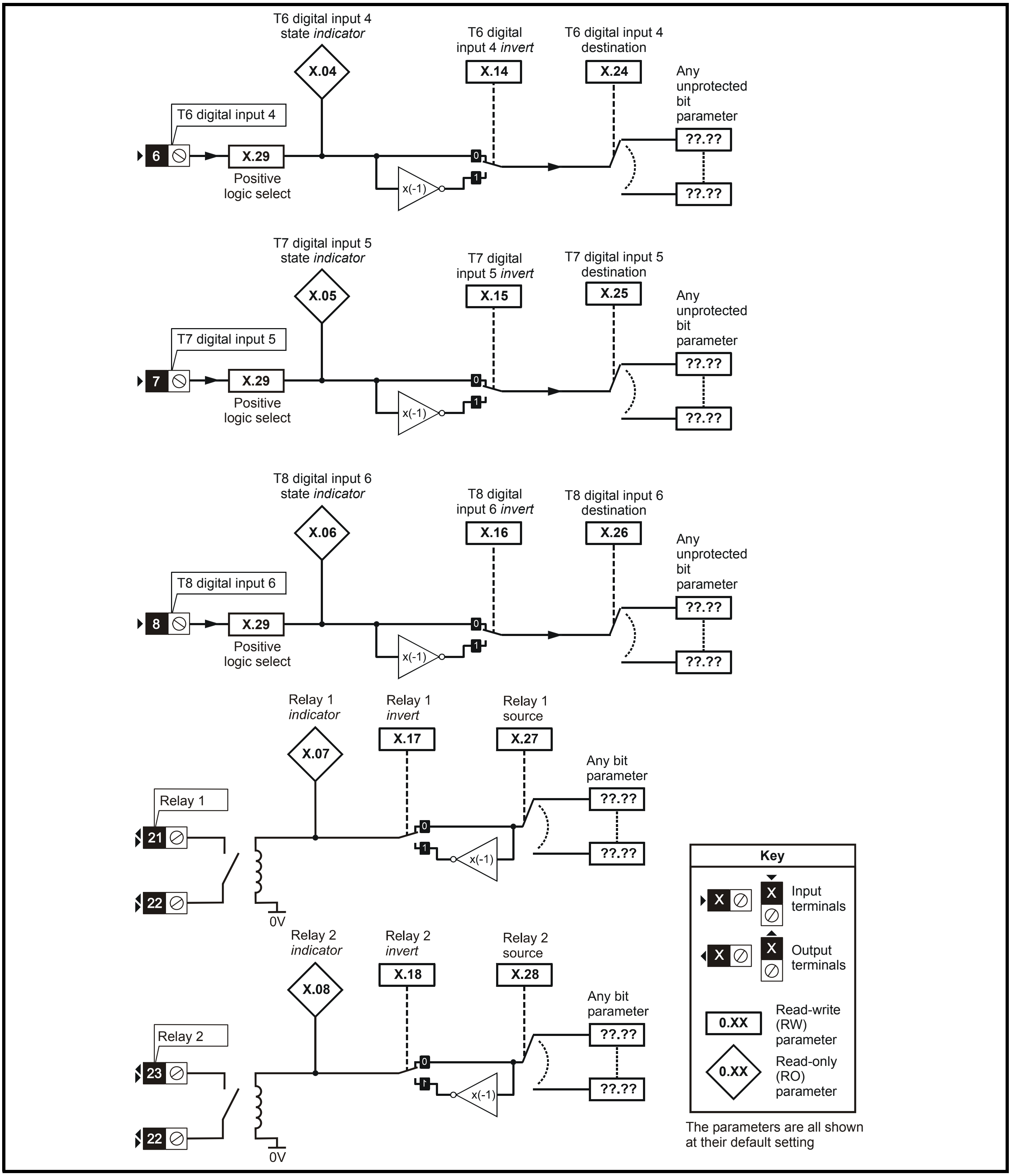


Figure 5-32 SM I/O Plus Digital Input/Output logic diagram 2

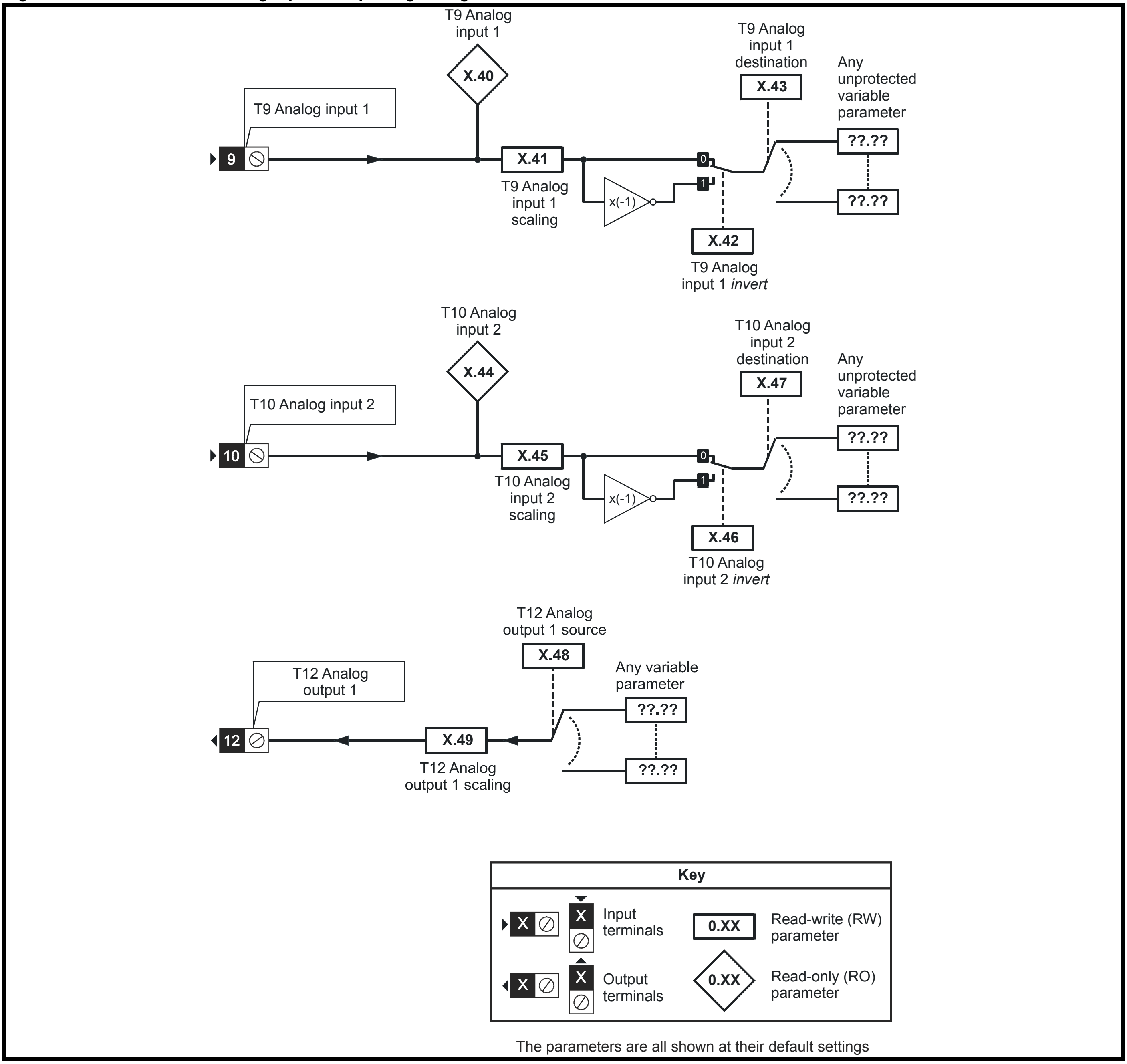


This module has three digital input/outputs (DI/O1 to DI/O3), three digital inputs (DI4 to DI6) and two relays outputs (D07 and DO8). The inputs can operate with positive or negative logic (defined by Pr **x.29**), the outputs operate with positive logic using high side drivers only and the relay outputs operate with positive logic only.

	Pr x.29=0 (negative logic)	Pr x.29=1 (positive logic)
Inputs	<5V = 1, >15V = 0	<5V = 0, >15V = 1
Non-relay Outputs	1 = >15V (high side drivers only)	1 = >15V (high side drivers only)
Relay outputs	0 = open, 1 = closed	0 = open, 1 = closed

Terminal	Type	I/O state	Invert		source/ destination		output select	
		Parameter	Parameter	Default	Parameter	Default	Parameter	Default
T2	DI/O1	Pr **x.09**	Pr **x.11**	0	Pr **x.21**	00.00	Pr **x.31**	0
T3	DI/O2	Pr **x.10**	Pr **x.12**	0	Pr **x.22**	00.00	Pr **x.32**	0
T4	DI/O3	Pr **x.03**	Pr **x.13**	0	Pr **x.23**	00.00	Pr **x.33**	0
T6	DI4	Pr **x.04**	Pr **x.14**	0	Pr **x.24**	00.00		
T7	DI5	Pr **x.05**	Pr **x.15**	0	Pr **x.25**	00.00		
T8	DI6	Pr **x.06**	Pr **x.16**	0	Pr **x.26**	00.00		
T21/T22	DO7(Relay)	Pr **x.07**	Pr **x.17**	0	Pr **x.27**	00.00		
T23/T22	DO8(Relay)	Pr **x.08**	Pr **x.18**	0	Pr **x.28**	00.00		

Figure 5-33 SM-I/O Plus Analog Input / Output logic diagram



This module has two analog inputs (AI1 and AI2) and one analog output (AO1). The input operates in voltage mode only and the nominal full scale level is 9.8V. This ensures that when the input is driven from a voltage produced from the drive's own 10V supply, the input can reach full scale. The output operates in voltage mode only.

Terminal	Input	Input modes	Resolution
T9	AI1	Voltage only	10 bit plus sign
T10	AI2	Voltage only	10 bit plus sign

Terminal	Output	Output modes	Resolution
T12	AO1	Voltage only	10 bit plus sign

Parameter update times

The SM-I/O Plus Solutions Module is a dumb Solutions Module and is controlled directly by the drive's main processor. The update time for some functions are affected by the number of dumb Solutions Modules installed to the drive. The update time for these functions is the sum of the update times for all dumb Solutions Modules installed to the drive, called the combined update time. This module contributes 8ms to the combined update time. The update time for dumb Solutions Modules can vary, for example, the update time for SM-Encoder plus and SM-resolver modules is 4ms. Therefore if an SM-Encoder plus and an SM-I/O plus module are installed to a drive, then the combined update time is 12ms. In this example all parameters shown as having an update rate of "combined update time" would be updated every 12ms.

When a digital input or an analog input is the source for a parameter outside the Solutions Module menu the data from the input is written to the destination parameter at the combined update time rate. When a digital output or the analog output is the destination for a parameter outside the Solutions Module menu, the data is taken from the source parameter at the rate defined by the combined update time.

x.01	Solutions Module ID code							
RO	Uni					PT	US	
⇳	0 to 599			⇨	201			
Update rate: Write on power-up								

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

201: SM-I/O Plus

The new parameters values are not stored in EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a SLx.dF or SLx.nf trip.

x.03	T4 digital I/O 3 state							
x.04	T6 digital input 4 state							
x.05	T7 digital input 5 state							
x.06	T8 digital input 6 state							
x.07	Relay 1 state							
x.08	Relay 2 state							
x.09	T2 digital I/O 1 state							
x.10	T3 digital I/O 2 state							
RO	Bit				NC	PT	US	
⇳	OFF (0) or On (1)			⇨				
Update rate: 8ms x number of dumb modules								

x.11	T2 digital I/O 1 invert							
x.12	T3 digital I/O 2 invert							
x.13	T4 digital I/O 3 invert							
x.14	T6 digital input 4 invert							
x.15	T7 digital input 5 invert							
x.16	T8 digital input 6 invert							
x.17	Relay 1 invert							
x.18	Relay 2 invert							
RW	Bit						US	
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: 8ms x number of dumb modules								

x.20	Digital I/O read word							
RO	Uni				NC	PT	US	
⇕	0 to 511			⇨				
Update rate: 8ms x number of dumb modules								

This word is used to determine the status of the digital I/O by reading one parameter. The bits in this word reflect the state of Pr **x.03** to Pr **x.10**.

Bit	Digital I/O	Parameter
0	T2 (I/O 1)	x.09
1	T3 (I/O 2)	x.10
2	T4 (I/O 3)	x.03
3	T6 (DI 4)	x.04
4	T7 (DI 5)	x.05
5	T8 (DI 6)	x.06
6	T21/T22 (Relay 1)	x.07
7	T22/23 (Relay 2)	x.08

x.21	T2 digital I/O 1 source/destination							
x.22	T3 digital I/O 2 source/destination							
x.23	T4 digital I/O 3 source/destination							
x.24	T6 digital input 4 destination							
x.25	T7 digital input 5 destination							
x.26	T8 digital input 6 destination							
x.27	Relay 1 source							
x.28	Relay 2 source							
RW	Uni		DE			PT	US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**			
Update rate: Read on drive reset								

x.29	Input polarity select							
RW	Bit		DE			PT	US	
⇕	OFF (0) or On (1)			⇨	On (1)			
Update rate: Background read								

This parameter changes the logic polarity for digital inputs, but not digital outputs or relay outputs.

	Pr x.29=0 (negative logic)	Pr x.29=1 (positive logic)
Inputs	<5V = 1, >15V = 0	<5V = 0, >15V = 1
Non-relay outputs	1 = >15V (high side drivers only)	1 = >15V (high side drivers only)
Relay outputs	0 = open, 1 = closed	0 = open, 1 = closed

x.31	T2 digital I/O 1 output select							
x.32	T3 digital I/O 2 output select							
x.33	T4 digital I/O 3 output select							
RW	Bit						US	
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

Programmable digital inputs and output					
Terminal	Input	Destination / Source	State	Invert	Output select
2	I/O 1	Pr **x.21**	Pr **x.09**	Pr **x.11**	Pr **x.31**
3	I/O 2	Pr **x.22**	Pr **x.10**	Pr **x.12**	Pr **x.32**
4	I/O 3	Pr **x.23**	Pr **x.03**	Pr **x.13**	Pr **x.33**

x.40	Analog input 1								
RO	Bi					NC	PT		
⇳	±100.0%			⇨					
Update rate: 8ms x number of dumb modules									

x.41	Analog input 1 scaling								
RW	Uni							US	
⇳	0 to 4.000			⇨	1.000				
Update rate: Background read									

x.42	Analog input 1 invert								
RW	Bit							US	
⇳	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: Background read									

x.43	Analog input 1 destination								
RW	Uni		DE				PT	US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on reset									

x.44	Analog input 2								
RO	Bi					NC	PT		
⇳	±100.0%			⇨					
Update rate: 8ms x number of dumb modules									

x.45	Analog input 2 scaling								
RW	Uni							US	
⇳	0.000 to 4.000			⇨	1.000				
Update rate: Background read									

x.46	Analog input 2 invert								
RW	Bit							US	
⇳	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: Background read									

x.47	Analog input 2 destination								
RW	Uni		DE				PT	US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on reset									

x.48	Analog output 1 source								
RW	Uni						PT	US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on reset									

x.49	Analog output 1 scaling								
RW	Uni							US	
⇳	0.000 to 4.000			⇨	1.000				
Update rate: Background read									

x.50	Solutions Module error status								
RO	Uni					NC	PT		
⇕	0 to 255				⇨				
Update rate: Background read									

The error status is provided so that the only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a ‘SLx.Er’ trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-16 on page 289 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

5.17.5 SM-IO Lite & SM-IO Timer

Table 5-17 Solutions Module error status values for SM-IO Lite & SM-IO Timer

Error code	Fault description
0	No errors
1	Digital output short circuit
2	Current input too high or too low
3	Reference encoder supply over current
4	Solutions Module serial communications error
5	Real time clock error (SM-I/O Timer only)
74	Solutions Module over temperature (>70°C)

Figure 5-34 SM-I/O Lite & SM-I/O Timer digital I/O logic diagram

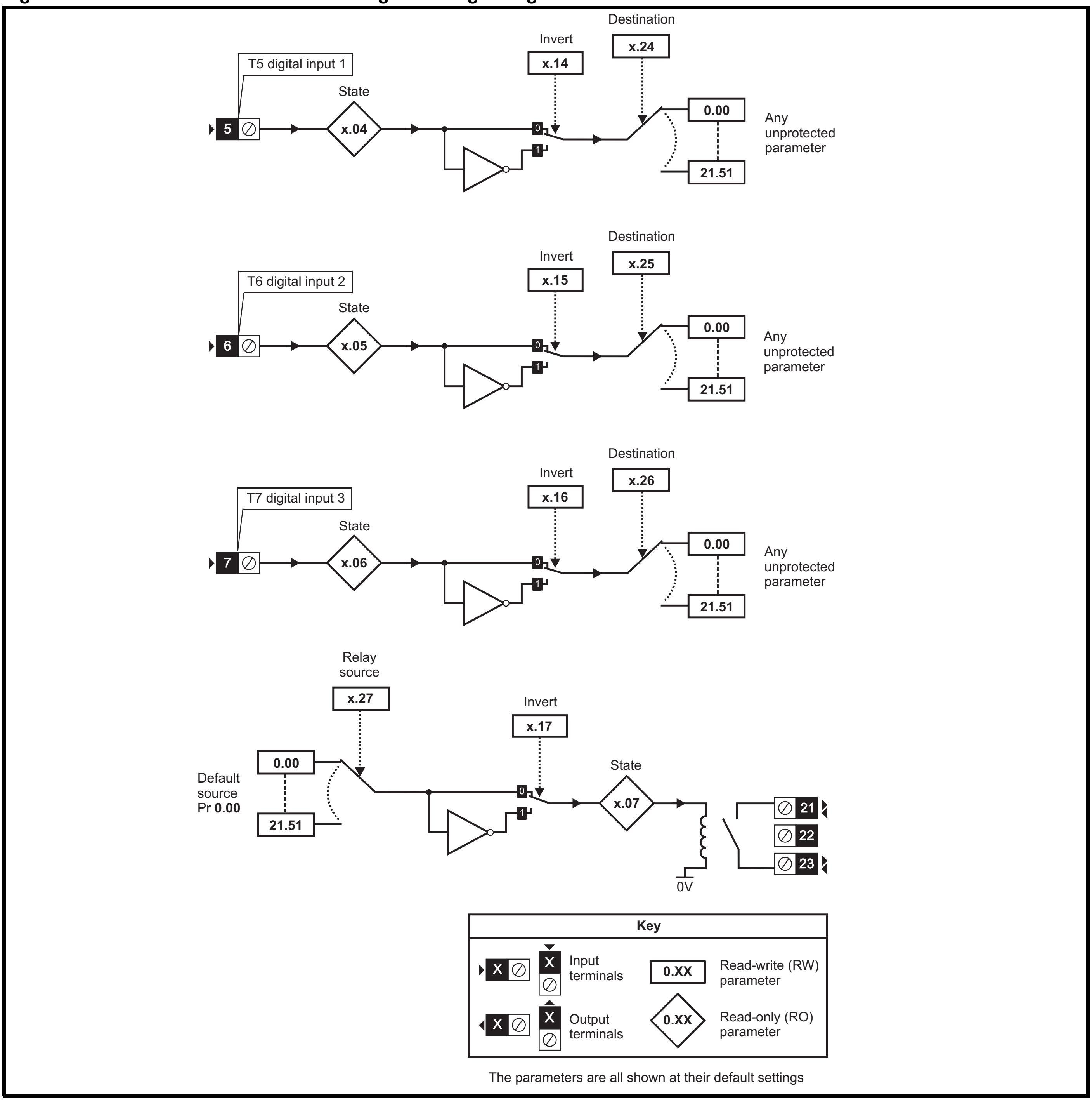


Figure 5-35 SM-I/O Lite & SM-I/O Timer analog I/O logic diagram

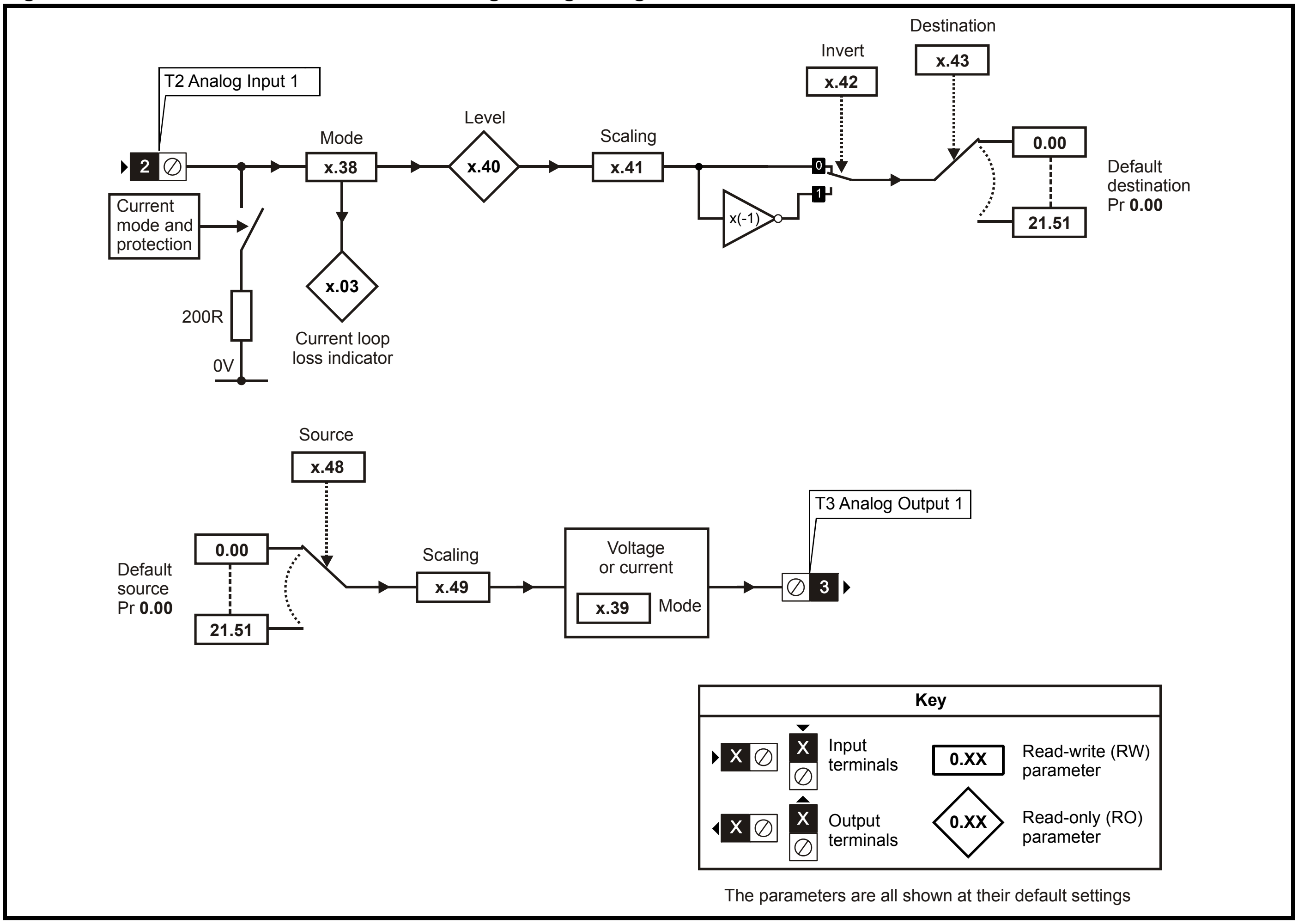
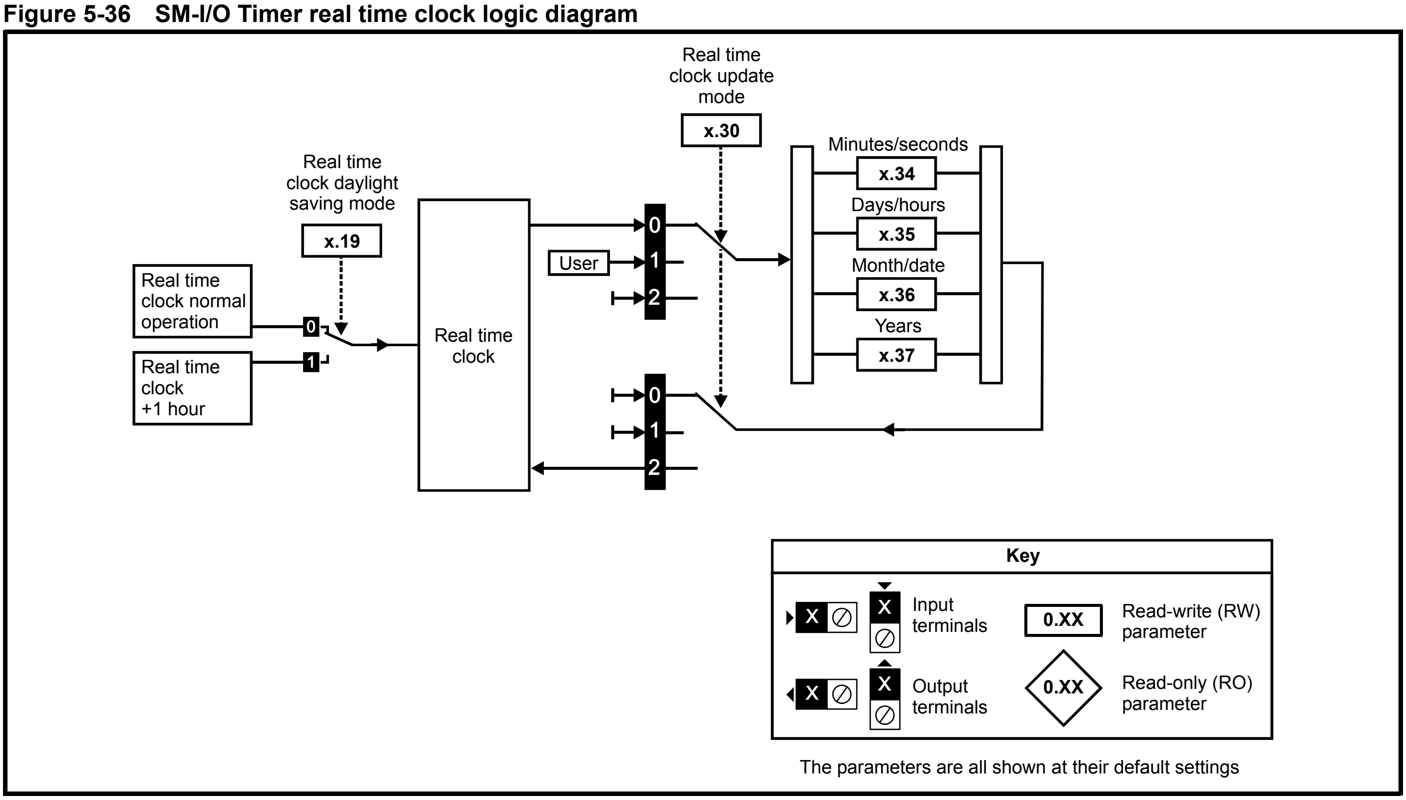


Figure 5-36 SM-I/O Timer real time clock logic diagram



x.01	Solutions Module ID code								
RO	Uni						PT	US	
⇳	0 to 599			⇨					
Update rate: Write on power-up									

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category.

When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

203: SM-I/O Timer
207: SM-I/O Lite

The new parameter values are not stored in the drive EEPROM until the user performs a parameter save by setting Pr xx.00 to 1000 and pressing the stop/reset button. When parameters are saved by the user in the drive EEPROM, the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module is installed when one was previously installed, the drive will trip on SLx.dF or SLx.nF.

x.02	Solutions Module software version								
RO	Uni					NC	PT		
⇳	00.00 to 99.99			⇨					
Update rate: Write on power-up									

This parameter shows the version of software programmed into the Solutions Module. The software sub version is displayed in Pr **x.51**.

These two parameters display the software version in the form of:

Pr **x.02** = xx.yy

Pr **x.51** = zz

x.03	Current loop loss indicator								
RO	Bit					NC	PT		
⇳	OFF(0) or On(1)			⇨					
Update rate: Background write									

If the Solutions Module analog input is programmed in any of the modes 2 to 5 (see Pr **x.38** on page 302) then this bit is set if the current input falls below 3mA. This bit can be designated to a digital output to indicate that the current input is less than 3mA.

x.04	Terminal T5 digital input 1 state								
x.05	Terminal T6 digital input 2 state								
x.06	Terminal T7 digital input 3 state								
RO	Bit					NC	PT		
⇳	OFF(0) or On(1)			⇨					
Update rate: Background write									

0: OFF inactive

1: On active

Terminals T5 to T7 are three programmable digital inputs.

These parameters indicate the state of the digital input terminals.

If an external trip is required, then one of the terminals should be programmed to control the external trip parameter (Pr **10.32**), with the invert set to a On so that the terminal must be made active for the drive not to trip.

NOTE

The digital inputs are set-up in positive logic only. This logic cannot be changed.

x.07	Relay state (Terminals T21 and T23)								
RO	Bit					NC	PT		
⇳	OFF(0) or On(1)			⇨					
Update rate: Background write									

0: OFF de-energized

1: On energized

This parameter indicates the state of the relay.

x.14	**Terminal T5 digital input 1 invert**								
x.15	**Terminal T6 digital input 2 invert**								
x.16	**Terminal T7 digital input 3 invert**								
RW	Bit							US	
⇕	OFF(0) or On(1)			⇨	OFF(0)				
Update rate: Background read									

Setting these parameters to a On causes the input sense to the destination parameter to be inverted.

x.17	**Relay invert**								
RW	Bit							US	
⇕	OFF(0) or On(1)			⇨	OFF(0)				
Update rate: Background read									

Setting this parameter to a 1 causes the relay sense to be inverted.

x.19	**Real time clock daylight saving mode**								
RW	Bit							US	
⇕	OFF(0) or On(1)			⇨	OFF(0)				
Update rate: Background read									

0: OFF Real time clock normal operation

1: On Real time clock + 1 hour

NOTE

This parameter is not available on the SM-I/O Lite.

x.20	**Digital I/O read word**								
RW	Uni					NC	PT		
⇕	0 to 120			⇨	0				
Update rate: Background write									

This word is used to determine the status of the digital I/O by reading one parameter.

Pr **x.20** contains a binary value 'xx'. This binary value is determined by the state of Pr **x.04** to Pr **x.07**. So for example, if all terminals were active the value displayed in Pr **x.20** would be the sum of the binary values shown in the table, i.e. 120.

Binary value for xx	Digital I/O
1	
2	
4	
8	Terminal T5
16	Terminal T6
32	Terminal T7
64	Terminals T21 & T23
128	

x.24	**Terminal T5 digital input destination**								
x.25	**Terminal T6 digital input destination**								
x.26	**Terminal T7 digital input destination**								
RW	Uni		DE				PT	US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

Destination parameters define the parameter each of the programmable inputs is to control. Only parameters that are not protected can be controlled by the programmable digital inputs. If a non-valid parameter is programmed, the digital input is not routed anywhere.

x.27	Terminal T21 / T23 relay/ source								
RW	Uni		DE				PT	US	
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

This parameter defines the parameter to be represented by the status relay. Only unprotected parameters can be selected as a source for the relay output. If a non-valid parameter is programmed, then the relay will remain in the last known state.

x.30	Real time clock update mode								
RW	Uni								
⇕	0 to 2				⇨	0			
Update rate: Background read/write									

0: Real time clock parameters controlled by real time clock

1: Real time clock parameters controlled by user

2: Real time clock reads real time clock parameters and sets Pr **x.30** to 0

NOTE

This parameter is not available on the SM-I/O Lite.

x.34	Real time clock minutes/seconds								
RW	Uni						PT		
⇕	00.00 to 59.59				⇨	00.00			
Update rate: Background read/write									

x.35	Real time clock days/hours								
RW	Uni						PT		
⇕	1.00 to 7.23				⇨	0.00			
Update rate: Background read/write									

x.36	Real time clock month/ date								
RW	Uni						PT		
⇕	00.00 to 12.31				⇨	00.00			
Update rate: Background read/write									

x.37	Real time clock years								
RW	Uni						PT		
⇕	2000 to 2099				⇨	2000			
Update rate: Background read/write									

NOTE

Pr **x.34** to Pr **x.37** are not available on the SM-I/O Lite.

x.38	Analog input 1 mode (Terminal T2)							
RW	Txt						US	
⇕	0-20(0), 20-0(1), 4-20(2), 20-4(3), 4-.20(4), 20-.4(5), VoLt(6)	⇨	0-20(0)					
Update rate: Background read								

Terminal T2 is a voltage/current reference input. The setting of this parameter configures the terminal to the required mode.

Value	SK Display	SP Display	Function
0	0-20	0-20	0 to 20mA
1	20-0	20-0	20 to 0mA
2	4-20	4-20.tr	4 to 20mA with trip on loss
3	20-4	20-4.tr	20 to 4mA with trip on loss
4	4-.20	4-20	4 to 20mA with no trip on loss
5	20-.4	20-4	20 to 4mA with no trip on loss
6	VoLt	VOLt	±10V

In modes 2 and 3, a current loop loss trip will be generated if the current input falls below 3mA, and Pr **x.50** will be set to a 2.

NOTE

If 4-20 or 20-4 modes are selected and the drive trips on current loop loss (cL), analog reference 2 cannot be selected if the current reference is <3mA. If 4-.20 or 20-.4 modes are selected, Pr **x.03** will switch from a OFF to On to indicate that the current reference is <3mA.

NOTE

If bi-polar operation is required, the -10V reference must be generated and supplied by an external power supply.

x.39	Analog output 1 mode (Terminal T3)							
RW	Txt						US	
⇕	0-20(0), 20-0(1), 4-20(2), 20-4(3), VoLt(4)	⇨	0-20(0)					
Update rate: Background read								

Terminal T3 is a voltage/current output. The setting of this parameter configures the terminal for the required mode.

Value	Display	Function
0	0-20	0 to 20mA
1	20-0	20 to 0mA
2	4-20	4 to 20mA
3	20-4	20 to 4mA
4	VoLt	0 to +10V

x.40	Analog input 1 level (Terminal T2)							
RO	Bi				NC	PT		
⇕	±100 %	⇨						
Update rate: Background write								

This parameter displays the level of the analog signal present at analog input 1.

In voltage mode, this is a bipolar voltage input where the input range is ±10V.

In current mode, this is a unipolar current input having a maximum measurable input of 20mA. The drive can be programmed to convert the measured current to any one of the defined ranges in Pr **x.38**. The selected range is converted to 0.0 - 100.0%.

x.41	Analog input 1 scaling (Terminal T2)							
RW	Uni						US	
⇕	0.000 to 0.400	⇨	1.000					
Update rate: Background read								

This parameter is used to scale the analog input if so desired. However in most cases it is not necessary as each input is automatically scaled such that for 100.0%, the destination parameters (defined by the settings of Pr **x.43**) will be at maximum.

x.42	Analog input 1 invert (Terminal T2)								
RW	Bit						PT	US	
⇕	OFF(0) or On(1)			⇨	OFF(0)				
Update rate: Background read									

This parameter can be used to invert the analog input reference (i.e. multiply the input scaling result by -1).

x.43	Analog input 1 destination (Terminal T2)								
RW	Uni						PT	US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

Only parameters that are not protected can be controlled by analog inputs. If a non-valid parameter is programmed to the destination of an analog input, the input is not routed anywhere. After a modification to this parameter, the destination is only changed when a reset is performed.

x.48	Analog output 1 source (Terminal T3)								
RW	Uni						PT	US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

The parameter required to be represented as an analog signal by the analog output on Terminal T3 should be programmed in this parameter. Only parameters that are not protected can be programmed as a source. If a non-valid parameter is programmed as a source, the output will remain at zero. After a modification to this parameter, the source is only changed when a reset is performed.

x.49	Analog output 1 scaling (Terminal T3)								
RW	Uni							US	
⇕	0.000 to 4.000			⇨	1.000				
Update rate: Background read									

This parameter can be used to scale the analog output if so desired. However in most cases it is not necessary as the output is automatically scaled such that when the source parameter is at its maximum, the analog output will be at its maximum.

x.50	Solutions Module error status								
RO	Uni					NC	PT		
⇕	0 to 255			⇨					
Update rate: Background write									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce an ‘SLX.Er’ trip (where X is the slot number). A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-17 on page 297 for the meaning of the values in this parameter for the SM-I/O Lite and SM-I/O Timer). When the drive is reset, this parameter is cleared.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 65°C, the drive fan is forced to operate at full speed (for a minimum of 20s). If the temperature falls below 65°C, the fan can operate normally again. If the PCB temperature exceeds 70°C, the drive will trip on SLX.Er, and the error status is set to 74.

x.51	Solutions Module software sub-version								
RO	Uni					NC	PT		
⇕	0 to 99			⇨					
Update rate: Write on power-up									

The Solutions Module includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz.
Where:
- xx specifies a change that affects hardware compatibility
- yy specifies a change that affects product documentation
- zz specifies a change that does not affect the product documentation

When a Solutions Module is installed that does not contain software, both Pr **x.02** and Pr **x.51** appear as zero.

5.17.6 SM-IO PELV

Table 5-18 Solutions Module error status values for SM-IO PELV

Error code	Fault description
0	No errors
1	Digital outputs overloaded
2	Digital inputs overloaded
3	Analog input trip (4-20.tr/20-4.tr). (Occurs when input is <3.0mA).
4	PELV user power supply absent
74	Solutions Module over temperature (>100°C)

Figure 5-19 SM-I/O PELV digital I/O logic diagram

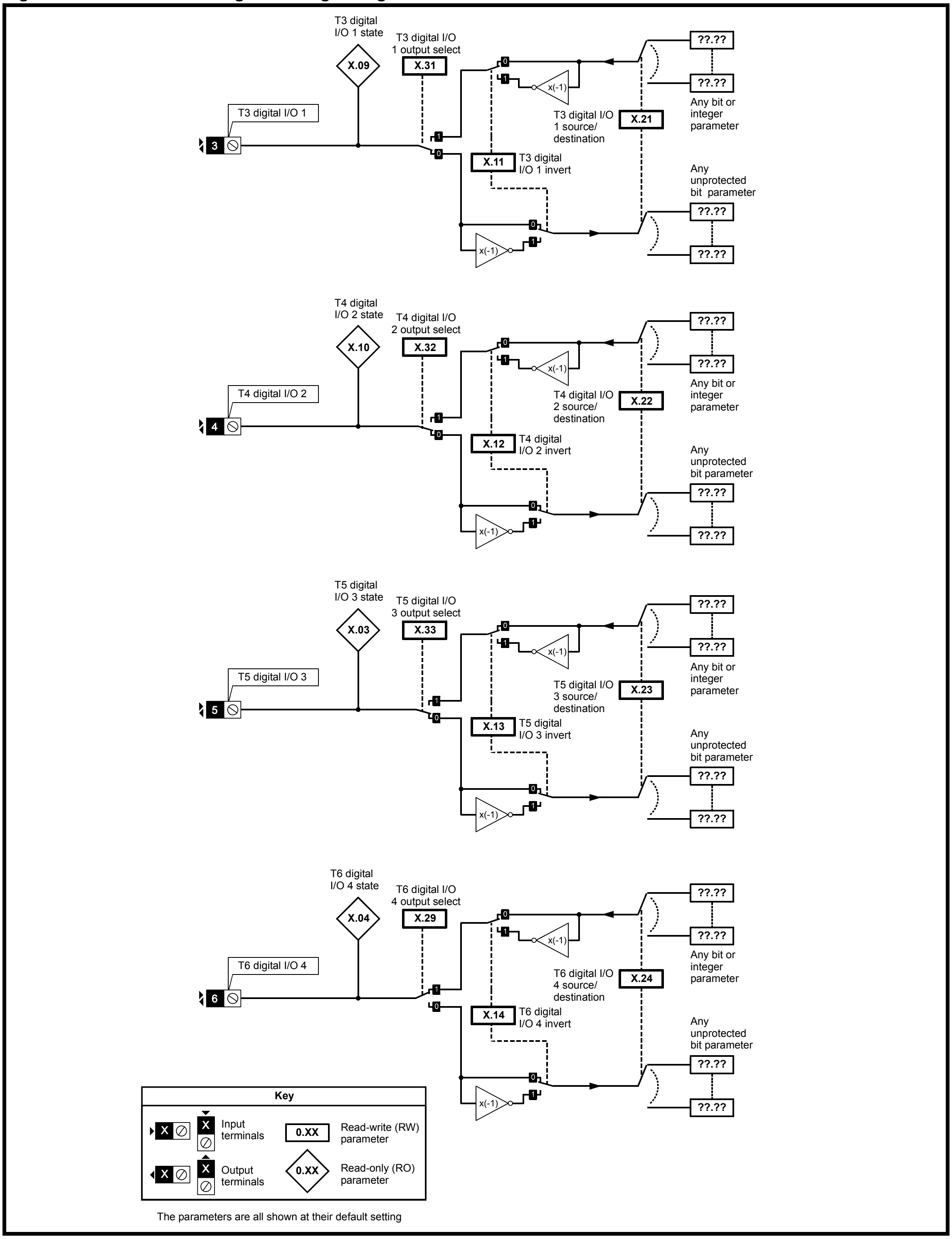
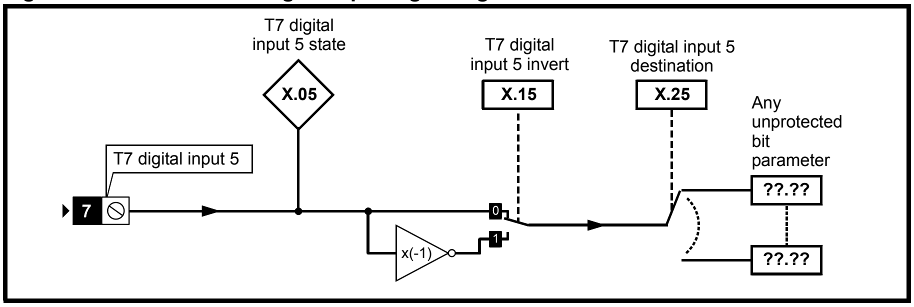


Figure 5-20 SM-I/O PELV digital input logic diagram



NOTE

The performance of the freeze input is highly dependant upon the quality of the signal driving it. If negative edge triggering is used then care should be taken to ensure that the input is actively pulled low via low impedance. If positive edge triggering is used then care should be taken to ensure that the input is actively pulled high, or pulled high via a suitably low pull-up resistance.

Figure 5-21 SM-I/O PELV relay logic diagram

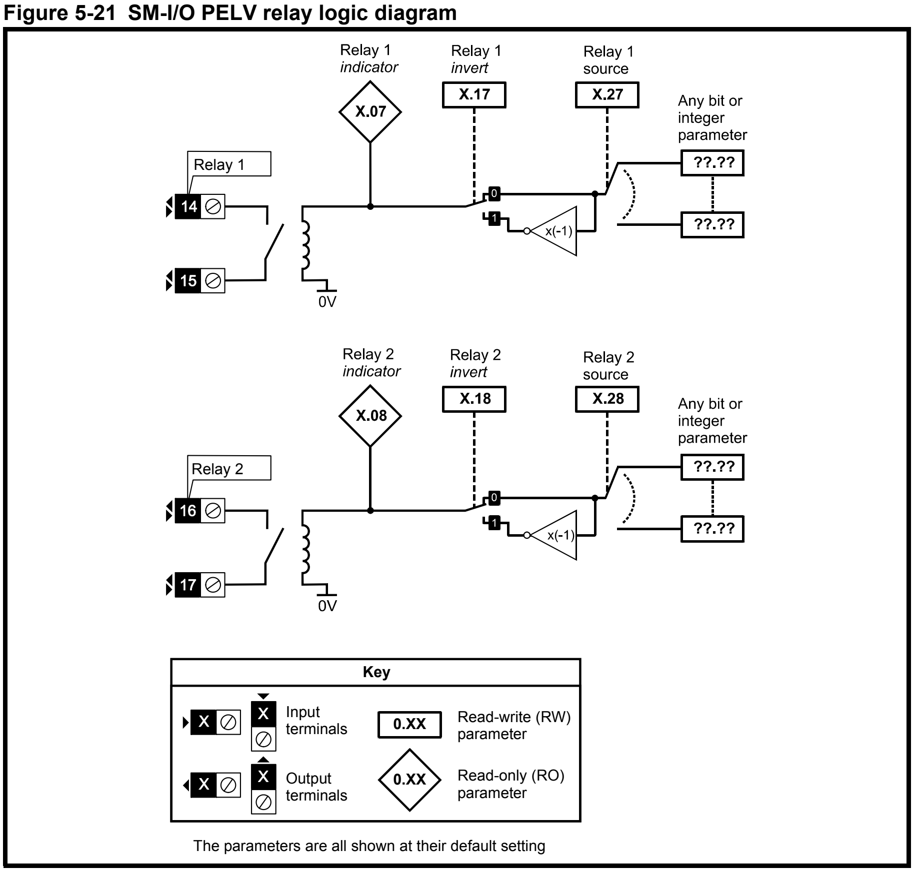


Figure 5-22 SM-I/O PELV analog input logic diagram (current mode)

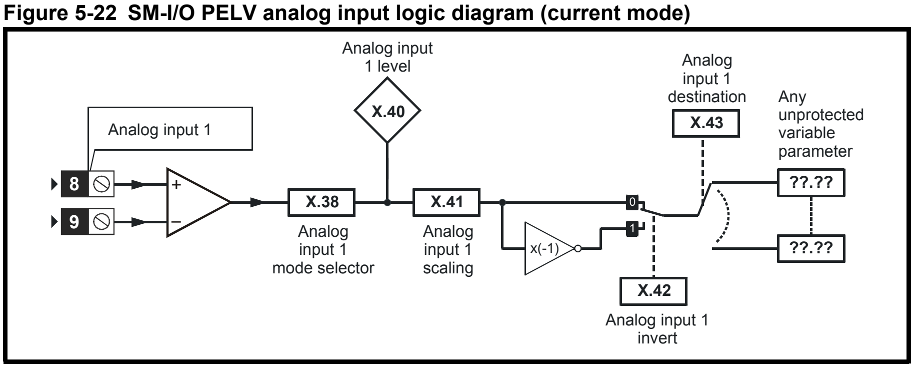


Figure 5-23 SM-I/O PELV analog input logic diagram (voltage mode)

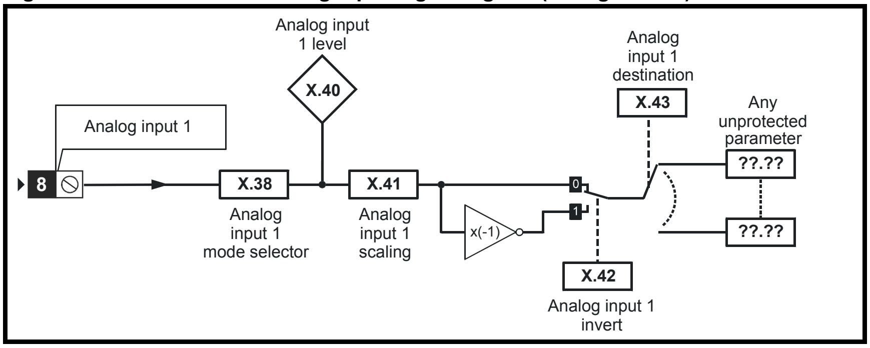
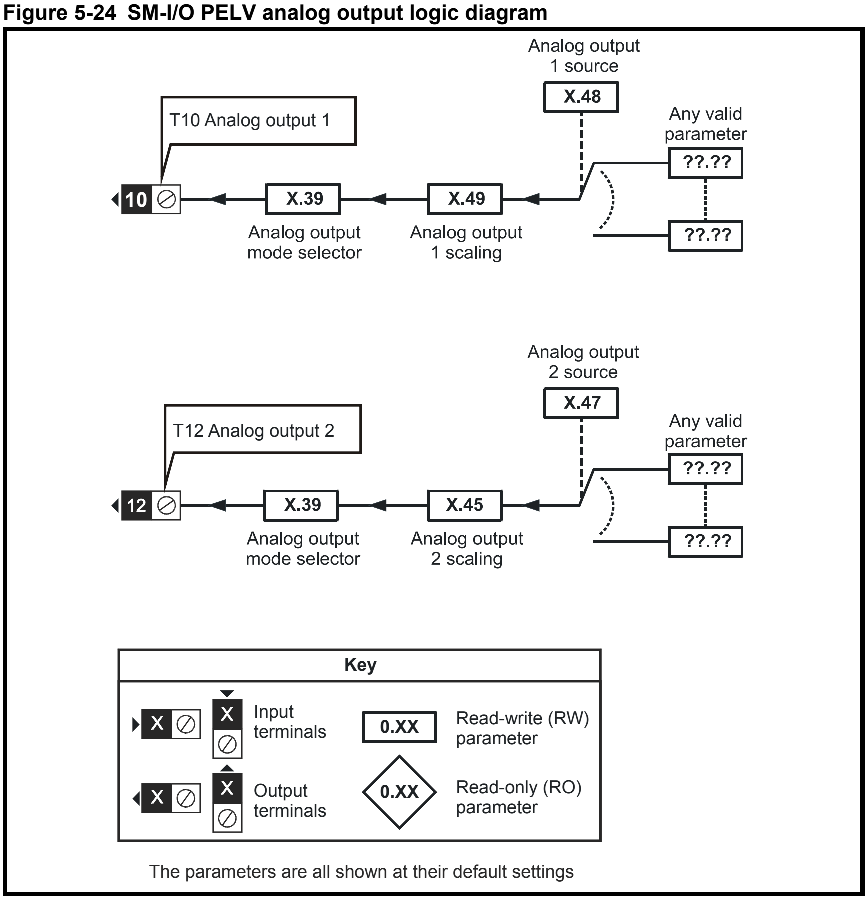


Figure 5-24 SM-I/O PELV analog output logic diagram



x.01	**Solutions Module ID code**								
RO	Uni						PT	US	
⇕	0 to 599			⇨					
Update rate: Write on power-up									

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category.

When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

204: SM-I/O PELV

The new parameter values are not stored in the drive EEPROM until the user performs a parameter save by setting Pr **xx.00** to 1000 (or 1001 in the case of solely using the 24V back-up power supply) and pressing the stop/reset button. When parameters are saved by the user in the drive EEPROM, the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module is installed when one was previously installed, the drive will trip on SLx.dF or SLx.nF.

x.02	**Solutions Module main software version**								
RO	Uni					NC	PT		
⇕	00.00 to 99.99			⇨					
Update rate: Write on power-up									

This module contains two processors, and thus two software versions. Pr **x.02** shows the version number of the main module processor. Pr **x.51**, which is normally used to give a sub-version number, shows the software version in the slave processor, which operates on the PELV side of the isolation barrier.

x.03	**T5 digital I/O 3 state**								
x.04	**T6 digital I/O 4 state**								
x.05	**T7 digital input 5 state/freeze input**								
RO	Bit					NC	PT		
⇕	OFF (0) or On (1)			⇨					
Update rate: 4ms write									

These parameters indicate the input and output states of the terminals.

The performance of the freeze input is highly dependant upon the quality of the signal driving it. If negative edge triggering is used then care should be taken to ensure that the input is actively pulled low via low impedance. If positive edge triggering is used then care should be taken to ensure that the input is actively pulled high, or pulled high via a suitably low pull-up resistance

x.06	**PELV user power supply state**								
RO	Bit					NC	PT		
⇕	OFF (0) or On (1)			⇨					
Update rate: 4ms write									

The status of the PELV user power supply is shown in this parameter.

x.07	**Relay 1 state**								
x.08	**Relay 2 state**								
x.09	**T3 digital I/O 1 state**								
x.10	**T4 digital I/O 2 state**								
RO	Bit					NC	PT		
⇕	OFF (0) or On (1)			⇨					
Update rate: 4ms write									

These parameters indicate the input and output states of the terminals.

x.11	**T3 digital I/O 1 invert**								
x.12	**T4 digital I/O 2 invert**								
x.13	**T5 digital I/O 3 invert**								
x.14	**T6 digital I/O 4 invert**								
x.15	**T7 digital input 5 invert**								
RW	Bit							US	
⇕	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: 4ms read									

Setting these parameters to On(1) causes the input sense to the destination parameter to be inverted or the output sense from the source to be inverted.

NOTE

When digital input 5 is used to provide a freeze function, the invert Pr **x.15** will select whether the freeze is applied on the rising (Pr **x.15** = Off) or the falling edge (Pr **x.15** = On) of the input signal.

x.16	**Disable PELV user power supply trip**								
RW	Bit							US	
⇕	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: Background read									

This parameter is only available on drive software V01.10.00 and later.

With Pr x.16 = OFF

The PELV user power supply absent trip is intended to detect when the PELV user supply connected to the module is below 19V. During power-up the PELV user supply may not be present until after the main drive supply. To avoid unwanted trips in this situation, the PELV user power supply present trip detection system is disabled until the supply has become active the first time. Therefore if the supply is applied and then removed a trip is initiated. The trip is also initiated at any time after drive power-up if the supply is not present and the drive becomes active (i.e. Pr **10.02** is one). This condition prevents the drive from operating if the PELV user supply is not present. The status of the PELV user supply can be monitored from parameter Pr **x.06** (Off (0) =inactive, On (1) =active).

With Pr x.16 = On

The state of the PELV user power supply will never trip the drive. The drive can be enabled without the PELV user power supply present but all of the module IO will be inoperable. Digital and analog inputs will read zero. Digital outputs will be in their inactive state and analog outputs will be at 0mA.

x.17	**Relay 1 invert**								
x.18	**Relay 2 invert**								
RW	Bit							US	
⇕	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: 4ms read									

Setting these parameters to On (1) causes the output sense from the source to be inverted.

x.19	**Freeze flag**								
RW	Bit								
⇕	OFF (0) or On (1)			⇨					
Update rate: See below									

The freeze input function is enabled for DI5 if the destination parameter for this input (Pr **x.25**) is set to Pr **x.19**. Each time the input becomes active (or inactive if the invert Pr **x.15** is on) the freeze flag (Pr **x.19**) is set, the freeze system in the drive is triggered and held active.

Pr **x.19** is updated within 500μs of the change on the freeze input, and the freeze event is registered with the drive after 500μs with a latency of 10μs. The freeze flag is not automatically cleared when DI5 reverts to its original state. Another freeze event cannot be registered by the drive until all freeze flags are cleared. If any other I/O destination is set to write to Pr **x.19**, the parameter value simply follows the data from the I/O and no freeze events are produced. If this parameter is set by the user, it will not cause a freeze event even if it is the destination for DI5.

A minimum of 500μs must pass between consecutive freeze inputs. If a freeze input should occur less than 500μs after the previous one, the second will be ignored and have no effect on the drive.

x.20	Digital I/O read word							
RO	Uni					NC	PT	US
⇕	0 to 255			⇨				
Update rate: 500µs write								

This word is used to determine the status of the digital I/O by reading one parameter. The bits in this word reflect the state of Pr **x.03** to Pr **x.10**.

Bit	Digital I/O	Parameter	Bit Update Rate Input/Output
0	T3 (Digital I/O 1)	Pr **x.09**	500µs / 4ms
1	T4 (Digital I/O 2)	Pr **x.10**	500µs / 4ms
2	T5 (Digital I/O 3)	Pr **x.03**	500µs / 4ms
3	T6 (Digital I/O 4)	Pr **x.04**	500µs / 4ms
4	T7 (Digital input 5)	Pr **x.05**	500µs / -
5	T2 (PELV user power supply state)	Pr **x.06**	500µs / -
6	T14 / T15 (Digital output 7 relay)	Pr **x.07**	- / 4ms
7	T16 / T17 (Digital output 8 relay)	Pr **x.08**	- / 4ms

x.21	T3 digital I/O 1 source/destination							
x.22	T4 digital I/O 2 source/destination							
x.23	T5 digital I/O 3 source/destination							
x.24	T6 digital I/O 4 source/destination							
x.25	T7 digital input 5 destination							
RW	Uni		DE					US
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**			
Update rate: Read on drive reset								

Source parameters define the parameter to be represented by the digital output terminal.

Destination parameters define the parameter each of the programmable inputs is to control.

x.27	Relay 1 source							
x.28	Relay 2 source							
RW	Uni							US
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**			
Update rate: Read on drive reset								

Source parameters define the parameter to be represented by the digital output terminal.

x.29	T6 digital I/O 4 output select							
RW	Bit							US
⇕	OFF (0) or On (1)			⇨	On (1)			
Update rate: Background read								

This parameter selects the function of terminal T6 as follows:

OFF (0) = digital input
On (1) = digital output

x.31	T3 digital I/O 1 output select							
x.32	T4 digital I/O 2 output select							
x.33	T5 digital I/O 3 output select							
RW	Bit							US
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: Background read								

These parameters select the function of terminals T3 to T5 as follows:

OFF (0) = digital input
On (1) = digital output

x.38	Analog input 1 mode							
RW	Uni						US	
⇳	0-20, 20-0, 4-20.tr (4-20), 20-4.tr (20-4), 4-20 (4-.20), 20-4 (20-.4), UOLt (UoLt)	⇨	0-20					
Update rate: Background read								

Parameter value	Parameter string		Mode	Comments
	SP	SK		
0	0-20	0-20	0-20mA	
1	20-0	20-0	20-0mA	
2	4-20.tr	4-20	4-20mA with trip on loss	Trip 2 if I < 3.0mA
3	20-4.tr	20-4	20-4mA with trip on loss	Trip 2 if I < 3.0mA
4	4-20	4-.20	4-20mA with no trip on loss	
5	20-4	20-.4	20-4mA with no trip on loss	
6	UOLt	UoLt	±10V	

x.39	Analog output mode							
RW	Uni						US	
⇳	0-20, 20-0, 4-20, 20-4	⇨	0-20					
Update rate: Background read								

This parameter sets the output mode for terminals 10 and 12 as follows:

Parameter value	Parameter string	Mode
0	0-20	0-20mA
1	20-0	20-0mA
2	4-20	4-20mA
3	20-4	20-4mA

x.40	Analog input 1 level							
RO	Bi					NC	PT	
⇳	0.0 to 100.0%	⇨						
Update rate: 4ms write								

This parameter displays the level of the analog signal present at analog input 1.

x.41	Analog input 1 scaling							
RW	Uni						US	
⇳	0 to 4.000	⇨	1.000					
Update rate: Background read								

This parameter is used to scale the analog input if so desired.

x.42	Analog input 1 invert							
RW	Bit						US	
⇳	OFF (0) or On (1)	⇨	OFF (0)					
Update rate: Background read								

This parameter can be used to invert the analog input reference (i.e. multiply the input scaling result by -1).

x.43	Analog input 1 destination							
RW	Uni		DE				US	
⇳	Pr **0.00** to Pr **21.51**	⇨	Pr **0.00**					
Update rate: Read on reset								

Only unprotected parameters can be controlled by analog inputs. If a non valid parameter is programmed to the destination, the input is not routed anywhere.

x.45	Analog output 2 scaling								
RW	Uni							US	
⇕	0.000 to 4.000			⇨	1.000				
Update rate: Background read									

This parameter can be used to scale the analog output if so desired.

x.47	Analog output 2 source								
RW	Uni							US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on reset									

The parameter required to be represented as an analog signal by the analog output on terminal 12, should be programmed into this parameter.

x.48	Analog output 1 source								
RW	Uni							US	
⇕	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on reset									

The parameter required to be represented as an analog signal by the analog output on terminal 10, should be programmed into this parameter.

x.49	Analog output 1 scaling								
RW	Uni							US	
⇕	0.000 to 4.000			⇨	1.000				
Update rate: Background read									

This parameter can be used to scale the analog output if so desired.

x.50	Solutions Module error status								
RO	Uni					NC	PT		
⇕	0 to 255			⇨					
Update rate: Background read									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a 'SLx.Er' trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-18 on page 304 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

x.51	Solutions Module software sub-version								
RO	Uni					NC	PT		
⇕	0 to 99			⇨					
Update rate: Write on power-up									

This module contains two processors, and thus two software versions. Pr **x.02** shows the version number of the main module processor. Pr **x.51**, which is normally used to give a sub-version number, shows the software version in the slave processor, which operates on the PELV side of the isolation barrier.

5.17.7 SM-IO 120V

Table 5-25 Solutions Module error status values for SM-IO 120V

Error code	Fault description
0	No errors
2	Digital inputs overloaded
74	Solutions Module over temperature (>100°C)

Figure 5-26 Digital input logic diagram

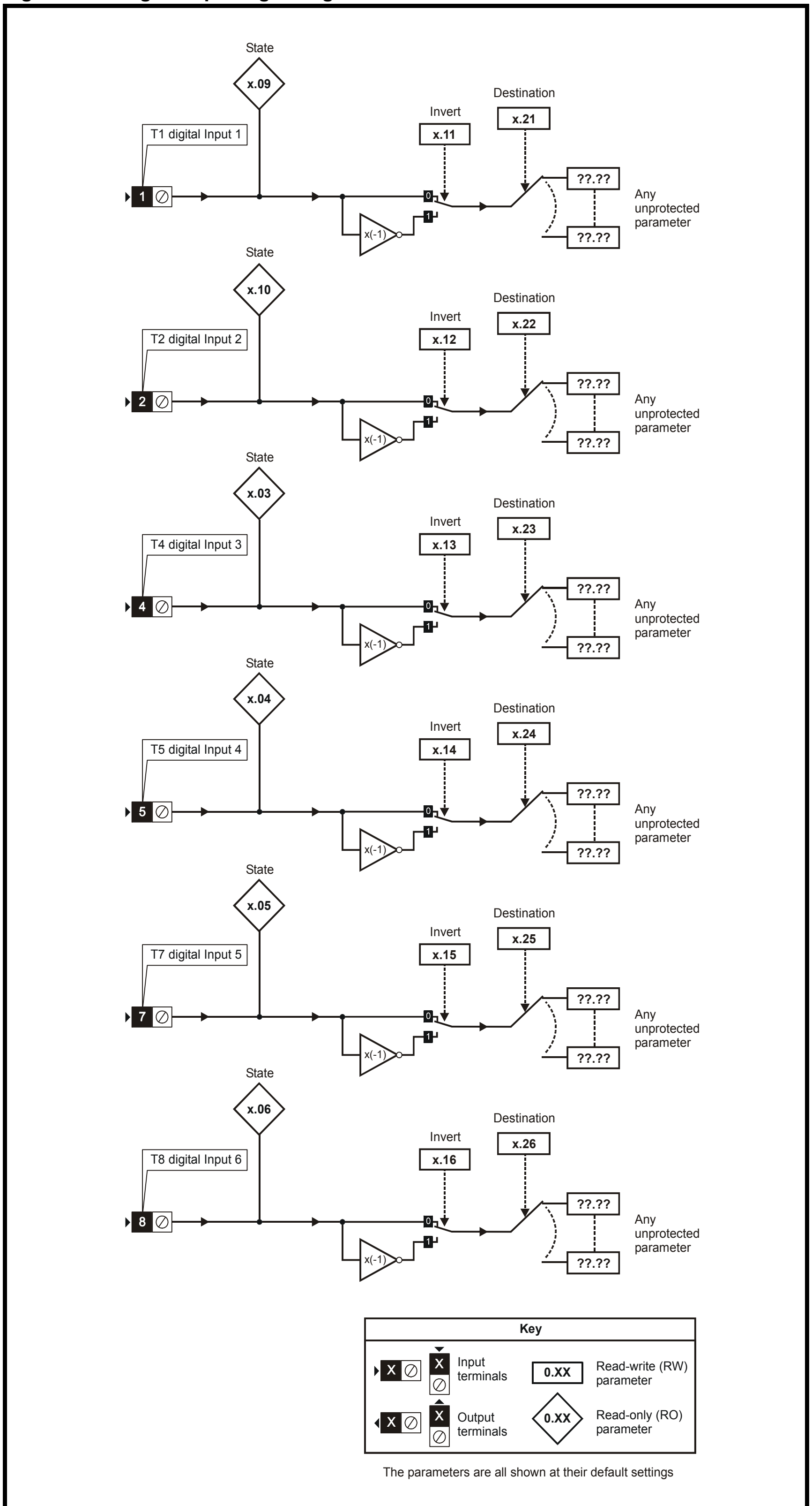
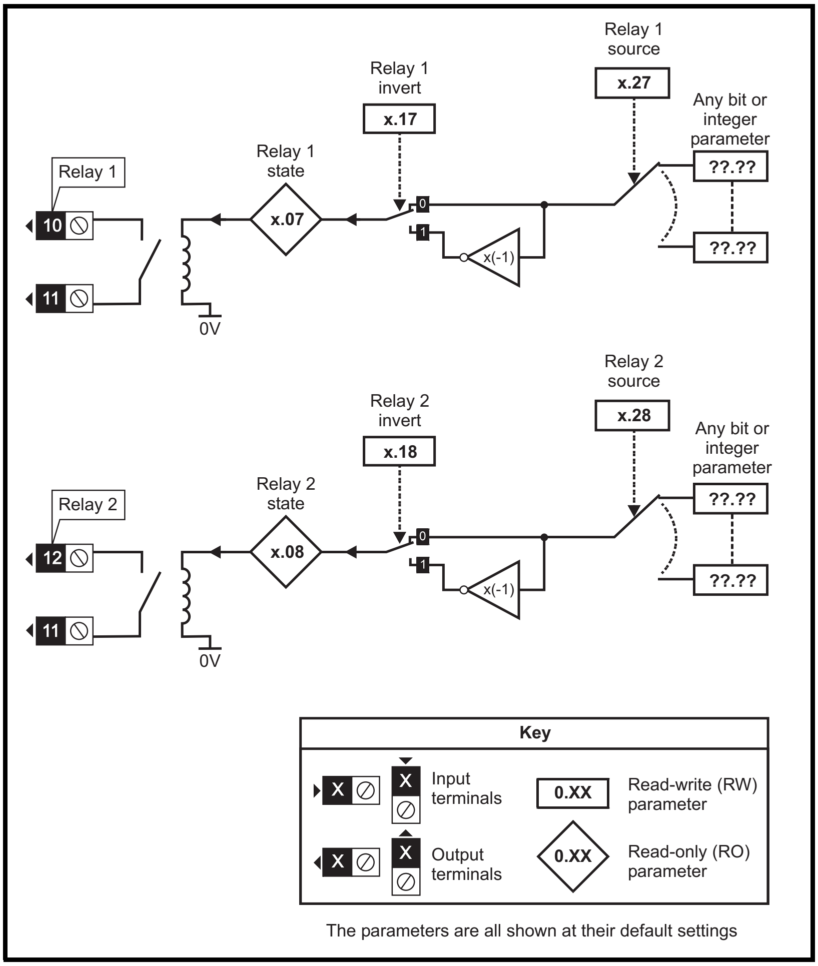


Figure 5-27 Relay logic diagram



Digital inputs and relay outputs					
Terminal	**Input**	**Destination**	**Source**	**State**	**Invert**
1	Input 1	Pr **x.21**		Pr **x.09**	Pr **x.11**
2	Input 2	Pr **x.22**		Pr **x.10**	Pr **x.12**
4	Input 3	Pr **x.23**		Pr **x.03**	Pr **x.13**
5	Input 4	Pr **x.24**		Pr **x.04**	Pr **x.14**
7	Input 5	Pr **x.25**		Pr **x.05**	Pr **x.15**
8	Input 6	Pr **x.26**		Pr **x.06**	Pr **x.16**
10	Relay 1		Pr **x.27**	Pr **x.07**	Pr **x.17**
12	Relay 2		Pr **x.28**	Pr **x.08**	Pr **x.18**

x.01	**Solutions Module ID code**							
RO	Uni						PT	US
⇕	0 to 599		⇨	206				
Update rate: Write on power-up								

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

206: SM-I/O 120V

The new parameters values are not stored in EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a SLx.dF or SLx.nf trip.

x.02	Solutions Module software version								
RO	Uni					NC	PT		
⇕	00.00 to 99.99				⇨				
Update rate: Write on power-up									

This parameter shows the version of software programmed into the Solutions Module. The software sub version is displayed in Pr **x.51**.

These two parameters display the software version in the form of:

Pr **x.02** = xx.yy

Pr **x.51** = zz

x.03	T4 digital input 3 state								
x.04	T5 digital input 4 state								
x.05	T7 digital input 5 state								
x.06	T8 digital input 6 state								
x.07	Relay 1 state								
x.08	Relay 2 state								
x.09	T1 digital input 1 state								
x.10	T2 digital input 2 state								
RO	Bit					NC	PT		
⇕	OFF (0) or On (1)				⇨				
Update rate: Background write									

x.11	T1 digital input 1 invert								
x.12	T2 digital input 2 invert								
x.13	T4 digital input 3 invert								
x.14	T5 digital input 4 invert								
x.15	T7 digital input 5 invert								
x.16	T8 digital input 6 invert								
x.17	Relay 1 invert								
x.18	Relay 2 invert								
RW	Bit							US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

x.20	Digital inputs/ relay outputs read word								
RO	Uni					NC	PT		
⇕	0 to 255				⇨				
Update rate: Background write									

This word is used to determine the status of the digital inputs and relays by reading one parameter. The bits in this word reflect the state of Pr **x.03** to Pr **x.10**.

Bit	Digital input/ relays
0	Digital input 1
1	Digital input 2
2	Digital input 3
3	Digital input 4
4	Digital input 5
5	Digital input 6
6	Relay 1
7	Relay 2

x.21	**T1 digital input 1 destination**								
x.22	**T2 digital input 2 destination**								
x.23	**T4 digital input 3 destination**								
x.24	**T5 digital input 4 destination**								
x.25	**T7 digital input 5 destination**								
x.26	**T8 digital input 6 destination**								
RW	Uni		DE					US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

x.27	**Relay 1 source**								
x.28	**Relay 2 source**								
RW	Uni							US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

x.50	**Solutions Module error status**								
RO	Uni					NC	PT		
⇳	0 to 255			⇨					
Update rate: Background read									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a SLx.Er trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-25 on page 312 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed for a minimum of 10s on Unidrive SP. If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

x.51	**Solutions Module software sub-version**								
RO	Uni					NC	PT		
⇳	0 to 99			⇨					
Update rate: Write on power-up									

The Solutions Module includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz.
Where:
xx specifies a change that affects hardware compatibility
yy specifies a change that affects product documentation
zz specifies a change that does not affect the product documentation
When a Solutions Module is installed that does not contain software, both Pr **x.02** and Pr **x.51** appear as zero.

5.17.8 SM-IO 24V Protected

Table 5-28 Solutions Module error status values for SM-IO 24V Protected

Error code	Fault description
0	No errors
1	Digital outputs overloaded
2	Digital inputs overloaded
3	Communications Error
74	Solutions Module over temperature (>100°C)

Figure 5-29 SM-I/O 24V Protected digital I/O logic diagram

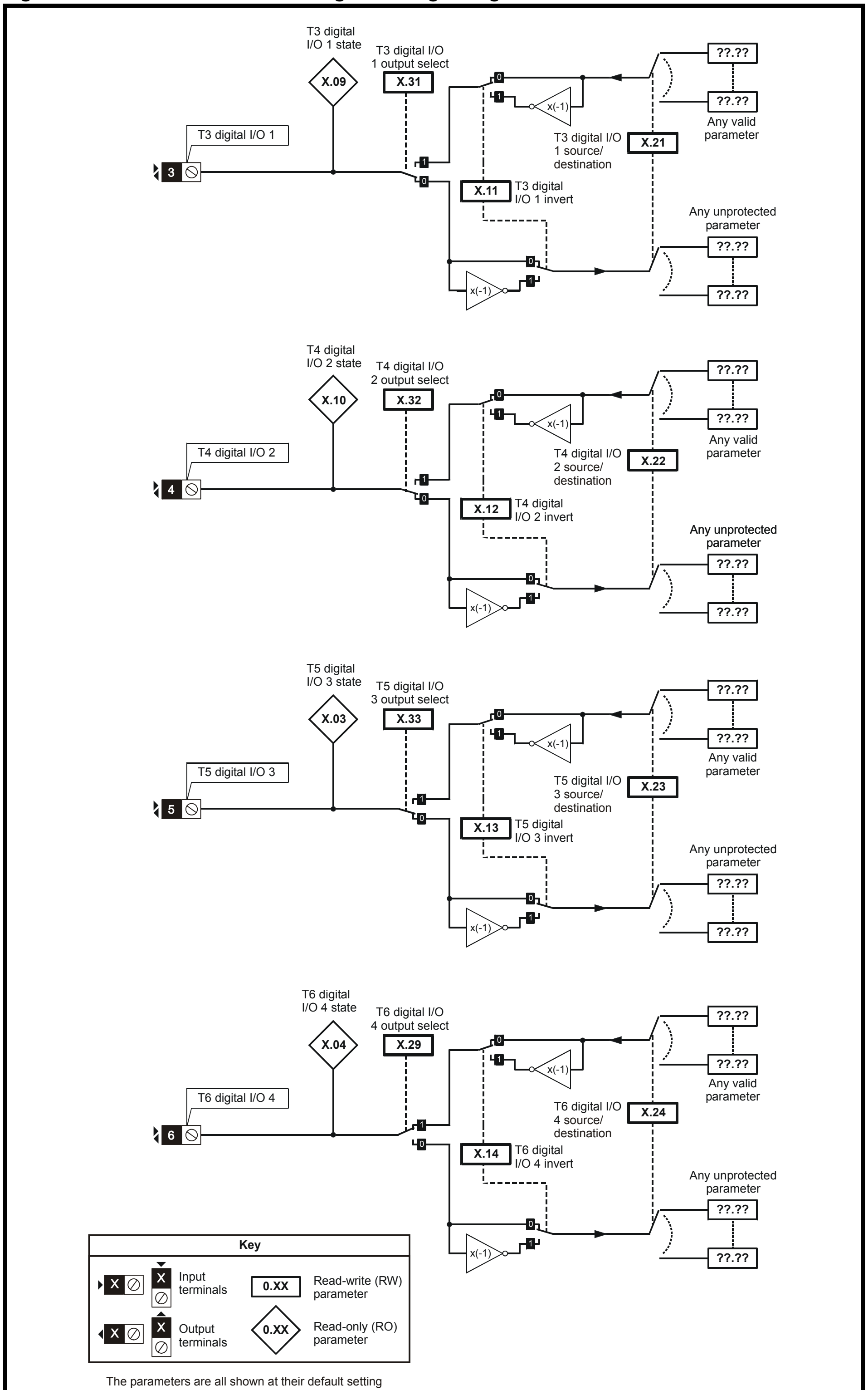


Figure 5-30 SM-I/O 24V Protected digital input logic diagram

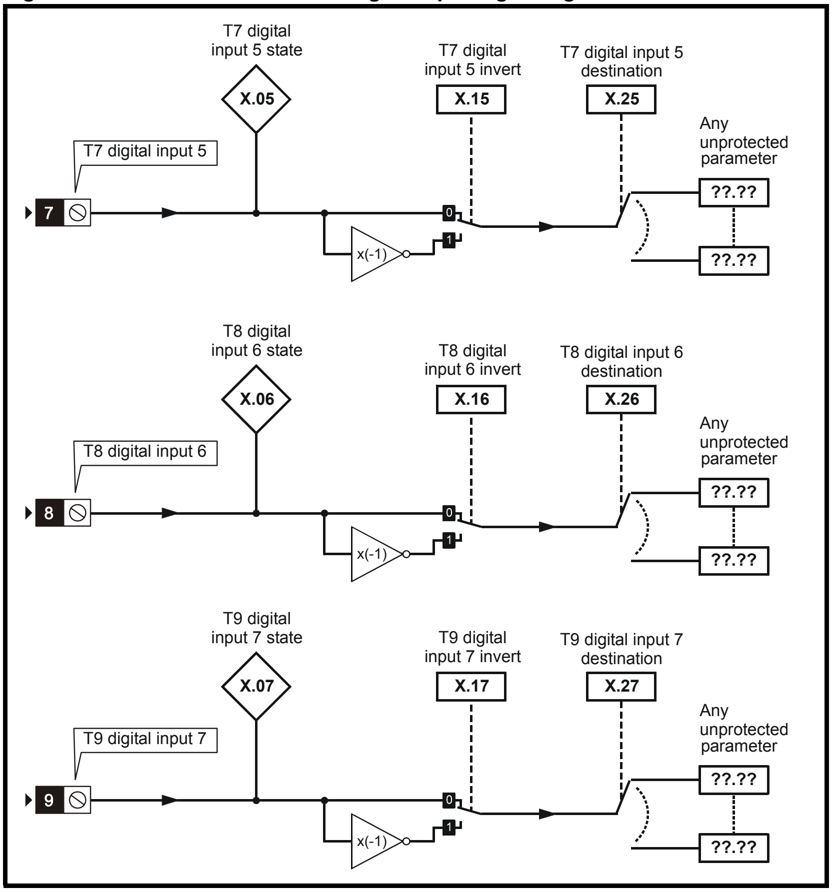


Figure 5-31 SM I/O 24V Protected relay logic diagram

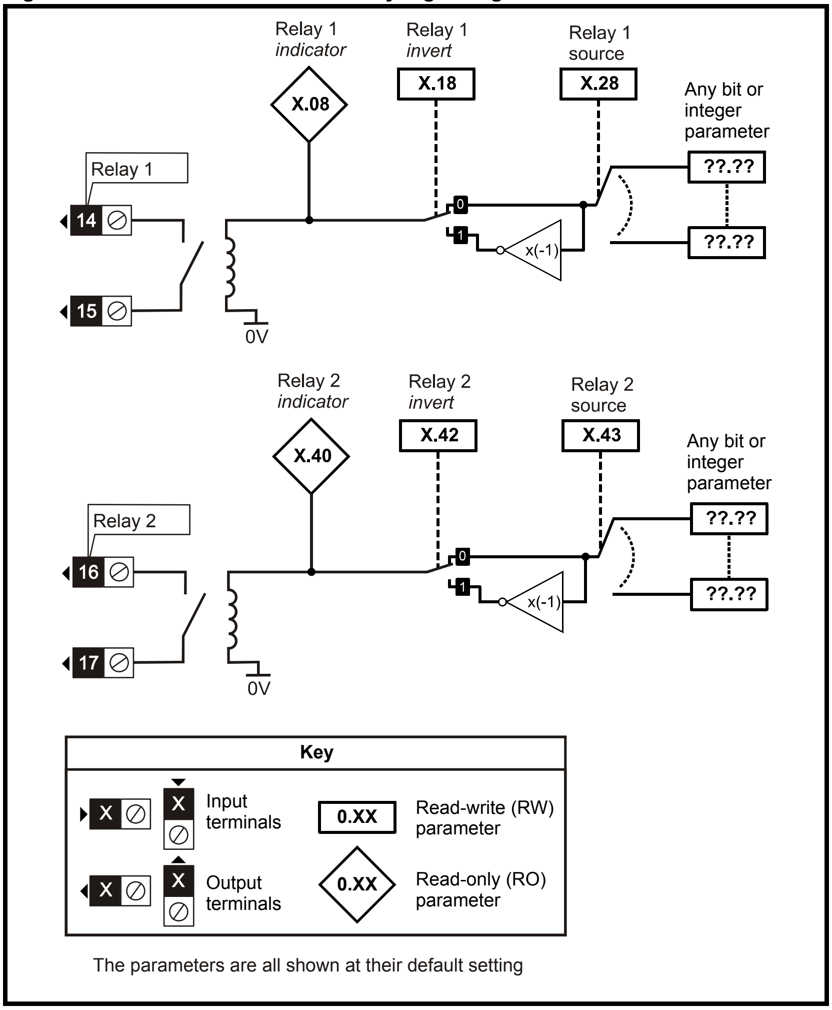
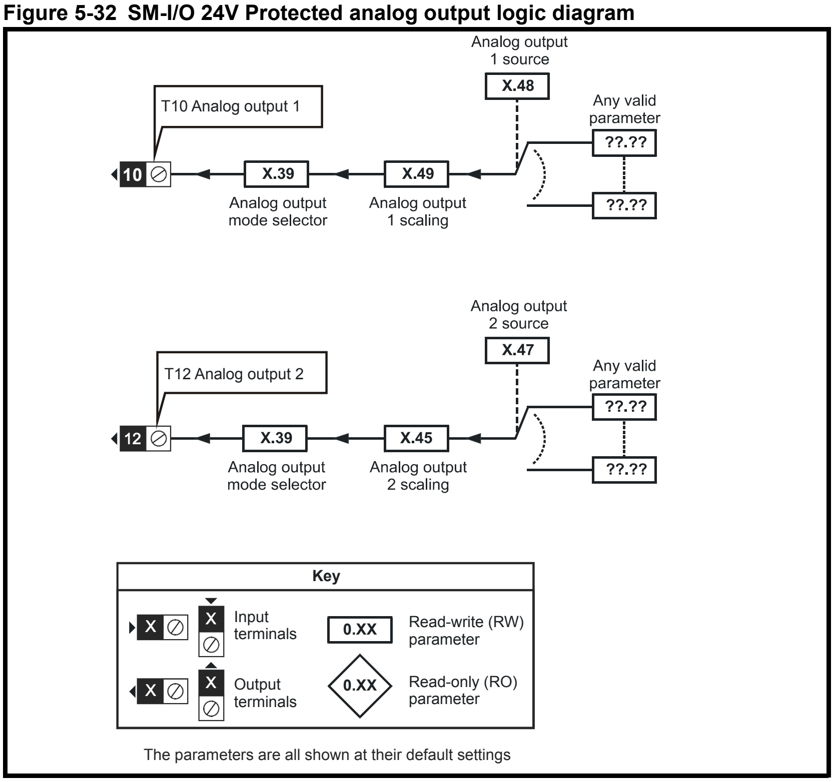


Figure 5-32 SM-I/O 24V Protected analog output logic diagram



x.01	Solutions Module ID code							
RO	Uni					PT	US	
⇕	0 to 599			⇨				
Update rate: Write on power-up								

On Unidrive SP the menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

205: SM-I/O 24V Protected

The new parameter values are not stored in the drive EEPROM until the user performs a parameter save by setting Pr **xx.00** to 1000 (or 1001 in the case of solely using the 24V back-up power supply) and pressing the stop/reset button. When parameters are saved by the user in the drive EEPROM, the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module is installed when one was previously installed, the drive will trip on SLx.dF or SLx.nF.

x.02	Solutions Module main software version							
RO	Uni				NC	PT		
⇕	00.00 to 99.99			⇨				
Update rate: Write on power-up								

This module contains two processors, and thus two software versions. Pr **x.02** shows the version number of the main module processor. Pr **x.51**, which is normally used to give a sub-version number, shows the software version in the slave processor.

x.03	T5 digital I/O 3 state							
x.04	T6 digital I/O 4 state							
x.05	T7 digital input 5 state							
x.06	T8 digital input 6 state							
x.07	T9 digital input 7 state							
x.08	Relay 1 state							
x.09	T3 digital I/O 1 state							
x.10	T4 digital I/O 2 state							
RO	Bit				NC	PT		
⇕	OFF (0) or On (1)			⇨				
Update rate: 4ms write								

These parameters indicate the input and output states of the terminals.

x.11	T3 digital I/O 1 invert							
x.12	T4 digital I/O 2 invert							
x.13	T5 digital I/O 3 invert							
x.14	T6 digital I/O 4 invert							
x.15	T7 digital input 5 invert							
x.16	T8 digital input 6 invert							
x.17	T9 digital input 7 invert							
x.18	Relay 1 invert							
RW	Bit						US	
⇕	OFF (0) or On (1)			⇨	OFF (0)			
Update rate: 4ms read								

Setting these parameters to On(1) causes the input sense to the destination parameter to be inverted or the output sense from the source to be inverted.

x.20	Digital I/O read word								
RO	Uni					NC	PT	US	
⇳	0 to 255			⇨					
Update rate: 500µs write									

This word is used to determine the status of the digital I/O by reading one parameter. The bits in this word reflect the state of Pr **x.03** to Pr **x.10**.

Bit	Digital I/O	Parameter	Bit Update Rate Input/Output*
0	T3 (Digital I/O 1)	Pr **x.09**	500µs / 4ms
1	T4 (Digital I/O 2)	Pr **x.10**	500µs / 4ms
2	T5 (Digital I/O 3)	Pr **x.03**	500µs / 4ms
3	T6 (Digital I/O 4)	Pr **x.04**	500µs / 4ms
4	T7 (Digital input 5)	Pr **x.05**	500µs / -
5	T8 (Digital input 6)	Pr **x.06**	500µs / -
6	T9 (Digital input 7)	Pr **x.07**	500µs / -
7	T14 / T15 (Digital output 8 relay)	Pr **x.08**	- / 4ms
8	T16 / T17 (Digital output 9 relay)	Pr **x.40**	- / 4ms

x.21	T3 digital I/O 1 source/destination								
x.22	T4 digital I/O 2 source/destination								
x.23	T5 digital I/O 3 source/destination								
x.24	T6 digital I/O 4 source/destination								
x.25	T7 digital input 5 destination								
x.26	T8 digital input 6 destination								
x.27	T9 digital input 7 destination								
x.28	Relay 1 source								
RW	Uni		DE					US	
⇳	Pr **0.00** to Pr **21.51**			⇨	Pr **0.00**				
Update rate: Read on drive reset									

Source parameters define the parameter to be represented by the digital output terminal.
Destination parameters define the parameter each of the programmable inputs is to control.

x.29	T6 digital I/O 4 output select								
RW	Bit							US	
⇳	OFF (0) or On (1)			⇨	On (1)				
Update rate: Background read									

This parameter selects the function of terminal T6 as follows:

OFF (0) = digital input
On (1) = digital output

x.31	T3 digital I/O 1 output select								
x.32	T4 digital I/O 2 output select								
x.33	T5 digital I/O 3 output select								
RW	Bit							US	
⇳	OFF (0) or On (1)			⇨	OFF (0)				
Update rate: Background read									

These parameters select the function of terminals T3 to T5 as follows:

OFF (0) = digital input
On (1) = digital output

x.39	**Analog output mode**								
RW	Uni							US	
⇕	0-20, 20-0, 4-20, 20-4				⇨	0-20			
Update rate: Background read									

This parameter sets the output mode for terminals 10 and 12 as follows:

Parameter value	Parameter string	Mode
0	0-20	0-20mA
1	20-0	20-0mA
2	4-20	4-20mA
3	20-4	20-4mA

x.40	**Relay 2 state**								
RO	Uni					NC	PT		
⇕	0.0 or 100.0%				⇨				
Update rate: 4ms write									

This parameter indicates the states of relay 2. This parameter can only have the values of 0.0% or 100.0%. 0.0% indicates relay open and 100% indicates relay closed.

x.42	**Relay 2 invert**								
RW	Bit							US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: 4ms read									

Setting this parameters to On(1) causes the output sense from the source to be inverted.

x.43	**Relay 2 source**								
RW	Uni		DE					US	
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

Source parameter defines the parameter to be represented by the relay 2 output terminal.

x.45	**Analog output 2 scaling**								
RW	Uni							US	
⇕	0.000 to 4.000				⇨	1.000			
Update rate: Background read									

This parameter can be used to scale the analog output if so desired.

x.47	**Analog output 2 source**								
RW	Uni							US	
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on reset									

The parameter required to be represented as an analog signal by the analog output on terminal 12, should be programmed into this parameter.

x.48	**Analog output 1 source**								
RW	Uni							US	
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on reset									

The parameter required to be represented as an analog signal by the analog output on terminal 10, should be programmed into this parameter.

x.49	**Analog output 1 scaling**								
RW	Uni							US	
⇕	0.000 to 4.000				⇨	1.000			
Update rate: Background read									

This parameter can be used to scale the analog output if so desired.

x.50	**Solutions Module error status**								
RO	Uni					NC	PT		
⇳	0 to 255				⇨				
Update rate: Background read									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a ‘SLx.Er’ trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-28 on page 316 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive is tripped and the error status is set to 74.

x.51	**Solutions Module software sub-version**								
RO	Uni					NC	PT		
⇳	0 to 99				⇨				
Update rate: Write on power-up									

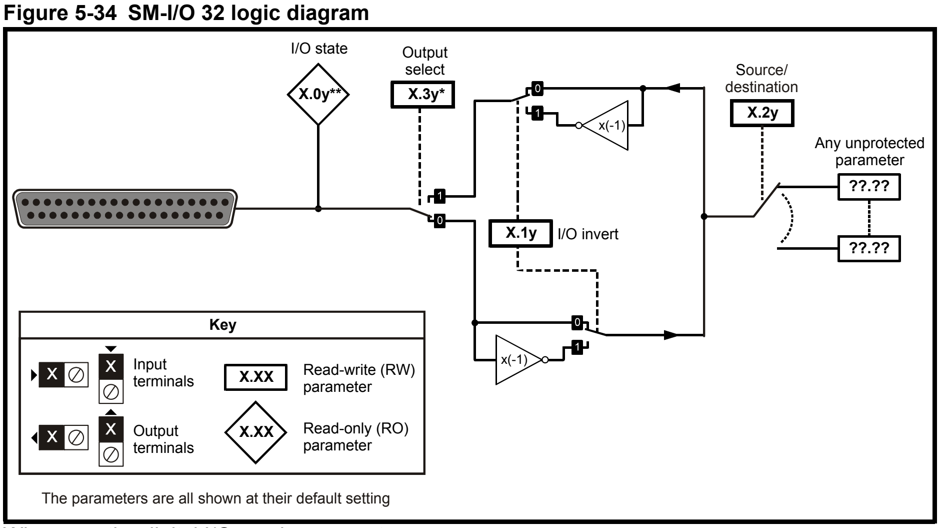
This module contains two processors, and thus two software versions. Pr **x.02** shows the version number of the main module processor. Pr **x.51**, which is normally used to give a sub-version number, shows the software version in the slave processor.

5.17.9 SM-IO 32

Table 5-33 Solutions Module error status values for SM-IO 32

Error code	Fault description
0	No errors
1	Digital outputs or 24Vout overloaded
74	Solutions Module over temperature (>90°C)

Figure 5-34 SM-I/O 32 logic diagram



Where y = the digital I/O number, except:

*Digital I/O 4 which is Pr **x.29**

Digital I/O 1 which is Pr **x.09 and digital I/O 2 which is Pr **x.10**

x.01	**Solutions Module ID code**								
RO	Uni						PT	US	
⇳	0 to 599			⇨	208				
Update rate: Write on power-up									

On Unidrive SP the menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

208: SM-I/O 32

The new parameter values are not stored in the drive EEPROM until the user performs a parameter save by setting Pr **xx.00** to 1000 (or 1001 in the case of solely using the 24V back-up power supply) and pressing the stop/reset button. When parameters are saved by the user in the drive EEPROM, the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module is installed when one was previously installed, the drive will trip on SLx.dF or SLx.nF.

x.02	**Solutions Module main software version**								
RO	Uni					NC	PT		
⇳	00.00			⇨					
Update rate: Write on power-up									

This parameter shows the version of software programmed into the Solutions Module. The software sub version is displayed in Pr **x.51**.

These two parameters display the software version in the form of:

Pr **x.02** = xx.yy

Pr **x.51** = zz

x.03	**Digital I/O 3 state**								
x.04	**Digital I/O 4 state**								
x.05	**Digital I/O 5 state**								
x.06	**Digital I/O 6 state**								
x.07	**Digital I/O 7 state**								
x.08	**Digital I/O 8 state**								
x.09	**Digital I/O 1 state**								
x.10	**Digital I/O 2 state**								
RO	Bit					NC	PT		
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: 4ms write									

Pr **x.03** to Pr **x.10** show the state of I/O lines DIO1 to DIO8. These bits reflect the I/O state even if fast update mode is being used.

x.11	**Digital I/O 1 invert**								
x.12	**Digital I/O 2 invert**								
x.13	**Digital I/O 3 invert**								
x.14	**Digital I/O 4 invert**								
x.15	**Digital I/O 5 invert**								
x.16	**Digital I/O 6 invert**								
x.17	**Digital I/O 7 invert**								
x.18	**Digital I/O 8 invert**								
RW	Bit							US	
⇕	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

Pr **x.11** to Pr **x.18** inverts DIO1 to DIO8 respectively for the standard update method. Each bit (DIO1 to DIO8) can be inverted individually.

x.20	**Digital I/O read word**								
RO	Uni					NC	PT		
⇕	0 to 255				⇨				
Update rate: 4ms write									

This parameter allows the state of DIO1 to DIO8 to be monitored by reading one parameter. It is a read only parameter which shows value of bits 0 to 7 (or DIO1 to DIO8) in decimal from 0 to 255. DIO9 to DIO32 have no affect on this parameter. The bits in this parameter reflect the state of Pr **x.03** to Pr **x.10** as follows:

Bit	Digital I/O	Parameter
0	DIO1	Pr **x.09**
1	DIO2	Pr **x.10**
2	DIO3	Pr **x.03**
3	DIO4	Pr **x.04**
4	DIO5	Pr **x.05**
5	DIO6	Pr **x.06**
6	DIO7	Pr **x.07**
7	DIO8	Pr **x.08**

x.21	**Digital I/O 1 source/destination**								
x.22	**Digital I/O 2 source/destination**								
x.23	**Digital I/O 3 source/destination**								
x.24	**Digital I/O 4 source/destination**								
x.25	**Digital I/O 5 source/destination**								
x.26	**Digital I/O 6 source/destination**								
x.27	**Digital I/O 7 source/destination**								
x.28	**Digital I/O 8 source/destination**								
RW	Uni				DE		PT	US	
⇳	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

The parameter specified in these parameters by the user is the source parameter when corresponding digital I/O line is set as an output or destination parameter when corresponding digital I/O line is set as an input. A total of 8 source or destination parameters can be defined. Pr **x.21** to Pr **x.28** corresponds to bits 0 to 7 (DIO1 to DIO8) respectively.

x.29	**Digital I/O 4 output select**								
RW	Bit						PT	US	
⇳	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

x.31	**Digital I/O 1 output select**								
x.32	**Digital I/O 2 output select**								
x.33	**Digital I/O 3 output select**								
RW	Bit							US	
⇳	OFF (0) or On (1)				⇨	OFF (0)			
Update rate: Background read									

When the output select parameter for an I/O line is set to On, the I/O is set up as an output as follows:

Digital I/O	Output select
DIO1	Pr **x.31**
DIO2	Pr **x.32**
DIO3	Pr **x.33**
DIO4	Pr **x.29**

x.43	**Fast update method direction register**								
RW	Uni				DE		PT	US	
⇳	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

The drive parameter defined by this parameter is the direction register for the fast update method. Setting the relevant bit to 1 within the direction register parameter will select the corresponding I/O line to function as an output. If this parameter is set to **0.00** or a non existent parameter then all I/O lines are defined as inputs for the fast update method. The direction register parameter range may not be large enough to allow all I/O lines to be controlled. Any bits that cannot be controlled are assumed to be zero and the corresponding I/O lines are defined as inputs for the fast update method.

x.47	**Fast update method read register**								
RW	Uni				DE		PT	US	
⇳	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

The drive parameter defined by this parameter is the read register for the fast update method. When an I/O line is set up as an input for the fast update method the corresponding bit in the read register shows the state of the input. Bits that correspond to I/O lines that are set as outputs in the direction register or in the direction registers for the standard update method show the state of the output I/O line. If this parameter is set to **0.00** or a non existent parameter then no read register is defined. The read register parameter range may not be large enough to allow the state of all I/O lines to be shown; in this case the value containing the I/O status for all 32 I/O lines will be limited to the read register parameter range before being written to the read register parameter.

x.48	**Fast update method write register**								
RW	Uni					PT	US		
⇕	Pr **0.00** to Pr **21.51**				⇨	Pr **0.00**			
Update rate: Read on drive reset									

The drive parameter defined by this parameter is the write register for the fast update method. Each bit in the write register will control the corresponding I/O line provided it has been set up as an output in the direction register parameter. If this parameter is set to **0.00** or a non existent parameter then all I/O lines set up as outputs are held in the non-active state. The write register parameter range may not be large enough to allow all I/O lines to be controlled. The value written to the write register is subject to the normal range limiting.

Worked Example

By storing 20.21 in **Pr x.43**, Pr **20.21** will become the direction register for the digital I/O lines on the SM-IO 32 module. Storing 20.22 in Pr **x.47** will make Pr **20.22** the read register. Storing 20.23 in **Pr x.48** will make **Pr 20.23** the write register.

Storing a value of 29 (11101 in binary) in Pr **20.21** will make digital I/O lines 1, 3, 4 and 5 (which corresponds to bit 0, 2, 3 and 4) as digital output bits and the remaining I/O lines will remain as digital input. Now these digital outputs can be written to using the write register Pr **20.23**. Storing a value of 23 (10111 in binary) in Pr **20.23** will set digital I/O 1, 3 and 5 high (ON) and digital I/O 4 low (OFF). The write register will have no effect on digital I/O 2 when it tries to set it high (ON) because this digital I/O line has not been set as a digital output line by direction register. The read register, Pr **20.22** will show a value of 21 (binary 10101).

NOTE

The control of the 32 digital I/O is limited by the range of the controlling parameter. Control of all the 32 digital I/O lines can only be achieved using software like SyPTLite and SyPTPro. For example, with Pr **18.13** as the write register, 16 digital outputs can be written and with Pr **20.23** as the write register, all the 32 digital outputs can be written

x.50	**Solutions Module error status**								
RO	Uni					NC	PT		
⇕	0 to 255				⇨				
Update rate: Background write									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce an 'SLX.Er' trip (where X is the slot number). A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-33 on page 323 for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 85°C (185°F), the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 75°C (167°F), the fan can operate normally again. If the PCB temperature exceeds 90°C (194°F), the drive will trip and the error status is set to 74.

x.51	**Solutions Module software sub-version**								
RO	Uni					NC	PT		
⇕	0 to 99				⇨				
Update rate: Write on power-up									

The Solutions Module includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz, where:

xx specifies a change that affects hardware compatibility
yy specifies a change that affects product documentation
zz specifies a change that does not affect the product documentation.

5.17.10 SM-Applications Modules

Product Variants

Different product variants within the SM-Applications range have different functionality and therefore some variants do not use all of the applications module parameters. Modules that do not support all of the features have had hardware support for the unsupported features removed.

A comprehensive list of differences between the modules can be found in the relevant user guide for the SM-Applications module being used.

As some variants do not support all features of the SM-Applications range (for example SM-Applications Lite does not support CTNet) some error codes and parameters are unused in these variants.

NOTE

A mark next to the following parameters will indicate whether that parameter is available for a particular variant of the Applications module. The mark for each variant is as follows:

- ♦SM-Applications Lite
- ♥SM-Applications
- ♣SM-Applications Plus

Table 5-35 Solutions Module error status value for Application modules

Error Code	Reason	Trip Drive?	ERROR task?	Prog Halted?
39	User program stack overflow	Yes	No	Yes
40	Unknown error - please contact supplier	Yes	No	Yes
41	Parameter does not exist. User has attempted to read or write a non-existent parameter in the DPL program.	May	Yes	Yes
42	Attempt to write to a read-only parameter.	May	Yes	Yes
43	Attempt to read from a write-only parameter.	May	Yes	Yes
44	Parameter value out of range. (User has written an illegal value to a parameter within a DPL program). If parameter #MM.17=0 the value written will be automatically limited and no error will occur.	May	Yes	Yes
45	Invalid synchronization modes	Yes	No	Not Run
46	Unused	N/A	N/A	N/A
47	Synchronization lost with CTSync Master.♣♥	Yes	Yes	Yes
48	RS485 not in user mode. Occurs if user attempts to use a user-mode RS485 DPL command but the RS485 port is not in a user-mode.♣♥	Yes	Yes	Yes
49	Invalid RS485 configuration. For example, invalid mode.♣♥	Yes	Yes	Yes
50	Maths error - divide by zero or overflow.	May	Yes	Yes
51	Array index out of range. E.g. arr%[20] where arr% has only been DIMensioned to 19 elements.	May	Yes	Yes
52	Control word user trip. Instigated by setting the trip bit in the control word #90.11	Yes	No	No
53	DPL program incompatible with target. For example, downloading a program compiled for UD70.	Yes	N/A	N/A
54	DPL task overrun. This occurs if the DPL code within a real-time task (e.g. POS0) cannot be completed in time. Use parameter #88.02 to identify the task in which this error occurred. Check that the task scheduling rate is correct and that there are no loops in the task. This can also occur as a result of external influences such as a large burst of data coming in over CTNet. This problem may be overcome by changing the CTNet priority so that it is lower than the POS tasks. This, however, may cause the CTNet task to be starved.	May	Yes	Yes
55	Invalid encoder configuration. Only applies to system file V01.02.01 or earlier.	Yes	N/A	N/A
56	Invalid timer unit configuration♣♥	Yes	Yes	Yes
57	Function block does not exist.	Yes	Yes	Not Run
58	Flash PLC Storage corrupt. Occurs at startup and will mean that the PLC register set (P/Q/T/U) and menu 20 will not have been restored. If this problem persists it may indicate a hardware failure so contact your supplier.	Yes	Yes	Not Run
59	Drive rejected application module as Sync master	Yes	Yes	Yes
60	CTNet hardware failure. Please contact your supplier.♣♥	May	No	No
61	CTNet invalid configuration. Check all configuration parameters.♣♥	May	No	No
62	CTNet invalid baud-rate. Check #MM.24 and network connections.♣♥	May	No	No
63	CTNet invalid node ID. Check #MM.23.♣♥	May	No	No
64	Digital Output overload. Both digital outputs will be taken inactive when this occurs and will remain inactive until the error condition is cleared. The trip threshold is 20mA.♣♥	Yes	Yes	Yes
65	Invalid function block parameter(s). You have called a FB within a DPL program but one or more of the inputs are invalid.	Yes	Yes	Yes
66	User heap too large. The program has been compiled for a target that has more RAM than this one has. Occurs at startup.	Yes	No	Not Run
67	RAM file does not exist or a non-RAM file id has been specified.	Yes	Yes	Yes
68	The RAM file specified is not associated to an array.	Yes	Yes	Yes
69	Failed to update drive parameter database cache in Flash memory.	Yes	No	Not Run
70	User program downloaded while drive enabled. Will occur if #MM.37 = 1 and a program is downloaded.	May	No	Yes
71	Failed to change drive mode	Yes	No	Yes
72	Invalid CTNet buffer operation.♣♥	Yes	Yes	Yes

Error Code	Reason	Trip Drive?	ERROR task?	Prog Halted?
73	Fast parameter initialisation failure	Yes	No	No
74	Over-temperature	Yes	Yes	Yes
75	Hardware unavailable. The user program attempted to access unavailable hardware. e.g. if access is made to digital I/O, RS485 port or CTNet on SM-Applications Lite module.	Yes	Yes	Yes
76	Module type cannot be resolved. Module is not recognized.	Yes	No	Not Run
77	Inter-Solutions Module comms error with module in slot 1.	Yes	Yes	Yes
78	Inter-Solutions Module comms error with module in slot 2.	Yes	Yes	Yes
79	Inter-Solutions Module comms error with module in slot 3.	Yes	Yes	Yes
80	Inter-Solutions Module comms error with module unknown slot.	Yes	Yes	Yes
81	• Slot selected as the reference or feedback does not contain a position Solutions Module • Attempt to change the Reference source or the Feedback source in more than one task. APC internal error. See parameter #81.38. This may be caused by one of the following: • CAM table too small • A change of too many CAM segments has occurred at the CAM table input • CAM is selected but size is zero • CAM absolute mode selected and Reset Index or Reset Position in segment is out of range	May	Yes	Yes
82	Communications to drive faulty.	May	Yes	Yes

The Applications Module will only detect a change in parameter values after start-up or on restart after being reset.

x.01	Module Code ♦♣♥		
Access	RO	**Range**	0 to 499
Default	N/A	**Update Rate**	N/A

The Module Code indicates the type of module that is installed in the corresponding slot.

301: SM-Applications module
302: SM-Applications Lite module
304: SM-Applications Plus module
305: SM-Applications Lite V2 module

x.02	Firmware Version - Major ♦♣♥		
Access	RO	**Range**	00.00 to 99.99
Default	N/A	**Update Rate**	N/A

Specifies the major revision number of the operating system of the Applications module. Use in conjunction with **Pr 81.51** to form the complete version number.

x.03	DPL Program Status ♦♣♥		
Access	RO	**Range**	0 to 3
Default	0	**Update Rate**	1ms of change

Provides the run status of the user DPL program in the Applications module. The following values are defined:

Display	Value	Description
nonE	0	No DPL program present
StoP	1	DPL program is stopped
run	2	DPL program is running
triP	3	Run-time error. ERROR task running or DPL program stopped

x.04	Available System Resource ♦♣♥		
Access	RO	**Range**	0 to 100
Default	N/A	**Update Rate**	200ms

Displays the free CPU resource as a percentage of the current background execution time calculated over 200ms.

x.05	EIA-RS485 Address ♣♥		
Access	RW	**Range**	0 to 255
Default	11	**Update Rate**	Initialisation

Defines the address of this node for ANSI and Modbus communications protocols.

For the ANSI protocol the address range is 11 to 99 where the first digit is the group address and the second digit is the unit number. Both digits must be in the range of 1-9. Zero is not permitted since it is used by the master for addressing groups of nodes.

This parameter has no effect if the EIA-RS485 mode is 25 (CTSync) or 26 (CTSync)

x.06	EIA-RS485 Mode♣♥		
Access	RW	**Range**	0 to 255
Default	1	**Update Rate**	Initialisation

Defines the mode of operation (or protocol) for the on-board EIA-RS485 port. For details of these modes, refer to the *Applications Modules User Guide*..

Table 5.37 Serial modes - parameter Pr x.06

Mode	Description
1	4-wire CT-ANSI Slave The port is set to 1 start bit, 7 data bits, even parity and 1 stop bit.
2	Reserved
3	Reserved
4	Reserved
5	2-wire CT-ANSI Slave The port is set to 1 start bit, 7 data bits, even parity and 1 stop bit.
6	User mode. 1 start bit, 7 data bits, EVEN parity, 1 stop bit (10 bits total)
7	User mode. 1 start bit, 8 data bits, EVEN parity, 1 stop bit (11 bits total)
8	User mode. 1 start bit, 8 data bits, NO parity, 1 stop bit (10 bits total)
9	Reserved
10	Reserved
11	Reserved
12	Reserved
13,43,73	4-wire Modbus RTU slave The EIA-RS485 port is set for: Mode 13: 1 start bit, 8 data bits, NO parity, 2 stop bits. Mode 43: 1 start bit, 8 data bits, EVEN parity, 1 stop bit. Mode 73: 1 start bit, 8 data bits, ODD parity, 1 stop bit.
14, 44, 74	4-wire Modbus ASCII slave The EIA-RS485 is set for: Mode 14: 1 start bit, 7 data bits, NO parity, 2 stop bits Mode 44: 1 start bit, 7 data bits, EVEN parity, 1 stop bit Mode 74: 1 start bit, 7 data bits, ODD parity, 1 stop bit
15, 45, 75	2-wire Modbus RTU slave The EIA-RS485 port is set for: Mode 15: 1 start bit, 8 data bits, NO parity, 2 stop bits. Mode 45: 1 start bit, 8 data bits, EVEN parity, 1 stop bit. Mode 75: 1 start bit, 8 data bits, ODD parity, 1 stop bit.
16, 46, 76	2-wire Modbus ASCII slave The EIA-RS485 is set for: Mode 16: 1 start bit, 7 data bits, NO parity, 2 stop bits Mode 46: 1 start bit, 7 data bits, EVEN parity, 1 stop bit Mode 76: 1 start bit, 7 data bits, ODD parity, 1 stop bit
17, 47, 77	4-wire Modbus RTU master The EIA-RS485 port is set for: Mode 17: 1 start bit, 8 data bits, NO parity, 2 stop bits. Mode 47: 1 start bit, 8 data bits, EVEN parity, 1 stop bit. Mode 77: 1 start bit, 8 data bits, ODD parity, 1 stop bit.
18, 48, 78	4-wire Modbus ASCII master The EIA-RS485 is set for: Mode 18: 1 start bit, 7 data bits, NO parity, 2 stop bits Mode 48: 1 start bit, 7 data bits, EVEN parity, 1 stop bit Mode 78: 1 start bit, 7 data bits, ODD parity, 1 stop bit
19, 49, 79	2-wire Modbus RTU master The EIA-RS485 port is set for: Mode 19: 1 start bit, 8 data bits, NO parity, 2 stop bits. Mode 49: 1 start bit, 8 data bits, EVEN parity, 1 stop bit. Mode 79: 1 start bit, 8 data bits, ODD parity, 1 stop bit.
20, 50, 80	2-wire Modbus ASCII master The EIA-RS485 is set for: Mode 18: 1 start bit, 7 data bits, NO parity, 2 stop bits Mode 48: 1 start bit, 7 data bits, EVEN parity, 1 stop bit Mode 78: 1 start bit, 7 data bits, ODD parity, 1 stop bit
25	Applications CT-Sync Master The baud rate is fixed at 896875bps
26	Applications CT-Sync Slave The baud rate is fixed at 896875bps

x.07	EIA-RS485 Baud Rate♣♥		
Access	RW	Range	0-9 (300-115200bps)
Default	4 (4800)	Update Rate	Initialisation

Defines the baud-rate (or bits-per-second) for the on-board EIA-RS485 port. The following are supported:

Display	Value	Description
300	0	300bps
600	1	600bps
1200	2	1200bps
2400	3	2400bps
4800	4	4800bps
9600	5	9600bps
19200	6	19200bps
38400	7	38400bps
57600	8	57600bps
115200	9	115200bps

Note that this parameter is not relevant when the EIA-RS485 port mode is set to 25 (CTSync Master) or 26 (CTSync Slave).

x.08	EIA-RS485 Turn-around Delay♣♥		
Access	RW	Range	0 to 255ms
Default	2ms	Update Rate	Initialisation

Defines a fixed delay between receiving a message on the EIA-RS485 port and the response being transmitted. This can be useful in 2-wire configurations where it takes a finite time for the master (host) to switch from transmit mode to receive mode. There is always at least a 1ms delay and this parameter can be used to extend it.

x.09	EIA-RS485 Tx Enable Delay♣♥		
Access	RW	Range	0 to 1ms
Default	0ms	Update Rate	Initialisation

This parameter allows a 1ms delay to be introduced between the Applications module enabling the EIA-RS485 transmitter and actually commencing the transmission. This should only be required if it is found that the recipient of the transmission is receiving a corrupted start of message.

x.10	DPL Print Routing♦♣♥		
Access	RW	Range	0♦♣♥/1♣♥
Default	0	Update Rate	Initialisation

This parameter is available on SM-Applications Lite module but is not allowed to be set to a 1 (On). Controls where the output of the DPL PRINT command is sent. If set to zero (Off), the output is sent to the programming client (SyPTPro) and if set to 1 (On) it will be sent to the EIA-RS485 port.

x.11	Clock Task Scheduling (ms)♦♣♥		
Access	RW	Range	0 to 200ms
Default	10ms	Update Rate	Initialisation

Defines the scheduling period (tick-time), in milliseconds, for the DPL CLOCK task. A value of zero will disable the CLOCK task.

NOTE

Prior to version 01.05.00 Unidrive SP the default for this parameter was 0ms (disabled).

x.12	POS task scheduling rate♦♣♥		
Access	RW	Range	0 to 6
Default	0	Update Rate	Initialisation

Defines the scheduling rate for the POS tasks to suit the application performance and the resource needed to run the user DPL program. The following values are defined::

Display	Value	Description
diSAbled	0	Disabled
0.25	1	250μs
0.5	2	500μs
1	3	1ms
2	4	2ms
4	5	4ms
8	6	8ms

Set this parameter in order for the user DPL program to automatically run at power-on/reset. If this is changed and the new setting needs to be used on power-up ensure that a **drive** parameter save is performed.

NOTE

With the Unidrive SP version 01.03.00 and earlier, the display will not show the actual rate, but its aliased number. For instance 250μs will be shown on the display as 1.

x.13	Auto-run Enable ♦♣♥		
Access	RW	Range	0/1
Default	1	Update Rate	Initialisation

x.14	Global Run-time Trip Enable ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Initialisation

Setting this parameter to 1 will cause the Unidrive SP to trip when certain run-time errors occur within the Applications module user DPL program.

For more information, see the *Applications Modules User Guide*.

x.15	Disable Reset on Trip Cleared ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Initialisation

When this parameter is 0, the module will be reset when a drive trip is cleared. When set to 1 the module will be unaffected by a drive trip reset (i.e. continue running).

x.16	Encoder Data Update Rate ♦♣♥		
Access	RW	Range	0-3
Default	0	Update Rate	Initialisation

When this parameter is 0 the APC data and menu 90 encoder parameters are updated every 250μs.

When this parameter is 1 the APC data and menu 90 encoder parameters are updated immediately prior to every POS task.

When this parameter is 2 the APC data and menu 90 encoder parameters are updated immediately prior to every CLOCK task.

When 3 the APC data and menu 90 encoder parameters are never updated. If these are never updated, more processor resource will become free

x.17	Enable Parameter Over-range Trips ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Initialisation

Defines the action taken if a user DPL program attempts to write an out of range value to a parameter. When set at 1, a run-time trip will occur (number 44); when set at zero the value will automatically be limited to the maximum/minimum of that parameter.

x.18	Watchdog Enable ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Initialisation

When set it enables the DPL program watchdog function. The DPL WDOG command must then be executed every 200ms. This can be used to protect the program against malfunction. If the command is not executed within a 200ms time period the drive will trip on **SLx.tO**. Please note that the WDOG command must also be executed once for the watchdog to be enabled. This is normally executed at the end of the Initial task.

x.19	Save Request ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	100ms

Setting this parameter to 1 will initiate an immediate save of all non-volatile Applications module data. This consists of the P/Q/T/U PLC register sets and optionally menu 20 (depending upon the setting of Pr **x.21**).

NOTE

Note that this will also cause a reset of the module and this parameter will return back to zero automatically. Also if the Unidrive SP is tripped, it will be reset. Menu 81 will not be saved.

x.20	Enable "UU trip" Save ♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Immediate

Setting this parameter to 1 signals that all non-volatile data of the Applications module will be automatically saved upon an under voltage (UU) trip of the drive.

NOTE

Note that when a 'UU' save occurs the Applications module will be reset.

x.21	Enable menu 20 save and restore♦♣♥		
Access	RW	Range	0/1
Default	0	Update Rate	Immediate

If set to 1, menu 20 will be saved/restored along with other non-volatile parameters upon a save request (**Pr x.19=**1) or power-down save (**Pr x.20=**1). If menu 20 is to be restored on power-up the user must ensure that this parameter is saved in the drive before powering down.

Since menu 20 is a global drive menu, only one option installed to the Unidrive SP should be used to store and restore menu 20, therefore if more than one Applications module is installed to the drive **only one** should have this parameter set otherwise menu 20 will not be restored correctly on power-up.

NOTE

Unlike other setup parameters, parameters Pr **x.20** and Pr **x.21** are **not cached**, which means a change to the parameter takes immediate effect.

x.22	CTNet Token Ring ID♣♥		
Access	RW	Range	0 to 255
Default	0	Update Rate	Initialisation

This parameter allows the user to specify the identity of the CTNet token ring to which a Applications module is connected. In a system incorporating a single token ring this parameter can be left at its default value. In a system incorporating multiple token rings, separate ID's should be set for each ring. The combination of CTNet Token Ring ID and CTNet node address should be unique.

x.23	CTNet Node Address♣♥		
Access	RW	Range	0 to 255
Default	0	Update Rate	Initialisation

Defines the node address for CTNet. Every node on a CTNet network must have a unique address. Setting this to zero will disable CTNet on this node.

x.24	CTNet Baud Rate♣♥		
Access	RW	Range	0 to 3
Default	1(2.5)	Update Rate	Initialisation

Specifies the data rate for CTNet. All nodes on the network must be set to the same data-rate. The rates are defined as follows:

Display	Value	Description
5.000	0	5Mbit/s
2.500	1	2.5Mbit/s
1.250	2	1.25Mbit/s
0.625	3	625kbit/s

x.25	CTNet Sync Setup♣♥		
Access	RW	Range	0 to 9999
Default	0	Update Rate	Initialisation

Specifies the synchronization message generation rate for CTNet. This message is used to tell all nodes when to transmit cyclic data. Only one node on the CTNet network should have this parameter set.

The format of the update parameter is SSFF, where FF defines the Fast Cyclic data channel update rate, and SS defines the slow cyclic data rate in multiples of FF. So if the parameter value is 1510, fast cyclic data is set every 10ms and slow every 150ms. When using easy mode (see below) it is only necessary to set up the FF (fast cyclic rate).

x.26, x.28, x.30	CTNet Easy Mode Setup Parameters♣♥		
Access	RW	Range	0 to 25503
Default	0	Update Rate	Initialisation

x.27, x.29, x.31-x.34	CTNet Easy Mode Setup Parameters♣♥		
Access	RW	Range	0 to 9999
Default	0	Update Rate	Initialisation

These parameters define the source and destinations for CTNet easy-mode cyclic data.

Parameter	Format	Channel	Description
Pr x.26	NNNSS	1	Defines the destination node number and slot NNN = Node number (1-255) SS = Slot number (1-3) e.g. A value of 201 means node ID 2, slot 1.
Pr x.27	MMPP	1	Defines the source drive parameter which is to be transmitted MM = Menu number PP = Parameter number e.g. A value of 302 means **Pr 3.02** (speed)
Pr x.28	NNNSS	2	Destination node number and slot for channel 2
Pr x.29	MMPP	2	Source drive parameter for channel 2
Pr x.30	NNNSS	3	Destination node number and slot for channel 3
Pr x.31	MMPP	3	Source drive parameter for channel 3
Pr x.32	MMPP	1	Slot 1 destination parameter for incoming data
Pr x.33	MMPP	2	Slot 2 destination parameter for incoming data
Pr x.34	MMPP	3	Slot 3 destination parameter for incoming data

More information on CTNet easy mode data can be found in the CTNet *User Guide*.

x.35	CTNet Sync. Event Task ID♣♥		
Access	RW	**Range**	0 to 4
Default	0	**Update Rate**	Initialisation

Identifies which of the EVENT tasks will be scheduled when a CTNet synchronization message is received or generated. This sync. is generated by a *master* node (which can be this node) on the CTNet network at a fixed time-base. The following values are defined:

Display	Value	Description
Disabled	0	No event task scheduled
Event	1	EVENT task scheduled
Event1	2	EVENT1 task scheduled
Event2	3	EVENT2 task scheduled
Event3	4	EVENT3 task scheduled

x.36	CTNet Diagnostics♣♥		
Access	RO	**Range**	-3 to 32767
Default	N/A	**Update Rate**	1 second

The status of the CTNet network is displayed in the CTNet Diagnostic parameter. When the Applications module is communicating successfully on the CTNet network the number of messages per second is displayed

Table 5.38 CTNet Diagnostics

#MM.36	Status	Description
>0	Network ok	Indicates the number of messages per second be processed every second.
0	Network ok, No Data Transfer	The low-level token ring has been established and is active, but the node is not receiving any CTNet data messages.
-1	RECON	A network reconfiguration has been detected.
-2	Initialisation Error	The Applications module was unable to configure the CTNet interface. Check that the node address and data rate are set correctly.
-3	MYRECON	The Applications module forced a CTNet network reconfiguration

x.37	Reject Download if Drive Enabled♦♣♥		
Access	RW	**Range**	0/1
Default	0	**Update Rate**	Initialisation

If this parameter is set, then if the user attempts to download a new user DPL program or operating system to this module and the drive is enabled the download will be rejected and a run-time trip 70 will occur, if the global run-time trip parameter (Pr **x.14**) is set.

Since downloading stops normal operations of the module it may be considered unsafe to do this if the drive system is running, therefore setting this parameter will prevent downloading under this condition.

x.38	APC Run-time trip♦♣♥		
Access	RW	**Range**	0/1
Default	0	**Update Rate**	Initialisation

When this parameter is 0 the drive will trip with runtime error 81 if an APC non-recoverable error occurs, such as use of an initialized CAM function. When this parameter is 1 the drive will not trip when an APC non-recoverable error occurs.

x.39	**Inter-module Drive Sync Status**♦♣♥		
Access	RW	**Range**	0/1
Default	0	**Update Rate**	NA

This parameter displays the current module's synchronization status.

Synchronisation Status	Status
0	The synchronization master request is zero or another Solutions Module is synchronization master.
1	The Solutions Module is synchronization master.
3	The Solutions Module is synchronization master, but the synchronization frequency is out of specification or not present.

x.41	**Indexer Control**		
Access	RW	**Range**	0/3
Default	0	**Update Rate**	NA

This is used to control the motion sequence user program.

x.42	**Pass Freeze Through to Drive**♣♥		
Access	RW	**Range**	0/1
Default	0	**Update Rate**	Initialisation

When this parameter is ON (1), the voltage on the Applications module's digital input 0 (zero) is passed through to the drive's internal Freeze line. This can be seen by other classes of SM-Solutions modules. For further information on the Freeze Input refer to the *Applications Modules User Guide*.

x.43	**Freeze Invert**♦♣♥		
Access	RW	**Range**	0/1
Default	0	**Update Rate**	Initialisation

♣♥When this parameter is set to zero a freeze occurs on the rising edge of the module's DIGIN0. When it is set to 1 a freeze occurs on the falling edge of the module's DIGIN0. For further information on the Freeze Input refer to the *Applications Modules User Guide*.

♦When this parameter is set to zero the module will freeze data when it sees a rising edge of a freeze pulse from the drive. When it is set to a 1 the module will freeze data when it sees a falling edge of a freeze pulse from the drive. For further information on the Freeze Input refer to the *Applications Modules User Guide*.

x.44	**Task Priority Level**♦♣♥		
Access	RW	**Range**	0 to 255
Default	0	**Update Rate**	Initialisation

The priority levels of different tasks may be changed with this parameter. The parameter is accessed in a bit-wise manner:

Bit	Value	Meaning
0♣♥	0	CTNet task priority is higher than Pos tasks priority.
	1	CTNet task priority is lower than Pos tasks priority. This will reduce the jitter of the POS tasks but could lead to the CTNet task being starved
1♦♣♥	0	Inter-option communication task priority is higher than the POS tasks.
	1	Inter option communication task priority lower than the POS tasks.
2♣♥	0	Turbo CTNet Disabled
	1	Turbo CTNet Enabled

x.45	**User Set-Up Parameter 1**♣		
Access	RO	**Range**	N/A
Default	0	**Update Rate**	N/A

This parameter is dependant on what is running in the module i.e. Indexer

x.46	**User Set-Up Parameter 2**♣		
Access	RO	**Range**	N/A
Default	0	**Update Rate**	N/A

This parameter is dependant on what is running in the module i.e. Indexer

x.47	User Set-Up Parameter 3♣		
Access	RO	**Range**	N/A
Default	0	**Update Rate**	N/A

This parameter is dependant on what is running in the module i.e. Indexer

x.48	Line Number of Error♦♣♥		
Access	RO	**Range**	32 bit
Default	0	**Update Rate**	On error

Specifies the DPL program line number that caused a run-time error. This is valid only when:

- The user program has been compiled with the *debug* option set
- The error is one that can be generated by user code, for example divide by zero (50) or parameter does not exist (41).

If both of these conditions are not met, the line number parameter will display zero (0).

x.49	User program ID♦♣♥		
Access	RO/RW	**Range**	Signed 16-bit
Default	0	**Update Rate**	See Note

This parameter is available for the user to put in an ID code of their program. This may, for example, be the software version number. Use the function block SETUSERID() to write to this parameter.

x.50	Run-time Error Code♦♣♥		
Access	RO	**Range**	0 to 255
Default	0	**Update Rate**	On error

When a run-time error occurs the error number is placed into this parameter. (See Table 5-35 on page 327 for the meaning of the values in this parameter).

See the *Applications Modules User Guide* for further information.

x.51	Firmware - Minor Version♦♣♥		
Access	RO	**Range**	0 to 99
Default	N/A	**Update Rate**	N/A

Specifies the minor revision number of the operating system of the Applications module. Use in conjunction with Pr **x.02** to form the complete version number.

5.17.11 SM-EZMotion

Table 5-36 Solutions Module error status values for the SM-EZMotion module

Error Code (Pr x.50)	Cause Trip?	Error	Possible Reason	Possible Solution
41	Y	SP Parameter Access Error - Parameter Doesn't Exist	The SP Menu Parameter that you are trying to read from or write to does not exist.	Please double check the parameter number
42	Y	SP Parameter Access Error - Parameter is Read Only	The SP Menu Parameter that you are trying to write to is a Read Only parameter	Avoid writing to Read Only parameters. Use Drive Menu Watch view in PowerTools Pro, or Unidrive SP User Guide to verify parameter accessibility
43	Y	SP Parameter Access Error - Parameter is Write Only	The SP Menu Parameter that you are trying to read from is Write Only	Avoid reading from Write Only parameters. Use Drive Menu Watch view in PowerTools Pro, or Unidrive SP User Guide to verify parameter accessibility
44	Y	SP Parameter Access Error - Written Value Out of Range	The value you are trying to write to the SP Menu Parameter is out of range.	Modify value that you are trying to write so that it is within valid range of the parameter. Use the Unidrive SP User Guide to verify the range of the parameter and try again
73	Y	SP Database Setup Error		
74	Y	Module Overheat Error	SM-EZMotion module temperature has exceeded 83 degrees Fahrenheit	Select lower switching frequency in PowerTools Pro configuration, or reduce motion performance (i.e. lower accel/decel, lengthen dwells). If problem persists, please contact factory
101	Y	Invalid Configuration Error		
102	Y	NVM Invalid Error		
103	Y	Power Up Test Failure Error	SM-EZMotion module Power Up Test failed	Cycle power to the system. If problem persists, please contact factory
104	Y	Following Error	Amount of following error exceeded following error limit set in PowerTools Pro software.	Increase Following Error Limit in PowerTools Pro configuration. Increase Velocity Loop Bandwidth and/or Position Loop Bandwidth in PowerTools Pro configuration. Lower Acceleration/Deceleration ramp values. Make sure that programmed velocity is within maximum operating speed of the given motor.
105	N	Travel Limit Plus	Hardware Travel Limit Plus switch has activated, or Software Travel Limit Plus position has been exceeded	Verify motion profiles/programs to make sure that motion is not configured to exceed desired travel positions
106	N	Travel Limit Minus	Hardware Travel Limit Minus switch has activated, or Software Travel Limit Minus position has been exceeded	Verify motion profiles/programs to make sure that motion is not configured to exceed desired travel positions
107	Y	No Program Error	SM-EZMotion module has no configuration loaded in it	Download a configuration to the SM-EZMotion module using PowerTools Pro software
108	Y	Motion Trajectory Error	Maximum allowable position change within one control loop update has been exceeded	If using the "Using Capture.#" instruction after an Index.#.Initiate instruction in your user program, make sure that the captured data is recent enough so that the motor can actually achieve the necessary acceleration
109	Y	Trajectory Update Overrun Error	Control Loop processing time has taken longer than the user selected Trajectory Update Rate	Select a longer Trajectory Update Rate in the PowerTools Pro configuration. A longer Trajectory Update Rate gives the control loop more time to process. Be sure not to enable any PLS's, Captures, or Queues that are not being used.
120	Y	File Corruption Error - Consult Factory		
121	Y	File Corruption Error - Consult Factory		
122	Y	File Corruption Error - Consult Factory		

Error Code (Pr x.50)	Cause Trip?	Error	Possible Reason	Possible Solution
123	Y	Program Error - Buffer Overrun		
124	Y	Program Error - Call Stack Overflow	Too many "Call Program" instructions have been processed without returning to original "calling" program	Do not nest more than four "Call Program" operations. To avoid this, return to the original calling programs before calling another program. (See Call Program instruction explanation in this manual for more information).
125	Y	File Corruption Error - Consult Factory		
126	Y	File Corruption Error - Consult Factory		
127	Y	Flash Error	Loading from Flash Memory has failed	Re-download original PowerTools Pro configuration file. If problem persists, please contact factory.
128	Y	File Corruption Error - Consult Factory		
129	Y	Program Error - Illegal Command	User Program has processed an illegal command	Re-download original PowerTools Pro configuration file. If problem persists, please contact factory.
130	Y	File Corruption Error - Consult Factory		
131	Y	File Corruption Error - Consult Factory		
132	Y	File Corruption Error - Consult Factory		
133	Y	File Corruption Error - Consult Factory		
134	Y	File Corruption Error - Consult Factory		
135	Y	Program Error - Math Addition Overflow	Math addition operation in user program has resulted in an overflow of the resultant parameter	Verify that the sum of all the operands in addition formulas will not result in a value in the following range: $-2^{31} \leq \text{SUM} \leq 2^{31}-1$
136	Y	Program Error - Math Divide By Zero	Formula in user program causes a divide by zero	Make sure that the denominator in all division formulas is not equal to zero.
137	Y	Program Error - Math Divide Operand Too Large		
138	Y	Program Error - Math Multiplication Normalization Failed	Normalization of multiplication parameters in user program has failed	
139	Y	Program Error - Math Multiplication Operand Too Large		
140	Y	Program Error - Overflow		
141	Y	Program Error - Math Subtraction Overflow		
142	Y	Program Error - Math Stack Overflow	User Program math process stack has overflown	
143	Y	File Corruption Error - Consult Factory		
144	Y	File Corruption Error - Consult Factory		
145	Y	File Corruption Error - Consult Factory		
146	Y	File Corruption Error - Consult Factory		
147	Y	Program Error - Flash Memory Size Exceeded	User configuration exceeds available flash memory size	Eliminate any unused Indexes or Programs and re-download the PowerTools Pro configuration
148	Y	Program Error - RAM Memory Size Exceeded	User configuration exceeds available RAM memory size	Eliminate any unused Indexes or Programs and re-download the PowerTools Pro configuration
153	Y	File Corruption Error - Consult Factory		
154	Y	File Corruption Error - Consult Factory		
155	Y	File Corruption Error - Consult Factory		
156	Y	Program Error - Too Many Wait For Instructions	No more than nine arguments in Wait for Instruction	Limit # of arguments and redownloads

Error Code (Pr x.50)	Cause Trip?	Error	Possible Reason	Possible Solution
157	Y	File Corruption Error - Consult Factory		
158	Y	File Corruption Error - Consult Factory		
159	Y	File Corruption Error - Consult Factory		
160	Y	File Corruption Error - Consult Factory		
161	Y	File Corruption Error - Consult Factory		
162	Y	File Corruption Error - Consult Factory		
163	Y	File Corruption Error - Consult Factory		
164	Y	File Corruption Error - Consult Factory		
165	Y	File Corruption Error - Consult Factory		
166	Y	Program Error - EZMotion Parameter Write Out of Range	Value written to SM-EZMotion parameter in user program is out of range	
171	Y	Invalid Slot 1 Selection	Solutions Module selected for Slot 1 in PowerTools Pro file does not match actual module type installed	Switch module located in Slot 1 to match module type selected in PowerTools Pro file. Alternatively, update the PowerTools Pro configuration to match the module type actually installed, and then re-download the configuration.
172	Y	Invalid Slot 2 Selection	Solutions Module selected for Slot 2 in PowerTools Pro file does not match actual module type installed	Switch module located in Slot 2 to match module type selected in PowerTools Pro file. Alternatively, update the PowerTools Pro configuration to match the module type actually installed, and then re-download the configuration.
173	Y	Invalid Slot 3 Selection	Solutions Module selected for Slot 3 in PowerTools Pro file does not match actual module type installed	Switch module located in Slot 3 to match module type selected in PowerTools Pro file. Alternatively, update the PowerTools Pro configuration to match the module type actually installed, and then re-download the configuration.
174	Y	File Corruption Error - Consult Factory		
175	Y	Module Output Overload	SM-EZMotion module can only supply 20mA maximum total output current. If this fault occurs, the digital output device attached to the module outputs is drawing too much current.	Modify circuitry of devices connected to the SM-EZMotion module digital outputs so that they draw no more than 20mA total.

x.01	**Solutions Module ID code**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1				1	1		1	
Range	Open-loop, Closed-loop, Servo, Regen							0 to 599								
Update rate	Write on power-up															

When no Solutions Module is installed in the relevant slot this parameter is zero. When a module is installed this parameter displays the identification code.

303: SM-EZMotion

When parameters are saved by the user in the drive EEPROM the option code of the currently installed module is saved in EEPROM. If the drive is subsequently powered-up with a different module installed, or no module installed where a module was previously installed, the drive gives a Slot.dF trip. The menu for the relevant slot appears for the new module category with the default parameter values for the new category. The new parameters values are not stored in EEPROM until the user performs a parameter save.

x.02	**Solutions Module software version**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	
Range	Open-loop, Closed-loop, Servo, Regen							00.00 to 99.99								
Update rate	Write on power-up															

x.13	**EZOutput.1.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Output #1 on the SM-EZMotion module. A value of 1 indicates that the Output is active. A value of 0 indicates that the Output is inactive. This equates Pin # 6 on the EZMotion I/O Connector.

x.14	**EZOutput.2.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Output #2 on the SM-EZMotion module. A value of 1 indicates that the Output is active. A value of 0 indicates that the Output is inactive. This equates Pin # 7 on the EZMotion I/O Connector.

x.17	**EZInput.1.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Input #1 on the SM-EZMotion module. A value of 1 indicates that the Input is active. A value of 0 indicates that the Input is inactive. This equates Pin # 2 on the EZMotion I/O Connector.

x.18	**EZInput.2.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Input #2 on the SM-EZMotion module. A value of 1 indicates that the Input is active. A value of 0 indicates that the Input is inactive. This equates Pin # 3 on the EZMotion I/O Connector.

x.19	**EZInput.3.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Input #3 on the SM-EZMotion module. A value of 1 indicates that the Input is active. A value of 0 indicates that the Input is inactive. This equates Pin # 4 on the EZMotion I/O Connector.

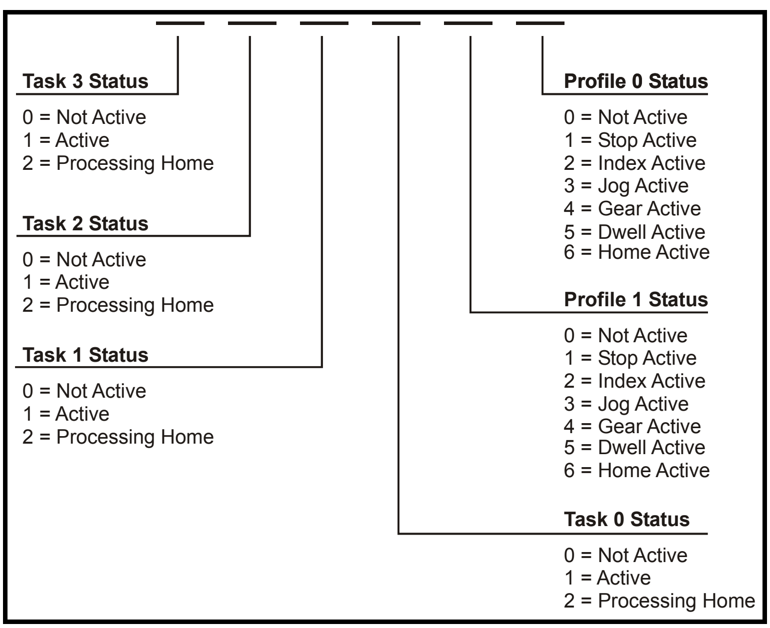
x.20	**EZInput.4.Status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

This parameter shows the status of digital Input #4 on the SM-EZMotion module. A value of 1 indicates that the Input is active. A value of 0 indicates that the Input is inactive. This equates Pin # 5 on the EZMotion I/O Connector.

x.48	**System status**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

The system status parameter is used to indicate the status of each of the user program tasks and motion profiles. This parameter can give the user some idea of what the SM-EZMotion module is commanding without being online using PowerTools Pro EZ.

There are six individual digits that indicate the status of different processes. This parameter will display a six digit number that can be used in conjunction with the graphic below to determine the status of each process. Leading zeros in the value are not displayed.



Examples:

Pr **x.48** = 11023 would signify that user programs are currently running on Task 2 and Task 1, and that a Index is running on Profile 1 while a Jog is running on Profile 0.

Pr **x.48** = 104 would signify that a user program is running on Task 0 and Gearing motion is running on Profile 0.

x.50	**Solutions Module error status**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop, Servo, Regen							0 to 255								
Update rate	Background write															

The error status is provided so that only one Solutions Module error trip is required for each Solutions Module slot. If an error occurs the reason for the error is written to this parameter and the drive may produce a SLx.Er trip, where x is the slot number. A value of zero indicates that the module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-36 on page 336 for the meaning of the values in this parameter). When the drive is reset this parameter is cleared for all Solutions Modules.

All modules include a temperature monitoring circuit. If the PCB temperature exceeds 90°C the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C the fan can operate normally again. If the PCB temperature exceeds 100°C the drive is tripped and the error status is set to 74.

x.51	**Solutions Module software sub-version**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, Closed-loop, Servo, Regen							0 to 99								
Update rate	Write on power-up															

Most Solutions Modules include a processor with software. The software version is displayed in these parameters in the form Pr **x.02** = xx.yy and Pr **x.50** = zz. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation. When a module is installed that does not contain software both these parameters appear as zero.

5.17.12 SM-SLM

The Solution Module checks for various errors as shown below.

Table 5-37 Solutions Module error status values

Error	Modes	Reason for error
0	Enc. Only, Host	No fault detected
1	Enc. Only, Host	SLM 24V power supply over-load
2	Enc. Only	SLM version too low
3	Enc. Only	Drive-Link error
4	Enc. Only, Host	Drive switching frequency incompatible (is not 4kHz, 8kHz or 16kHz)
5	Enc. Only, Host	Feedback selection (Pr **3.26**) is not the current Solutions Module
6	Enc. Only	Encoder error
7	Enc. Only	EEPROM motor object number of instances error
8	Enc. Only	EEPROM motor object list version error
9	Enc. Only	EEPROM performance object number of instances error
10	Enc. Only, Host	Option to drive parameter channel error
11	Enc. Only, Host	Drive operating mode incompatible (is not Closed loop or Servo)
12	Enc. Only	EEPROM writing error
13	Enc. Only	EEPROM motor type incorrect (Servo object with drive in Closed loop etc)
14	Enc. Only	EEPROM UniSP object error or does not exist.
15	Enc. Only	EEPROM encoder object CRC error
16	Enc. Only	EEPROM motor object CRC error
17	Enc. Only	EEPROM performance object CRC error
18	Enc. Only	EEPROM UniSP object CRC error
19	Enc. Only	Sequencer time-out
74	Enc. Only, Host	Solutions Module internal over temperature trip

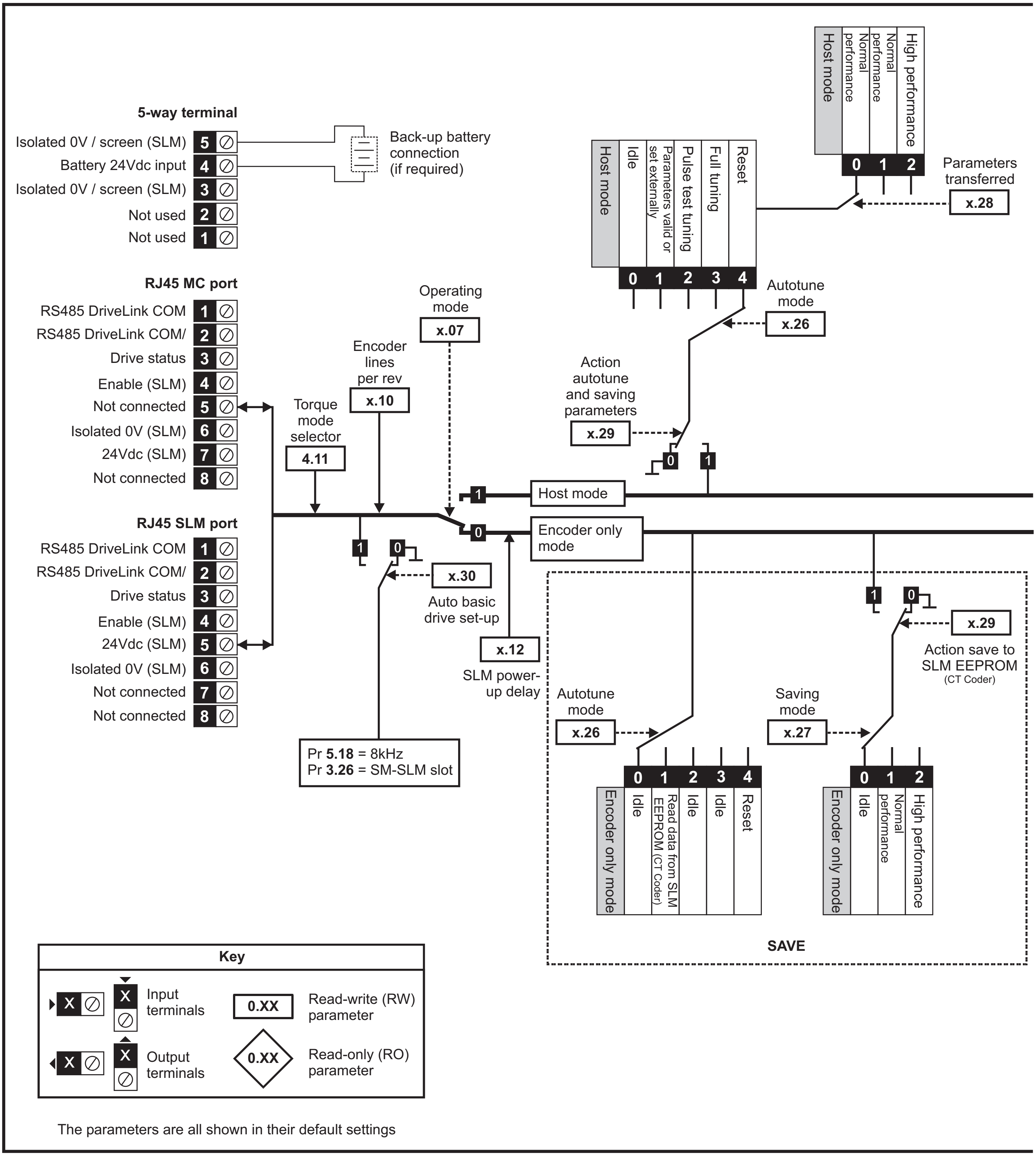
Menu 81 may be used to address the current user slot menu parameters of the slot that is addressed through the DriveLink comms port.

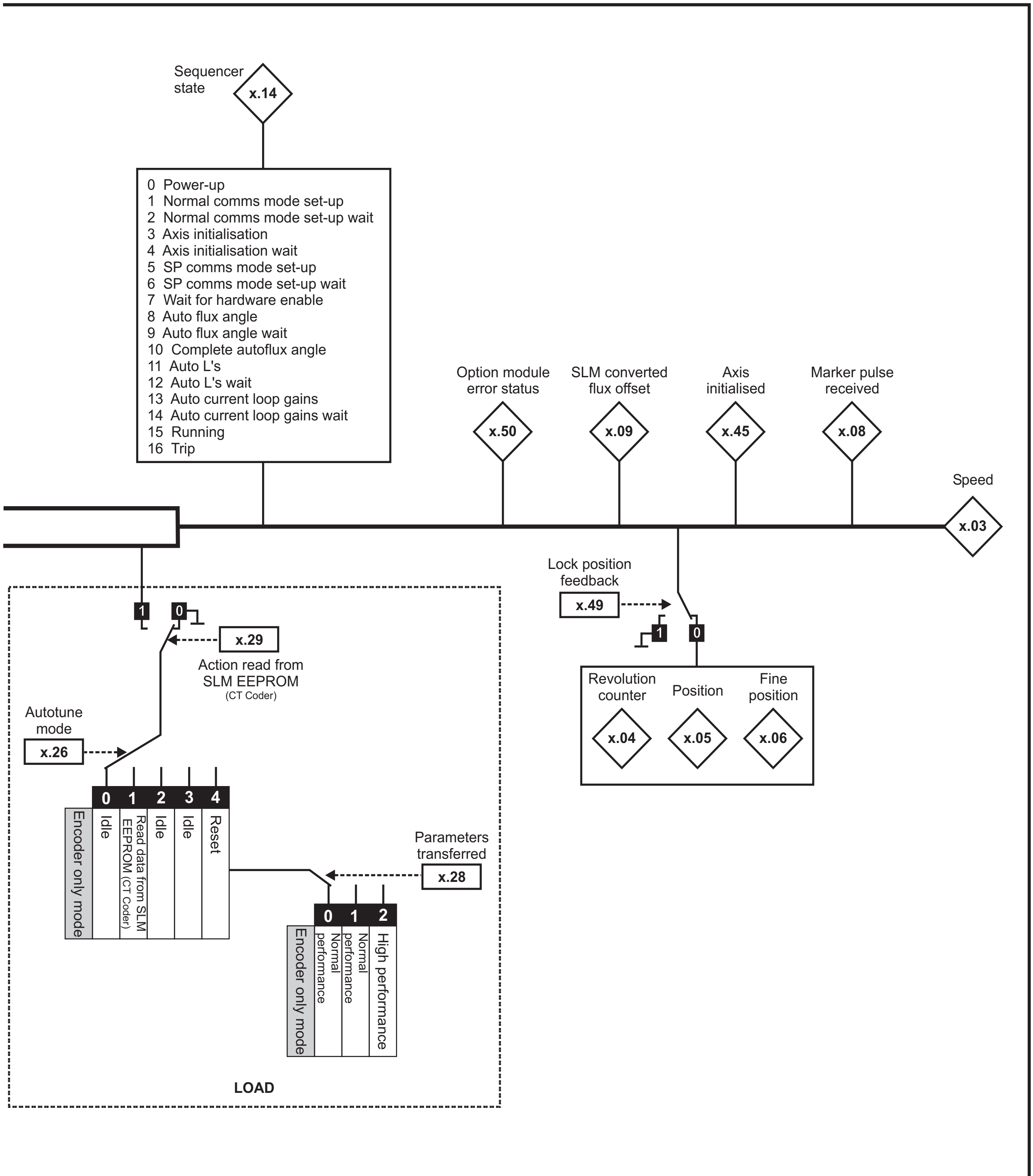
The mode naming conventions are:

The mode naming conventions are:

- Encoder only mode (**Enc.OnLy**) - uses the SLM module for position feedback and nameplate data only.
- External-host mode (**hoSt**) - uses an external position controller host and an SLM module for the speed loop control and position feedback.
- Standalone mode (**S.AlonE**) - uses the SLM module for position feedback, nameplate data and speed loop control.
- Fieldbus mode (**FiELd.bS**) - uses an external host for the speed demand only.

Figure 5-38 SM-SLM logic diagram




Sequencer state
x.14
0 Power-up
1 Normal comms mode set-up
2 Normal comms mode set-up wait
3 Axis initialisation
4 Axis initialisation wait
5 SP comms mode set-up
6 SP comms mode set-up wait
7 Wait for hardware enable
8 Auto flux angle
9 Auto flux angle wait
10 Complete autoflux angle
11 Auto L's
12 Auto L's wait
13 Auto current loop gains
14 Auto current loop gains wait
15 Running
16 Trip
Option module error status
x.50
SLM converted flux offset
x.09
Axis initialised
x.45
Marker pulse received
x.08
Speed
x.03
Lock position feedback
x.49
Revolution counter
x.04
Position
x.05
Fine position
x.06
x.29
Action read from SLM EEPROM
(CT Coder)
Autotune mode
x.26
Encoder only mode
Idle
Read data from SLM EEPROM (CT Coder)
Idle
Idle
Reset
Parameters transferred
x.28
Encoder only mode
Normal performance
Normal performance
High performance
LOAD

x.01	Solutions Module ID code								
RO	Uni					PT	US		
⇳	0 to 599			⇨	501				
Update rate: Write on power-up									

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category. When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

501: SM-SLM

The new parameters values are not stored in the drive EEPROM until the user performs a parameter save. When parameters are saved by the user in the drive EEPROM the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module installed where one was previously installed, the drive gives a SLx.dF or SLx.nf trip.

x.02	Solutions Module software version								
RO	Uni				NC	PT			
⇳	00.00 to 99.99			⇨					
Update rate: Write on power-up									

x.03	Speed								
RO	Bi	FI			NC	PT			
⇳	±40,000.0 rpm			⇨					
Drive modes: Host, Encoder only									
Update rate: 4ms write									

Provided the set-up parameters for the position feedback are correct this parameter shows the speed feedback in rpm. This parameter is filtered to increase readability.

x.04	Revolution counter								
RO	Uni	FI			NC	PT			
⇳	0 to 65535 revolutions			⇨					
Drive modes: Host, Encoder only									
Update rate: 4ms write									

x.05	Position								
RO	Uni	FI			NC	PT			
⇳	0 to 65535 (1/2^{16}ths of a revolution)			⇨					
Drive modes: Host, Encoder only									
Update rate: 4ms write									

x.06	Fine position								
RO	Uni	FI			NC	PT			
⇳	0 to 65535 (1/2^{32}nds of a revolution)			⇨					
Drive modes: Host, Encoder only									
Update rate: 4ms write									

These parameters effectively give the position with a resolution of 1/2^{32}ths of a revolution as a 48 bit number as shown below.

47 ... 32	31 ... 16	15 ... 0
Revolutions	Position	Fine position

When the feedback device rotates by more than one revolution, the revolutions in Pr **x.04** increment or decrement in the form of a sixteen bit roll-over counter.

The marker offset corrects this position.

x.07	Operating mode								
RW	Txt							US	
⇕	HoSt (0) to Enc.Only (1)			⇨	HoSt (0)				
Drive modes: Host, Encoder only									
Update rate: Background read									

This parameter defines the mode of operation of the drive:

0 - **HoSt**: Host mode (Torque amplifier only)

1 - **Enc.Only**: Encoder only mode

Host mode uses an external position controller host and an SM-SLM for the speed loop. The host controller will handle all SLM calculations for initialisation. The UniSP acts as torque amplifier similar in operation as the MultiAx drive.

Enc.Only mode uses the SLM module for speed feedback and nameplate data only.

x.08	Marker pulse, received indicator								
RO	Bit					NC			
⇕	OFF (0) or On (1)			⇨	OFF (0)				
Drive modes: Host, Encoder only									
Update rate: Background									

The encoder has a marker channel and this is used to correct the absolute position within a revolution after power-up. After passing through the marker this bit is set and the zero offset parameter is updated with the difference between zero of the encoder position and the marker. This error is due to the initial angle calculation using the single cycle SinCos. The power-up single cycle SinCos method has a maximum error of ±3°.

x.09	SLM converted flux offset								
RO	Uni								
⇕	0 to 65535			⇨	0				
Drive modes: Host, Encoder only									
Update rate: Background read									

This parameter converts the drive phase angle (Pr **3.25**) into an SLM EEPROM (CT Coder) nameplate flux offset value. The drive is the electrical angle offset in degrees. The SLM flux offset is the mechanical offset in 65535 places per revolution offset by 120°.

x.10	Encoder lines per revolution								
RW	Uni							US	
⇕	0 to 50000			⇨	1024				
Drive modes: Host, Encoder only									
Update rate: Background read									

This parameter is used to set the mask used on the fine position sent from the SLM module to the Solutions Module. 1024 lines results in 6 extra bits of fine position information being used. This takes the full position resolution to 22 bits. A 2046 line encoder uses 7 extra bits of fine position etc.

x.11	SLM software version								
RO	Uni					NC	PT		
⇕	.0.000 to 9.999			⇨	0.000				
Drive modes: Host, Encoder only									
Update rate: Background read									

Indicates the software version of the SLM module installed to the motor. This is SLM Pr **100** which needs to have been transferred if in HOST mode. The format is p.vvv where p is the page and vvv is the software version of the page.

x.12	SLM power-up delay								
RW	Txt							US	
⇕	0 to 5			⇨	1 (0.250 s)				
Drive modes: Encoder only									
Update rate: Background read									

This parameter specifies the time delay between the drive power-up and the SLM being available in 250ms units.

x.14	Sequencer status								
RO	ni					NC	PT		
⇳	0 to 16				⇨				
Drive modes: Host, Encoder only									
Update rate: Background write									

The sequencer status is used to determine in what state the start-up sequencer is. The states used depend on the option mode operating mode, the auto-tuning set-up and the load/save requests. The state can be useful in fault finding and for waiting for an operation to complete.

Sequencer State		Comments
0	Power-up	Start-up state
1	Normal mode comms set-up	Set-up of the normal SLM comms
2	Normal mode comms set-up wait	In Host mode wait for SLM to change to page 1
3	Axis initialisation	SLM normal axis initialisation transfers
4	Axis initialisation wait	Host mode, wait for SLM to get absolute position
5	SP mode comms set-up	Conversion to Unidrive SP type comms
6	SP mode comms set-up wait	Host mode, wait for SLM to change to page 2
7	Wait for hardware enable	Wait for the first initialised hardware enable
8	Auto flux angle	Start tuning the flux angle
9	Wait for auto flux angle	Wait for the tuning of the flux angle to finish
10	Complete auto flux angle	Complete the tuning of the flux angle
11	Auto Ls	Start tuning the stator transient inductance
12	Wait for auto Ls	Wait for stator transient inductance tuning to complete
13	Auto I gains	Calculate current controller gains (Pr **4.13**, Pr **4.14**)
14	Wait for I gains	Wait for the current controller gains to be set
15	Running	Axis HE, tuned and enabled
16	Trip	Axis fault condition

x.19	Feedback filter								
RW	Uni							US	
⇳	0 (0), 1 (1), 2 (2), 3 (4), 4 (8), 5 (16) ms				⇨	0 (0)			
Drive modes: Host, Encoder only									
Update rate: Background read									

A sliding window filter may be applied to the feedback. This is particularly useful in applications where the feedback is used to give speed feedback for the speed controller and where the load includes a high inertia, and so the speed controller gains are very high. Under these conditions, without a filter on the feedback, it is possible for the speed loop output to change constantly from one current limit to the other and lock the integral term of the speed controller.

x.26	Autotune mode								
RW	Uni							US	
⇳	0 to 4				⇨	0			
Drive modes: Host, Encoder only									
Update rate: Background									

Only read when Pr **x.29** *Action request* is set high.

Host mode:

0 - Idle: No tuning or set-up

1 - Parameters are valid or will be set externally
- SERVO - Flux angle and all other parameter known - run only the **current gains calculation**.
- CLOSED LOOP - All parameters known - run only the **current gains calculation**.

2 - Pulse test tuning
- SERVO - Only flux angle known - run the **pulse test** to tune the current controller.
- CLOSED LOOP - Only field controller parameters known - run the **pulse test** to tune the current controller.

3 - Full tuning
- SERVO - run the **minimal movement test** to find the flux angle and then run the **pulse test** to tune the current controller.
- CLOSED LOOP - run the **movement test (2/3 base speed)** to tune the field controller and then run the pulse test to tune the current controller.

4 - RESET the whole initialisation system including trigger SLM command 245 and 246.

NOTE

4 will hold the sequencer in reset.

Encoder only mode:
0 - Idle: No tuning or set-up

1 - Read information from the SLM EEPROM (CT Coder) and update the UniSP parameters

NOTE
The parameter set to use is determined by the value of *Parameters Transferred* (Pr **x.28**).

2 - Idle - no tuning or set-up

3 - Idle - no tuning or set-up

4 - RESET the whole initialisation system

NOTE
4 will hold the sequencer in reset.

x.27	Saving mode								
RW	Uni							US	
⇕	0 to 2			⇨	0				
Drive modes: Host, Encoder only									
Update rate: Background									

Only read when Pr **x.29** *Action request* is set high. Only effective in Encoder only mode.

0 - IDLE
1 - Parameters updated in the SLM EEPROM (CT Coder) for normal performance
2 - Parameters updated in the SLM EEPROM (CT Coder) for high performance

Servo motors:
Pr **x.27** = 1:
- Rated motor current Pr **5.07** (in 10^{th} Amp units)
- Rated motor base speed Pr **5.08** (in rpm)
- Number of poles Pr **5.11**
- Flux angle Pr **3.25**

NOTE
Pr **3.25** is in electrical degrees. SLM EEPROM (CT Coder) data is in mechanical (65536 per rev) offset by +120°.

Pr **x.27** = 2:
All for Pr **x.27** = 1 and -
- Rated motor voltage Pr **5.09**
- Stator resistance Pr **5.17** (per phase in 0.000) (delta (4/3 times per phase) in 0.00)
- Stator transient inductance Pr **5.24** (per phase in 0.000) (delta (4/3 times per phase) in 0.00)
- Current controller Kp gain Pr **4.13**
- Current controller Ki gain Pr **4.14**

Induction motors:
Pr **x.27** = 1:
- Rated motor current Pr **5.07** (in 10th Amp units)
- Rated motor base speed Pr **5.08** (in rpm)
- Rated motor frequency Pr **5.06**
- Rated motor voltage Pr **5.09**
- Stator resistance Pr **5.17** (per phase in 0.000) (delta (4/3 times per phase) in 0.00)
- Stator transient inductance Pr **5.24** (per phase in 0.000) (delta (4/3 times per phase) in 0.00)
- Current controller Kp gain Pr **4.13**
- Current controller Ki gain Pr **4.14**
- Power factor Pr **5.10**

Pr **x.27** = 2:
All for Pr **x.27** = 1 (except Pr **5.10**) and -
- L_s value Pr **5.25** (per phase in 0.00) (limit 655.35mH) (per phase in 0.00)
- Motor saturation point 1 Pr **5.29**
- Motor saturation point 2 Pr **5.30**

NOTE
In Encoder only mode, a parameter save cannot be performed with the drive in either RUN or STOP.

x.28	Parameters transferred							
RW	Uni						US	
⇳	0 to 2			⇨	0			
Drive modes: Host, Encoder only								
Update rate: Background								

Host mode:
0 - NONE: No motor parameters have been sent to the UniSP
1 - MIN: Minimal parameters have been transferred so normal performance is possible
2 - FULL: All parameters have been transferred so high performance is possible

NOTE
The EEPROM CRC check performed by the host is listened to by the SM-SLM which stores parameters ready to transfer to the drive. When Pr **x.28** is written to by the host, the appropriate stored EEPROM data is written to the drive parameters. If the host does not wish to use this function, nothing or 0 should be written to Pr **x.28**.

Encoder only mode:
If Autotune mode is equal to one:

0 - MIN: Minimal parameters to be transferred so normal performance is possible
1 - MIN: Minimal parameters to be transferred so normal performance is possible
2 - FULL: All parameters to be transferred so high performance is possible

When loading using Pr **x.26** = 1, the parameter set loaded on power-up or restart depends on Pr **x.28**.

The parameter set is the same as was controlled by Pr **x.27** when saving was performed.

NOTE
In Encoder only mode, a parameter transfer cannot be performed with the drive in either RUN or STOP.

x.29	Action the tuning and saving parameters							
RW	Txt						US	
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Drive modes: Host, Encoder only								
Update rate: Background								

Values of Pr **x.26**, Pr **x.27** and Pr **x.28** are read when Pr **x.29** = 1. The sequencer is reset to POWER_UP. Pr **x.29** is reset to 0 after the update - which is very fast.

x.30	Automatic basic drive set-up request							
RW	Uni						US	
⇳	0 to 1			⇨	0			
Drive modes: Host, Encoder only								
Update rate: Background								

Sets Pr **3.26** to the slot with the SLM module in it as primary feedback.

Pr **5.18** to 8kHz switching frequency.

These are the only drive parameters that require setting when the drive has been defaulted.

NOTE
The user must set Pr **3.40** and Pr **7.15** appropriately.

This parameter is reset to zero by the Solutions Module on completion.

x.45	Axis initialised							
RO	Txt					PT		
⇳	OFF (0) or On (1)			⇨	OFF (0)			
Drive modes: Host, Encoder only								
Update rate: Background								

Indicates that the axis has been correctly initialized and is ready to run.
- Encoder only mode: Axis initialised active from sequencer status
- Host mode: Axis initialised active from sequencer plus external motion controller

x.49	Lock position feedback								
RW	Bit								
⇳			⇨						
Drive modes: Host, Encoder only									
Update rate: Combined update time. SM-SLM adds 4ms to the combined update time									

If Pr **x.49** is set to 1, Pr **x.04**, Pr **x.05** and Pr **x.06** are not updated. If this parameter is set to 0 Pr **x.04**, Pr **x.05** and Pr **x.06** are updated normally.

x.50	Solutions Module error status								
RO	Uni					NC	PT		
⇳	0 to 255		⇨						
Update rate: Background write									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce a 'SLx.Er' trip, where x is the slot number. A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-37 on page 342) for the meaning of the values in this parameter). When the drive is reset, this parameter is cleared for the relevant Solutions Module.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 94°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 94°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive will trip and the error status is set to 74.

x.51	Solutions Module software sub-version								
RO	Uni					NC	PT		
⇳	0 to 99		⇨						
Update rate: Write on power-up									

The SM-SLM includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz.

Where:

- xx specifies a change that affects hardware compatibility
- yy specifies a change that affects product documentation
- zz specifies a change that does not affect the product documentation

When a Solutions Module is installed that does not contain software, both Pr **x.02** and Pr **x.51** appear as zero.

5.17.13 Fieldbus module category parameters

Table 5-39 Solutions Module error status values for Fieldbus modules

Error code	Module	Trip Description
0	All	No trip
1	SM-Ether CAT	No field bus mode has been selected
2	SM-Ether CAT	Critical task over-run
52	SM-PROFIBUS-DP, SM-Interbus, SM-DeviceNet, SM-CANOpen	User control word trip
58	SM-LON	Incorrect non-volatile storage
61	SM-PROFIBUS-DP, SM-Interbus, SM-DeviceNet, SM-CANOpen, SM-SERCOS	Configuration error
62	SM-Ether CAT	Database initialisation error
63	SM-Ether CAT	File system initialisation error
64	SM-DeviceNet	Expected packet rate timeout
65	SM-PROFIBUS-DP, SM-Interbus, SM-DeviceNet, SM-CANOpen, SM-SERCOS	Network loss
66	SM-PROFIBUS-DP	Critical link failure
	SM-CAN, SM-DeviceNet, SM-CANOpen	Bus off error
69	SM-CAN	No acknowledgement
70	All (except SM-Ethernet, SM-Ether CAT)	Flash transfer error
	SM-Ethernet	No valid menu data available for the module from the drive
74	All	Solutions module over temperature
75	SM-Ethernet, SM-Ether CAT	The drive is not responding
76	SM-Ethernet, SM-Ether CAT	The Modbus connection has timed out
80	All (except SM-SERCOS)	Inter-option communications error
81	All (except SM-SERCOS)	Communications error to slot 1
82	All (except SM-SERCOS)	Communications error to slot 2
83	All (except SM-SERCOS)	Communications error to slot 3
84	SM-Ethernet, SM-Ether CAT	Memory allocation error
85	SM-Ethernet, SM-Ether CAT	File system error
86	SM-Ethernet, SM-Ether CAT	Configuration file error
87	SM-Ethernet, SM-Ether CAT	Language file error
98	All	Internal watchdog error
99	All	Internal software error

Below are the parameters that are common to all Fieldbus category modules. For more information, refer to the specific *Fieldbus Module User Guide*.

x.01	Solutions Module ID code								
RO	Uni						PT	US	
⇳	0 to 599				⇨				
Update rate: Write on power-up									

The menu for the relevant slot appears for the new Solutions Module category with the default parameter values for the new category.

When no Solutions Module is installed in the relevant slot this parameter is zero. When a Solutions Module is installed this parameter displays the identification code.

401: SM-LON
403: SM-PROFIBUS DP
404: SM-INTERBUS
406: SM-CAN
407: SM-DeviceNet
408: SM-CANOpen
409: SM-SERCOS
410: SM-Ethernet
421: SM-Ethernet CAT

The new parameter values are not stored in the drive EEPROM until the user performs a parameter save by setting Pr xx.00 to 1000 and pressing the stop/reset button. When parameters are saved by the user in the drive EEPROM, the option code of the currently installed Solutions Module is saved in the drive EEPROM. If the drive is subsequently powered-up with a different Solutions Module installed, or no Solutions Module is installed when one was previously installed, the drive will trip on SLx.dF or SLx.nF.

x.02	**Solutions Module software version**								
RO	Uni					NC	PT		
⇕	00.00 to 99.99				⇨				
Update rate: Write on power-up									

This parameter shows the version of software programmed into the Solutions Module. The software sub version is displayed in Pr **x.51**.

These two parameters display the software version in the form of xx.yy.zz, where:

Pr **x.02** = xx.yy

Pr **x.51** = zz

x.50	**Solutions Module error status**								
RO	Uni					NC	PT		
⇕	0 to 255				⇨				
Update rate: Background write									

The error status is provided so that only one option error trip is required for each Solutions Module slot. If an error occurs, the reason for the error is written to this parameter and the drive may produce an 'SLx.Er' trip (where x is the slot number). A value of zero indicates that the Solutions Module has not detected an error, a non-zero value indicates that an error has been detected. (See Table 5-39 on page 352 for the meaning of the values in this parameter for Fieldbus category modules). When the drive is reset, this parameter is cleared.

This Solutions Module includes a temperature monitoring circuit. If the PCB temperature exceeds 90°C, the drive fan is forced to operate at full speed (for a minimum of 10s). If the temperature falls below 90°C, the fan can operate normally again. If the PCB temperature exceeds 100°C, the drive will trip on SLx.Er, and the error status is set to 74.

x.51	**Solutions Module software sub-version**								
RO	Uni					NC	PT		
⇕	0 to 99				⇨				
Update rate: Write on power-up									

The Solutions Module includes a processor with software. The software version is displayed in Pr **x.02** and Pr **x.51** in the form Pr **x.02** = xx.yy and Pr **x.51** = zz.

Where:

xx specifies a change that affects hardware compatibility

yy specifies a change that affects product documentation

zz specifies a change that does not affect the product documentation

When a Solutions Module is installed that does not contain software, both Pr **x.02** and Pr **x.51** appear as zero.

5.18 Menu 18: Application menu 1

Menu 18 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu can be saved in the drive.

18.01	Application menu 1 power-down saved integer															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

18.02 to 18.10	Application menu 1 read-only integer															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

18.11 to 18.30	Application menu 1 read-write integer															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

18.31 to 18.50	Application menu 1 read-write bit															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

5.19 Menu 19: Application menu 2

Menu 19 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu can be saved in the drive.

19.01	**Application menu 2 power-down saved integer**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

19.02 to 19.10	**Application menu 2 read-only integer**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

19.11 to 19.30	**Application menu 2 read-write integer**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen	-32,768 to 32,767														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

19.31 to 19.50	**Application menu 2 read-write bit**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	N/A															

5.20 Menu 20: Application menu 3

Menu 20 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu cannot be saved in the drive.

20.01 to 20.20	Application menu 3 read-write integer															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1*				1		
Range	Open-loop, Closed-loop vector, Servo, Regen								-32,768 to 32,767							
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	N/A															

20.21 to 20.40	Application menu 3 read-write long integer															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1*				1		
Range	Open-loop, Closed-loop vector, Servo, Regen								-2^{31} to $2^{31}-1$							
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	N/A															

*Menu 20 parameters are non-clonable and cannot be saved in a full parameter type data block or difference from default data block on a SMART card with software versions before V01.07.00. However, with V01.07.00 onwards these parameters are saved in a difference from defaults type data block if they are not at their default value.

5.21 Menu 21: Second motor parameters

The following parameters are used instead of the normal motor set-up parameters when Pr **11.45** = 1.

When the alternative parameter set is being used by the drive the decimal point after the right hand digit in the 1st row is on.

For more information about a particular parameter, see the equivalent normal motor map 1 parameter.

21.01	**Maximum reference clamp**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	Closed-loop vector, Servo = VM															
Range	Open-loop Closed-loop vector, Servo								0 to 3,000.0Hz SPEED_LIMIT_MAX rpm							
Default	Open-loop Closed-loop vector Servo								EUR: 50.0, USA: 60.0 EUR: 1,500.0, USA: 1,800.0 3,000.0							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **1.06**							
Update rate	Background read															

21.02	**Minimum reference clamp**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1					1	1	1		
	Closed-loop vector and Servo = VM															
Range	Open-loop Closed-loop vector and Servo								±3,000.0 Hz * ±SPEED_LIMIT_MAX rpm							
Default	Open-loop, Closed-loop vector, Servo								0.0							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **1.07**							
Update rate	Background read															

* The range shown for Pr **1.07** shows the range used for scaling purposes (i.e. for routing to an analog output etc). Further range restrictions are applied as given below.

01.08 (Neg min ref enable)	**01.10 (Bipolar mode enable)**	**Open-loop**	**Closed-loop vector and Servo**
0	0	0 to 01.06	0 to 21.01
0	1	0	0
1	0	-3000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm
1	1	-3000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm

21.03	**Reference selector**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo								0 to 5							
Default	Open-loop, Closed-loop vector, Servo								0 (A1.A2)							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **1.14**							
Update rate	4ms read															

Unlike the motor 1 (Pr **1.14**) this parameter is not used for T28 and T29 digital input auto-selection (see Pr **8.39** on page 169).

Pr **21.03** defines how the value of Pr **1.49** is derived as follows:

Value of Pr 21.03	Display String	Pr 1.49
0	A1.A2	*Selected by terminal input
1	A1.Pr	1
2	A2.Pr	2
3	Pr	3
4	Pad	4
5	Prc	5

*The bit Pr **1.41** to Pr **1.44** can be controlled to force the value of Pr **1.49**:

all bits equal to zero gives 1,

Pr **1.41** = 1 then Pr **1.49** = 2
Pr **1.42** = 1 then Pr **1.49** = 3
Pr **1.43** = 1 then Pr **1.49** = 4
Pr **1.44** = 1 then Pr **1.49** = 5

The bit parameters with lower numbers have priority over those with higher numbers.

Pr **1.49** and Pr **1.50** then define the reference as follows:

Pr 1.49	Pr 1.50	Reference
1	1	Analog reference 1
1	>1	Preset defined by Pr **1.50**
2	1	Analog reference 2
2	>1	Preset defined by Pr **1.50**
3	x	Preset defined by Pr **1.50**
4	x	Keypad reference
5	x	Precision reference

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**, have no effect and jog is disabled.

Reference selected by timer
The presets are selected automatically in turn. Pr **1.16** defines the time between each change.

<table>
<tr><th>21.04</th><th colspan="16">Acceleration rate</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="3">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td colspan="16">Closed-loop vector, Servo DP = 3</td></tr>
<tr><td>Range</td><td colspan="8">Open-loop
Closed-loop vector, Servo</td><td colspan="8">0.0 to 3200.0 s/100Hz
0.000 to 3200.000 s/1000rpm</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop
Closed-loop vector
Servo</td><td colspan="8">5.0
2.000
0.200</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">Pr 2.11</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

21.05	**Deceleration rate**	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	(see coding table below)	
Range	Open-loop Closed-loop vector and Servo	0.0 to 3200.0 s/100Hz 0.000 to 3200.000 s/1000rpm
Default	Open-loop Closed-loop vector Servo	10.0 2.000 0.200
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **2.21**
Update rate	Background read	

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

Closed-loop vector, Servo DP = 3

21.06	**Rated frequency**	
Drive modes	Open-loop, Closed-loop vector	
Coding	(see coding table below)	
Range	Open-loop Closed-loop vector	0 to 3000.0 Hz 0 to 1250.0 Hz
Default	Open-loop, Closed-loop vector	EUR: 50.0, USA: 60.0
Normal parameter	Open-loop, Closed-loop vector	Pr **5.06**
Update rate	Background read	

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

21.07	**Rated current**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Coding	(see coding table below)	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to RATED_CURRENT_MAX A
Default	Open-loop, Closed-loop vector, Servo, Regen	max heavy duty current (Pr **11.32**)
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.07**
Update rate	Background read	

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1	2		1				1	1	1	

21.08	**Rated load rpm**	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	(see coding table below)	
Range	Open-loop, Closed-loop vector, Servo	0 to 180,000 rpm 0.00 to 40,000.00 rpm
Default	Open-loop, Closed-loop vector Servo	1500 1450.00 3000.00
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.08**
Update rate	Background read	

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

Closed-loop vector DP=2

21.09	**Rated voltage**	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	see coding table below	
Range	Open-loop, Closed-loop vector, Servo	0 to AC_VOLTAGE_SET_MAX V
Default	Open-loop, Closed-loop vector, Servo	200V rating drive: 230V 400V rating drive: EUR: 400V, USA: 460V 575V rating drive: 575V 690V rating drive: 690V
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.09**
Update rate	Level 4 read	

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

21.10	**Rated power factor**	
Drive modes	Open-loop, Closed-loop vector	
Coding	see coding table below	
Range	Open-loop, Closed-loop vector	0.000 to 1.000
Default	Open-loop, Closed-loop vector	0.850
Normal parameter	Open-loop, Closed-loop vector	Pr **5.10**
Update rate	Background read	

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						3		1				1	1	1	

21.11	**Number of motor poles**	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	see coding table below	
Range	Open-loop, Closed-loop vector, Servo	0 to 60 (Auto to 120 POLE)
Default	Open-loop, Closed-loop vector Servo	0 (Auto) 3 (6 POLE)
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.11**
Update rate	Background read	

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

21.12	**Stator resistance**	
Drive modes	Open-loop, Closed-loop vector, Servo	
Coding	see coding table below	
Range	Open-loop, Closed-loop vector, Servo	0.000 to 65.000
Default	Open-loop, Closed-loop vector, Servo	0.000
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.17**
Update rate	Background read	

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						3		1				1	1	1	

Pr **21.12** shows the stator resistance of the motor. The units vary with the drive size to ensure that the full range of likely resistances can be represented with suitable resolution. The table below shows the units. Therefore 1.000 in the parameter represents the resistance shown in the units column.S

Drive size	**Units** Ω
SP0xxx	10.0
SP1xxx to SP5xxx	1.0
SP6xxx to SP9xxx and SPMxxxxx	0.01

<table>
<tr><th>21.13</th><th colspan="16">Voltage offset</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop</td><td colspan="8">0.0 to 25.0 V</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop</td><td colspan="8">0.0</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Open-loop</td><td colspan="8">Pr 5.23</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

<table>
<tr><th>21.14</th><th colspan="16">Transient inductance (σL_s)</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>3</td><td></td><td>1</td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0.000 to 500.000 mH</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0.000</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">Pr 5.24</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

<table>
<tr><th>21.15</th><th colspan="16">Motor 2 active</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Default</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">1</td></tr>
<tr><td>Normal motor parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">Pr 21.15</td></tr>
<tr><td>Update rate</td><td colspan="16">Background write</td></tr>
</table>

Pr **21.15** does not have an equivalent normal motor parameter, but shows when motor 2 is active.

<table>
<tr><th>21.16</th><th colspan="16">Thermal time constant</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo, Regen</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">0.0 to 3000.0</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop,
Closed-loop vector,
Servo
Regen</td><td colspan="8">89.0

20.0
89.0</td></tr>
<tr><td>Normal motor parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">Pr 4.15</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

21.17	**Speed controller Kp gain**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							4						1	1	1	
Range	Closed-loop vector, Servo							0.00 to 6.5535 (1/rad s^{-1})								
Default	Closed-loop vector, Servo							0.0300 0.0100								
Normal motor parameter	Closed-loop vector, Servo							Pr **3.10**								
Update rate	Background read															

21.18	**Speed controller Ki gain**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Closed-loop vector, Servo							0.00 to 655.35 s/rad s^{-1}								
Default	Closed-loop vector, Servo							0.10 1.00								
Normal motor parameter	Closed-loop vector, Servo							Pr **3.11**								
Update rate	Background read															

21.19	**Speed controller Kd gain**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5						1	1	1	
Range	Closed-loop vector, Servo							0.00000 to 0.65535 s^{-1} / rad s^{-1}								
Default	Closed-loop vector, Servo							0.00000								
Normal motor parameter	Closed-loop vector, Servo							Pr **3.12**								
Update rate	Background read															

When the second motor is selected the gains defined in Pr **21.17** to Pr **21.19** are used directly by the speed controller. The speed controller set-up method defined by Pr **3.13** is ignored.

21.20	**Encoder phase angle**															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1					1	1	1	
Range	Servo							0.0 to 359.9 ° electrical								
Default	Servo							0.0								
Normal motor parameter	Servo							Pr **3.25**								
Update rate	Background read															

21.21	Speed feedback selector															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Closed-loop vector, Servo							0 to 3								
Default	Closed-loop vector, Servo							0								
Normal motor parameter	Closed-loop vector, Servo							Pr **3.26**								
Update rate	Background read															

0, drv: Drive encoder

The position feedback from the encoder connected to the drive itself is used to derive the speed feedback for the speed controller and to calculate the motor rotor flux position.

1, Slot1: Solutions Module in slot 1

The position feedback from the Solutions Module in Solutions Module slot 1 is used to derive the speed feedback for the speed controller and to calculate the motor rotor flux position. If a position feedback category Solutions Module is not installed in slot 1 the drive produces an EnC9 trip.

2, Slot2: Solutions Module in slot 2

3, Slot3: Solutions Module in slot 3

21.22	Current controller Kp gain															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 30,000								
Default	Drive voltage rating: Open-loop, Closed-loop vector, Servo Regen							200V 400V 575V 690V 20 20 20 20 75 150 180 215 45 90 110 130								
Normal parameter	Open-loop, Closed-loop vector, Servo, Regen							Pr **4.13**								
Update rate	Background read															

21.23	Current controller Ki gain															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 30,000								
Default	Drive voltage rating: Open-loop, Closed-loop vector, Servo, Regen							200V 400V 575V 690V 40 40 40 40 1,000 2,000 2,400 3,000								
Normal parameter	Open-loop, Closed-loop vector, Servo, Regen							Pr **4.14**								
Update rate	Background read															

21.24	Stator inductance (L_s)															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2		1				1	1	1	
Range	Closed-loop vector							0.00 to 5,000.00 mH								
Default	Closed-loop vector							0.00								
Normal parameter	Closed-loop vector							Pr **5.25**								
Update rate	Background read															

<table>
<tr><th>21.25</th><th colspan="16">Motor saturation breakpoint 1</th></tr>
<tr><td>Drive modes</td><td colspan="16">Closed-loop vector</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Closed-loop vector</td><td colspan="8">0 to 100% of rated flux</td></tr>
<tr><td>Default</td><td colspan="8">Closed-loop vector</td><td colspan="8">50</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Closed-loop vector</td><td colspan="8">Pr 5.29</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

<table>
<tr><th>21.26</th><th colspan="16">Motor saturation breakpoint 2</th></tr>
<tr><td>Drive modes</td><td colspan="16">Closed-loop vector</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Closed-loop vector</td><td colspan="8">0 to 100% of rated flux</td></tr>
<tr><td>Default</td><td colspan="8">Closed-loop vector</td><td colspan="8">75</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Closed-loop vector</td><td colspan="8">Pr 5.30</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

<table>
<tr><th>21.27</th><th colspan="16">Motoring current limit</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo, Regen</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">0 to MOTOR2_CURRENT_LIMIT_MAX %</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop
Closed-loop vector, Servo, Regen</td><td colspan="8">165.0*
175.0*</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">Pr 4.05</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

<table>
<tr><th>21.28</th><th colspan="16">Regen current limit</th></tr>
<tr><td>Drive modes</td><td colspan="16">Open-loop, Closed-loop vector, Servo, Regen</td></tr>
<tr><td rowspan="2">Coding</td><td>Bit</td><td>SP</td><td>FI</td><td>DE</td><td>Txt</td><td>VM</td><td>DP</td><td>ND</td><td>RA</td><td>NC</td><td>NV</td><td>PT</td><td>US</td><td>RW</td><td>BU</td><td>PS</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td>1</td><td>1</td><td>1</td><td></td></tr>
<tr><td>Range</td><td colspan="8">Open-loop, Closed-loop vector, Servo</td><td colspan="8">0 to MOTOR2_CURRENT_LIMIT_MAX %</td></tr>
<tr><td>Default</td><td colspan="8">Open-loop
Closed-loop vector, Servo, Regen</td><td colspan="8">165.0*
175.0*</td></tr>
<tr><td>Normal parameter</td><td colspan="8">Open-loop, Closed-loop vector, Servo, Regen</td><td colspan="8">Pr 4.06</td></tr>
<tr><td>Update rate</td><td colspan="16">Background read</td></tr>
</table>

21.29	**Symmetrical current limit**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to MOTOR2_CURRENT_LIMIT_MAX %
Default	Open-loop Closed-loop vector, Servo, Regen	165.0* 175.0*
Normal parameter	Open-loop, Closed-loop vector, Servo, Regen	Pr **4.07**
Update rate	Background read	

Coding

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

*These are the maximum default values. If the variable maximum of this parameter (MOTOR2_CURRENT_LIMIT_MAX) gives a lower value with the default value of Motor rated current (Pr **21.07**) the default of this parameter is at the lower value.

21.30	**Motor volts per 1000rpm (Ke)**	
Drive modes	Servo	
Range	Servo	0 to 10,000
Default	Servo	98
Normal parameter	Servo	Pr **5.33**
Update rate	Background read	

Coding

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

21.31	**Motor pole pitch**	
Drive modes	Open-loop, Closed-loop vector, Servo, Regen	
Range	Open-loop, Closed-loop vector, Servo	0 to 655.35mm
Default	Open-loop, Closed-loop vector, Servo	0.00mm
Normal parameter	Open-loop, Closed-loop vector, Servo	Pr **5.36**
Update rate	Background read	

Coding

Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						2						1	1	1	

5.22 Menu 22: Additional menu 0 set-up

Menu 22 contains parameters that are used to set up the source parameters for menu 0 in addition to those that are set up from within Menu 11.

22.01 to 22.07 22.10 to 22.11 22.18 22.20 to 22.29	**Parameter 00.xy set-up**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								Pr **1.00** to Pr **21.51**							
Default	Open-loop, Closed-loop vector, Servo, Regen								See Table 5-40							
Update rate	Background read															

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

Table 5-40 Menu 22 default settings

Parameter	Menu 0 parameter	Open-loop	Closed-loop vector	Servo	Regen
Pr **22.01**	Pr **031**	Pr **11.33**			
Pr **22.02**	Pr **0.32**	Pr **11.32**			
Pr **22.03**	Pr **0.33**	Pr **6.09**	Pr **5.16**	Pr **0.00**	
Pr **22.04**	Pr **0.34**	Pr **11.30**			
Pr **22.05**	Pr **0.35**	Pr **11.24**			
Pr **22.06**	Pr **0.36**	Pr **11.25**			
Pr **22.07**	Pr **0.37**	Pr **11.23**			
Pr **22.10**	Pr **0.40**	Pr **5.12**			Pr **0.00**
Pr **22.11**	Pr **0.41**	Pr **5.18**			
Pr **22.18**	Pr **0.48**	Pr **11.31**			
Pr **22.20**	Pr **0.50**	Pr **11.29**			
Pr **22.21**	Pr **0.51**	Pr **0.00**			
Pr **22.22**	Pr **0.52**	Pr **0.00**			
Pr **22.23**	Pr **0.53**	Pr **0.00**			
Pr **22.24**	Pr **0.54**	Pr **0.00**			
Pr **22.25**	Pr **0.55**	Pr **0.00**			
Pr **22.26**	Pr **0.56**	Pr **0.00**			
Pr **22.27**	Pr **0.57**	Pr **0.00**			
Pr **22.28**	Pr **0.58**	Pr **0.00**			
Pr **22.29**	Pr **0.59**	Pr **0.00**			

It should be noted that if the parameter values saved in the drive EEPROM or on a SMARTCARD are all zero for menu 22 the drive will automatically load defaults for this menu when the drive is powered up or the parameters are transferred from the SMARTCARD. This ensures that defaults are used for this menu if the saved parameters are from a software version which did not include this menu.

5.23 32 bit parameters

All parameters in the drive are 1 bit, 16 bit or 32 bit. This section identifies all the 32 bit parameters in the drive and Solution Modules.

5.23.1 Drive parameters

The table below contains all the 32 bit parameters present in the drive for all four modes of operation (open loop, closed loop vector, servo and regen).

Table 5-41 32 bit drive parameters

Menu	32-bit parameters							
Menu 1	Pr **1.01**	Pr **1.02**	Pr **1.03**	Pr **1.04**	Pr **1.06**	Pr **1.07**	Pr **1.17**	Pr **1.18**
	Pr **1.21**	Pr **1.22**	Pr **1.23**	Pr **1.24**	Pr **1.25**	Pr **1.26**	Pr **1.27**	Pr **1.28**
	Pr **1.36**	Pr **1.37**	Pr **1.39**					
Menu 2	Pr **2.01**	Pr **2.07**	Pr **2.11**	Pr **2.12**	Pr **2.13**	Pr **2.14**	Pr **2.15**	Pr **2.16**
	Pr **2.17**	Pr **2.18**	Pr **2.19**	Pr **2.21**	Pr **2.22**	Pr **2.23**	Pr **2.24**	Pr **2.25**
	Pr **2.26**	Pr **2.27**	Pr **2.28**	Pr **2.29**				
Menu 3	Pr **3.01**	Pr **3.02**	Pr **3.03**	Pr **3.10**	Pr **3.18**	Pr **3.22**	Pr **3.27**	
Menu 4	Pr **4.01**	Pr **4.02**	Pr **4.08**	Pr **4.17**				
Menu 5	Pr **5.01**	Pr **5.03**	Pr **5.04**	Pr **5.07**	Pr **5.08**	Pr **5.24**	Pr **5.25**	
Menu 11	Pr **11.32**							
Menu 20	Pr **20.21**	Pr **20.22**	Pr **20.23**	Pr **20.24**	Pr **20.25**	Pr **20.26**	Pr **20.27**	Pr **20.28**
	Pr **20.29**	Pr **20.30**	Pr **20.31**	Pr **20.32**	Pr **20.33**	Pr **20.34**	Pr **20.35**	Pr **20.36**
	Pr **20.37**	Pr **20.38**	Pr **20.39**	Pr **20.40**				
Menu 21	Pr **21.01**	Pr **21.02**	Pr **21.04**	Pr **21.05**	Pr **21.07**	Pr **21.08**	Pr **21.14**	Pr **21.24**

Some of the parameters listed above are only 32 bit parameters in certain modes. Below is a table listing these parameters and the modes in which they are 32 bit parameters.

Parameter	Modes in which the parameter is 32 bit
Pr **3.01**	Closed Loop Vector and Servo
Pr **3.03**	Closed Loop Vector and Servo
Pr **3.10**	Regen
Pr **3.18**	Closed Loop Vector and Servo
Pr **4.08**	Open Loop, Closed Loop Vector and Servo

5.23.2 Solutions module parameters

Some Solutions Modules contain 32 bit parameters. Below is a table listing these parameters and the modules in which they are 32 bit parameters

Table 5-42 32 bit Solution Module parameters

Parameter	Solutions modules in which the parameter is 32 bit
Pr **x.03**	SM-Universal Encoder Plus, SM-Resolver, SM-Encoder Plus, SM-SLM
Pr **x.20**	SM-Universal Encoder Plus
Pr **x.35**	All Fieldbus modules
Pr **x.48**	SM-Applications Plus, SM-Applications, SM-Applications Lite, SM-Applications Lite V2

The SM-Applications and SM-Applications Lite modules contain their own parameter database. Some of the parameters within these modules are 32 bit, and are listed in the table below.

Table 5-43 32 bit SM-Applications Plus, SM-Applications and SM-Applications Lite, and SM-Applications Lite V2 parameters

Menu	32-bit parameters							
Menu 70 to Menu 75	Pr **70.00** to Pr **70.99**	Pr **71.00** to Pr **71.99**	Pr **72.00** to Pr **72.99**	Pr **73.00** to Pr **73.99**	Pr **74.00** to Pr **74.99**	Pr **75.00** to Pr **75.99**		
Menu 90	Pr **90.01**	Pr **90.03**	Pr **90.19**	Pr **90.25**	Pr **90.29**	Pr **90.31**	Pr **90.32**	Pr **90.33**
	Pr **90.34**	Pr **90.35**	Pr **90.37**	Pr **90.38**	Pr **90.49**			
Menu 91	Pr **91.02**	Pr **91.03**	Pr **91.04**	Pr **91.05**	Pr **91.06**	Pr **91.17**	Pr **91.18**	Pr **91.19**
	Pr **91.20**							
Menu 100 to Menu 105	Pr **100.00** to Pr **100.99**	Pr **101.00** to Pr **101.99**	Pr **102.00** to Pr **102.99**	Pr **103.00** to Pr **103.99**	Pr **104.00** to Pr **104.99**	Pr **105.00** to Pr **105.99**		
Menu 130 to Menu 135	Pr **130.00** to Pr **130.99**	Pr **131.00** to Pr **131.99**	Pr **132.00** to Pr **132.99**	Pr **133.00** to Pr **133.99**	Pr **134.00** to Pr **134.99**	Pr **135.00** to Pr **135.99**		
Menu 160 to Menu 165	Pr **160.00** to Pr **160.99**	Pr **161.00** to Pr **161.99**	Pr **162.00** to Pr **162.99**	Pr **163.00** to Pr **163.99**	Pr **164.00** to Pr **164.99**	Pr **165.00** to Pr **165.99**		

6 Macros

6.1 Introduction

A macro is a simple and easy way of setting up the parameter routing in a drive for a specific application. It brings specific parameters into the programmable section of menu 0 for easy access and sets up internal software routing to give the user I/O terminals the functions required for the application.
Unidrive classic had several predefined macros available for the following types of set up.

Table 6-1 Macros that are available

Macro	Description
1	Easy mode
2	Motorized potentiometer
3	Preset frequencies / speeds
4	Torque control
5	PID (set-point control)
6	Axis-limit control
7	Brake control
8*	Digital lock / shaft orientation

* Only available in closed loop vector or servo operating modes.

Macro 1 – Easy Mode

The Easy mode macro gives the simplest operation of the drive for basic applications. It is identical to the default condition except that menu 0 has less parameters.

Macro 2 – Motorized potentiometer

The Motorized potentiometer macro enables the drive's own internal motorized potentiometer to control the speed of the drive via digital inputs. A digital input selects between an analog speed reference and the motorized potentiometer reference.

Macro 3 – Preset frequencies / speeds

The Preset reference macro enables the use of preset references to control the speed of the motor via digital inputs. A digital input selects between an analog speed reference and the preset references.

Macro 4 – Torque control

The Torque control macro configures the drive for use in Torque control mode, selectable via a digital input. Analog input 1 is configured for the torque reference. When in speed control analog 2 is the speed reference. When in torque control with the drive in closed loop mode analog input 2 is the speed override reference. Enabling torque mode with the drive in open loop mode will put the drive in to pure torque control. In closed loop mode the drive will be put in to torque control with speed override.

Macro 5 – PID (set-point control)

The PID control macro enables the drive's own internal PID controller to control the speed of the motor. Analog input 1 is configured for the main speed reference, analog input 2 is the PID reference and analog input 3 is the PID feedback. A digital input selects between an analog speed reference and the PID control.

Macro 6 – Axis-limit control

The Axis limit control macro configures the drive for use with limit switches so that the drive is stopped when a position limit has been reached. The speed reference can be either unipolar or bipolar.

Macro 7 – Brake control

The brake control macro configures the drive to apply or release a mechanical brake on a motor in a crane or hoist application. The drive issues a brake release signal via a digital output when the relevant conditions are met.

Macro 8 – Digital lock / shaft orientation

Only available in closed loop vector or servo operating modes.

Digital lock:
The drive operates as a slave in a closed loop master-slave system. The slave motor is digitally locked to the master motor.

Shaft orientation:
The motor speed is controlled in the same way as for default operation, but the motor shaft can be orientated to a specified angular position before and/or after running the motor.
This section details how to replicate the Unidrive classic macros in a Unidrive SP.

The programmable section of Menu 0 is from Pr **0.11** - Pr **0.30** inclusive. The other menu 0 parameters have fixed functions used in every mode as described below:

Table 6-2 Parameters that are common to each macro:

Parameter			Range(⇕)			Default(⇨)			Type					
			OL	VT	SV	OL	VT	SV						
0.00	**xx.00**													
0.01	Minimum reference clamp	{**1.07**}	±3,000.0Hz	±Speed_limit_max rpm		0.0			RW	Bi			PT	US
0.02	Maximum reference clamp	{**1.06**}	0 to 3,000.0Hz	Speed_limit_max rpm		EUR> 50.0 USA> 60.0	EUR> 1,500.0 USA> 1800.0	3,000.0	RW	Uni				US
0.03	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	0.0200	RW	Uni				US
0.04	Deceleration rate	{**2.21**}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm		5.0	2.000	0.0200	RW	Uni				US
0.05	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
0.06	Current limit	{**4.07**}	0 to Current_limit_max %			165.0	175.0		RW	Uni		RA		US
0.07	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 6.5335 1/rad s^{-1}			0.0300	0.0100	RW	Uni				US
0.08	OL> Voltage boost	{**5.15**}	0.0 to 25.0% of motor rated voltage			Size 1 to 3: 3.0 Size 4 to 5: 2.0 Size 6 to 9: 1.0			RW	Uni				US
	CL> Speed controller I gain	{**3.11**}		0.00 to 653.35 1/rad			0.10	1.00	RW	Uni				US
0.09	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 0.65336 (s)			0.00000		RW	Uni				US
0.10	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	
0.31	Drive rated voltage	{**11.33**}	200 (0), 400 (1), 575 (2), 690 (3) V						RO	Txt		NC	PT	
0.32	Drive rated current	{**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		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), 1,200 (2), 2,400 (3), 4,800 (4), 9,600 (5), 19,200 (6), 38,400 (7), 57,600 (8) Modbus RTU only, 115,200 (9) Modbus RTU only			19,200 (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)			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^{o}				RW	Uni		NC	PT	
0.44	Motor rated voltage	{**5.09**}	0 to AC_voltage_set_max V			200V drive: 200 400V drive: EUR> 400, USA> 480 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	

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

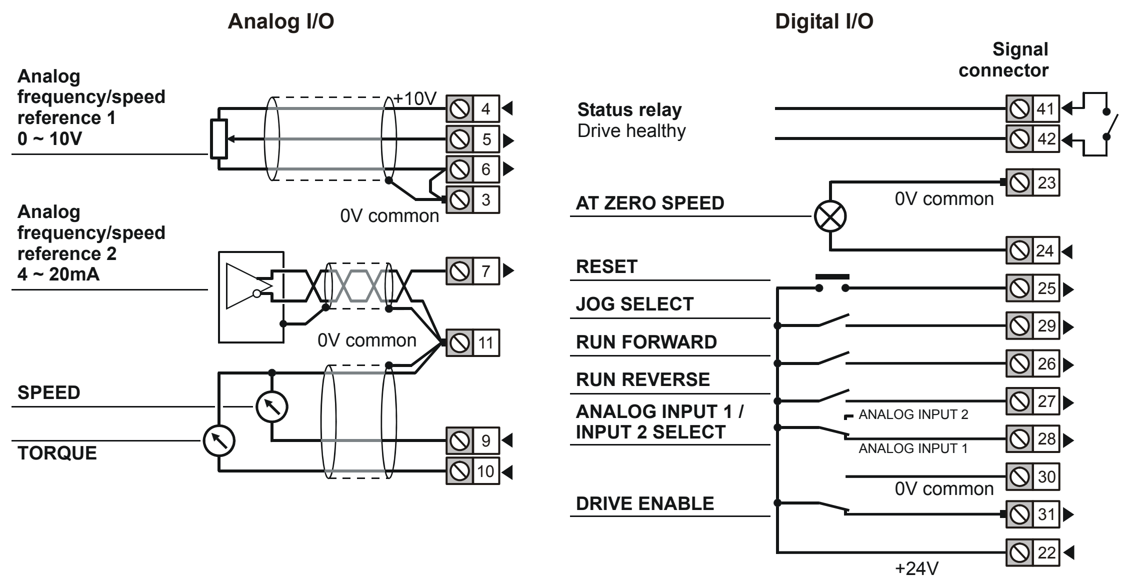
6.1.1 Fundamental differences between Unidrive SP and Unidrive Classic

The following Macros simulate the equivalent Macros in Unidrive classic. The following are exceptions in functionality between the Macros in Unidrive Classic and Unidrive SP:

- The Unidrive SP Macros run in positive logic, unlike Unidrive Classic Macros which run in negative logic.
- You do not have access to change Analog Input 1 mode in any Unidrive SP macro, as analog input 1 is now a dedicated high precision voltage input, and cannot be turned into a current loop input.
- The Safe Torque Off input on Unidrive SP, which is an enhanced equivalent of the enable input on Unidrive Classic, is now on terminal 31, unlike Unidrive Classic which uses terminal 30. The Safe Torque Off input is also permanently positive logic, unlike the enable input in Unidrive Classic, which can be changed to negative logic.
- Macro 3 on Unidrive SP works in a slightly different way to Unidrive Classic. In the Unidrive Classic Macro 3, the only way in which the preset speeds can be enabled was to switch digital input F6 to logic 1. In Unidrive SP the software structure has changed, to be in line with Commander SE. This means that if you switch on either, or both of the preset selects, then regardless of the state of the preset enable, the drive will automatically enable the preset speeds as the speed reference.
- The brake is now an additional feature in Menu 12, with enhanced features over the Unidrive Classic. It is recommended that the brake controller in Menu 12 is used instead of Macro 7 - Brake Control.

6.2 Macro 1 - Easy Mode

Macro 1	Easy mode
The Easy mode macro gives the simplest operation of the drive for basic applications. It is identical to the default condition except that menu 0 has less parameters.	



Macro 1 specific parameters

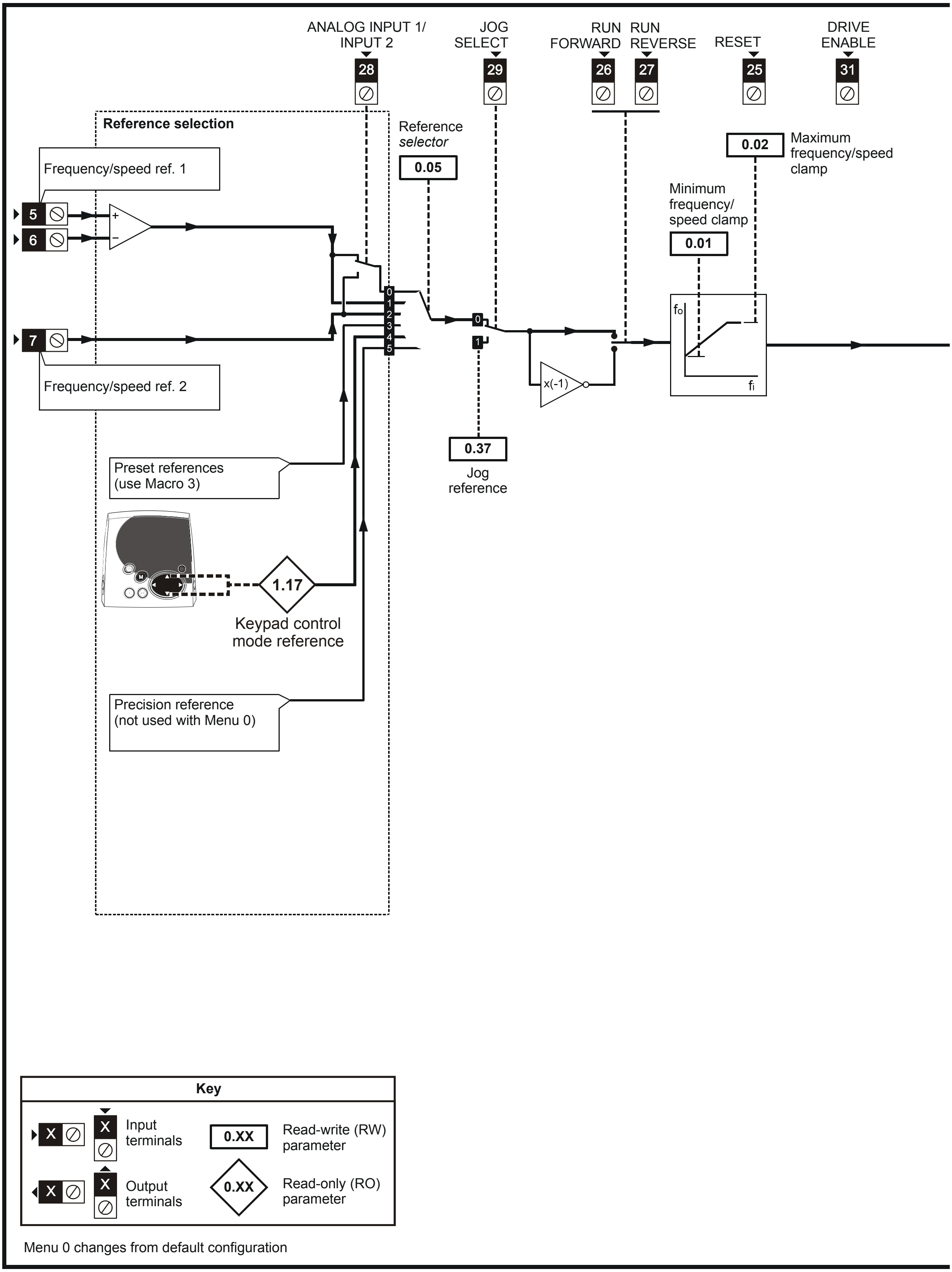
There are no additional parameters present other than those described in Table 6-2 on page 369, as this is Easy mode.

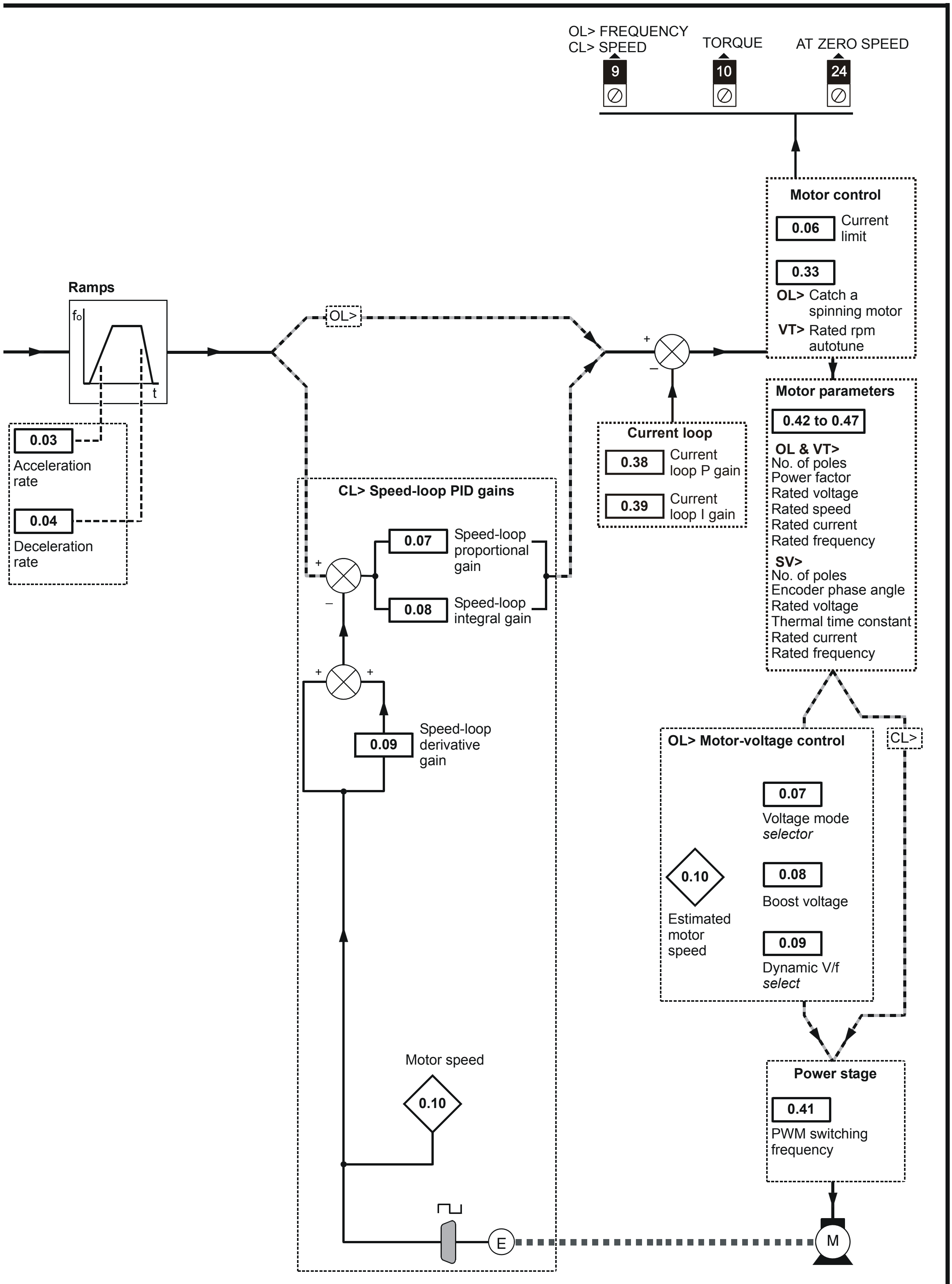
Pr **0.11** to Pr **0.30** are not configured to point to any other parameter in this mode.

Table 6-3 Parameter set-up to reproduce Macro 1 on a Unidrive SP

Parameter		Value	
		OL	CL
5.14	Voltage mode select	Fd	
7.11	T9 - Analog input 2 mode	4-20	
11.01	Define Pr **0.11**	Pr **0.00**	
11.02	Define Pr **0.12**	Pr **0.00**	
11.03	Define Pr **0.13**	Pr **0.00**	
11.04	Define Pr **0.14**	Pr **0.00**	
11.05	Define Pr **0.15**	Pr **0.00**	
11.06	Define Pr **0.16**	Pr **0.00**	
11.07	Define Pr **0.17**	Pr **0.00**	
11.08	Define Pr **0.18**	Pr **0.00**	
11.09	Define Pr **0.19**	Pr **0.00**	
11.10	Define Pr **0.20**	Pr **0.00**	
11.11	Define Pr **0.21**	Pr **0.00**	
11.12	Define Pr **0.22**	Pr **0.00**	
11.13	Define Pr **0.23**	Pr **0.00**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **0.00**	
11.16	Define Pr **0.26**	Pr **0.00**	
11.17	Define Pr **0.27**	Pr **0.00**	
11.18	Define Pr **0.28**	Pr **0.00**	
11.19	Define Pr **0.29**	Pr **0.00**	
11.20	Define Pr **0.30**	Pr **0.00**	

Figure 6-1 Macro 1 Easy Mode logic diagram




OL> FREQUENCY
CL> SPEED
TORQUE
AT ZERO SPEED
9
10
24
Motor control
0.06
Current limit
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Ramps
OL>
0.03
Acceleration rate
0.04
Deceleration rate
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
Current loop
0.38
Current loop P gain
0.39
Current loop I gain
CL> Speed-loop PID gains
0.07
Speed-loop proportional gain
0.08
Speed-loop integral gain
0.09
Speed-loop derivative gain
OL> Motor-voltage control
CL>
0.07
Voltage mode selector
0.10
Estimated motor speed
0.08
Boost voltage
0.09
Dynamic V/f select
Motor speed
0.10
Power stage
0.41
PWM switching frequency
E
M

6.3 Macro 2 - Motorized potentiometer

Macro 2	Motorized potentiometer
The Motorized potentiometer macro enables the drive's own internal motorized potentiometer to control the speed of the drive via digital inputs. A digital input selects between an analog speed reference and the motorized potentiometer reference.	

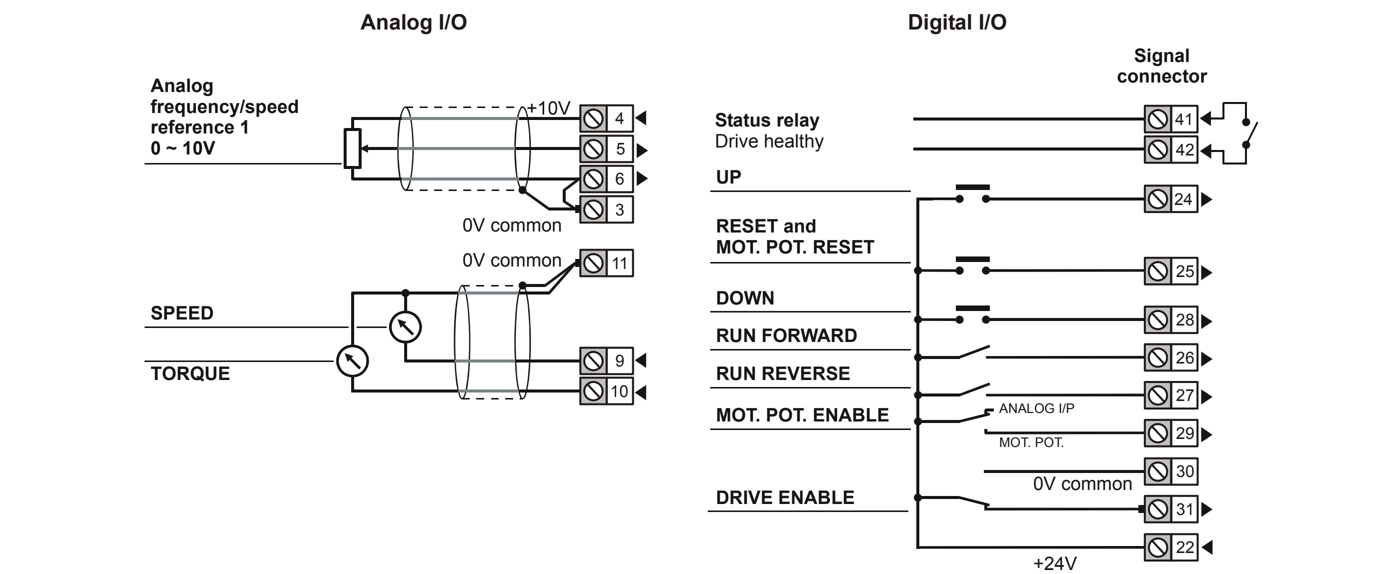


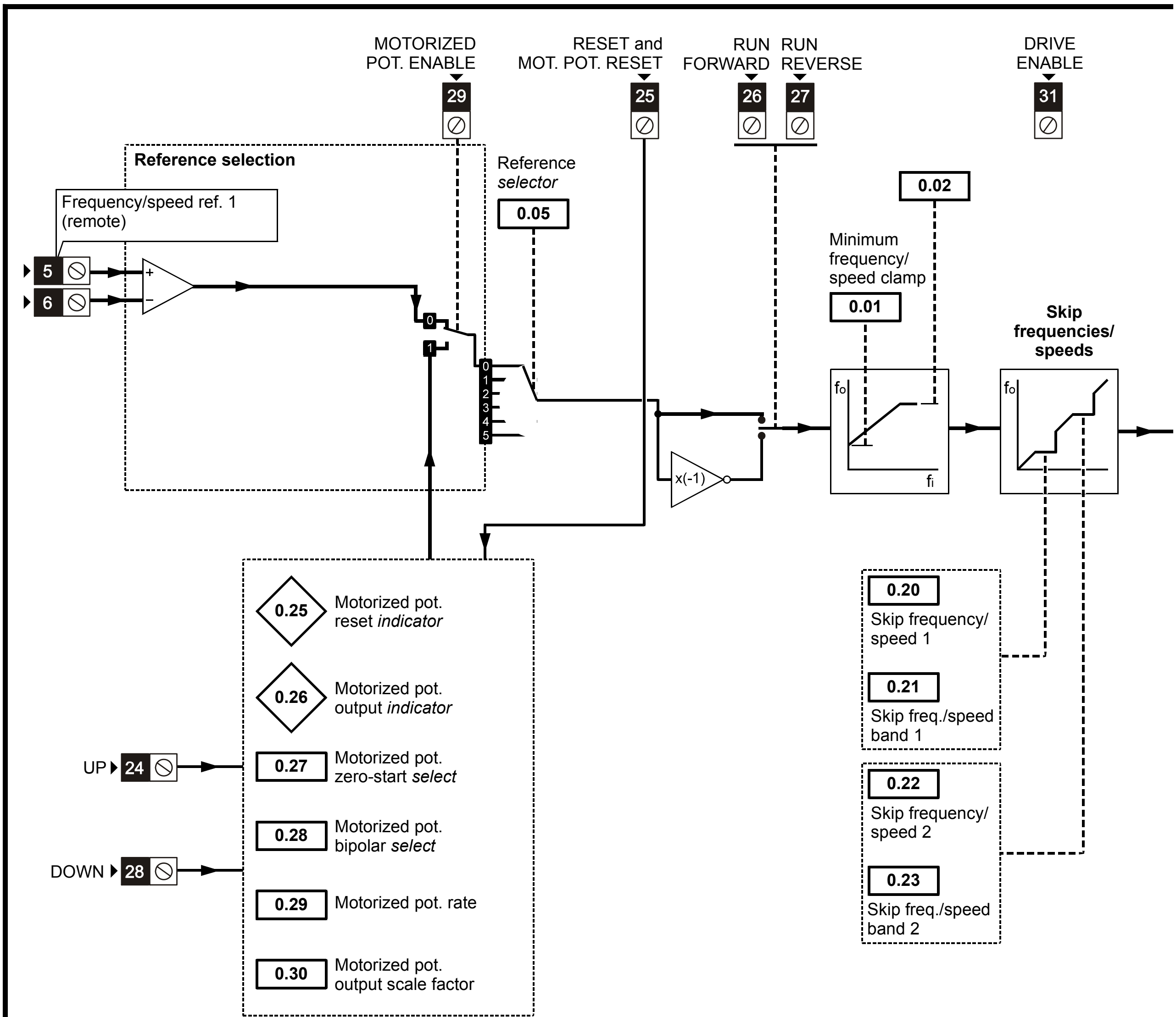
Table 6-4 Macro 2 menu 0 programmable parameters

Parameter			Range(⇳) OL	Range(⇳) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	Jog reference	{**1.05**}	0 to 400.0 Hz	0 to 4,000.0 rpm	0.0			RW	Uni				US
0.15	Ramp mode select	{**2.04**}	FASt (0), Std (1), Std.hV (2)	FASt (0) Std (1)	Std (1)			RW	Txt				US
0.16	Stop mode	{**6.01**}	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4)	COASt (0), rP (1), no.rP (2)	rP (1)		no.rP (2)	RW	Txt				US
0.17	Relay source invert	{**8.17**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.18	S ramp enable	{**2.06**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.19	S ramp acceleration limit	{**2.07**}	0.0 to 300.0 s^2/100Hz	0.000 to 100.000 s^2/1000rpm	3.1	1.500	0.030	RW	Uni				US
0.20	Skip reference 1	{**1.29**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.21	Skip reference band 1	{**1.30**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.22	Skip reference 2	{**1.31**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.23	Skip reference band 2	{**1.32**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.24	Not used												
0.25	Motorized pot reset	{**9.28**}	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
0.26	Motorized pot output	{**9.03**}	±100.00 %					RO	Bi		NC	PT	PS
0.27	Motorized pot mode	{**9.21**}	0 to 3		2			RW	Uni				US
0.28	Motorized pot bipolar select	{**9.22**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.29	Motorized pot rate	{**9.23**}	0 to 250 s		20			RW	Uni				US
0.30	Motorized pot scale factor	{**9.24**}	0.000 to 4.000		1.000			RW	Uni				US

Table 6-5 Parameter set-up to reproduce Macro 2 on a Unidrive SP

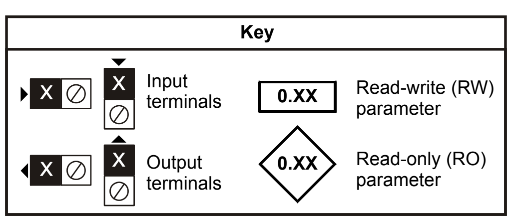
Parameter		Value OL	Value CL
7.14	T7 analog input 2 destination	Pr **0.00**	
8.21	T24 digital I/O 1 source / destination	Pr **9.26**	
8.25	T28 digital input 5 destination	Pr **9.27**	
8.26	T26 digital input 6 destination	Pr **1.41**	
8.31	T24 digital I/O 1 output select	OFF (0)	
8.39	T28 & T29 digital input auto selection disable	On (1)	
9.04	Logic function 1 source 1	Pr **9.22**	
9.07	Logic function 1 source 2 invert	On (1)	
9.10	Logic function 1 destination	Pr **1.10**	
9.14	Logic function 2 source 1	Pr **8.02**	
9.17	Logic function 2 source 2 invert	On (1)	
9.20	Logic function 2 destination	Pr **9.28**	
9.21	Motorized pot mode	0	
9.25	Motorized pot destination	Pr **1.37**	
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **1.05**	
11.05	Define Pr **0.15**	Pr **2.04**	
11.06	Define Pr **0.16**	Pr **6.01**	
11.07	Define Pr **0.17**	Pr **8.17**	
11.08	Define Pr **0.18**	Pr **2.06**	
11.09	Define Pr **0.19**	Pr **2.07**	
11.10	Define Pr **0.20**	Pr **1.29**	
11.11	Define Pr **0.21**	Pr **1.30**	
11.12	Define Pr **0.22**	Pr **1.31**	
11.13	Define Pr **0.23**	Pr **1.32**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **9.28**	
11.16	Define Pr **0.26**	Pr **9.03**	
11.17	Define Pr **0.27**	Pr **9.21**	
11.18	Define Pr **0.28**	Pr **9.22**	
11.19	Define Pr **0.29**	Pr **9.23**	
11.20	Define Pr **0.30**	Pr **9.24**	

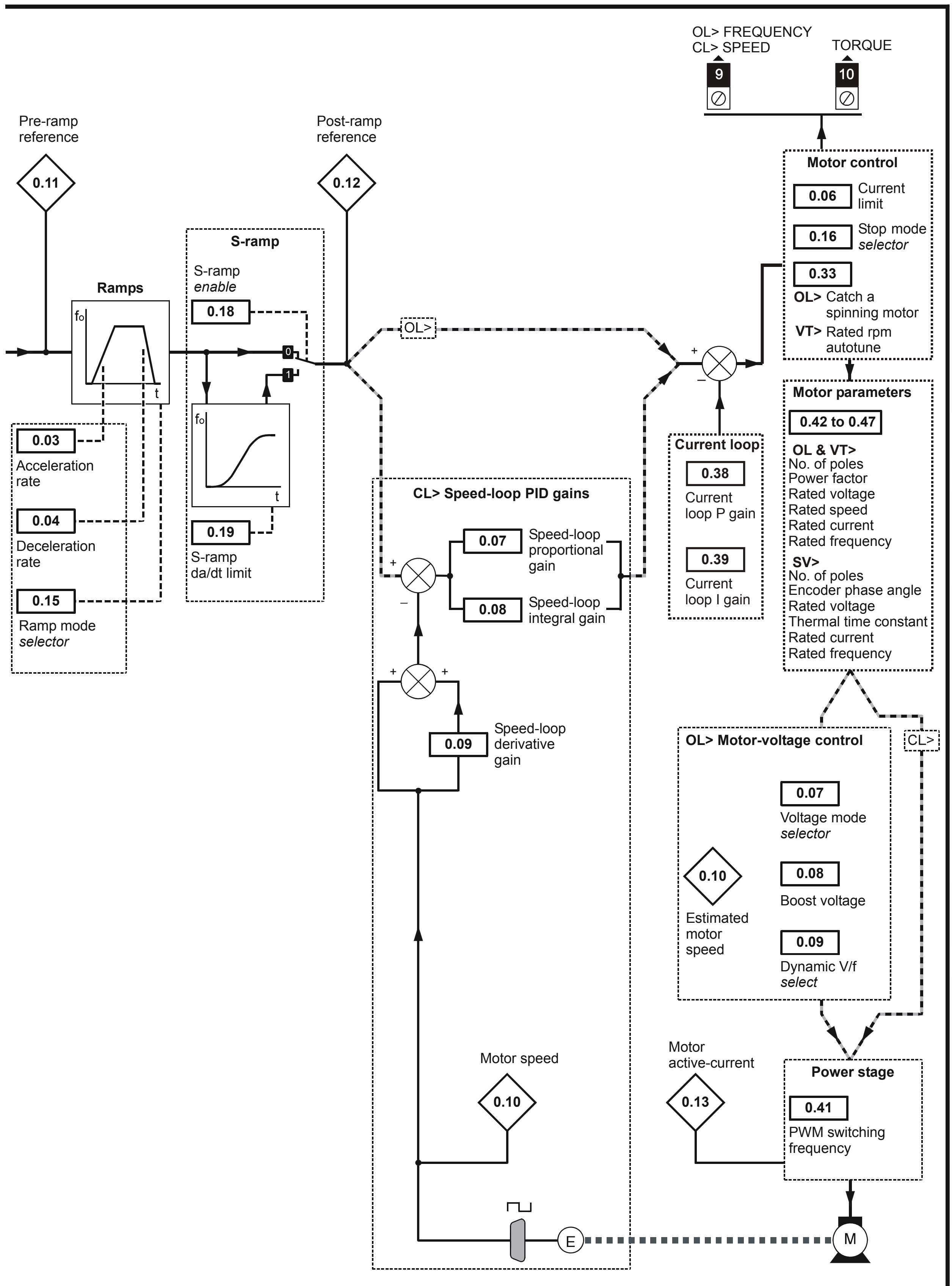
Figure 6-2 Macro 2 Motorized potentiometer logic diagram



Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Jog reference (not used)
0.15	Ramp mode *selector*
0.16	Stop mode *selector*
0.17	Status relay *invert*
0.18	S-ramp *enable*
0.19	S-ramp da/dt
0.20	Skip frequency/speed 1
0.21	Skip freq./speed band 1
0.22	Skip frequency/speed 2
0.23	Skip freq./speed band 2
0.25	Motorized pot. reset *indicator*
0.26	Motorized pot. output *indicator*
0.27	Motorized pot. zero-start *select*
0.28	Motorized pot. Bipolar *select*
0.29	Motorized pot. rate
0.30	Motorized pot.output scale factor

Menu 0 changes from default configuration




OL> FREQUENCY
CL> SPEED
TORQUE
9
10
Pre-ramp reference
0.11
Post-ramp reference
0.12
Ramps
S-ramp
S-ramp enable
0.18
0.03
Acceleration rate
0.04
Deceleration rate
0.15
Ramp mode selector
0.19
S-ramp da/dt limit
OL>
Motor control
0.06
Current limit
0.16
Stop mode selector
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
Current loop
0.38
Current loop P gain
0.39
Current loop I gain
CL> Speed-loop PID gains
0.07
Speed-loop proportional gain
0.08
Speed-loop integral gain
0.09
Speed-loop derivative gain
OL> Motor-voltage control
CL>
0.07
Voltage mode selector
0.10
Estimated motor speed
0.08
Boost voltage
0.09
Dynamic V/f select
Motor speed
0.10
Motor active-current
0.13
Power stage
0.41
PWM switching frequency
E
M

6.4 Macro 3 - Preset speeds

Macro 3	Preset speeds
The Preset reference macro enables the use of preset references to control the speed of the motor via digital inputs. A digital input selects between an analog speed reference and the preset references.	

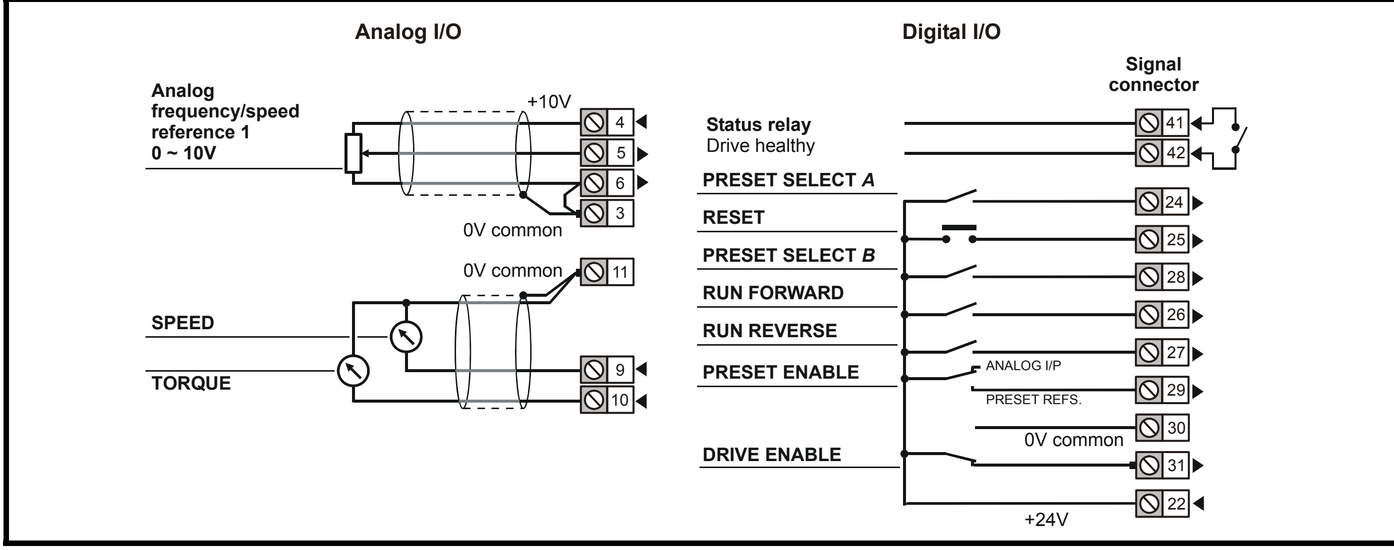


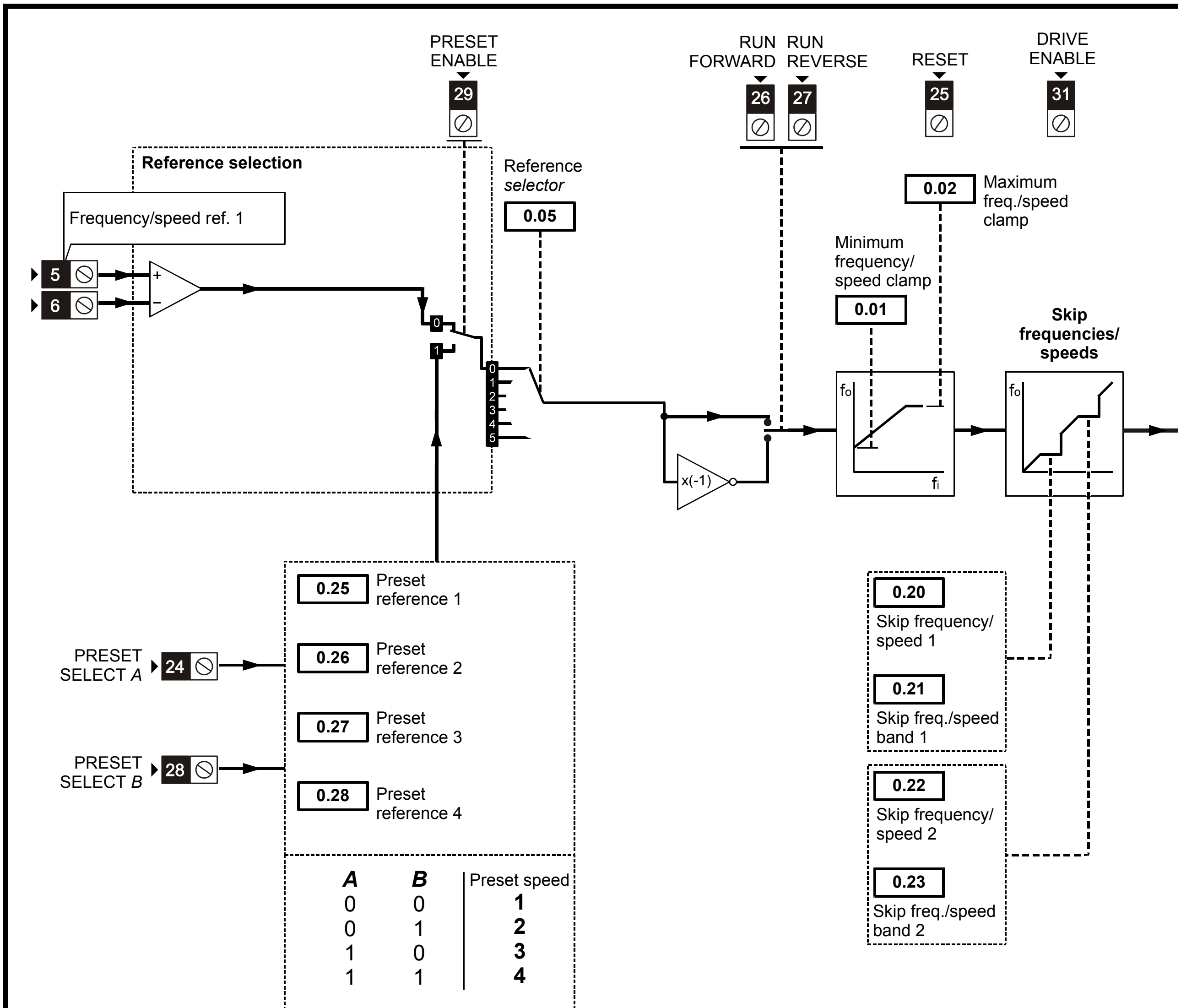
Table 6-6 Macro 3 menu 0 programmable parameters

Parameter		Range(⇳) OL	Range(⇳) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference {**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference {**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current {**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	Jog reference {**1.05**}	0 to 400.0 Hz	0 to 4,000.0 rpm	0.0			RW	Uni				US
0.15	Ramp mode select {**2.04**}	FASt (0), Std (1), Std.hV (2)	FASt (0) Std (1)	Std (1)			RW	Txt				US
0.16	Stop mode {**6.01**}	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4)	COASt (0), rP (1), no.rP (2)	rP (1)		no.rP (2)	RW	Txt				US
0.17	Relay source invert {**8.17**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.18	S ramp enable {**2.06**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.19	S ramp acceleration limit {**2.07**}	0.0 to 300.0 s^2/100Hz	0.000 to 100.000 s^2/1000rpm	3.1	1.500	0.030	RW	Uni				US
0.20	Skip reference 1 {**1.29**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.21	Skip reference band 1 {**1.30**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.22	Skip reference 2 {**1.31**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.23	Skip reference band 2 {**1.32**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.24	Not used											
0.25	Preset reference 1 {**1.21**}	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.26	Preset reference 2 {**1.22**}	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.27	Preset reference 3 {**1.23**}	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.28	Preset reference 4 {**1.24**}	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.29	Not used											
0.30	Not used											

Table 6-7 Parameter set-up to reproduce Macro 3 on a Unidrive SP

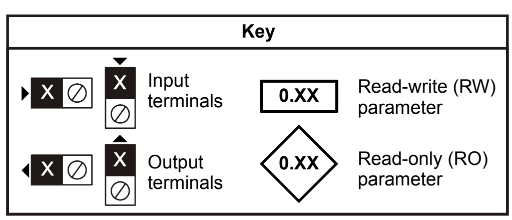
Parameter		Value	
		OL	CL
8.21	T24 digital I/O 1 source / destination	Pr **1.46**	
8.25	T28 digital input 5 destination	Pr **1.45**	
8.26	T29 digital input 6 destination	Pr **1.42**	
8.31	T24 digital I/O 1 output select	OFF (0)	
8.39	T28 & T29 digital input auto selection disable	On (1)	
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **1.05**	
11.05	Define Pr **0.15**	Pr **2.04**	
11.06	Define Pr **0.16**	Pr **6.01**	
11.07	Define Pr **0.17**	Pr **8.17**	
11.08	Define Pr **0.18**	Pr **2.06**	
11.09	Define Pr **0.19**	Pr **2.07**	
11.10	Define Pr **0.20**	Pr **1.29**	
11.11	Define Pr **0.21**	Pr **1.30**	
11.12	Define Pr **0.22**	Pr **1.31**	
11.13	Define Pr **0.23**	Pr **1.32**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **1.21**	
11.16	Define Pr **0.26**	Pr **1.22**	
11.17	Define Pr **0.27**	Pr **1.23**	
11.18	Define Pr **0.28**	Pr **1.24**	
11.19	Define Pr **0.29**	Pr **0.00**	
11.20	Define Pr **0.30**	Pr **0.00**	

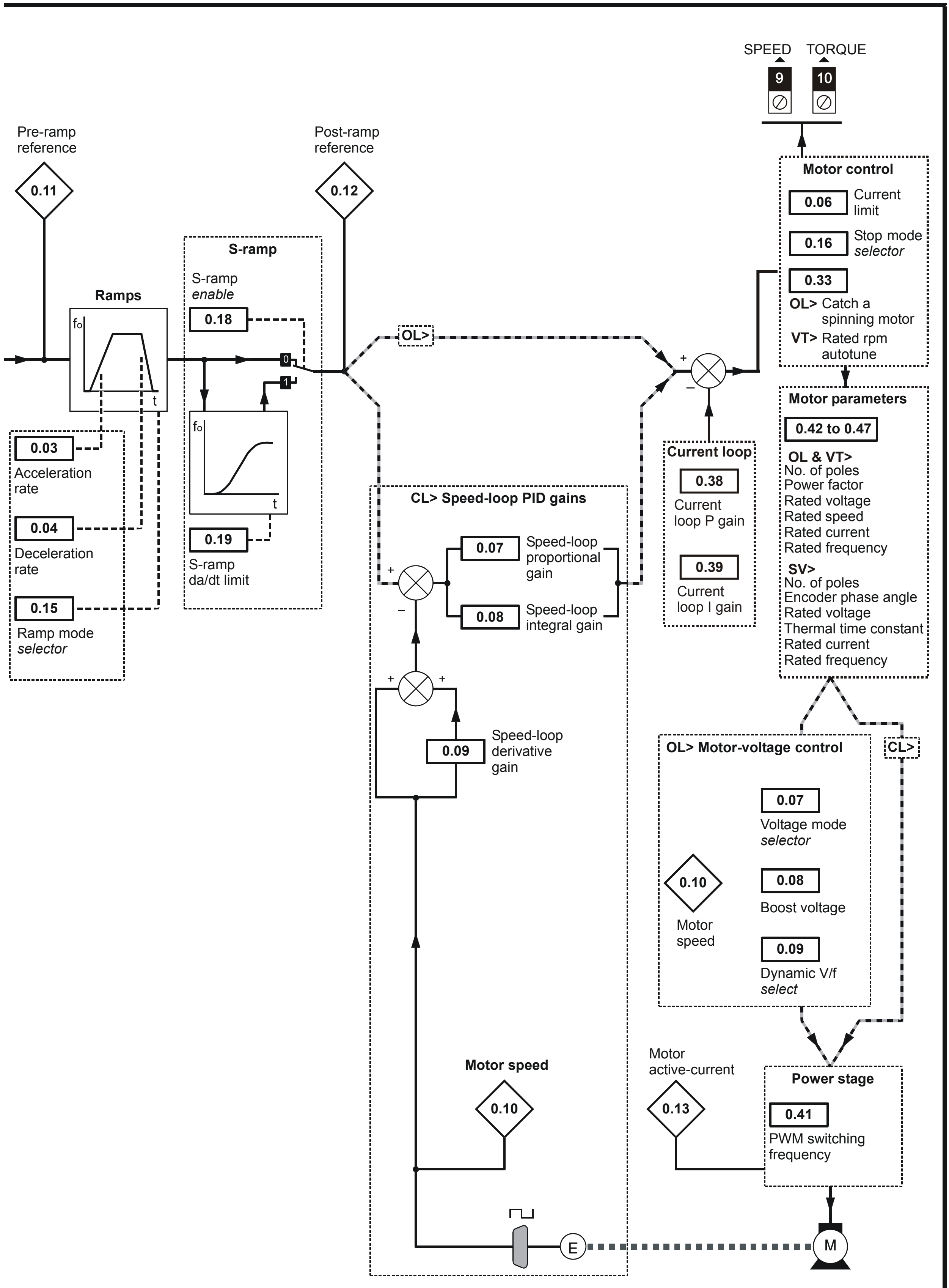
Figure 6-3 Macro 3 Preset speeds logic diagram



Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Jog reference (not used)
0.15	Ramp mode *selector*
0.16	Stop mode *selector*
0.17	Status relay *invert*
0.18	S-ramp *enable*
0.19	S-ramp da/dt
0.20	Skip frequency/speed 1
0.21	Skip freq./speed band 1
0.22	Skip frequency/speed 2
0.23	Skip freq./speed band 2
0.24	(Not used)
0.25	Preset reference 1
0.26	Preset reference 2
0.27	Preset reference 3
0.28	Preset reference 4
0.29	(Not used)
0.30	(Not used)

Menu 0 changes from default configuration





SPEED
TORQUE
9
10
Pre-ramp reference
0.11
Post-ramp reference
0.12
Ramps
S-ramp
S-ramp enable
0.18
0.03
Acceleration rate
0.04
Deceleration rate
0.15
Ramp mode selector
0.19
S-ramp da/dt limit
OL>
Motor control
0.06
Current limit
0.16
Stop mode selector
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
Current loop
0.38
Current loop P gain
0.39
Current loop I gain
CL> Speed-loop PID gains
0.07
Speed-loop proportional gain
0.08
Speed-loop integral gain
0.09
Speed-loop derivative gain
OL> Motor-voltage control
CL>
0.07
Voltage mode selector
0.10
Motor speed
0.08
Boost voltage
0.09
Dynamic V/f select
Motor speed
0.10
Motor active-current
0.13
Power stage
0.41
PWM switching frequency
E
M

6.5 Macro 4 - Torque control

Macro 4	Torque control

The Torque control macro configures the drive for use in Torque control mode, selectable via a digital input. Analog input 1 is configured for the torque reference. When in speed control analog 2 is the speed reference. When in torque control with the drive in closed loop mode analog input 2 is the speed override reference. Enabling torque mode with the drive in open loop mode will put the drive in to pure torque control. In closed loop mode the drive will be put in to torque control with speed override.

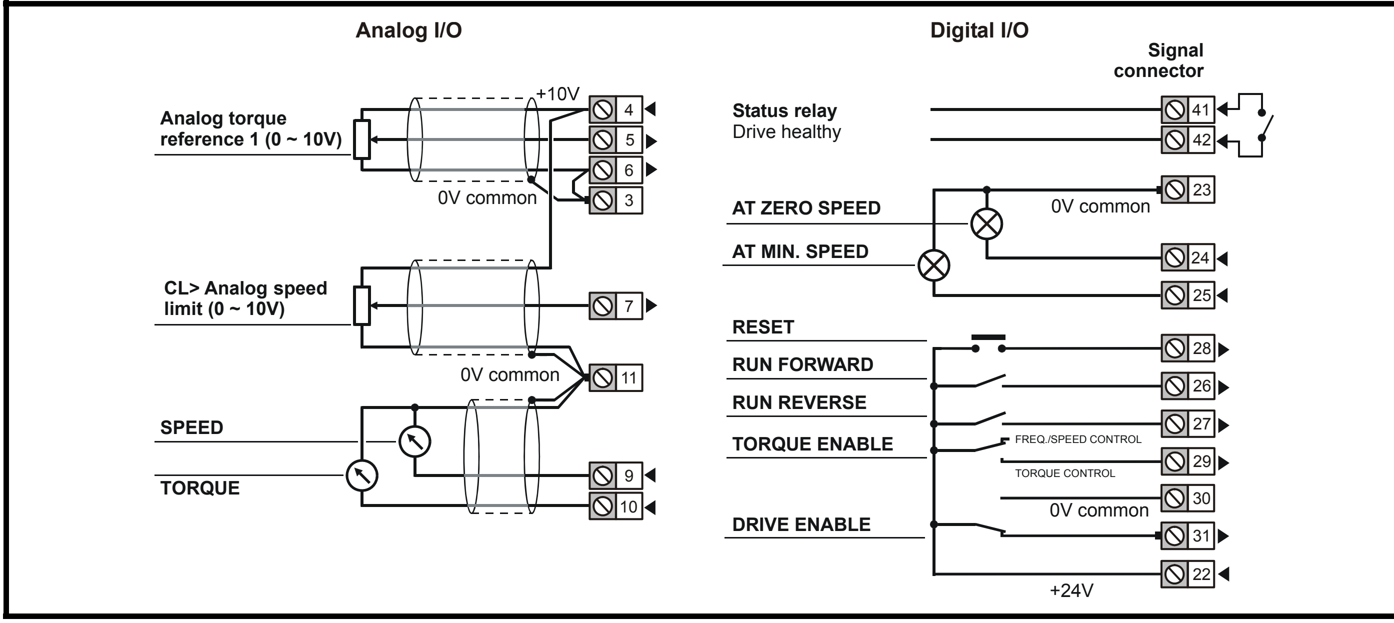


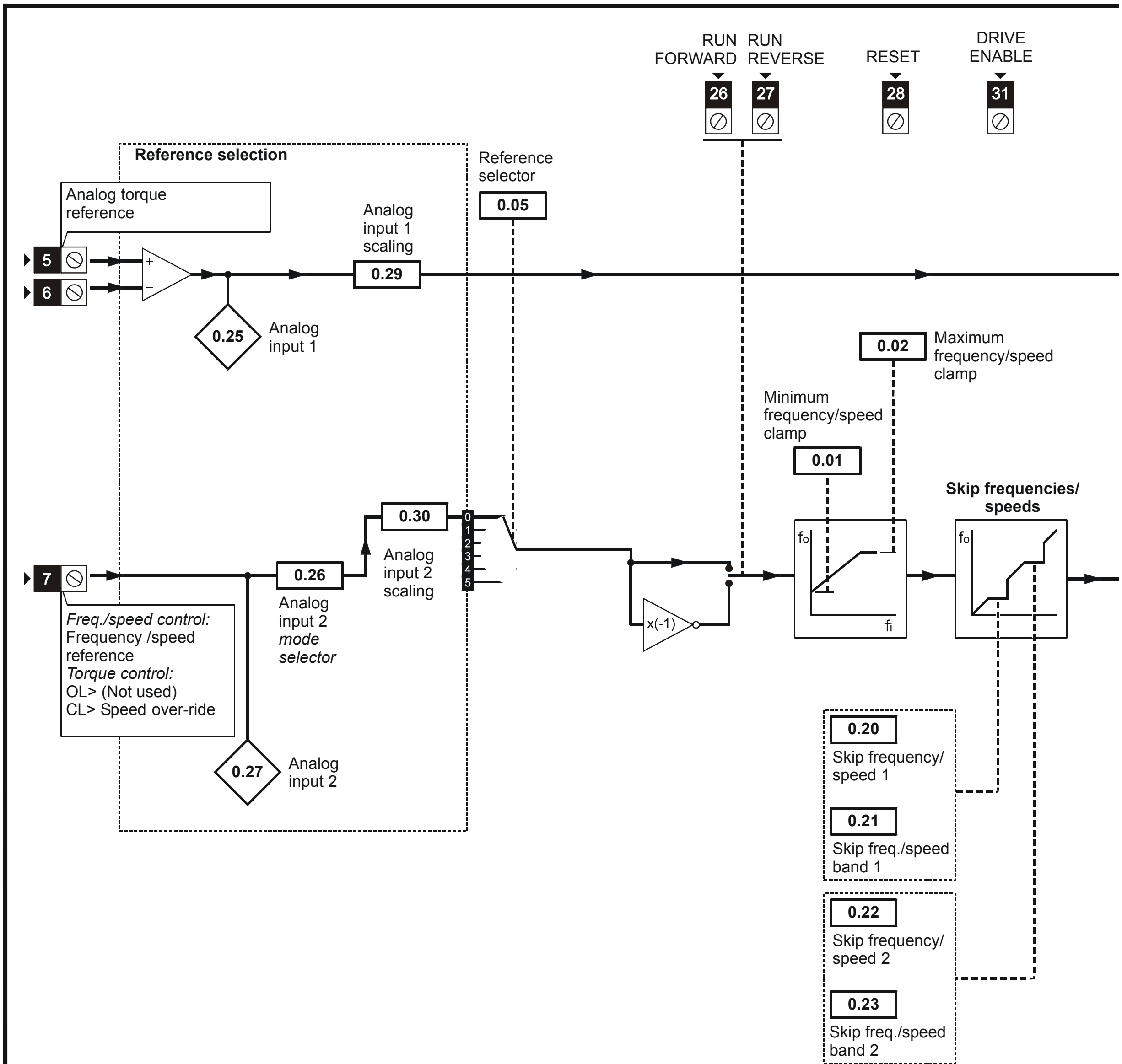
Table 6-8 Macro 4 menu 0 programmable parameters

Parameter			Range(⇕) OL	Range(⇕) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	Jog reference	{**1.05**}	0 to 400.0 Hz	0 to 4,000.0 rpm	0.0			RW	Uni				US
0.15	Ramp mode select	{**2.04**}	FASt (0), Std (1), Std.hV (2)	FASt (0) Std (1)	Std (1)			RW	Txt				US
0.16	Stop mode	{**6.01**}	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4)	COASt (0), rP (1), no.rP (2)	rP (1)		no.rP (2)	RW	Txt				US
0.17	Relay source invert	{**8.17**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.18	S ramp enable	{**2.06**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.19	S ramp acceleration limit	{**2.07**}	0.0 to 300.0 s^2/100Hz	0.000 to 100.000 s^2/1000rpm	3.1	1.500	0.030	RW	Uni				US
0.20	Skip reference 1	{**1.29**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.21	Skip reference band 1	{**1.30**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.22	Skip reference 2	{**1.31**}	0.0 to 3,000.0 Hz	0 to 40,000 rpm	0.0	0		RW	Uni				US
0.23	Skip reference band 2	{**1.32**}	0.0 to 25.0 Hz	0 to 250 rpm	0.5	5		RW	Uni				US
0.25	T5/6 analog input 1 level	**(7.01)**	±100.00 %					RO	Bi		NC	PT	
0.26	T7 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
0.27	T7 analog input 2 level	**(7.02)**	±100.0 %					RO	Bi		NC	PT	
0.28	Overspeed threshold	**(3.08)**		0 to 40,000 rpm		0		RW	Uni				US
0.29	T5/6 analog input 1 scaling	**(7.08)**	0 to 4.000		1.000			RW	Uni				US
0.30	T7 analog input 2 scaling	**(7.12)**	0 to 4.000		1.000			RW	Uni				US

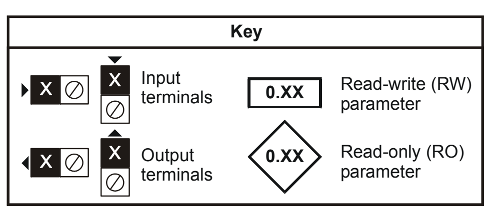
Table 6-9 Parameter set-up to reproduce Macro 4 on a Unidrive SP

Parameter		Value	
		OL	CL
7.10	Analog input 1 destination	Pr **4.08**	
7.14	Analog input 2 destination	Pr **1.36**	
8.22	T25 digital I/O 2 source / destination	Pr **10.04**	
8.25	T28 digital input 5 destination	Pr **10.33**	
8.26	T29 digital input 6 destination	Pr **9.29**	Pr **9.30**
8.32	T25 digital I/O 2 output select	On (1)	
8.39	T28 & T29 digital input auto selection disable	On (1)	
9.04	Logic function 1 source 1	Pr **6.32**	
9.07	Logic function 1 source 2 invert	On (1)	
9.10	Logic function 1 destination	Pr **7.09**	
9.33	T26 digital I/O 3 output select	Pr **4.11**	
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **1.05**	
11.05	Define Pr **0.15**	Pr **2.04**	
11.06	Define Pr **0.16**	Pr **6.01**	
11.07	Define Pr **0.17**	Pr **8.17**	
11.08	Define Pr **0.18**	Pr **2.06**	
11.09	Define Pr **0.19**	Pr **2.07**	
11.10	Define Pr **0.20**	Pr **1.29**	
11.11	Define Pr **0.21**	Pr **1.30**	
11.12	Define Pr **0.22**	Pr **1.31**	
11.13	Define Pr **0.23**	Pr **1.32**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **7.01**	
11.16	Define Pr **0.26**	Pr **7.11**	
11.17	Define Pr **0.27**	Pr **7.02**	
11.18	Define Pr **0.28**	Pr **3.08**	
11.19	Define Pr **0.29**	Pr **7.08**	
11.20	Define Pr **0.30**	Pr **7.12**	

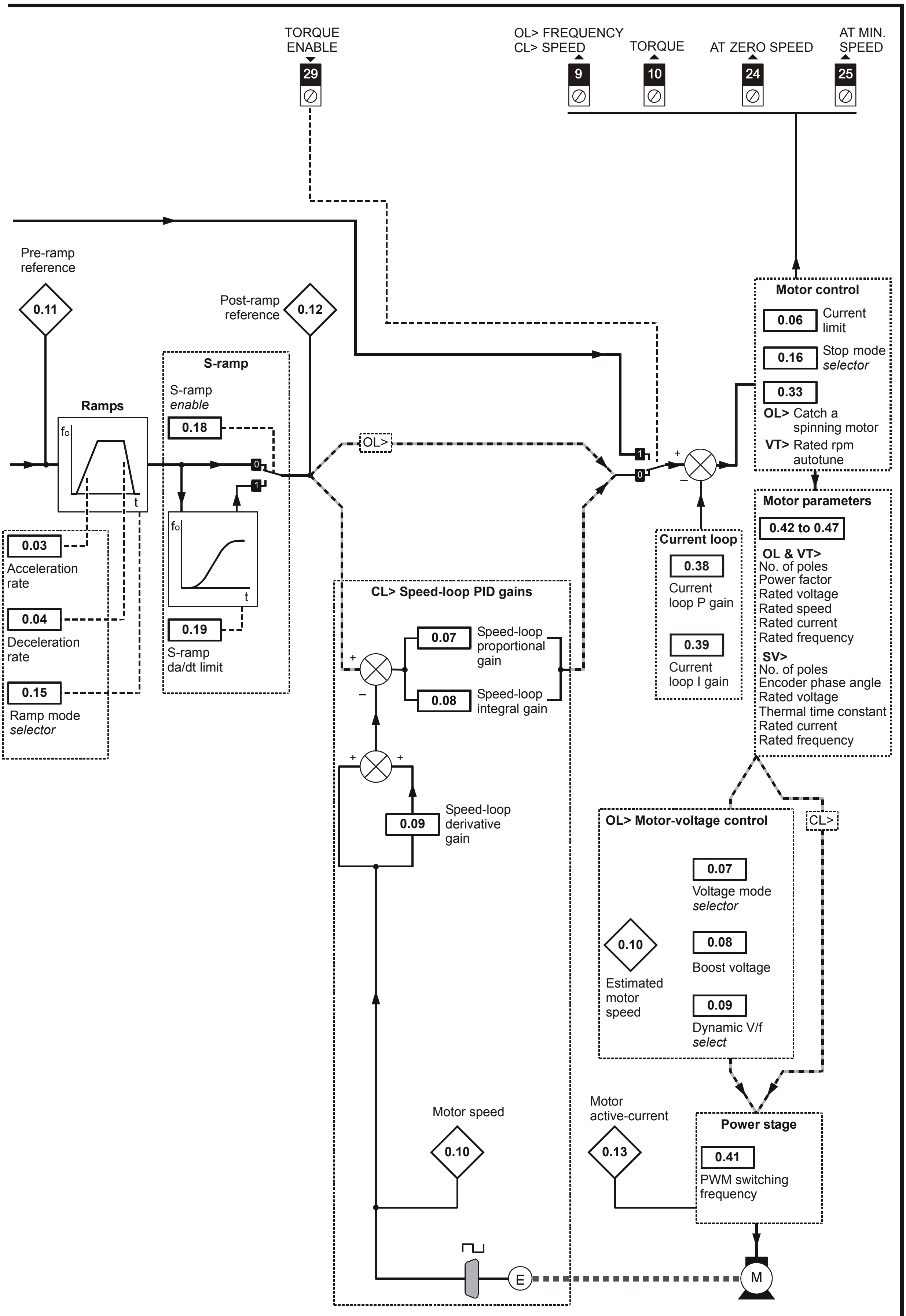
Figure 6-4 Macro 4 Torque control logic diagram



Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Jog reference (not used)
0.15	Braking mode *selector*
0.16	Stop mode *selector*
0.17	Status relay *invert*
0.18	S-ramp *enable*
0.19	S-ramp da/dt
0.20	Skip frequency/speed 1
0.21	Skip freq./speed band 1
0.22	Skip frequency/speed 2
0.23	Skip freq./speed band 2
0.24	(Not used)
0.25	Analog input 1(torque reference)
0.26	Analog input 2 mode *selector*
0.27	Analog input 2 (maximum speed override level)
0.28	Over-speed threshold
0.29	Analog input 1 scaling
0.30	Analog input 2 scaling



Menu 0 changes from default configuration


TORQUE ENABLE
29
OL> FREQUENCY
CL> SPEED
9
TORQUE
10
AT ZERO SPEED
24
AT MIN. SPEED
25
Pre-ramp reference
0.11
Post-ramp reference
0.12
Ramps
S-ramp
S-ramp enable
0.18
0.03
Acceleration rate
0.04
Deceleration rate
0.15
Ramp mode selector
0.19
S-ramp da/dt limit
OL>
CL> Speed-loop PID gains
0.07
Speed-loop proportional gain
0.08
Speed-loop integral gain
0.09
Speed-loop derivative gain
Motor control
0.06
Current limit
0.16
Stop mode selector
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Current loop
0.38
Current loop P gain
0.39
Current loop I gain
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
CL>
OL> Motor-voltage control
0.07
Voltage mode selector
0.10
Estimated motor speed
0.08
Boost voltage
0.09
Dynamic V/f select
Motor speed
0.10
Motor active-current
0.13
Power stage
0.41
PWM switching frequency
E
M

6.6 Macro 5 - PID control

Macro 5	PID control
The PID control macro enables the drive's own internal PID controller to control the speed of the motor. Analog input 1 is configured for the main speed reference, analog input 2 is the PID reference and analog input 3 is the PID feedback. A digital input selects between an analog speed reference and the PID control.	

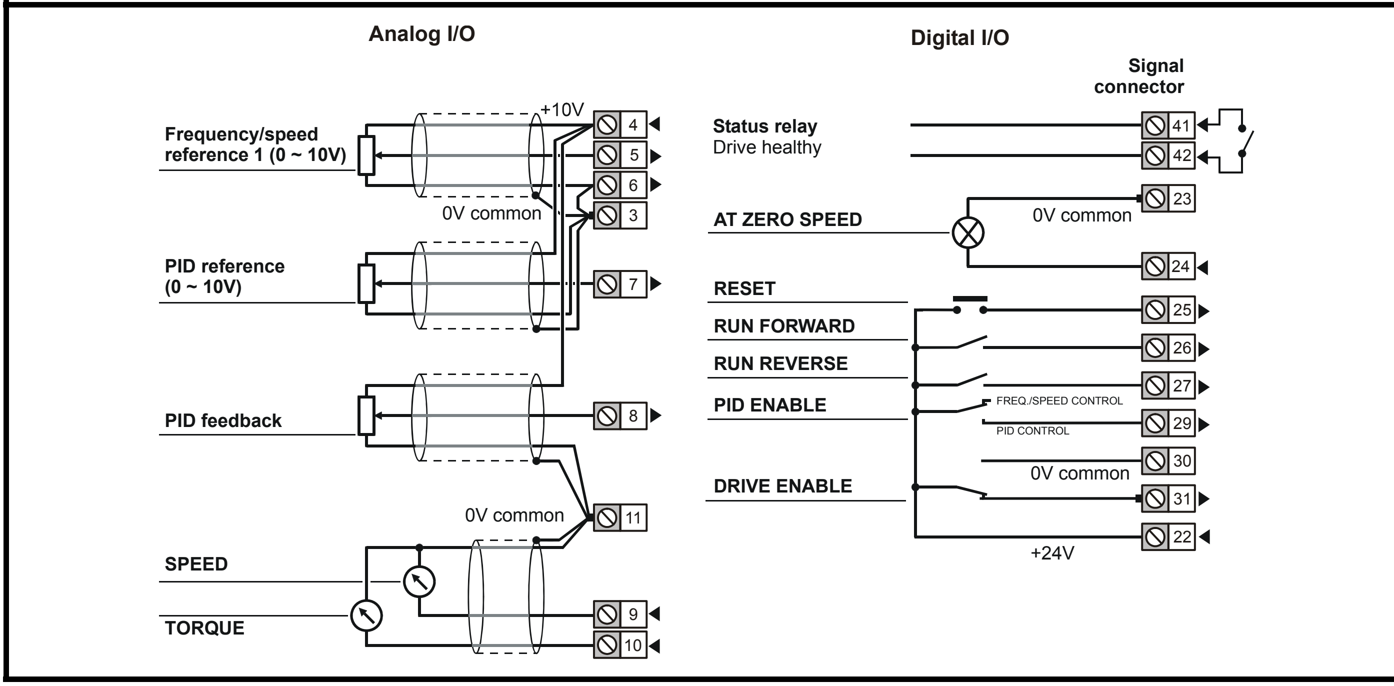


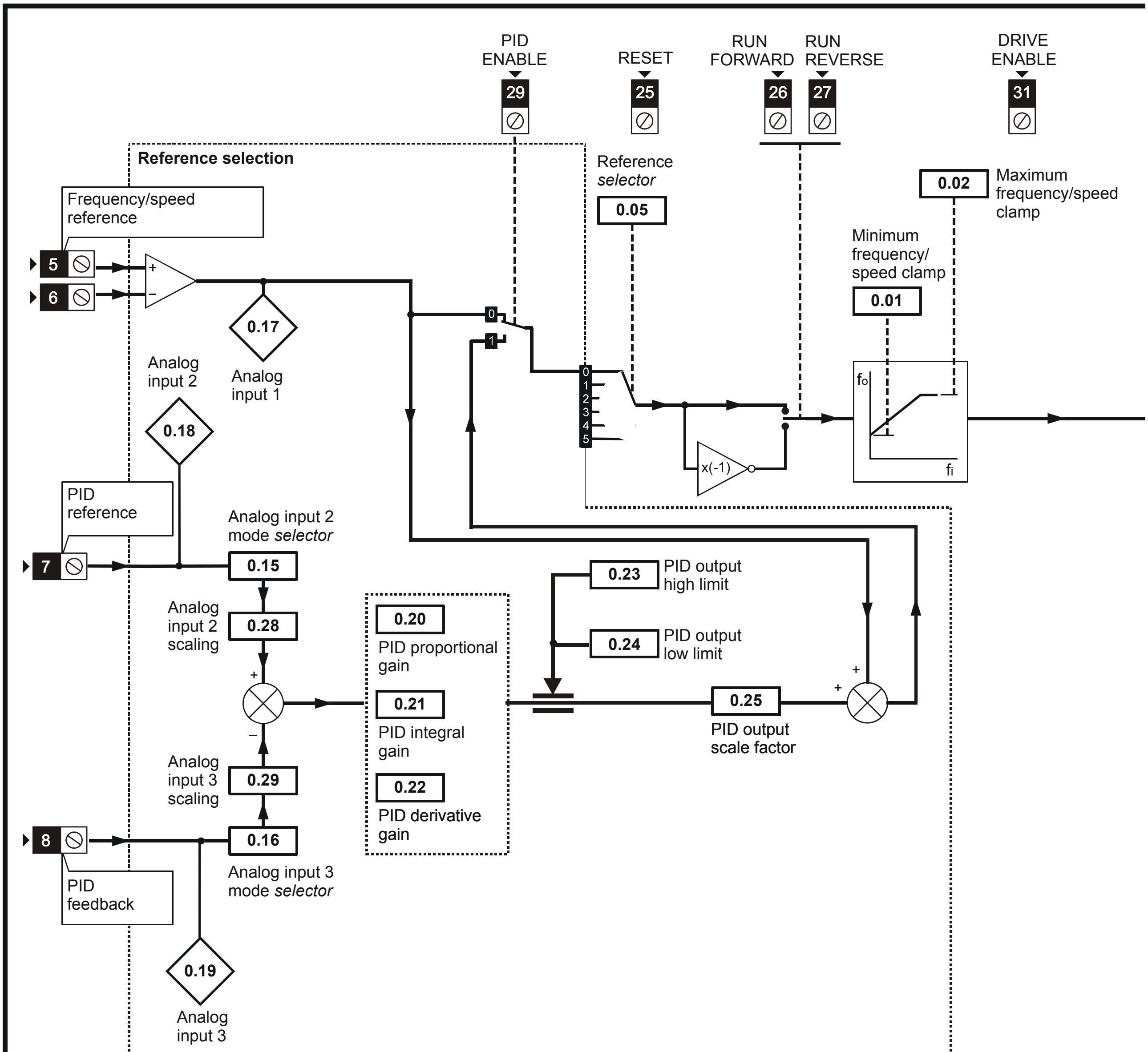
Table 6-10 Macro 5 menu 0 programmable parameters

Parameter			Range(⇕) OL	Range(⇕) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.15	T7 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
0.16	T8 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)		VOLt (6)			RW	Txt				US
0.17	T5/6 analog input 1 level	**(7.01)**	±100.00 %					RO	Bi		NC	PT	
0.18	T7 analog input 2 level	**(7.02)**	±100.0 %					RO	Bi		NC	PT	
0.19	T8 analog input 3 level	**(7.03)**	±100.0 %					RO	Bi		NC	PT	
0.20	PID P gain	**(14.10)**	0.000 to 4.000		1.000			RW	Uni				US
0.21	PID I gain	**(14.11)**	0.000 to 4.000		0.500			RW	Uni				US
0.22	PID D gain	**(14.12)**	0.000 to 4.000		0.000			RW	Uni				US
0.23	PID upper limit	**(14.13)**	0.00 to 100.00 %		100.00			RW	Uni				US
0.24	PID lower limit	**(14.14)**	±100.0 %		100.00			RW	Bi				US
0.25	PID scaling	**(14.15)**	0.000 to 4.000		1.000			RW	Uni				US
0.26	Preset reference 7	**(1.27)**	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.27	Preset reference 8	**(1.28)**	±SPEED_FREQ_MAX Hz/rpm		0.0			RW	Bi				US
0.28	T7 analog input 2 scaling	**(7.12)**	0 to 4.000		1.000			RW	Uni				US
0.29	T8 analog input 3 scaling	**(7.16)**	0 to 4.000		1.000			RW	Uni				US
0.30	PID optional enable source	**(14.09)**	Pr **0.00** to **21.51**		Pr **0.00**			RW	Uni			PT	US

Table 6-11 Parameter set-up to reproduce Macro 5 on a Unidrive SP

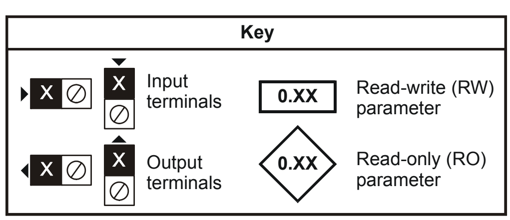
Parameter		Value	
		OL	**CL**
7.10	Analog input 1 destination	Pr **0.00**	
7.14	Analog input 2 destination	Pr **1.27**	
7.15	Analog input 3 mode	Volt (6)	
7.18	Analog input 3 destination	Pr **1.28**	
8.26	T29 digital input 6 destination	Pr **14.08**	
8.39	T28 and T29 digital input auto selection disable	On (1)	
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **0.00**	
11.05	Define Pr **0.15**	Pr **7.11**	
11.06	Define Pr **0.16**	Pr **7.15**	
11.07	Define Pr **0.17**	Pr **7.01**	
11.08	Define Pr **0.18**	Pr **7.02**	
11.09	Define Pr **0.19**	Pr **7.03**	
11.10	Define Pr **0.20**	Pr **14.10**	
11.11	Define Pr **0.21**	Pr **14.11**	
11.12	Define Pr **0.22**	Pr **14.12**	
11.13	Define Pr **0.23**	Pr **14.13**	
11.14	Define Pr **0.24**	Pr **14.14**	
11.15	Define Pr **0.25**	Pr **14.15**	
11.16	Define Pr **0.26**	Pr **1.27**	
11.17	Define Pr **0.27**	Pr **1.28**	
11.18	Define Pr **0.28**	Pr **7.12**	
11.19	Define Pr **0.29**	Pr **7.16**	
11.20	Define Pr **0.30**	Pr **14.09**	
14.02	Main reference source	Pr **7.01**	
14.03	PID reference source	Pr **1.27**	
14.04	PID feedback source	Pr **1.28**	
14.16	PID output destination	Pr **1.36**	

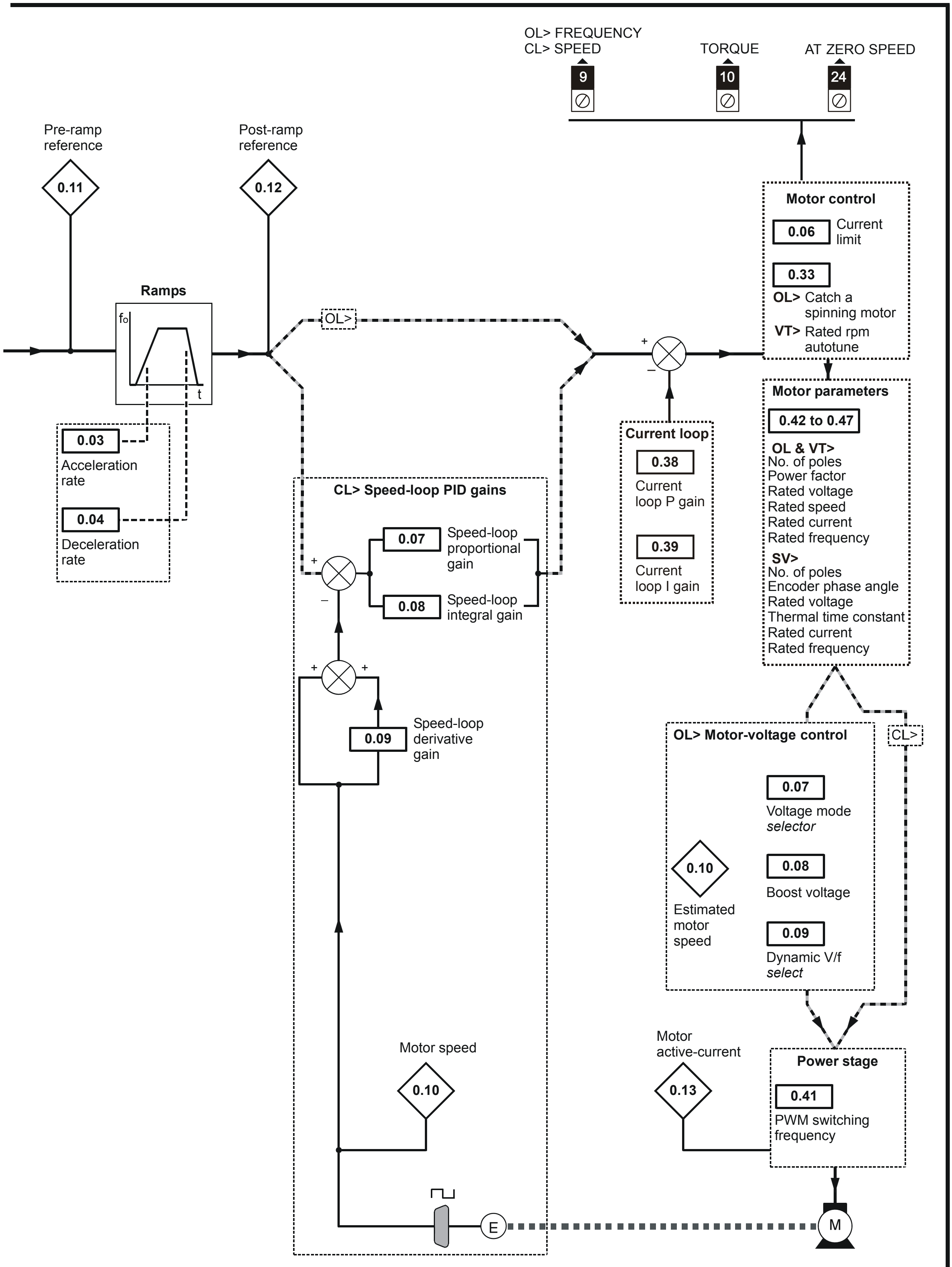
Figure 6-5 Macro 5 PID control logic diagram



Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	(Not used)
0.15	Analog input 2 (PID reference) mode *selector*
0.16	Analog input 3 (PID feedback) mode *selector*
0.17	Analog input 1 (freq./speed ref.)
0.18	Analog input 2 (PID reference)
0.19	Analog input 3 (PID feedback)
0.20	PID proportional gain
0.21	PID integral gain
0.22	PID derivative gain
0.23	PID output high limit
0.24	PID output low limit
0.25	PID output scale factor
0.26	Preset reference 7
0.27	Preset reference 8
0.28	Analog input 2 scaling
0.29	Analog input 3 scaling
0.30	Optional PID-enable source *selector*

Menu 0 changes from default configuration




OL> FREQUENCY
CL> SPEED
TORQUE
AT ZERO SPEED
9
10
24
Pre-ramp reference
0.11
Post-ramp reference
0.12
Ramps
OL>
Motor control
0.06 Current limit
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
0.03 Acceleration rate
0.04 Deceleration rate
CL> Speed-loop PID gains
0.07 Speed-loop proportional gain
0.08 Speed-loop integral gain
0.09 Speed-loop derivative gain
Current loop
0.38 Current loop P gain
0.39 Current loop I gain
OL> Motor-voltage control
CL>
0.07 Voltage mode selector
0.08 Boost voltage
0.09 Dynamic V/f select
0.10 Estimated motor speed
Motor speed
0.10
Motor active-current
0.13
Power stage
0.41 PWM switching frequency
E
M

6.7 Macro 6 - Axis limit control

Macro 6	**Axis limit control**
The axis limit control macro configures the drive for use with limit switches so that the drive is stopped when a position limit has been reached. The speed reference can be either unipolar or bipolar.	

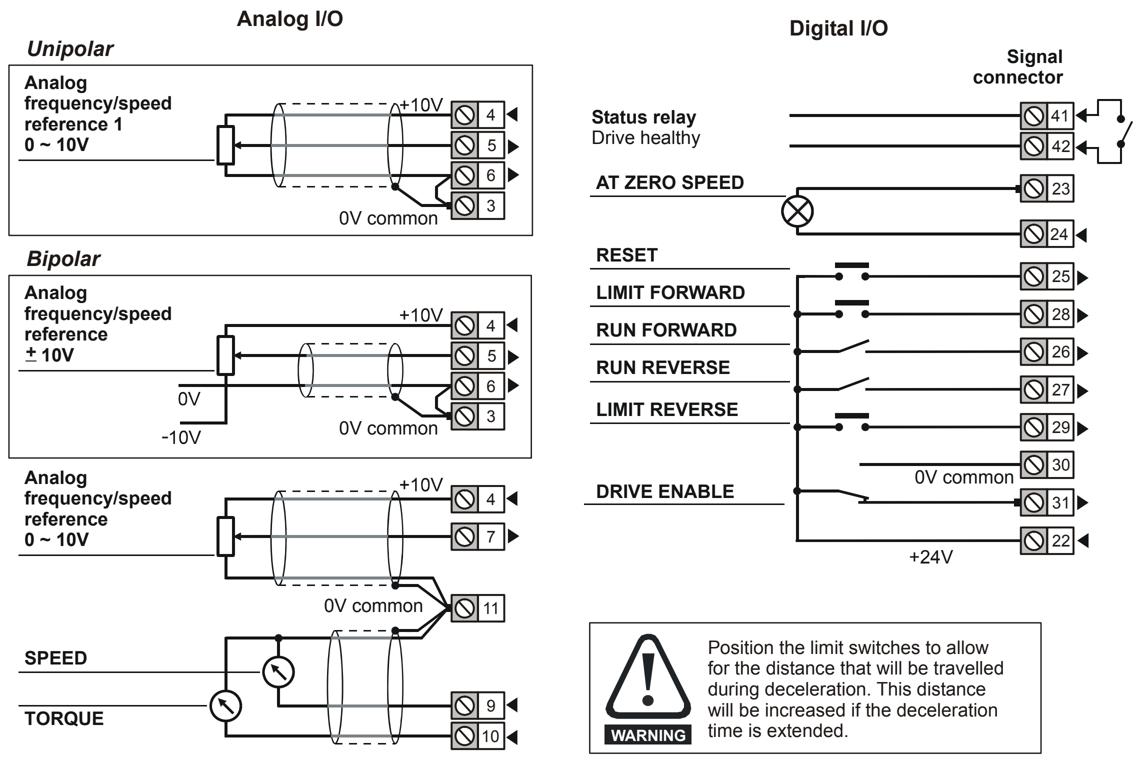


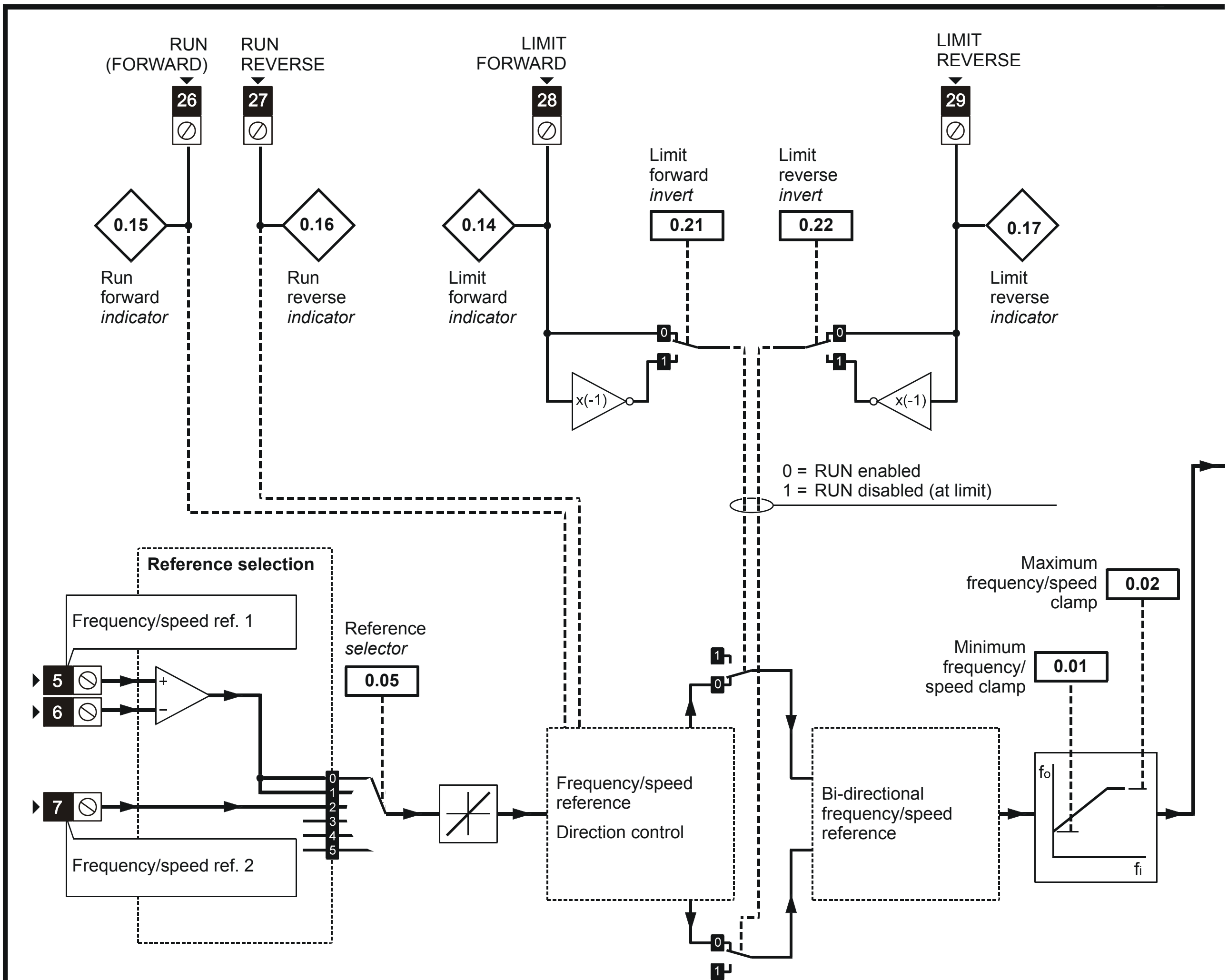
Table 6-12 Macro 6 menu 0 programmable parameters

Parameter			Range(⇳) OL	Range(⇳) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	T28 digital input 5 state	{**8.05**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.15	T26 digital I/O 3 state	{**8.03**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.16	T27 digital input 4 state	{**8.04**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.17	T29 digital input 6 state	{**8.06**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.18	Stop mode	{**6.01**}	COASt (0), rP (1), rP.dcl (2), dcl (3), td.dcl (4)	COASt (0), rP (1), no.rP (2)	rP (1)		no.rP (2)	RW	Txt				US
0.19	Hold zero speed	{**6.08**}	OFF (0) or On (1)		OFF (0)		On (1)	RW	Bit				US
0.20	OL> Deceleration rate 2	{**2.22**}	0.0 to 3,200.0 s/100Hz		5.0			RW	Uni				US
	CL> Not used												
0.21	T28 digital input 5 invert	{**8.15**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.22	T29 digital input 6 invert	{**8.16**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.23	Not used												
0.24	Not used												
0.25	Not used												
0.26	Not used												
0.27	Not used												
0.28	Not used												
0.29	Not used												
0.30	Not used												

Table 6-13 Parameter set-up to reproduce Macro 6 on a Unidrive SP

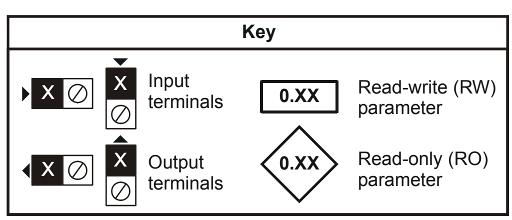
Parameter		Value	
		OL	**CL**
1.10	Bipolar select	On (1)	
2.04	Ramp mode	FASt	
2.22	Deceleration rate 2	1.0	2.0
8.39	T28 & T29 digital input auto selection disable	On (1)	
8.25	T28 digital input 5 destination	Pr **6.35**	
8.26	T29 digital input 6 destination	Pr **6.36**	
9.04	Logic function 1 source 1	Pr **6.35**	Pr **0.00**
9.05	Logic function 1 source 1 invert	On (1)	OFF (0)
9.06	Logic function 1 source 2	Pr **6.36**	Pr **0.00**
9.07	Logic function 1 source 2 invert	On (1)	OFF (0)
9.08	Logic function 1 output invert	On (1)	OFF (0)
9.10	Logic function 1 destination	Pr **2.35**	Pr **0.00**
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **8.05**	
11.05	Define Pr **0.15**	Pr **8.03**	
11.06	Define Pr **0.16**	Pr **8.04**	
11.07	Define Pr **0.17**	Pr **8.06**	
11.08	Define Pr **0.18**	Pr **6.01**	
11.09	Define Pr **0.19**	Pr **6.08**	
11.10	Define Pr **0.20**	Pr **2.22**	Pr **0.00**
11.11	Define Pr **0.21**	Pr **8.15**	
11.12	Define Pr **0.22**	Pr **8.16**	
11.13	Define Pr **0.23**	Pr **0.00**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **0.00**	
11.16	Define Pr **0.26**	Pr **0.00**	
11.17	Define Pr **0.27**	Pr **0.00**	
11.18	Define Pr **0.28**	Pr **0.00**	
11.19	Define Pr **0.29**	Pr **0.00**	
11.20	Define Pr **0.30**	Pr **0.00**	

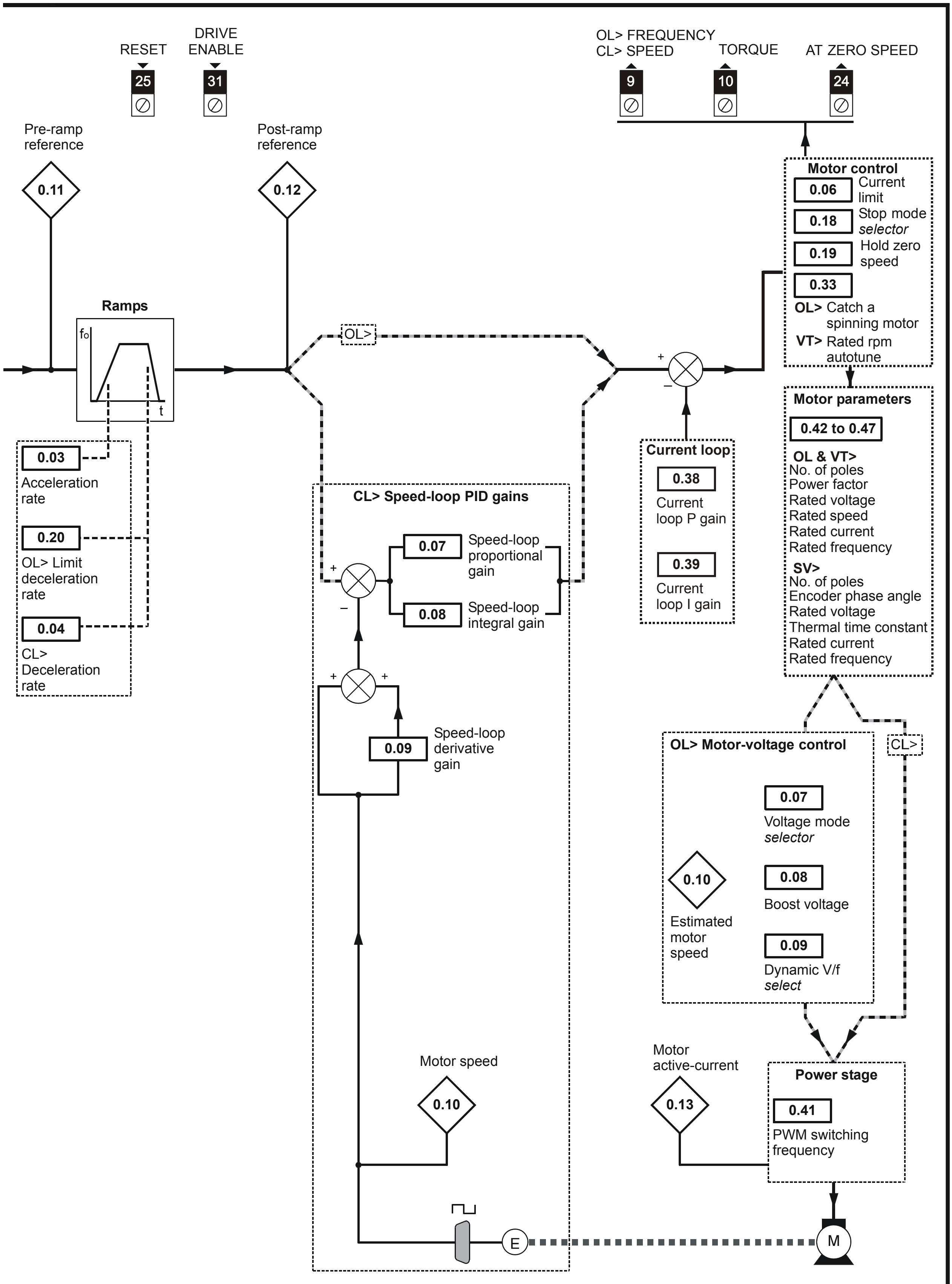
Figure 6-6 Macro 6 Axis limit control logic diagram



Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Limit forward *indicator*
0.15	Run forward *indicator*
0.16	Run reverse *indicator*
0.17	Limit reverse *indicator*
0.18	Stop mode *selector*
0.19	Hold zero speed *enable*
0.20	OL> Limit deceleration rate CL> (not used)
0.21	Limit forward *invert*
0.22	Limit reverse *invert*
0.23	(not used)
0.24	(not used)
0.25	(not used)
0.26	(not used)
0.27	(not used)
0.28	(not used)
0.29	(not used)
0.30	(not used)

Menu 0 changes from default configuration




RESET
DRIVE ENABLE
25
31
OL> FREQUENCY
CL> SPEED
TORQUE
AT ZERO SPEED
9
10
24
Pre-ramp reference
0.11
Post-ramp reference
0.12
Ramps
f0
t
OL>
Motor control
0.06 Current limit
0.18 Stop mode selector
0.19 Hold zero speed
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Motor parameters
0.42 to 0.47
OL & VT>
No. of poles
Power factor
Rated voltage
Rated speed
Rated current
Rated frequency
SV>
No. of poles
Encoder phase angle
Rated voltage
Thermal time constant
Rated current
Rated frequency
0.03 Acceleration rate
0.20 OL> Limit deceleration rate
0.04 CL> Deceleration rate
CL> Speed-loop PID gains
0.07 Speed-loop proportional gain
0.08 Speed-loop integral gain
0.09 Speed-loop derivative gain
Current loop
0.38 Current loop P gain
0.39 Current loop I gain
OL> Motor-voltage control
0.07 Voltage mode selector
0.08 Boost voltage
0.09 Dynamic V/f select
0.10 Estimated motor speed
CL>
Motor speed
0.10
Motor active-current
0.13
Power stage
0.41 PWM switching frequency
E
M

6.8 Macro 7 - Brake control

WARNING

The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

WARNING

Where a safety hazard may exist the drive alone must not be permitted to release the brake. An independent safety interlock must be provided to ensure safe operation in the event of drive failure or incorrect operation.

NOTE

It is recommended that the brake control in menu 12 is used instead of Macro 7 - Brake control.

Macro 7	Brake control
The brake control macro configures the drive to apply or release a mechanical brake on a motor in a crane or hoist application. The drive issues a brake release signal via a digital output when the relevant conditions are met.	

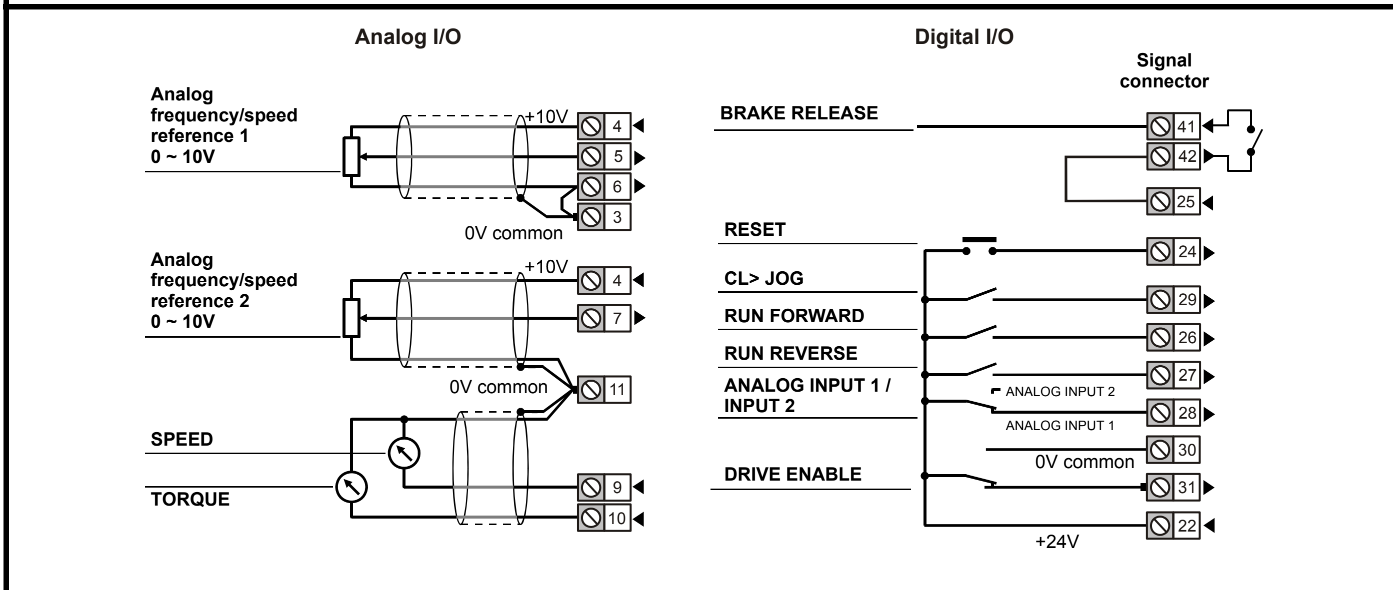


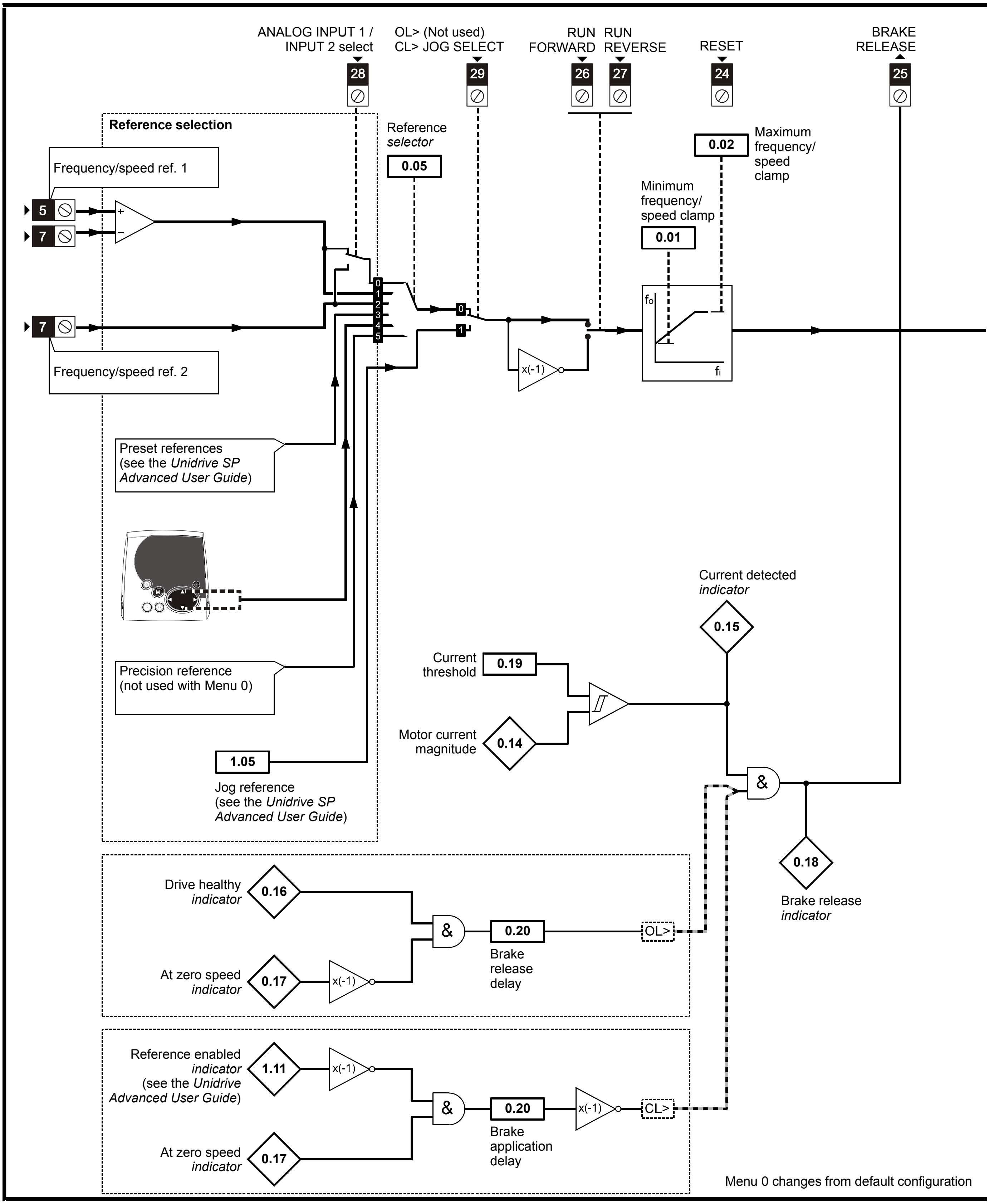
Table 6-14 Macro 7 menu 0 programmable parameters

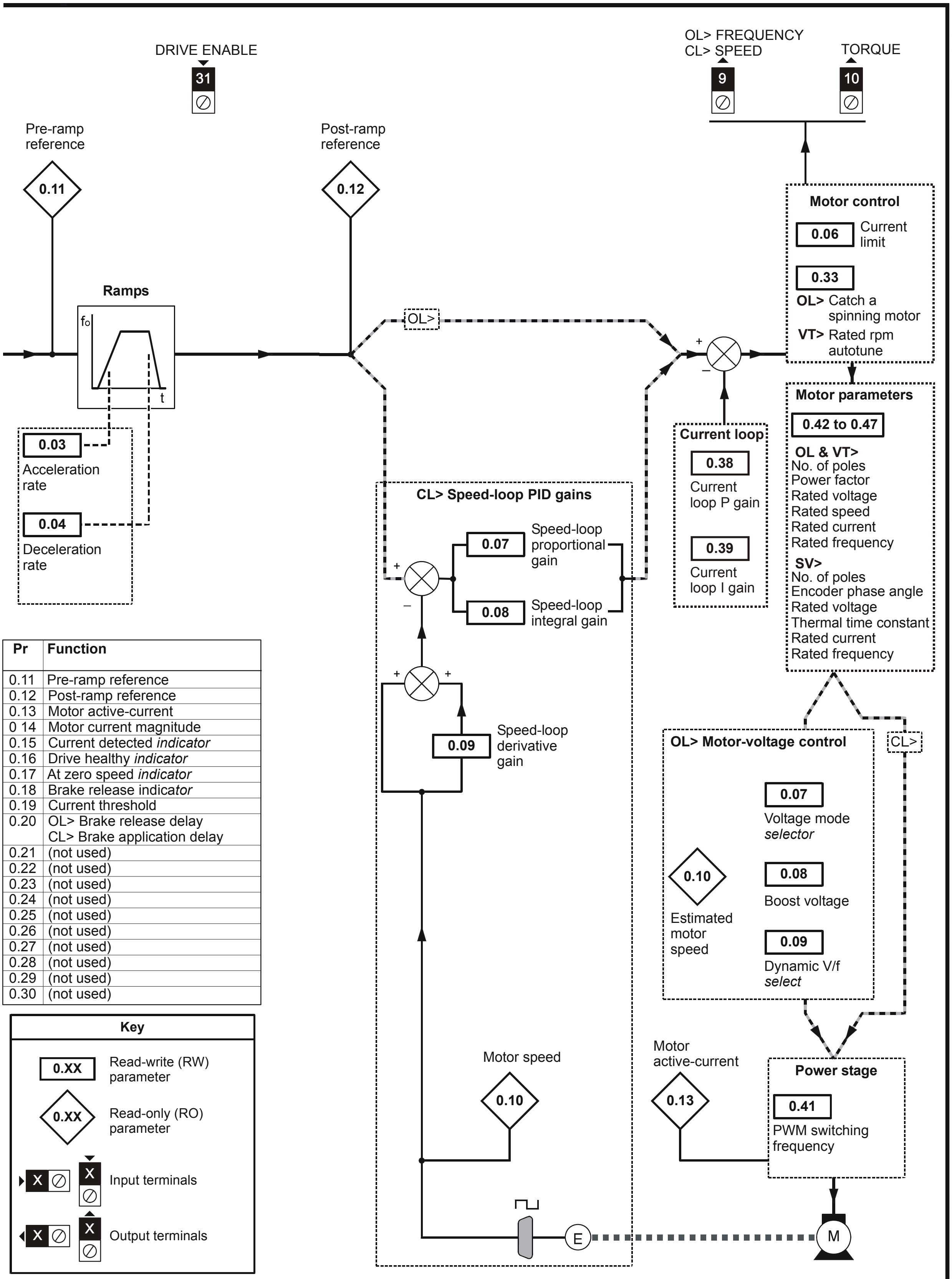
Parameter			Range(⇕) OL	Range(⇕) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	Current magnitude	{**4.01**}	0 to DRIVE_CURRENT_MAX A					RO	Uni	FI	NC	PT	
0.15	Threshold detector 1 output	{**12.01**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.16	Drive ok	{**10.01**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.17	Zero speed	{**10.03**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.18	Logic function 1 output	{**9.01**}	OFF (0) or On (1)					RO	Bit		NC	PT	
0.19	Threshold detector 1 level	{**12.04**}	0.00 to 100.00 %		0.00			RW	Uni				US
0.20	Logic function 2 delay	{**9.19**}	±25.0 s		0.0			RW	Bi				US
0.21	Not used												
0.22	Not used												
0.23	Not used												
0.24	Not used												
0.25	Not used												
0.26	Not used												
0.27	Not used												
0.28	Not used												
0.29	Not used												
0.30	Not used												

Table 6-15 Parameter set-up to reproduce Macro 7 on a Unidrive SP

Parameter		Default(⇨) OL	Default(⇨) CL
2.04	Ramp mode	FASt (0)	
3.05	Zero speed threshold	2.0	2
5.27	Enable slip compensation	OFF (0)	
6.08	Hold zero speed	On (1)	
8.21	T24 digital I/O source / destination	Pr **10.33**	
8.22	T25 digital I/O source / destination	Pr **9.01**	
8.31	T24 digital output enable	OFF (0)	
8.32	T25 digital output enable	On (1)	
9.04	Logic function 1 source 1	Pr **12.01**	
9.06	Logic function 1 source 2	Pr **9.02**	
9.07	Logic function 1 source 2 invert	OFF (0)	On (1)
9.14	Logic function 2 source 1	Pr **10.01**	Pr **1.11**
9.15	Logic function 2 output invert	OFF (0)	On (1)
9.16	Logic function 2 source 2	Pr **10.03**	
9.17	Logic function 2 source 2 invert	On (1)	OFF (0)
9.19	Logic function 2 delay	0.2	
11.01	Define Pr **0.11**	Pr **1.03**	
11.02	Define Pr **0.12**	Pr **2.01**	
11.03	Define Pr **0.13**	Pr **4.02**	
11.04	Define Pr **0.14**	Pr **4.01**	
11.05	Define Pr **0.15**	Pr **12.01**	
11.06	Define Pr **0.16**	Pr **10.01**	
11.07	Define Pr **0.17**	Pr **10.03**	
11.08	Define Pr **0.18**	Pr **9.01**	
11.09	Define Pr **0.19**	Pr **12.04**	
11.10	Define Pr **0.20**	Pr **9.19**	
11.11	Define Pr **0.21**	Pr **0.00**	
11.12	Define Pr **0.22**	Pr **0.00**	
11.13	Define Pr **0.23**	Pr **0.00**	
11.14	Define Pr **0.24**	Pr **0.00**	
11.15	Define Pr **0.25**	Pr **0.00**	
11.16	Define Pr **0.26**	Pr **0.00**	
11.17	Define Pr **0.27**	Pr **0.00**	
11.18	Define Pr **0.28**	Pr **0.00**	
11.19	Define Pr **0.29**	Pr **0.00**	
11.20	Define Pr **0.30**	Pr **0.00**	
12.03	Threshold detector 1 source	Pr **4.01**	
12.04	Threshold detector 1 level	**10.00**	
12.05	Threshold detector 1 hysterisis	**10.00**	

Figure 6-7 Macro 7 Brake control logic diagram





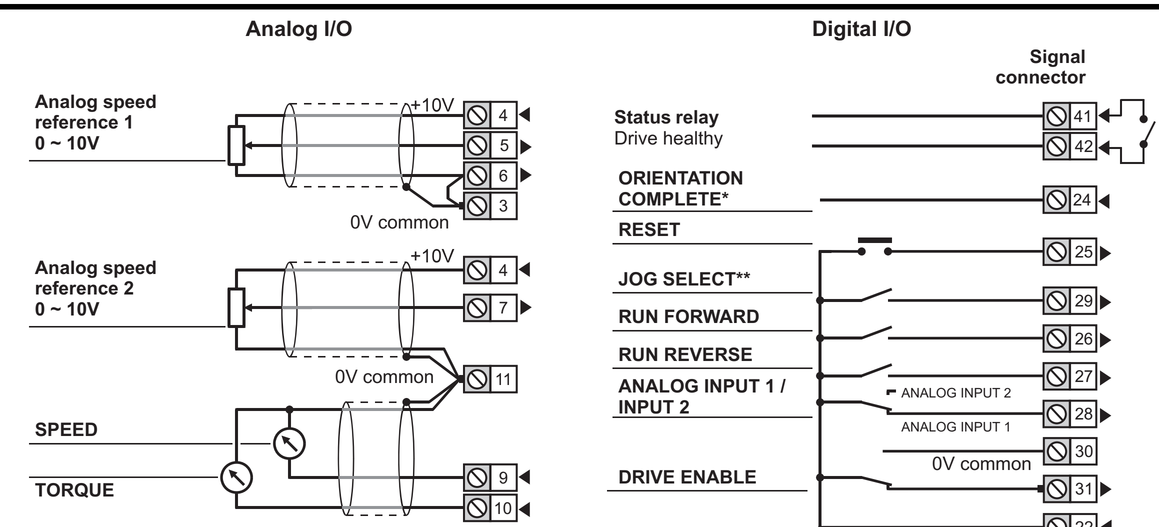
Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Motor current magnitude
0.15	Current detected *indicator*
0.16	Drive healthy *indicator*
0.17	At zero speed *indicator*
0.18	Brake release indicator
0.19	Current threshold
0.20	OL> Brake release delay CL> Brake application delay
0.21	(not used)
0.22	(not used)
0.23	(not used)
0.24	(not used)
0.25	(not used)
0.26	(not used)
0.27	(not used)
0.28	(not used)
0.29	(not used)
0.30	(not used)

6.9 Macro 8 - Digital Lock

Macro 8	Motorized potentiometer

Only available in closed loop vector or servo operating modes. This macro requires that a feedback solutions module (SM-Universal Encoder Plus, SM-Encoder Plus or SM-Resolver) is installed in slot 3 of the drive. This macro uses the feedback solutions module in slot 3 as the position reference and the drives encoder port as the position feedback source.

Digital lock: The drive operates as a slave in a closed loop master-slave system. The slave motor is digitally locked to the master motor.
Shaft orientation: The motor speed is controlled in the same way as for default operation, but the motor shaft can be orientated to a specified angular position before and/or after running the motor.



	Pr **0.15**
0	Speed control
1	Rigid digital lock with feed forward
2	Rigid digital lock without feed forward
3	Non rigid digital lock with feed forward
4	Non rigid digital lock without feed forward
5	Orientate when stopping the drive
6	Orientate when enabling and stopping the drive

** Shaft orientation only*
*** Relative Jog when in Digital Lock mode*

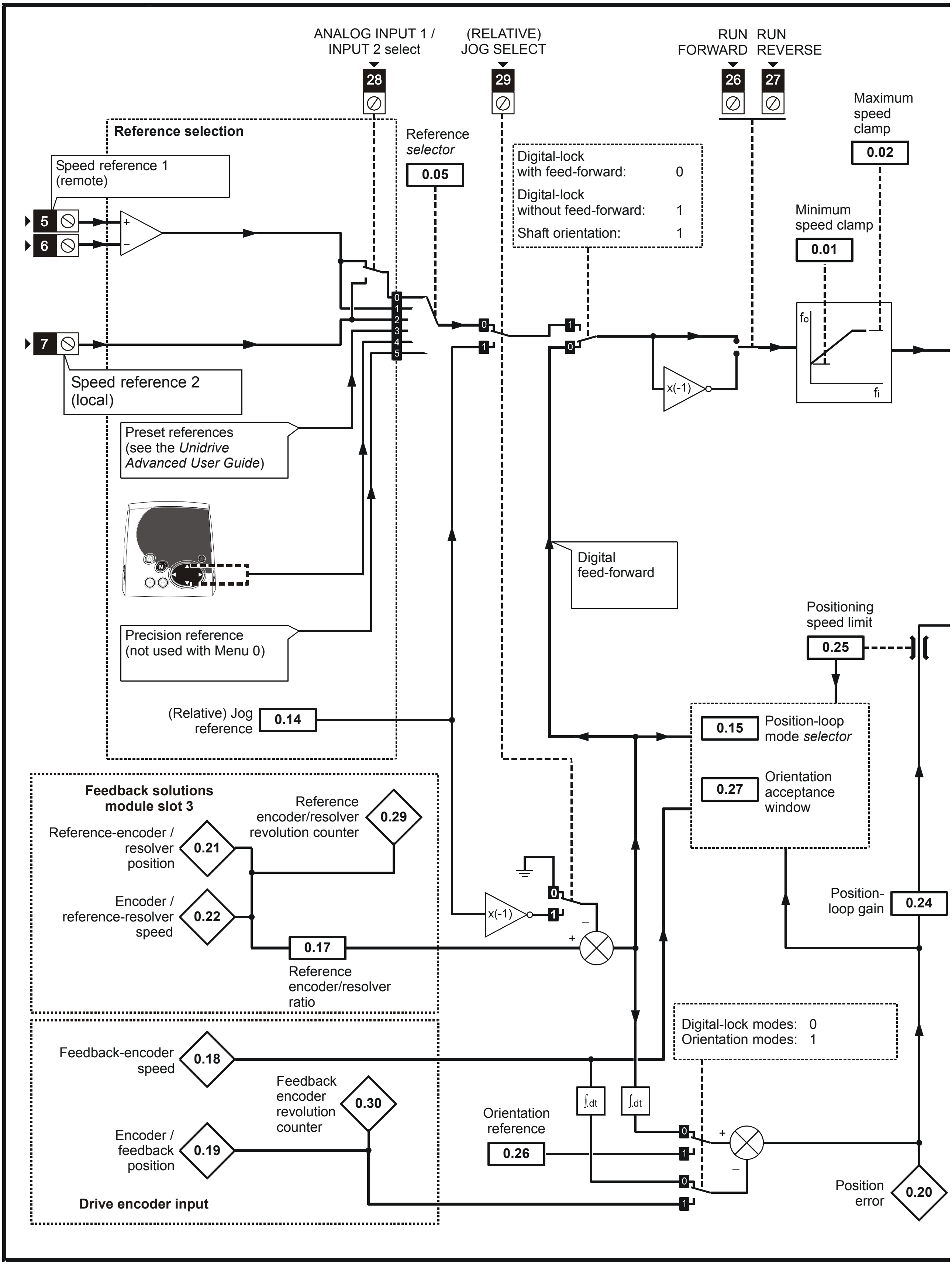
Table 6-16 Macro 8 menu 0 programmable parameters

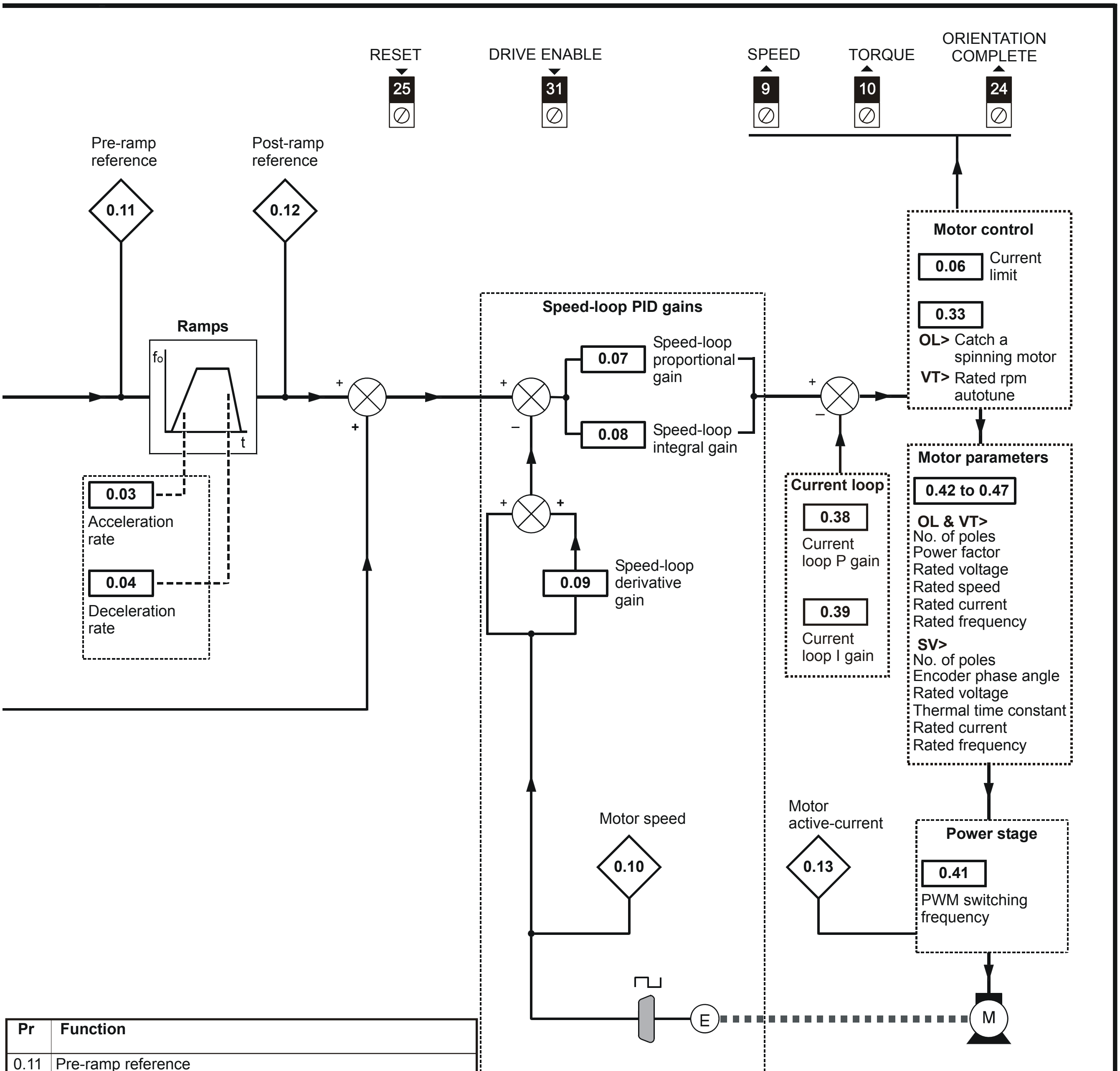
Parameter			Range(⇳) OL	Range(⇳) CL	Default(⇨) OL	Default(⇨) VT	Default(⇨) SV	Type					
0.11	Pre-ramp reference	**{1.03}**		±SPEED_FREQ_MAX Hz/rpm				RO	Bi		NC	PT	
0.12	Post ramp reference	**{2.01}**		±SPEED_FREQ_MAX Hz/rpm				RO	Bi			PT	
0.13	Active current	**{4.02}**		±DRIVE_CURRENT_MAX A				RO	Bi	FI	NC	PT	
0.14	Relative jog reference	**{13.17}**		0.0 to 4,000.0 rpm		0.0		RW	Uni		NC		
0.15	Position controller mode	**{13.10}**		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)		Rigid position control - feed fwd (1)		RW	Uni				US
0.16	Drive encoder lines per revolution	**{3.34}**		0 to 50,000		1024	4096	RW	Uni				US
0.17	Ratio numerator	**{13.07}**		0.000 to 4.000		1.000		RW	Uni				US
0.18	Drive encoder speed feedback	**{3.27}**		±40,000.0 rpm				RO	Bi	FI	NC	PT	
0.19	Drive encoder position	**{3.29}**		0 to 65,535 1/2^{16}ths of a revolution				RO	Uni	FI	NC	PT	
0.20	Position error	**{13.02}**		-32,768 to +32,767				RO	Uni		NC	PT	
0.21	Position	**{x.05}**		0 to 65,535 1/2^{16}ths of a revolution				RO	Uni	FI	NC	PT	
0.22	Speed	**{x.03}**		±40,000.0 rpm				RO	Bi	FI	NC	PT	
0.23	Equivalent lines per revolution	**{x.10}**		0 to 50,000		4096		RW	Uni				US
0.24	Position controller P gain	**{13.09}**		0.00 to 100.00 rad $s^{-1}/_{rad}$		25.0		RW	Uni				US
0.25	Position controller speed clamp	**{13.12}**		0 to 250		150		RW	Uni				US
0.26	Orientation position reference	**{13.13}**		0 to 65,535		0		RW	Uni				US
0.27	Orientation acceptance window	**{13.14}**		0 to 4,096		256		RW	Uni				US
0.28	Stop mode	**{6.01}**		COASt (0), rP (1), no.rP (2)		rP (1)	no.rP (2)	RW	Txt				US
0.29	Revolution counter	**{x.04}**		0 to 65,535 revolutions				RO	Uni	FI	NC	PT	
0.30	Drive encoder revolution counter	**{3.28}**		0 to 65,535 revolutions				RO	Uni	FI	NC	PT	

Table 6-17 Parameter set-up to reproduce Macro 8 on a Unidrive SP

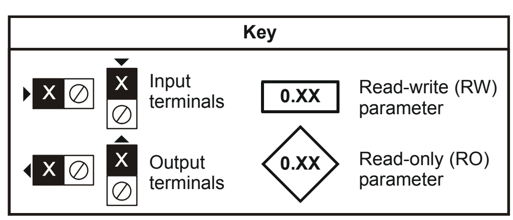
Parameter		Value
		CL
2.02	Ramp enable	OFF (0)
2.04	Ramp mode	FASt
8.21	T24 digital I/O source / destination	Pr **13.15**
11.01	Define Pr **0.11**	Pr **1.03**
11.02	Define Pr **0.12**	Pr **2.01**
11.03	Define Pr **0.13**	Pr **4.02**
11.04	Define Pr **0.14**	Pr **13.17**
11.05	Define Pr **0.15**	Pr **13.10**
11.06	Define Pr **0.16**	Pr **3.34**
11.07	Define Pr **0.17**	Pr **13.07**
11.08	Define Pr **0.18**	Pr **3.27**
11.09	Define Pr **0.19**	Pr **3.29**
11.10	Define Pr **0.20**	Pr **13.02**
11.11	Define Pr **0.21**	Pr **17.05**
11.12	Define Pr **0.22**	Pr **17.03**
11.13	Define Pr **0.23**	Pr **17.10**
11.14	Define Pr **0.24**	Pr **13.09**
11.15	Define Pr **0.25**	Pr **13.12**
11.16	Define Pr **0.26**	Pr **13.13**
11.17	Define Pr **0.27**	Pr **13.14**
11.18	Define Pr **0.28**	Pr **6.01**
11.19	Define Pr **0.29**	Pr **17.04**
11.20	Define Pr **0.30**	Pr **3.28**
13.04	Position controller reference source	Slot 3 (3)
13.10	Position loop mode	1

Figure 6-8 Macro 8 Digital lock logic diagram





Pr	Function
0.11	Pre-ramp reference
0.12	Post-ramp reference
0.13	Motor active-current
0 14	Relative jog reference
0.15	Position loop mode *selector*
0.16	Feedback encoder no. of lines per revolution (drive)
0.17	Reference encoder/resolver ratio
0.18	Feedback-encoder/Reference-resolver speed (drive)
0.19	Feedback-encoder/Reference-resolver position (drive)
0.20	Position error
0.21	Reference-encoder/Feedback-resolver position (option)
0.22	Reference-encoder/Feedback-resolver speed (option)
0.23	Reference encoder no. of lines/pulses per revolution (option)
0.24	Position-loop gain
0.25	Positioning speed limit
0.26	Orientation reference
0.27	Orientation acceptance window
0.28	Stop mode *selector*
0.29	Reference encoder/resolver revolution counter
0.30	Feedback encoder/resolver revolution counter



Menu 0 changes from default configuration

7 Serial communications protocol

7.1 ANSI communications protocol

7.1.1 Introduction

Unidrive SP supports an ANSIx3.28 type comms protocol as supported by previous Control Techniques products with some modification to allow access to 32 bit parameters. This chapter describes the implementation of the protocol for Unidrive SP.

7.1.2 Physical layer and UART

Attribute	Description
Physical layer	2 wire EIA485
Bit stream	Standard UART asynchronous symbols with Non Return to Zero (NRZ)
Symbol	Each symbol consists of: 1 start bit 7 data bits (ASCII) 1 parity bit (even parity) 1 stop bit
Baud rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400

7.1.3 Reading a parameter

The command to read a parameter is:

EOT	End of transmission (Ctl D)
A1	Drive address: 1st digit
A1	Drive address: 1st digit
A2	Drive address: 2nd digit
A2	Drive address: 2nd digit
M1	Menu number: 1st digit
M2	Menu number: 2nd digit
P1	Parameter number: 1st digit
P2	Parameter number: 2nd digit
ENQ	Enquiry (Ctl E)

If the message is correct and the parameter exists the response is:

STX	Start of text (Ctl B)
M1	Menu number: 1st digit
M2	Menu number: 2nd digit
P1	Parameter number: 1st digit
P2	Parameter number: 2nd digit
D1	Data: 1st digit
D2	Data: 2nd digit
-	
-	
Dn	Data: nth digit
ETX	End of text (Ctl C)
	Checksum

The length of the data field varies depending on the number of significant digits required to represent the value of the parameter. The maximum length is 12 digits including the sign and decimal point if present. The data field always starts with a sign, minus sign for negative numbers, or a plus sign for zero and positive numbers. The field may contain a decimal point, but this will not be before all the numbers in the field or after all the numbers in the field. The following examples demonstrate some possible data fields.

Value	Data field
0	+0 (parameter with no decimal places)
0	+0.00 (parameter with 2 decimal places)
1.2	+1.2
-345.78	-345.78
123456	+123456

If the parameter to be read does not exist the End of transmission character (Ctl D) is returned.

The checksum is derived by exclusive ORing the message byte together excluding the STX and the checksum, i.e. Checksum = M1 ^ M2 ^ P1^ P2 ^ D1 ^ D2 ^ ...... Dn ^ ETX. The checksum is an unsigned 8 bit value and if the checksum is less than 32 then 32 is added to the calculated checksum.

7.1.4 Writing to a parameter

The command to write to a parameter is:

EOT	End of transmission (Ctl D)
A1	Drive address: 1st digit
A1	Drive address: 1st digit
A2	Drive address: 2nd digit
A2	Drive address: 2nd digit
STX	Start of text (Ctl B)
M1	Menu number: 1st digit
M2	Menu number: 2nd digit
P1	Parameter number: 1st digit
P2	Parameter number: 2nd digit
D1	Data: 1st digit
D2	Data: 2nd digit
-	
-	
Dn	Data: nth digit
ETX	End of text (Ctl C)
	Checksum

The following rules apply to the data field:

1. The maximum length is 12 characters.
2. The field may contain leading spaces, but not after any other character.
3. A sign character is optional. No sign indicates positive.
4. A decimal point is optional. This can appear at any point in the data field, but not before the sign or before 10 numbers (i.e. the value written should not have more than 9 decimal places). If the decimal point is not in the same position as used by the parameter some accuracy may be lost or extra decimal places added (i.e. if +1.2345 is written to a parameter with one decimal place the result is +1.2, if +1.2 is written to a parameter with three decimal places the result is +1.200). It should be noted that parameters can only have 0, 1, 2, 3, 4, 5, or 6 decimal places.
5. The data field can contain up to 10 numbers, but the value even ignoring decimal points must not exceed the range -2^{31} to 2^{31}-1.

If the parameter is written successfully an Acknowledge character (Ctl F) is returned. If the parameter does not exist, the value written exceeds the allowed parameter range or the data field rules are not obeyed an Not acknowledge character (Ctl U) is returned.

The checksum is derived by exclusive ORing the message byte together excluding the STX and the checksum, i.e. Checksum = M1 ^ M2 ^ P1^ P2 ^ D1 ^ D2 ^ ...... Dn ^ ETX. The checksum is an unsigned 8 bit value and if the checksum is less than 32 then 32 is added to the calculated checksum.

7.1.5 Drive address

The drive only acts on messages received that contain a drive address if the whole drive address or drive group address match the whole address or the group address in the message, or if the address in the message is 0 (i.e. a global message). Global or group addressing allows data to be written to more than one drive with one command. The drive does not give a response to a global or group write message. Although it is possible to perform a global or group read, this would result in messages crashing if more than one drive responds to the command.

Drive address	Message address	Command	Action
7.8	7.8	Read	Read
7.8	7.8	Write	Write
7.8	7.0	Read	Read
7.8	7.0	Write	Write with no response
7.8	0.0	Read	Read
7.8	0.0	Write	Write with no response

7.1.6 Short commands

The following short commands can be used:

NAK	Not acknowledge (Ctl U)

This is the same as requesting the value of the last parameter to be read or written to. The response is the same as for a normal read.

ACK	Acknowledge (Ctl F)

This is the same as requesting the value of the parameter after the last parameter to be read or written to. The response is the same as for a normal read.

BS	Back space (Ctl H)

This is the same as requesting the value of the parameter before the last parameter to be read or written to. The response is the same as for a normal read.

STX	Start of text (Ctl B)
M1	Menu number: 1st digit
M2	Menu number: 2nd digit
P1	Parameter number: 1st digit
P2	Parameter number: 2nd digit
D1	Data: 1st digit
D2	Data: 2nd digit
-	
-	
Dn	Data: nth digit
ETX	End of text (Ctl C)
	Checksum

Writes to the specified parameter at the same drive address as used by the last read or write.

All the short commands will only read from the drive or write to the drive if a valid address has already been sent to the drive in a previous command. The address is registered as being valid once a read or write command has been completed provide the address was valid for the drive even if the parameter does not exist. The valid address is cancelled if a message is received for a non-valid address or one of the following occurs:

1. The command is aborted because a non-numerical value is received in the drive address, menu or parameter numbers.
2. The command is aborted because the two digits for drive address 1st digit, drive address 2nd digit, menu number or parameter number are not the same as each other.
3. EOT is received.
4. A character other than NAK, ACK, BS or STX is sent as a short command.
5. A character other than ENQ is sent at the end of a read command.

7.1.7 Summary of control characters

		ASCII code	Ctl code
STX	Start of text	02	B
ETX	End of text	03	C
EOT	End of transmission	04	D
ENQ	Enquiry	05	E
ACK	Acknowledge	06	F
BS	Back space	08	H
NAK	Not acknowledge	15	U

7.2 CT Modbus RTU specification

This section describes the adaptation of the MODBUS RTU protocol offered on Control Techniques' products. The portable software class which implements this protocol is also defined.

MODBUS RTU is a master slave system with half-duplex message exchange. The Control Techniques (CT) implementation supports the core function codes to read and write registers. A scheme to map between MODBUS registers and CT parameters is defined. The CT implementation also defines a 32bit extension to the standard 16bit register data format.

7.2.1 MODBUS RTU

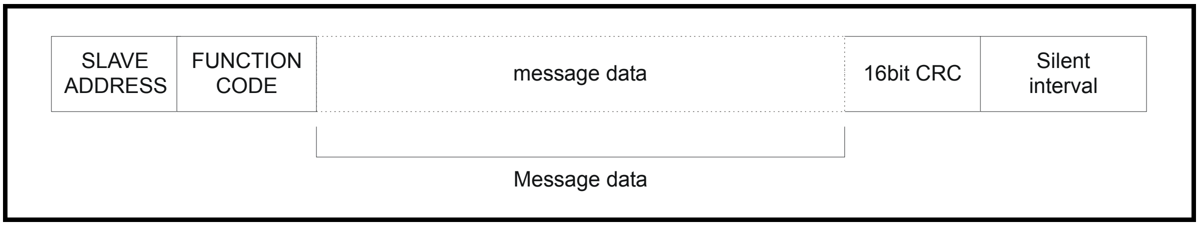
Physical layer

Attribute	Description
Normal physical layer for multi-drop operation	EIA485 2 wire
Bit stream	Standard UART asynchronous symbols with Non Return to Zero (NRZ)
Symbol	Each symbol consists of:- 1 start bit 8 data bits (transmitted least significant bit first) 2 stop bits*
Baud rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200

* The drive will accept a packet with 1 or 2 stop bits but will always transmit 2 stop bits

RTU framing

The frame has the following basic format

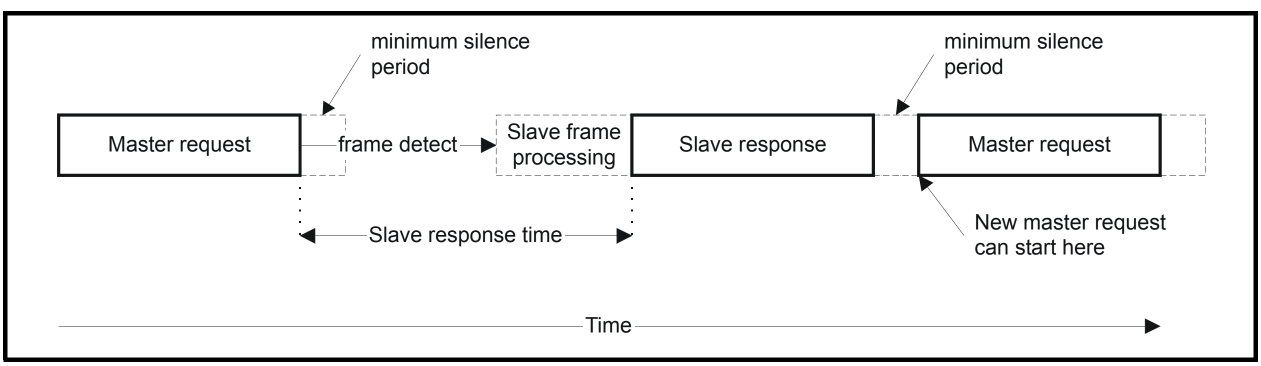


The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2 ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without any gaps greater or equal to the silence period. If an erroneous gap is inserted then receiving nodes may start frame processing early in which case the CRC will fail and the frame will be discarded.

MODBUS RTU is a master slave system. All master requests, except broadcast requests, will lead to a response from an individual slave. The slave will respond (i.e. start transmitting the response) within the quoted maximum slave response time (this time is quoted in the data sheet for all Control Techniques products). The minimum slave response time is also quoted but will never be less that the minimum silent period defined by 3.5 character times.

If the master request was a broadcast request then the master may transmit a new request once the maximum slave response time has expired.

The master must implement a message time out to handle transmission errors. This time out period must be set to the maximum slave response time + transmission time for the response.



7.2.2 Slave address

The first byte of the frame is the slave node address. Valid slave node addresses are 1 through 247 decimal. In the master request this byte indicates the target slave node; in the slave response this byte indicates the address of the slave sending the response.

Global addressing

Address zero addresses all slave nodes on the network. Slave nodes suppress the response messages for broadcast requests.

7.2.3 MODBUS registers

The MODBUS register address range is 16bit (65536 registers) which at the protocol level is represented by indexes 0 through 65535.

PLC registers

Modicon PLCs typically define 4 register 'files' each containing 65536 registers. Traditionally, the registers are referenced 1 through 65536 rather than 0 through 65535. The register address is therefore decremented on the master device before passing to the protocol.

File type	Description
1	Read only bits ("coil")
2	Read / write bits ("coil")
3	Read only 16bit register
4	Read / write 16bit register

The register file type code is NOT transmitted by MODBUS and all register files can be considered to map onto a single register address space. However, specific function codes are defined in MODBUS to support access to the "coil" registers.

All standard CT drive parameters are mapped to register file '4' and the coil function codes are not required.

CT parameter mapping

All CT products are parameterized using the #menu.param notation. Indexes 'menu' and 'param' are in the range 0 through 99. The #menu.param is mapped into the MODBUS register space as menu*100 + param.

To correctly map the parameters at the application layer, the slave device increments the received register address. The consequence of this behavior is that #0.0 cannot be accessed.

CT parameter	MODBUS PLC register	Register address (protocol level)	Comments
#X.Y	40000 + X x 100 + Y	X x 100 + Y - 1	#0.0 cannot be accessed
Examples:			
#1.02	40102	101	
#1.00	40100	99	
#0.01	40001	0	
#20.00	42000	1999	

Data types

The MODBUS protocol specification defines registers as 16bit signed integers. All CT devices support this data size.

Refer to the section 7.2.7 *Extended data types* on page 406 for detail on accessing 32bit register data.

7.2.4 Data consistency

All CT devices support a minimum data consistency of one parameter (16bit or 32bit data). Some devices support consistency for a complete multiple register transaction.

7.2.5 Data encoding

MODBUS RTU uses a 'big-endian' representation for addresses and data items (except the CRC, which is 'little-endian'). This means that when a numerical quantity larger than a single byte is transmitted, the MOST significant byte is sent first. So for example

16 - bits 0x1234 would be 0x12 0x34

32 - bits 0x12345678 would be 0x12 0x34 0x56 0x78

7.2.6 Function codes

The function code determines the context and format of the message data. Bit 7 of the function code is used in the slave response to indicate an exception.

The following function codes are supported:

Code	Description
3	Read multiple 16bit registers
6	Write single register
16	Write multiple 16bit registers
23	Read and write multiple 16bit registers

FC03 Read multiple

Read a contiguous array of registers. The slave imposes an upper limit on the number of registers, which can be read. If this is exceeded the slave will issue an exception code 2.

Table 7-1 Master request

Byte	Description
0	Slave destination node address 1 through 247, 0 is global
1	Function code 0x03
2	Start register address MSB
3	Start register address LSB
4	Number of 16bit registers MSB
5	Number of 16bit registers LSB
6	CRC LSB
7	CRC MSB

Table 7-2 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x03
2	Length of register data in read block (in bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

FC06 Write single register

Writes a value to a single 16bit register. The normal response is an echo of the request, returned after the register contents have been written. The register address can correspond to a 32bit parameter but only 16 bits of data can be sent.

Table 7-3 Master request

Byte	Description
0	Slave node address 1 through 247 0 is global
1	Function code 0 x 06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

Table 7-4 Slave response

Byte	Description
0	Slave source node address
1	Function code 0 x 06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

FC16 Write multiple

Writes a contiguous array of registers. The slave imposes an upper limit on the number of registers which can be written. If this is exceeded the slave will discard the request and the master will time out.

Table 7-5 Master request

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 16bit registers MSB
5	Number of 16bit registers LSB
6	Length of register data to write (in bytes)
7	Register data 0 MSB
8	Register data 0 LSB
7+byte count	CRC LSB
8+byte count	CRC MSB

Table 7-6 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 16bit registers written MSB
5	Number of 16bit registers written LSB
6	CRC LSB
7	CRC MSB

FC23 Read/Write multiple

Writes and reads two contiguous arrays of registers. The slave imposes an upper limit on the number of registers which can be written. If this is exceeded the slave will discard the request and the master will time out.

Table 7-7 Master request

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x17
2	Start register address to read MSB
3	Start register address to read LSB
4	Number of 16bit registers to read MSB
5	Number of 16bit registers to read LSB
6	Start register address to write MSB
7	Start register address to write LSB
8	Number of 16bit registers to write MSB
9	Number of 16bit registers to write LSB
10	Length of register data to write (in bytes)
11	Register data 0 MSB
12	Register data 0 LSB
11+byte count	CRC LSB
12+byte count	CRC MSB

Table 7-8 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x17
2	Length of register data in read block (in bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

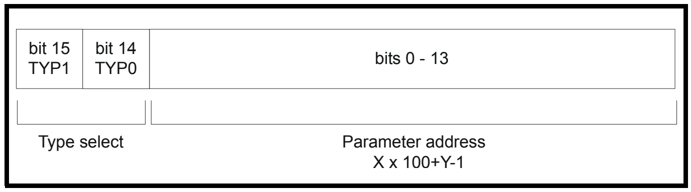
7.2.7 Extended data types

Standard MODBUS registers are 16bit and the standard mapping maps a single #X.Y parameter to a single MODBUS register. To support 32bit data types (integer and float) the MODBUS multiple read and write services are used to transfer a contiguous array of 16bit registers.

Slave devices typically contain a mixed set of 16 bit and 32 bit registers. To permit the master to select the desired 16 bit or 32 bit access the top two bits of the register address are used to indicate the selected data type.

NOTE

The selection is applied for the whole block access.



The 2bit type field selects the data type according to the table below:

Type field bits 15-14	Selected data type	Comments
00	INT16	backward compatible
01	INT32	
10	Float32	IEEE754 standard Not supported on all slaves
11	Reserved	

If a 32bit data type is selected then the slave uses two consecutive 16bit MODBUS registers (in 'big endian'). The master must also set the correct 'number of 16bit registers'.

Example, read #20.21 through #20.24 as 32bit parameters using FC03 from node 8:

Table 7-9 Master request

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x47	Start register address #20.21 (16384 + 2021 - 1) = 18404 = 0x47E4
3	0xE4	
4	0x00	Number of 16bit registers to read #20.21 through #20.24 is 4x32bit registers = 8x16bit registers
5	0x08	
6	CRC LSB	
7	CRC MSB	

Table 7-10 Slave response

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x10	Length of data (bytes) = 4x32bit registers = 16bytes
3-6		#20.21 data
7-10		#20.22 data
11-14		#20.23 data
15-18		#20.24 data
19	CRC LSB	
20	CRC MSB	

Reads when actual parameter type is different from selected

The slave will send the least significant word of a 32 bit parameter if that parameter is read as part of a 16 bit access.

The slave will sign extend the least significant word if a 16 bit parameter is accessed as a 32 bit parameter. The number of 16 bit registers must be even during a 32 bit access.

Example, If #1.28 is a 32 bit parameter with a value of 0x12345678, #1.29 is a signed 16 bit parameter with a value of 0xABCD, and #1.30 is a signed 16 bit parameter with a value of 0x0123.

Read	Start register address	Number of 16bit registers	Response	Comments
#1.28	127	1	0x5678	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#1.28	16511*	2	0x12345678	Full 32bit access
#1.28	16511*	1	Exception 2	Number of words must be even for 32bit access
#1.29	128	1	0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of data
#1.29	16512*	2	0xFFFFABCD	32bit access to a 16bit register will return 32bit sign extended data
#1.30	16513*	2	0x00000123	32bit access to a 16bit register will return 32bit sign extended data
#1.28 - #1.29	127	2	0x5678, 0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#1.28 - #1.29	16511*	4	0x12345678, 0xFFFFABCD	Full 32bit access

* Bit 14 is set to allow 32bit access

Writes when actual parameter type is different from selected

The slave will allow writing a 32 bit value to a 16 bit parameter as long as the 32 bit value is within the normal range of the 16 bit parameter.

The slave will allow a 16 bit write to a 32 bit parameter. The slave will sign extend the written value, therefore the effective range of this type of write will be -32768 to +32767.

Examples, if #1.28 has a range of ±100000, and #1.29 has a range of ±10000.

Write	Start register address	Number of 16bit registers	Data	Comments
#1.28	127	1	0x1234	Standard 16 bit write to a 32bit register. Value written = 0x00001234
#1.28	127	1	0xABCD	Standard 16 bit write to a 32bit register. Value written = 0xFFFFABCD
#1.28	16511	2	0x00001234	Value written = 0x00001234
#1.29	128	1	0x0123	Value written = 0x0123
#1.29	16512	2	0x00000123	Value written = 0x00000123

* Bit 14 is set to allow 32bit access

7.2.8 Exceptions

The slave will respond with an exception response if an error is detected in the master request. If a message is corrupted and the frame is not received or the CRC fails then the slave will not issue an exception. In this case the master device will time out. If a write multiple (FC16 or FC23) request exceeds the slave maximum buffer size then the slave will discard the message. No exception will be transmitted in this case and the master will time out.

Exception message format

The slave exception message has the following format.

Byte	Description
0	Slave source node address
1	Original function code with bit7 set
2	Exception code
3	CRC LSB
4	CRC MSB

Exception codes

The following exception codes are supported.

Code	Description
1	Function code not supported
2	Register address out of range, or request to read too many registers

Parameter over range during block write FC16

The slave processes the write block in the order the data is received. If a write fails due to an out of range value then the write block is terminated. However, the slave does not raise an exception response, rather the error condition is signalled to the master by the number of successful writes field in the response.

Parameter over range during block read/write FC23

There will be no indication that there has been a value out of range during a FC23 access.

7.2.9 CRC

The CRC is a 16bit cyclic redundancy check using the standard CRC-16 polynomial x16 + x15 + x2 + 1. The 16bit CRC is appended to the message and transmitted LSB first.

The CRC is calculated on ALL the bytes in the frame.

7.2.10 Device compatibility parameters

All devices have the following compatibility parameters defined:

Parameter	Description
Device ID	Unique device identification code
Minimum slave response time	The minimum delay between the end of a message from the master and the time at which the master is ready to receive a response from the slave. Refer to para 11-26
Maximum slave response time	When global addressing, the master must wait for this time before issuing a new message. In a network of devices, the slowest time must be used
Maximum baud rate	
32bit float data type supported	If this data type is not supported then an over range error will be raised if this data type is used
Maximum buffer size	Determines the maximum block size.

8 Electronic nameplate

The electronic nameplate system is a means of storing some specific drive parameters within the EEPROM of a Stegmann or Heidenhain encoder attached to the drive. The system used is similar to that implemented in other Control Techniques products. The parameters stored in the encoder are in two categories: motor object parameters, and performance object parameters.

Motor object parameters
The encoder can contain one motor object which holds parameters related to the motor on which the encoder is installed and the motor load.

Performance object parameters
The encoder can contain up to 2 performance objects each of which contains a set of parameters that can be used to give different levels of motor performance.

Loading/storing object parameters
Parameters may be transferred to or from the drive to a suitable encoder attached to the drive or one of its Solutions Modules by entering a code into Pr **x.00** and then resetting the drive as shown in the table below. The z in the request defines the location of the encoder for the transfer (0=drive, 1=Solutions Module slot 1, etc).

Parameter x.00 code	Data transferred	Direction
110z0	Motor object parameters	Drive to encoder
110z1	Motor object parameters	Encoder to drive
110z2	Performance object block 1 parameters	Drive to encoder
110z3	Performance object block 1 parameters	Encoder to drive
110z4	Performance object block 2 parameters	Drive to encoder
110z5	Performance object block 2 parameters	Encoder to drive

The motor object includes some data that does not normally have associated parameters, but would be entered into the object by the motor manufacturer. To allow this data to be transferred to an encoder from a drive without additional equipment, Pr **18.11** to Pr **18.17** can be used to transfer this data if Pr **3.49** is set to one.

It should be noted that the data within the objects in the encoder is undefined until it has been written and that the manufacturer's data is undefined until it has been written by a complete motor object write with Pr **3.49** set to one.

The tables given below show the motor and performance objects. For HIPERFACE encoders the data block and the byte address within the block is given. For EnDat encoders the data is stored as words in the OEM parameter area at the addresses shown. (Byte 0 indicates LS byte).

NOTE

The function only works with SC.Hiper and SC.Endat encoders.

The checksum for each object is Zero – sum of bytes in the object excluding the checksum itself. The number of bytes defines the number of bytes used to generate the checksum. This includes all the parameters and the number of bytes parameter, and so this value will always be 62 for the motor object and 30 for a performance object.

When either a motor or performance object is transferred to the drive all drive parameters are saved. When a performance object is loaded the speed control gain select parameter is automatically set to zero.

Therefore, either the speed controller gains defined in the performance object or those derived from the compliance angle, bandwidth and damping factor parameters are used.

8.1 Motor object

Table 8-1 Motor object

HIPERFACE		EnDat		Parameter	Parameter description	Byte
Block	Address	Address	Byte			
0	0	0	0		Checksum	0
0	1	0	1			1
0	2	1	0		Number of bytes	0
0	3	1	1			1
0	4	2	0	(**18.11**)	Motor object version number	0
0	5	2	1			1
0	6	3	0	(**18.12**)	Motor type (LSW)	0
0	7	3	1			1
0	8	4	0	(**18.13**)	Motor type (MSW)	0
0	9	4	1			1
0	10	5	0	(**18.14**)	Motor manufacturer	0
0	11	5	1			1
0	12	6	0	(**18.15**)	Motor serial number (LSW)	0
0	13	6	1			1
0	14	7	0	(**18.16**)	Motor serial number	0
0	15	7	1			1
0	16	8	0	(**18.17**)	Motor serial number (MSW)	0
0	17	8	1			1
0	18	9	0	**1.06**	Maximum speed	0
0	19	9	1			1
0	20	10	0			2
0	21	10	1	**3.18**	Motor and load inertia	0
0	22	11	0			1
0	23	11	1			2
0	24	12	0	**3.25**	Encoder phase angle	0
0	25	12	1			1
0	26	13	0	**4.15**	Motor thermal time constant	0
0	27	13	1			1
0	28	14	0	**4.25**	Low speed thermal protection mode	0
0	29	14	1	**5.06**	Rated frequency	0
0	30	15	0			1
0	31	15	1	**5.07**	Rated current	0
0	32	16	0			1
0	33	16	1			2
0	34	17	0	**5.08**	Rated load rpm	0
0	35	17	1			1
0	36	18	0			2
0	37	18	1	**5.09**	Rated voltage	0
0	38	19	0			1
0	39	19	1	**5.10**	Rated power factor	0
0	40	20	0			1
0	41	20	1	**5.11**	Motor poles	0
0	42	21	0	**5.17**	Stator resistance (Rs)	0
0	43	21	1			1
0	44	22	0	**5.24**	Transient inductance (Ls')	0
0	45	22	1			1
0	46	23	0			2
0	47	23	1	**5.25**	Stator inductance (Ls)	0
0	48	24	0			1
0	49	24	1			2
0	50	25	0	**5.29**	Motor saturation breakpoint 1	0
0	51	25	1	**5.30**	Motor saturation breakpoint 2	0
0	52	26	0	**5.32**	Motor torque per amp (Kt)	0

HIPERFACE		EnDat		Parameter	Parameter description	Byte
Block	Address	Address	Byte			
0	53	26	1			1
0	54	27	0	**5.33**	Motor volts per 1,000 rpm (Ke)	0
0	55	27	1			1
0	56	28	0		Spare 0	0
0	57	28	1		Spare 1	0
0	58	29	0		Spare 2	0
0	59	29	1		Spare 3	0
0	60	30	0		Spare 4	0
0	61	30	1		Spare 5	0
0	62	31	0		Spare 6	0
0	63	31	1		Spare 7	0

8.2 Performance objects

Table 8-2 Performance object 1

HIPERFACE		EnDat		Parameter	Parameter description	Byte
Block	Address	Address	Byte			
1	0	32	0		Checksum	0
1	1	32	1			1
1	2	33	0		Number of bytes	0
1	3	33	1			1
1	4	34	0	**3.10**	Speed controller Kp gain	0
1	5	34	1			1
1	6	35	0	**3.11**	Speed controller Ki gain	0
1	7	35	1			1
1	8	36	0	**3.12**	Speed controller Kd gain	0
1	9	36	1			1
1	10	37	0	**3.17**	Speed controller set-up method	0
1	11	37	1	**3.19**	Compliance angle	0
1	12	38	0			1
1	13	38	1	**3.20**	Bandwidth	0
1	14	39	0	**3.21**	Damping factor	1
1	15	39	1	**4.05**	Motoring current limit	0
1	16	40	0			1
1	17	40	1	**4.06**	Regen current limit	0
1	18	41	0			1
1	19	41	1	**4.12**	Torque demand filter	0
1	20	42	0	**4.13**	Current controller Kp gain	0
1	21	42	1			1
1	22	43	0	**4.14**	Current controller Ki gain	0
1	23	43	1			1
1	24	44	0		Spare 0	0
1	25	44	1		Spare 1	0
1	26	45	0		Spare 2	0
1	27	45	1		Spare 3	0
1	28	46	0		Spare 4	0
1	29	46	1		Spare 5	0
1	30	47	0		Spare 6	0
1	31	47	1		Spare 7	0

Table 8-3 Performance object 2

HIPERFACE		EnDat		Parameter	Parameter description	Bytes
Block	**Address**	**Address**	**Byte**			
2	0	48	0		Checksum	0
2	1	48	1			1
2	2	49	0		Number of bytes	0
2	3	49	1			1
2	4	50	0	**3.10**	Speed controller Kp gain	0
2	5	50	1			1
2	6	51	0	**3.11**	Speed controller Ki gain	0
2	7	51	1			1
2	8	52	0	**3.12**	Speed controller Kd gain	0
2	9	52	1			1
2	10	53	0	**3.17**	Speed controller set-up method	0
2	11	53	1	**3.19**	Compliance angle	0
2	12	54	0			1
2	13	54	1	**3.20**	Bandwidth	0
2	14	55	0	**3.21**	Damping factor	1
2	15	55	1	**4.05**	Motoring current limit	0
2	16	56	0			1
2	17	56	1	**4.06**	Regen current limit	0
2	18	57	0			1
2	19	57	1	**4.12**	Torque demand filter	0
2	20	58	0	**4.13**	Current controller Kp gain	0
2	21	58	1			1
2	22	59	0	**4.14**	Current controller Ki gain	0
2	23	59	1			1
2	24	60	0		Spare 0	0
2	25	60	1		Spare 1	0
2	26	61	0		Spare 2	0
2	27	61	1		Spare 3	0
2	28	62	0		Spare 4	0
2	29	62	1		Spare 5	0
2	30	63	0		Spare 6	0
2	31	63	1		Spare 7	0

9 Performance

9.1 Digital speed reference

Table 9-1 Accuracy and resolution

	Open loop		Closed loop	
	Preset	**Precision**	**Preset**	**Precision**
Accuracy	0.01%*	0.01%*	0.01%*	0.01%*
Resolution	0.1 Hz	0.001 Hz	0.1 rpm	0.001 rpm

*0.01% of the reference

9.2 Analog reference

Table 9-2 Update rates

		Open Loop				Closed loop			
		Pr 1.36 / Pr 1.37	**Pr 4.08**	**Pr 3.19**	**Other**	**Pr 1.36 / Pr 1.37**	**Pr 4.08**	**Pr 3.22**	**Other**
All kHz	**Analog input 1**	4ms	4ms	4ms	4ms	250μs*	4ms*	250μs*	4ms*
	Analog input 2 / 3	4ms	4ms	4ms	4ms	250μs	250μs	250μs	4ms

* Analog input 1 is subject to a window filter as defined in Pr **7.26**.

Table 9-3 Resolution

	Open loop	Closed loop
Analog input 1	16 bits plus sign*	16 bits plus sign*
Analog input 2 / 3	10 bit plus sign	10 bit plus sign

*16 bit plus sign as a speed reference, resolution = Pr **7.26** x 500 x 10^3 .

9.3 Analog outputs

Table 9-4

Resolution (voltage mode)	10 bit plus sign
Resolution (current mode)	10bit
Update rate	4ms
Update rate (high speed update - voltage mode only)*	250μs

*When sourced from Pr **4.02**, Pr **4.17** in any mode and Pr **3.02**, Pr **5.03** in closed-loop.

9.4 Digital inputs and outputs

Table 9-5 Response times

Switching frequency	Terminals	Open loop		Closed loop	
		Pr 6.35 / Pr 6.36 (Limit switches)	**Other**	**Pr 6.35 / Pr 6.36 (Limit switches)**	**Other**
All	24-26 as input	4ms	4ms	250μs	4ms
All	24-26 as output	4ms	4ms	4ms	4ms
All	27-29	4ms	4ms	250μs	4ms
All	31 (enable)	-	4ms*	-	4ms*
All	31 (disable)	-	<100us	-	<100μs
All	Relay output closing	4ms*	4ms*	4ms*	4ms*
All	Relay output opening	4ms*	4ms*	4ms*	4ms*

*software only

9.5 Current feedback

Accuracy: 5% worst case, 2% typical.
Resolution: 10 bit plus sign
Full scale resolution is equivalent to 222% drive rated current (OI.AC trip level)

9.6 Bandwidth

The following bandwidth values are for 12kHz PWM switching frequency:

9.6.1 Speed loop

The speed loop bandwidth is 160Hz

9.6.2 Current loop

The current loop bandwidth is 1100Hz for the 3dB point, and 400Hz for the 45°point.

1. The gain characteristic and associated 3dB point is most useful where drive is used in an application where the current controller is not included within an outer control loop.
2. The phase characteristic and associated 45° point is most useful where the current controller is used within an outer control loop such as a speed controller. The phase delay of the current controller has a limiting effect on the response of the outer loop.

10 Rotor Flux Control (RFC) mode

10.1 Introduction

Rotor Flux Control (RFC) mode is a sub mode of closed loop vector mode on the drive. Instead of using a position feedback device the drive uses a position estimator to determine the position of the flux in the motor. The drive uses motor currents, motor voltages and key motor parameters in a robust model of the motor to estimate flux position, flux magnitude and motor speed. The control system is exactly the same as the system used with closed loop vector with position feedback except that in RFC mode the feedback is derived from a position estimator instead of an actual feedback device. The position estimator gives an effective resolution of 16384 lines per revolution.

RFC mode has two major benefits.

1. RFC mode can eliminate instability when operating a large motor on light load and at low frequencies, for example in large fan applications.
2. With RFC mode it is possible to switch between closed loop vector mode with a position feedback device and RFC mode while running without interruption. This is useful for high-speed application that requires accurate position control at low speeds but also requires operation at speeds above the range of the feedback device.

In the Unidrive SP Advanced User Guide RFC mode is also sometimes referred to as closed-loop vector mode without position feedback.

10.2 Setting up the RFC mode

This section describes how to set up the drive to run in RFC mode.

Unidrive SP software V01.10.00 or later should be used for RFC mode. It is recommended that the lowest possible switching frequency is used, preferably 3 kHz. This is because as the switching frequency is increased, the effect of the IGBT switching dead times is greater, which reduces stability. This is more of an issue on larger drives where the IGBT dead times are longer.

To set up the Unidrive SP in RFC mode follow the instructions below.

	Action	Detail
1	Set the drive into closed loop vector mode	Set Pr **xx.00** to 1253 (EUR defaults) or 1254 (US defaults), set Pr **11.31** (or Pr **0.48**) to CL VECt, and perform a drive reset.
2	Select RFC mode	Set Pr **3.24** to 1 or 3
3	Disable the encoder wire break trip	Set Pr **3.40** to 0
4	Enter the motor nameplate values	Ensure all the following motor map parameters are entered into the drive using the motor nameplate. • Motor rated frequency in Pr **5.06** • Motor rated current in Pr **5.07** • Motor rated speed in Pr **5.08** • Motor rated voltage in Pr **5.09**
5	Select or deselect catch a spinning motor mode	If catch a spinning motor mode is not required then set Pr **6.09** to 0. If catch a spinning motor mode is required then leave Pr **6.09** at the default of 1, but depending on the size of the motor the value in Pr **5.40** may need to be adjusted. Pr **5.40** defines a scaling function used by the algorithm that detects the speed of the motor. The default value of Pr **5.40** is 1 which is suitable for small motors (<4kW). For larger motors the value in Pr **5.40** will need to be increased. Approximate values of Pr **5.40** for different motor sizes are as follows, 2 for 11kW, 3 for 55kW and 5 for 150kW. If the value of Pr **5.40** 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.
6	Autotune	It is highly recommended that a rotating autotune is performed (Pr **5.12** set to 2). If a rotating autotune is not possible then a static autotune must be performed (Pr **5.12** set to 1) and the nameplate value of power factor entered into Pr **5.10**

10.3 Further Tuning

The position estimator used in RFC mode has a filter with a time constant of 4ms which will reduce the possible bandwidth of the speed controller compared with the bandwidth possible when position feedback is used. This means that the speed loop integral gain will need to be lower than the value normally used when a feedback device used. With Unidrive SP software version V01.10.00 onwards, the default of the speed loop I gain has been decreased from 1.00 to 0.10 and the P gain increased from 0.0100 to 0.0300 to help in allowing RFC mode to work well from the default parameter settings. The speed loop gains should be modified to obtain the best possible performance for the application, but it is unlikely that the integral gain can be increased much above 0.50.

A filter with a 4ms time constant is always present on the output of the speed estimator, but this filter may be extended by setting Pr **3.42** as follows: 0 = 4 ms, 1 = 8 ms, 2 = 16 ms, 3 = 32 ms, 4 = 64 ms, 5 = 128 ms. 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. When operating above rated speed it may be necessary to include further filtering of the current demand (Pr **4.12** set to a value between 1.0 and 5.0 ms) to achieve stable operation.

10.4 Other Considerations

If the drive encoder lines per rev in Pr **3.34** is set to a value that is not a power of 2 and the drive encoder type in Pr **3.38** is set to any type of SINCOS encoder, Pr **3.24** is forced to zero and RFC mode is not available. This is because the extra processing time required to support the feedback device would not allow enough time for the rotor flux control algorithm to be executed. It should be noted that if RFC mode is active, that the current controller sample rate used with 6kHz and 12 kHz switching frequencies is reduced from 12 kHz to 6 kHz (i.e. the current controller sample time is increased from 83 us to 167 us). Also operation at 4 kHz, 8 kHz or 16 kHz switching frequency is not possible, and if these frequencies are selected the actual switching frequency is switched down to the next lower frequency. Pr **5.37** displays the actual switching frequency being used.

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