CONTROL TECHNIQUES

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Advanced User Guide

Unidrive SP

Universal Variable Speed AC Drive for induction and servo motors

Part Number: 0471-0002-06
Issue: 6

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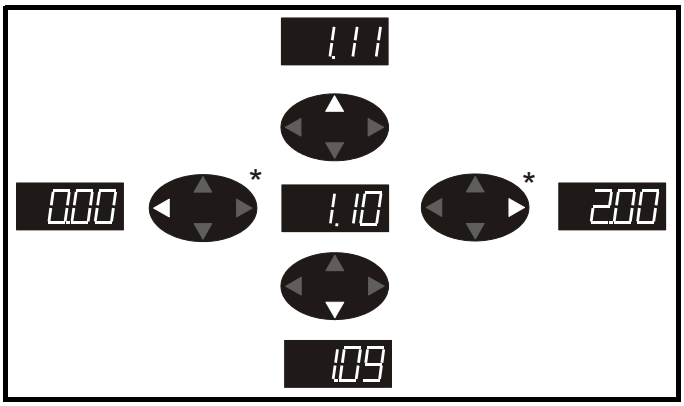
1 Parameter structure

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 2.6 *Parameter access level and security* on page 7.

Figure 1-1 Parameter navigation

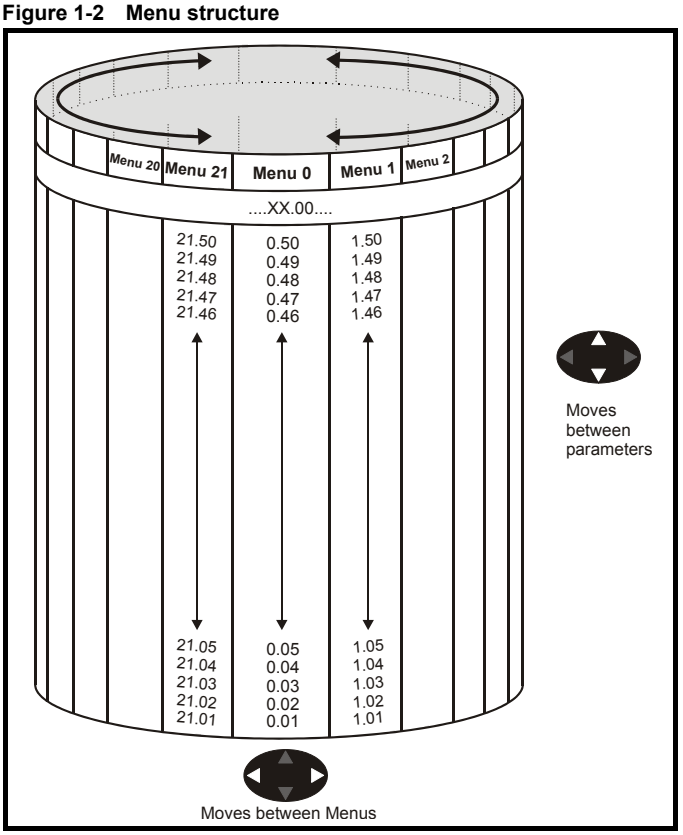


* can only be used to move between menus if L2 access has been enabled (Pr **0.49**).

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 31 fixed parameters and 20 programmable parameters that are defined in menu 11. Menu 0 parameters are copies of advanced menu parameters, and although these parameters are accessible via drive 485 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 cloning

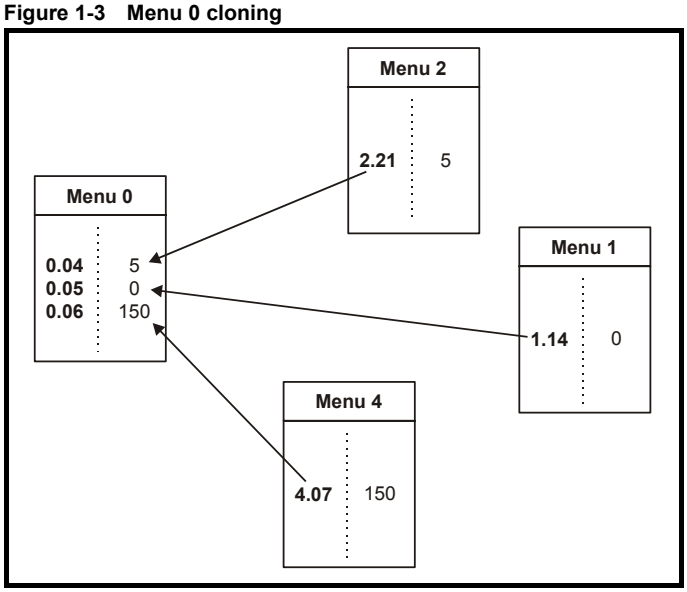


Table 1-1 Menu 0 parameters

Parameter			Range(⇳)			Default(⇨)			Type					
			OL	VT	SV	OL	VT	SV						
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 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		10.0	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 6.5535 1/rad s^{-1}			0.0100		RW	Uni				US
0.08	OL> Voltage boost	{**5.15**}	0.0 to 25.0% of motor rated voltage			3.0			RW	Uni				US
	CL> Speed controller I gain	{**3.11**}		0.00 to 655.35 1/rad			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						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)			VOLt (6)			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
0.29	SMARTCARD parameter data	{**11.36**}	0 to 999			0			RO	Uni		NC	PT	US
0.30	Parameter cloning	{**11.42**}	nonE (0), rEAd (1), Prog (2), AutO (3), boot (4)			nonE (0)			RW	Txt		NC		*
0.31	Drive rated voltage	{**11.33**}	200 (0), 400 (1), 575 (2), 690 (3) V						RO	Txt		NC	PT	

Parameter			Range(⇳)			Default(⇨)			Type					
			OL	VT	SV	OL	VT	SV						
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)			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 3		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		NC	PT	
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 400.0			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

Key:

Coding	Attribute
OL	Open loop
VT	Closed loop vector
SV	Servo
{X.XX}	Cloned 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: indicates that this parameter can be a destination parameter.
RA	Rating dependant: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. This parameters is not transferred by SMARTCARDs when the rating of the destination drive is different from the source drive.

Coding	Attribute
NC	Not cloned: not transferred to or from SMARTCARDs during cloning.
PT	Protected: cannot be used as a destination.
US	User save: saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: automatically saved in drive EEPROM at power-down.

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 485 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 sensing thresholds
4	Current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
9	Programmable logic and motorised 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

1.3 Solutions Modules

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

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 fitted to the drive but the SM-Keypad Plus can also be remotely mounted on an enclosure door.

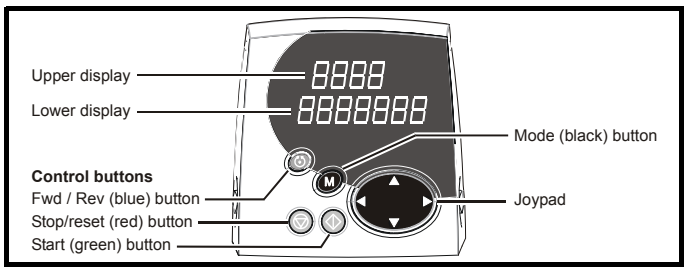
2.1.1 SM-Keypad

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



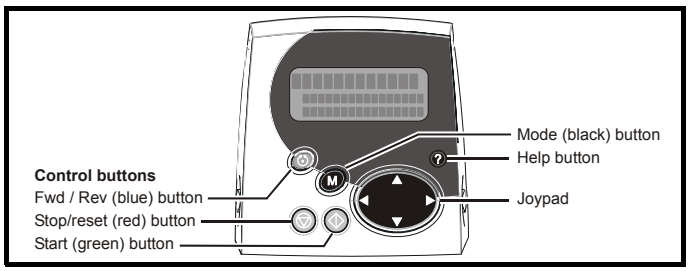
2.1.2 SM-Keypad Plus

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.

Figure 2-2 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:

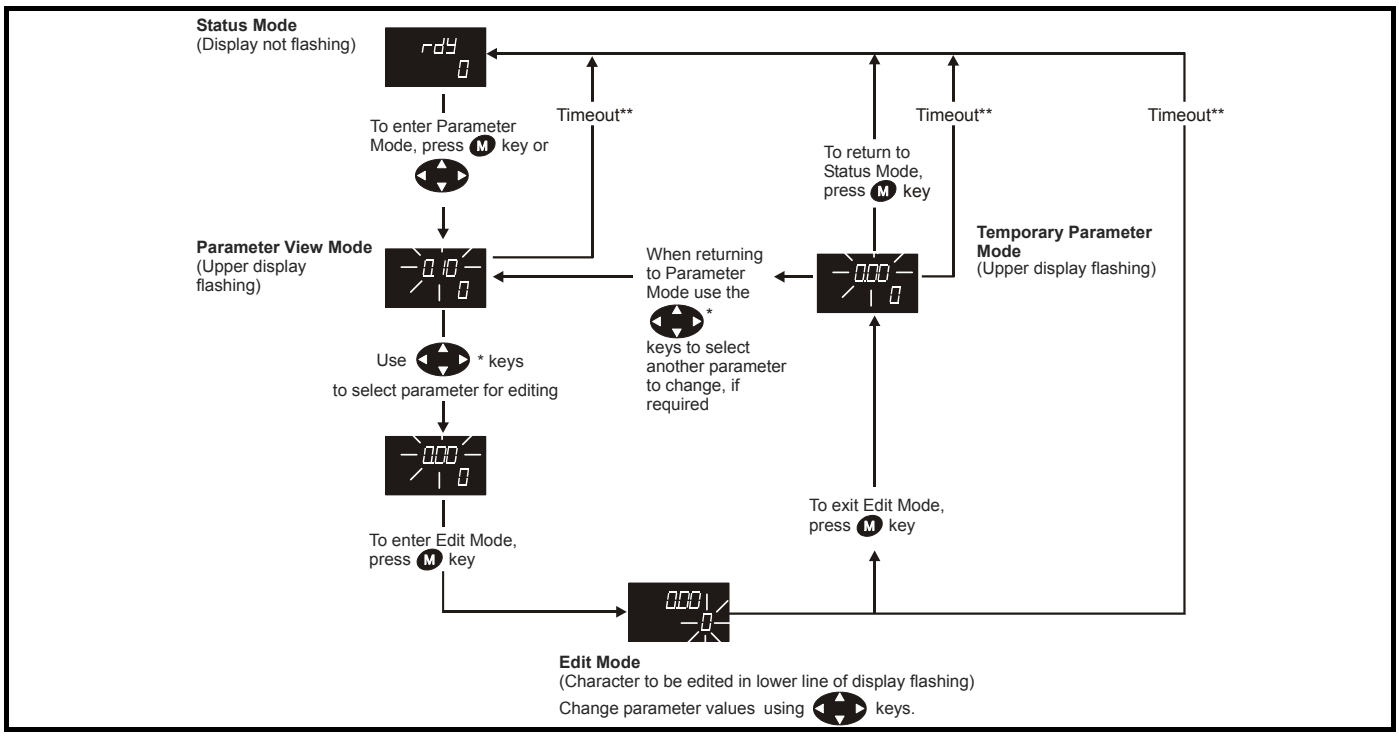
1. Joypad - used to navigate the parameter structure and change parameter values.
2. Mode button - used to change between the display modes – parameter view, parameter edit, status.
3. Three control buttons - used to control the drive if keypad mode is selected.
4. Help button (SM-Keypad Plus only) -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

Figure 2-3 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
Auto tune in progress	Auto tune
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 21 is reached. A single Right key action when Menu 21 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 21. 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 3 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 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 21) 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

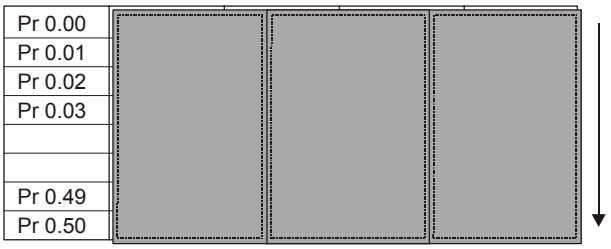
RW = Read / write access RO = Read only access

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.

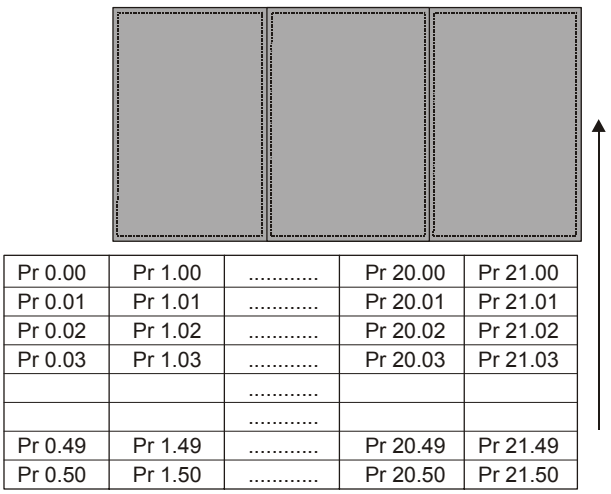
2.6.1 Access Level

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



L2 access selected - All parameters visible



Pr 0.00	Pr 1.00	.....	Pr 20.00	Pr 21.00
Pr 0.01	Pr 1.01	.....	Pr 20.01	Pr 21.01
Pr 0.02	Pr 1.02	.....	Pr 20.02	Pr 21.02
Pr 0.03	Pr 1.03	.....	Pr 20.03	Pr 21.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 20.49	Pr 21.49
Pr 0.50	Pr 1.50	.....	Pr 20.50	Pr 21.50

2.6.2 Changing the Access Level

The Access Level is determined by the setting of Pr **0.49** as follows:

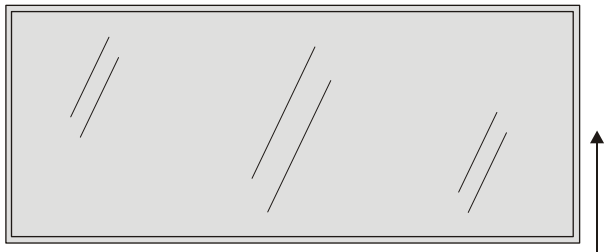
String	Value	Effect
L1	0	Access to menu 0 only
L2	1	Access to all menus (menu 0 to menu 21)

The Access Level can be changed through the keypad even if the User Security has been set.

2.6.3 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 20.00	Pr 21.00
Pr 0.01	Pr 1.01	.....	Pr 20.01	Pr 21.01
Pr 0.02	Pr 1.02	.....	Pr 20.02	Pr 21.02
Pr 0.03	Pr 1.03	.....	Pr 20.03	Pr 21.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 20.49	Pr 21.49
Pr 0.50	Pr 1.50	.....	Pr 20.50	Pr 21.50

User security closed - All parameters: Read Only access

Pr 0.00	Pr 1.00	.....	Pr 20.00	Pr 21.00
Pr 0.01	Pr 1.01	.....	Pr 20.01	Pr 21.01
Pr 0.02	Pr 1.02	.....	Pr 20.02	Pr 21.02
Pr 0.03	Pr 1.03	.....	Pr 20.03	Pr 21.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 20.49	Pr 21.49
Pr 0.50	Pr 1.50	.....	Pr 20.50	Pr 21.50

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.

2.7 Alarm and trip display

In any mode an alarm flashes alternately with the data displayed on the 2nd row when one of the following conditions occur. If action is not taken to eliminate the all alarms except “Auto tune” the drive may eventually trip. Warnings are not displayed when a parameter is being edited.

Alarm string	Alarm condition
br.rS	Braking resistor (Pr **10.37** > 75.0% and the braking IGBT is active)
OVLd	Motor overload (Pr **4.17** > 75% and the drive output current > Pr **5.07**)
hot	Heatsink or control board alarms are active

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. The read only parameters listed below are frozen 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 HF19 then no key action is recognised.

Parameter	Description
1.01	Frequency/speed reference
1.02	Frequency/speed reference
1.03	Pre-ramp reference
2.01	Post-ramp reference
3.01	Frequency slaving demand/Final speed ref
3.02	Speed feedback
3.03	Speed error
3.04	Speed controller output
4.01	Current magnitude
4.02	Active current
4.17	Magnetising current
5.01	Output frequency
5.02	Output voltage
5.03	Power
5.04	DC bus voltage
7.01	Analog input 1
7.02	Analog input 2
7.03	Analog input 3

2.8 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

2.9 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**. 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**).

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 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.

2.10 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.

2.11 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 5 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)
3yyy	Transfer drive EEPROM data to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive ladder program to SMARTCARD block number yyy
6yyy	Transfer SMARTCARD data block yyy to the drive
7yyy	Erase SMARTCARD data block yyy
8yyy	Compare drive parameters with block yyy
9999	Erase SMARTCARD
9888	Set SMARTCARD read-only flag
9777	Clear SMARTCARD read-only flag
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.

Saving parameters

When parameters are saved all user save (US) parameters are saved to EEPROM within the drive. Normally Pr **x.00** is set to 1000 to save parameters. When the parameter save is complete Pr **x.00** is reset to zero by the drive. The drive must not be in the under voltage condition (Pr **10.16** = 0) and must not be using the 48V supply (Pr **6.44** = 0) for this action to occur. Saving parameters can take between 400ms and several seconds depending on the number of parameter values that are different from the values already saved in EEPROM within the drive. If the power is removed from the drive during a parameter save it is possible for the EEPROM data to be corrupted giving an EEF failure when the drive is next powered up. If the drive is operating from the 24V supply (under voltage condition is active) or from the 48V supply (Pr **6.44** = 1) the power down time is very short. Therefore using Pr **x.00** = 1000 to save parameters is a safe method that minimises the risk of corrupting the data in EEPROM. However, if it is necessary to save parameters when the drive is in the under voltage condition or when operating from the 48V supply, Pr **x.00** should be set to 1001 to initiate the parameter save.

Loading defaults

When defaults are loaded the new parameters are automatically saved to the drive EEPROM in all modes.

SMARTCARD

It should be noted that there could be some conflict between the actions of Pr **x.00** and Pr **11.42** (Parameter cloning) 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 SMARTCARD each time a parameter save is performed.

The following differences from standard defaults are available:

3.1 US default differences (1244)

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

3.2 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**.

3.3 Electronic nameplate transfers

Some encoders using Stegmann 485 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 346 for details.

3.4 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) 0 (Auto) 3 (6 POLE)								
Second motor parameter	Open-loop Closed-loop vector, Servo							Pr **21.18**								
Update rate	Background read															

The top row gives the menu.parameter number and the parameter name. The other rows give 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 - with the Unidrive SP hardware and open loop drive mode selected. The control strategy is V/F mode with fixed boost or open-loop vector.

Closed-loop vector - with the Unidrive hardware and closed-loop vector mode selected. 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 - with the Unidrive hardware and servo mode selected. 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 - with the Unidrive hardware and regen mode selected. The drive operates as a PWM rectifier.

Coding

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.
TE	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 dependant: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. This parameters is not transferred by SMARTCARDs when the rating of the destination drive is different from the source drive.
NC	Not cloned: not transferred to or from SMARTCARDs during cloning.
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: automatically saved in drive EEPROM at power-down.

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 (if used) as being "OFF" or "On" ("OFF"= 0, "On" = 1).

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 400kHz. The maximum is defined by SPEED_LIMIT_MAX (in rpm) = 400kHz x 60 / ELPR = 2.4×10^7 / ELPR subject to an absolute maximum of 40,000 rpm. ELPR is equivalent encoder lines per revolution and is the number of lines that would be produced by a quadrature encoder. Quadrature encoder ELPR = number of lines per revolution F and D encoder ELPR = number of lines per revolution / 2 Resolver ELPR = resolution / 4 SINCOS encoder ELPR = number of sine waves per revolution Serial comms encoder ELPR = resolution / 4 This maximum is defined by the device selected with the speed feedback selector (Pr **3.26**) and the ELPR set for the position feedback device.
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** RATED_CURRENT_MAX ≤ 1.36 x Maximum Heavy Duty current rating (Pr **11.32**) The rated current can be increased above the rated drive current up to a level not exceeding 1.36 x Maximum Heavy Duty current rating (Pr **11.32**). The actual level varies from one drive size to another, 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 = Maximum Heavy Duty current rating (Pr **11.32**) / 0.45

Maximum	Definition
MOTOR1_CURRENT_LIMIT_MAX [1000.0%]	**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 Heavy Duty rating) 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 Heavy Duty rating) 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** $\varphi 1 = \cos\text{-}1(PF) - \varphi 2$. This is measured by the drive during an autotune. See section *Closed-loop vector* on page 74 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**
MOTOR2_CURRENT_LIMIT_MAX [1000.0%]	**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**.
TORQUE_PROD_CURRENT_MAX [1000.0%]	**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.
USER_CURRENT_MAX [1000.0%]	**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**
AC_VOLTAGE_SET_MAX [690V]	**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
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

Maximum	Definition
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 POWER_MAX = √3 x AC_VOLTAGE_MAX x RATED_CURRENT_MAX x 1.75

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

Table 4-2 Maximum motor rated current

Model	Maximum Heavy Duty current rating (Pr 11.32)	Maximum Normal Duty current rating
SP1201	4.3	5.2
SP1202	5.8	6.8
SP1203	7.5	9.6
SP1204	10.6	11
SP2201	12.6	15.5
SP2202	17	22
SP2203	25	28
SP3201	31	42
SP3202	42	54
SP1401	2.1	2.8
SP1402	3	3.8
SP1403	4.2	5.0
SP1404	5.8	6.9
SP1405	7.6	8.8
SP1406	9.5	11
SP2401	13	15.3
SP2402	16.5	21
SP2403	25	29
SP3401	32	35
SP3402	40	43
SP3403	46	56
SP3501	4.0	5.4
SP3502	5.4	6.1
SP3503	6.1	8.4
SP3504	9.5	11
SP3505	12	16
SP3506	18	22
SP3507	22	27

Default

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

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.

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 large CMP data blocks to/from the drive (not a Solutions Module) via the drive serial comms port.

4.2 Sources and destinations

Sources

Some functions have source parameters, i.e. drive outputs, PID controller etc. The source parameter range is Pr **0.00** to Pr **21.51**.

1. If the source parameter does not exist the input is taken as zero.
2. The input is given by (source value x 100%) / source parameter maximum.

Destinations

Some functions have destination parameters, i.e. drive inputs, etc. The destination parameter range is Pr **0.00** to Pr **21.51**.

1. If the destination 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 value is either 0 or 1 depending on the state of the function output. If the function output is not a bit value (i.e. analog input) the destination value is given by (function output x destination parameter maximum) / 100%. Pr **1.36** and Pr **1.37** are a special case. The scaling shown in the description of Pr **1.08** is used when any non-bit type quantity is routed to these parameters.
4. 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.

Sources and destinations

1. Bit and non-bit parameters may be connected to each other as sources or destinations. The maximum for bit parameters is taken as one.
2. All new source and destination routing only changes to new set-up locations when the drive is reset.
3. When a destination is changes 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 hearder 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 minimises 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 50rpm or more. Typical differences (1500rpm maximum speed, menu 7 scaling of 1.000, analog input 1 filter of 4ms) 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 250µs 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 250µs. When a position feedback Solutions Module writes to the hard speed reference, although the module can write every 250µs, the data is only acted on every 4ms. When the reference comes from a Solutions Module there is no guarantee that all pulses are counted. The encoder reference can be scaled in high speed update mode by modifying the number of encoder lines per revolution.

4.3.3 Torque reference update rate

The normal update rate for the torque reference (Pr **4.08**) is 4ms, however it is possible to reduce the sample time to 250µs 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, motorised pot and binary sum
10	Status and trips
11	General drive set-up
12	Threshold detectors and variable selectors
13	Position control
14	User PID controller
15, 16, 17	Solutions Module slots
18	Application menu 1
19	Application menu 2
20	Application menu 3
21	Second motor parameters

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

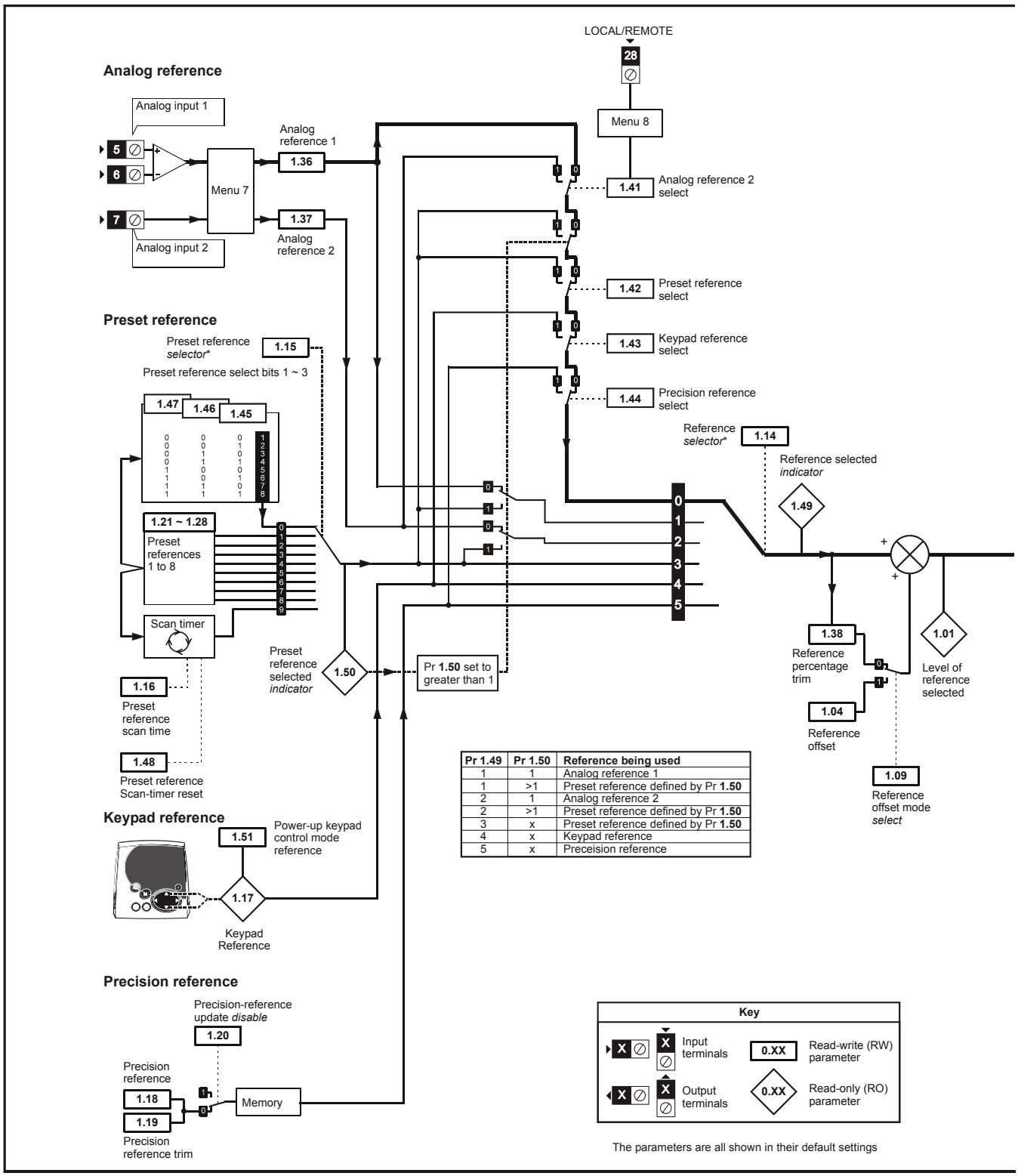
Table 5-2 Key to parameter coding

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 dependant: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. These parameters are not transferred by SMARTCARDs when the rating of the destination drive is different from the source drive.
NC	Not cloned: not transferred to or from SMARTCARDs during cloning.
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: automatically saved in drive EEPROM at power-down.

5.2 Menu 1: Frequency/speed reference

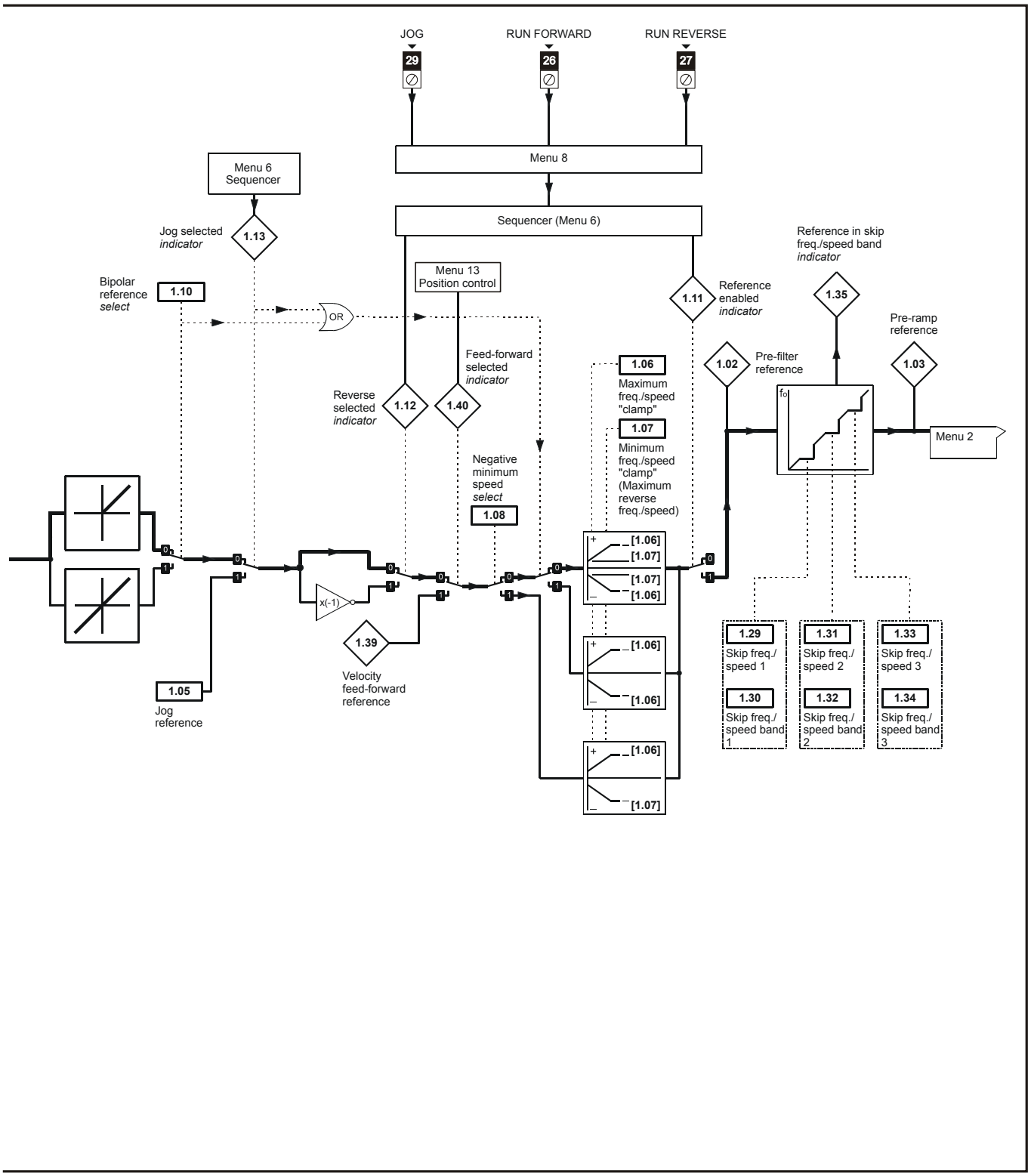
Menu 1 controls the main reference selection. When the drive operates in open-loop mode a frequency reference is produced, and when Unidrive SP operates in closed-loop vector or servo modes a speed reference is produced.

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	Preceision reference

*Refer to Pr **1.14** on page 25.


JOG
RUN FORWARD
RUN REVERSE
29
26
27
Menu 8
Sequencer (Menu 6)
Menu 6 Sequencer
Jog selected indicator
1.13
Bipolar reference select
1.10
OR
Menu 13 Position control
Feed-forward selected indicator
1.40
Reverse selected indicator
1.12
1.11
Reference enabled indicator
Reference in skip freq./speed band indicator
1.35
Pre-ramp reference
1.03
1.02
Pre-filter reference
1.06
Maximum freq./speed "clamp"
1.07
Minimum freq./speed "clamp" (Maximum reverse freq./speed)
Menu 2
Negative minimum speed select
1.08
x(-1)
1.39
Velocity feed-forward reference
1.05
Jog reference
[1.06]
[1.07]
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 24.

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 5.7 *Menu 6: Sequencer and clock* on page 113 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 5.14 *Menu 13: Position control* on page 197).

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.

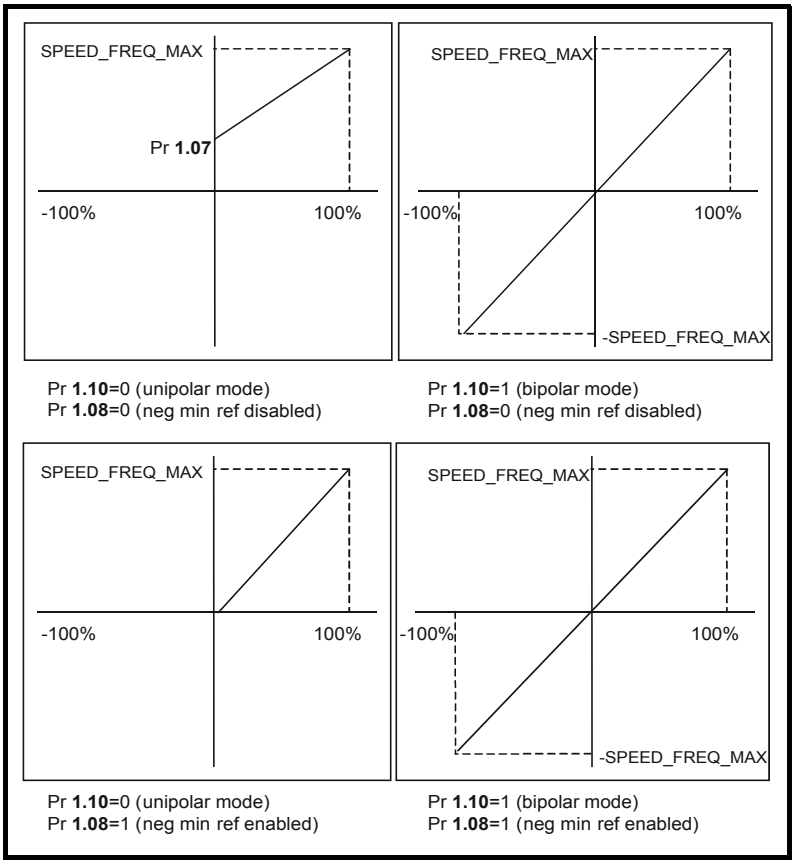
The variable maximum limit for reference parameters, SPEED_FREQ_MAX, is defined as:

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**.



Pr **1.10**=0 (unipolar mode)
Pr **1.08**=0 (neg min ref disabled)

Pr **1.10**=1 (bipolar mode)
Pr **1.08**=0 (neg min ref disabled)

Pr **1.10**=0 (unipolar mode)
Pr **1.08**=1 (neg min ref enabled)

Pr **1.10**=1 (bipolar mode)
Pr **1.08**=1 (neg min ref enabled)

Reference limits

With reference to the block diagram for Menu 1 (Figure 5-1 on page 20) the following table shows the limits applied to the reference by variaous 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 23.

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.

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 31 (*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	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 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	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	4ms read															

1.29	**Skip reference 1**															
1.31	**Skip reference 2**															
1.33	**Skip reference 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 3,000.0 Hz 0 to 40,000 rpm								
Default	Open-loop Closed-loop vector, Servo							0.0 0								
Update rate	Background read															

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 23.

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								
Update rate	4ms read															

See Pr **1.09** on page 24.

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 5.14 *Menu 13: Position control* on page 197).

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 25 and Pr **1.15** on page 26)
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 26 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

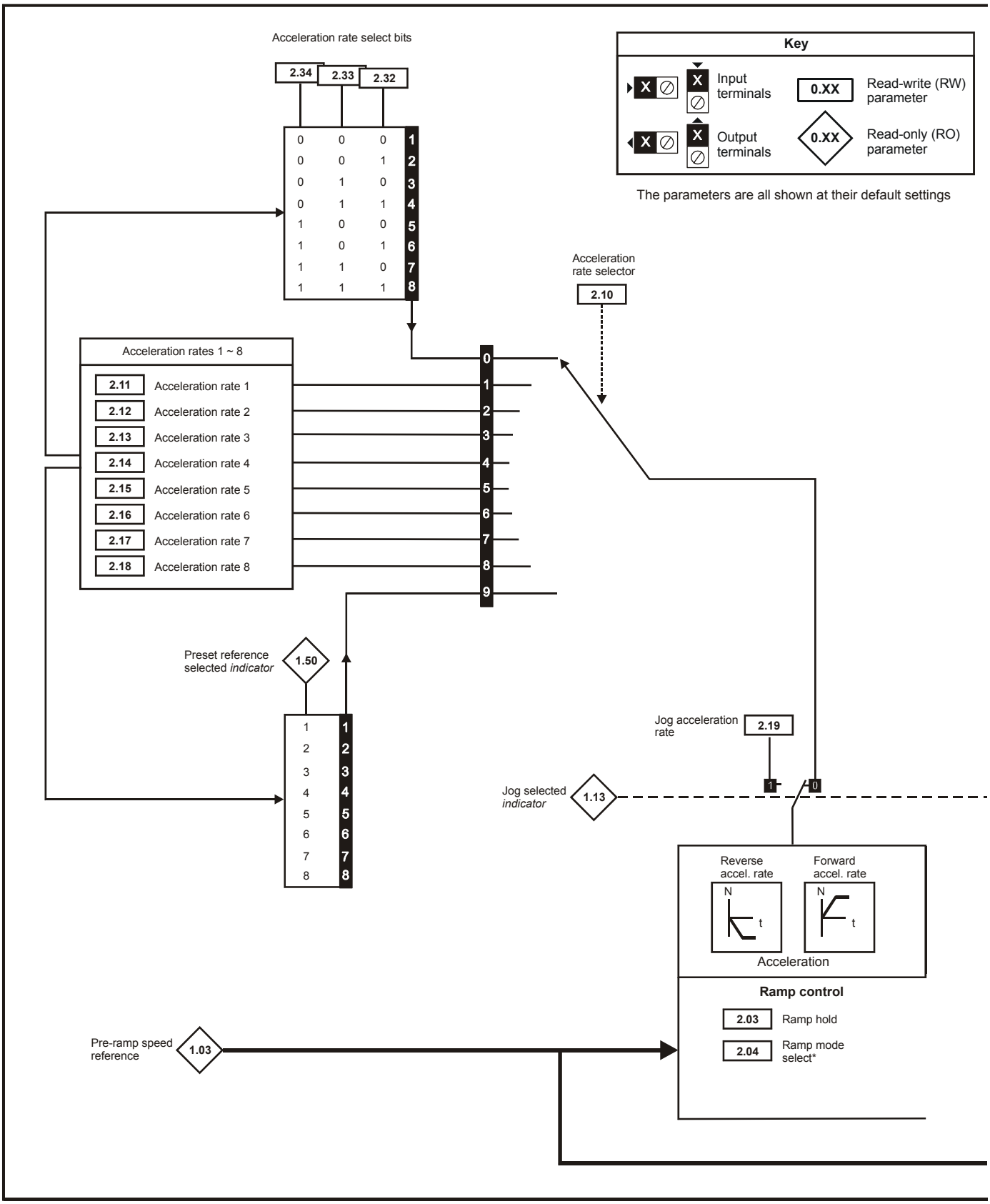
1 LASt last value used before power-down

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

5.3 Menu 2: Ramps

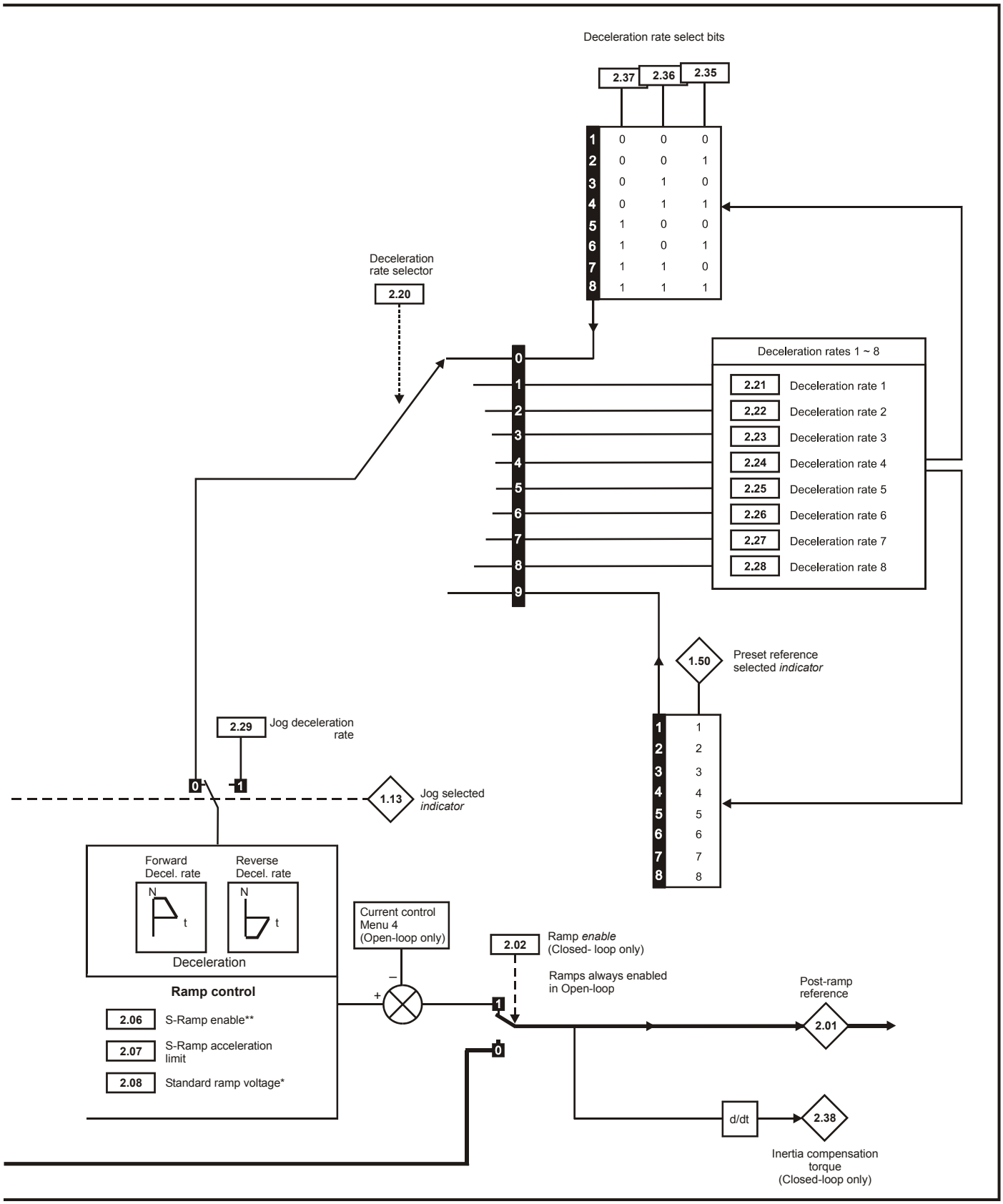
The pre-ramp frequency or speed reference passes through the ramp block controlled by menu 2 before being used by the drive to produce the basic output frequency (Open-loop modes), or as an input to the speed controller (Closed-loop vector or Servo modes). The ramp block includes: linear ramps, an S 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 fitted.

Figure 5-2 Menu 2 logic diagram



* For more information refer to Pr **2.04** on page 34.

** For more information refer to Pr **2.06** on page 35.



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															

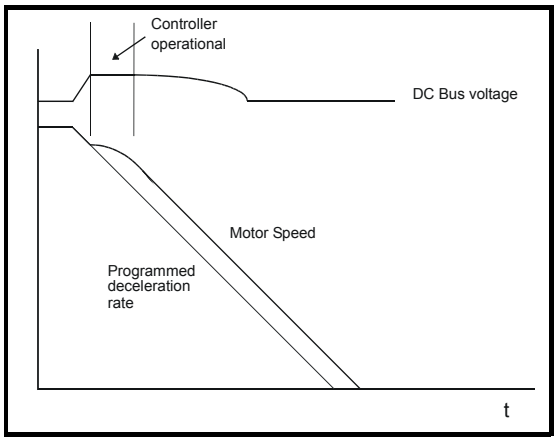
If this bit is set the ramp will be held. If S ramp is enabled the acceleration will ramp towards zero causing the ramp output to curve towards a constant speed. If a drive stop is demanded the ramp hold function is disabled.

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.

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

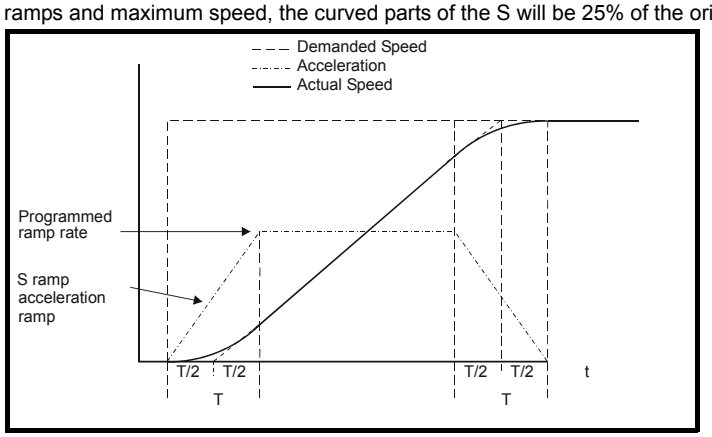
This mode is the same as normal standard ramp mode except that the motor voltage is boosted by 20%. This increases the losses in the motor giving faster deceleration.

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. The default values have been chosen such that for the default ramps and maximum speed, the curved parts of the S will be 25% of the original ramp if S ramp is enabled.



Since the ramp rate is defined in s/100Hz or s/1000rpm and the S ramp parameter is defined in s^2/100Hz or s^2/1000rpm, the time T for the 'curved' part of the S can be determined from:

T = S ramp rate of change / Ramp rate

Enabling S ramp increases the total ramp time by the period T since an additional T/2 is added to each end of the ramp in producing the S.

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.

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.

2.11	**Acceleration rate 1**															
2.12	**Acceleration rate 2**															
2.13	**Acceleration rate 3**															
2.14	**Acceleration rate 4**															
2.15	**Acceleration rate 5**															
2.16	**Acceleration rate 6**															
2.17	**Acceleration rate 7**															
2.18	**Acceleration 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							5.0 2.000 0.200								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.04** for Pr **2.11** only								
Update rate	4ms read															

2.19	**Jog acceleration 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 3200.0 s/100Hz 0.000 to 3200.000 s/1000rpm								
Default	Open-loop Closed-loop vector, Servo							0.2 0.000								
Update rate	Background read															

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

2.20	**Deceleration 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 **2.21**, 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	02.21
0	0	1	02.22
0	1	0	02.23
0	1	1	02.24
1	0	0	02.25
1	0	1	02.26
1	1	0	02.27
1	1	1	02.28

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															

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 **2.22** to Pr **2.25** on page 38).

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.

5.4 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 mode the frequency controlled by an analog input has a resolution of ±12bits from analog input 1 or ±10bits from analog inputs 2 or 3.

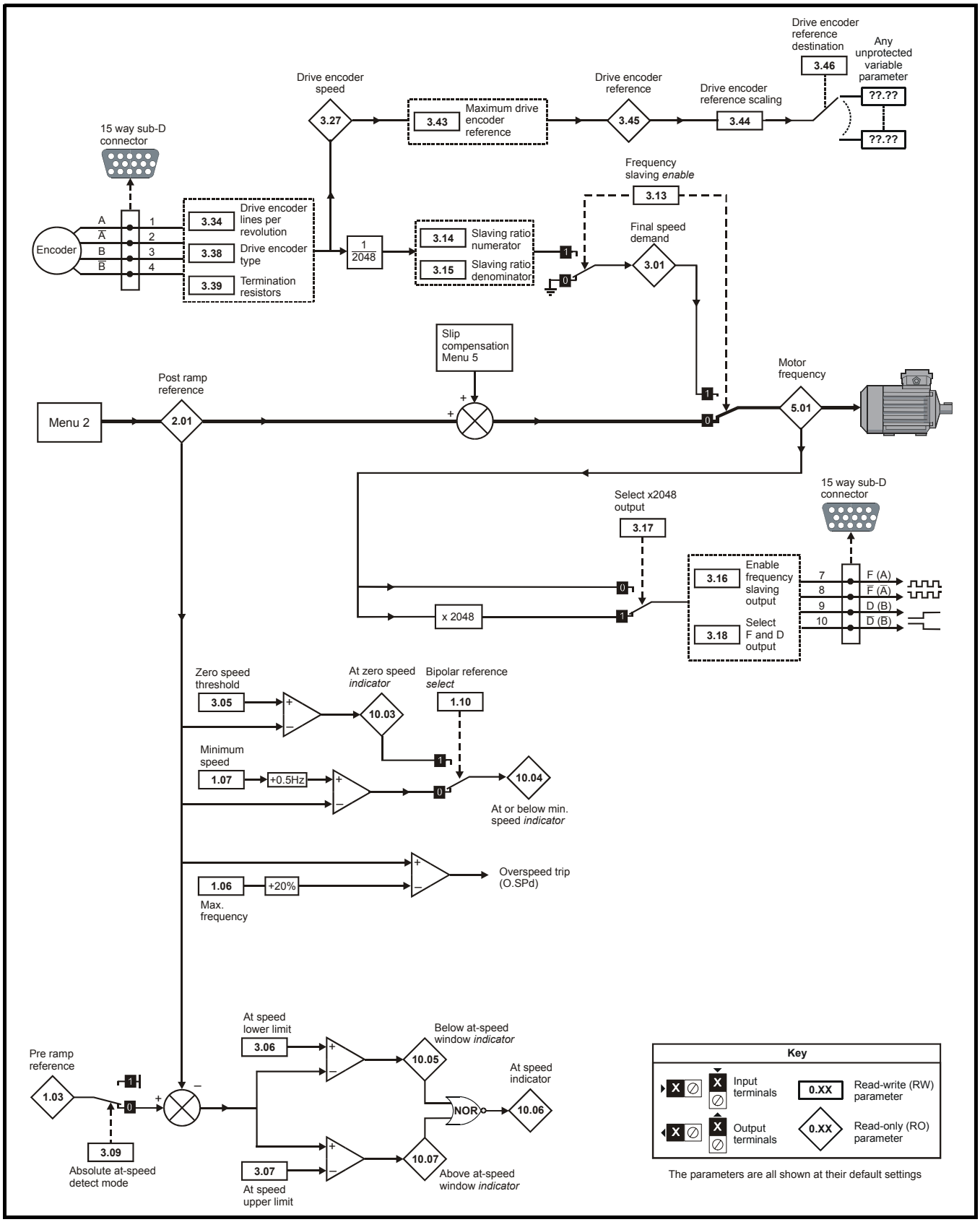
In Closed-loop vector or Servo mode the resolution from analog input 1 is infinite (excluding the deadband around zero which limits the resolution to ±16bits) provided the speed reference is routed via Pr **1.36**, Pr **1.37** or Pr **3.22** in high speed update mode. The resolution is ±10bits from analog inputs 2 or 3.

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 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 43).

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															

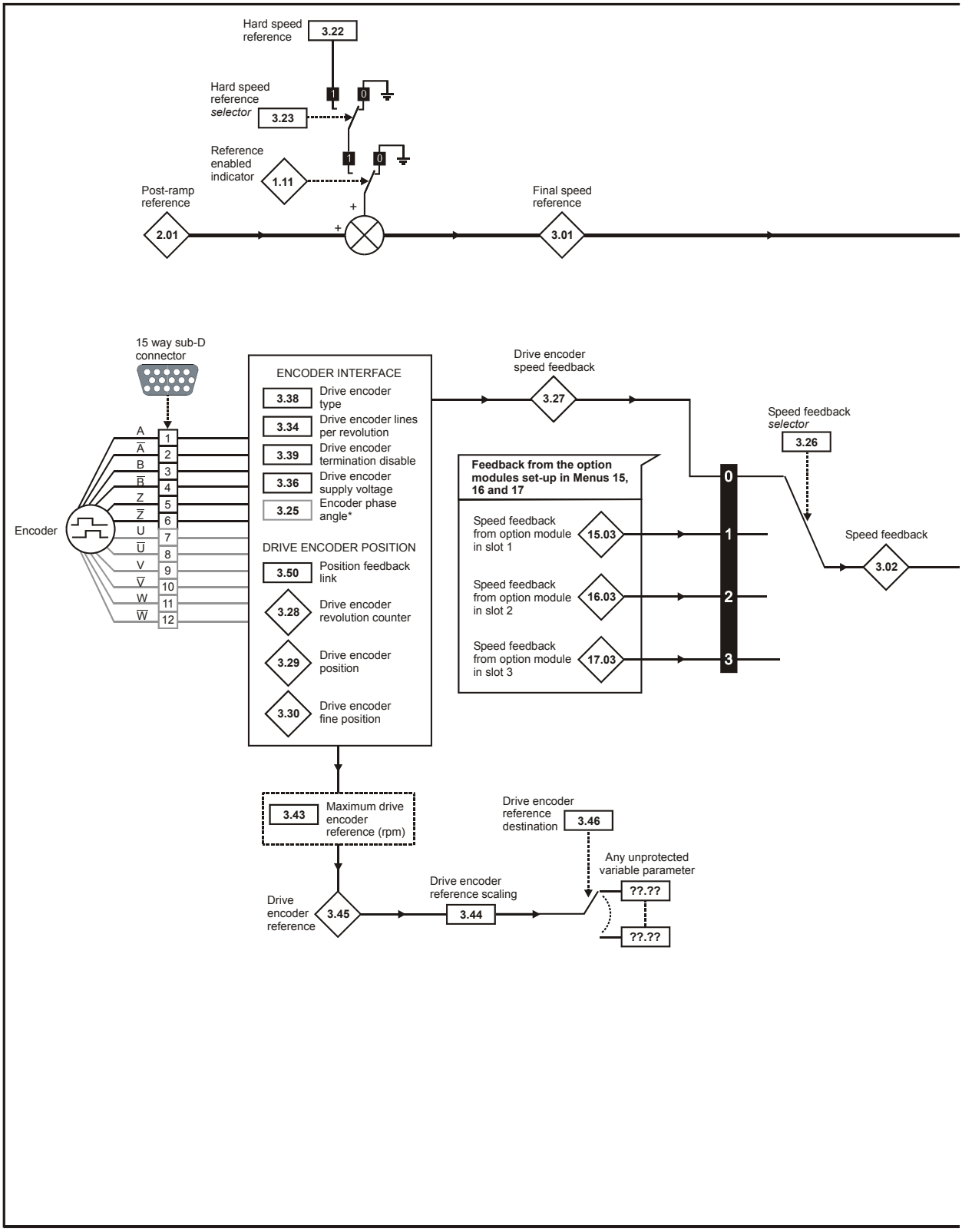
3.18	F and D frequency slaving output															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop							0								
Update rate	Background read															

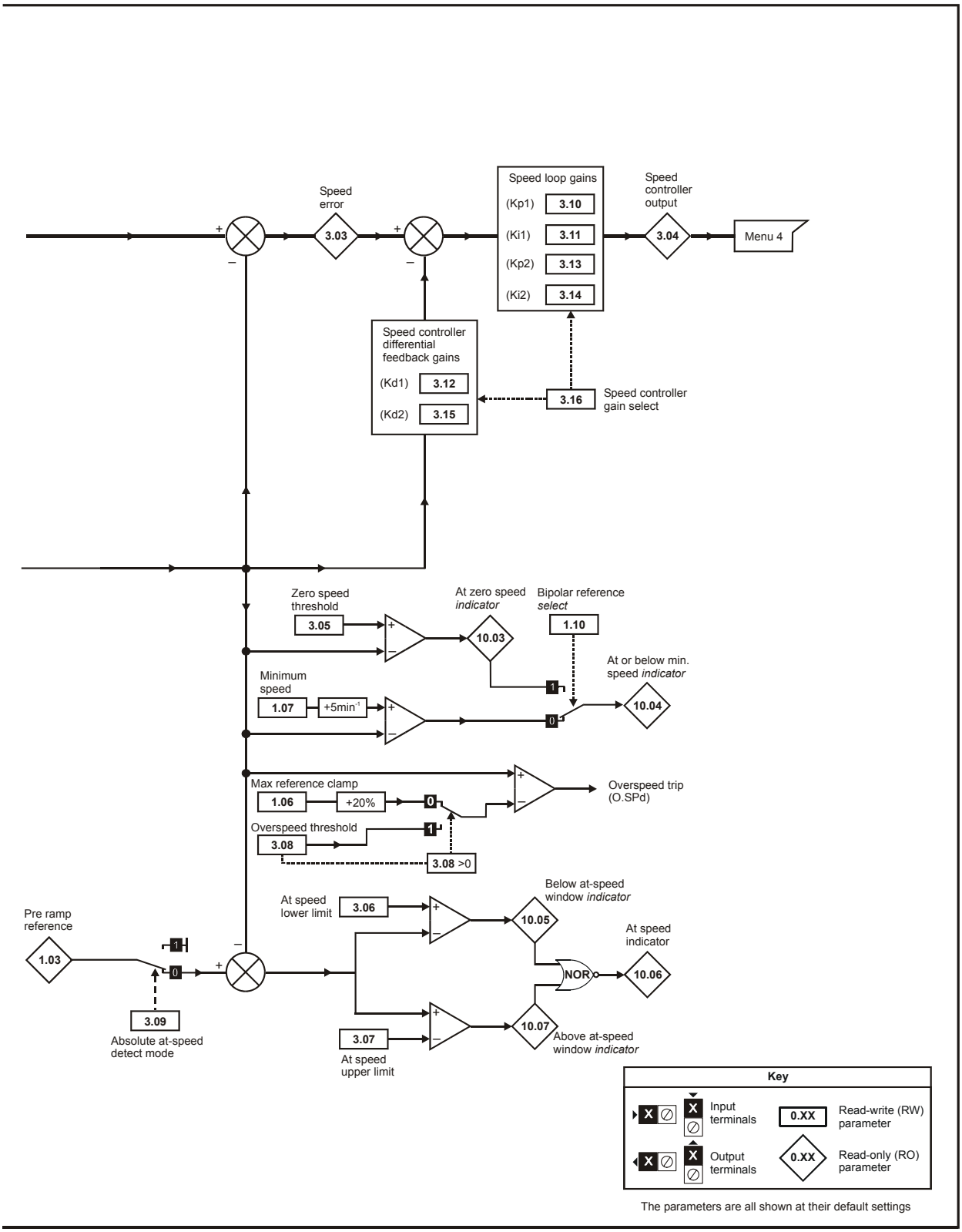
The frequency slaving output is in the form of F and D or quadrature A/B signals (Pr **3.18** = 0 gives quadrature, Pr **3.18** = 1 gives F and D). When F and D is used the output frequency is either 1 or 2048 times the drive fundamental output frequency (selected by Pr **3.17**). When quadrature A/B 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 57.

Parameter descriptions: Closed-loop vector and Servo

Figure 5-4 Menu 3 Closed-loop logic diagram




Speed error
3.03
Speed loop gains
(Kp1) 3.10
(Ki1) 3.11
(Kp2) 3.13
(Ki2) 3.14
Speed controller output
3.04
Menu 4
Speed controller differential feedback gains
(Kd1) 3.12
(Kd2) 3.15
3.16
Speed controller gain select
Zero speed threshold
3.05
At zero speed indicator
10.03
Bipolar reference select
1.10
At or below min. speed indicator
10.04
Minimum speed
1.07
+5min-1
Max reference clamp
1.06
+20%
Overspeed trip (O.SPd)
Overspeed threshold
3.08
3.08 >0
Pre ramp reference
1.03
3.09
Absolute at-speed detect mode
At speed lower limit
3.06
Below at-speed window indicator
10.05
At speed indicator
NOR
10.06
3.07
At speed upper limit
10.07
Above at-speed window indicator
Key
Input terminals
Output terminals
Read-write (RW) parameter
Read-only (RO) parameter
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															

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 connector or a position feedback module fitted in any slot as selected with Pr **3.26**. This parameter shows the speed feedback used by the speed controller. The speed feedback from an encoder includes quantisation ripple given by

Encoder speed ripple = 60 / 250 x 10^{-6} / 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

Although Pr **3.34** can be set to any value from 0 to 50,000 there are restrictions on the values actually used by the drive as follows:

Position feedback device	ELPR used by the drive
Ab, Fd, Fr	Pr **3.34** < 2, ELPR = 2 Pr **3.34** <= 16383, ELPR = Pr **3.34** Pr **3.34** > 16383, ELPR = Pr **3.34** rounded down to nearest value divisible by 4
Ab.Servo, Fd.Servo, Fr.Servo	Pr **3.34** < 2, ELPR = 2 Pr **3.34** > 16384, ELPR = 16384 Otherwise, Pr **3.34** rounded down to the nearest value that is a power of 2
SC.HiPEr, SC.EnDat, SC, SC.SSI	Pr **3.34** < 2, ELPR = 2 Pr **3.34** > 32768, ELPR = 32768 Otherwise, Pr **3.34** rounded down to the nearest value that is a power of 2

For example, with a 4096 line encoder the speed ripple is 14.6rpm. If a SINCOS encoder is used then the ripple is reduced to 1/256 x 14.6 rpm = 0.06 rpm. The value seen on the drive display is filtered so that it can be read by the user, however, the actual parameter held within the drive is not filtered. If the parameter is routed to an analog output or used by a Solutions Module the ripple is present. It should be noted that the quantisation of the speed feedback does not affect the resolution or accuracy of the speed controller. The ripple is passed to the torque/current controller via the speed controller gains and can cause ripple in the current applied to the motor, which in turn results in acoustic noise. The noise can be reduced by using a position feedback device with higher resolution, or by filtering the speed feedback (see Pr **3.42** on page 64) or the current demand (see Pr **4.12** on page 86).

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 49.

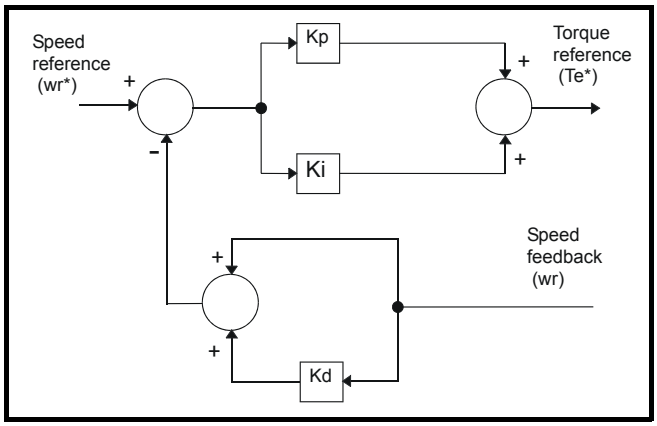
3.10	Speed controller proportional gain (Kp1)															
3.13	**Speed controller proportional gain (Kp2)**															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							4						1	1	1	
Range	Closed-loop vector, Servo							0.0000 to 6.5335 (1/ rad s^{-1})								
Default	Closed-loop vector, Servo							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 653.35 s/rad s^{-1}								
Default	Closed-loop vector, Servo							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 0.65335 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		
Range	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).

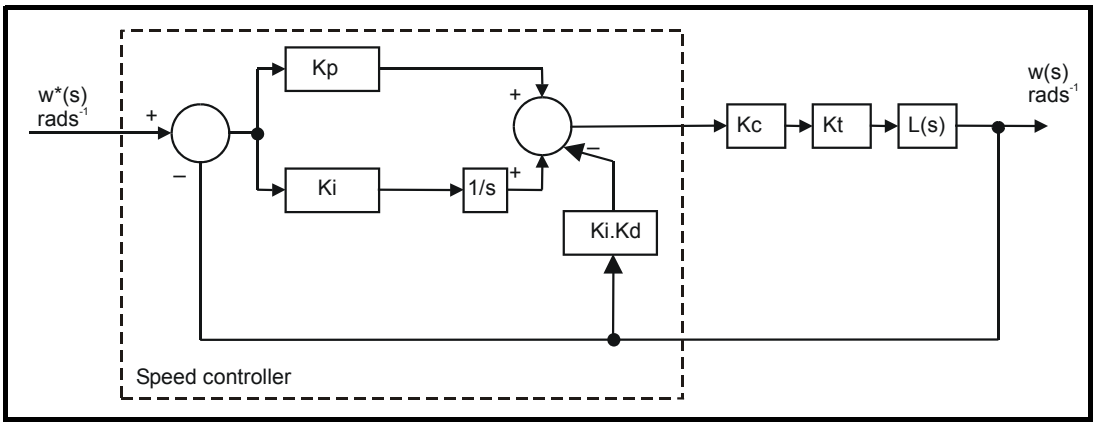
Integral gain (Ki)

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 analyse 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 torque producing current. A value of unity at the input to this block gives a torque producing current equivalent to the rated current of the drive. 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.

Kc = Drive rated current

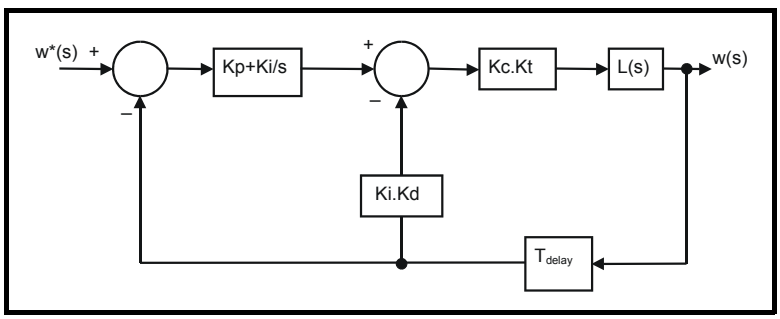
Kt is the torque constant of the motor (i.e. torque in Nm per amp of torque producing current). This value is normally available for a servo motor from the manufacturer, however for induction motors the value must be calculated from

Kt = Motor rated torque / Motor rated torque producing current

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

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 table below shows the delays that should be used with different switching frequencies assuming that the current controllers have been set up correctly.

Switching frequency (kHz)	Sample period for speed feedback (µs)	Speed controller delay (µs)	Current/torque controller delay (µs)	Total delay (µs)
3	125	167	1160	1452
4	125	125	875	1125
6	125	83	581	789
8	125	125	625	875
12	125	83	415	623
16	125	125	625	875

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 for Servo mode (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 the speed and current controller delays. The Kd gain is not affected. This parameter may also be used to boost the Kp by a factor of 4.

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 101), Pr **5.32** = motor torque per amp (for Servo mode only).

$Ki = J / (Kc \times Kt) \times (2\pi \times Bandwidth / Kbw)^2 = Pr\ \mathbf{3.18} / (Rated\ drive\ current \times Pr\ \mathbf{5.32}) \times (2\pi \times Pr\ \mathbf{3.20} / Kbw)^2$

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

$Kp = 2\ \xi\ \sqrt{[(Ki \times J) / (Kc \times Kt)]} = 2\ \xi\ \sqrt{[(Pr\ \mathbf{3.11} \times Pr\ \mathbf{3.18}) / (Rated\ drive\ current \times Pr\ \mathbf{5.32})]}$

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 101), Pr **5.24** = motor torque per amp (for Servo mode only).

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

$Kp = 2\ \xi\ \sqrt{[(Ki \times J) / (Kc \times Kt)]} = 2\ \xi\ \sqrt{[(Pr\ \mathbf{3.11} \times Pr\ \mathbf{3.18}) / (Rated\ drive\ current \times Pr\ \mathbf{5.32})]}$

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 **3.33**). If the feedback or output are 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							0.00010 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 50) and to provide torque feed-forwards during acceleration when required. (see Pr **4.11** on page 84) (It is possible to measure the inertia as part of the auto-tune process, see Pr **5.12** on page 101.

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 °								
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 motor rated current (Pr **5.07**) 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°.

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.

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							1								
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 correction 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: 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: 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.

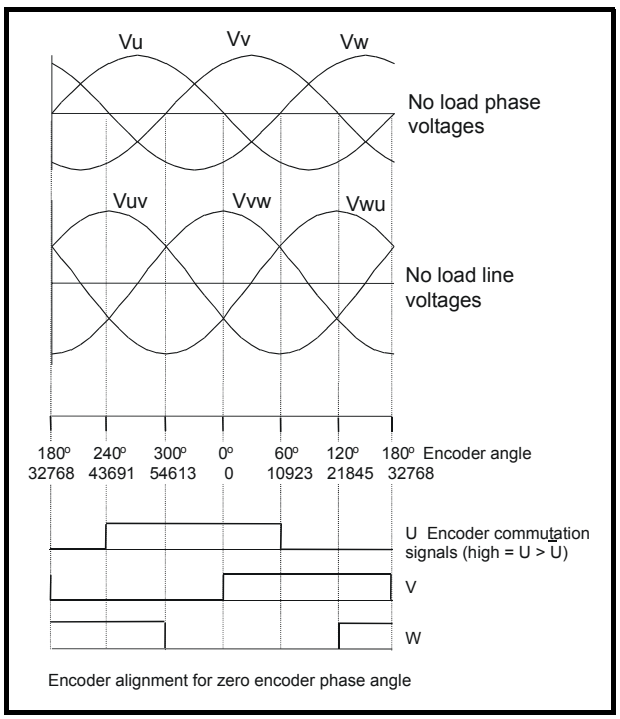
3.25	Encoder phase angle															
Drive modes	Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1					1	1	1	
Range	Servo								0.0 to 359.9 ° electrical							
Second motor parameter	Servo								Pr **21.20**							
Update rate	Background read															

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 101). 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

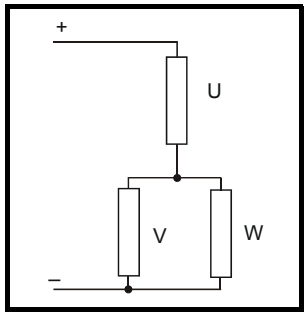
The alignment required between the no-load motor voltages and the commutation signals is shown in the following diagram for a 2 pole motor.



Encoder alignment for zero encoder phase angle

When commutation signals are used with a motor that has more than 2 poles, the sequence shown above must be repeated for each pole pair and aligned in the same way with the motor voltages.

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. The number of positions is 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.

Absolute encoder or resolver

The alignment required between the no-load motor voltages and the commutation signals is shown in the alignment diagram above. The encoder can be aligned statically by connecting the motor to a DC power supply as shown above. The motor will move to one of a number of positions. The number of positions is 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 / pole_pairs, where n = 0, 1, ... (pole_pairs - 1).

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 fitted 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															

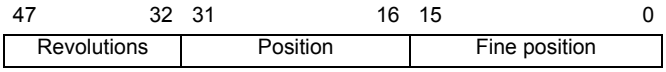
Provided the set-up parameters for the drive encoder are correct this parameter shows the encoder speed in rpm.

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															

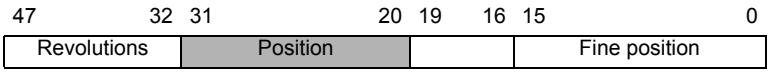
3.29	Drive encoder position															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo	0 to 65,535 ($1/2^{16}$ths of a revolution)														
Update rate	4ms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



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.



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 initialised at power-up with the absolute position. If a multi-turn absolute encoder is used the revolution counter is also initialised with the absolute revolutions at power-up.

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	4ms write															

An incremental digital encoder 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). When the position is reset by the marker, Pr **3.29** and Pr **3.30** are 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.
The marker function only operates when Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo type encoders are selected with Pr **3.38**.

3.33	Drive encoder turns bits															
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 16								
Default	Open-loop, Closed-loop vector, Servo							16								
Update rate	Background read (Only has any effect when the drive is disabled)															

When an encoder without comms is used it is sometimes desirable to mask off the most significant bits of the revolution counter. Normally this would be required with an absolute multi-turn encoder where the number of turns measured is less than 65536. 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.

When an encoder with comms is used, 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. 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** on page 64).

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)															

When Ab, Fd, Fr, AbServo, Fd.Servo, Fr.Servo or SINCOS signals 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 waves per revolution

Although Pr **3.34** can be set to any value from 0 to 50,000 there are restrictions on the values actually used by the drive as follows:

Position feedback device	ELPR used by the drive
Ab, Fd, Fr	Pr **3.34** < 2, ELPR = 2 Pr **3.34** <= 16383, ELPR = 03.34 Pr **3.34** > 16383, ELPR = 03.34 rounded down to nearest value divisible by 4
Ab.Servo, Fd.Servo, Fr.Servo,	Pr **3.34** < 2, ELPR = 2 Pr **3.34** > 16384, ELPR = 16384 Otherwise, Pr **3.34** rounded down to the nearest value that is a power of 2
SC.Hiper, SC.EnDat, SC, SC.SSI	Pr **3.34** < 2, ELPR = 2 Pr **3.34** > 32768, ELPR = 32768 Otherwise, Pr **3.34** rounded down to the nearest value that is a power of 2

For Ab, Fd, Fr, Ab.Servo, Fd.Servo and Fr.Servo encoders the incremental (A/B) signal frequency should not exceed 500kHz.

For SC.Hiper, SC.EnDat, SC and SC.SSI encoders 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.

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

Where encoder comms alone is used as position feedback, the equivalent lines per revolution parameter (Pr **3.34**) 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 the encoder via HIPERFACE or EnDat interfaces (see Pr **3.41** on page 64).

3.35	**Drive encoder single turn comms resolution**															
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)															

Where encoder comms is used for initial setting of absolute position (SC.Hiper, SC.EnDat or SC.SSI), the single turn comms resolution in bits must be set correctly. This is the number of 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.

Where encoder comms alone is used the encoder single turn comms resolution (Pr **3.35**) and the encoder turns bits (Pr **3.33**) must be set correctly. 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 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** on page 62). If the encoder gives this information the comms resolution should be set up to include this bit whether or not it is being monitored by the drive.

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** on page 64).

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).

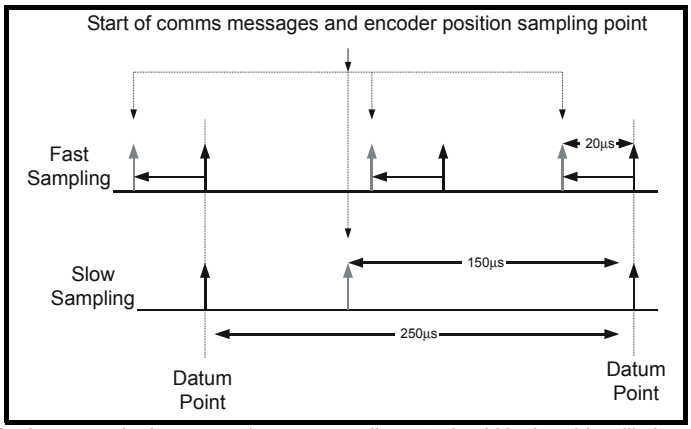
3.37	**Drive encoder comms baud rate**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo							0 to 7								
Default	Open-loop, Closed-loop vector, Servo							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 initialisation. When encoder comms is used alone the time taken to obtain the comms position must be 160µs or less, otherwise the drive initiates an EnC4 trip.

There is a delay associated with obtaining the position from an encoder using comms alone to transmit the position. 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 the position within one turn can be obtained in 30µs and the whole comms message including CRC (if appropriate) can be obtained in 60µs then fast sampling is used, otherwise slow sampling is used as shown below. In each case the encoder position is sampled by the encoder at the start of the comms message.



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 (between the last two datum points).

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)

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)

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 10								
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 connector.

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 U, V, W 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.

6, SC: SinCos encoder with no serial communications

This type of encoder gives incremental position and can only be used for control in Closed-loop vector mode.

7, SC.Hiper: Absolute SinCos encoder using Stegman 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 trips. 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 Solutions 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 trips. 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**. Most SSI encoders use 13 bit single turn position information, and so Pr **3.35** 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, and the drive can be set up to monitor it via Pr **3.40**. 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.

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.

The following should be noted:
All SinCos encoders and encoders using communications must be initialised before their position data can be used. The encoder is automatically initialised at power-up, after trips EnC1 - EnC8 are reset, and when the initialisation parameter (Pr **3.47**) is set to 1. If the encoder is not initialised or the initialisation is invalid the drive initiates trip EnC8.

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 option 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-initialising the encoder interface (see Pr **3.47** on page 65).

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 initialised 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.

3.39	Drive encoder termination selection															
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															

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

A-A\ and B-B\ terminations cannot be disabled when encoders with SinCos waveforms are selected.
Z-Z\ terminations cannot be disabled except when Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo encoders are selected.

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)	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	Comms failure (timeout)	EnC4
EnDat	Comms failure or transfer time too long	
SSI	Comms transfer time is too long	
SC.Hiper, SC.EnDat, EnDat	Checksum or CRC error	EnC5
SC.Hiper, SC.EnDat, EnDat	The encoder has indicated an error	EnC6
SSI, SC.SSI	Data was not at one before position was transmitted +Power supply failure	
SC, SC.Hiper, SC.EnDat, SC.SSI, EnDat, SSI	Initialisation failed	EnC7
SC.Hiper, SC.EnDat, EnDat	Auto configuration requested and failed	EnC8
All	Speed feedback selected from a Solutions Module slot that does not have a position feedback category Solutions Module fitted	EnC9
All (Servo mode only)	Incorrect encoder phasing(4)	EnC10

+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.
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.

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

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 are reset. Initialisation causes an encoder with comms to be re-initialised and auto-configuration to be performed if selected. After initialisation Ab.Servo, Fd.Servo and Fr.Servo encoders will use the UVW commutations signals to give position feedback for the first 120° (electrical) of rotation when the motor is restarted.

A delay is provided during intialisation 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	100ms
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, option 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 trip. This means that both the original trip (EnC2 to EnC8) 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 and the encoder type is recognised based on the information provided by the encoder, the drive will set the encoder turns (Pr **3.33**), the equivalent lines per revolution (Pr **3.34**) and the encoder comms resolution (Pr **3.35**) for the encoder. If the encoder is recognised these parameters will all become read only. If the encoder is not recognised, the drive initiates an EnC7 trip to prompt the user to enter the information. The drive should be able to auto-configure with any EnDat encoder where the number of turns and lines per revolution are a power of 2, and the following HIPERFACE encoders: SCS 60/70, SCM 60/70, SRS 50/60, SRM 50/60, SHS 170, LINCODER, SCS-KIT 101, SKS36, SKM36.

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.

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				
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 initialised. 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 the drive or to a position category Solutions Module, and the encoder type is SC, SC.Hiper, SC.EnDat, SC.SSI or EnDat the encoder will no longer be initialised. When an encoder is no longer initialised Pr **3.48** is reset to zero and the drive cannot be enabled. The encoder may be re-initialised, provided the drive is not active, by setting Pr **3.47** to one. This parameter is automatically reset to zero when the initialisation is complete.

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.

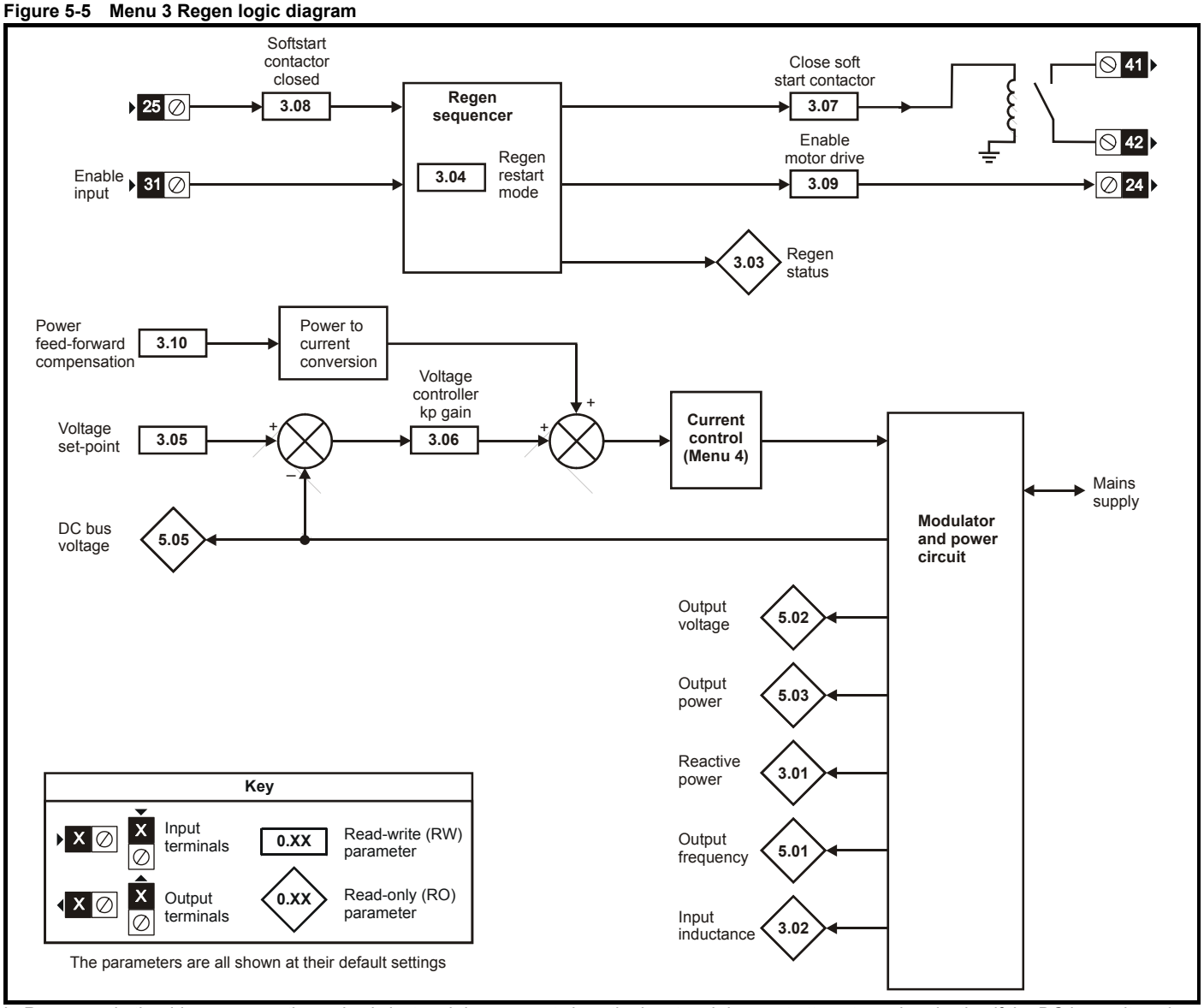
User parameter	Motor object parameter
Pr **18.11**	Motor object version number
Pr **18.12**	Motor type (MSW)
Pr **18.13**	Motor type (LSW)
Pr **18.14**	Motor manufacturer
Pr **18.15**	Motor serial number (MSW)
Pr **18.16**	Motor serial number
Pr **18.17**	Motor serial number (LSW)

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		
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.

Parameter descriptions: Regen

Figure 5-5 Menu 3 Regen logic diagram



In Regen mode the drive assumes the mains is lost and does cannot close the input and does not attempt synchronisation if the DC bus voltage is below the levels given in the table below. If the unit is synchronised and the DC bus voltage falls below this level the unit is disabled and the input contactor is opened. The Regen unit also monitors the voltage at its AC terminals for mains loss and if this falls below the levels given in the table the unit is disabled and the input contactor is opened.

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

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 15								
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 synchronise to the supply waveforms.

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

3.04	Regen restart mode															
Drive 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 synchronisation failure occurs.

0, rESYnC: Continuously attempt to re-synchronise

1, del.triP: delayed trip

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

2, triP: immediate trip

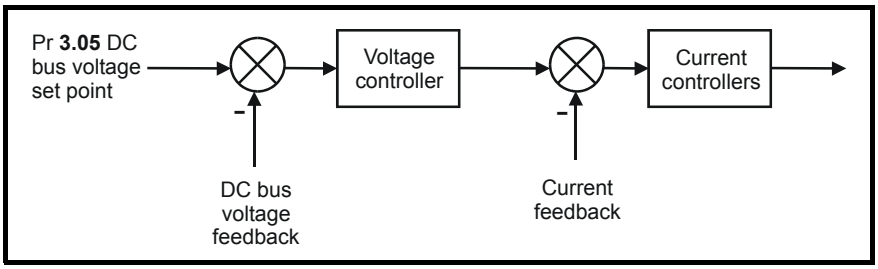
Attempt to synchronise for 30s. If unsuccessful after this time then give a LI.SYnC trip. After a failure during running, trip immediately.

3.05	**Voltage set-point**															
Drive 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: 1005							
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.

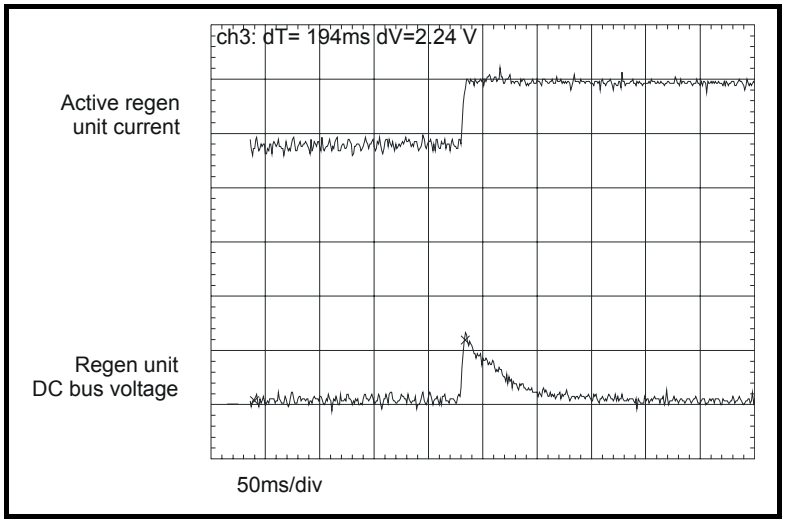
Setting the current controller gains

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/IDR mH per phase, where IDR is the drive rated current), then the proportional gain may need to be increased. The supply inductance is likely to be negligible compared to the regen inductor value with small drives, but is likely to be significant with larger drives. The proportional gain 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 d.c. 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 d.c. 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 soft-start 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															

When the regen unit has powered-up through the soft-start resistor and the DC bus voltage has stabilised this bit changes from 0 to 1. When regen mode is selected this bit is routed to the relay on terminals 41 (T41) and 42 (T42) as default. This output, or an alternative output, should be used to control the soft-start contactor.

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

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 synchronised this bit will become active. If the regen unit attempts to re-synchronise or trips, this bit becomes inactive. When regen mode is selected this bit is routed to a the digital output on terminal 24 (T24) as default. The output, or an alternative output, should be used to enable the motor drive(s) connected to the DC bus of the regen 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	2			1				1		
Range	Regen							±100 %								
Default	Regen							0.00								
Update rate	4ms read															

Power feed-forward compensation can be used to reduce the transient DC bus voltage produced when a fast load transient occurs on drives connected to the Regen unit. 100.0% power feed-forward is equivalent to an active current of Rated drive current / 0.45 (i.e. over current trip level) and an AC terminal peak phase voltage equal to DC_VOLTAGE_MAX / 2. This scaling is the same as the power output from Pr **5.03** when high speed output mode is used (see section 5.8 *Menu 7: Analog I/O*). Therefore an analog output of the drive supplying 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 Rated drive current / Regen unit rated drive current

5.5 Menu 4: Torque and current control

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

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

*Rated drive current is 1 per unit current and is related to the scaling of the drive current feedback. For most drive sizes the rated drive current 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** on page 89 for more details). If the rated drive current 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 of the larger drive sizes the maximum Heavy Duty current rating is higher than the rated drive current, therefore the potential overload at 1.75 x rated drive current is reduced.

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 (except for Servo and Regen modes). 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 89 for more details). The maximum rated current is the maximum rated current allowed for Normal Duty operation.

Table 5-3 gives the Rated drive current, maximum Heavy Duty current rating and maximum Normal Duty rated current for all drive sizes and voltage ratings.

Table 5-3

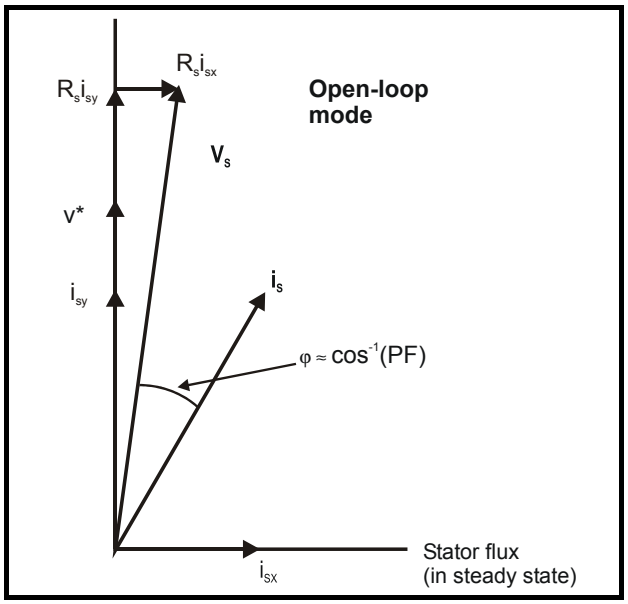
200V				400V				575V			
Model	**Rated drive current**	**Max Heavy Duty current rating**	**Max Normal Duty rated current**	**Model**	**Rated drive current**	**Max Heavy Duty current rating**	**Max Normal Duty rated current**	**Model**	**Rated drive current**	**Max Heavy Duty current rating**	**Max Normal Duty rated current**
1201	4.3	4.3	5.2	1401	2.1	2.1	2.8	3501	4.1	4.1	5.4
1202	5.8	5.8	6.8	1402	3.0	3.0	3.8	3502	5.4	5.4	6.1
1203	7.5	7.5	9.6	1403	4.2	4.2	5.0	3503	6.1	6.1	8.4
1204	10.6	10.6	11	1404	5.8	5.8	6.9	3504	9.5	9.5	11
2201	12.6	12.6	15.5	1405	7.6	7.6	8.8	3505	12	12	16
2202	17	17	22	1406	9.5	9.5	11	3506	18	18	22
2203	25	25	28	2401	13	13	15.3	3507	22	22	27
3201	31	31	42	2402	16.5	16.5	21				
3202	42	42	54	2403	23	25	29				
				3401	32	32	35				
				3402	40	40	43				
				3403	46	46	56				

Open-loop

In open-loop mode the drive operates in the stator flux reference frame under steady state conditions. The absolute maximum motor current is defined by the peak limit system as 1.75 x rated drive current. 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 rated drive current, 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. rated drive current / 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 Rated drive current) when the rated current set by Pr **5.07** (or Pr **21.07** if motor map 2 is selected) is less than or equal to the Maximum Heavy Duty current rating, otherwise it is (1.1 x Maximum motor 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 = $\sqrt{(1 - \text{power factor}^2)}$ x motor rated current

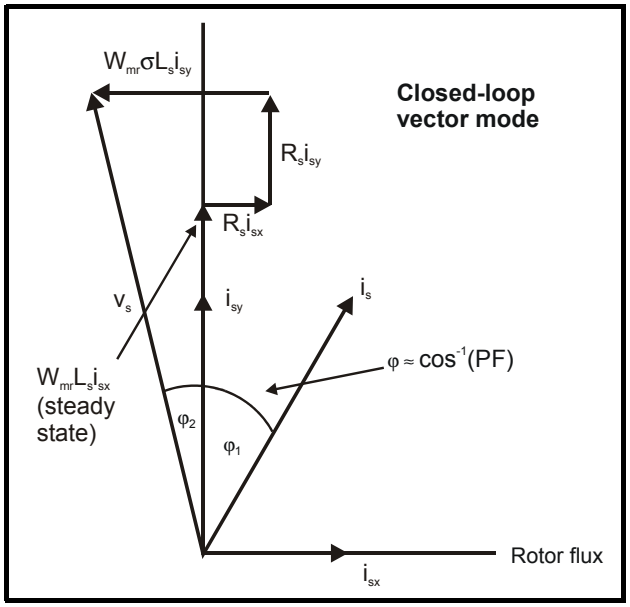
In this mode of operation the drive only requires the motor rated current and the power factor at rated load to set up the maximum current limits, scale the current limits correctly and calculate the rated active and magnetising currents. The user may enter the nameplate values in Pr **5.07** and Pr **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 101 for details.

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. rated drive current / 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 magnetising 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%):

$$\textbf{MOTOR1_CURRENT_LIMIT_MAX} = \frac{\sqrt{\left[\left[\frac{\textbf{Maximum current}}{\textbf{Motor rated current}}\right]^2 + \cos(\varphi\textbf{1})^2 - \textbf{1}\right]}}{\cos(\varphi\textbf{1})} \times \textbf{100\%}$$

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

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

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 (Pr **5.24**)

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.

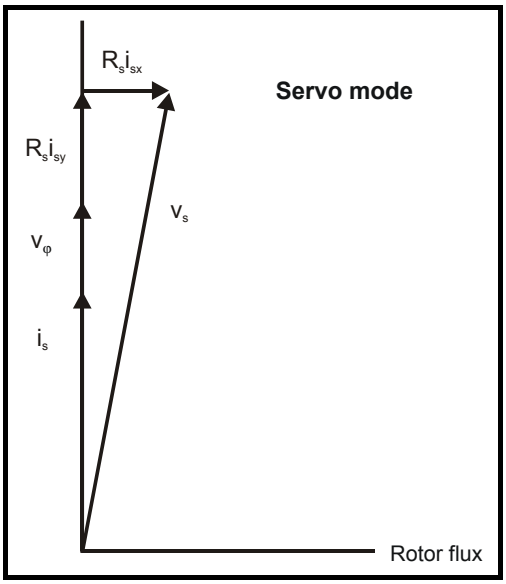
Parameters	Current limit accuracy
Motor rated current, power factor at rated load (R_s and σL_s are zero)	Moderate accuracy
Motor rated current, power factor at rated load, measured values of R_s and σL_s	Good accuracy
Motor rated current, power factor at rated load, measured values of R_s, σL_s and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

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. rated drive current / 0.45.

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



Definitions:

v_s = motor terminal voltage vector

i_s = motor current vector

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

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

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

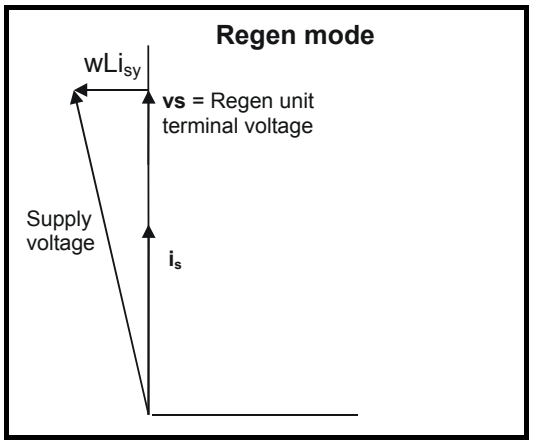
In this mode the drive only requires the motor rated current to set the maximum current limit correctly and scale the current limits, and so no auto-tuning is required to set these accurately.

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 rated drive current. The drive can operate up to this level under normal conditions.

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



Definitions:

i_s = regen drive terminal voltage vector

vs = regen drive current vector

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

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

Where:

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

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

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

rated active current = regen mode rated current

rated magnetising current = 0

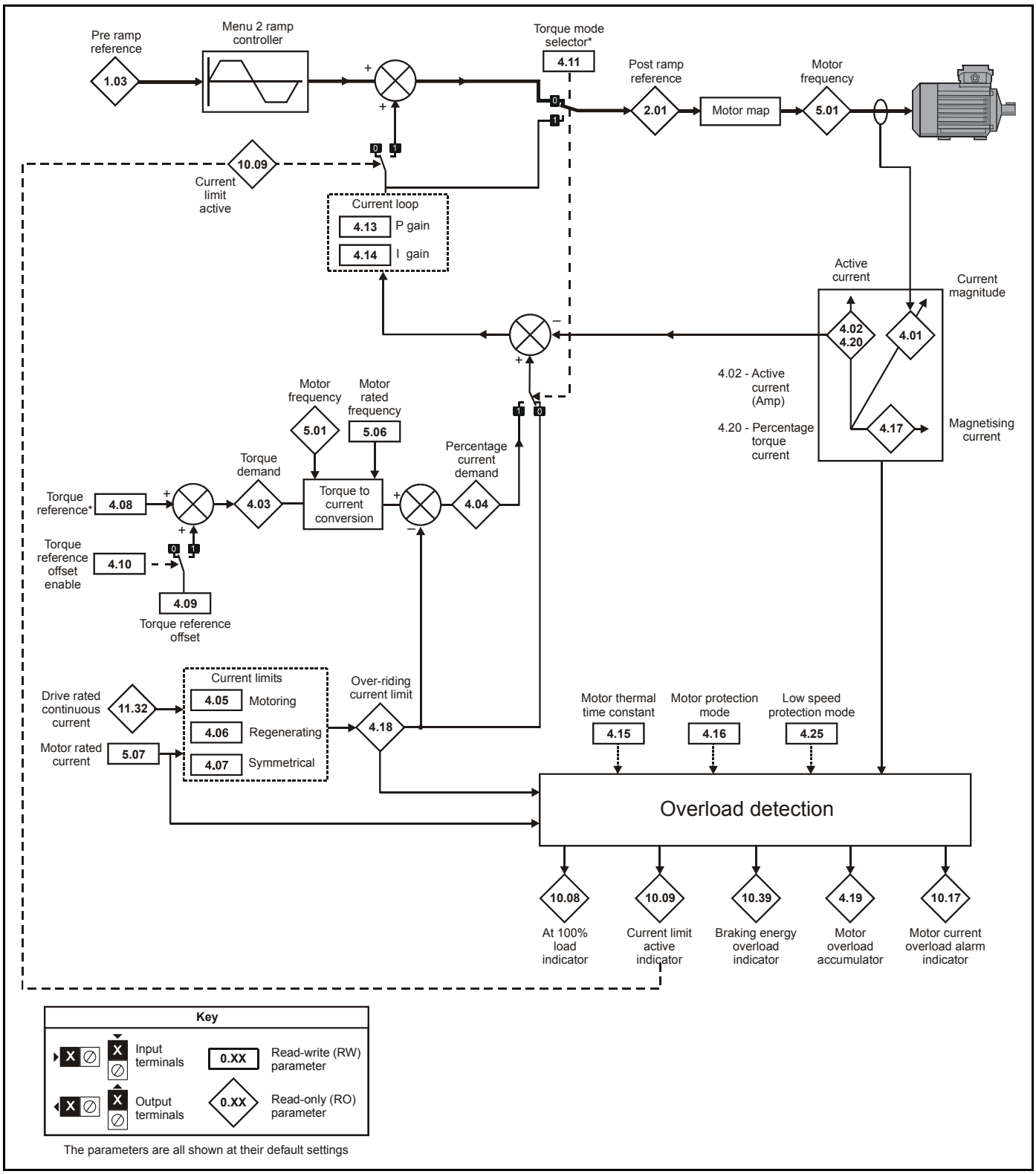
In this mode the drive only requires the regen mode rated current to set the maximum current limit correctly and scale the current limits, and so no auto-tuning is required to set these accurately.

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

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

Parameter descriptions: Open-loop

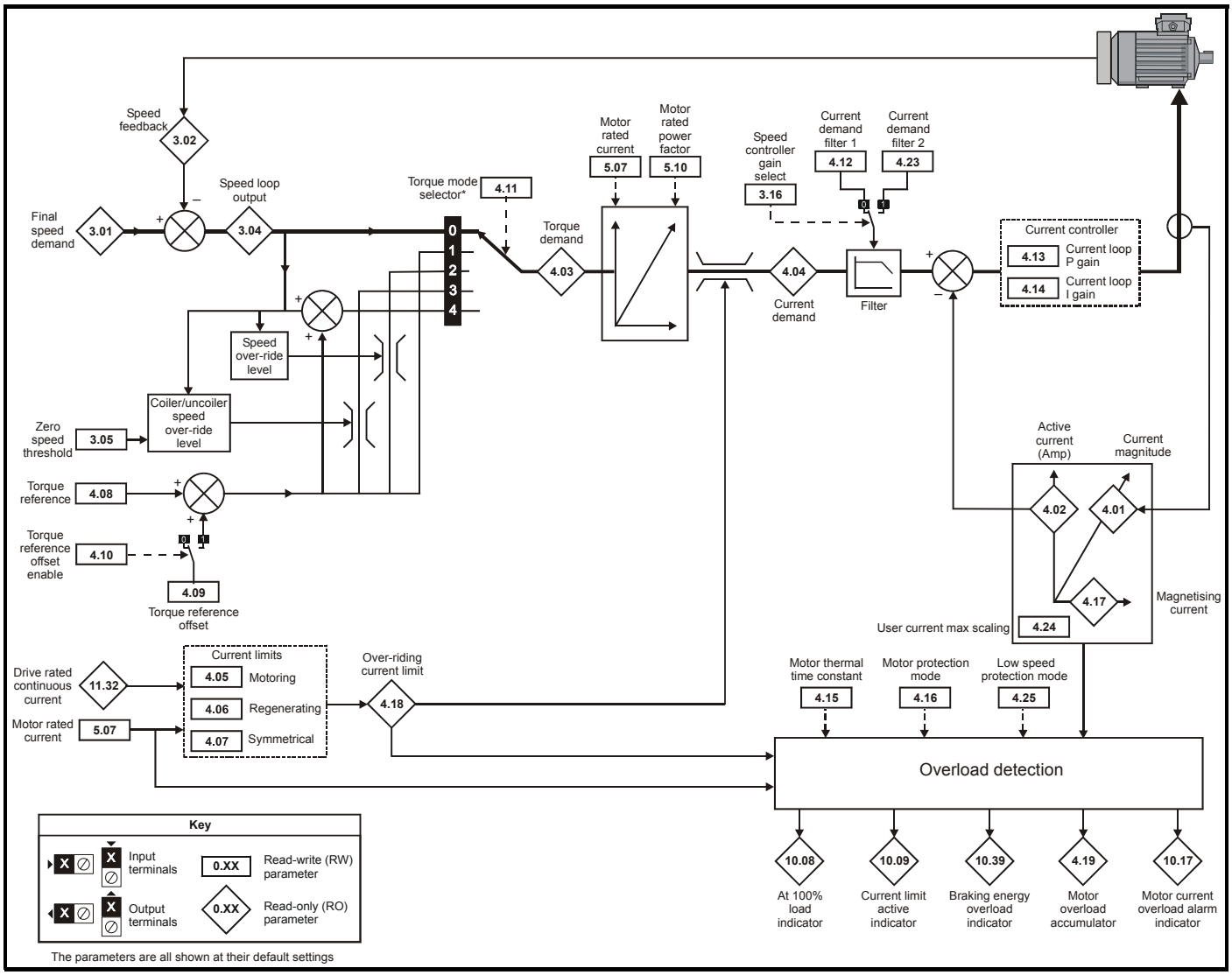
Figure 5-6 Menu 4 Open-loop logic diagram



The parameters are all shown at their default settings

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

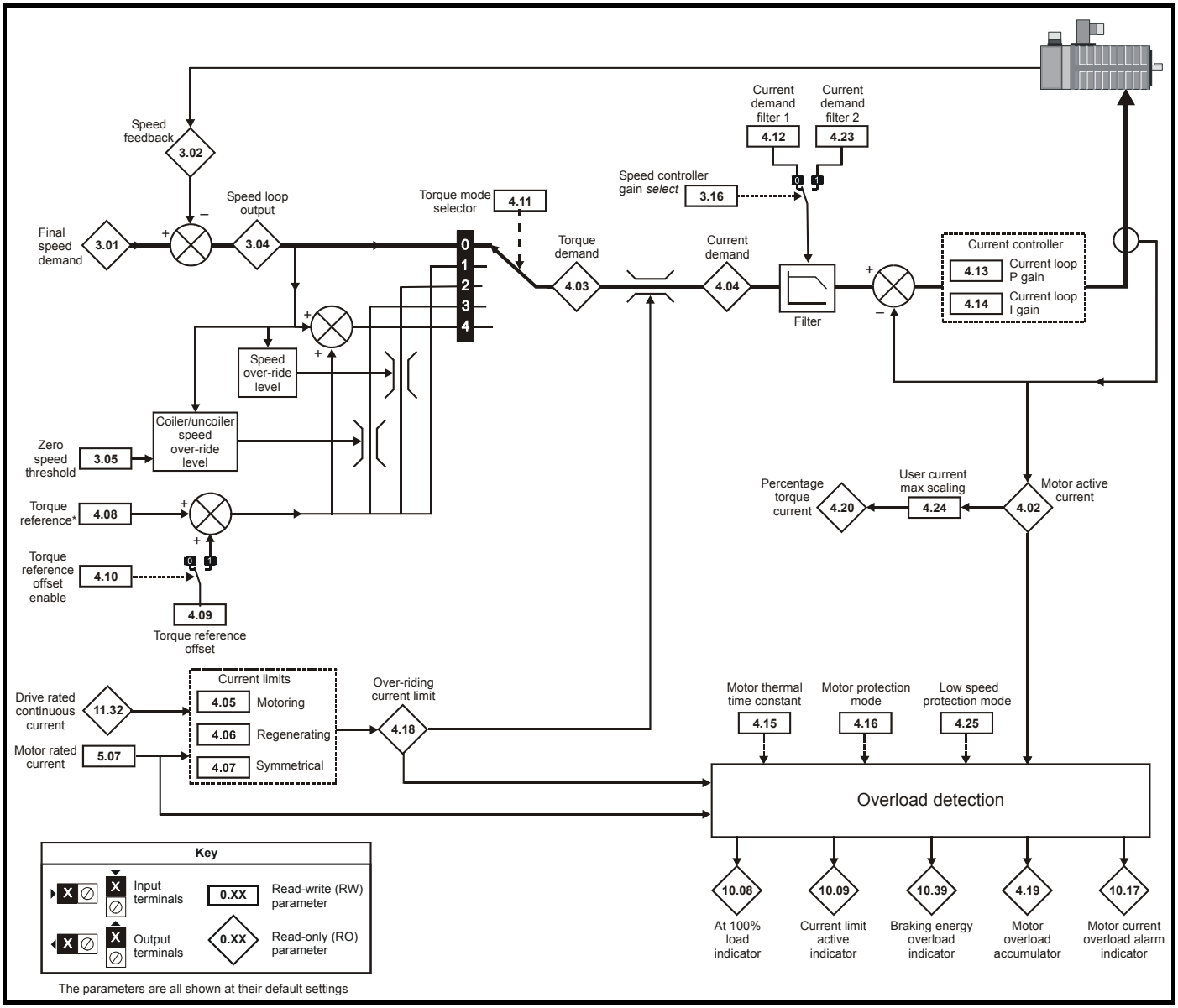
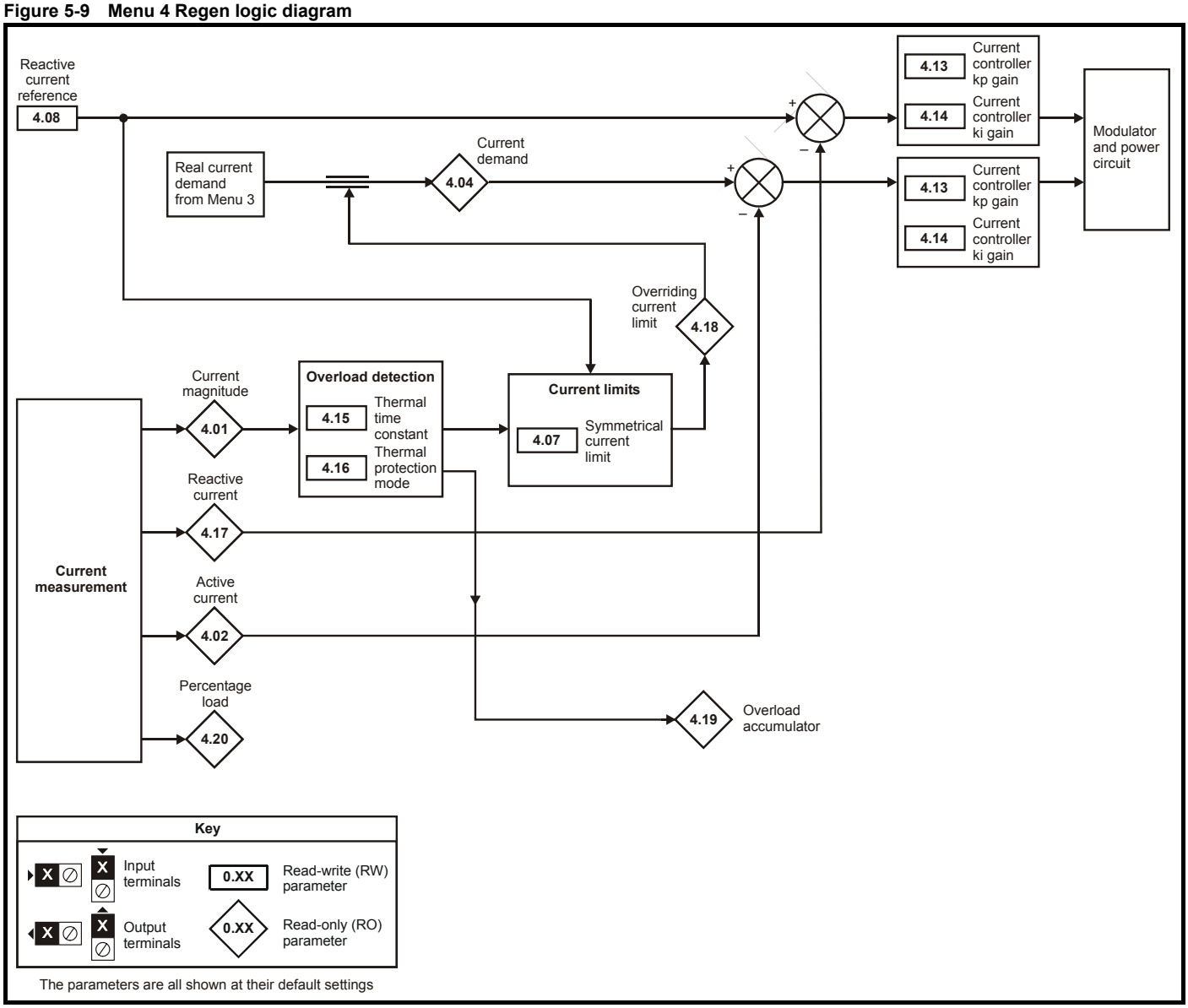


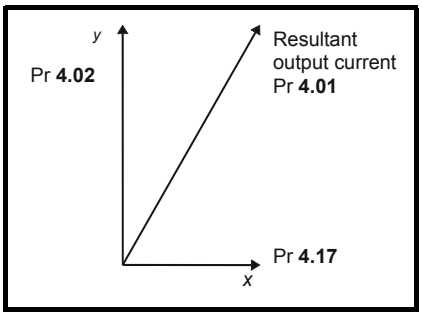
Figure 5-9 Menu 4 Regen logic diagram



The parameters are all shown at their default settings

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 magnetising 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.

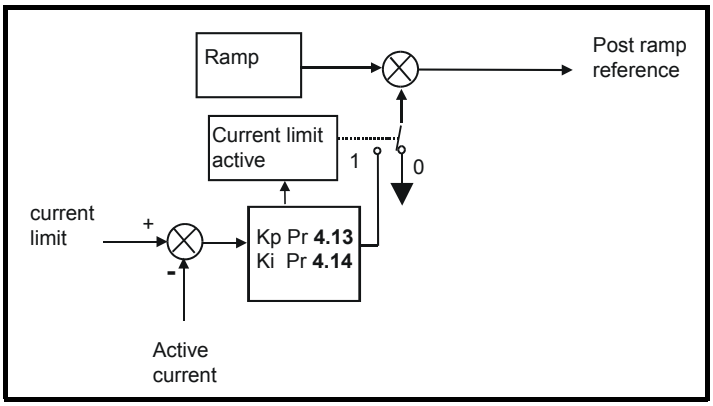
4.05	Motoring current limit															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to MOTOR1_CURRENT_LIMIT_MAX %														
Default	Open-loop Closed-loop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

4.06	Regen current 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	1	1	
Range	Open-loop, Closed-loop vector, Servo	0 to MOTOR1_CURRENT_LIMIT_MAX %														
Default	Open-loop Closed-loop vector, Servo	165.0 175.0														
Second motor parameter	Open-loop, Closed-loop vector, Servo	Pr **21.28**														
Update rate	Background read															

4.07	**Symmetrical 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	Pr **21.29**														
Update rate	Background read															

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 87 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.

4.08	**Torque 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	2						1	1		
Range	Open-loop, Closed-loop vector, Servo	±USER_CURRENT_MAX %														
Default	Open-loop, Closed-loop vector, Servo	0.00														
Update rate	4ms read															

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															

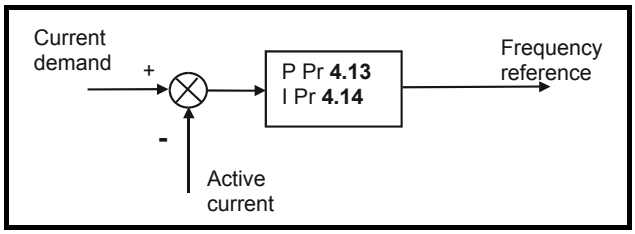
4.10	Torque offset select															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	4ms read															

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 whilst 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

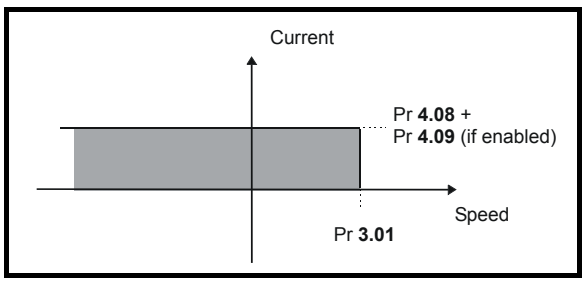
The torque demand is equal to the speed loop output.

1: Torque control

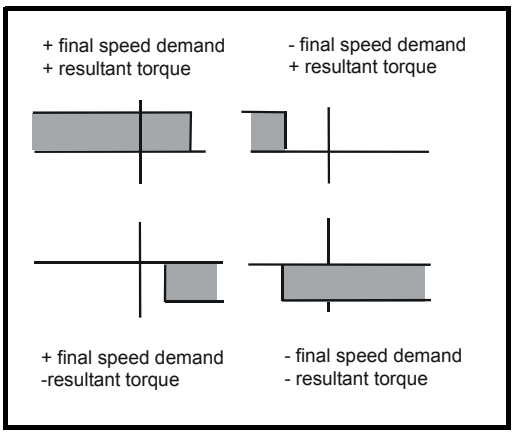
The torque demand is given by the sum of the torque reference and the torque offset, if enabled. The speed is not limited in any way, however, the drive will trip at the overspeed threshold if runaway occurs.

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.

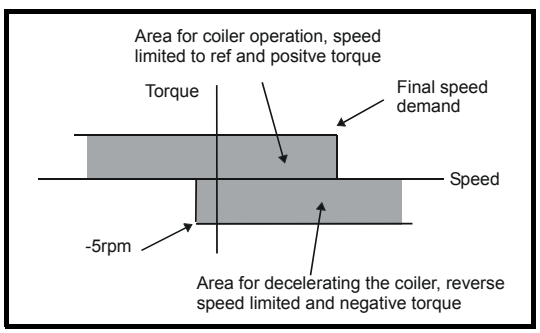
3: Coiler/uncoiler mode

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:

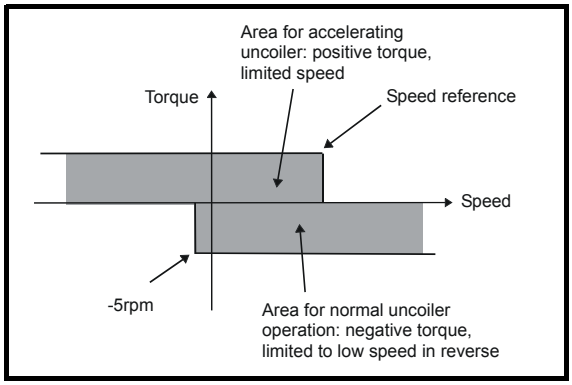
This is an example of a coiler operating in the positive direction. The final speed demand is set to a positive value just above the coiler reference speed. If the resultant torque demand is positive the coiler operates with a limited speed, so that if the material breaks the speed does not exceed a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

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															
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:							200V	400V	575V	690V					
	Open-loop,							20	20	20	20					
	Closed-loop vector, Servo							75	150	180	215					
	Regen							45	90	110	130					
	Closed-loop vector, Servo							Pr **21.22**								
Update rate	Background read															

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:	200V	400V	575V	690V											
	Open-loop,	40	40	40	40											
	Closed-loop vector, Servo, Regen	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

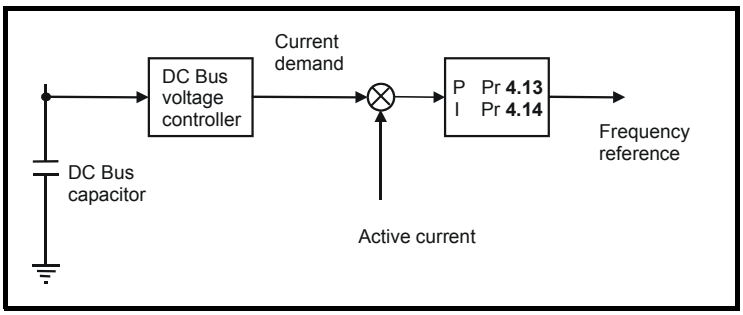
The current limits will normally operate with an integral term only, particularly below the point where field weakening begins. The proportional term is inherent in the loop. The integral term must be increased enough to counter the effect of the ramp which is still active even in current limit. For 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 Kp and Ki gains are used in the voltage based current controller. The default values give satisfactory operation with most motors. However it may be necessary to change the gains to improve the performance. The proportional gain (Pr **4.13**) is the most critical value in controlling the performance. Either the value can be set by auto-tuning (see Pr **5.12** on page 101) or it can be set by the user so that

Pr **4.13** = Kp = (L / T) x (I_{fs} / V_{fs}) x (256 / 4)

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. If σLs cannot be measured it can be calculated (see Pr **5.24** on page 108).

I_{fs} is the peak full scale current feedback = Rated drive current x $\sqrt{2}$ / 0.45. Where rated drive current is given by Pr **11.32**.

V_{fs} is the maximum DC bus voltage.

Therefore:

Pr **4.13** = Kp= (L / 167µs) x (Rated drive current x $\sqrt{2}$ / 0.45 / V_{fs}) x (256 / 4)

= K x L x Rated drive current

Where:

K = $\sqrt{2}$ / (0.45 x V_{fs} x 167µs) x (256 / 4)

Drive voltage rating	V_{fs}	K
200V	415V	2,902
400V	830V	1,451
575V	990V	1,217
690V	1,190V	1,013

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

Switching frequency (kHz)	Current control sample time (µs)	Gain bandwidth (Hz)	Delay (µs)
3	167	TBA	1,160
4	125	TBA	875
6	83	TBA	581
8	125	TBA	625
12	83	TBA	415
16	125	TBA	625

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

Pr **4.14** = 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

Pr **4.14** = Ki = (K x L x Rated drive current) x 256 x 167µs x R / L

= 0.0427 x K x R x Rated drive current

The previous equation gives a conservative value of integral gain. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed closed-loop induction motor applications) the integral gain may need to have a significantly higher value.

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

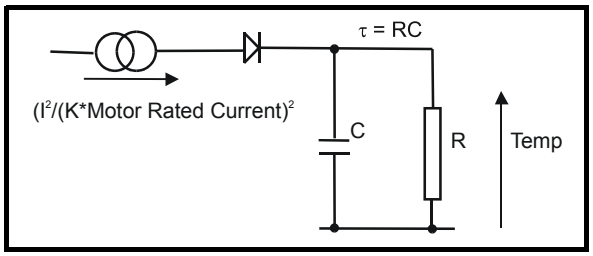
Regen

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 69 for guidelines on setting the regen unit current controller gains.

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 400.0								
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.

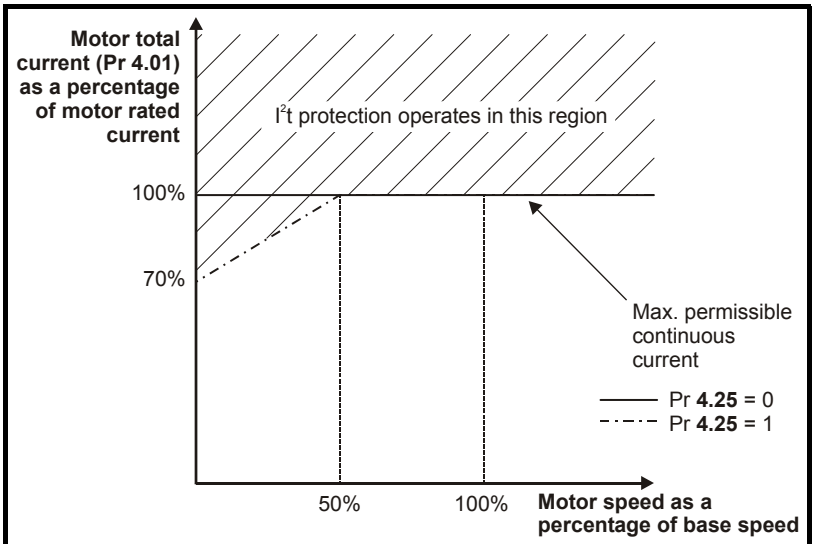


The temperature of the motor as a percentage of maximum temperature, with a constant current magnitude of I, constant value of K and constant value of motor rated current (set by Pr **5.07** or Pr **21.07**) after time t is given by

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

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 1.05% current. (In Regen mode K = 1.05 over the whole operating frequency range.)

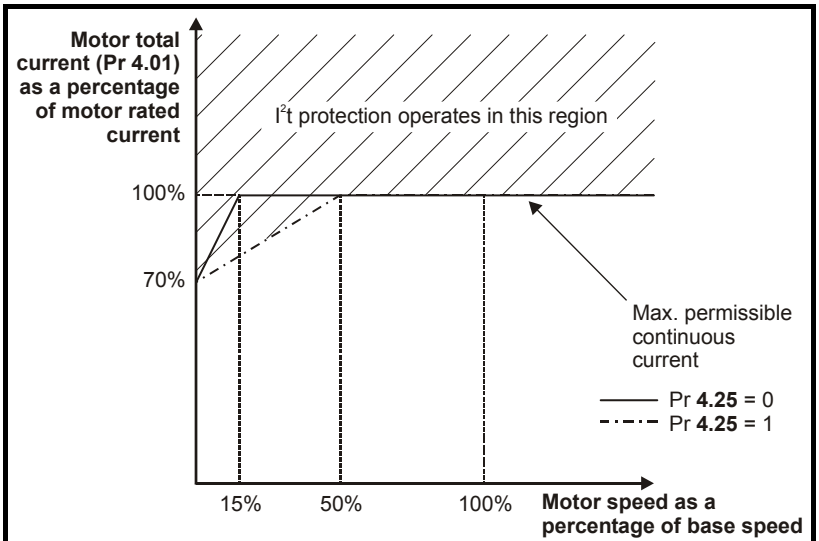


Open loop: Proportion of rated frequency Pr **5.06**.

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 1.01% 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 frequency dependant profile is not available in regen mode and the rated current cannot be increased above the maximum Heavy Duty rating.

The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the motor whilst 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 89.

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	
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															

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 89.

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															

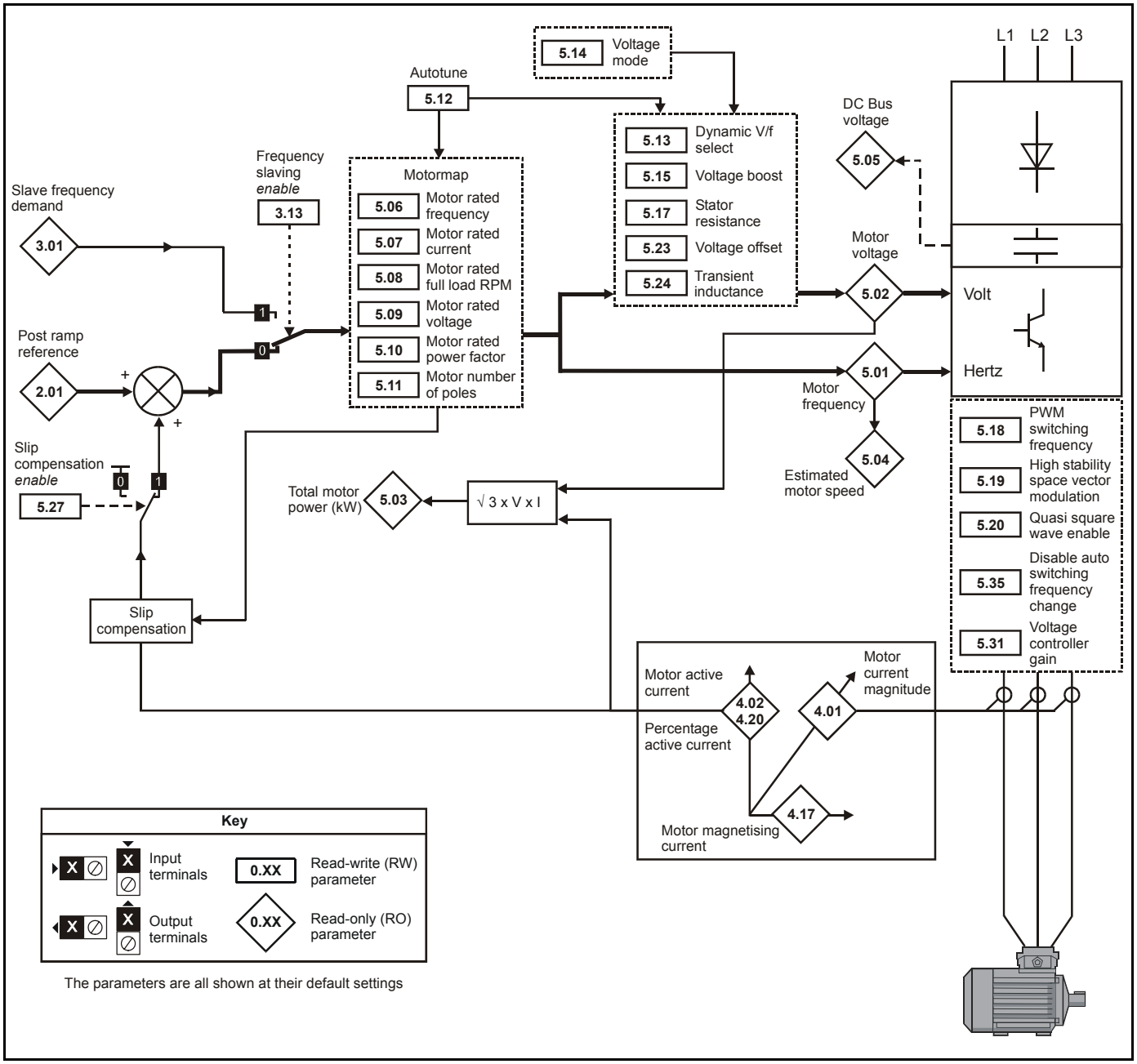
Pr **4.26** shows the torque producing current (Pr **4.02**) as a percentage of the active torque producing current, but with an additional adjustment above base speed so that this parameter shows percentage torque. Below base speed Pr **4.26** is equal to Pr **4.20**. Above base speed the percentage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

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

5.6 Menu 5: Motor control

Open loop

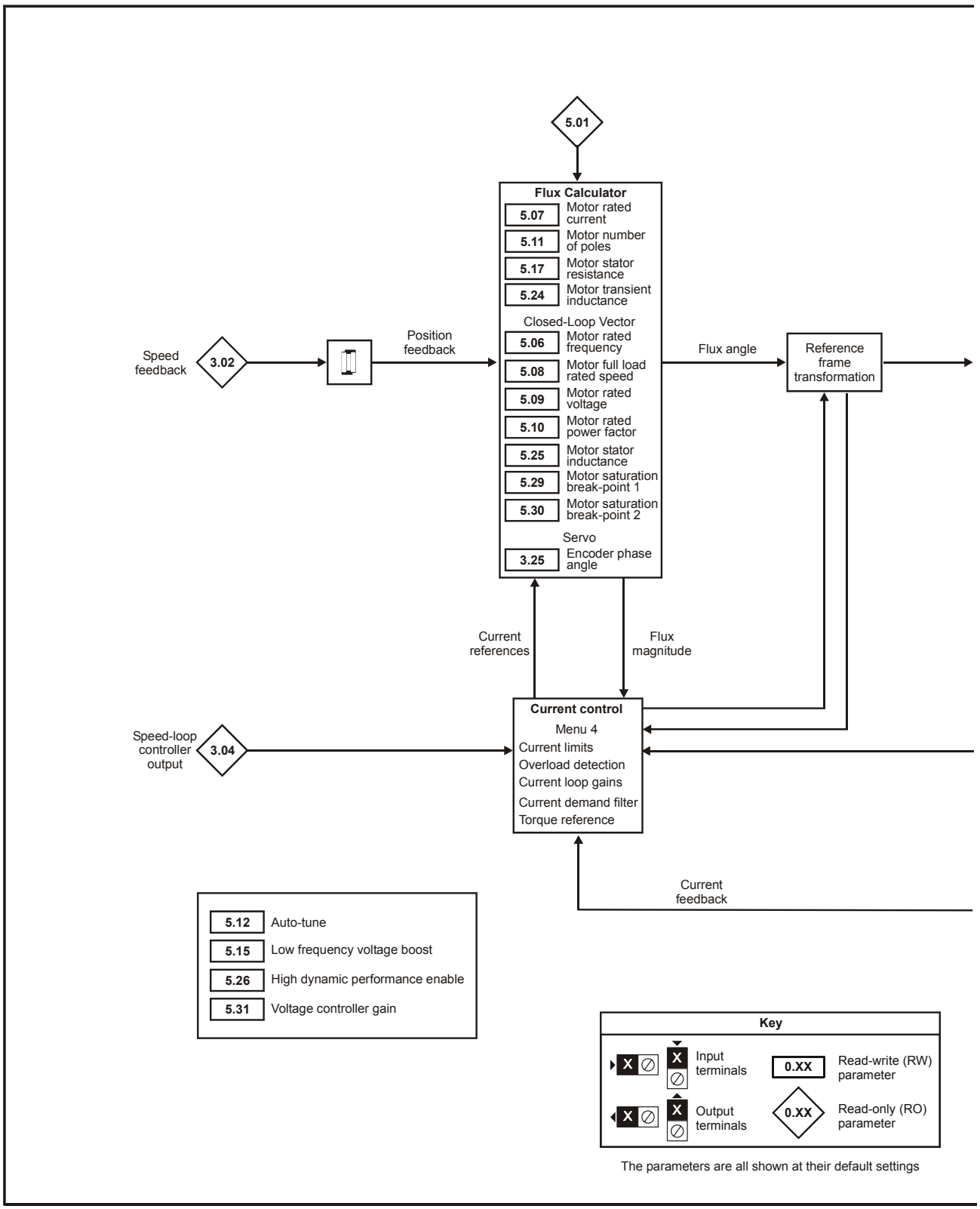
Figure 5-10 Menu 5 Open-loop logic diagram

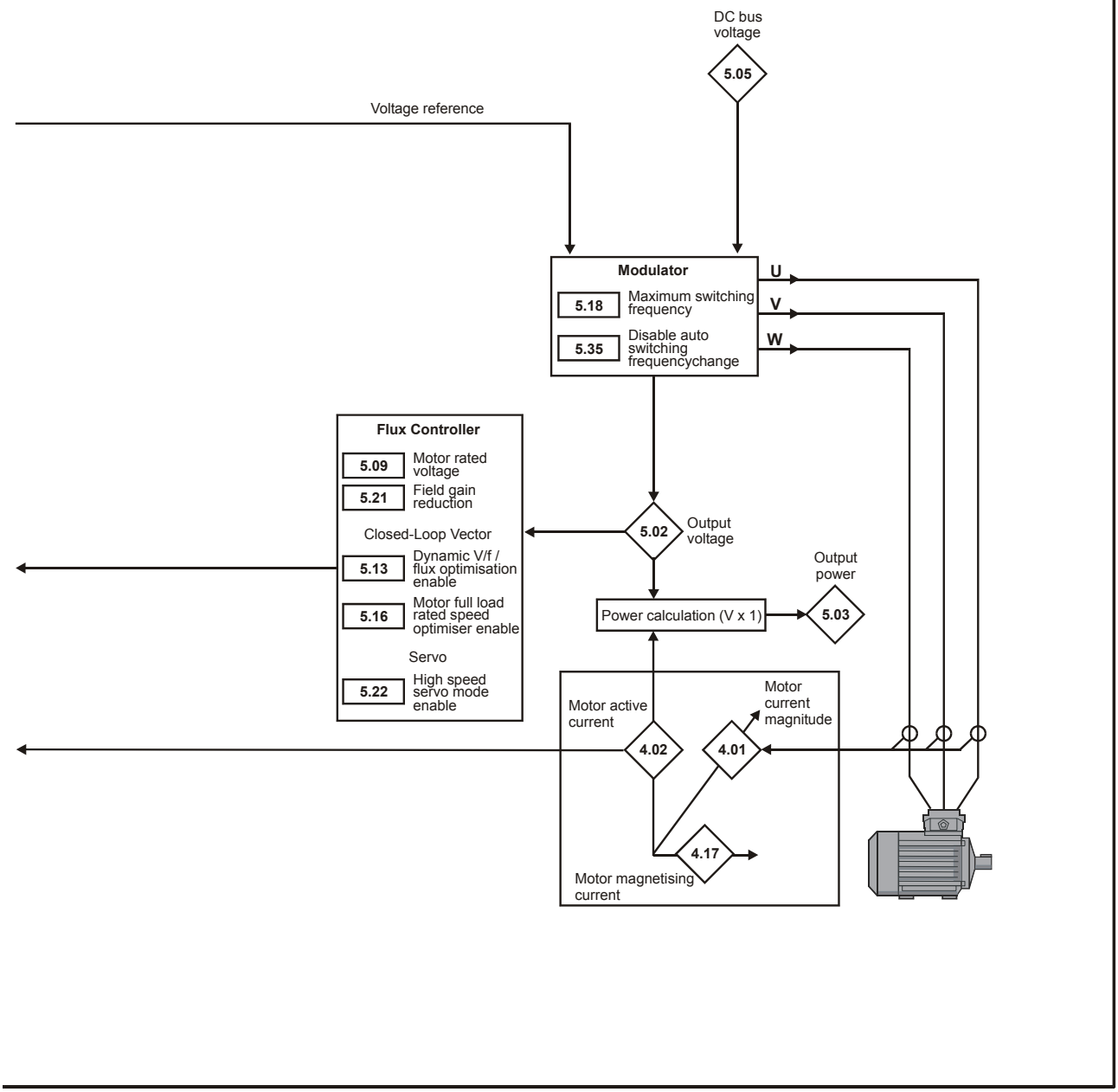


The parameters are all shown at their default settings

Closed-loop vector and Servo

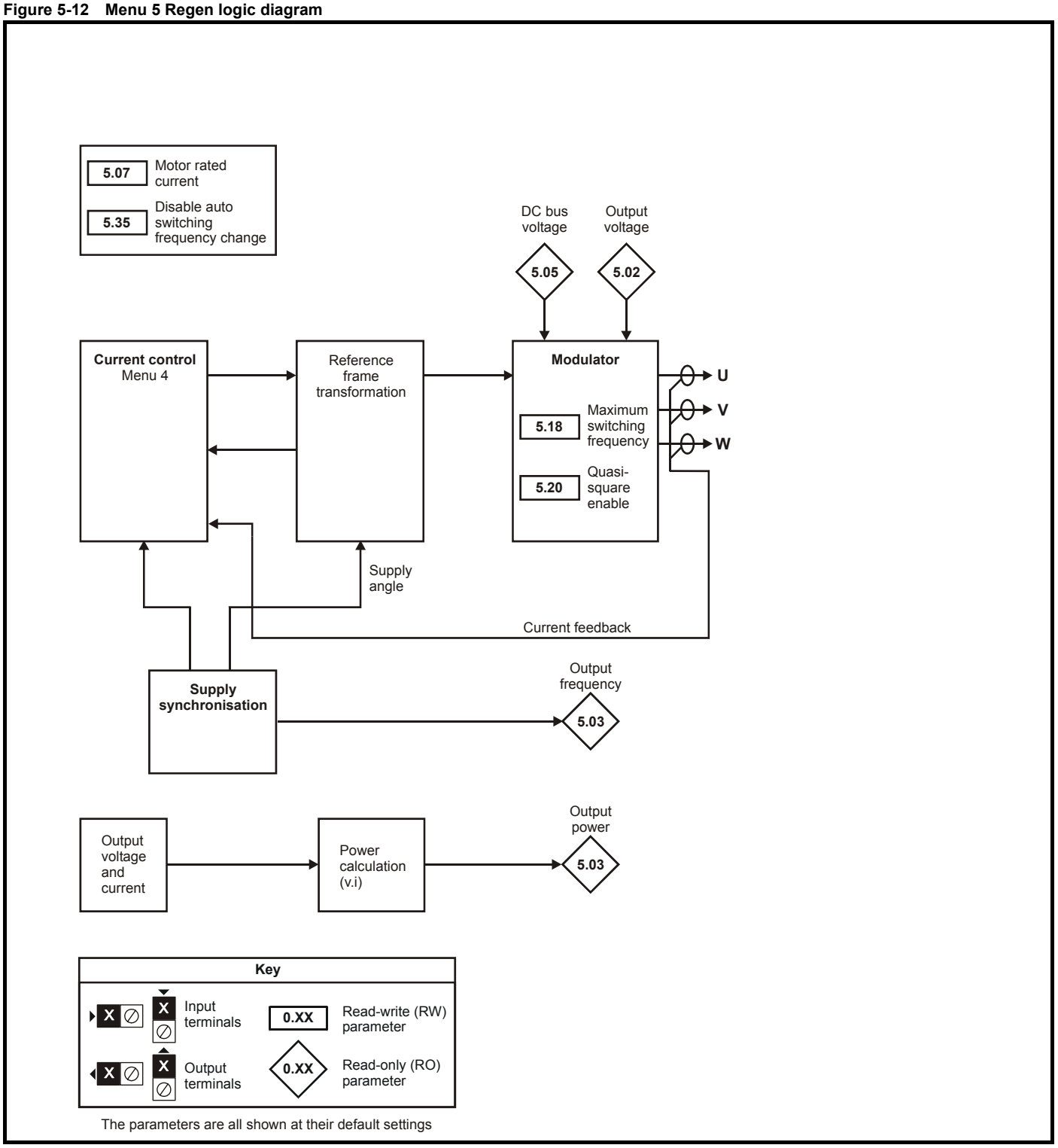
Figure 5-11 Menu 5 Closed-loop logic diagram




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



The parameters are all shown at their default settings

5.01	**Output 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		1				
	Closed-loop vector, Servo,Regen: VM = 0															
Range	Open-loop: ±SPEED_FREQ_MAX Hz Closed-loop vector, Servo: ±1250.0 Hz Regen: ±100.0 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, 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 AC_VOLTAGE_MAX V															
Update rate	Background write															

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

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															
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 +DC_VOLTAGE_MAX V								
Update rate	Background write															

Voltage across the internal DC bus of the drive.

5.06	Rated 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	
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															

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 99). 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 99).

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 99). 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															
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, Servo, Regen							0 to RATED_CURRENT_MAX A								
Default	Open-loop, Closed-loop vector, Servo, Regen							Drive rated current (Pr **11.32**)								
Second motor parameter	Open-loop, Closed-loop vector, Servo, Regen							Pr **21.07**								
Update rate	Background read															

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 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 optimisation system may be used to automatically adjust this parameter (see Pr **5.16** on page 106). It should be noted that the optimisation system does not operate when closed-loop vector mode is used with no position feedback (see Pr **3.24** on page 54).

Servo

The Rated load rpm defines the rated speed of the motor and is only used in the motor thermal protection scheme (see Pr **5.12** on page 101.) and to determine the speed used in the auto tuning inertia test (see Pr **5.12** on page 101).

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

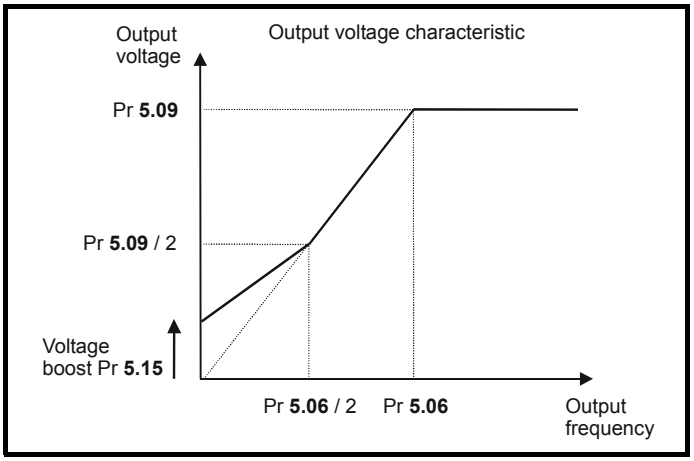
The rated voltage is used in conjunction with the motor rated frequency (Pr **5.06**) to define the voltage to frequency characteristic applied to the motor. The following operating methods selected by Pr **5.14** are used to define the drive frequency to voltage characteristic.

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.

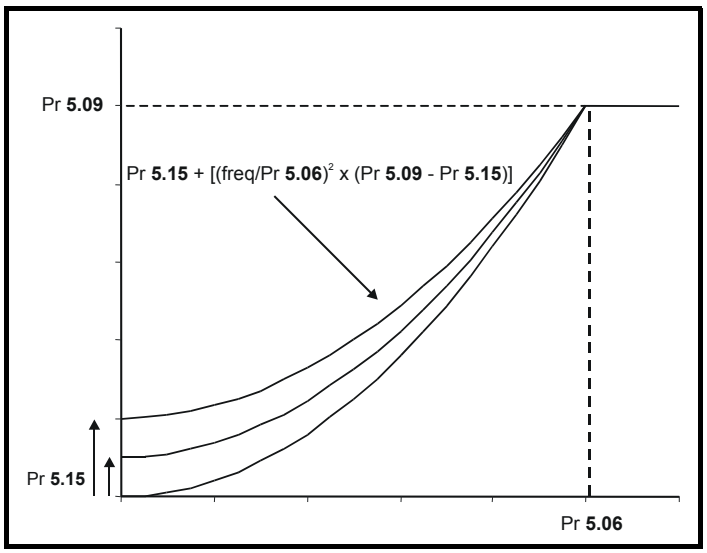
Fixed boost mode: Fd

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 101) and in the calculations required for automatic optimisation 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 field weakening 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															
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							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															

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															
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															

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															
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 0 to 3								
Default	Open-loop, Closed-loop vector, Servo							0								
Update rate	Background read															

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. The motor can only be restarted if the drive is first in a state where the run command is not applied (i.e. the run or enable command must be removed, or the drive must be tripped etc.) As the tests progress 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 cloning 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.

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**.
- 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**		✓

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.

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 109), 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.

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 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 parameter 03.25, 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.

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.

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
	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
tunE3	Drive encoder commutation signals connected incorrectly, i.e. direction incorrect. (Drive encoder only.)	Servo 1,2
	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 set-up incorrectly This trip may also occur if the encoder lines parameter is incorrect. This trip will not occur if the motor poles are 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 30.000Ω. The maximum measurable value for a particular drive size can be calculated from the following formula.

Rs_{max} = DC_VOLTAGE_MAX / Drive rated current / 0.45 / √2

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 optimisation 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 optimises the copper losses in the motor and reduces the iron losses.

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.

5.15	**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							3.0 1.0								
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.

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 optimisation 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. Optimisation is disabled again if the load falls below half rated load. For best optimisation results the correct values of stator resistance (Pr **5.17**), transient inductance (Pr **5.24**), stator inductance (Pr **5.25**) and saturation breakpoints (Pr **5.29** 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.

The gain of the optimiser, 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.

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							0.0 to 30.000 Ω								
Default	Open-loop, Closed-loop vector, Servo							0.0								
Second motor parameter	Open-loop, Closed-loop vector, Servo							Pr **21.12**								
Update rate	Background read															

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															

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 112). 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	250µs	Current limit and ramps	Speed controller and ramps		Voltage controller
Level 3	1ms	1ms	Voltage controller			
Level 4	4ms	4ms	Time critical user interface			
Background	N/A	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.

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 / (Ke x √2)	400 / √2
400	800 / (Ke x √2)	800 / √2
575	955 / (Ke x √2)	955 / √2
690	1145 / (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/rpm**.** Care must also be taken not to de-magnetise 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															

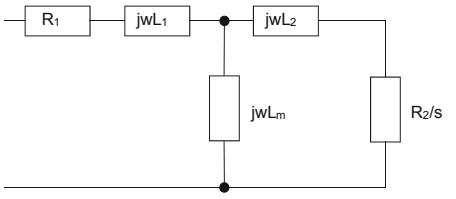
Due to various effects in the drive inverter a voltage offset must be produced before any current flows. To obtain good performance at low frequencies where the machine terminal voltage is small this offset must be taken into account. The value shown in Pr **5.23** is this offset given in line to line 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 105).

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 overleaf, the transient inductance is defined as

$\sigma L_s = L_1 + (L_2.L_m / (L_2 + L_m))$



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

$$\sigma L_s = L_s - (L_m^2 / L_r)$$

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.

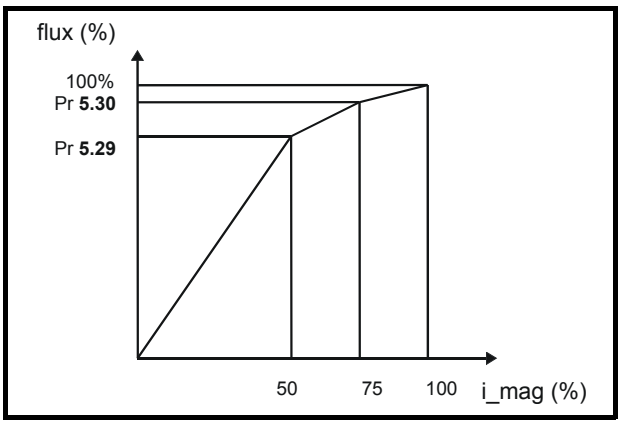
5.28	Field weakening compensation disable															
Drive modes	Closed-loop vector															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Closed-loop vector							0								
Update rate	Background read															

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%.

$$\mathbf{Kt} = \frac{\sqrt{3} \times \mathbf{Vrated} \times \mathbf{Irated} \times \mathbf{Rated\ power\ factor} \times \mathbf{Efficiency}}{\mathbf{Rated\ speed\ (rad\ s^{-1})} \times \mathbf{Rated\ active\ current}}$$

$$\mathbf{Kt} = \frac{\sqrt{3} \times \mathbf{Pr\ 5.09} \times \mathbf{Pr\ 5.07} \times \mathbf{Pr\ 5.10} \times 0.9}{(2\pi \times \mathbf{Pr\ 5.08} / 60) \times \mathbf{Rated\ active\ current}}$$

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.

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															

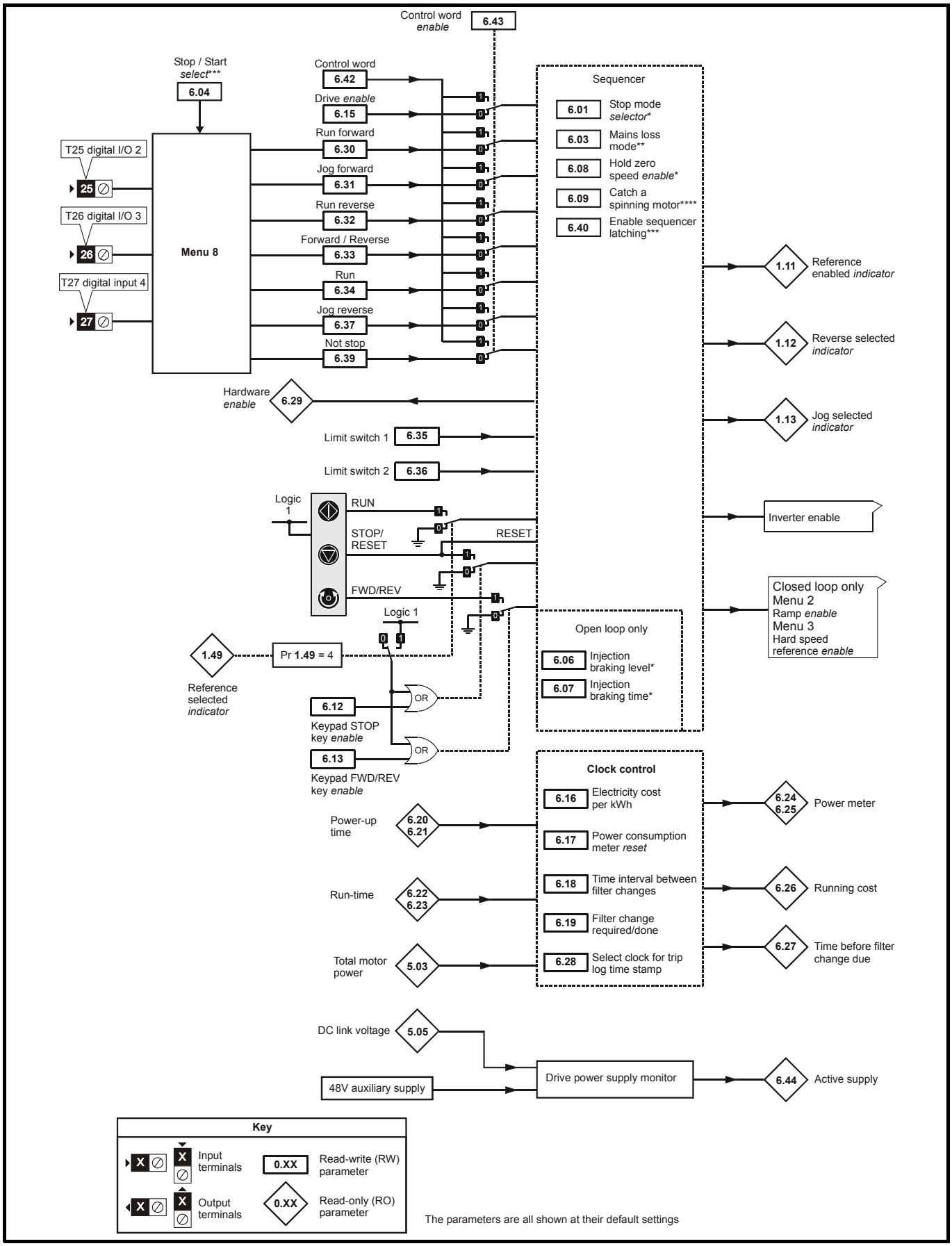
This parameter is used to set up the current controller integral terms when the drive is disabled to prevent current transients when the drive is enabled with a spinning motor. It is also used to provide a voltage feed forward term if high dynamic performance is selected with Pr **5.26**.

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 106) 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.

5.7 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 4 0 to 2									
Default	Open-loop, Closed-loop vector Servo							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.	

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.

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.

Stopping Mode	Action
0: Coast	Inhibits the inverter
1: Ramp	Stop with ramp
2: No ramp	Stop with no ramp

The motor can be stopped with position orientation after stopping. This mode is selected with the position controller mode (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. At this point, unless the mains has been restored, the drive is likely to initiate a UU trip.

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.

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_1 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 87 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	195	390	515	515
Vuu Restart	215	425	590	590

6.04	Start/stop logic 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	
Range	Open-loop, Closed-loop vector, Servo						0 to 4									
Default	Open-loop, Closed-loop vector, Servo						4									
Update rate	Background read															

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.)

Pr 6.04	T25	T26	T27	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

6.06	Injection braking level															
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 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	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															

Defines the time of injection braking during phase 1 with stopping modes 3 and 4 (see Pr **6.01** on page 114) for injection braking stop.

6.08	Hold 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		
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.

6.09	Catch a spinning motor															
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 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 250ms, however, if the motor has a long rotor time constant (usually large motors) it may be necessary to extend the test time. The drive will do this automatically if the motor parameters including the rated load rpm are set up correctly for the motor.

For the test to operate correctly it is important that the stator resistance (Pr **5.17**, 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 magnetising current of the motor during the test, therefore the rated current (Pr **5.07**, Pr **21.07** and Pr **5.10**, Pr **21.10**) and power factor should be set to values close to those of the motor, although these parameters are not as critical as the stator resistance.

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.

6.12	Enable stop key															
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															

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 is done 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.

The drive can then be restarted by activating the necessary bits to give a normal start.

Sequencer latching enabled (06.40 = 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.

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	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															

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	Txt	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	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 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	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 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	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/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.

6.20	Powered-up 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 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	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 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	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 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	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 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	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	±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	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	±99.99 kWh														
Update rate	Background write															

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

6.26	**Running cost**															
Drive 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	±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	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 30,000 hrs														
Update rate	Background read															

See Pr **6.18** on page 118.

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

6.29	Hardware enable															
Drive 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				
Update rate	4ms write															

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

6.30	Sequencing bit: Run 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		
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	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															

6.32	Sequencing bit: Run 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	4ms read															

6.33	Sequencing bit: Forward/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	4ms read															

6.34	Sequencing bit: Run															
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															

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 forwards / 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	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 read															

6.36	Reverse limit switch															
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 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	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															

6.39	Sequencing bit: Not stop															
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															

6.40	Enable sequencer latching															
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															

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

Drive mode changed (Bit 1)

The drive sets bit 1 when the drive mode has changed and the associated parameter save has been completed. The drive does not reset this flag except at power-up. This flag is intended to be used in a similar way as bit 0.

6.42	Control word															
Drive 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	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	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	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*	Analogue/Preset reference	Pr **1.42**
9*	Jog reverse	Pr **6.37**
10	Reserved	
11	Reserved	
12	Trip drive	
13	Reset drive	Pr **10.33**
14	Keypad watchdog	

Bits 0-7 and bit 9: sequencing control

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

Bit 8: 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 analogue reference 1 (bit8 = 0) or preset reference 1 (bit8 = 1). If any other drive parameters are routed to Pr **1.42** the value of Pr **1.42** is undefined.

Bit12: Trip drive

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

Bit 13: Reset drive

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

Bit 14: Keypad watchdog

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

6.44	**Active supply**															
Drive 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															

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

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

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

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

6.45	**Force cooling fan to run at full speed**															
Drive 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		
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.

6.46	**Nominal low voltage supply**															
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							Size 1: 48 V Size 2 & 3: 48 to 72 V								
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 actual value of the parameter is not used directly by the drive, but is used to define the braking IGBT switching threshold and the over voltage trip level for low voltage mode (see Pr **6.44**).

5.8 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.

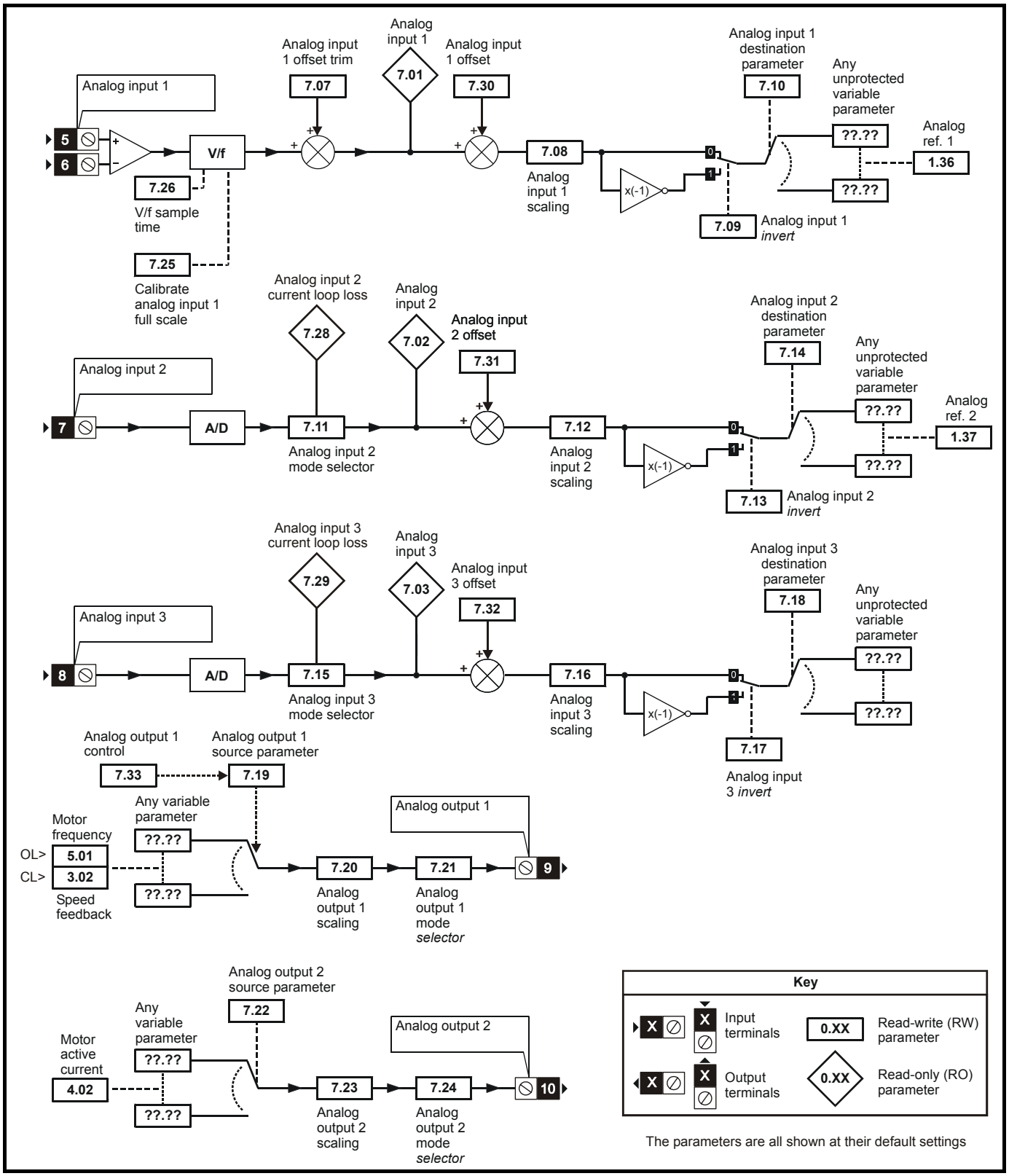
Input destination	Closed-loop vector or Servo mode sample rate	Regen mode sample rate
Pr **1.36** - Analog reference	250µs (AI1 subject to window filter. See Pr **7.26** on page 132)	
Pr **1.37** - Analog reference	250µs (AI1 subject to window filter. See Pr **7.26** on page 132)	
Pr **3.14** - Power ff comp		AI1 - 4ms AI2 or 3 - 1ms
Pr **3.19** - Hard speed ref	250µs (AI1 subject to window filter. See Pr **7.26** on page 132)	
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 = Rated drive current / 0.45
Pr **4.17** - magnetising current	10.0V = Rated drive current / 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 = Rated drive current / 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															

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															

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

7.04	**Stack temperature 1**															
Drive 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	**Stack 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			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	-128 to 127°C														
Update rate	Background write															

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

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

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

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

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

The drive cooling fan is controlled as follows:

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

7.07	**T5/6 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. A current loop loss trip is generated if the input current falls below 3mA. In modes 4 and 5 the analog input level goes to 0.0% if the input current falls below 3mA.

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

7.12	**T7 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	6														
Update rate	Background read															

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

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

7.16	T8 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 up date mode

If high speed update mode is selected and the source for the output is one of the parameters designated for high speed 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															
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 **4.02** Pr **5.05**								
Update rate	Read on drive reset															

7.23	T10 analog output 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															

7.24	T10 analog output 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 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 up date mode

If high speed update mode is selected and the source for the output is one of the parameters designated for high speed 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															
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															

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															
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 8.0 ms														
Default	Open-loop, Closed-loop vector, Servo, Regen	4.0														
Update rate	Background read															

Analog input 1 is filtered using a window filter to remove quantisation noise and adjust the resolution of this input. The length of the window can be adjusted with this parameter. The shortest possible window is 250µs. It should be noted that if this input is not used as a speed reference (Pr **1.36**, Pr

1.37) or as a hard speed reference (Pr **3.22**) the sample time affects the resolution. The nominal resolution is given by Pr **7.26** x 10^6, therefore the default setting gives approximately 12 bit resolution.

7.28	**T5/6 analog input 1 current loop loss**															
7.29	**T7 analog input 2 current loop 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	Background write															

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** -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															
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, Regen								±100.00 %							
Default	Open-loop, Closed-loop vector, Servo, Regen								0.00							
Update rate	Background read															

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 is calculated using Stack 1 temperature (Pr **7.04**) and a thermal model of the drive power stage. The resulting temperature is displayed in this parameter. The calculated IGBT junction temperature is used to modify the drive switching frequency to reduce losses if the devices become too hot (see Pr **5.18** on page 106).

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															

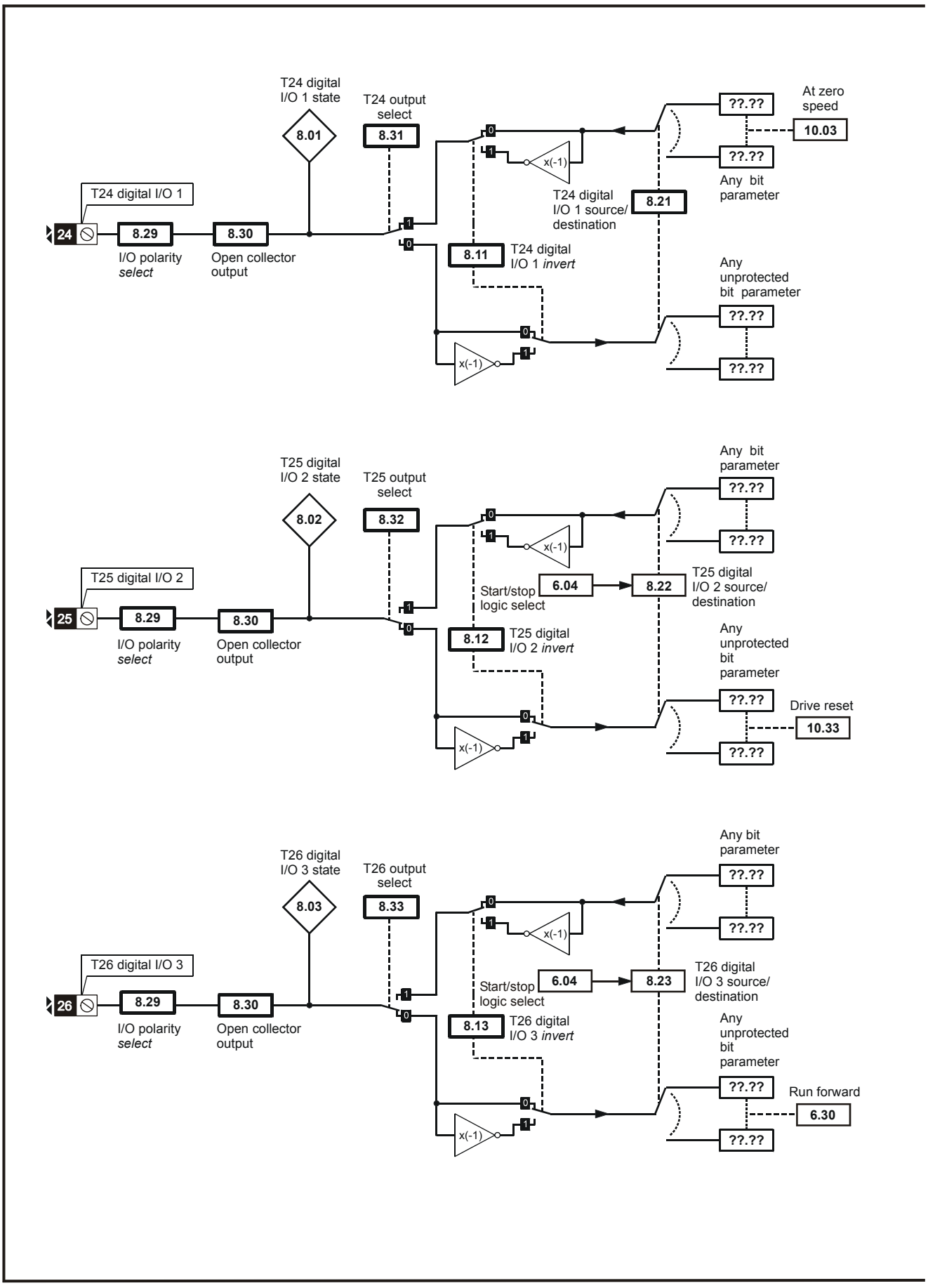
In addition to monitoring the IGBT junction temperatures the drive includes a thermal protection system to protect the other components within the drive. This includes the effects of drive output current and DC bus ripple. The estimated temperature is displayed as a percentage of the trip level in this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

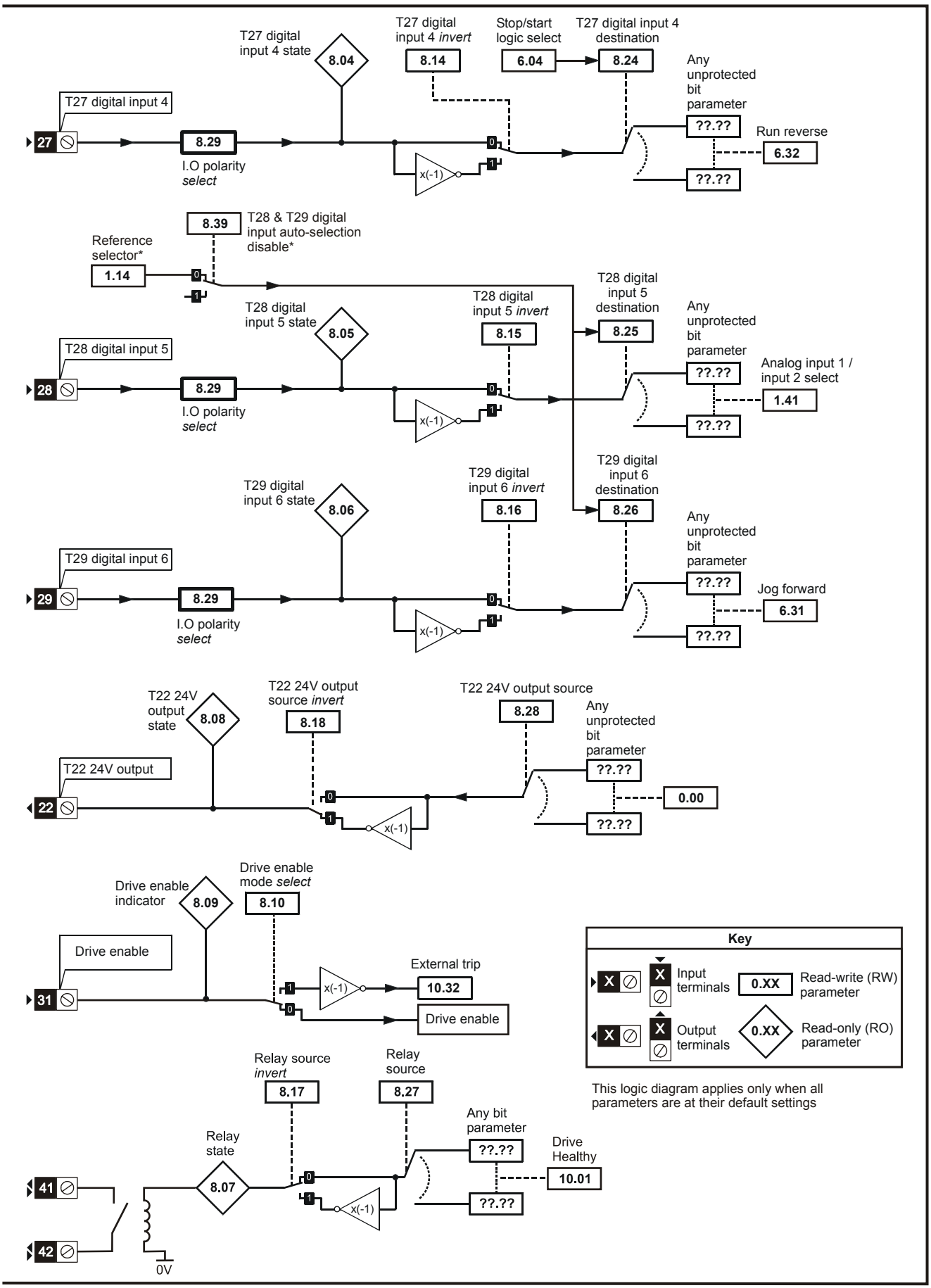
5.9 Menu 8: Digital I/O

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 I/O is sampled every 4ms, except when inputs are routed to the limit switches Pr **6.35** and Pr **6.36** when the sample time is reduced to 250µs. Any changes to the source/destination parameters only become effect after drive reset is activated.

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

Figure 5-15 Menu 8 logic diagram




T27 digital input 4
27
8.29
I.O polarity select
T27 digital input 4 state
8.04
T27 digital input 4 invert
8.14
Stop/start logic select
6.04
T27 digital input 4 destination
8.24
Any unprotected bit parameter
??.??
??.??
Run reverse
6.32
x(-1)
8.39
T28 & T29 digital input auto-selection disable*
Reference selector*
1.14
T28 digital input 5
28
8.29
I.O polarity select
T28 digital input 5 state
8.05
T28 digital input 5 invert
8.15
T28 digital input 5 destination
8.25
Analog input 1 / input 2 select
1.41
T29 digital input 6
29
8.29
I.O polarity select
T29 digital input 6 state
8.06
T29 digital input 6 invert
8.16
T29 digital input 6 destination
8.26
Jog forward
6.31
T22 24V output
22
T22 24V output state
8.08
T22 24V output source invert
8.18
T22 24V output source
8.28
0.00
Drive enable
31
Drive enable indicator
8.09
Drive enable mode select
8.10
External trip
10.32
Drive enable
Relay source invert
8.17
Relay source
8.27
Relay state
8.07
Any bit parameter
Drive Healthy
10.01
41
42
0V
Key
Input terminals
Output terminals
0.XX
Read-write (RW) parameter
Read-only (RO) parameter
This logic diagram applies only when all parameters are at their default settings

Open-loop, closed-loop vector and servo
Table 5-4

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 healthy		
T22 24V output	Pr **8.08**	Pr **8.18**	1	Pr **8.28**	Pr **0.00**		
T31 Enable	Pr **8.09**						

Regen
Table 5-5

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** - Enble motor drive	Pr **8.31**	1
T25 input / output 2	Pr **8.02**	Pr **8.12**	0	Pr **8.22**	Pr **3.08** - Contactor closed	Pr **8.32**	0
T26 input / output 3	Pr **8.03**	Pr **8.13**	0	Pr **8.23**	Pr **10.01** – Drive healthy	Pr **8.33**	1
T27 input 4	Pr **8.04**	Pr **8.14**	0	Pr **8.24**	Pr **0.00** - Not used		
T28 input 5	Pr **8.05**	Pr **8.15**	0	Pr **8.25**	Pr **0.00** - Not used		
T29 input 6	Pr **8.06**	Pr **8.16**	0	Pr **8.26**	Pr **0.00** - Not used		
T41 / 42 Relay	Pr **8.07**	Pr **8.17**	0	Pr **8.27**	Pr **3.07** – Close contactor		
T22 24V output	Pr **8.08**	Pr **8.18**	1	Pr **8.28**	Pr **0.00** - Not used		
T31 Enable	Pr **8.09**						

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				
Update rate	4ms write															

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 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															

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	Enable

8.21	**T24 digital I/O 1 source/destination**															
8.22	**T25 digital I/O 2 source/destination**															
8.23	**T26 digital I/O 3 source/destination**															
8.24	**T27 digital input 4 destination**															
8.25	**T28 digital input 5 destination**															
8.26	**T29 digital input 6 destination**															
Drive 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 5-4 on page 138 See Table 5-5 on page 138								
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 5-4 on page 138 See Table 5-5 on page 138								
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															

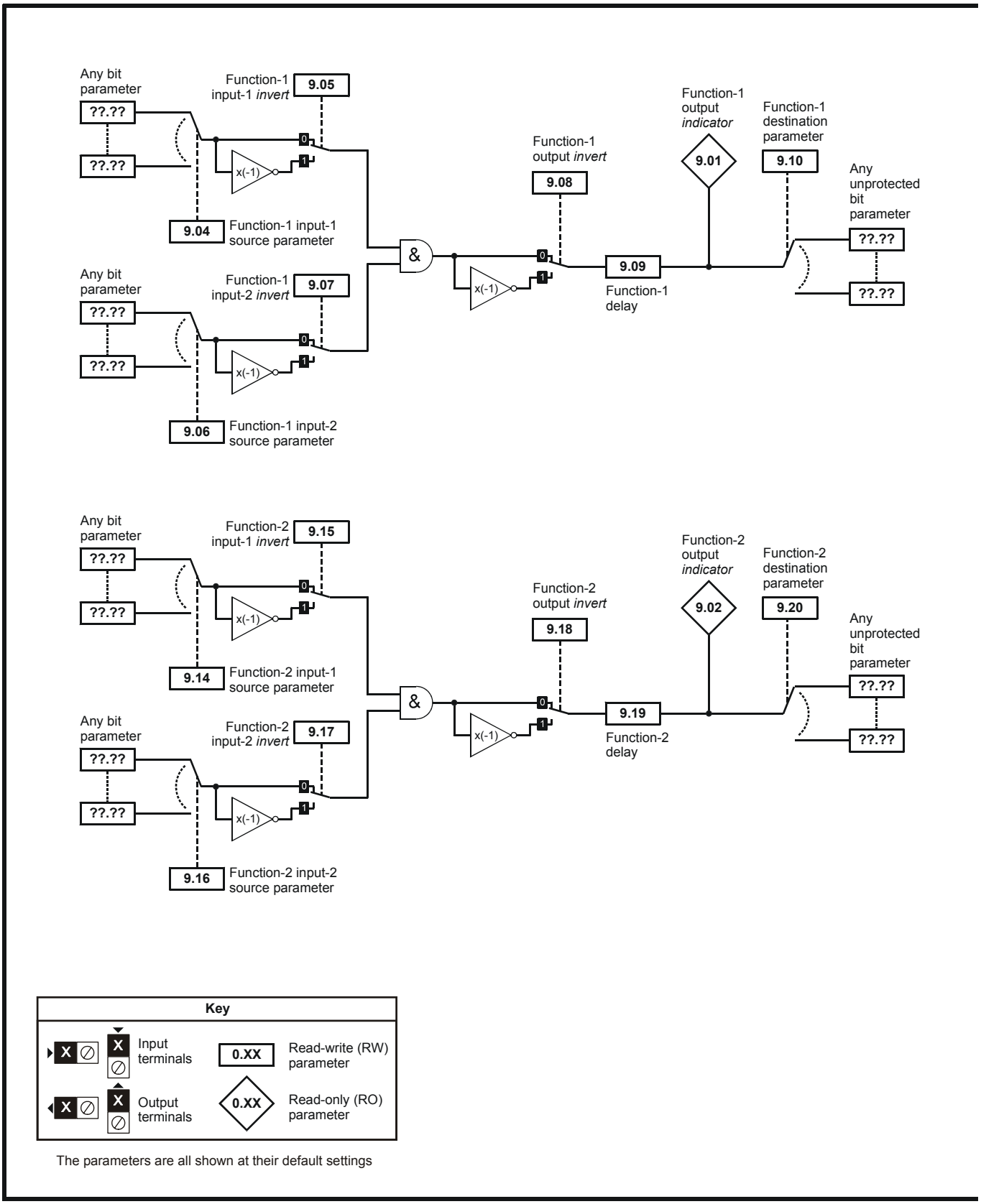
8.39	**T28 & T29 digital input auto-selection disable**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, Closed-loop vector, Servo							OFF (0)								
Update rate	Background 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.

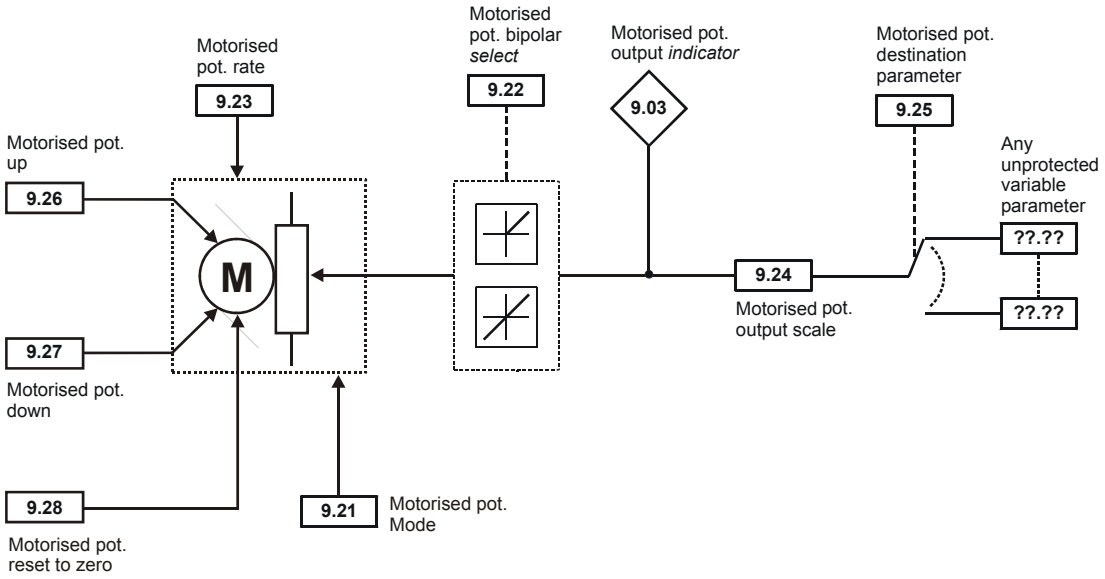
Reference select Pr 1.14		**Pr 8.25 set to:**	**Pr 8.26 set to:**
0, A1.A2	Reference selection by terminal input	Pr **1.41** - Analog ref 2 select	Pr **6.31** - jog
1, A1.Pr	Analog reference 1 or presets selected by terminal input	Pr **1.45** - preset select bit 0	Pr **1.46** - preset select bit 1
2,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

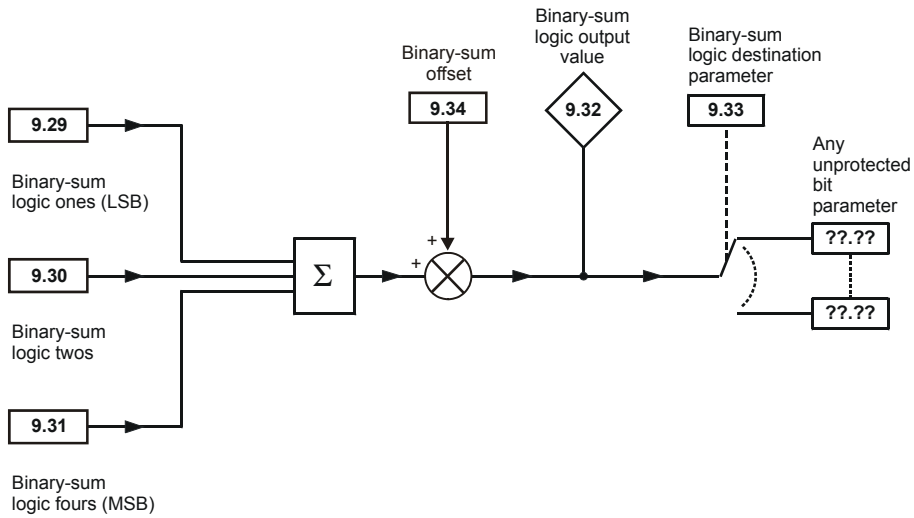
5.10 Menu 9: Programmable logic, motorised pot and binary sum

Figure 5-16 Menu 9 logic diagram



The parameters are all shown at their default settings


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


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

Menu 9 contains 2 logic block functions (which can be used to produce any type of 2 input logic gate, with or without a delay), a motorised pot function and a binary sum block. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. The logic functions are active if one or both the sources are routed to a valid parameter. The other functions are active if the output destination is routed to a valid unprotected parameter.

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

9.04	**Logic function 1 source 1**															
9.14	**Logic function 2 source 1**															
Drive 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															

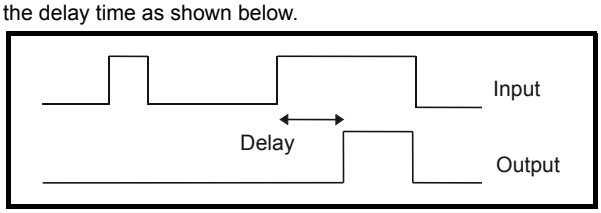
9.06	**Logic function 1 source 2**															
9.16	**Logic function 2 source 2**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								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															

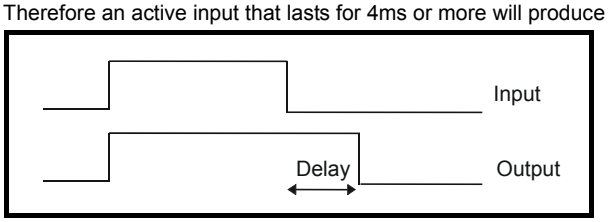
9.08	**Logic function 1 output invert**															
9.18	**Logic function 2 output invert**															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Coding	RW, Bit, US															
Default	Open-loop, 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	Motorised 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 motorised pot modes are given in the following table.

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

9.22	Motorised pot bipolar select															
Drive 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 motorised pot output is limited to positive values only (i.e. 0 to 100.0%). Setting it to 1 allows negative outputs (i.e. ±100.0 %).

9.23	Motorised pot rate															
Drive 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 motorised pot function to ramp from 0 to 100.0%. Twice this time will be taken to adjust the output from -100.0 % to +100.0 %.

9.24	**Motorised pot scale factor**															
Drive 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 motorised pot to operate over a reduced range so that it can be used as a trim, for example.

9.25	**Motorised pot destination**															
Drive 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	**Motorised 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	**Motorised 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	**Motorised 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 motorised pot. The up and down inputs increase and decrease the output at the programmed rate respectively. If both up and down are active together the up function dominates and the output increases. If the reset input is one, the motorised pot output is reset and held at 0.0%.

9.29	Binary sum ones input															
Drive 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															

9.30	Binary sum twos input															
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															

9.31	Binary sum fours input															
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															

9.32	Binary sum 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	
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															

9.33	Binary sum 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															

9.34	**Binary sum 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			2					1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 248								
Default	Open-loop, Closed-loop vector, Servo, Regen							0								
Update rate	4ms x number of menu 9 or 12 functions active write															

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)

5.11 Menu 10: Status and trips

10.01	**Drive healthy**															
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. These flags are only set if the drive is running.

See Pr **3.06**, Pr **3.07** on page 49 and Pr **3.09** on page 50.

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 one 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 one 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 114).

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 114). 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 rated drive current (Pr **11.32**) the overload alarm is given when the current is higher than 100% of rated current.)

10.18	Drive over temperature alarm															
Drive 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 either the heatsink temperature is greater than or equal to 90°C, or the control board temperature is greater than or equal to 90°C, or

the IGBT junction temperature calculated from the drive thermal model is above 135°C (see Pr **5.18** on page 106 and Pr **7.06** on page 127).

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. Possible trips are shown in the table below. A time stamp is stored for each trip (see Pr **10.41** to Pr **10.51** on page 171). All trips are stored including HF trips numbered from 20 to 30. (HF trips below numbered from 1 to 19 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.

Table 5-6 Trip indications

Trip	Diagnosis
C.Acc	**SMARTCARD trip: SMARTCARD Read / Write fail**
185	Check SMARTCARD is fitted / located correctly Replace SMARTCARD
C.Chg	**SMARTCARD trip: Data location already contains data**
179	Erase data in data location Write data to an alternative data location
C.Cpr	**SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different**
188	Press the red reset button
C.dat	**SMARTCARD trip: Data location specified does not contain any data**
183	Ensure data block number is correct
C.Err	**SMARTCARD trip: SMARTCARD data is corrupted**
182	Ensure the card is located correctly Erase data and retry Replace SMARTCARD
C.Full	**SMARTCARD trip: SMARTCARD full**
184	Delete a data block or use different SMARTCARD
CL2	**Analog input 2 current loss (current mode)**
28	Check analog input 2 (terminal 7) current signal is present (0-20mA, 4-20mA etc.)

Trip	Diagnosis
CL3	**Analog input 3 current loss (current mode)**
29	Check analog input 3 (terminal 8) current signal is present (0-20mA, 4-20mA etc.)
CL.bit	**Trip initiated from the control word (Pr 6.42)**
35	Disable the control word by setting Pr **6.43** to 0 or check setting of Pr **6.42**
C.Optn	**SMARTCARD trip: Solutions Modules fitted are different between source drive and destination drive**
180	Ensure correct Solutions Modules are fitted Ensure Solutions Modules are in the same Solutions Module slot Press the red reset button
C.rdo	**SMARTCARD trip: SMARTCARD has the Read Only bit set**
181	Enter 9777 in Pr **xx.00** to allow SMARTCARD Read / Write access Ensure card is not writing to data locations 500 to 999
C.rtg	**SMARTCARD trip: SMARTCARD attempting to change the destination drive ratings** **No drive rating parameters have been transferred**
186	Press the red reset button Drive rating parameters are: **Parameter** / **Function** **2.08** Standard ramp voltage **4.05**/**6**/**7**, **21.27**/**8**/**9** Current limits **5.07**, **21.07** Motor rated current **5.09, 21.09** Motor rated voltage **5.17**, **21.12** Stator resistance **5.18** Switching frequency **5.23, 21.13** Voltage offset **5.24**, **21.14** Transient inductance **5.25**, **21.24** Stator inductance **6.06** DC injection braking current The above parameters will be set to their default values.
C.Typ	**SMARTCARD trip: SMARTCARD parameter set not compatible with drive**
187	Press the reset button Ensure destination drive type is the same as the source parameter file drive type
dESt	**Two or more parameters are writing to the same destination parameter**
199	Set Pr **xx.00** = 12001 check all visible parameters in the menus for duplication
EEF	**EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.**
31	This trip can only be cleared by loading default parameters and saving parameters
EnC1	**Drive encoder trip: Encoder power supply overload**
189	Check encoder power supply wiring and encoder current requirement Maximum current = 200mA @ 15V, or 300mA @ 8V and 5V
EnC2	**Drive encoder trip: Wire break**
190	Check cable continuity Check wiring of feedback signals is correct Check encoder power is set correctly 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
EnC3	**Drive encoder trip: UVW phase offset incorrect whilst running**
191	Check the encoder signal for noise Check encoder shielding Check the integrity of the encoder mechanical mounting Repeat the offset measurement test
EnC4	**Drive encoder trip: Feedback device comms failure**
192	Ensure encoder power supply is correct Ensure baud rate is correct Check encoder wiring Replace feedback device

Trip	Diagnosis
EnC5	**Drive encoder trip: Checksum or CRC error**
193	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**
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 fitted**
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 speed 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.
ENP.Er	**Data error from electronic nameplate stored in selected position feedback device**
176	Replace feedback device
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

Trip	Diagnosis
HF10	**Data processing error: Router error**
	Hardware fault - return drive to supplier
HF11	**Data processing error: Access to EEPROM failed**
	Hardware fault - return drive to supplier
HF20	**Power stage recognition: serial code error**
220	Hardware fault - return drive to supplier
HF21	**Power stage recognition: unrecognised frame size**
221	Hardware fault - return drive to supplier
HF22	**Power stage recognition: multi module frame size mismatch**
222	Hardware fault - return drive to supplier
HF23	**Power stage recognition: multi module voltage rating mismatch**
223	Hardware fault - return drive to supplier
HF24	**Power stage recognition: unrecognised drive size**
224	Hardware fault - return drive to supplier
HF25	**Current feedback offset error**
225	Hardware fault - return drive to supplier
HF26	**Soft start relay failed to close, soft start monitor failed or braking IGBT short circuit at power up**
226	Hardware fault - return drive to supplier
HF27	**Power stage thermistor 1 fault**
227	Hardware fault - return drive to supplier
HF28	**Power stage thermistor 2 fault or internal fan fault (size 3 only)**
228	Hardware fault - return drive to supplier
HF29	**Control board thermistor fault**
229	Hardware fault - return drive to supplier
It.AC	**Output current overload timed out (I^2t) - accumulator value can be seen in Pr 4.19**
20	Ensure the load is not jammed / sticking Check the load on the motor has not changed 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
O.CtL	**Drive control board over temperature**
23	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Check ambient temperature Reduce drive switching frequency
O.ht1	**Power device over temperature based on thermal model**
21	Reduce drive switching frequency Reduce duty cycle Decrease acceleration / deceleration rates Reduce motor load

Trip	Diagnosis
O.ht2	**Heatsink over temperature**
22	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle 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 cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Increase ventilation Decrease acceleration / deceleration rates Reduce duty cycle Reduce motor load
OI.AC	**Instantaneous output over current detected: peak output current greater than 225%**
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)
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
O.Ld1	**Digital output overload: total current drawn from 24V supply and digital outputs exceeds 200mA**
26	Check total load on digital outputs (terminals 24,25,26)and +24V rail (terminal 22)
OV	**DC bus voltage has exceeded the peak level or the maximum continuous level for 30 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** 200 / 415 / 405 400 / 830 / 810 575 / 990 / 960
O.SPd	**Motor speed has exceeded the over speed threshold**
7	Increase the over speed trip threshold in Pr **3.08** (closed loop 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 modes only)
PAd	**Keypad has been removed when the drive is receiving the speed reference from the keypad**
34	Fit keypad and reset Change speed reference selector to select speed reference from another source
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.

Trip	Diagnosis
PS	**Internal power supply fault**
5	Remove any Solutions Modules and reset Check integrity of interface ribbon cables and connections (size 4,5,6 only) Hardware fault - return drive to supplier
PS.10V	**10V user power supply current greater than 10mA**
8	Check wiring to terminal 4 Reduce load on terminal 4
PS.24V	**24V internal power supply overload**
9	The total user load of the drive and Solutions Modules has exceeded the internal 24V power supply limit. The user load consists of the drive's digital outputs plus the SM-I/O Plus digital outputs, or the drive's main encoder supply plus the SM-Universal Encoder Plus and SM-Encoder Plus encoder supply. • Reduce load and reset • Provide an external 24V >50W power supply • Remove any Solutions Modules and reset
rS	**Failure to measure resistance during autotune or when starting in open loop vector mode 0 or 3**
33	Check motor power connection continuity
SCL	**Drive RS485 serial comms loss to remote keypad**
30	Refit the cable between the drive and keypad Check cable for damage Replace cable Replace keypad
SLX.dF	**Solutions Module slot X trip: Solutions Module type fitted in slot X changed**
204,209,214	Save parameters and reset

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**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 Plus and SM-Resolver.

Error code	Trip Description	Diagnostic
0	No trip	No fault detected
1	Encoder trip: Encoder power supply overload	Check encoder power supply wiring and encoder current requirement Maximum current = 200mA @ 15V, or 300mA @ 8V and 5V
2	Encoder trip: Wire break	Check cable continuity Check wiring of feedback signals is correct Check supply voltage level Replace feedback device
3	Encoder trip: UVW phase offset incorrect whilst running	Check the encoder signal for noise Check encoder shielding Check the integrity of the encoder mechanical mounting Repeat the offset measurement test
4	Encoder trip: Feedback device communications failure	Ensure encoder power supply is correct Ensure baud rate is correct Check encoder wiring Replace feedback device
5	Encoder trip: Checksum or CRC error	Check the encoder signal for noise Check the encoder cable shielding
6	Encoder trip: Encoder has indicated an error	Replace encoder
7	Encoder trip: 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	Encoder trip: 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 (Pr **15**/**16**/**17.09**) and the equivalent number of lines per revolution (Pr **15**/**16**/**17.10**)
9	All	Thermistor trip
10	All	Thermistor short circuit
11	Resolver: Poles not compatible with motor	Check that the correct number of resolver poles has been set in Pr **15**/**16**/**17.15**.
74	All	The Solutions Module has over-heated

Trip	Diagnosis
SLX.Er	**Solutions Module slot X trip: Solutions Module in slot X has detected a fault**
202,207,212	**Automation module category** Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the SM-Applications and SM-Applications Lite.

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

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

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

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>SLX.Er</td><td>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</td></tr>
<tr><td>202,207,212</td><td>Fieldbus module category
Check value in Pr 15/16/17.50. The following table lists the possible error codes for the Fieldbus modules.
<table>
<tr><th>Error code</th><th>Fieldbus Option</th><th>Reason for fault</th></tr>
<tr><td>52</td><td>All except DPLCAN</td><td>Control word user trip</td></tr>
<tr><td>61</td><td>All</td><td>Invalid configuration parameters.</td></tr>
<tr><td>65</td><td>All except DPLCAN</td><td>Network loss</td></tr>
<tr><td>66</td><td>DeviceNet, CANopen and DPLCAN</td><td>"Bus-Off" Node sees an excessive number of transmission errors.</td></tr>
<tr><td>67</td><td>CANopen</td><td>Node has not received a SYNC telegram within a specified time - to be defined.</td></tr>
<tr><td>68</td><td>CANopen</td><td>Node has not received the guarding telegram within the time period specified.</td></tr>
<tr><td>69</td><td>DPLCAN</td><td>Node sends a data frame and no other node acknowledges receipt of the frame message.</td></tr>
<tr><td>70</td><td>All</td><td>No valid Fieldbus Menu data available in the module to download to the drive – The user may not have saved any data, or the data save may not have been completed successfully.</td></tr>
<tr><td>71</td><td>DeviceNet</td><td>The External power supply has been lost. This trip will only occur if the module was on line with a master when the loss occurs. i.e. will not occur if the power supply is not present during module initialisation.</td></tr>
<tr><td>74</td><td>All</td><td>The Solutions Module has overheated.</td></tr>
<tr><td>98</td><td>All</td><td>The Solutions Module background task has not been completed.</td></tr>
<tr><td>99</td><td>All</td><td>Software Fault.</td></tr>
</table></td></tr>
<tr><td>SLX.HF</td><td>Solutions Module slot X trip: Solutions Module X hardware fault</td></tr>
<tr><td>200,205,210</td><td>Ensure Solutions Module is fitted correctly
Return Solutions Module to supplier</td></tr>
<tr><td>SLX.nF</td><td>Solutions Module slot X trip: Solutions Module has been removed</td></tr>
<tr><td>203,208,213</td><td>Ensure Solutions Module is fitted correctly
Re-fit Solutions Module
Save parameters and reset drive</td></tr>
<tr><td>SL.rtd</td><td>Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect</td></tr>
<tr><td>215</td><td>Press reset.
If the trip persists, contact the supplier of the drive.</td></tr>
<tr><td>SLX.tO</td><td>Solutions Module slot X trip: Solutions Module watchdog timeout</td></tr>
<tr><td>203,208,211</td><td>Press reset.
If the trip persists, contact the supplier of the drive.</td></tr>
<tr><td>t010</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>10</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t036 to t038</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>36 to 38</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t040 to t089</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>40 to 89</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t099</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>99</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t109 to t110</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>109 to 110</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t119 to t120</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>119 to 120</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t129 to t130</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>129 to 130</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t139 to t140</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>139 to 140</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
</table>

Trip	Diagnosis
t149 to t150	**User trip defined in 2nd processor Solutions Module code**
149 to 150	SM-Applications program must be interrogated to find the cause of this trip
t159 to t170	**User trip defined in 2nd processor Solutions Module code**
159 to 170	SM-Applications program must be interrogated to find the cause of this trip
t172 to t175	**User trip defined in 2nd processor Solutions Module code**
172 to 175	SM-Applications program must be interrogated to find the cause of this trip
t177 to t178	**User trip defined in 2nd processor Solutions Module code**
177 to 178	SM-Applications program must be interrogated to find the cause of this trip
t198	**User trip defined in 2nd processor Solutions Module code**
198	SM-Applications program must be interrogated to find the cause of this trip
t216 to t219	**User trip defined in 2nd processor Solutions Module code**
216 to 219	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 secure disable 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 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
UFlt	**Multi module drive: Unidentified fault**
171	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

Trip	Diagnosis
UP div0	**Onboard PLC program attempted divide by zero**
90	Check program
UP OFL	**Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)**
95	Check program
UP ovr	**Onboard PLC program attempted out of range parameter write**
94	Check program
UP PAr	**Onboard PLC program attempted access to a non-existent parameter**
91	Check program
UP ro	**Onboard PLC program attempted write to a read-only parameter**
92	Check program
UP So	**Onboard PLC program attempted read of a write-only parameter**
93	Check program
UP udf	**Onboard PLC program un-defined trip**
97	Check program
UP uSEr	**Onboard PLC program requested a trip**
96	Check program
UV	**DC bus under voltage threshold reached**
1	Check AC supply voltage level **Drive voltage rating (Vac) — Under voltage threshold (Vdc)** 200 — 175 400 — 350 575 — 435
X.Oht2	**Multi module drive: Heatsink over temperature detected by module X**
121 to 128	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Check ambient temperature Reduce drive switching frequency Increase ventilation
X.OI.AC	**Multi module drive: Instantaneous output over current detected by module X – peak output current greater than 225%**
111 to 118	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 (if present) Check feedback device mechanical coupling (if present) Check feedback signals are free from noise Is the motor cable length within limits for the 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 Pr **4.13** and Pr **4.14** - current loop gains (closed loop vector and servo modes only)
X.OI.br	**Multi module drive: Braking IGBT over current detected in module X**
141 to 148	Short circuit protection for the braking transistor. Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum Check braking resistor insulation

Trip	Diagnosis
X.OV	**Multi module drive: DC bus voltage has exceeded the peak level or the maximum continuous level for 30 seconds on module X**
151 to 158	Increase deceleration ramp (Pr **0.02**) 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, power factor correction or other large equipment being switched on and off the supply. Check motor insulation **Drive voltage rating** / **Peak voltage** / **Maximum continuous voltage level** 200 / 415 / 405 400 / 830 / 810 575 / 990 / 960
X.PH	**Multi module drive: Phase loss trip on module X**
101 to 108	Check input supply voltage phases are at the correct value and balanced Check the drive output current is stable
X.PS	**Internal power supply fault detected on module X**
131 to 138	Remove any Solutions Module and reset Check integrity of interface ribbon cables and connections Hardware fault - return drive to supplier

Table 5-7 Serial communications look-up table

No.	Trip	No.	Trip	No.	Trip
1	UU	39	L.SYNC	184	C.FULL
2	OU	40 to 89	t040 to t089	185	C.Acc
3	OI.AC	90	UP div0	186	C.rtg
4	OI.br	91	UP PAr	187	C.Typ
5	PS	92	UP ro	188	C.cpr
6	Et	93	UP So	189	EnC1
7	O.SPd	94	UP ovr	190	EnC2
8	PS.10V	95	UP OFL	191	EnC3
9	PS.24V	96	UP uSEr	192	EnC4
10	t010	97	UP udf	193	EnC5
11	tunE1	98	UP ACC	194	EnC6
12	tunE2	99	t099	195	EnC7
13	tunE3	100		196	EnC8
14	tunE4	101 to 108	X.PH	197	EnC9
15	tunE5	109 to 110	t109 to t110	198	EnC10
16	tunE6	111 to 118	X.OI.AC	199	DESt
17	tunE7	119 to 120	t119 to t120	200	SL1.HF
18	tunE	121 to 128	X.Oht2	201	SL1.tO
19	It.br	129 to 130	t129 to t130	202	SL1.Er
20	It.AC	131 to 138	1.PS to 8.PS	203	SL1.nF
21	O.ht1	139 to 140	t139 to t140	204	SL1.dF
22	O.ht2	141 to 148	X.OIBr	205	SL2.HF
23	O.CtL	149 to 150	t149 to t150	206	SL2.tO
24	Th	151 to 158	X.OV	207	SL2.Er
25	ThS	159 to 160	t159 to t160	208	SL2.nF
26	O.Ld1	161 to 168	t161 to t168	209	SL2.dF
27	O.ht3	169 to 170	t169 to t170	210	SL3.HF
28	CL2	171	UFLt	211	SL3.tO
29	CL3	172 to 175	t172 to t175	212	SL3.Er
30	SCL	176	EnP.Er	213	SL3.nF
31	EEF	177 to 178	t177 to t178	214	SL3.dF
32	PH	179	C.Chg	215	SL.rtd
33	RS	180	C.Optn	216 to 219	t216 to 219
34	Pad	181	C.RdO	220 to 230	HF20 to HF30
35	CL.bit	182	C.Err		
36 to 38	t036 to t038	183	C.dat		

Trips can be grouped into the following categories:

Category	Trips	Comments
Hardware faults	HF01 to HF19	These indicate fatal problems and cannot be reset. The drive is inactive after one of these trips and the display shows HFxx.
Self resetting trips	UU	Under voltage trip cannot be reset by the user, but is automatically reset by the drive when the supply voltage is with specification.*
Non-resettable trips	HF20 to HF30, SL1.HF, SL2.HF, SL3.HF	Cannot be reset.
EEF trip	EEF	Cannot be reset unless a code to load defaults is first entered in Pr **x.00** or Pr **11.43**.
Normal trips	All other trips	Can be reset after 1.0s
Normal trips with extended reset	OI.AC, OI.Br, x.OIAC, x.OIBr	Can be reset after 10.0s
Low priority trips	Old1, cL2, cL3, SCL	If Pr **10.37** is 1 or 3 the drive will stop before tripping.
Phase loss	PH	The drive stops before tripping provided the drive motoring power is suitably reduced after 500ms of detecting phase loss
Drive over-heat based on thermal model	O.ht3	The drive stops before tripping, but if it does not stop within 10s the drive will automatically trip.

*Under voltage trip and restart levels are as follows:

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

The braking IGBT continues to operate even when the drive is not enabled, it is only disabled if any of the following trips occur or would occur if another trip had not already become active: OI.Br, PS, or It.Br.

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. Parameter values are only loaded from EEPROM if the supply voltage is low enough for the switch mode power supply in the drive to shut down and then it is increased to restart the drive power supplies. The differences between UU and other trips are as follows:

1. Power down save user parameters are saved when UU trip is activated except when the low voltage supply is active (Pr **6.44** = 1).
2. The UU trip is self-resetting when the DC bus voltage rises above the drive restart voltage level.
3. The drive can change between using the main high voltage supply and low voltage supply only when the UU trip is active.
4. When the drive is first powered up a UU trip is initiated if the supply voltage is below the restart voltage level. This does not save power down save parameters. If another trip occurs during power-up it is the active trip in preference to the UU trip. If this trip is cleared and the supply voltage is still below the restart voltage threshold a UU trip is then initiated.

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															

The default value is either 0.0, or a suitable value for standard braking resistors that can be mounted within the drive heatsink as given in the table below.

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

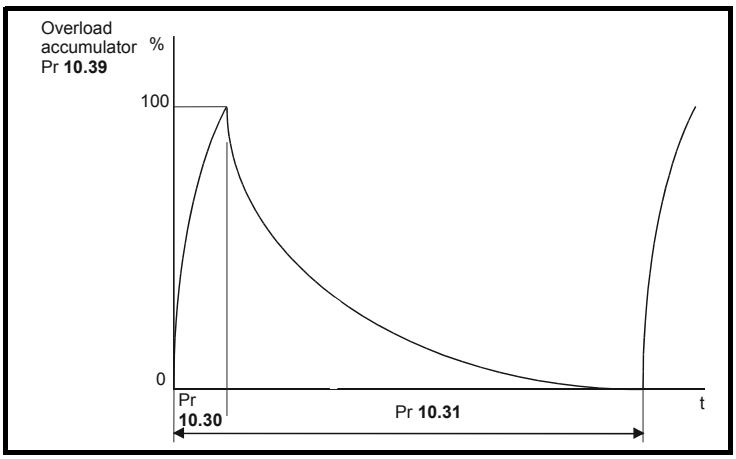
This parameter defines the time period that the braking resistor fitted can stand full braking volts without damage. The setting of this parameter is used in determining the braking overload time.

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

10.31	Full power braking period															
Drive modes	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	2.0														
Update rate	Background read															

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

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



Assuming that the full power braking time is much shorter than the full power braking period (which is normally the case) the values for Pr **10.30** and Pr **10.31** can be calculated as follows:

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

Where:

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

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

Where:

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

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

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

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

Where:

Tp is the full power braking period

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

Therefore $P_{av} = E / Tp$

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

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

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

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

10.37	**Action on trip detection**															
Drive 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	0														
Update rate	Background read															

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

For details of braking IGBT trip mode see Pr **10.31** on page 167.

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

10.38	**User trip**															
Drive 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.

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

10.39	**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 167. Zero indicates the resistor is close to ambient and 100% is the maximum temperature (trip level). An OVLd 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 9.365 Years.Days								
Update rate	Background write															

10.42	**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	**Trip 1 time**															
10.44	**Trip 2 time**															
10.45	**Trip 3 time**															
10.46	**Trip 4 time**															
10.47	**Trip 5 time**															
10.48	**Trip 6 time**															
10.49	**Trip 7 time**															
10.50	**Trip 8 time**															
10.51	**Trip 9 time**															
Drive 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															

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.

5.12 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 5-8									
Update rate	Background read																

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

Table 5-8 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 **5.03**
Pr **11.04**	Pr **0.14**	Pr **4.11**	Pr **4.11**	Pr **4.11**	Pr **0.00**
Pr **11.05**	Pr **0.15**	Pr **2.04**	Pr **2.04**	Pr **2.04**	Pr **0.00**
Pr **11.06**	Pr **0.16**	Pr **8.39**	Pr **2.02**	Pr **2.02**	Pr **0.00**
Pr **11.07**	Pr **0.17**	Pr **8.26**	Pr **4.12**	Pr **4.12**	Pr **0.00**
Pr **11.08**	Pr **0.18**	Pr **8.29**	Pr **8.29**	Pr **8.29**	Pr **0.00**
Pr **11.09**	Pr **0.19**	Pr **7.11**	Pr **7.11**	Pr **7.11**	Pr **0.00**
Pr **11.10**	Pr **0.20**	Pr **7.14**	Pr **7.14**	Pr **7.14**	Pr **0.00**
Pr **11.11**	Pr **0.21**	Pr **7.15**	Pr **7.15**	Pr **7.15**	Pr **0.00**
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 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
												1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	Pr **0.00** to Pr **0.50**														
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	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 1														
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

ANSIx3.28 protocol
Full details of the CT implementation of ANSIx3.28 are given in Chapter 7 *Serial communications protocol* on page 338.

Modbus RTU protocol
Full details of the CT implementation of Modbus RTU are given in Chapter 7 *Serial communications protocol* on page 338.

The protocol provides the following facilities:

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

The following product specific limitations apply:

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

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

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

Note that the drive holds its own transmit buffers active for up to 1ms after it has transmitted data before switching to the receive mode, and so the host should not send any data during this time.

Modbus RTU uses a silent period detection system to detect the end of a message. This silent period is either the length of time for 3.5 characters at the present baud rate or the length of time set in Pr **11.26**, whichever is the longest.

11.28	**Drive derivative**															
Drive 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. See introduction section for details.

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							0 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 5.5 *Menu 4: Torque and current control* on page 72 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	1 to 8														
Update rate	Write at power-up															

Indicates the number of modules fitted in a system. If the drive cannot be used in a multi-module system the value is always 1.

11.36	**SMARTCARD parameter data previously loaded**															
Drive 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 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 1,000														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background read															

Data blocks are stored on a SMARTCARD with header information which includes a number which identifies the block. The header information also includes the type of data stored in the block, the drive mode if the data is parameter data, the version number and a checksum. This data can be viewed through Pr **11.38** to Pr **11.40** by increasing or decreasing Pr **11.37**. This parameter jumps between the data numbers of the data blocks present on the card inserted into the drive. If this parameter is set to 1000 the checksum parameter shows the number of bytes left on the card. If there is no data on the card Pr **11.37** can only have values of 0 or 1000.

The actions of erasing a card, erasing a file, changing a menu 0 parameter, or inserting a new card will effectively set Pr **11.37** to 0 or the lowest data block number in the card.

Data transfer and erasing can be performed by entering a code in Pr **x.00** and then resetting the drive as shown in the table below.

Code	Action
3yyy	Transfer drive EEPROM data to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive ladder program to SMARTCARD block number yyy
6yyy	Transfer SMARTCARD data block yyy to the drive
7yyy	Erase SMARTCARD data block yyy
8yyy	Compare drive parameters with block yyy
9999	Erase SMARTCARD
9888	Set SMARTCARD read-only flag
9777	Clear SMARTCARD read-only flag

Data blocks with numbers from 1 to 499 can be created or erased by the user. Data block with numbers 500 and above are read only and cannot be created or erased by the user. The whole card may be protected from writing or erasing by setting the read-only flag (i.e if the flag is set then only codes 6yyy or 9777 are effective).

If the destination drive has a different drive mode to the parameters on the card, the drive mode will be changed by the action of transferring parameters from the card to the drive.

After an attempt to read, write or erase a trip may occur, see Pr **10.20** on page 153 for details. If the card is removed during data transfer from the card for a data block that was saved with code 3yyy, the drive EEPROM checksum will be set up to be incorrect and an EEF trip will be initiated. If the card is removed during data transfer from the card for a data block that was saved with code 4yyy then no data will be saved to EEPROM and a C.Acc trip

will be initiated. It should be noted that in both cases the parameters held in drive parameter RAM are likely to be incorrect.

During SMARTCARD or EEPROM data transfer the user will not be able to exit keypad edit mode when the current parameter is in menu 0.

Parameter data block when 3yyy is used to transfer data to a card

The data blocks contain the complete data from the drive EEPROM, i.e. all user save (US) except the parameters with the NC coding bit set. Power-down save (PS) are not saved to the SMARTCARD. A SMARTCARD can hold up to 4 data blocks of this type.

When the data is transferred back to a drive, using 6yyy in Pr **x.00**, it is transferred to the drive RAM and drive EEPROM. A parameter save is not required to retain the data after power-down. (When parameters are copied to the drive RAM this action is performed twice to prevent interdependent parameters from being copied incorrectly.) Before the data is taken from the card, defaults are loaded in the destination drive using the same default code as was last used in the source drive.

The categories of modules fitted to the card data source drive are stored on the card. If these are different from the destination drive, the menus for the slots where the Solutions Module categories are different, are not modified and so they will contain their default values, and the drive will produce a C.Optn trip. If the data is transferred to a drive of a different voltage, or current rating from the source drive, all parameters with the RA coding bit set (as given in the table below) are not modified and a C.rtg trip occurs.

Parameter number	Function
Pr **2.08**	Standard ramp voltage
Pr **3.05**	Regen unit voltage setpoint
Pr **4.05** to Pr **4.07**, Pr **21.27** to Pr **21.29**	Current limits
Pr **5.07**, Pr **21.07**	Motor rated current
Pr **5.09**, Pr **21.09**	Motor rated voltage
Pr **5.17**, Pr **21.12**	Stator resistance
Pr **5.18**	Switching frequency
Pr **5.23**, Pr **21.13**	Voltage offset
Pr **5.24**, Pr **21.14**	Transient inductance
Pr **5.25**, Pr **21.24**	Stator inductance
Pr **6.06**	DC injection braking current

A compare action on this data block type, setting 8yyy in Pr **x.00**, will compare the SMARTCARD data block with the data in the EEPROM. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated.

Parameter data block when 4yyy is used to transfer data to a card

The only parameter data stored on the SMARTCARD is the number for the last set of defaults loaded and the differences from the last defaults loaded. This requires six bytes for each parameter difference. The data density is not as high as when using the data format described in the previous section, but in most cases the number of differences from default is small and the data blocks are therefore smaller. This method can be used for creating drive macros. Parameters that are not transferred when using 3yyy are also not transferred with this method. Also parameters that do not have a default value (attribute ND is set) cannot be transferred with this method (i.e. Pr **3.25** or Pr **21.20** which are the servo mode phasing angle have no default value). Parameter RAM is used as the source of this information.

When the data is transferred back to a drive, using 6yyy in Pr **x.00**, it is transferred to the drive RAM and the drive EEPROM. A parameter save is not required to retain the data after power-down. (When parameters are copied to the drive RAM this action is performed twice to prevent interdependent parameters from not being set correctly.) The categories of modules fitted to the card data source drive are stored on the card. If these are different from the destination drive, the menus for the slots where the Solutions Module categories are different are not modified and will contain their default values, and the drive will produce a C.Optn trip if any of the parameters from the card are in the option menus. If the data is transferred to a drive of a different voltage or current rating from the source drive then parameters with the RA coding bit set (see table above) will not be written to the drive and these parameters will contain their default values. The drive will produce a C.rtg trip whether any of the parameters from the card are parameters with the RA coding bit set or not if the current or voltage rating are different.

A compare action on this data block type, setting 8yyy in Pr **x.00**, will compare the SMARTCARD data block with the data in the drive RAM. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated.

Drive Onboard PLC program data blocks

The Onboard PLC program from a drive may be transferred to/from internal flash memory from/to a SMARTCARD. If the ladder program is transferred from a drive with no ladder program loaded the block is still created on the card, but contains no data. If this is then transferred to a drive, the drive will then have no ladder program. A SMARTCARD has a capacity of 4K bytes and each block of this type can take up to 4K bytes.

SMARTCARD compare function

If 8yyy is entered in Pr **x.00** and the drive is reset, data block yyy on the SMARTCARD is compared with the relevant parameters in the drive. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated. This function can be used with all data block types except type 18. If a compare is requested with data block type 18 the result will always be a C.cpr trip.

11.38	**SMARTCARD data type/mode**															
Drive 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															

Indicates the type/mode of the data block selected with Pr **11.37** as shown in the following table.

Pr 11.38	String	Type/mode	Data stored
0	FrEE	Value when Pr **11.37** = 0	
2	3OpEn.LP	Open-loop mode parameters	Data from EEPROM
3	3CL.VECt	Closed-loop vector mode parameters	Data from EEPROM
4	3SErVO	Servo mode parameters	Data from EEPROM
5	3rEgEn	Regen mode parameters	Data from EEPROM
6 to 8	3Un	Unused	
10	4OpEn.LP	Open-loop mode parameters	Defaults last loaded and differences
11	4CL.VECt	Closed-loop vector mode parameters	Defaults last loaded and differences
12	4SErVO	Servo mode parameters	Defaults last loaded and differences
13	4rEgEn	Regen mode parameters	Defaults last loaded and differences
14 to 16	4Un	Unused	
17	LAddEr	Drive Onboard PLC program	
18	Option	A Solutions Module file	

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															

Indicates the version number of the data block. This is intended to be used when data blocks are used as drive macros. If a version number is to be stored with a data block this parameter should be set to the required version number before the data is transferred. Each time Pr **11.37** is changed by the user the drive puts the version number of the currently viewed data block in this parameter.

11.40	**SMARTCARD data checksum**															
Drive 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															

Indicates the checksum of the data block.

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 cloning															
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.

Reading (1)

Setting Pr **11.42** to 1 and resetting the drive will load the parameters from the card into the drive parameter set and the drive EEPROM. All SMARTCARD trips apply. When the action is complete this parameter is automatically reset to zero. Parameters are saved to drive EEPROM after this action is complete.

NOTE

This operation is only performed if block 1 on the card is a complete copy of the EEPROM (i.e. types 1 to 5) and not a difference from default file. If block 1 does not exist or the type is incorrect a C.typ trip occurs.

NOTE

When Pr **11.42** is 1 the value is NOT saved to EEPROM or card.

Programming (2)

Setting Pr **11.42** to 2 and resetting the drive will save the parameters in the drive EEPROM to a card, i.e. equivalent to writing 3001 to Pr **x.00**. All SMARTCARD trips apply except C.Chg. If the data block already exists it is automatically over-written. When the action is complete this parameter is automatically reset to zero.

NOTE

When Pr **11.42** is 2 the value is NOT saved to EEPROM or card.

Auto (3)

Changing Pr **11.42** to 3 and resetting the drive will save the complete parameter set from the EEPROM to the card. All SMARTCARD trips apply, except C.Chg. If the data block already exists it is automatically overwritten.

If the card is removed when Pr **11.42** is set to 3 Pr **11.42** will be set to 0. If a card with a file 1 is inserted into a drive the drive must overwrite the file to ensure that the data is correct. The action of setting Pr **11.42** to 0 when a card is removed will force the user to change Pr **11.42** if auto mode is still required. Therefore the user will need to set Pr **11.42** to 3 and press reset to write the complete parameter set to the new card. (When a parameter in menu zero is changed, and a card is fitted, a save to EEPROM, is initiated. Only the new value of the modified parameter is written to the EEPROM and card. If Pr **11.42** were not cleared automatically when a card is removed, then when a new card is inserted that contains data block 1 the modified parameter would be written to the existing data block 1 on the new card. The rest of the parameters in this data block may not be the same as those in the drive.)

When Pr **11.42** is equal to 3 and the parameters in the drive are saved, the card is also updated, therefore the card becomes a copy of the drives stored configuration.

At power up, if Pr **11.42** is set to 3, the drive will save the complete parameter set to the card. This is done to ensure that if a card is inserted whilst the drive is powered down the new card will have the correct data after the drive is powered up again.

NOTE

When Pr **11.42** is 3 the value is saved to EEPROM but NOT the card.

Boot (4)

When Pr **11.42** is set 4 the drive operates the same way as for Auto mode except when the drive is powered-up. At power-up, provided a card is inserted in the drive and parameter data block 1 exists, it is type 1 to 5, with Pr **11.42** on the card set to 4, the parameters are automatically transferred to the drive. If the drive mode is different from that on the card the drive gives a C.Typ trip and the data is not transferred.

If the 'boot' mode is stored in the cloning card this makes the cloning the master device. This provides a very fast and efficient way of re-programming a number of drives.

NOTE

If the card and drive have Pr **11.42** set to 4, the card will be the master. Boot mode is saved to the card but when the card is read the drive value of Pr **11.42** is not transferred to the drive.

11.43	**Load defaults**															
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								0							
Update rate	Background read															

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															
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, Servo, Regen								0 to 2							
Default	Open-loop, Closed-loop, Servo, Regen								0							
Update rate	Background read															

This parameter controls access via the drive LED keypad as follows:

Value	String	Action
0	L1	Only menu 0 can be accessed
1	L2	All menus can be accessed
2	Loc	Lock user security when drive is reset. (This parameter is set to L1 after reset.)

The LED keypad can adjust this parameter even when user security is set.

11.45	**Motor 2 parameters select**															
Drive 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															

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															
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 2,000							
Default	Open-loop, Closed-loop vector, Servo, Regen								Number of defaults loaded, i.e. 1,233 etc.							
Update rate	Background write															

Displays the number of the last set of defaults loaded, i.e. 1,233, 1,244, etc.

11.47	Drive Onboard PLC 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 PLC program.
1	Run the drive Onboard PLC program (if fitted). Any out-of-range parameter writes attempted will be clipped to the maximum / minimum values valid for that parameter before being written.
2	Run the drive Onboard PLC program (if fitted). Any out-of-range parameter writes attempted will cause a drive trip.

11.48	Drive Onboard PLC program status															
Drive 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 PLC program status parameter indicates to the user the actual state of the drive Onboard PLC program. (not fitted / running / stopped / tripped.)

Value	Description
-n	Onboard PLC program caused a drive trip due to an error condition while running rung n. Note that the rung number is shown on the display as a negative number.
0	Onboard PLC program is not fitted.
1	Onboard PLC program is fitted but stopped.
2	Onboard PLC program is fitted and running.

11.49	Drive Onboard PLC programming events															
Drive 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 PLC programming events parameter holds the number of times a Onboard PLC program download has taken place and is 0 on dispatch from the factory. If the drive Onboard PLC programming events is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value. This parameter is not altered when defaults are loaded.

11.50	Drive Onboard PLC program maximum scan time															
Drive 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 PLC program execution period															

The Onboard PLC program maximum scan time parameter gives the longest scan time within the last ten scans of the drive Onboard PLC program. If the scan time is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value.

11.51	**Drive Onboard PLC program first run**															
Drive 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 PLC program execution period															

The drive Onboard PLC program first run parameter is set for the duration of the first ladder diagram scan from the ladder diagram stopped state. This enables the user to perform any required initialisation every time the ladder diagram is run. This parameter is set every time the ladder is stopped.

5.13 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 5-17 Menu 12 logic diagram

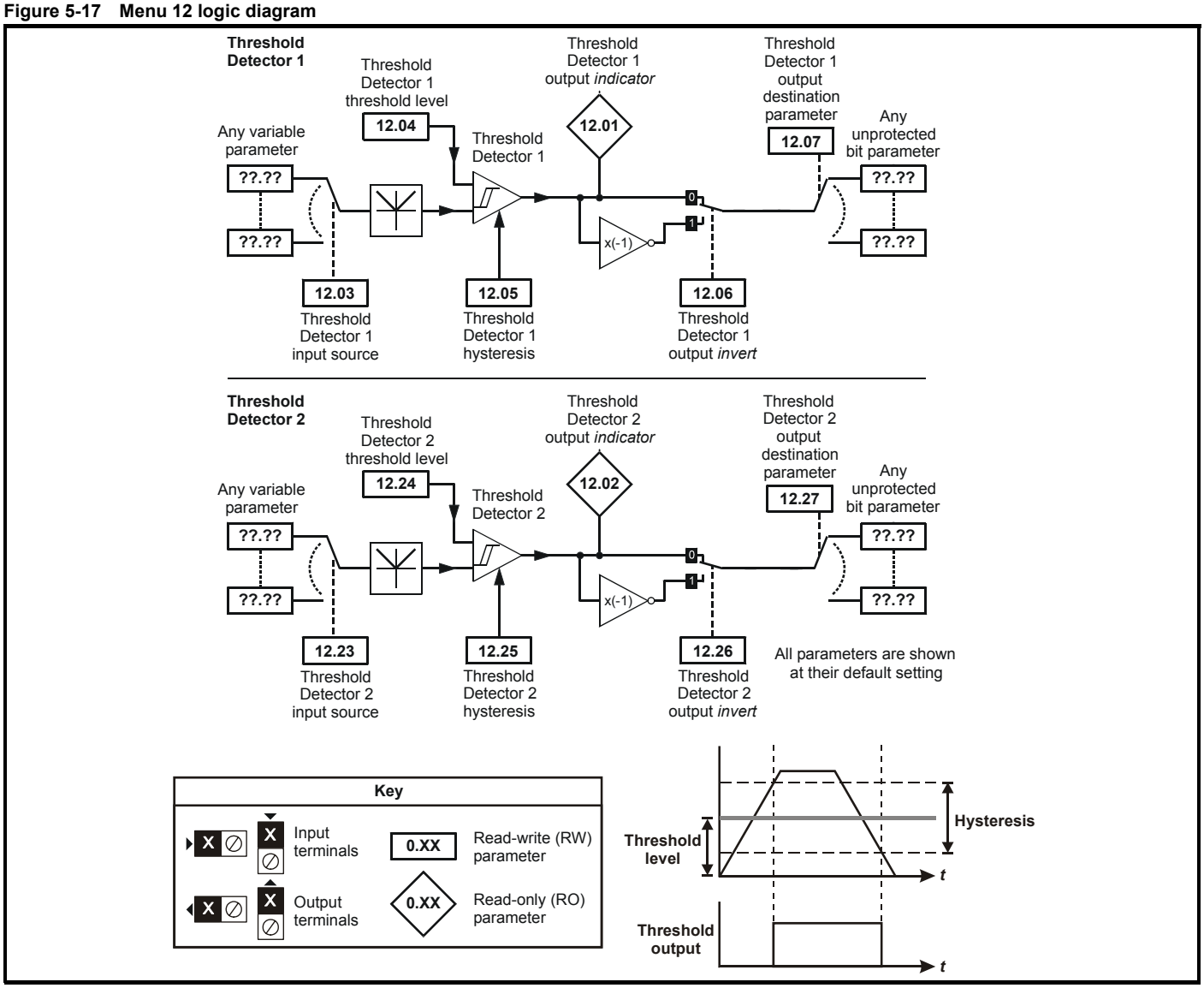
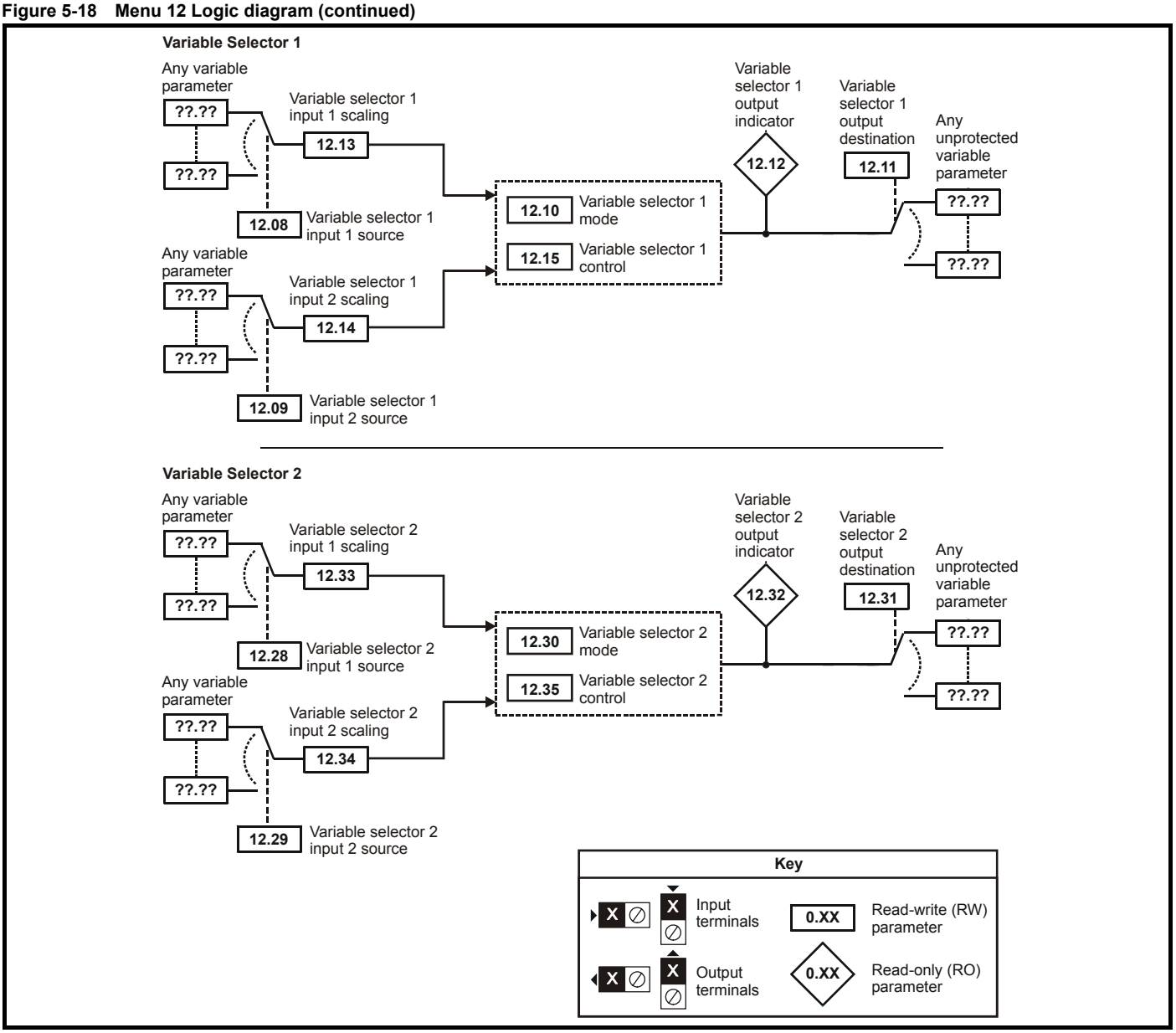


Figure 5-18 Menu 12 Logic diagram (continued)



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 9								
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.

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

5.13.1 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															

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 healthy 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

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 **10.01**	1	0	Pr **12.40**
2	0	Pr **12.40**	1	No action	
3	No action				

Open-loop

Figure 5-19 Open-loop brake function

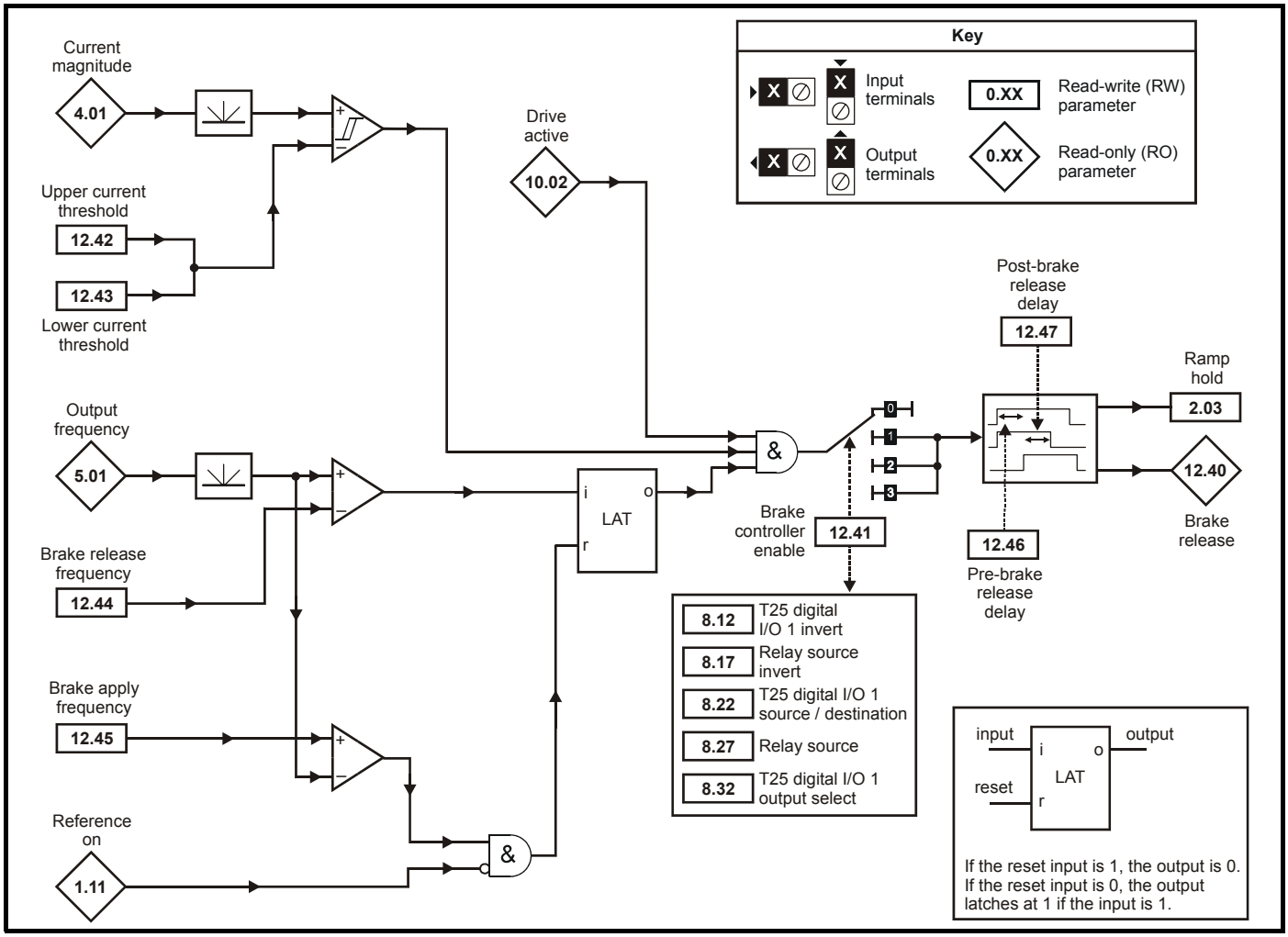
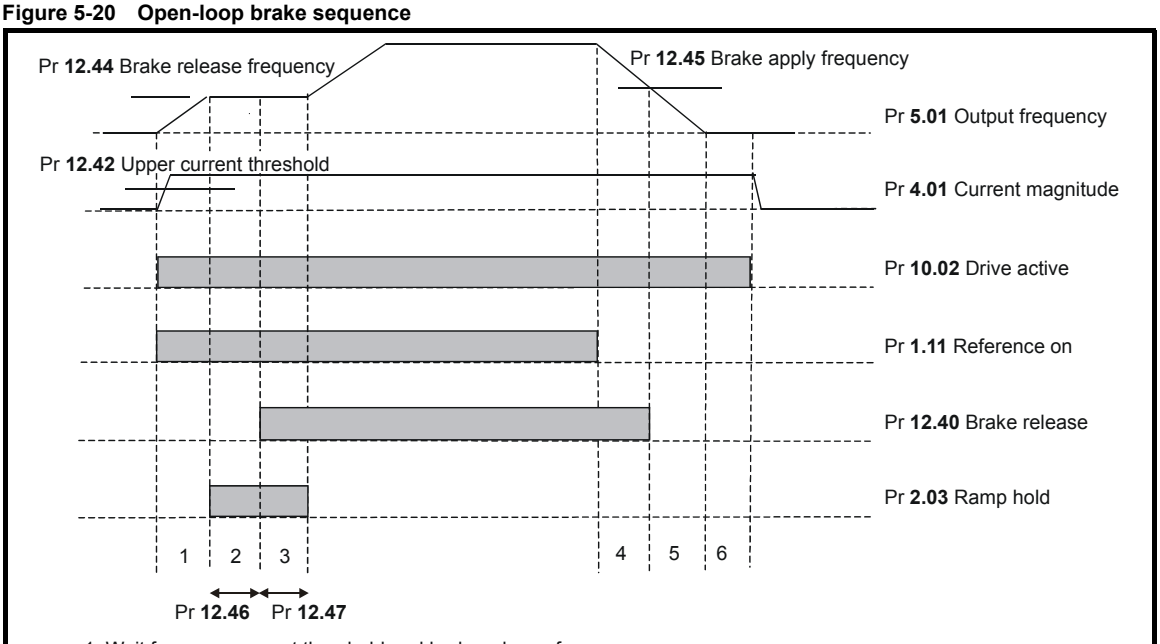


Figure 5-20 Open-loop brake sequence



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 magnetising 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, 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							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

Figure 5-21 Closed-loop vector and Servo brake function

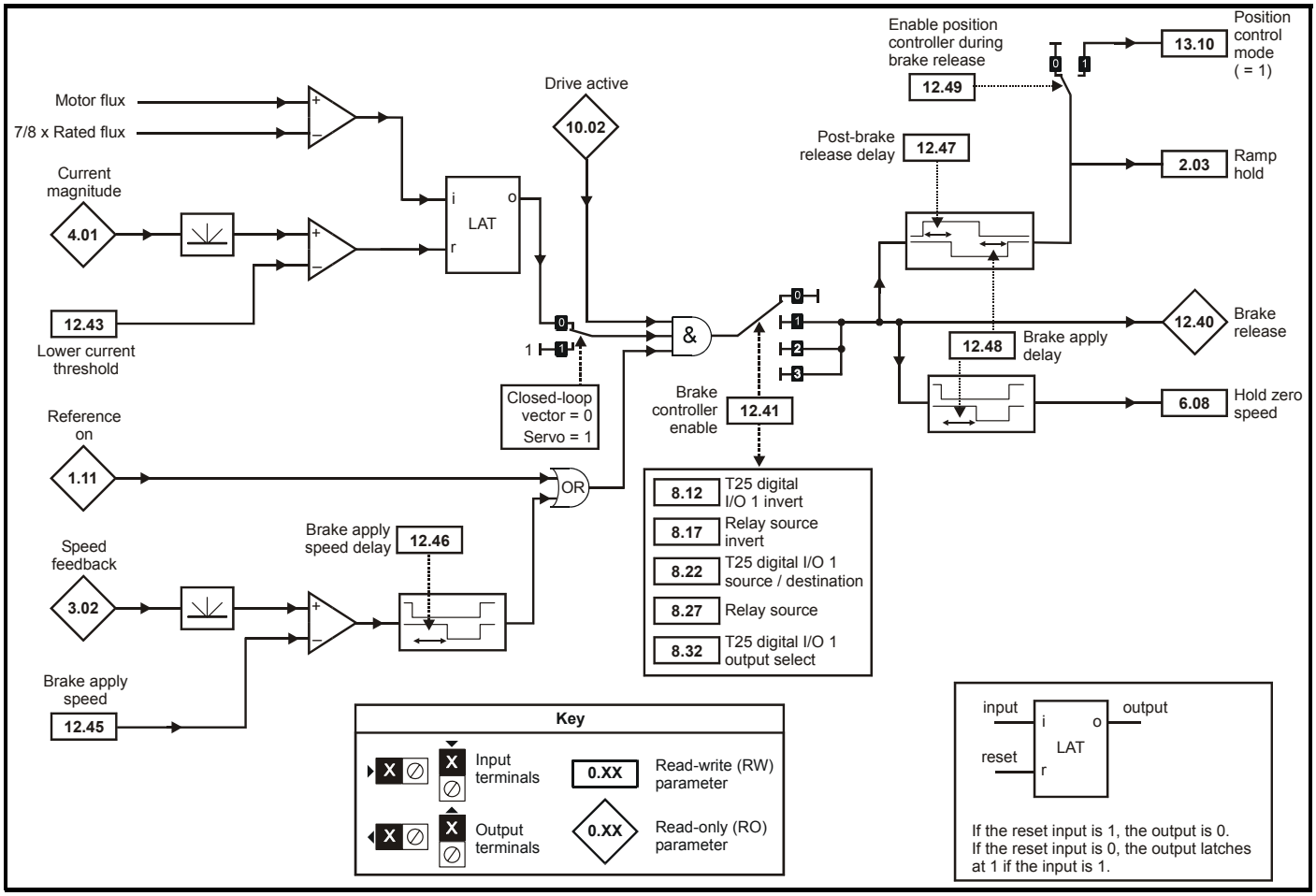
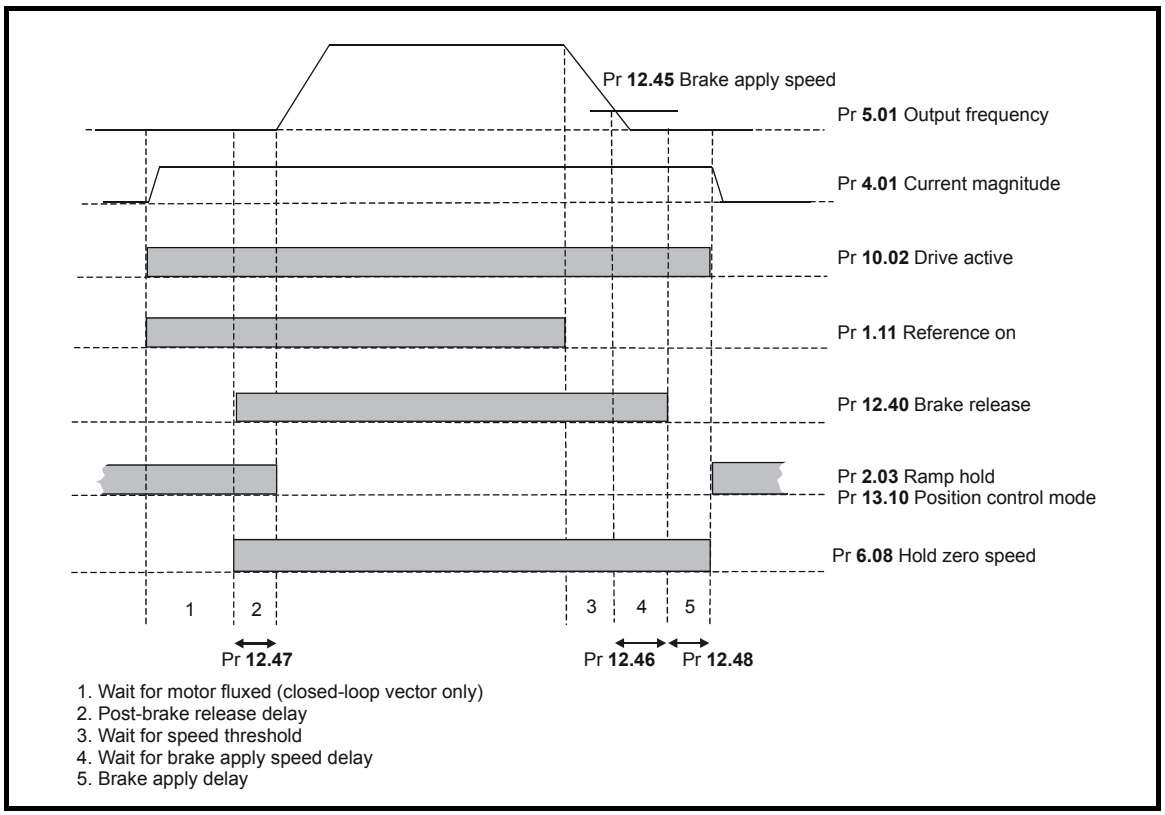


Figure 5-22 Closed-loop vector and Servo brake sequence



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.

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 energised (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.

5.14 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 5.7 *Menu 6: Sequencer and clock* on page 113).

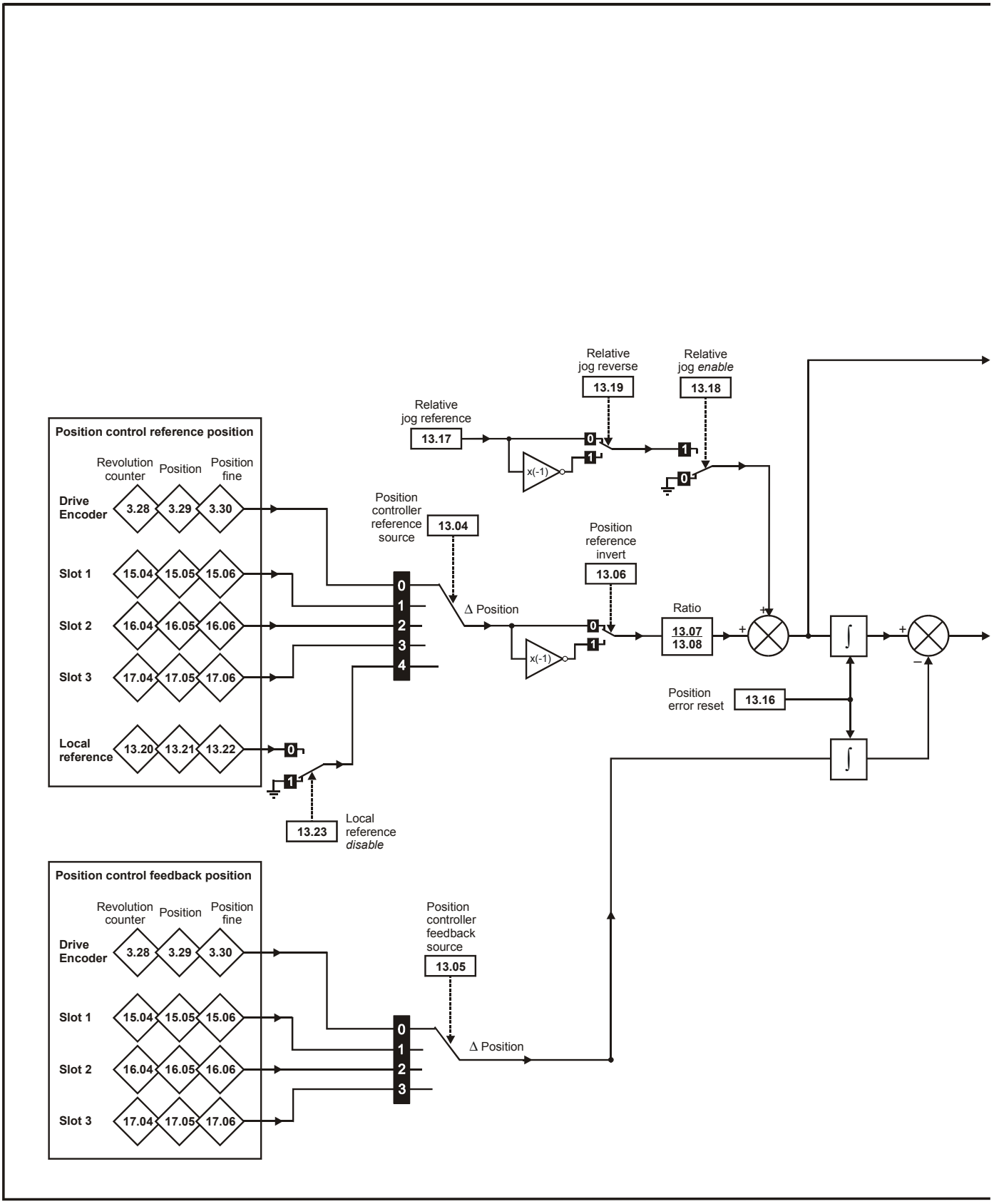
Open–loop mode

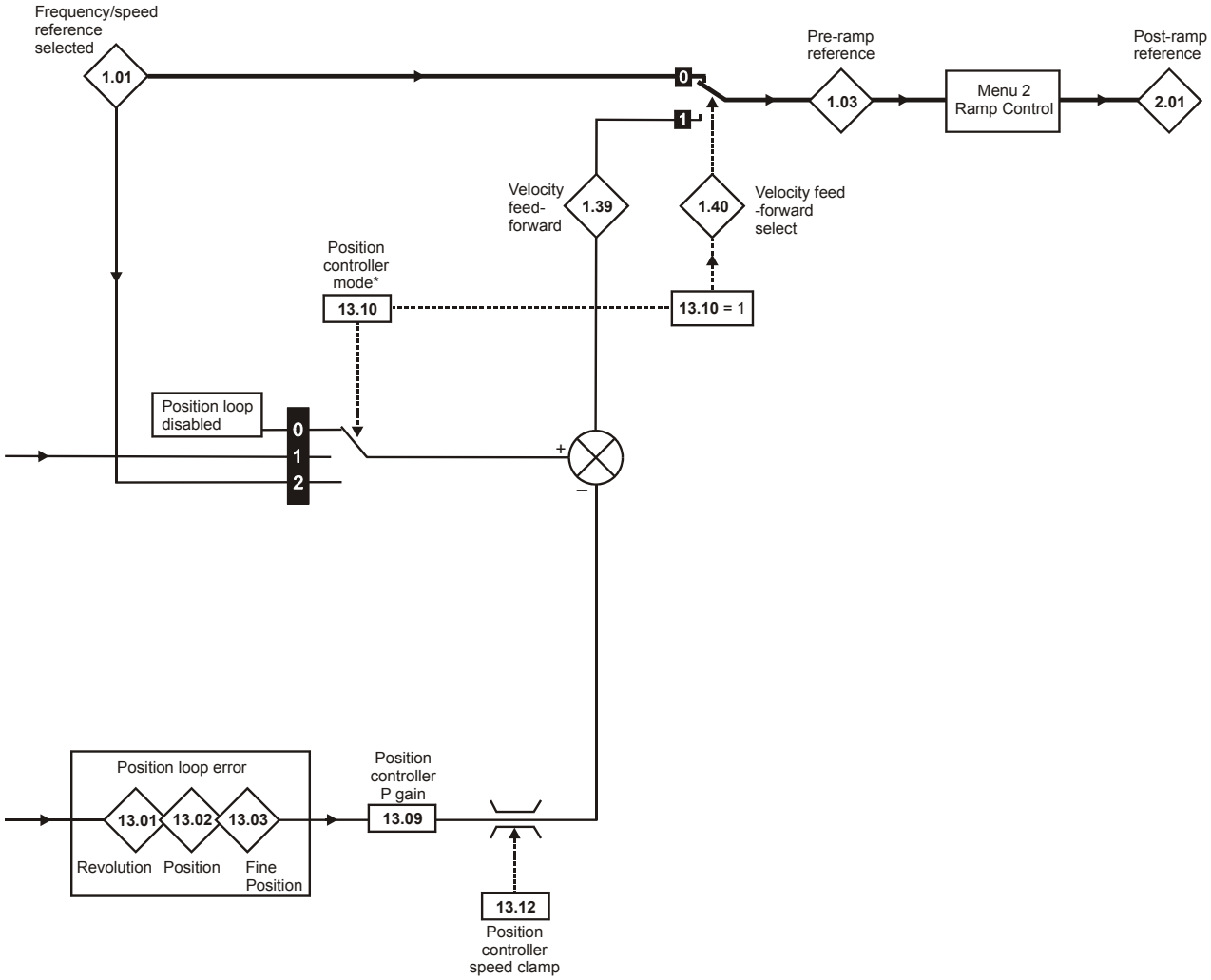
The position controller outputs are a velocity feed forward and a speed reference (both in 0.1rpm units). When the position controller is selected (i.e. Pr **13.10** is non-zero) these values are converted to 0.1Hz units and combined as shown below, before being written to the velocity feed forward parameter (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.

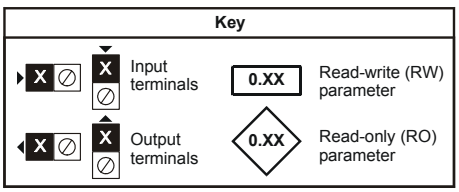
Closed-loop modes

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 5-23 Menu 13 Open-loop logic diagram

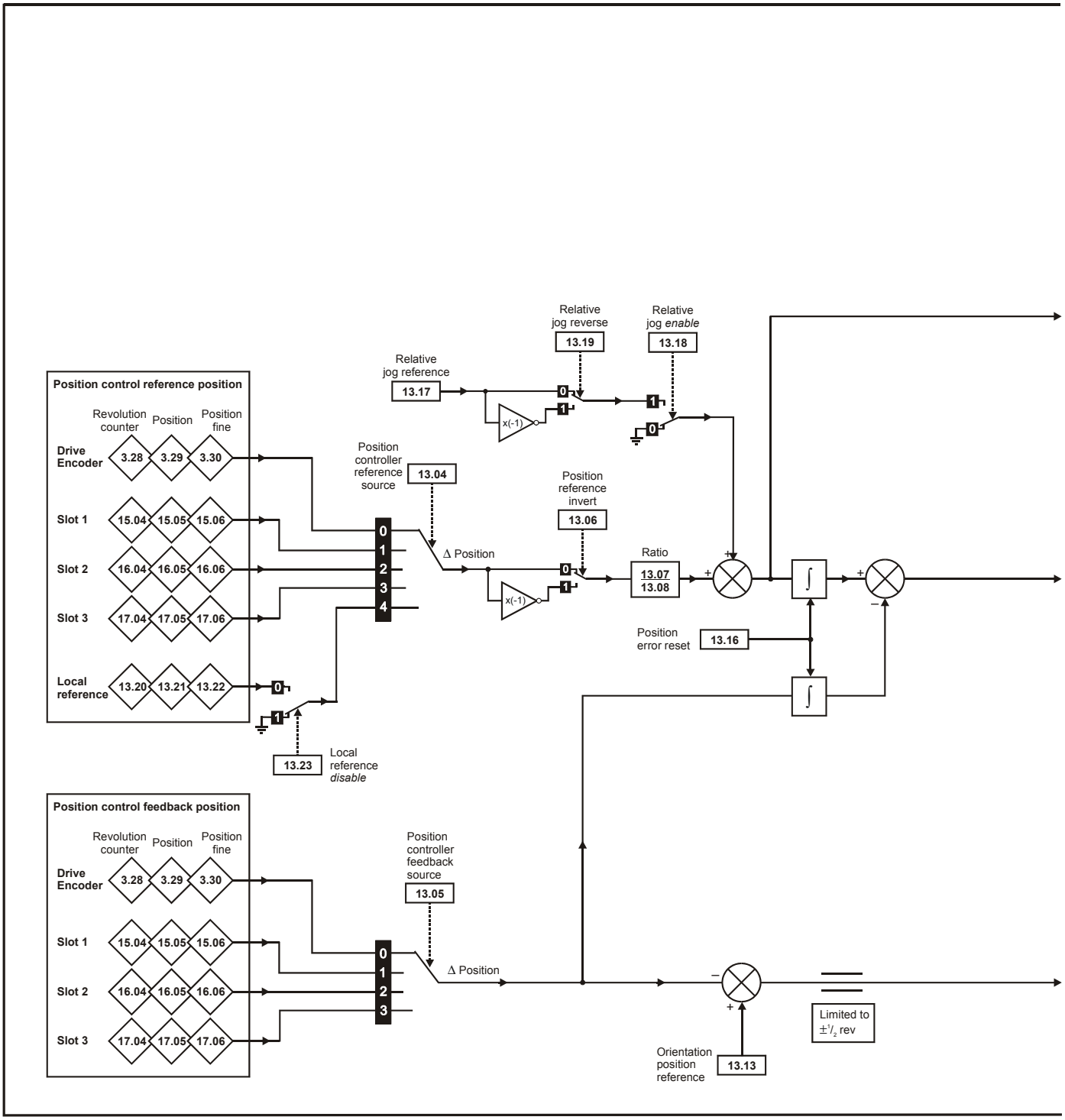


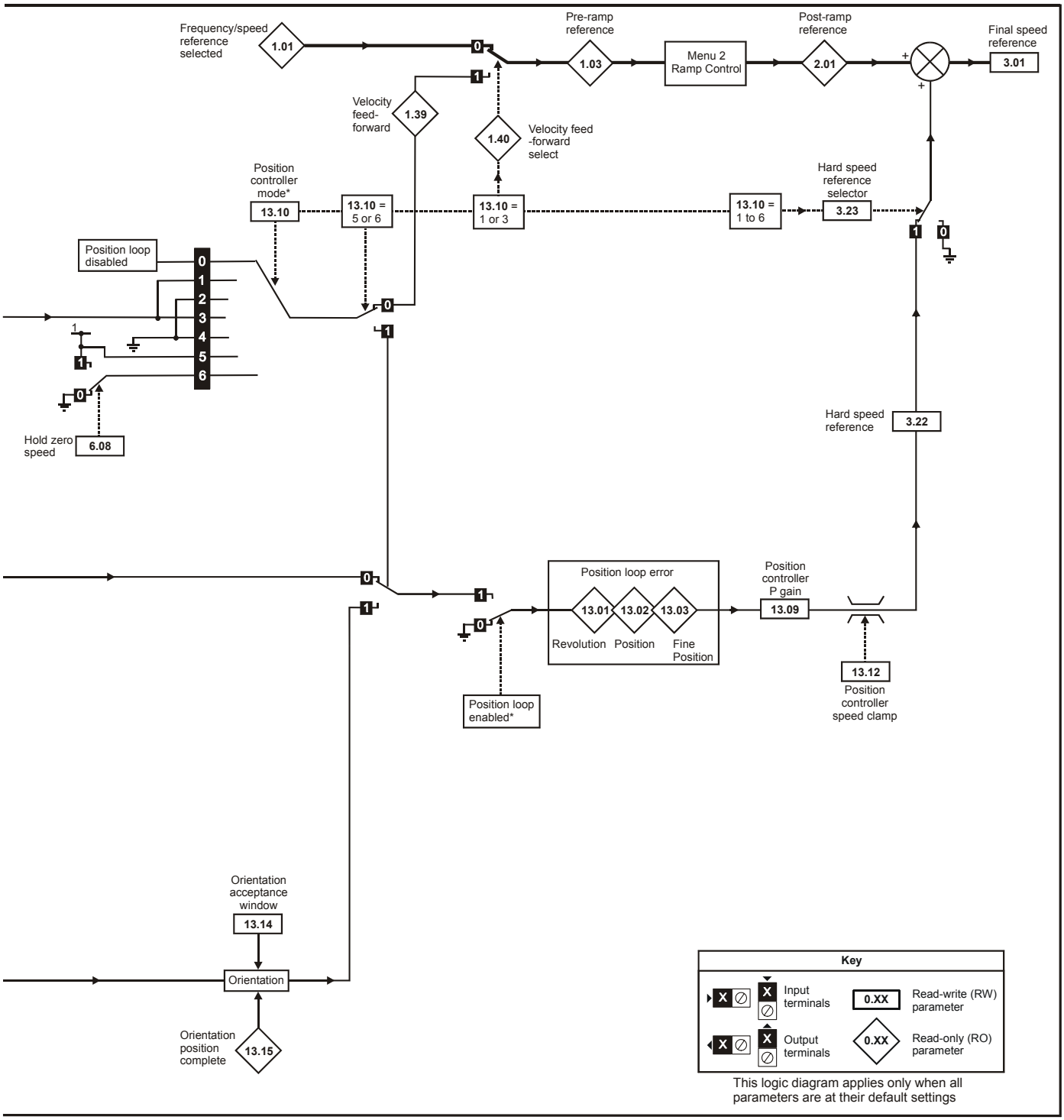




This logic diagram applies only when all parameters are at their default settings

Figure 5-24 Menu 13 Closed-loop logic diagram




Frequency/speed reference selected
1.01
Pre-ramp reference
1.03
Menu 2 Ramp Control
Post-ramp reference
2.01
Final speed reference
3.01
Velocity feed-forward
1.39
1.40
Velocity feed -forward select
Position controller mode*
13.10
13.10 = 5 or 6
13.10 = 1 or 3
13.10 = 1 to 6
Hard speed reference selector
3.23
Position loop disabled
Hold zero speed
6.08
Hard speed reference
3.22
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
Position loop enabled*
Orientation acceptance window
13.14
Orientation
Orientation position complete
13.15
Key
Input terminals
Output terminals
Read-write (RW) parameter
Read-only (RO) parameter
0.XX
This logic diagram applies only when all parameters are at their default settings

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 (locAI)	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, 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.

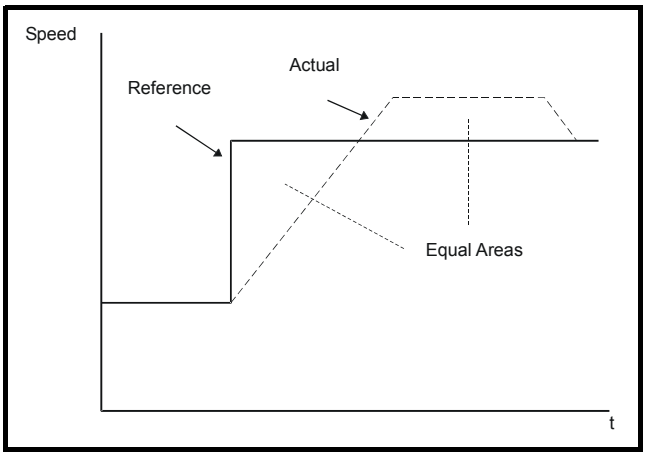
13.10	**Position controller mode**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop Closed-loop vector, Servo	0 to 2 0 to 6														
Default	Open-loop, Closed-loop vector, Servo	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	

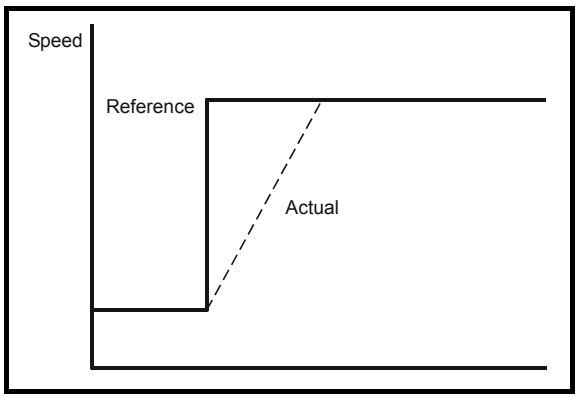
Rigid position control

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 42). This allows slippage to occur while the speed error is high.



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

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 initialised (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														
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															

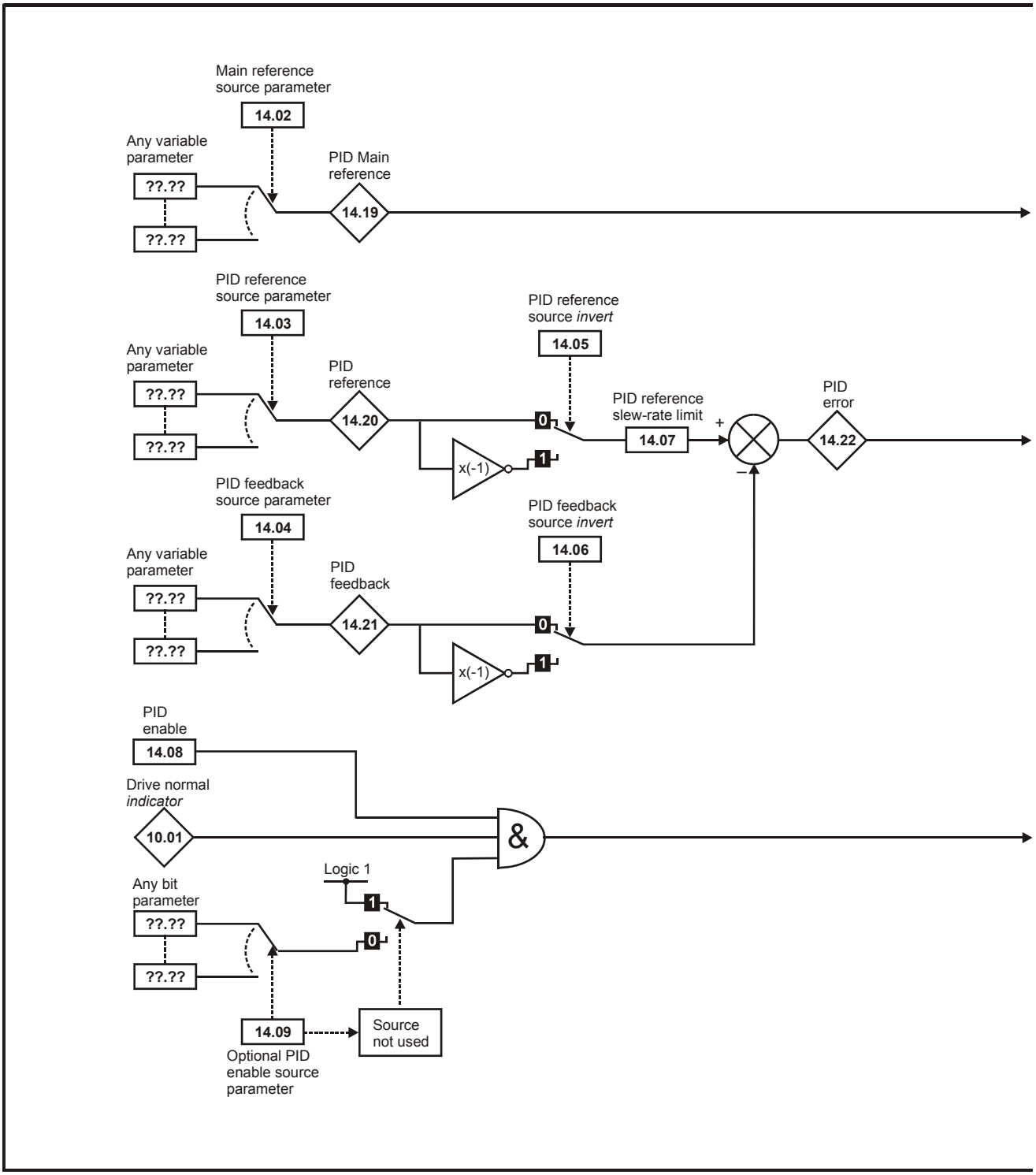
13.23	**Local reference disable**															
Drive modes	Open-loop, Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, Closed-loop vector, Servo	0														
Update rate	4ms read															

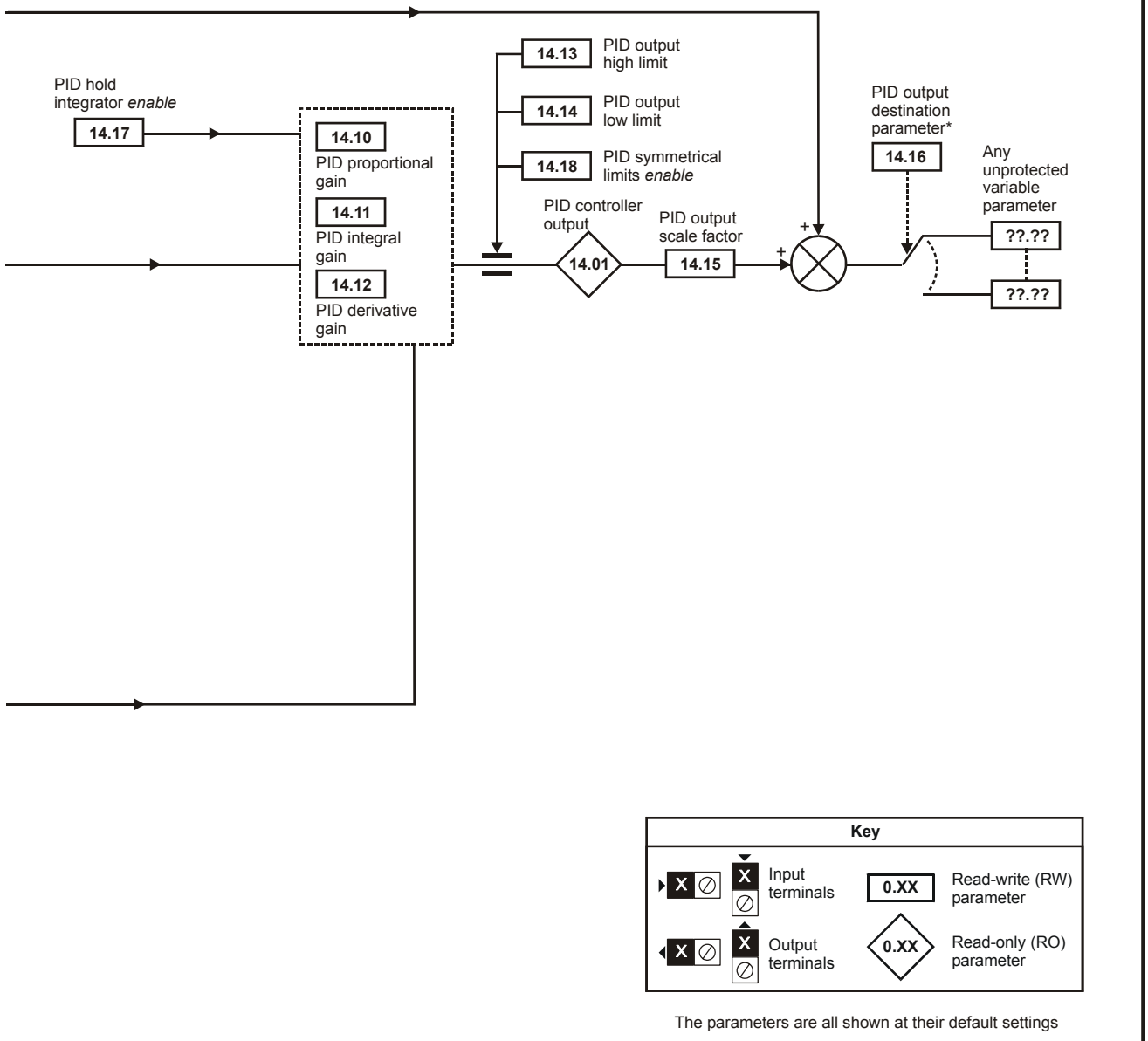
The local reference can be used to control the position of the motor shaft. If the local reference disable parameter is one the previously written value is used. This allows all three parts of the local reference position to be changed without data skew problems. The local reference position is sampled within 250µs of the level 2 task beginning that initiates the level 4 (4ms) task that operates the position controller. Therefore the reference may be written synchronously from an application category module provided it is not written within 250µs of a level 2 task RMINT transition that will initiate a level 4 task.

5.15 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 5-25 Menu 14 logic digram





The parameters are all shown at their default settings

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 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															
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	100.00														
Update rate	Background read															

14.14	PID lower 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
							2						1	1		
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.00 %														
Default	Open-loop, Closed-loop vector, Servo, Regen	-100.00														
Update rate	Background read															

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															
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 read															

14.16	PID 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 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															
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															

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															

5.16 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 fitted). When a module is fitted 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 fitted. The possible categories are shown below.

Category	Modules
Feedback	SM-Universal Encoder Plus
	SM-Encoder Plus
	SM-Resolver
Fieldbus	SM-PROFIBUS-DP
	SM-DeviceNet
	SM-INTERBUS
	SM-CAN
	SM-CANopen
Automation	SM-I/O Plus
	SM-EZMotion
	SM-Applications
	SM-Applications Lite

Most modules include a processor and parameters are updated by the processor in the option module. However, dumb modules do not contain a processor and all parameters are updated by the drive processor.

Dumb option 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 option modules fitted to the drive. For each option 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 option modules fitted.

For example, if a module with 4ms update time and a module with 8ms are fitted 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.

5.16.1 SM-Universal Encoder Plus

Solutions Module error status values

The Solutions Module checks for various errors as shown below.

Error code	Encoders	Reason for error
0	All	No fault detected
1	All	Power supply short circuit
2	Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo, SC, SC.Hiper, SC.EnDat, SC.SSI	+#Wire-break detect
3	Ab.Servo, Fd.Servo, Fr.Servo SC.Hiper, SC.EnDat, SC.SSI	+UVW phase angle incorrect while running, i.e. incremental pulses not counted correctly. +*Sine/cosine phase error.
4	SC.Hiper, SC.EnDat, EnDat SSI, SC.SSI	+Comms failure (time-out)
5	SC.Hiper, SC.EnDat, EnDat	Checksum or CRC error
6	SC.Hiper, SC.EnDat, EnDat SSI, SC.SSI	The encoder has indicated an error. Data was not at one before position was transmitted. Power supply bit error.
7	SC, SC.Hiper, SC.EnDat, EnDat, SSI, SC.SSI	Initialisation failed
8	SC.Hiper, SC.EnDat, EnDat	Auto configuration failed
9	All	Thermistor trip
10	All	Thermistor short circuit
74	All	The Solutions Module has overheated

* Phase errors are detected when the error is greater than 10^{o} electrical over ten consecutive one second samples.

+ These trips can be enabled/disabled by Pr **x.17**.

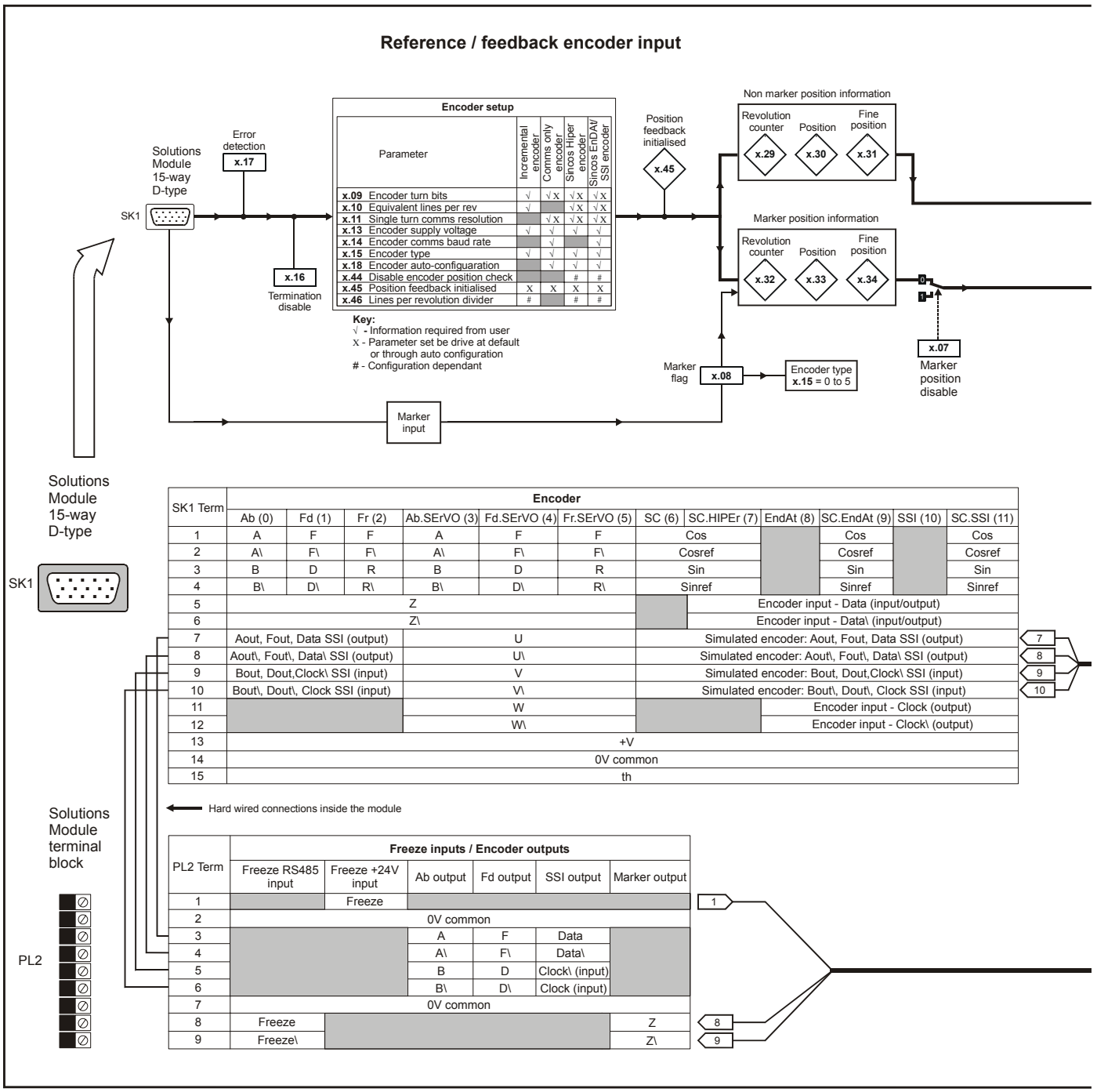
If the terminations are not enabled on the A, B or Z inputs the wire break system will not operate. (Note that as default the Z input terminations are disabled to disable wire break detection on this input.)

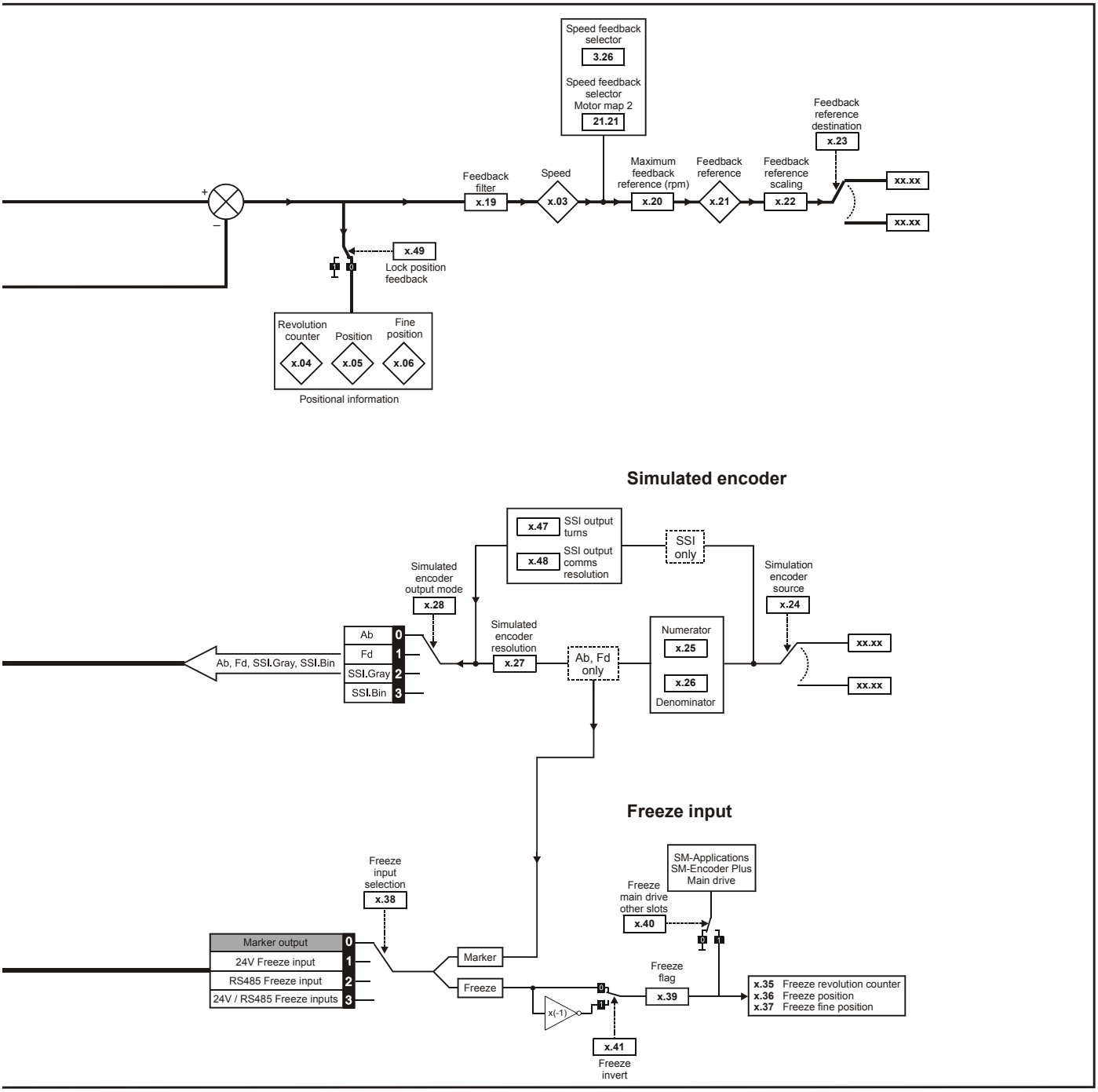
Encoder initialisation will occur when trips 1 to 8 are reset. This causes an encoder with comms to be re-initialised and auto-configuration to be performed if selected. Ab.Servo, Fd.Servo and Fr.Servo encoders will use the UVW commutations signals for the first 120° electrical when the motor is restarted.

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 below.

Device	Detection method	Error produced
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.	2
SC, SC.HiPEr, SC.EnData	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.	2
SC.HiPEr, SC.EnDat, EnDat	Wire break in the comms link is detected by a CRC or time-out error. Data line (Z) checked. Comms transfer time too long.	4, 5
SC.HiPEr, SC.EnDat, EnDat	The encoder has failed to initialise.	7
SC.HiPEr, SC.EnDat, EnDat	Auto parameter configuration on power-up has been requested Pr **x.17**>1 but the encoder type has not been recognised. The user must supply Pr **x.09** and Pr **x.11** and possibly Pr **x.10**.	8

Figure 5-26 SM-Universal Encoder Plus logic diagram




Speed feedback selector
3.26
Speed feedback selector Motor map 2
21.21
Feedback reference destination
x.23
Feedback filter
x.19
Speed
x.03
Maximum feedback reference (rpm)
x.20
Feedback reference
x.21
Feedback reference scaling
x.22
xx.xx
xx.xx
x.49
Lock position feedback
Revolution counter
x.04
Position
x.05
Fine position
x.06
Positional information
Simulated encoder
x.47
SSI output turns
x.48
SSI output comms resolution
SSI only
Simulated encoder output mode
x.28
Simulation encoder source
x.24
Ab
Fd
SSI.Gray
SSI.Bin
Ab, Fd, SSI.Gray, SSI.Bin
Simulated encoder resolution
x.27
Ab, Fd only
Numerator
x.25
x.26
Denominator
xx.xx
xx.xx
Freeze input
Freeze input selection
x.38
SM-Applications SM-Encoder Plus Main drive
Freeze main drive other slots
x.40
Marker output
24V Freeze input
RS485 Freeze input
24V / RS485 Freeze inputs
Marker
Freeze
x(-1)
Freeze flag
x.39
x.35 Freeze revolution counter
x.36 Freeze position
x.37 Freeze fine position
x.41
Freeze invert

x.01	Option 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 499														
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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.03	Speed															
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	±40,000.0 rpm														
Update rate	4ms write															

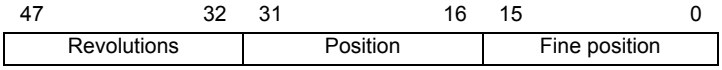
Provided the set-up parameters for the position feedback are correct this parameter shows the speed in rpm.

x.04	Revolution counter															
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 revolutions								
Update rate	4ms write															

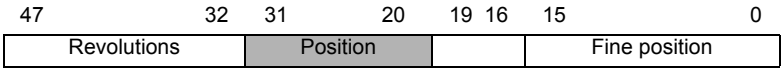
x.05	Position															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0 to 65,535 ($1/2^{16}$ths of a revolution)								
Update rate	4ms write															

x.06	Fine position															
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 65535 ($1/2^{32}$ths of a revolution)								
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.



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. 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.



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 initialised at power-up with the absolute position. If a multi-turn absolute encoder is used the revolution counter is also initialised with the absolute revolutions at power-up.

x.07	Marker position reset 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, Regen							0								
Update rate	Background read															

x.08	Marker flag															
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 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 drive, and so this must be done by the user. The marker function only operates when Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo type encoders are selected with Pr **x.15**.

x.09	**Encoder turns**															
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	2^x $0 \le x \le 16$														
Default	Open-loop, Closed-loop vector, Servo, Regen	2^{16} (65,536)														
Update rate	Background read															

When an encoder without comms is used it is sometimes desirable to mask off the most significant bits of the revolution counter. Normally this would be required with an absolute multi-turn encoder where the number of turns measured is less than 65,536. 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. For example, if Pr **x.09** = 5, then Pr **x.04** counts up to 31 before being reset.

When an encoder with comms is used, 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. 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 **x.18** on page 224).

x.10	**Equivalent lines per revolution**															
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 50,000														
Default	Open-loop, Closed-loop vector, Servo, Regen	4,096														
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	number of sine waves per revolution

For Ab, Fd, Fr, Ab.Servo, Fd.Servo and Fr.Servo encoders the incremental (A/B) signal frequency should not exceed 500kHz.

For SC.Hiper, SC.EnDat, SC and SC.SSI encoders the sine wave signal frequency can be up to 166kHz, 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.

Volt/Freq	1,000	5,000	50,000	100,000	150,000
1.2	11	11	11	10	10
1.0	11	11	10	10	9
0.8	10	10	10	10	9
0.6	10	10	10	9	9
0.4	9	9	9	9	8

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 the encoder via HIPERFACE or EnDat interfaces (see Pr **x.18** on page 224).

x.11	Encoder single turn comms resolution															
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 32 bits														
Default	Open-loop, Closed-loop vector, Servo, Regen	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.17** on page 224), in Pr **x.11**. The comms resolution may be higher than the resolution of the sine waves per revolution.

Where encoder comms alone is used the encoder single turn comms resolution (Pr **x.11**) and the encoder turns bits (Pr **x.09**) must be set correctly. 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 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 **x.17** on page 224). If the encoder gives this information the comms resolution should be set up to include this bit whether or not it is being monitored by the drive.

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 **x.18** on page 224).

x.12	Motor thermistor check 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															

This bit should be set if the Solutions Module is connected to a motor thermistor and the user wants the temperature to be checked. The Solutions Module will trip for over temperature and thermistor short circuit.

x.13	Encoder supply voltage															
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	0														
Update rate	Background read															

The encoder supply voltage present on the SM-Universal Encoder Plus is defined by this parameter as 0 (5V), 1 (8V) or 2 (15V)

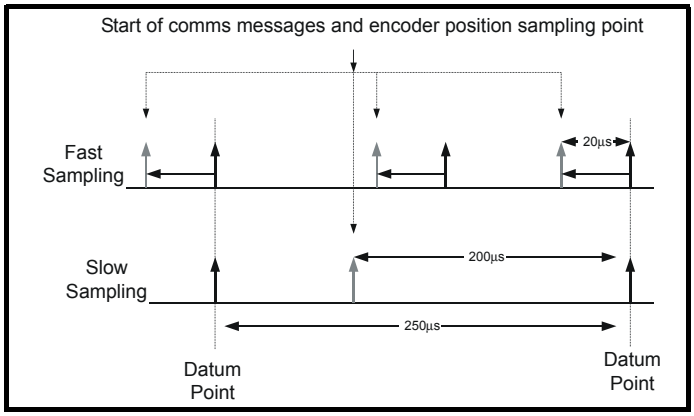
x.14	Encoder comms baud rate															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 7														
Default	Open-loop, Closed-loop vector, Servo, Regen	2														
Update rate	Background read															

This parameter defines the baud rate for the encoder comms when using SSI or EnDat encoders. However, a fixed baud rate of 9,600 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	1,000	1M
6	1,500	1.5M
7	2,000	2M

Any baud rate can be used when encoder comms is used with a SINCOS encoder to obtain the absolute position during initialisation. When encoder comms is used alone the time taken to obtain the comms position must be 160µs or less.

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



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. If slow sampling is used the control position is obtained 200µs 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 so that it appears to have been sampled at the datum. This compensation is based on the delay (i.e. 20µs or 200µs) and the change of position over the previous sample (between the last two datum points).

EnDat comms

The following equations are used by the Solutions Module 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. This value would be significantly less for shorter cable distances. 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 **x.11**) 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 **x.09** + 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)

SSI comms

The whole position must be obtained from an SSI encoder before it can be used by the Solutions Module, therefore the time for the single turn position and the time for the whole message are the same. It is also assumed that $t_D \leq 1.25\mu s$ where t_D is the data delay from the encoder for 105m of cable. This value would be significantly less for shorter cable distances. It should be noted that all values are rounded up to the nearest microsecond.

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

= ((Pr **x.09** + Pr **x.11** + 1) x T) + t_D

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)

x.15	**Encoder type**															
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	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 initialised.

6, SC: SinCos encoder with no serial communications

This type of encoder gives incremental position and can only be used for control in Closed-loop vector mode.

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, and the Solutions Module can 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.

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.

The following should be noted:

It should be noted that all SINCOS encoders and encoders using communications must be initialised before their position data can be used. The encoder is automatically initialised 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 option 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-initialising the encoder interface (see Pr **3.47** on page 65).

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 initialised 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** on page 62). 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.16	Encoder termination															
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							1								
Update rate	Background read															

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

A-A\ and B-B\ terminations cannot be disabled when encoders with SinCos waveforms are selected.

Z-Z\ terminations cannot be disabled except when Ab, Fd, Fr, Ab.Servo, Fd.Servo, Fr.Servo encoders are selected.

x.17	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								
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 bit monitor

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	Phase error detect	2
0	1	1	Wire break + phase error detect	3
1	0	0	SSI power supply bit monitor	4
1	0	1	Wire break + SSI power supply bit monitor	5
1	1	0	Phase error detect + SSI power supply bit monitor	6
1	1	1	Wire break detect + phase error detect + SSI power supply bit monitor	7

x.18	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 Solutions Module will interrogate the encoder on power-up. If Pr **x.18** is set and the encoder type is recognised based on the information provided by the encoder, the Solutions Module will set the encoder turns (Pr **x.09**), the equivalent lines per revolution (Pr **x.10**) and the encoder comms resolution (Pr **x.11**) for the encoder. If the encoder is recognised these parameters will all become read only. If the encoder is not recognised, the Solutions Module initiates an SLx.Er trip (Pr **x.50** = 7) to prompt the user to enter the information. The Solutions Module should be able to auto-configure with any EnDat encoder where the number of turns and lines per revolution are a power of 2, and the following HIPERFACE encoders: SCS 60/70, SCM 60/70, SRS 50/60, SRM 50/60, SHS 170, LINCODER, SCS-KIT 101, SKS36, SKM36.

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.

x.19	**Feedback filter**															
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 5 (0 to 16 ms)								
Default	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. 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.20	**Maximum feedback 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
							1						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0 to 40,000.0 rpm								
Default	Open-loop, Closed-loop vector, Servo, Regen							1,500								
Update rate	Background read															

x.21	**Feedback 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
							1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.0 %								
Update rate	4ms write															

x.22	**Feedback reference 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															

x.23	Feedback reference 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 position feedback can be used as a reference for any unprotected parameter. The percentage of the maximum position feedback reference (Pr **x.20**) is calculated and displayed via the feedback reference (Pr **x.21**). The value written to the destination parameter is a percentage of the full-scale value of the destination defined by Pr **x.23**.

To enable a faster update rate, 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.

x.24	Encoder simulation 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															

x.25	Encoder simulation ratio numerator															
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
							4						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0000 to 3.0000								
Default	Open-loop, Closed-loop vector, Servo, Regen							0.2500								
Update rate	Background read															

x.26	Encoder simulation ratio denominator															
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
							4						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen							0.0001 to 3.0000								
Default	Open-loop, Closed-loop vector, Servo, Regen							1.0000								
Update rate	Background read															

x.27	Encoder simulation resolution 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	Background read															

x.28	**Encoder simulation 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															

This parameter defines the output mode for encoder simulation as follows.

Pr x.28	String	Mode
0	A B	Quadrature
1	F d	Frequency and direction
2	SSI.Gray	SSI output in Gray code
3	SSI.bin	SSI output in binary code

AB or FD modes

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 -32,768 to 32,767 or 0 to 65,535 are normally used. The marker is simulated when the source rolls over or under.

When the Solutions Module is connected to a high precision encoder (i.e. SinCos or Comms only) and the source has been selected as the internal position (Pr **x.05**), the resolution can be increased to a 24 bit position value by setting Pr **x.27** to a one.

Software simulation: high resolution encoder

This situation occurs when the source parameter is the position parameter of the same module (Pr **x.05**), the source device is a high precision encoder (i.e. Comms only), the output is AB or FD and Pr **x.27** is set.

The position and fine position parameters are read every 250µs and the output generated during the next period under software control. This gives encoder simulation of the encoder with higher resolution (used as a 24 bit counter). The output position is defined as follows.

Output position = Counted input position x (Pr **x.25**) / (Pr **x.26**)

For example: in order to simulate one to one with a 13 bit (8192 count) Resolution Comms only encoder. (The current position is taken in 16,777,216th of a revolution (24 bit)).

The ratio down to 8192 pulses requires 1/2048, or 0.0001/0.2048. So Pr **x.25** = 0.0001 and Pr **x.26** = 0.2048.

It should be noted that the output is limited to 500kHz. Pulses are lost if the required output frequency exceeds this level.

Software simulation: any other condition

If the source parameter is not as described above the parameter will be read every 250µs and the output generated during the next period under software control within the Solutions Module. The output position is defined as follows.

Output position = Parameter value x (Pr **x.25**) / (Pr **x.26**)

For example: in order to simulate one to one with a 1024 line (4096 counts) encoder. (The current position is taken from the source parameter as a 65536th of a revolution (16 bit)).

The ratio down to 4096 counts requires 1/16, or 0.01/0.16. So Pr **x.25** = 0.01 and Pr **x.26** = 0.16.

It should be noted that the output is limited to 500kHz. Pulses are lost if the required output frequency exceeds this level.

SSI output

The SSI is an absolute encoder so if possible the position will be synchronised to the source's full position. If the source is the drive position (Pr **3.29**) or any SM-Universal Encoder Plus (Pr **x.05**), and source's marker reset is enabled (Pr **3.31** = 0, or Pr **x.07** = 0), the source will become synchronised to the marker reset position.

If the position source is the drive or a SM-Universal Encoder Plus, Pr **x.47** (the SSI output turns) and Pr **x.48** (the SSI output resolution) are used to construct the SSI output position which is updated every 250µs. The position is in binary (or Gray) SSI with the start bit high and the power supply alarm bit (the last bit) low.

If the source is a 32 bit parameter, the 32 bits will be used as the SSI output string. Therefore the master controls the size of the transfer and decides how many bits are in the turns information and how many bits are in the position information. The same applies for a 16 bit source. The master can transfer up to the full 49 bits as the source parameter data will be the most significant part and the rest of the data will be packed with zeros. The position is in binary (or Gray) SSI with the start bit high and the power supply alarm bit (the last bit) low.

It must be remembered that the Solutions Module acts as a slave and is clocked by the master device. As the position is updated synchronised to the drive, this position will not be synchronised to the master.

The Solutions Module detects the end of a transfer when the master pauses the clock for more than 90µs. During this time the SSI interface resets and prepares for the next transfer. The baud rate is set in the master device, but the Solutions Module can output up to 500kHz. **The pause time of 90µs must never be reduced.**

The SM-Universal Encoder Plus simulator requires a longer time to initialise than the encoder input port on the both the SM-Universal Encoder Plus and the drive. The power failure bit will not be set by the simulating SM-Universal Encoder Plus until it is ready. If the simulating SM-Universal Encoder Plus and the receiver connected to it are powered-up simultaneously, the receiver will fail to initialise due to the power failure bit. The user must then request a re-initialisation using Pr 3.47 now that the simulating SM-Universal Encoder Plus is ready.

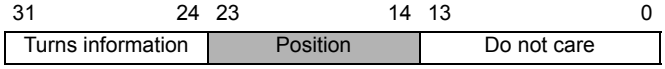
A typical drive source example is given below:

The SSI output turns (Pr **x.47**) is set to its maximum (16) and the SSI output resolution (Pr **x.48**) is set to its maximum (32) to produce the full 48 bit multi-turn position (the start/latching bit is added to this to give 49 bits that will be transferred). The master is set up for this also, and its clock rate is set at 400kHz. The master transfers a position value every 250µs.

At 400kHz, the transfer takes 122.5µs. As the next transfer will be 127.5µs later the pause condition is satisfied. If the clock were to be reduced to 300kHz, the pause time would be less than 90us so the communication channel could not be guaranteed.

A typical 32 bit source parameter example is given below:

The master controls the number of bits transferred and how many of the bits are the turns information. For example a 32 bit parameter could contain 8 bits of turn information as the most significant part, and 10 bits of positional information as the next significant part. The bit string is shown below:



The master is set to transfer 18 bits (plus one for the start/latch). The least significant bit sent will be forced low to indicate that the power supply is fine. The master is also set to take the most significant 8 bits as the turns information. The user is responsible for preparing the source parameter.

Marker output

The marker pulse is simulated if the marker output port is not being used for RS485 freeze input. The marker is synchronised with the zero count and the duration is calculated from the current position (taken every 250µs) and the change in position. If the source is the drive position (Pr **3.29**) or any SM-Universal Encoder Plus (Pr **x.05**), and the source's marker reset is enabled (Pr **3.31** = 0, or Pr **x.07** = 0), the source will become synchronised to the marker reset position. The marker is output when both the A and B channels are high.

x.29	**Non-marker reset revolution counter**															
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							0 to 65,535 revolutions								
Update rate	4ms write															

x.30	**Non-marker reset position**															
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 ($1/2^{16}$ths of a revolution)								
Update rate	4ms write															

x.31	**Non-marker reset fine position**															
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 ($1/2^{32}$ths 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**															
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 revolutions								
Update rate	4ms write															

x.33	**Marker position**															
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 ($1/2^{16}$ths of a revolution)								
Update rate	4ms write															

x.34	**Marker fine position**															
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 ($1/2^{32}$ths 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**															
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 revolutions								
Update rate	Level 2 write															

x.36	**Freeze position**															
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 ($1/2^{16}$ths of a revolution)								
Update rate	Level 2 write															

x.37	**Freeze fine position**															
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 65535 ($1/2^{32}$ths of a revolution)								
Update rate	Level 2 write															

x.38	Freeze input mode selection															
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		
Default	Open-loop, Closed-loop vector, Servo, Regen	1														
Update rate	Background read															

The freeze input can take the form of either a 485 signal through the encoder marker simulation output pins or a 24V signal on the freeze 24V input. The selection of which mode is used is dependent on the value of Pr **x.38**. The values correspond to the modes as described in the following table. The default is 1 that corresponds to only the 24V input.

Value in Pr x.38	24V input	485 input
0	No	No
1	Yes	No
2	No	Yes
3	Yes	Yes

x.39	Freeze flag															
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	Level 2 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.

If a freeze source (24V or RS485) is to be used to freeze more than one SM-Universal Encoder Plus, the freeze must be connected to all the SM-Universal Encoder Plus in which the freeze is to be latched.

x.40	Freeze main drive position															
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	0														
Update rate	Background read															

When a freeze occurs on the Solutions Module the main drive position can also be stored if this parameter is set to one. Whenever a SM-Applications and a SM-Universal Encoder Plus are used, the freeze should be connected to the SM-Universal Encoder Plus and Pr **x.40** should be set to allow the drive and SM-Applications to see the freeze.

x.41	Freeze falling edge 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	Background read															

When Pr **x.40** = 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**															
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 65,535														
Update rate	Background read															

x.43	**Encoder comms receive register**															
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 65,535														
Default	Open-loop, Closed-loop vector, Servo, Regen	0														
Update rate	Background write															

x.44	**Disable encoder position check**															
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 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 SC.Hiper or SC.Endat as follows:

For both comms protocols more than one byte of data must be written to the transmit register or read from the receive register during the transfer of one message. Bit 13-15 are used to indicate the following:

Register	Bit	Function
Transmit	15	Must be set for the Solutions Module 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.

Data should be written to the transmit buffer when the buffer has been reset to zero by the module. The data will be transferred to the comms buffer and the transmit register will be cleared. Data can be read from the receive buffer at any time. If there is receive data in the buffer bit 15 will be set. Once the data has been read the buffer should be cleared and the module will then transfer more data. The 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.
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.
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 time-out occurred.
6	The last message was to auto-configure the drive encoder and the encoder was identified successfully.
7	The last message was initiated through the Solutions Module interface or from the drive electronic nameplate system and the last message was successful.

SC.Hiper

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 module and added to the end of the message before the message is transmitted to the encoder. The module checks the checksum of the received message. If successfully received, the receive message can be read via the receive register 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 module. Also the data block security should not be enabled if the Solutions Module 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

Example of a HIPERFACE transfer

Requesting the position from a 12/14 HIPERFACE encoder.

Pr **x.44** set to one to open the parameter channel. For position, only two bytes need to be sent from the Solutions Module – the address and the command 0x42 (hex). For simplicity the address is chosen as the broadcast address 0xFF, which can be seen by encoders of any address.

The first message:

The 16 bit word to be placed through drive comms, or a SM-Applications, is made up of a transfer command byte (the highest byte) and the data to be transferred (the least significant byte). To alert the Solutions Module to the fact that there is new data in Pr **x.42**, the most significant bit of the transfer command byte (bit 15 of the full word) must be set. To alert the Solutions Module that this is the first byte to be transferred, bit 13 of the full word should be high. The first byte to be sent is the address, so the full word to be placed in Pr **x.42** is below in binary:

Most significant end

1010 0000 : 1111 1111

Transfer command : Data to transfer

0xa0 : 0xff

Gives the decimal number 41215

Once placed into Pr **x.42**, the parameter will be read by the Solutions Module and its value returned to zero to signify that the next word can be entered. This is the last byte required to send (as the Solutions Module will add the checksum) so bit 15 and bit 14 of the full word must be set. The data byte to be sent is the read position command 0x42. The last byte to be sent is the HIPERFACE command, so the full word to be placed in Pr **x.42** is below in binary:

Most significant end

1100 0000 : 0100 0010

Transfer command : Data to transfer

0xc0 : 0x42

Gives the decimal number 49218

Once placed into Pr **x.42**, the parameter will be read by the Solutions Module and its value returned to zero to signify that the data has been sent. Next the receive parameter (Pr **x.43**) should be read. If the most significant bit is high (if the value is higher equal or higher than 32,768) new data has been placed there by the Solutions Module. This data should be read by the user and then the parameter should be set to zero by the user to alert the Solutions Module that the next word should be placed into this parameter.

In this particular example the position with SinCos interpolation according to Pr **x.04** and Pr **x.05** was turn 3,429 and position 36,446. The position requires dividing by 8 to produce a 14 bit position as will be given from the read position data transfer, this gives a position of 9,112. The returned data from the encoder and read through Pr **x.43** is given below:

Word number	Returned value	Returned value in hex.	Data in decimal	Data in hex.	Data in binary
1	32,832	0x8040	64	0x40	0100 0000
2	32,834	0x8042	66	0x42	0100 0010
3	32,771	0x8003	03	0x03	0000 0011
4	32,857	0x8059	89	0x59	0101 1001
5	32,867	0x8063	99	0x63	0110 0011
6	32,919	0x8097	151	0x97	1001 0111
7	49,324	0xc0ac	172	0xac	1010 1100

All the returned values have been offset by 32,768 which is the most significant bit. The last byte has an addition offset of 16,384 to denote that it is the last byte.

First check the CRC (which is also checked by the Solutions Module), this is the XOR of all the data bytes before bit position by bit position, for example the least significant bit of the CRC is zero as the XOR(001111) is zero.

Words 3 to 6 are the position with the least significant bit as the least significant bit of word 6 so any unused bits being placed in the more significant part of word 3. Below are the numbers laid out in the correct order:

Word 3	Word 4	Word 5	Word 6
3	89	99	151
0000 0011	0101 1001	0110 0011	1001 0111

Shifted to turns and position (which is 12 bits then 14 bits):

1101 0110 0101 (end of turns and start of the position) 10 0011 1001 0111
3429 9111

So the absolute position is 3429/9111 which should be compared to the displayed interpolated position of 3429/9112.

SC.EnDat

The Heidenhain EnDat protocol is a synchronous protocol using the following message format.

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.

LS byte	1st byte	Bit 7-0 = 0
		Bit 7-0 = 0
		Bit 7-0 = 0
		Bit 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 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:

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

Example of a EnDat transfer

Requesting the position from a 12/13 Endat encoder.

To request the position the following data output must be sent:

Command = 0x00	1st byte
Address = not needed = 0x00	
Data (LSB) = not needed = 0x00	
Data (MSB) = not needed = 0x00	4th byte

The 16 bit word to be placed through drive comms, or a SM-Applications, is made up of a transfer command byte (the highest byte) and the data to be transferred (the least significant byte). To alert the Solutions Module to the fact that there is new data in Pr **x.42**, the most significant bit of the transfer command byte (bit 15 of the full word) must be set. To alert the Solutions Module that this is the first byte to be transferred, bit 13 of the full word should be high. The first byte to be sent is the command, so the full word to be placed in Pr **x.42** is below in binary:

Most significant end

1010 0000 : 000 0000

Transfer command : Data to transfer

0xa0 : 0x00

Gives the decimal number 40960

Once placed into Pr **x.42**, the parameter will be read by the Solutions Module and its value returned to zero to signify that the next word can be entered.

The next two words only require the most significant bit to be high:

32768

32768

Once placed into Pr **x.42**, the parameter will be read by the Solutions Module and its value returned to zero to signify that the next word can be entered. This is the last byte required to send so bit 15 and bit 14 of the full word must be set. The data byte to be sent is the read position command 0x42. The last byte to be sent is the most significant byte of data, so the full word to be placed in Pr **x.42** is below in binary:

Most significant end

1100 0000 : 0000 0000

Transfer command : Data to transfer

0xc0 : 0x00

Gives the decimal number 49152

Once placed into Pr **x.42**, the parameter will be read by the Solutions Module and its value returned to zero to signify that the data has been sent. Next the receive parameter (Pr **x.43**) should be read. If the most significant bit is high (if the value is higher equal of higher than 32,768) new data has been place there by the Solutions Module. This data should be read by the user and then the parameter should be set to zero by the user to alert the Solutions Module that the next word should be placed into this parameter.

In this particular example the position with SinCos interpolation according to Pr **x.04** and Pr **x.05** was turn 1,860 and position 59,887. The position requires dividing by 16 to produce a 13 bit position as will be given from the read position data transfer, this gives a position of 7,485. The returned data from the encoder and read through Pr **x.43** is given below:

Word number	Returned value	Data in decimal	Data in binary
1	32,832	00	0000 0000
2	32,832	00	0000 0000
3	32,832	00	0000 0000
4	32,832	00	0000 0000
5	32,832	00	0000 0000
6	32,927	159	1001 1111
7	32,846	78	0100 1110
8	49,268	116	0111 0100

All the returned values have been offset by 32,768 which is the most significant bit. The last byte has an additional offset of 16,384 to denote that it is the last byte.

Words 5 to 8 are the position with the least significant bit in word 5. Below are the numbers laid out in the correct order:

Word 8	Word 7	Word 6	Word 5
116	78	159	00
0111 0100	0100 1110	1001 1111	0000 0000

Shifted to turns and position (which is 12 bits then 13 bits):

0111 0100 0100 (end of turns and start of the position) 1 1101 0011 1110

1860 7486

So the absolute position is 1860/7486 which should be compared to the displayed interpolated position of 1860/7485.

x.45	**Position feedback initialised**															
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															

At power-up Pr **x.45** is initially zero, but is set to one when the encoder connected to position module has been initialised. 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 initialised. When an encoder is no longer initialised Pr **x.45** is reset to zero and the drive cannot be enabled. The encoder may be re-initialised, provided the drive is not active, by setting Pr **3.47** to one. Pr **3.47** is automatically reset to zero when the initialisation is complete.

x.46	**Line per revolution divider**															
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 1,024							
Default	Open-loop. Closed-loop vector, Servo, Regen								1							
Update rate	Background read															

The equivalent line per revolution (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.

For 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.

x.47	**SSI output turns**															
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 16							
Default	Open-loop, Closed-loop vector, Servo, Regen								16							
Update rate	Background read															

Used by the simulation module.

x.48	**SSI output comms resolution**															
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 32 bits							
Default	Open-loop, Closed-loop vector, Servo, Regen								0							
Update rate	Background read															

Used by the simulation module.

x.49	Lock 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		
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															
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 SLotx.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 descriptions for each category 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	Option 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 fitted that does not contain software both these parameters appear as zero.

5.16.2 SM-Resolver

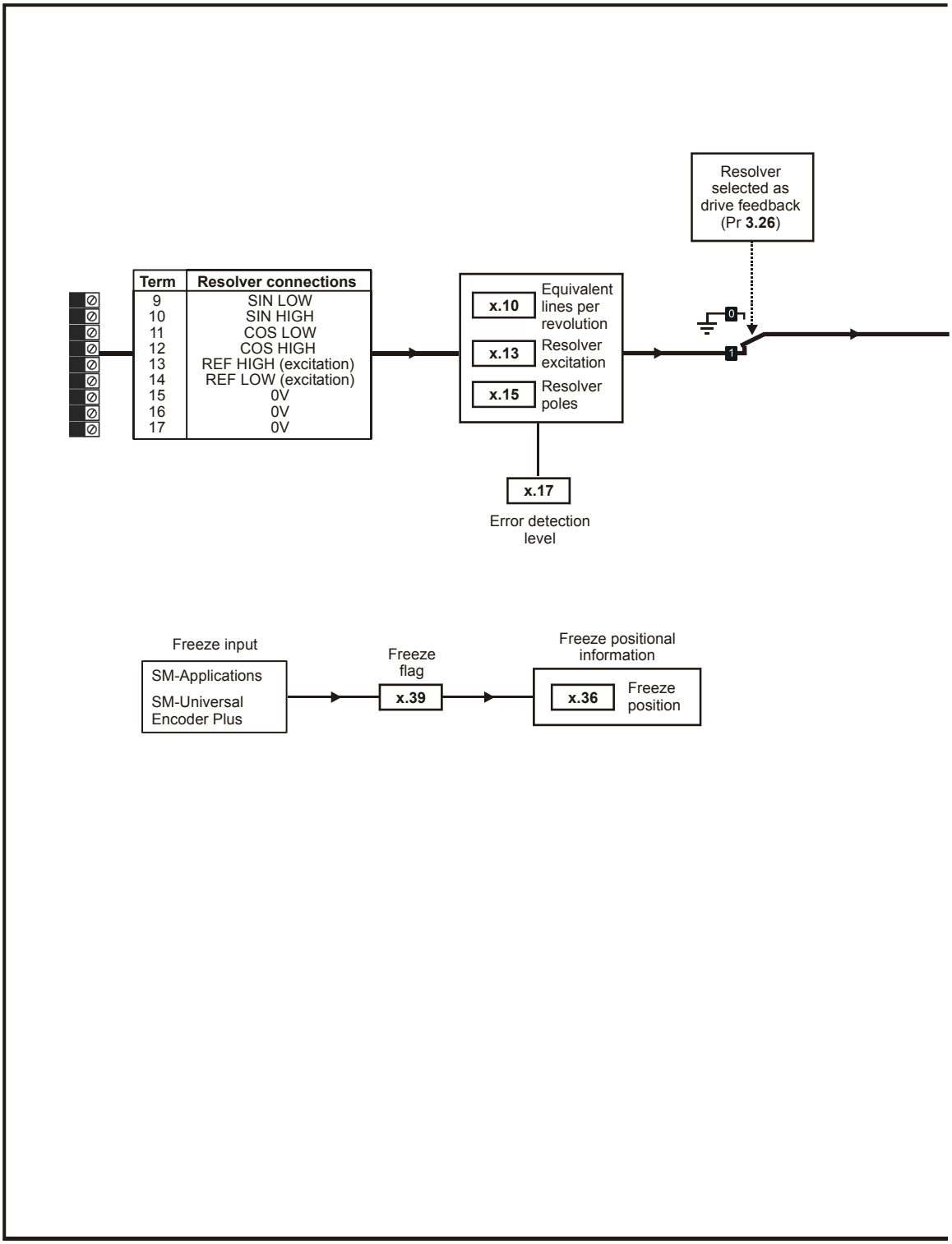
Solutions Module error status values

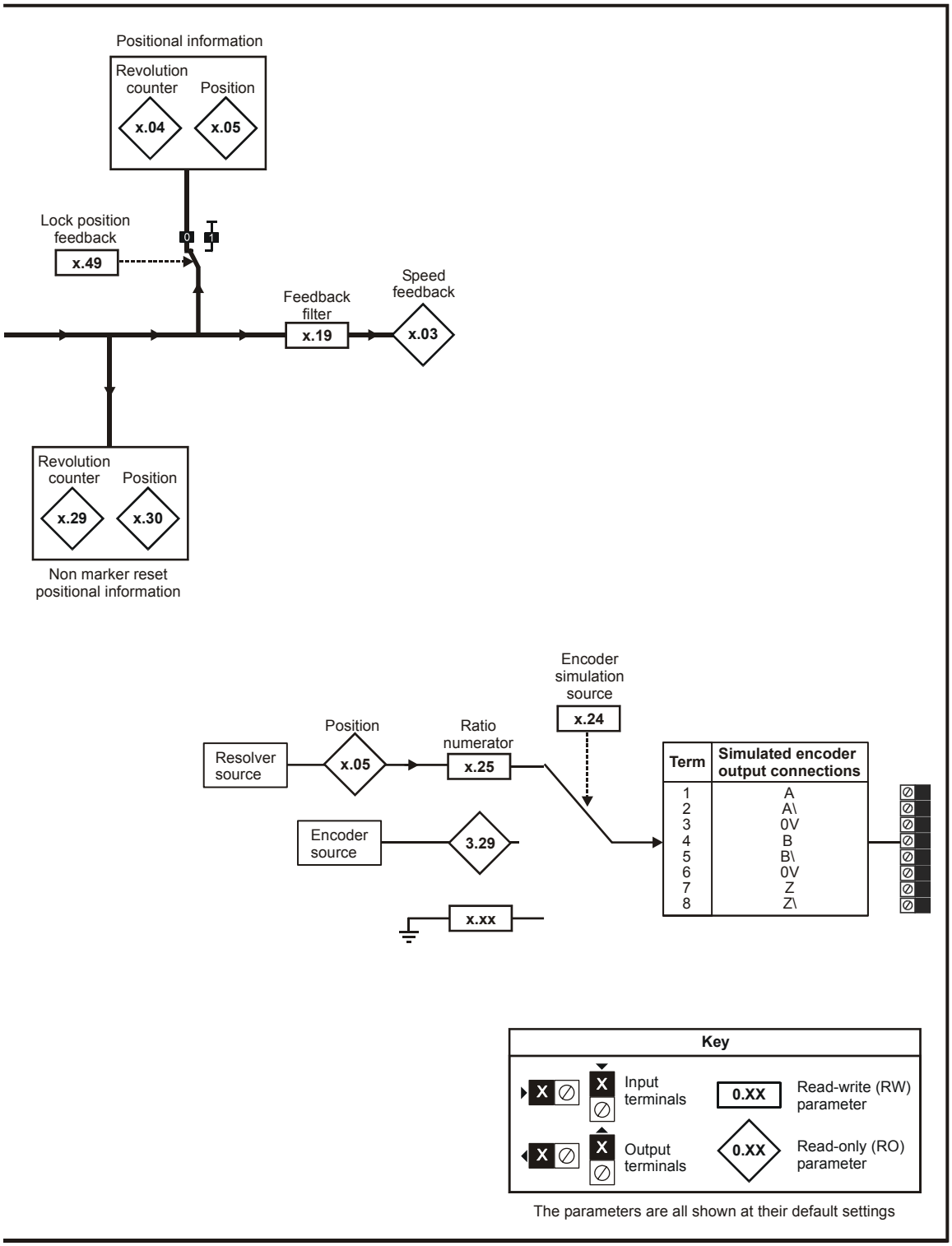
The Solutions Module checks for various errors as shown below.

Error code	Reason for error
0	No fault detected
1	Excitation supply short circuit
2	+Wire-break detect
11	Resolver poles are not compatible with the motor
74	The Solutions Module has overheated.

+ This trip can be enabled/disabled by Pr **x.17**.

Figure 5-27 SM-Resolver logic diagram





The parameters are all shown at their default settings

When an SM-Resolver is fitted 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.

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 option module combined update time so that:

Maximum speed (rpm) < 60 / Combined update time / Resolver poles

Therefore with a combined update time of 4ms and a 2 pole resolver the maximum speed is 7500rpm. If the module is selected for motor control position feedback the speed is limited as described in Pr **x.10**.

The update time for some functions are affected by the number of dumb option modules fitted to the drive. The update time for these functions is the sum of the update times for all dumb option modules fitted 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 fitted to the drive, then the combined update time for the time critical parameters of each module is 12ms.

x.01	Option 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 499								
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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															

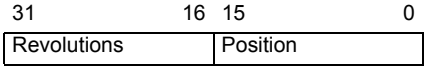
x.03	Speed															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1				1	1		1		1				
Range	Open-loop, Closed-loop vector, Servo, Regen	±40,000.0 rpm														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

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

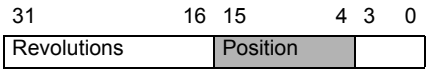
x.04	Revolution counter															
Drive modes	Open-loop, Closed-loop vector, Servo, Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1			1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0 to 65,535 revolutions														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.05	Position															
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 ($1/2^{16}$ths of a revolution)														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

These parameters effectively give the position with a resolution of $1/2^{16}$ths of a revolution as a 32 bit number as shown below.



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.



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.10	Equivalent lines per revolution															
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 50,000														
Default	Open-loop. Closed-loop vector, Servo, Regen	4,096														
Update rate	Background read															

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 **3.23**) then variable maximum SPEED_LIMIT_MAX is defined as shown below.

Resolver poles	Resolution	SPEED_LIMIT_MAX
2	14	3,300.0
2	12	13,200.0
2	10	40,000.0
4	14	1,650.0
4	12	6,600.0
4	10	26,400.0
6	14	1,100.0
6	12	4,400.0
6	10	17,600.0
8	14	825.0
8	12	3,300.0
8	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															
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	0														
Update rate	Background read															

The excitation level can be controlled for use with 3:1 ratio resolvers (Pr **x.12** = 0), or 2:1 ratio resolvers (Pr **x.12** = 1 or 2).

x.15	Resolver poles															
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	Background read															

Resolvers with the following numbers of poles can be used with the Solutions Module.

0: 2POLE
1: 4POLE
2: 6POLE
3-11: 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 with the same number of poles. If the number of resolver poles is set up incorrectly and the resolver is selected as the drive speed feedback for motor control Solutions Module error 11 is produced.

x.17	**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														
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

x.19	**Feedback filter**														
Drive modes	Closed-loop vector, Servo														
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU
													1	1	1
Range	Closed-loop vector, Servo	0 to 5 (0 to 16ms)													
Default	Closed-loop vector, Servo	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 0ms(0) or 1ms(1), but operates over the defined window for parameter values of 2ms(2), 4ms(3), 8ms(4) and 16ms(5).

x.24	**Encoder simulation 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	Background read															

x.25	**Encoder simulation ratio numerator**															
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
							4						1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen	0.0000 to 3.0000														
Default	Open-loop. Closed-loop vector, Servo, Regen	0.2500														
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. Some ratios are not possible when the resolver resolution is reduced below 14 bits as shown in the following table.

Pr x.25	Ratio (14 bit resolver resolution)	Ratio (12 bit resolver resolution)	Ratio (10 bit resolver resolution)
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															
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 revolutions								
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.30	Non-marker reset position															
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 ($1/2^{16}$ths of a revolution)								
Update rate	Combined update time. This module adds 4ms to the combined update time.															

Pr **x.29** and Pr **x.30** are duplicates of Pr **x.04** and Pr **x.05** respectively.

x.36	Freeze position															
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 ($1/2^{16}$ths of a revolution)								
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.39	Freeze flag															
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	Combined update time. This module adds 4ms to the combined update time.															

This Solutions Module does not have its own freeze input, so the freeze input must come from another Solutions Module that is set up to freeze the drive position. The freeze data is processed every 4ms x number of dumb modules fitted. If a freeze event occurs when the freeze flag (Pr **x.39**) is zero, the position (Pr **x.30**) is sampled at the freeze event point and subsequently 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**															
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 **x.45** is initially zero, but is set to one when the resolver module can provide position feedback. Pr **x.45** then remains at one while the drive is powered-up.

x.49	**Lock 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 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**															
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 SLotx.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 descriptions for each category 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	**Option 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 fitted that does not contain software both these parameters appear as zero.

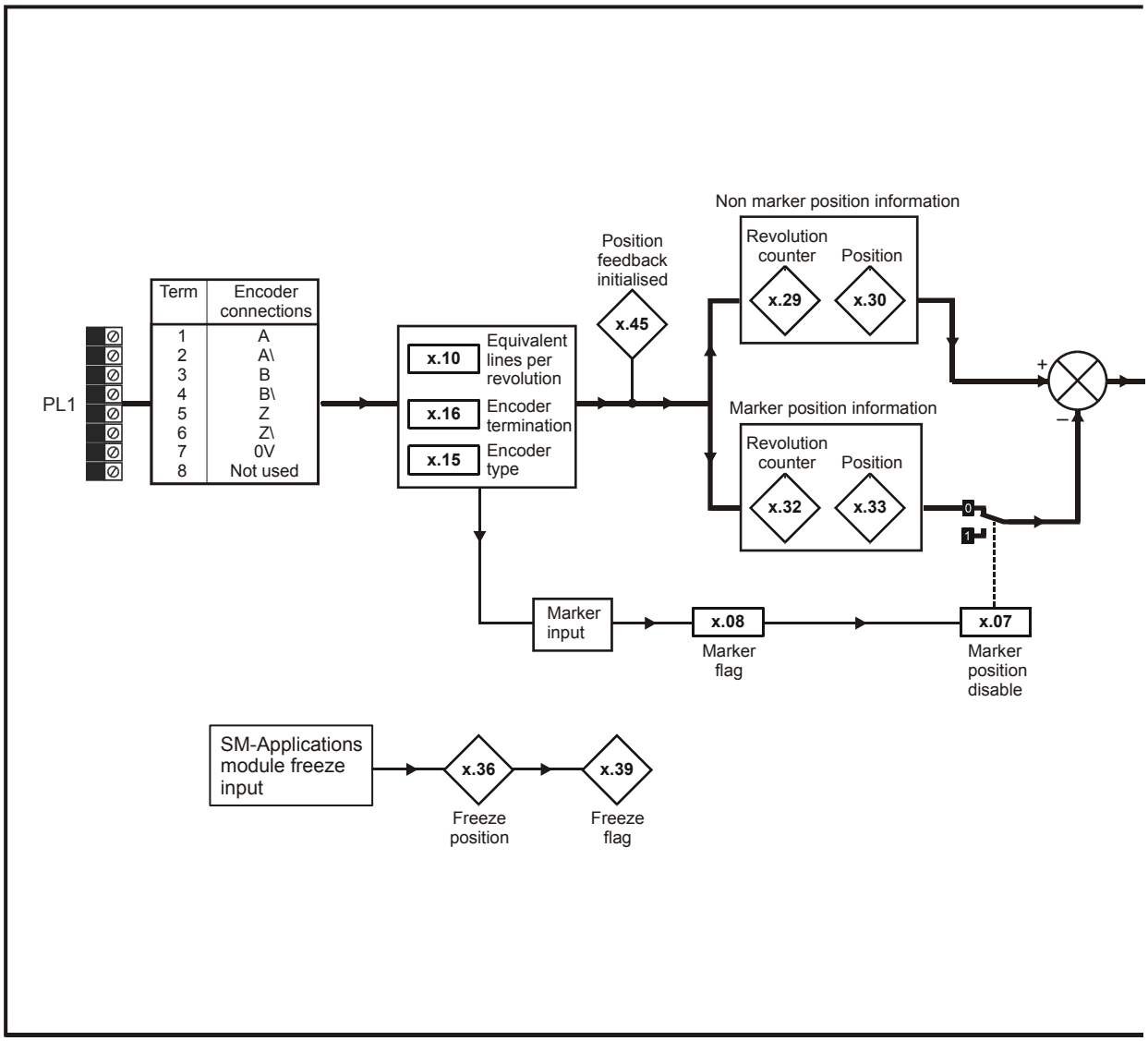
5.16.3 SM-Encoder Plus

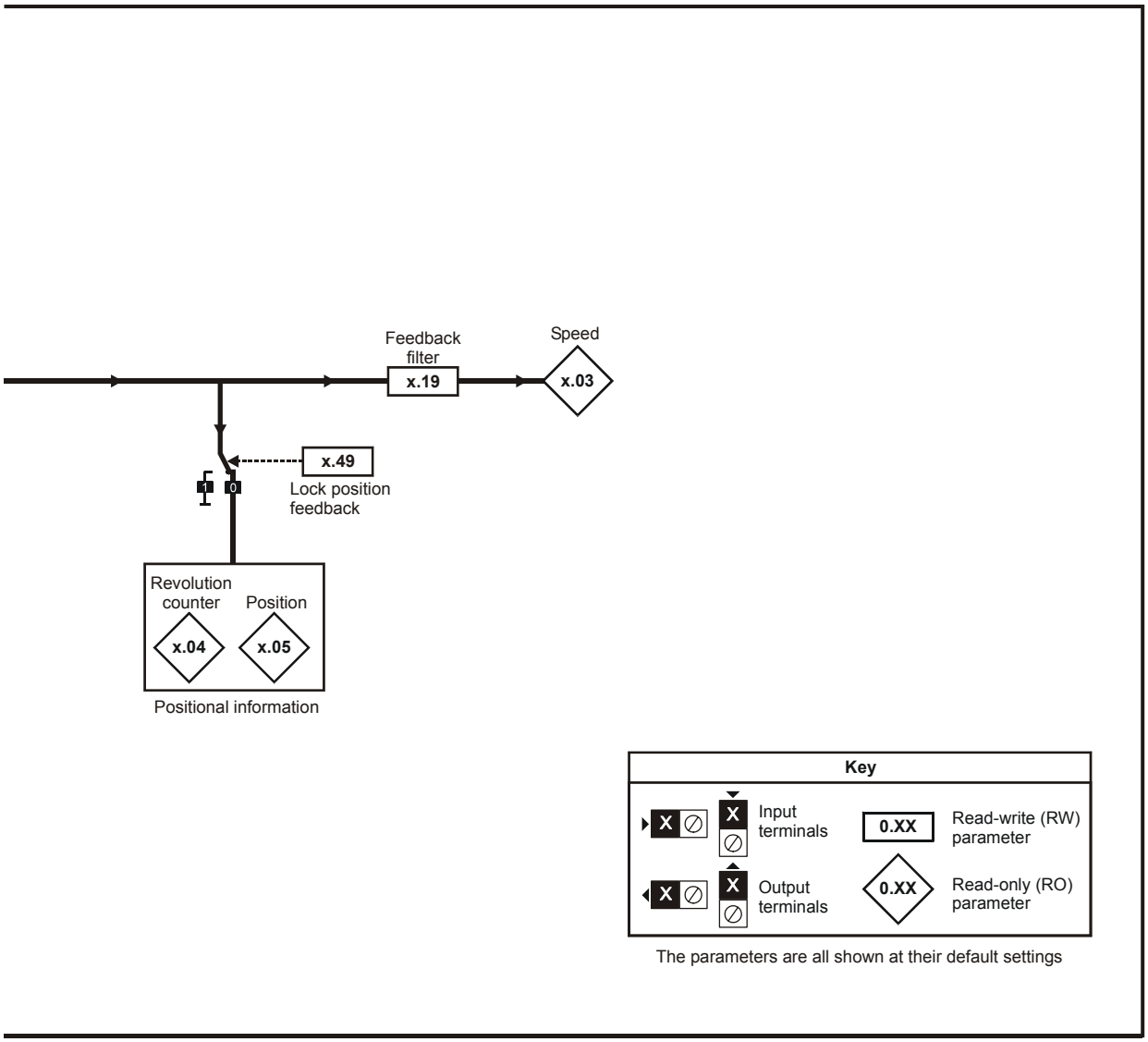
Solutions Module error status values

The Solutions Module checks for various errors as shown below.

Error code	Reason for error
0	No fault detected

Figure 5-28 SM-Encoder Plus logic diagram





When an SM-Encoder Plus is fitted the user parameter menu for the module contains all the parameters for a position feedback category option module. However, not all parameters are used by this Solutions Module, but only those covered in the descriptions below.

The update time for some functions are affected by the number of dumb option modules fitted to the drive. The update time for these functions is the sum of the update times for all dumb option modules fitted 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 fitted 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 do not function correctly if the update time is too long. The maximum encoder speed for various functions is defined below.

Function	Maximum speed (rpm)
Position and speed feedback	40,000
Marker	2 x 60 / combined update time
Freeze	2 x 60 / combined update time

x.01	Option 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 499														
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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.03	Speed															
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	±40,000.0 rpm														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

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

x.04	Revolution counter															
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 revolutions								
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.05	Position															
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 ($1/2^{16}$ths of a revolution)								
Update rate	Combined update time. This module adds 4ms to the combined update time.															

These parameters effectively 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 1,024 line digital encoder produces 4,096 counts per revolution, and so the position is represented by the bits in the shaded area only.

31 16	15 0	4 3
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															
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															

x.08	Marker flag															
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	Combined update time. This module adds 4ms to the combined update time.															

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															
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 50,000														
Default	Open-loop. Closed-loop vector, Servo, Regen	4,096														
Update rate	Background read (Only has effect when the drive is disabled)															

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** rounded down to the nearest value that is a power of 2.

x.15	Encoder type															
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	Background read (Only has effect when the drive is disabled)															

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															
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	1														
Update rate	Background read															

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

x.19	Feedback filter														
Drive modes	Closed-loop vector, Servo														
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU
							1						1	1	1
Range	Closed-loop vector, Servo	0.0 to 5.0 (0 to 16ms)													
Default	Closed-loop vector, Servo	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 0ms(0) or 1ms(1), but operates over the defined window for parameter values of 2ms(2), 4ms(3), 8ms(4) and 16ms(5).

x.29	**Non-marker reset revolution counter**															
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 revolutions														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.30	**Non-marker reset position**															
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 ($1/2^{16}$ths of a revolution)														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

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**															
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 revolutions														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.33	**Marker position**															
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 ($1/2^{16}$ths of a revolution)														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

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**															
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 revolutions														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.36	**Freeze position**															
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 ($1/2^{16}$ths of a revolution)														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.39	**Freeze flag**															
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	Combined update time. This module adds 4ms to the combined update time.															

This Solutions Module does not have its own freeze input, so the freeze input must come from another Solutions Module that is set up to freeze the drive position. The freeze data is processed every 4ms x number of dumb modules fitted. If a freeze event occurs when the freeze flag (Pr **x.39**) is zero, the non-marker reset position values (Pr **x.29** and Pr **x.30**) are sampled at freeze event point and then subsequently 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**															
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 **x.45** is initially zero, but is set to one when the resolver module can provide position feedback. Pr **x.45** then remains at one while the drive is powered-up.

x.49	**Lock 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 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**															
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 SLotx.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 descriptions for each category 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	**Option 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															

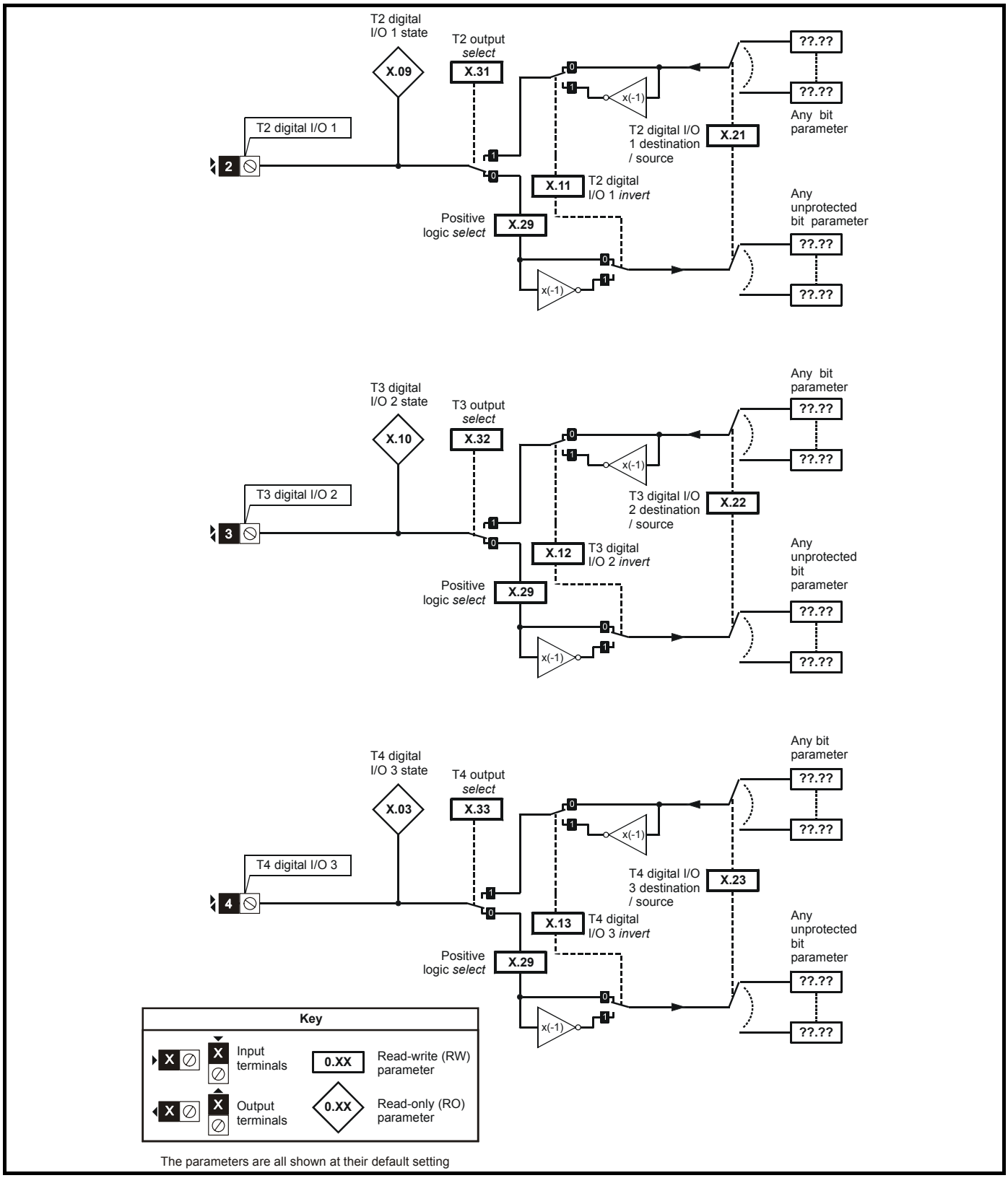
Most Solutions Modules include a processor with software. The software version is displayed in these parameters in the form Pr **x.02** = xx.yy and Pr **x.50** = zz. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation. When a module is fitted that does not contain software both these parameters appear as zero.

5.16.4 SM I/O Plus

Possible Solutions Module error status values

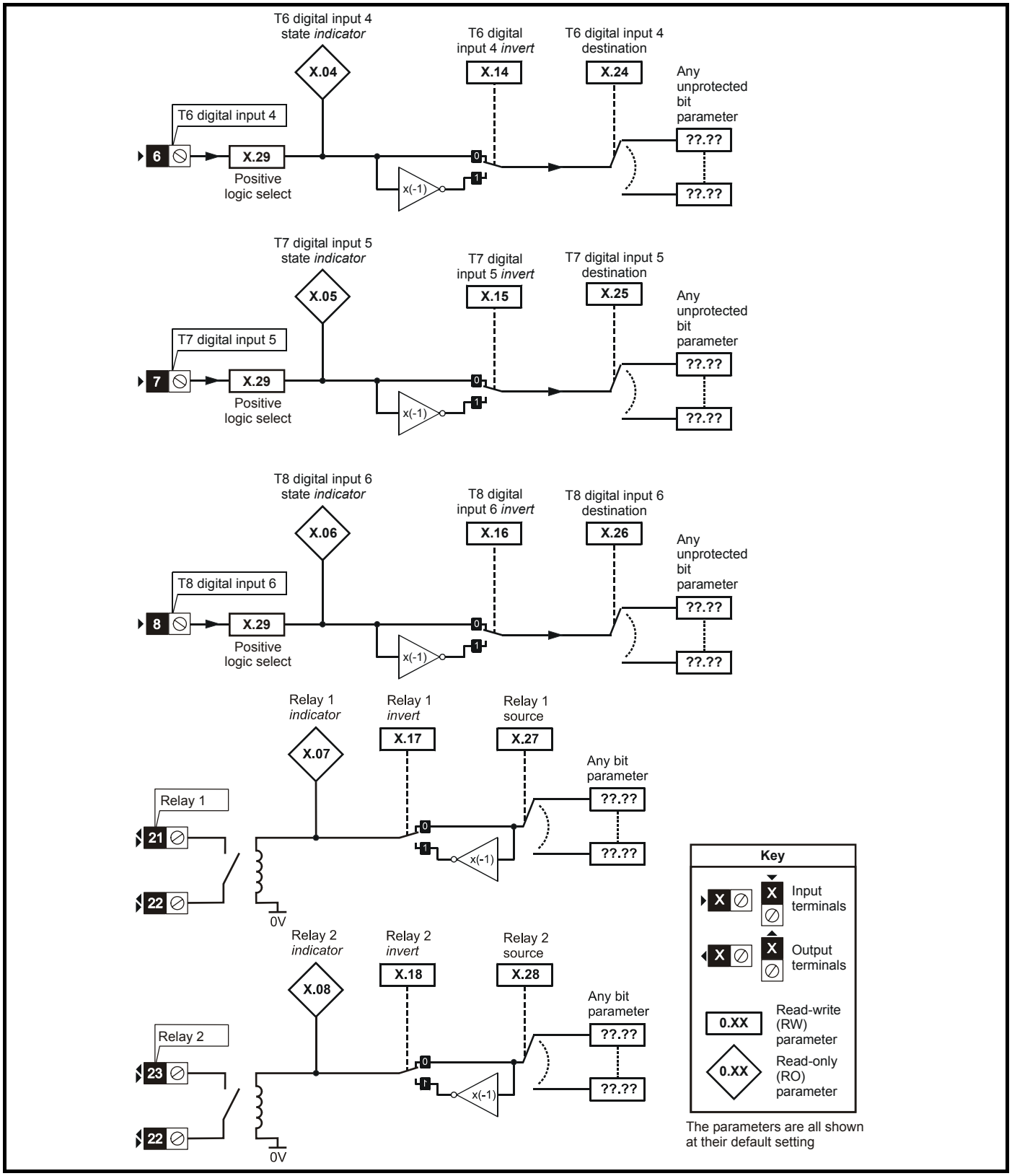
Error code	Reason for fault
0	No errors
1	Digital output short circuit
74	Module over-temperature

Figure 5-29 SM I/O Plus Digital Input/Output logic diagram 1



The parameters are all shown at their default setting

Figure 5-30 SM I/O Plus Digital Input/Output logic diagram 2

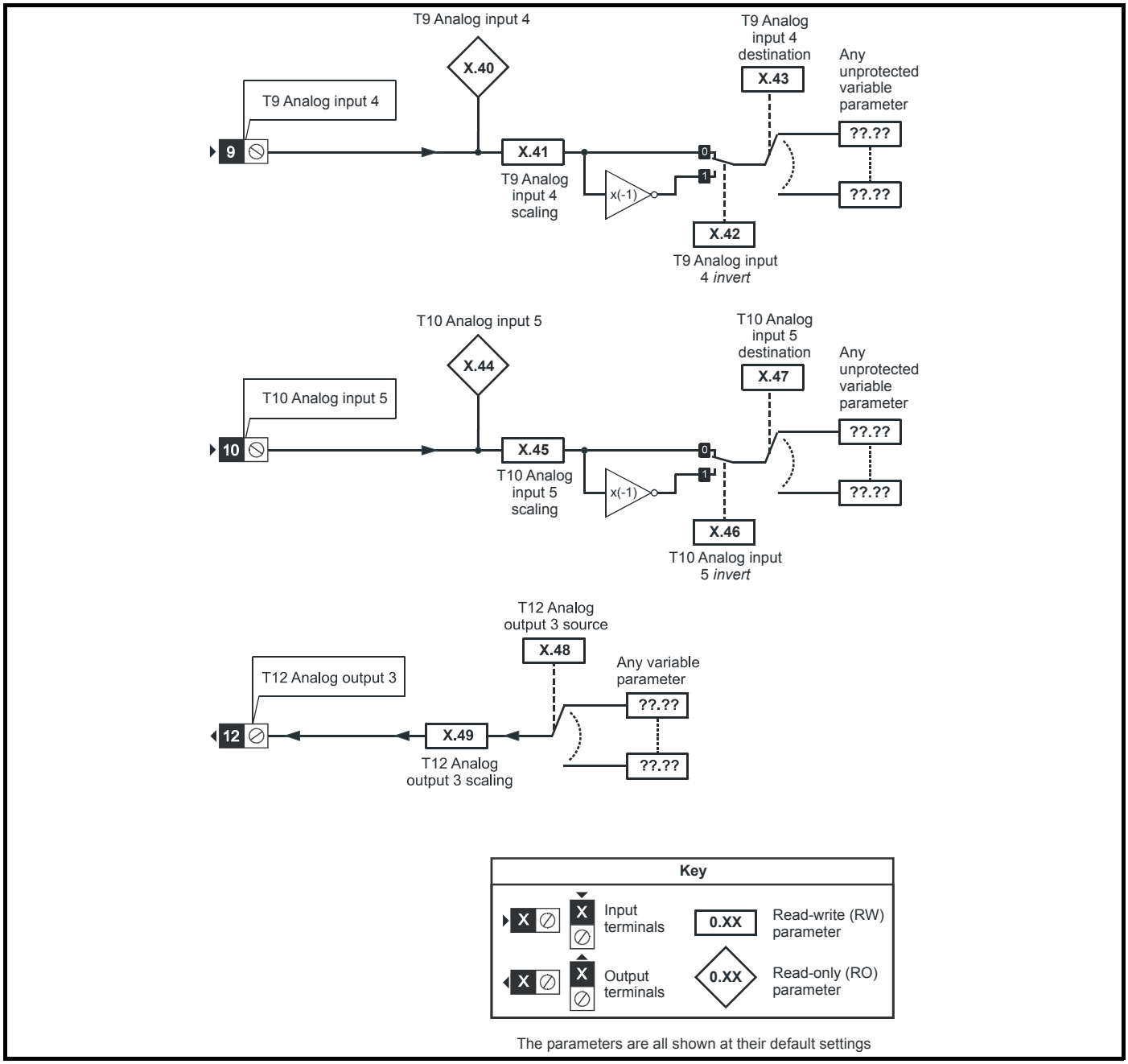


The module has three digital input/outputs (DI/O1 to DI/O3), three digital inputs (DI/O4 to DI/O6) and two relays outputs (DI/07 and DI/O8). The inputs can operate with positive or negative logic, but the outputs operate with positive logic with high side drivers only. All digital outputs are disabled when the drive is in the UU condition.

Table 5-9

Terminal and Type	I/O state	Invert		Source/ destination		Output select	
	Parameter	Parameter	Default	Parameter	Default	Parameter	Default
T2 input / output 1	Pr **x.09**	Pr **x.11**	0	Pr **x.21**	00.00	Pr **x.31**	0
T3 input / output 2	Pr **x.10**	Pr **x.12**	0	Pr **x.22**	00.00	Pr **x.32**	0
T4 input / output 3	Pr **x.03**	Pr **x.13**	0	Pr **x.23**	00.00	Pr **x.33**	0
T6 input 4	Pr **x.04**	Pr **x.14**	0	Pr **x.24**	00.00		
T7 Input 5	Pr **x.05**	Pr **x.15**	0	Pr **x.25**	00.00		
T8 Input 6	Pr **x.06**	Pr **x.16**	0	Pr **x.26**	00.00		
T21 Relay 7	Pr **x.07**	Pr **x.17**	0	Pr **x.27**	00.00		
T23 Relay 8	Pr **x.08**	Pr **x.18**	0	Pr **x.28**	00.00		

Figure 5-31 SM-I/O Plus Analog Input/Output logic diagram



The module has two analog inputs (AI1 and AI2) and one analog output (AO1). The inputs operate in voltage mode only and the nominal full scale level 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. The output operates in voltage mode only.

Terminal	Input	Input modes	Resolution
9	AI1	Voltage only	10 bit plus sign
10	AI2	Voltage only	10 bit plus sign

Terminal	Output	Output modes	Resolution
12	AO1	Voltage only	10 bit plus sign

The update time for some functions are affected by the number of dumb option modules fitted to the drive. The update time for these functions is the sum of the update times for all dumb option modules fitted 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 Solutions Module with 4ms update time and a Solutions Module with 8ms are fitted to the drive, then the combined update time for the time critical parameters of each Solutions Module is 12ms.

x.01	Option 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 499														
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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.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**															
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	Combined update time. This module adds 4ms to the combined update time.															

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**															
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	Combined update time. This module adds 4ms to the combined update time.															

x.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	Combined update time. This module adds 4ms to the combined update time.															

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
0	T2 Input / output 1
1	T3 Input / output 2
2	T4 Input / output 3
3	T6 Input 4
4	T7 Input 5
5	T8 Input 6
6	T21 Relay 7
7	T23 Relay 8

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**

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							Pr **0.00**									
Range	Open-loop, Closed-loop vector, Servo, Regen							Pr **0.00** to Pr **21.51**									
Update rate	Read on drive reset																

x.29	**Input polarity 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			
Default	Open-loop, Closed-loop vector, Servo, Regen							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**

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																

x.40	**Analog input 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		1					
Range	Open-loop, Closed-loop vector, Servo, Regen							±100.0 %									
Update rate	Combined update time. This module adds 4ms to the combined update time.																

x.41	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 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

x.42	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															

x.43	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 **0.00**														
Update rate	Read on reset															

x.44	Analog input 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		1				
Range	Open-loop, Closed-loop vector, Servo, Regen	±100.0 %														
Update rate	Combined update time. This module adds 4ms to the combined update time.															

x.45	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 to 4.000														
Default	Open-loop, Closed-loop vector, Servo, Regen	1.000														
Update rate	Background read															

x.46	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															

x.47	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 **0.00**								
Update rate	Read on reset															

x.48	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 **0.00**								
Update rate	Read on reset															

x.49	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															

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 SLotx.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 descriptions for each category 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	Option 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 fitted that does not contain software both these parameters appear as zero.

5.16.5 SM-EZMotion

Possible Solutions Module error status values

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 Farenheit	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: $-2^{31} \leq SUM \leq 2^{31}-1$
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	Option module selected for Slot 1 in PowerTools Pro file does not match actual module type fitted	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 fitted, and then re-download the configuration.
172	Y	Invalid Slot 2 Selection	Option module selected for Slot 2 in PowerTools Pro file does not match actual module type fitted	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 fitted, and then re-download the configuration.
173	Y	Invalid Slot 3 Selection	Option module selected for Slot 3 in PowerTools Pro file does not match actual module type fitted	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 fitted, and then re-download the configuration.
174	Y	File Corruption Error - Consult Factory		
175	Y	Module Output Overload	SM-EZMotoin 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	Option 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 499														
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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.

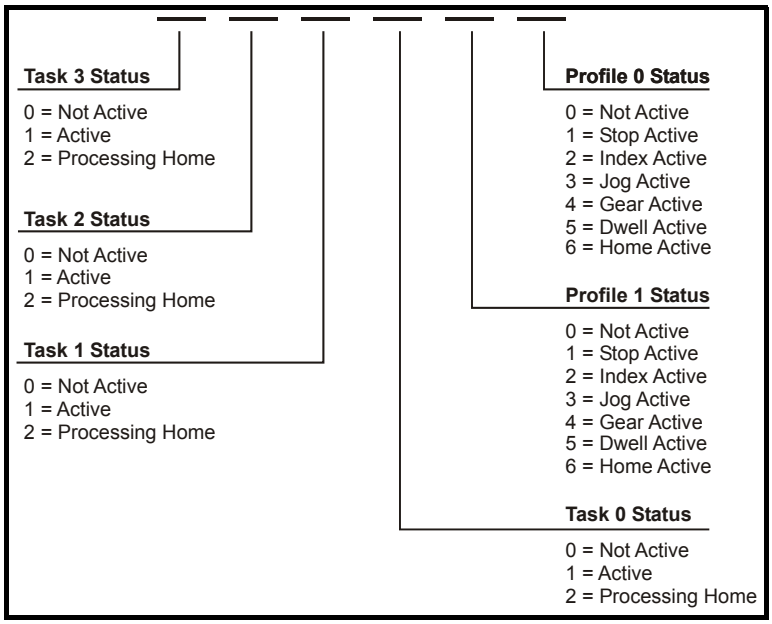
x.20	EZInput.4.Status															
Drive modes	Closed-loop vector, Servo															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Trajectory update rate (user configured)															

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 SLotx.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 descriptions for each category 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	Option 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 fitted that does not contain software both these parameters appear as zero.

5.16.6 Fieldbus module category parameters

Possible Solutions Module error status values

Error code	Fieldbus Solutions Module	Reason for fault
52	All except SM-CAN	Control word user trip
61	All	Invalid configuration parameters.
64	SM-DeviceNet	No Polled data has been received for a length of time defined by the EPR x0 004.
65	All except SM-CAN	Network loss
66	SM-DeviceNet, SM-CANopen, SM-CAN	"Bus-Off" Node sees an excessive number of transmission errors.
67	SM-CANopen	Node has not received a SYNC telegram within a specified time - to be defined.
68	SM-CANopen	Node has not received the guarding telegram within the time period specified.
69	SM-CAN	Node sends a data frame and no other node acknowledges receipt of the frame message.
70	All	No valid Fieldbus Menu data available in the module to download to the drive – The user may not have saved any data, or the data save may not have been completed successfully.
74	All	The Solutions Module has overheated.
75	All	The drive is not responding
80	All	Inter-option communication failure
81	All	Inter-option communication to slot 1 timeout.
82	All	Inter-option communication to slot 2 timeout.
83	All	Inter-option communication to slot 3 timeout.
98	All	The Solutions Module background task has not been completed.
99	All	Software Fault.

x.01	Option 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 499								
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	**Option 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.03	**Fieldbus Node Address**															
Drive types	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	All drives							65,535								
Range	All drives							65,535								

x.04	**Fieldbus Baud Rate**															
Drive types	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		
Default	All drives							127								
Range	All drives							-128 to 127								

x.05	**Mode**															
Drive types	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	All drives							4								
Range	All drives							65,535								

This parameter has different behaviour depending on the fieldbus type:

Fieldbus	Mode function
SM-PROFIBUS-DP	Sets the number of cyclic words and the format of the non-cyclic channel as follows: Value = (X × 100) + Y X = Non-Cyclic Mode (0 = disabled, 1 = CTNC, 2 = Siemens compatible) Y = Number of cyclic words (0 = none, 1-28 words) If Pr **x.05** is zero the input and output data lengths, and PPO types can be selected explicitly – See SM-PROFIBUS-DP documentation for further details.
SM-INTERBUS	Sets the number of cyclic words and the number of words used by PCP Value = (X × 100) + Y X = Non-Cyclic Mode (0 = disabled, 1 = PCP, 2 = CTNC) Y = Number of cyclic words (0 = none, 1-10 words) Note: X+Y must be 10 or less
SM-DeviceNet	Sets the number of cyclic words and the format of the non-cyclic channel as follows:- Value = (X × 100) + Y X = Non-Cyclic Mode (0 = disabled, 1 = CTNC, 2 = Siemens compatible) Y = Number of cyclic words (0 = none, 1-28 words) If Pr **x.05** is zero assembly objects should be explicitly set in Pr **x.39** and Pr **x.40** – See SM-DeviceNet documentation for further details. The maximum amount of polled data that can be transferred is 28 words.
SM-CANopen, SM-CAN	To be defined

If Pr **x.05** = 0 then the input and output cyclic data lengths will be configured independently by Pr **x.38**, Pr **x.39** and Pr **x.40**.

x.06	Fieldbus diagnostic															
Drive types	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	All drives							0								
Range	All drives							±9,999								

< -10	Fieldbus specific state.
-4	Software error
-3	Invalid configuration parameters.
-2	Fieldbus initialisation failure.
-1	Initialisation complete but no network running.
0	Network running but no network cycles per second detected.
X	Network cycles per second detected. See Fieldbus specific documentation for further details.

x.07	Trip Delay Time															
Drive types	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	All drives							200								
Range	All drives							0 to 3,000								

The trip is primed when cyclic data transfer begins. If there are no cyclic data transfers for a time that is greater than or equal to Pr **x.07** a "network loss" trip will occur. The trip delay time can be entered into Pr **x.07** in ms (zero is disabled). A network loss trip will not effect the internal state of the module, it is only a user indication. The fieldbus specific network management schemes are used to influence the master, and control the state of the module.

x.08	Endianism															
Drive types	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	All drive types							0								

Selects the order of 16 and 32bit data (transferred in the cyclic channels (and non-cyclic channels if fieldbus permits).

NOTE

Not all fieldbuses support both endian types – See the fieldbus specific documentation for further details.

OFF	Big Endianism - MSByte first.
ON	Little Endianism - LSByte first.

Pr **x.09** through Pr **x.29** control how network data is handled depending on the fieldbus type.

x.09	Register control															
Drive types	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	All drive types							0								

Defines how the 'I' and 'O' data registers are handled. If Pr **x.05** > 0 then Pr **x.09** being set to 1 will result in Pr **x.06** showing -3 (Invalid configuration parameters) and detailed mapping status information will be shown in Pr **x.49**.

Fieldbus	Pr x.09 set to zero	Pr x.09 set to 1
SM-INTERBUS SM-PROFIBUS-DP SM-DeviceNet SM-CANopen	I registers (Pr **x.10** to Pr **x.19**) map drive parameters to PLC IN data registers. O registers (Pr **x.20** to Pr **x.29**) map PLC OUT data registers to drive parameters	The values in the I registers (Pr **x.10** to Pr **x.19**) will be sent to the PLC IN data registers. Values received from the PLC OUT registers will be placed directly into the O registers (Pr **x.20** to Pr **x.29**).
SM-CAN	I and O registers are reserved and must not be used	I and O registers are reserved and must not be used

If Pr **x.09** is changed form 0 to 1, prior to the drive being re-initialised then the re-initialisation will cause all I and O registers (Pr **x.10** to Pr **x.29**) to be cleared, assuming that all configuration parameters are valid. Any other drive re-initialisation or cycling of the drive's power will leave the registers unaffected.

x.10	**'I' data register 0**															
x.11	**'I' data register 1**															
x.12	**'I' data register 2**															
x.13	**'I' data register 3**															
x.14	**'I' data register 4**															
x.15	**'I' data register 5**															
x.16	**'I' data register 6**															
x.17	**'I' data register 7**															
x.18	**'I' data registers 8**															
x.19	**'I' data registers 9**															
Drive types	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	
Default	All drive types							Fieldbus specific								
Range	All drives							-32,768 to 32,767								

Defines parameters that are input to the PLC.

If Pr **x.09** = 0 then Pr **x.10** to Pr **x.19** will be used for configuring the input cyclic data mappings.

Pr **x.10** to Pr **x.19** will only be read following a reset. Any invalid entry will result in a trip 61 (Invalid configuration parameter(s)). Cyclic communication will not commence unless all configuration parameter(s) are found to be correct, following a reset. Pr **x.06** will remain at -2 therefore indicating an unsuccessful initialisation.

x.20	**'O' data register 0**															
x.21	**'O' data register 1**															
x.22	**'O' data register 2**															
x.23	**'O' data register 3**															
x.24	**'O' data register 4**															
x.25	**'O' data register 5**															
x.26	**'O' data register 6**															
x.27	**'O' data register 7**															
x.28	**'O' data register 8**															
x.29	**'O' data register 9**															
Drive types	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	
Default	All drive types							Fieldbus specific								
Range	All drives							-32,768 to 32,767								

Defines parameters that are output from the PLC.

If Pr **x.09** = 0 then Pr **x.20** to Pr **x.29** will be used for configuring the output cyclic data mappings.

Pr **x.20** to Pr **x.29** will only be read following a reset. Any invalid entry will result in the status being set to -3 and mapping error information being placed in Pr **x.49**. Cyclic communication will not commence unless all configuration parameter(s) are found to be correct, following a reset. Pr **x.06** will remain at -3 therefore indicating an unsuccessful initialisation.

If after a drive mode change the mappings parameters become invalid, the drive will trip 'invalid configuration parameters'.

Effect of register control on mapping parameters

If Pr **x.09** = 1 then the input cyclic data will be mapped directly from Pr **x.10** to Pr **x.19** and the output cyclic data will be mapped directly into Pr **x.20** to Pr **x.29**. For this reason if a length of more than 10 is selected for either the input or output cyclic data only the first 10 words can be used. A cyclic data mode of greater length than 10 will result in an over-length error.

Effects of non-cyclic data modes on mapping parameters

If Pr **x.05** has been set to enable a non-cyclic data type then during the module's initialisation the first 'I' and 'O' parameters will be checked. If either of these parameters is already mapped to non-cyclic virtual parameter then it will be over written to make sure that it is of the correct format (1 word CTNC or 4 word PPONC). If either of the parameters are found not to be non-cyclic virtual parameters then the first 9 parameters in the relevant group will be shuffled up a place and the first parameter will be set for the non-cyclic channel. This means that if Pr **x.19** or Pr **x.29** has been set and a non-cyclic data type has been selected this mapping could be lost.

If Pr **x.05** has been set to not enable any form of non-cyclic data the first 'I' and 'O' parameters are checked. If either is set to a non-cyclic virtual parameter then the last 9 parameters in the relevant group will be shuffled down to remove the non-cyclic channel and the last mapping parameter will be set to 0. Non-cyclic virtual parameters placed anywhere else in the mappings won't be removed.

If Pr **x.05** = 0 and Pr **x.09** = 0 any non-cyclic virtual parameters in the first 'I' or 'O' parameter will be left.

A maximum of 1 non-cyclic channel can be placed in both the 'I' and 'O' parameters for each non-cyclic type. If multiple non-cyclic channels of the same type are defined then a mapping error will be produced.

Fieldbus setup menu access

Setting an 'I' or 'O' parameter to a UT7x fieldbus setup menu must specify the slot in which the fieldbus Solutions Module is placed by using menus 15 -> 17 for slots 1 -> 3 respectively. Mapping into another fieldbus modules setup menu parameters Pr **x.10** to Pr **x.29** will only be allowed if that module is in register control (Pr **x.09** = 1) to prevent corruption of mapping configurations. Mapping into a Solutions Modules own setup menu by either direct mapping or by use of the virtual fieldbus setup menu (menu 60) is not allowed. Any invalid mapping into a fieldbus setup menu will show as a read-write mismatch error.

SM-Applications parameter access

Setting an 'I' or 'O' parameter to a SM-Applications database parameter without a slot specified will cause the fieldbus module to select the SM-Applications fitted in the lowest numbered slot. If access to two SM-Applications is required, then the slots must be addressed specifically by using menus 100 -> 181 (See Table 5-10). These values have been chosen to allow complete access to the SM-Applications menus and yet still keep an 8 bit menu identifier, which is needed for CT non-cyclic compatibility.

Table 5-10 Solutions Module slot equivalent menus

Menu	Slot 1	Slot 2	Slot 3
70 -> 91 – SM-Applications PLC Menus	100 -> 127	130 -> 157	160 -> 187

Advanced SM-Applications parameter mapping

Should adjacent parameters within Pr **x.10** to Pr **x.19** and/or Pr **x.20** to Pr **x.29** represent mappings to different parameters within the same SM-Applications PLC menu (70 -> 75), or the drives application menus (18 -> 20), then the mappings will be interpreted to indicate a range.

Ranges will only be generated if the first parameter value of the adjacent pair is lower than the second parameter value.

Table 5-11 illustrates a possible (although not expected) mapping configuration for a drive with a SM-PROFIBUS-DP in slot 1 and SM-Applications in slots 2 and 3 respectively.

Table 5-11 Example 'I' and 'O' Mappings

Mapping parameter	Mapping parameter setting	Data Width	Total Data Width (Running Total in Bytes)	Comment
Pr **15.10**	Pr **10.40**	1*16 bit	2	Default - Status (not fixed)
Pr **15.11**	Pr **2.01**	1*32 bit	6	Default - Post ramp speed reference (not fixed)
Pr **15.12**	Pr **4.20**	1*16 bit	8	Default - % of rated load (not fixed)
Pr **15.13**	Pr **130.11**	5*32 bit	28	A range of 5, slot 2, SM-Applications PLC registers will be the source of cyclic data
Pr **15.14**	Pr **130.15**			
Pr **15.15**	Pr **71.03**	1*32 bit	32	A slot 2 SM-Applications parameter will source cyclic data
Pr **15.16**	Pr **160.11**	5*32 bit	52	A range of 5, slot 3, SM-Applications PLC registers will be the source of cyclic data
Pr **15.17**	Pr **160.15**			
Pr **15.18**	0	0	52	Channel disabled
Pr **15.19**	0	0	52	Channel disabled
Pr **15.20**	Pr **6.42**	1*16 bit	2	Default – Control word (not fixed)
Pr **15.21**	Pr **1.21**	1*32 bit	6	Default – Pre-set speed reference (not fixed)
Pr **15.22**	Pr **4.08**	1*32 bit	10	Default – Torque reference (not fixed)
Pr **15.23**	Pr **130.01**	5*32 bit	30	A range of 5, slot 2, SM-Applications PLC registers will receive cyclic data
Pr **15.24**	Pr **130.05**			
Pr **15.25**	Pr **131.03**	1*32 bit	34	A slot 2 SM-Applications parameter will receive cyclic data
Pr **15.26**	Pr **160.01**	5*32 bit	54	A range of 5, slot 3, SM-Applications PLC registers will receive cyclic data
Pr **15.27**	Pr **160.05**			
Pr **15.28**	0	0	54	Channel disabled
Pr **15.29**	0	0	54	Channel disabled

Table 5-12 illustrates what the resulting message would look like.

Table 5-12 Resulting Data Structure

In Data	
Word 0	Pr **10.40**
Word 1	Pr **2.01**
Word 2	Pr **2.01**
Word 3	Pr **4.20**
Word 4	Pr **130.11**
Word 5	Pr **130.11**
Word 6	Pr **130.12**
Word 7	Pr **130.12**
Word 8	Pr **130.13**
Word 9	Pr **130.13**
Word 10	Pr **130.14**
Word 11	Pr **130.14**
Word 12	Pr **130.15**
Word 13	Pr **130.15**
Word 14	Pr **71.03**
Word 15	Pr **71.03**
Word 16	Pr **160.11**
Word 17	Pr **160.11**
Word 18	Pr **160.12**
Word 19	Pr **160.12**
Word 20	Pr **160.13**
Word 21	Pr **160.13**
Word 22	Pr **160.14**
Word 23	Pr **160.14**
Word 24	Pr **160.15**
Word 25	Pr **160.15**
Word 26	-
Word 27	-

Out Data	
Word 0	Pr **6.42**
Word 1	Pr **1.21**
Word 2	Pr **1.21**
Word 3	Pr **4.08**
Word 4	Pr **4.08**
Word 5	Pr **130.01**
Word 6	Pr **130.01**
Word 7	Pr **130.02**
Word 8	Pr **130.02**
Word 9	Pr **130.03**
Word 10	Pr **130.03**
Word 11	Pr **130.04**
Word 12	Pr **130.04**
Word 13	Pr **130.05**
Word 14	Pr **130.05**
Word 15	Pr **131.03**
Word 16	Pr **131.03**
Word 17	Pr **160.01**
Word 18	Pr **160.01**
Word 19	Pr **160.02**
Word 20	Pr **160.02**
Word 21	Pr **160.03**
Word 22	Pr **160.03**
Word 23	Pr **160.04**
Word 24	Pr **160.04**
Word 25	Pr **160.05**
Word 26	Pr **160.05**
Word 27	-

Inter-option communication handling

When SM-Applications parameters are mapped (except direct access to set-up menu 15,16 or 17) the data transfer takes place through the inter-option communications channel. This channel gives complete access to all SM-Applications parameters but due to the nature of the transfer method transferring multiple parameters this way can be slow. The server (SM-Applications) polls the client (fieldbus module) every 1ms looking for a new request. Only one request can be carried out on each poll, therefore to transfer 10 parameters individually will take approximately 10ms.

To reduce the speed problem data can be transferred in blocks. A block consists of up 10 words of data from consecutive parameters from in a single SM-Applications PLC menu (all PLC menus parameters are treated as 32bit, so up to 5 parameters per block). To reduce overhead in block transfers mapping information for a block is sent to the SM-Applications during initialisation, once cyclic data transfer starts block data is sent or received without the need for mapping information. There are 8 input, and 8 output, blocks available to provide up to 80 words in each direction (more than is currently required).

Blocks are only set up for ranges of 2 or more SM-Applications PLC mappings. A single parameter is always transferred using the standard transfer method, as there is no speed advantage in using up a block. Large ranges will span across multiple blocks, however if after creating a block only a single parameter remains it will be mapped using the single transfer method. For example a range of 7 PLC parameters will use a full block of 5 and a block containing 2 parameters whereas a range of 11 PLC parameters will use up 2 full blocks and a single transfer. Fewer but larger ranges are therefore more efficient that multiple smaller ranges.

With only 10 mapping parameters (once expanded up to 32 words can be mapped) available to the user it is only possible to create up to 5 ranges. For this reason the maximum number of blocks that can currently be used is 6 (4 ranges of 2 parameters and 1 range of 8), although 8 blocks are available.

Timeout Trips:

If inter-option communication is in use and the server (e.g. SM-Applications) is reset but no reset request has been made to the client then a client timeout trip will occur.

If both the client and server are reset (e.g. by 1070 being set in Pr **x.00**) no trip will occur, both will reset and communication will restart.

If the client is reset (e.g. by Pr **x.31** in a fieldbus setup menu being set to 1) the client will restart, no trip will occur and the server will continue normal operation.

x.30	**Load option defaults**															
Drive types	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	All drive types							0								

The value set in Pr **x.30** will affect the drive 'parameter default' sequence and will be cleared once defaults are loaded.

If Pr **x.30** = 0 and a Unidrive SP default is requested then step 4 will be bypassed.
If Pr **x.30** = 1 and a Unidrive SP default is requested then step 4 will be included.

1. Fieldbus communication will be stopped.
2. The drive will load its default parameter values and automatically save them to its EEPROM.
3. Solutions Module will over-write any general drive default values with fieldbus specific ones. e.g. if a SM-DeviceNet is fitted and it sees that 65535 (general drive default) is present in the node address parameter the module will over-write this with 63.

NOTE

The module also monitors for "general drive default" values in the background task and over-writes as necessary.

4. **Default Solutions Module parameter settings will be saved within the Solutions Modules Flash memory**.
5. The module will reset itself.
6. The Solutions Module will perform its standard start-up procedure using the default values.

x.31	**Save option parameters**															
Drive types	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	All drive types							0								

The value set in Pr **x.31** will affect the drive 'parameter save' sequence and will be cleared once parameters are saved as follows:

If Pr **x.31** = 0 and a Unidrive SP save is requested:

1. The Unidrive SP will save its parameters.

If Pr **x.31** = 1 and a Unidrive SP save is requested:

1. The Unidrive SP will save its parameters.
2. Fieldbus communication will be halted immediately.
3. Fieldbus menu parameters will be saved within the Solutions Module Flash.
4. The module will reset itself.
5. The Solutions Module will perform its standard start-up procedure using the saved values.

The ability to save the Fieldbus specific parameters within the Solutions Module enables the user to place a pre-programmed module into a replacement drive and retain its settings, see Pr **x.33**.

NOTE

In most cases the user can simply perform a Unidrive SP parameter save - this is enough to ensure that the system will recover from a power supply cycle and does not result in an interruption to Fieldbus communication.

x.32	**Request to reinitialise**															
Drive types	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		
Default	All drive types							0								

The parameter will be continuously polled and cleared once 'Request to reinitialise' is performed. When set, the following will occur:

1. Fieldbus communication will be stopped.
2. Pr **x.32** will be cleared.
3. Standard start-up procedure will be performed using current fieldbus configuration values

Setting the value 1,070 in any parameter 0 and pressing the drive reset button will cause any modules fitted in the drive to be reset.

x.33	Download from Fieldbus Solutions Module															
Drive types	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		
Default	All drive types							0								

Pr **x.33** is used to configure the Solutions Module set-up menu with values stored within the Fieldbus Solutions Modules flash memory and is cleared once 'download' performed.

The parameter will be continuously polled. When set, the following will occur:

1. Fieldbus communication will be stopped.
2. Fieldbus menu parameter values will be downloaded to the Unidrive SP from the Solutions Modules flash memory - if a valid parameter set has not been saved then a trip 70 will occur.
3. Pr **x.33** will be cleared.
4. The module will reset itself.
5. The Solutions Module will perform its standard start-up procedure using the downloaded values.

x.34	Compression															
Drive types	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	All drive types							0								
Range	All drives							0 to 1								

If this parameter is set to 'OFF' then all mapped parameters (except PPONC which is 64 bit) will be treated as 32 bit. This provides the user with a simpler method of configuring the cyclic data. The negative aspect is that network bandwidth can be wasted. If the parameter is set to 'ON' then all mapped parameters that are 16 bits or less, will only require 16bits of data to be transmitted.

x.35	Serial Number															
Drive types	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	All drives							0								
Range	All drives							-2,147,483,648 to 2,147,483,647								

The serial number is programmed into the product during manufacture. This enables the hardware and software compatibility to be checked, and provide each module with a unique identifier that is accessible via software.

x.36	Fieldbus specific															
x.37	Fieldbus specific															
Drive types	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	All drive types							0								

x.38	Fieldbus specific defined mode															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

Used to enable cyclic data configurations that have been pre-defined in the fieldbus specifications. See fieldbus specific documentation for more details.

x.39	Cyclic input configuration															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

x.40	Cyclic output configuration															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

Used to configure or display the input cyclic data length or object type, actual implementation is fieldbus dependent.

Fieldbus	Configuration details shown in Pr x.39 / Pr x.40
SM-PROFIBUS-DP, SM-CANopen, SM-INTERBUS	Length of Input/Output cyclic data in words
SM-DeviceNet	Input/Output assembly object selected
SM-CAN	To be defined

x.41	Fieldbus specific															
x.42	Fieldbus specific															
x.43	Fieldbus specific															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

x.44	Fieldbus specific															
x.45	Fieldbus specific															
x.46	Fieldbus specific															
x.47	Fieldbus specific															
x.48	Fieldbus specific															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

x.49	Mapping error status															
Drive types	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	All drives							0								
Range	All drives							0 to 255								

The mapping error status indicates more detailed information regarding any problems with the current mapping parameters (See Table 5-13). If there are multiple errors in the mapping information only the first error that is found will be shown. Once this error has been rectified the module will have to

be re-initialised in order to show any other errors.

Table 5-13 Mapping error status meanings

	General	In	Out	Cause of error
Mappings OK	0			
Fieldbus specific	1	101	201	Fieldbus specific error has occurred.
Register + Non-cyclic	2			Register mode Pr **x.09** and Non-cyclic data mode Pr **x.05** have been selected together.
Unsupported non-cyclic	3			A non-cyclic mode has been selected that is not supported.
Multiple non-cyclic		104	204	The same non-cyclic type has been mapped multiple times in either the 'In' or 'Out' mappings.
Unsupported mode	5			The value in Pr **x.05** is not valid.
Error reading mappings		110	210	An error has occurred reading the mapping parameters from the drive.
Parameter not possible		111	211	Mapping value represents a parameter that is outside the drives range. Either parameter is less than Pr **0.00** or greater than Pr **199.99**.
Read/write mismatch.		112	212	A read-only parameter has been mapped to an 'Out' mapping or a parameter that cannot be read has been mapped to an 'In' mapping (parameter might not exist). Mapping an 'Out' parameter to a fieldbus set-up menu that is not in register mode also produces this error.
Hole in mapping		113	213	Mapping parameters are not contiguous.
Duplicate mapping			214	2 'Out' mappings are identical. In mappings can be duplicated.
Inter-option communications error (*)		115	215	A request to set up an inter-option communications block failed. Either the server does not support block transfer or parameters were not legal.
Too many mapped objects		120	220	After expanding ranges more than 32 'In' or 'Out' mappings exist.
Mapping over length		121	221	Total size of complete 'In' or 'Out' mappings exceed the length of the cyclic data channel.
Too many for register mode		122	222	A cyclic data size of greater than 10 has been selected for register mode.

(*) Currently this error should not occur as all parameters are verified before an attempt is made to set up a block.

Other error codes can occur but are fieldbus specific errors and defined in the fieldbus specific documentation.

These fieldbus errors will be in the range 30 to 39 for general errors and 130 to 139 / 230 to 239 for 'I' and 'O' specific errors.

The mappings are checked during initialisation and due to the order that the checks take place error codes will be effectively prioritised. The order in which checks are carried out is as follows.

1. **Generate initial mappings** (Error codes: 2, 3, 5, 22, 110, 111, 210, 211, Fieldbus specific)
   Mapping configuration parameters from drive and checks that the requested mode and Solutions Modules are valid.
2. **Convert IN mappings** (Error codes - None)
   Converts all menu short-cut values for IN mappings.
   e.g. Menu 60 will be converted to Menu 15, 16 or 17.
3. **Convert OUT mappings** (Error codes - None)
   Converts all menu short-cut values for OUT mappings.
   e.g. Menu 60 will be converted to Menu 15, 16 or 17.
4. **Expand IN mappings** (Error codes – 113, 120)
   Expand all ranges declared in IN mappings. Check that the resulting mappings don't consist of more than the maximum allowed objects.
5. **Expand OUT mappings** (Error codes – 213, 220)
   Expand all ranges declared in OUT mappings. Check that the resulting mappings don't consist of more than the maximum allowed objects.
6. **Check read mismatch** (Error codes – 104, 112)
   Check that all IN parameters can be successfully read.
7. **Check write mismatch** (Error codes – 204, 212, 214)
   Check that all OUT parameters have write permissions. Also check that 2 mappings are not attempting to write to the same place.
8. **Check IN data size** (Error codes - 121)
   Check that the total size of all IN mapped data is ok for the set mode.
9. **Check OUT data size** (Error codes - 221)
   Check that the total size of all OUT mapped data is ok for the set mode.
10. **Update IN inter-option comms blocks** (Error codes - 115)
    Set up cyclic blocks for IN mappings in inter-option comms channel.
11. **Update OUT inter-option comms blocks** (Error codes - 215)
    Set up cyclic blocks for OUT mappings in inter-option comms channel.

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 SLotx.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 descriptions for each category 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	Option 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 fitted that does not contain software both these parameters appear as zero.

5.16.7 SM-Applications

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.

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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.

Throughout this document the ♣ symbol is used to denote that a feature is not available or not supported on SM-Applications Lite.

If a parameter is unsupported it will contain a value of zero during execution.

Possible Solutions Module error status value.

Error code	Reason for fault	
39	User stack overflow	
40	Unknown error	
41	Parameter does not exist	
42	Parameter read only	
43	Parameter write only	
44	Parameter value over range	
45	Invalid synchronisation modes	♣
46	Not Used	
47	Sync lost with Virtual Master	♣
48	RS485 not in user mode	♣
49	Invalid RS485 configuration	♣
50	Math fault	
51	Array index out of range	
52	Control word user trip	
53	DPL program not compatible with this target	
54	Processor overload/ Task Overrun	
55	Invalid encoder configuration	
56	Invalid timer unit configuration	
57	Function block not supported by system	
58	Corrupted Nonvolatile flash	
59	Drive rejected application module as Sync master	♣
60	CTNet hardware error	♣
61	Invalid CTNet configuration	♣
62	CTNet baud rate does not match network	♣
63	CTNet node ID already in use	♣
64	Digital Output Overload	♣
65	Invalid Function Block Parameters	
66	User Heap Requirement too large	
67	File Does Not Exist	
68	File Not Associated	
69	Flash Access Failed during DB up-load from drive	
70	User Program download while drive enabled	
71	Failed to change drive mode	
72	Invalid CTNet Buffer Operation	♣
73	Fast Parameter Initialisation Failure	
74	Solutions Module over temperature	
75	Hardware unavailable for requested operation on this module	
76	Illegal module type	
77	Illegal virtual mode operation attempted	
78	Slot 1 module timed out during inter-option communications transaction	
79	Slot 2 module timed out during inter-option communications transaction	
80	Slot 3 module timed out during inter-option communications transaction	
81	Unknown error during inter-option communications transaction	

The Applications Module will only detect a change in parameter values after start-up or on restart after being reset.

x.01	Option 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 499								
Update rate	Write on power-up															

When no Solutions Module is fitted in the relevant slot this parameter is zero. When a module is fitted this parameter displays the identification code of the module as shown below.

Code	Module	Category	Dumb module
0	No module fitted		
101	SM-Resolver	Position feedback	✓
102	SM-Universal Encoder Plus	Position feedback	
103	SM-SLM	Position feedback	
104	SM-Encoder Plus	Position feedback	✓
201	SM-I/O Plus	I/O expansion module	✓
301	SM-Applications	Applications module	
302	SM-Applications Lite	Applications module	
303	SM-EZMotion		
401	reserved	Fieldbus	
402	reserved	Fieldbus	
403	SM-PROFIBUS-DP	Fieldbus	
404	SM-INTERBUS	Fieldbus	
405	reserved	Fieldbus	
406	SM-CAN	Fieldbus	
407	SM-DeviceNet	Fieldbus	
408	SM-CANopen	Fieldbus	

When parameters are saved by the user in the drive EEPROM the option code of the currently fitted module is saved in EEPROM. If the drive is subsequently powered-up with a different module fitted, or no module fitted where a module was previously fitted, 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	Option 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.03	DPL program status															
Drive types	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	All drives							0								
Range	All drives							0 to 3								
Update Rate	Within 1ms of status change															

The following strings 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															
Drive types	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	All drives							0								
Range	All drives							0 to 100								
Update Rate	Every 200ms															

Displays free CPU resource as current background execution time / 200ms x 100%

x.05	RS485 address ♣															
Drive types	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	All drives							11								
Range	All drives							0 to 255								
Update Rate	Not Applicable															

x.06	RS485 mode ♣															
Drive types	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	All drives							1								
Range	All drives							0 to 255								
Update Rate	Not Applicable															

x.07	RS485 baud rate ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 9								
Update Rate	Not Applicable															

These parameters are the general setup parameters for the RS485 port. The following baud rate strings are defined:

Display	Value	Description
300	0	300 baud
600	1	600 baud
1200	2	1200 baud
2400	3	2400 baud
4800	4	4800 baud
9600	5	9600 baud
19200	6	19200 baud
38400	7	38400 baud
57600	8	57600 baud
115200	9	115200 baud

x.08	RS485 turnaround delay ♣															
Drive types	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	All drives							2								
Range	All drives							0 to 255 ms								
Update Rate	Not Applicable															

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 application module (slave). The application module does not respond until at least 1ms after the message has been received from the host allowing 1ms for the host to change from transmit to receive mode. This delay can be extended using Pr **x.08** if required for both ANSI and Modbus protocols.

x.09	RS485 Tx enable delay ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 1 ms								
Update Rate	Not Applicable															

This parameter allows a delay to be configured between enabling the RS485 transmitter and commencing transmission of data.

x.10	DPL print routing ♣															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

Control where the output of the DPL Print command is sent. The following strings are defined:

Display	Value	Description
SYPT	0	Print out sent to SYPT.
RS485	1	Print output sent to application module local RS485.

x.11	Clock tick time (ms)															
Drive types	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	All drives							0								
Range	All drives							0 to 200								
Update Rate	Not Applicable															

The scheduling rate for the user program clock task in milliseconds. A value of zero disables the clock task.

x.12	Motion engine sample rate															
Drive types	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	All drives							0								
Range	All drives							0 to 6								
Update Rate	Not Applicable															

The internal motion engine can be scheduled at different sample rates to suit the application performance and the resource needed to run the user DPL program. The following values are defined:

Value	Description	String
0	Disabled	diSAblEd
1	250µs sample time	0.25
2	500µs sample time	0.5
3	1ms sample time	1
4	2ms sample time	2
5	4ms sample time	4
6	8ms sample time	8

x.13	Enable autorun															
Drive types	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	All drives							1								
Update Rate	Not Applicable															

x.14	Global run time trip enable															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

While debugging it is generally not convenient to trip the drive on run time errors (the error will be reported directly to SYPT). Once debug has completed this parameter is generally set to allow drive trips.

x.15	Disable reset on trip cleared															
Drive types	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	All drives							0 to 1								
Default	All drives							0								
Update Rate	Not Applicable															

When this parameter is 0 (default) the module will be reset when a drive trip is cleared.

This may be set to 1 which will enable the module to continue running unaffected by a drive trip reset.

x.16	**Encoder data update rate**															
Drive types	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	All drives							0								
Range	All drives							0 to 3								
Update Rate	Not Applicable															

When this parameter is 0 the APC data and menu 90 parameters are updated every 250µs.

When this parameter is 1 the APC data and menu 90 parameters are updated every POS task

When this parameter is 2 the APC data and menu 90 parameters are updated every CLOCK.

When this parameter is 3 the APC data and menu 90 parameters are never updated.

x.17	**Enable parameter over range trips**															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

Above parameters selectively enable/disable particular run time trips

x.18	**Watchdog enable**															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

Allows the DPL WDOG function block to be used to protect the user program. The drive will trip if the WDOG FB is not executed within 200ms.

x.19	**Save request**															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

The PLC menus 70, 71, 74 and 75 will be saved to flash. Pr **x.00** will be set to 1,070 followed by a reset (Pr **10.38** = 100) which will cause a Solutions Module restart on other Solutions Modules in the drive.

x.20	**Enable power down save**															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

This parameter is not cached i.e. the current value will be used at the next power down.

x.21	Enable menu 20 save and restore															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

These three bit parameters control the non-volatile save and restore features of the application module. The non-volatile PLC register sets and menu 20 parameter data can be saved in the application module flash memory (note: only one application module out of the possible maximum of three slots should be used to save and restore menu 20 otherwise the behaviour is undefined). Data can be saved on request by setting the save request bit (the module will clear this bit once the data has been saved).

NOTE

The DPL program is stopped during the save sequence and a warm restart generated once the save is over. If the power down enable bit is set then data is saved automatically when a UU trip is detected.

This parameter is not cached i.e. the current value will be used at the next power down.

x.22	CTNet token ring ID ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 255								
Update Rate	Not Applicable															

This parameter allows the user to specify the identity of the CTNet token ring to which a SM-Applications 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 IDs 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 ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 255								
Update Rate	Not Applicable															

x.24	CTNet baud rate ♣															
Drive types	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	All drives							1								
Range	All drives							0 to 3								
Update Rate	Not Applicable															

x.25	CTNet sync setup ♣															
Drive types	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	All drives							0								
Range	All drives							0,000 to 9,999								
Update Rate	Not Applicable															

These parameters are the general setup parameters for the CTNet port. The baud rate strings are defined as follows:

Display	Value	Description
5.000	0	5Mbit/s
2.500	1	2.5Mbit/s (default)
1.250	2	1.25Mbit/s
0.625	3	625kbit/s

x.26	CTNet easy mode - first cyclic parameter destination node ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 25,503								
Update Rate	Not Applicable															

x.27	CTNet easy mode - first cyclic source parameter ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 9,999								
Update Rate	Not Applicable															

x.28	CTNet easy mode - second cyclic parameter destination node ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 25,503								
Update Rate	Not Applicable															

x.29	CTNet easy mode - second cyclic source parameter ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 9,999								
Update Rate	Not Applicable															

x.30	CTNet easy mode - third cyclic parameter destination node ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 25,503								
Update Rate	Not Applicable															

x.31	CTNet easy mode - third cyclic source parameter ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 9,999								
Update Rate	Not Applicable															

x.32	CTNet easy mode set-up - transfer slot 1 destination parameter ♣															
Drive types	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	All drives							0								
Range	All drives							0,000 to 9,999								
Update Rate	Not Applicable															

x.33	CTNet easy mode set-up - transfer slot 2 destination parameter♣															
Drive types	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	All drives							0								
Range	All drives							0,000 to 9,999								
Update Rate	Not Applicable															

x.34	CTNet easy mode set-up - transfer slot 3 destination parameter ♣															
Drive types	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	All drives							0								
Range	All drives							0,000 to 9,999								
Update Rate	Not Applicable															

The above parameters are the CTNet Easy Mode set-up parameters. Pr **x.26** to Pr **x.31** allow 3 parameters to be setup for cyclic transmission to remote nodes via CTNet. Pr **x.32** to Pr **x.34** allow the user to specify which parameters should be updated from cyclic data received in slots 1 to 3 on the local node.

x.35	CTNet sync event task ID ♣															
Drive types	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	All drives							0								
Range	All drives							0 to 4								
Update Rate	Not Applicable															

The identity of the DPL event task which is to be scheduled when a CTNet Sync (master or slave) occurs. The following strings 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 Diagnostic parameter ♣															
Drive types	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				
Default	All drives							0								
Update Rate	1 second															

The value displayed is in messages per second. If the network is not healthy e.g. a bad connection, then the parameter will display -1. Similarly, if the network has an intermittent connection problem, the -1 indication will be displayed occasionally. The value of -2 indicates that the CTNet failed to initialise e.g. two nodes have the same ID, etc. The value of -3 indicates that this node has caused a recon message.

x.37	Reject download if drive enabled															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

This parameter indicates whether the application module should reject a user program or OS download attempt if the drive is enabled. If clear a download is not rejected.

x.38	Do not trip drive on APC run-time error															
Drive types	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	All drives							0								
Update Rate	Not Applicable															

This parameter indicates whether the SM-Applications module should request a drive trip if a fatal error occurs in the APC kernel while running or allow the drive to remain untripped.

- A value of 0 (default) causes the SM-Applications to trip the drive in the event of a non-recoverable error in the APC kernel.
- A value of 1 causes the SM-Applications to leave the drive untripped in the event of a non-recoverable error in the APC kernel.

An error which may occur while the APC kernel is running (i.e. not during attempted reconfiguration of the APC) can be detected in this way if required, e.g. if the user enables the CAM function without initialising the CAM generator.

NOTE

User operations which return a status code do not cause a drive trip even if this parameter is set.

x.39	Inter-SM-Applications drive synchronisation status ♣															
Drive types	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	
Default	All drives							0								
Range	All drives							0 to 3								
Update Rate	Not Applicable															

The drive controls bit 0 of the synchronisation status to indicate whether the particular Solutions Module is the synchronisation master. Once the Solutions Module is the synchronisation master it remains the master unless another module requests to be the master and the request is granted or the synchronisation mode request is set to zero. If the Solutions Module is synchronisation master and stops providing a synchronisation waveform the synchronisation system continues to run, but the frequency remains constant. If the Solutions Module produces a synchronisation frequency that is out of specification the synchronisation system runs at the limit of the tolerance until a signal is produced that is within the specification. The synchronisation system status is monitored by a counter. The counter is set to zero at when the synchronisation system is not active and at power-up, and can count up or down once every 4ms in the range between 0 and 32. If the synchronisation waveform is present and within specification the counter counts up otherwise it counts down. When the counter has a value of 16 or more status bit 1 is cleared otherwise it is set.

Synchronisation status	Status
0	The synchronisation master request is zero or another Solutions Module is synchronisation master
1	The Solutions Module is synchronisation master
3	The Solutions Module is synchronisation master, but the synchronisation frequency is out of specification or not present

x.40	Inter-SM-Applications master transfer mode ♣															
Drive types	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	All drives							1								
Range	All drives							0 to 10								
Update Rate	Not Applicable															

The user will be able to automatically transfer predefined data.
In master mode 0 the values of Pr **91.13** and Pr **91.14** can be loaded with user defined values. The delay will be the position loop rate plus 250µs.
In master mode 1 the values of Pr **90.01** and Pr **90.02** will be placed in Pr **91.13** and Pr **91.14**. This will ensure that the slave gets the position reference of the master with the minimum delay (250µs).
In master mode 2 the MSW of Pr **90.01** and Pr **90.02** will be placed in Pr **91.13** and the speed reference (Pr **3.22**) in Pr **91.14**. This will ensure that the slave gets the position and speed references of the master with the minimum delay (250µs).
In master mode 3 the Pr **90.01** will be placed in Pr **91.13** and the speed reference (Pr **3.22**) in Pr **91.14**. This will ensure that the slave gets the position and speed references of the master with the minimum delay (250µs).

x.42	Freeze main drive position ♣															
Drive types	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							0								
Update Rate	Not Applicable															

When a freeze occurs on the Solutions Module the main drive position can also be stored if this parameter is set to one.

x.43	Freeze invert ♣															
Drive types	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	Not Applicable															

When Pr **x.43** = 0 freeze occurs on the rising edge of the freeze input. When Pr **x.43** = 1 freeze occurs on the falling edge of the freeze input.

x.44	Task priority level															
Drive types	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	All drives							0								
Range	All drives							0 to 255								
Update Rate	Not Applicable															

The priority levels of different tasks may be changed with this parameter. The parameter is accessed bit wise.

Bit 0

The value of 0 will give the same priority levels for tasks as UD70. Setting the value to 1 will reduce the priority of CTNet to below that of POS0 and POS1. This will reduce the jitter of the POS tasks but could lead to the CTNet task being starved.

Bit 1

The value of 0 will mean that the inter option communication task priority is higher than the POS tasks. Setting the value to 1 will make the inter option communication task priority lower than the POS tasks.

x.48	DPL line number in error															
Drive types	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	
Default	All drives							0								
Range	All drives							0 to 2,147,483,647								
Update Rate	Not Applicable															

If a run-time error is logged, this parameter gives the line number (where available) of the DPL statement which caused the error to be raised. If a value of 0 is shown then the line number is unavailable. If the error was caused by execution of code within a ladder or function block diagram, the line number shown will be the first source line on which the diagram appears.

x.49	User program ID															
Drive types	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				
Coding	RW															
Default	All drives							0								
Range	All drives							-32,768 to +32,767								

General user parameter intended for displaying a user program ID.

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 SLotx.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 descriptions for each category 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	Option 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 fitted that does not contain software both these parameters appear as zero.

5.17 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															

5.18 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															

5.19 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															

5.20 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.

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															

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 141).

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.

21.04	**Acceleration 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, Servo DP = 3															
Range	Open-loop Closed-loop vector, Servo												0.0 to 3200.0 s/100Hz 0.000 to 3200.000 s/1000rpm			
Default	Open-loop Closed-loop vector Servo												5.0 2.000 0.200			
Normal parameter	Open-loop, Closed-loop vector, Servo												Pr **2.11**			
Update rate	Background read															

21.05	**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, Servo DP = 3															
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												5.0 2.000 0.200			
Normal parameter	Open-loop, Closed-loop vector, Servo												Pr **2.21**			
Update rate	Background read															

21.06	**Rated 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	
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															

21.07	**Rated 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	2		1				1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								0 to RATED_CURRENT_MAX A							
Default	Open-loop, Closed-loop vector, Servo, Regen								Drive rated current (Pr **11.32**)							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **5.07**							
Update rate	Background read															

21.08	**Rated load rpm**															
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 DP=2															
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								EUR: 1,500, USA: 1,800 EUR: 1,450.00, USA: 1,770.00							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **5.08**							
Update rate	Background read															

21.09	**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 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															

21.10	**Rated power factor**															
Drive modes	Open-loop, Closed-loop vector															
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								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															

21.11	**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)							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **5.11**							
Update rate	Background read															

21.12	**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 30.000 Ω							
Default	Open-loop, Closed-loop vector, Servo								0.000							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **5.17**							
Update rate	Background read															

21.13	**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							
Normal parameter	Open-loop								Pr **5.23**							
Update rate	Background read															

21.14	**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							
Normal parameter	Open-loop, Closed-loop vector, Servo								Pr **5.24**							
Update rate	Background read															

21.15	**Motor 2 active**															
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								1							
Normal motor parameter	Open-loop, Closed-loop vector, Servo								Pr **21.15**							
Update rate	Background write															

Pr **21.15** does not have an equivalent normal motor parameter, but shows when motor 2 is active.

21.16	**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 400.0														
Default	Open-loop, Closed-loop vector, Regen Servo	89.0 20.0														
Normal motor parameter	Open-loop, Closed-loop vector, Servo, Regen	Pr **4.15**														
Update rate	Background read															

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
							2						1	1	1	
Range	Closed-loop vector, Servo	0.00 to 6.5335 (1/rad s^{-1})														
Default	Closed-loop vector, Servo	1.00														
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 653.35 s/rad s^{-1}														
Default	Closed-loop vector, Servo	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 0.65335 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															

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															

21.25	**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								
Normal parameter	Closed-loop vector							Pr **5.29**								
Update rate	Background read															

21.26	**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								
Normal parameter	Closed-loop vector							Pr **5.30**								
Update rate	Background read															

21.27	**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 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 **4.05**								
Update rate	Background read															

21.28	**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 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 **4.06**								
Update rate	Background read															

21.29	**Symmetrical 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 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															

21.30	**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							
Normal parameter	Servo								Pr **5.33**							
Update rate	Background read															

5.21 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 5-14								
Update rate	Background read															

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

Table 5-14 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.

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. A SMARTCARD is available with these macros pre-programmed for download into a Unidrive SP.

Table 6-1 Macros that are available

Macro	Description
1	Easy mode
2	Motorised 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 – Motorised potentiometer

The Motorised potentiometer macro enables the drive's own internal motorised potentiometer to control the speed of the drive via digital inputs. A digital input selects between an analog speed reference and the motorised 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}			0.0100		RW	Uni				US
0.08	OL> Voltage boost	{**5.15**}	0.0 to 25.0% of motor rated voltage			3.0			RW	Uni				US
	CL> Speed controller I gain	{**3.11**}		0.00 to 653.35 1/rad			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)			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 3		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 359.9º				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 400.0			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 cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save	

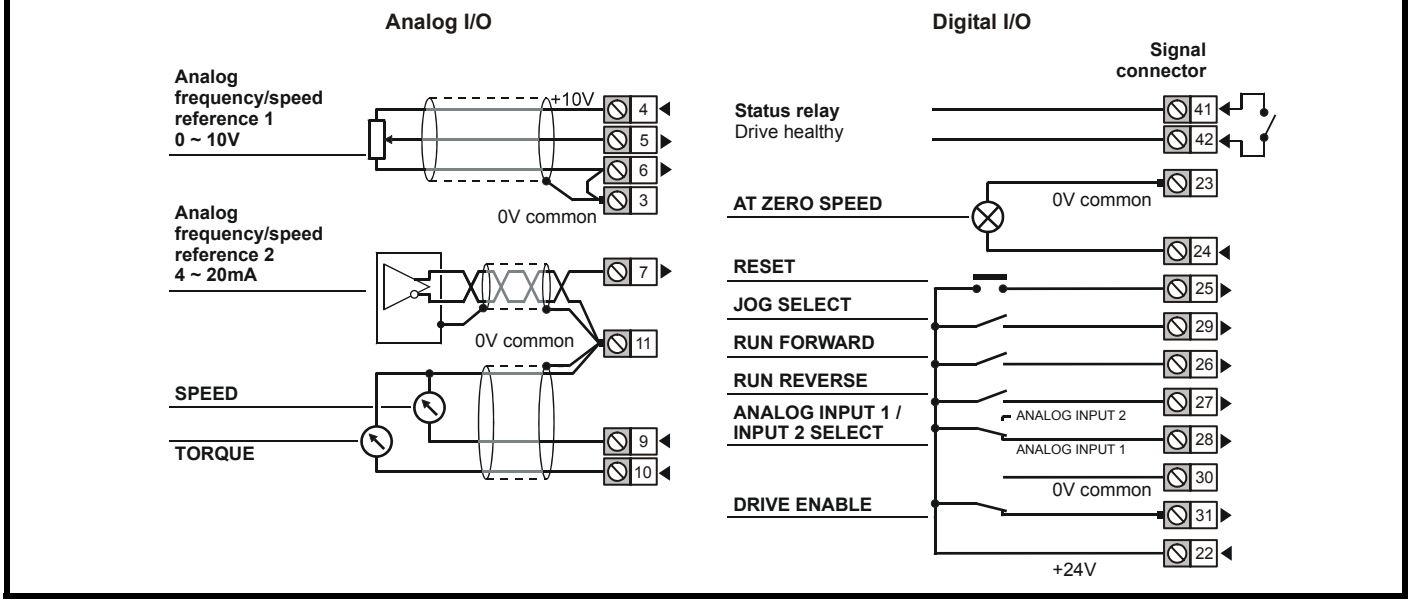
6.1.1 Fundamental differences between Unidrive SP and Unidrive Classic

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 SECURE DISABLE 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 SECURE DISABLE 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 order of the digital inputs has been changed to match those of the Unidrive classic.
- The brake is now an additional feature in Menu 12, with enhanced features over the Unidrive Classic.
- Analog input 3 is now defaulted to a voltage input. The input can be configured via Pr **7.15**.

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

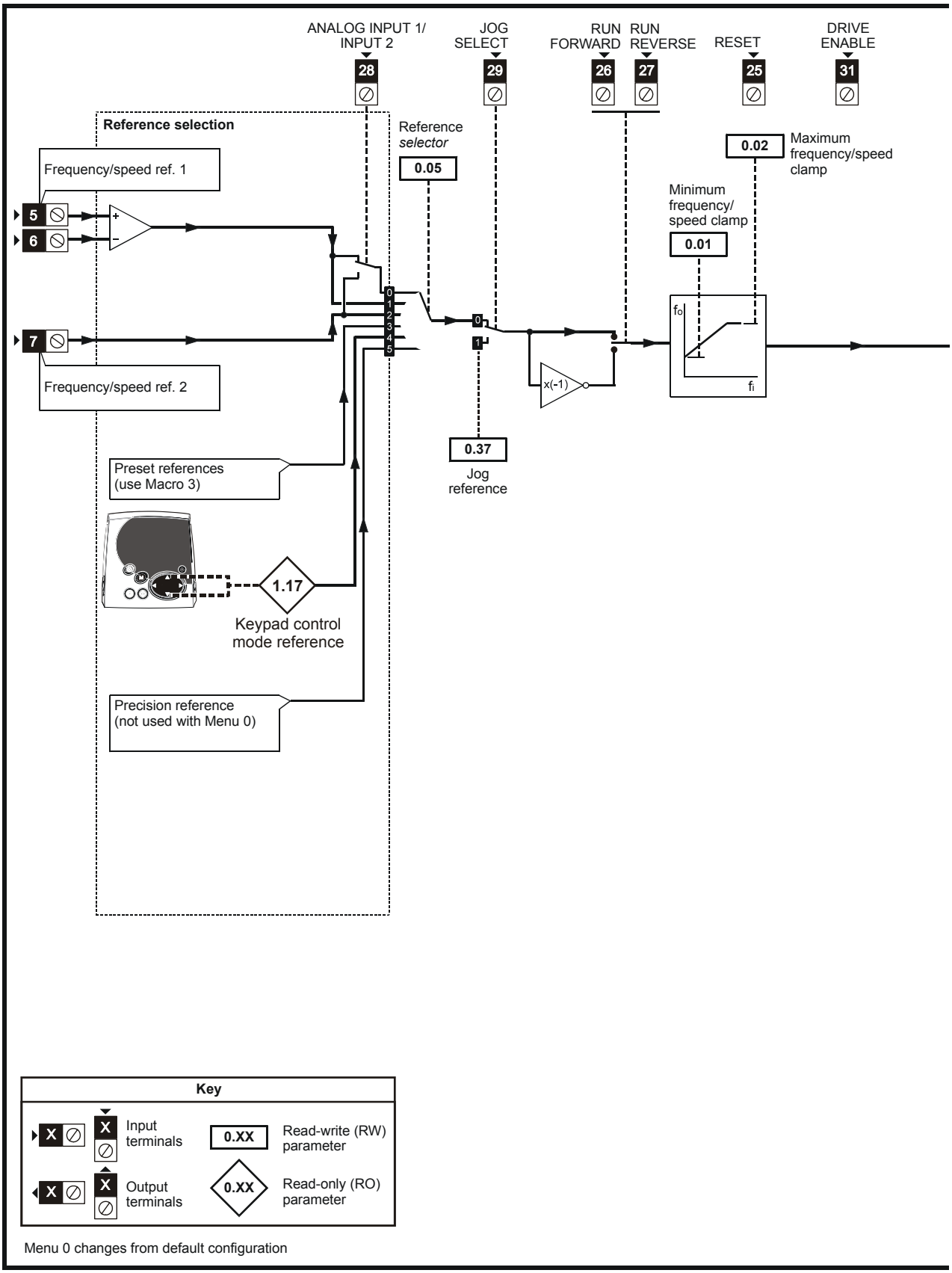
There are no additional parameters present other than those described in Table 6-2 on page 304, as this is Easy mode.

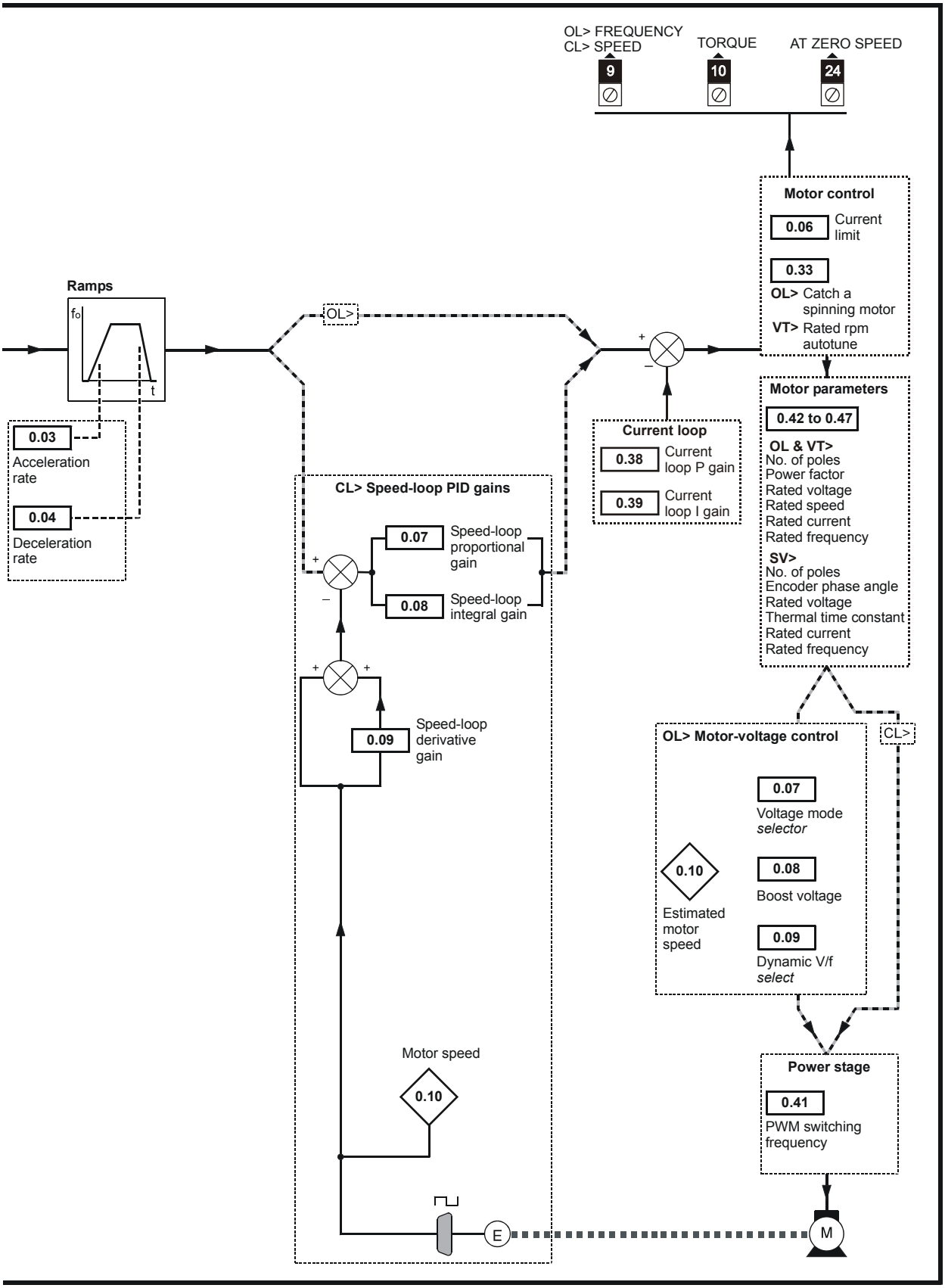
Pr **0.11** to Pr **0.30** are not configured to point to any other parameter in this mode.

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
9
TORQUE
10
AT ZERO SPEED
24
Motor control
0.06
Current limit
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
Ramps
fo
t
OL>
0.03
Acceleration rate
0.04
Deceleration rate
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> 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 - Motorised potentiometer

Macro 2	**Motorised potentiometer**
The Motorised potentiometer macro enables the drive's own internal motorised potentiometer to control the speed of the drive via digital inputs. A digital input selects between an analog speed reference and the motorised potentiometer reference.	

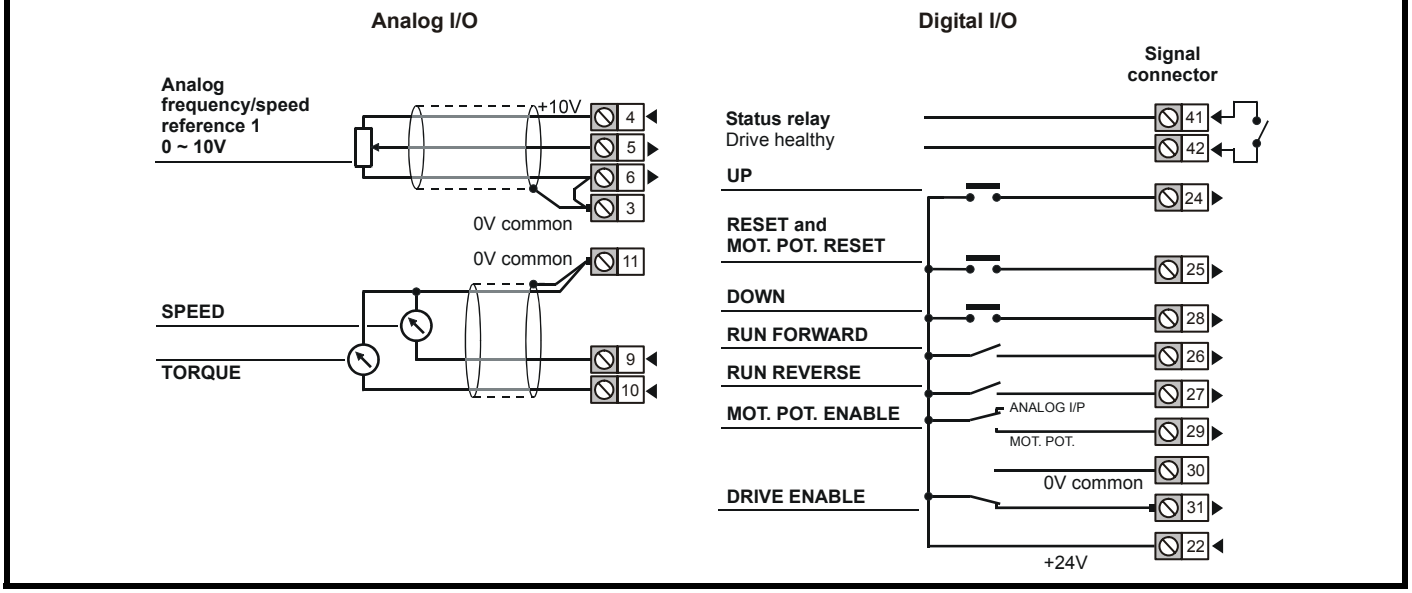


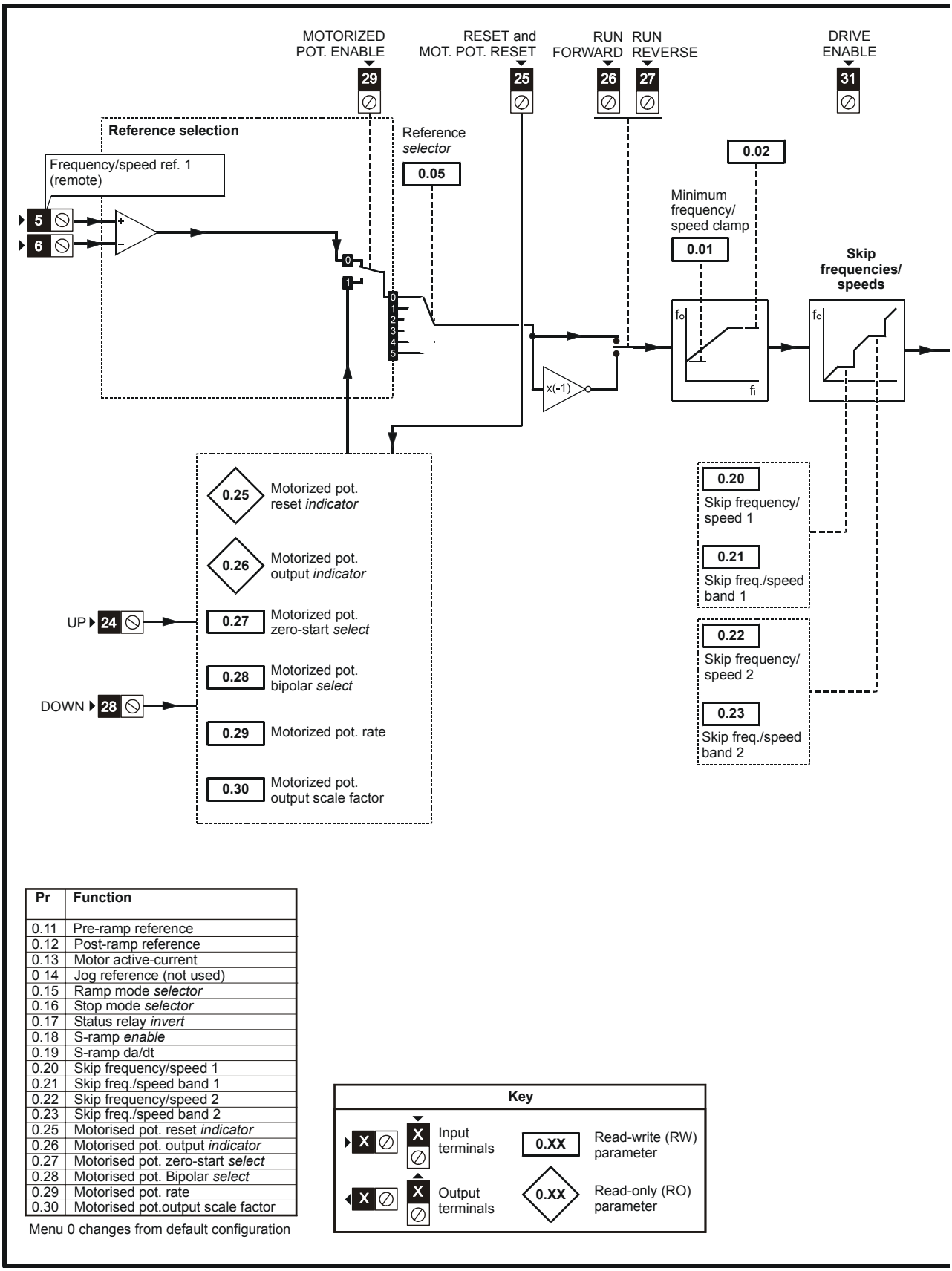
Table 6-4 Macro 2 menu 0 programmable parameters

Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
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	Motorised pot reset	{**9.28**}	OFF (0) or On (1)		OFF (0)			RW	Bit		NC		
0.26	Motorised pot output	{**9.03**}	±100.00 %					RO	Bi		NC	PT	PS
0.27	Motorised pot mode	{**9.21**}	0 to 3		2			RW	Uni				US
0.28	Motorised pot bipolar select	{**9.22**}	OFF (0) or On (1)		OFF (0)			RW	Bit				US
0.29	Motorised pot rate	{**9.23**}	0 to 250 s		20			RW	Uni				US
0.30	Motorised 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

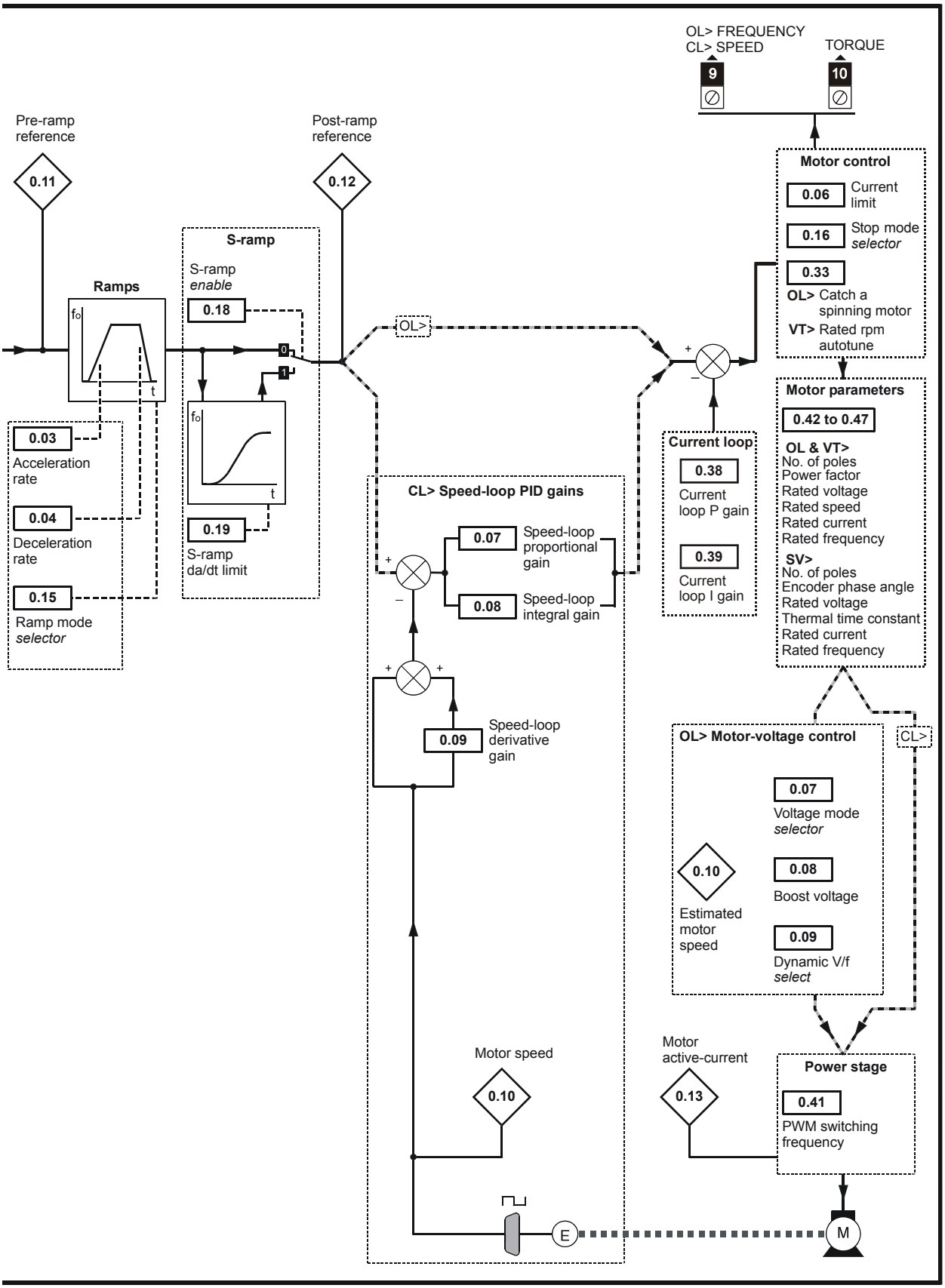
Parameter		Value	
		OL	CL
7.14	T7 analog input 2 destination	Pr **0.00**	
8.21	T24 digital I/O 1 source / destination	Pr **9.26**	
8.25	T28 digital input 5 destination	Pr **9.27**	
8.26	T26 digital input 6 destination	Pr **1.41**	
8.31	T24 digital I/O 1 output select	OFF (0)	
8.39	T28 & T29 digital input auto selection disable	On (1)	
9.04	Logic function 1 source 1	Pr **9.22**	
9.07	Logic function 1 source 2	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**	
9.25	Motorised 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 Motorised 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	Motorised pot. reset *indicator*
0.26	Motorised pot. output *indicator*
0.27	Motorised pot. zero-start *select*
0.28	Motorised pot. Bipolar *select*
0.29	Motorised pot. rate
0.30	Motorised 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
Motor control
0.06 Current limit
0.16 Stop mode selector
0.33
OL> Catch a spinning motor
VT> Rated rpm autotune
S-ramp
S-ramp enable
0.18
Ramps
fo
t
OL>
0.03 Acceleration rate
0.04 Deceleration rate
0.15 Ramp mode selector
0.19 S-ramp da/dt limit
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> 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.	

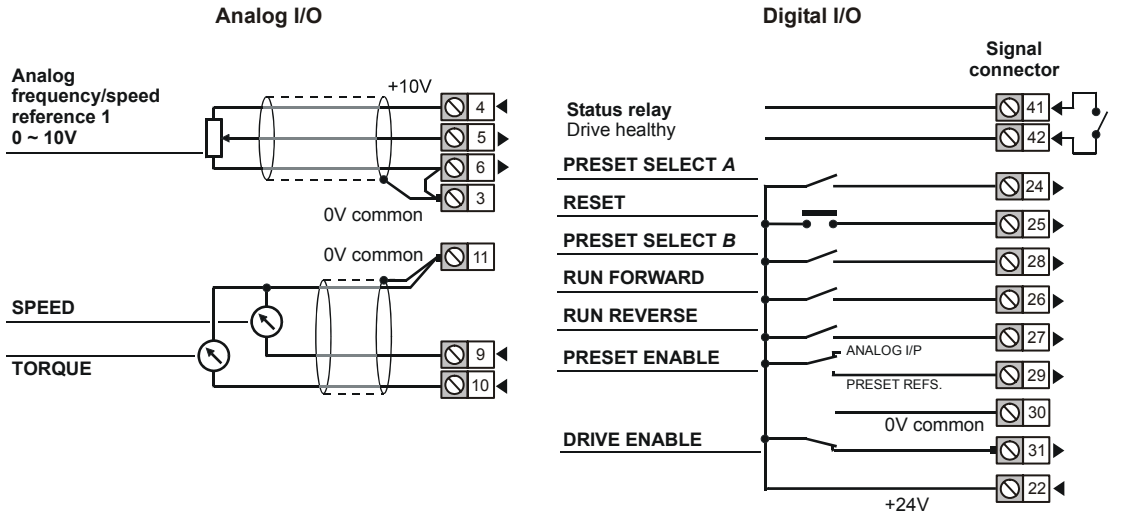


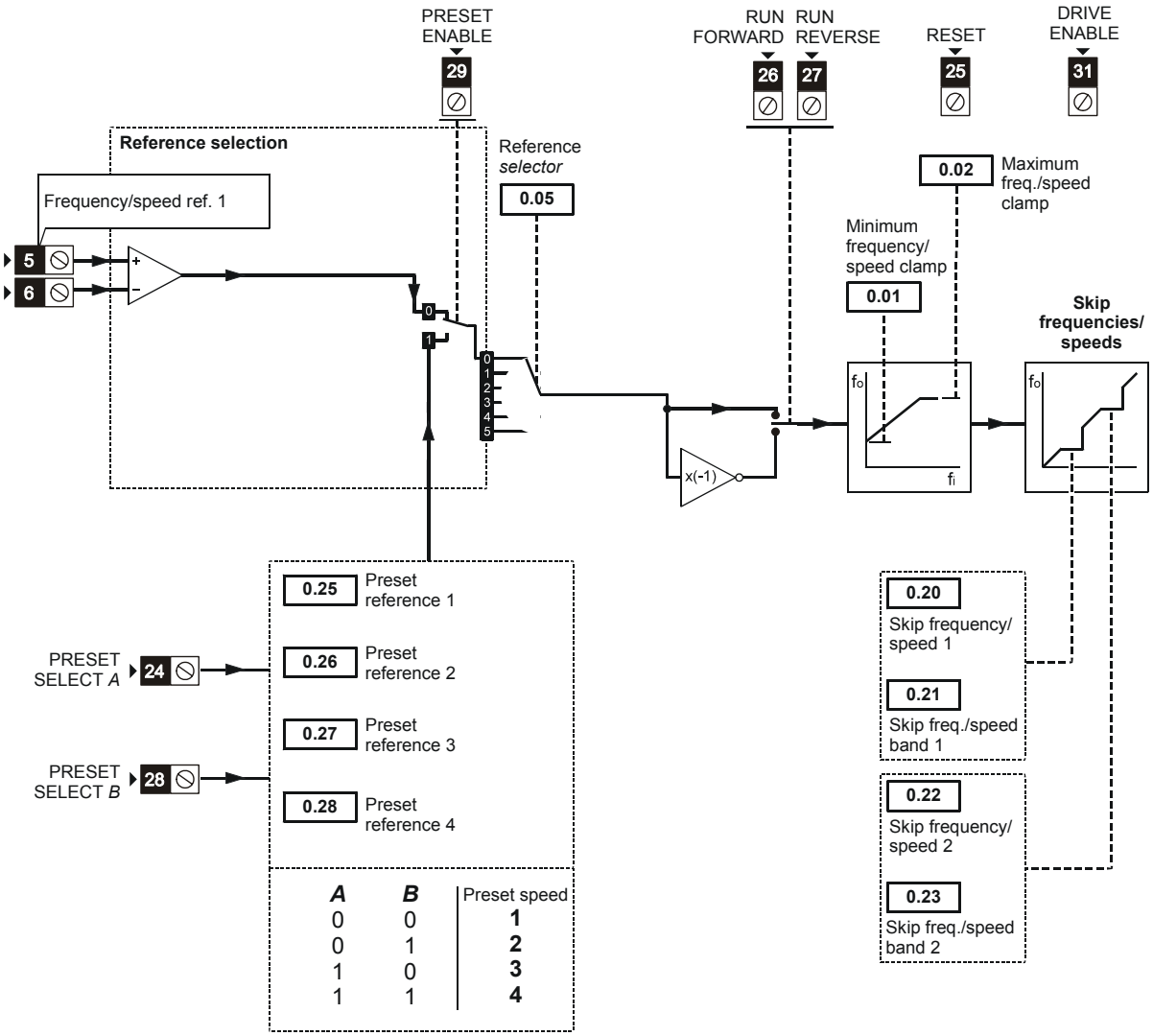
Table 6-6 Macro 3 menu 0 programmable parameters

Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
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

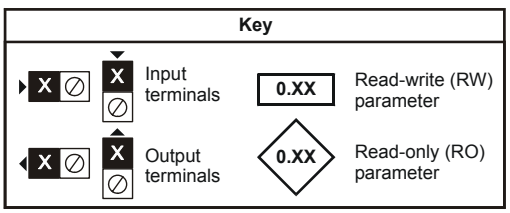
Parameter		Value	
		OL	CL
8.21	T24 digital I/O 1 source / destination	Pr **1.46**	
8.25	T28 digital input 5 destination	Pr **1.45**	
8.26	T29 digital input 6 destination	Pr **1.42**	
8.31	T24 digital I/O 1 output select	OFF (0)	
8.39	T28 & T29 digital input auto selection disable	On (1)	
11.01	Define 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**	

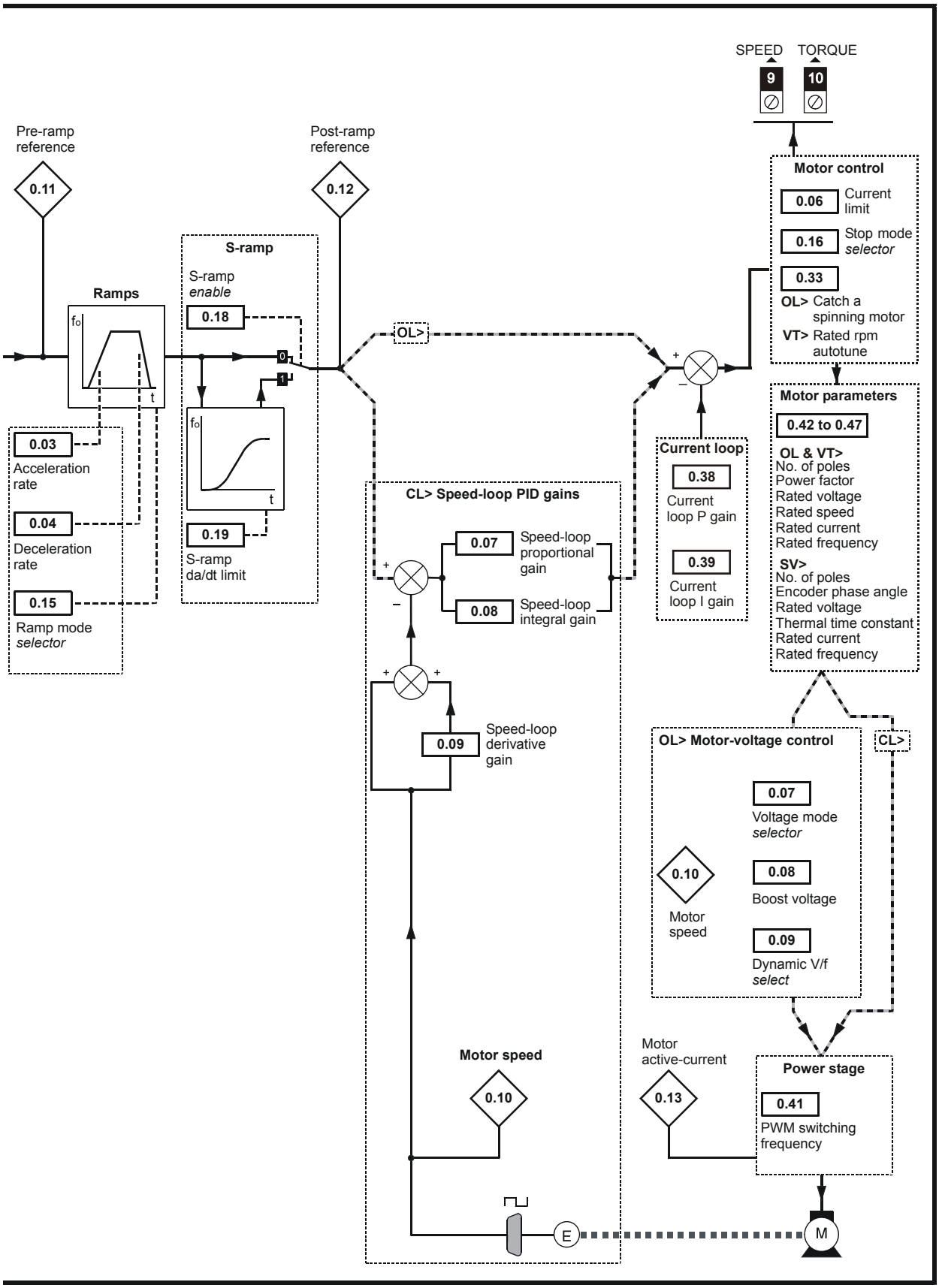
Figure 6-3 Macro 3 Preset speeds logic diagram



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.

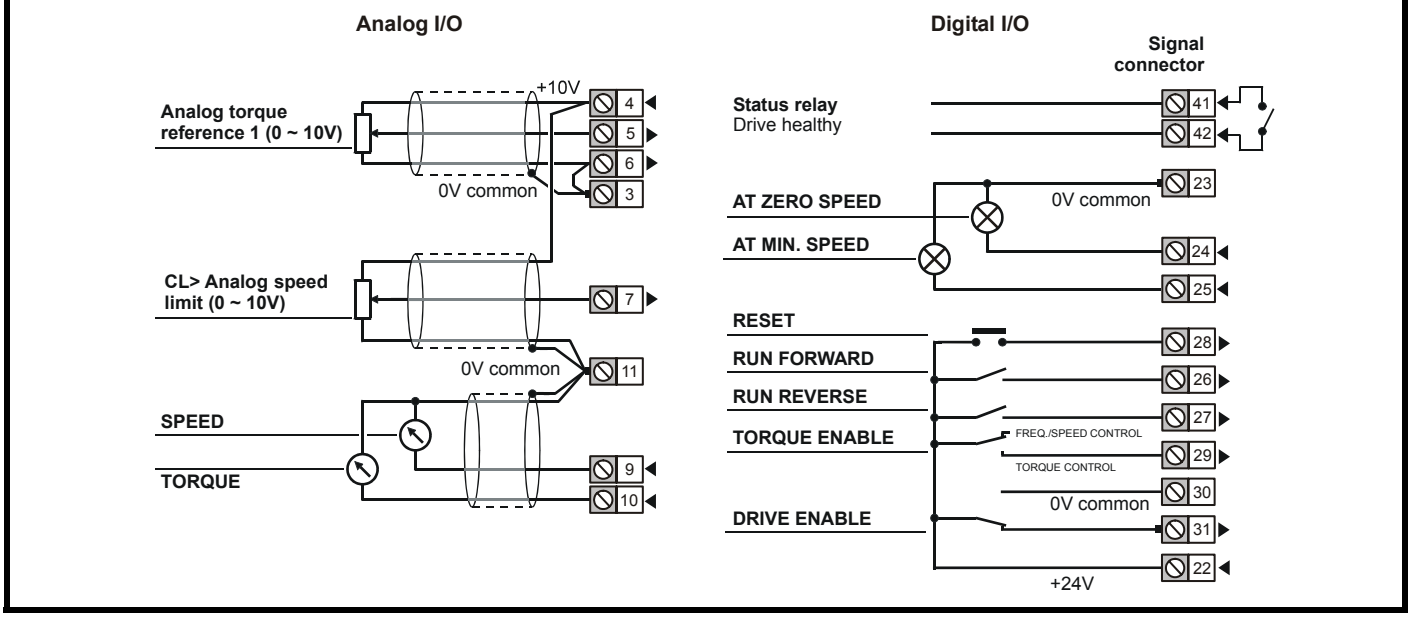


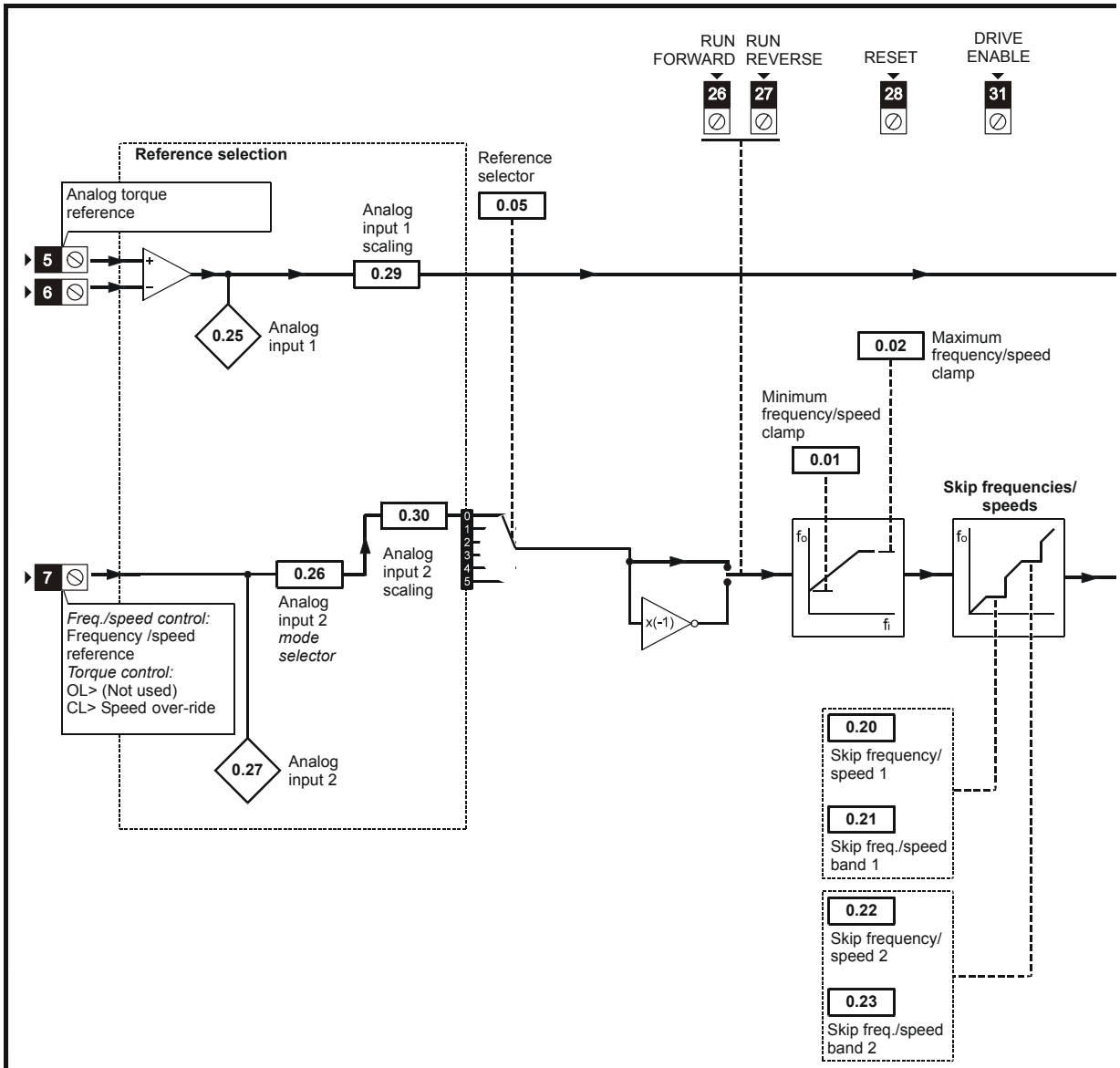
Table 6-8 Macro 4 menu 0 programmable parameters

Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
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

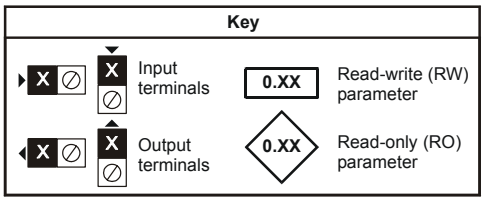
Parameter		Value	
		OL	CL
7.10	Analog input 1 destination	Pr **4.08**	
7.14	Analog input 2 destination	Pr **1.36**	
8.22	T25 digital I/O 2 source / destination	Pr **10.04**	
8.25	T28 digital input 5 destination	Pr **10.33**	
8.26	T29 digital input 6 destination	Pr **9.29**	Pr **9.30**
8.32	T25 digital 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**	

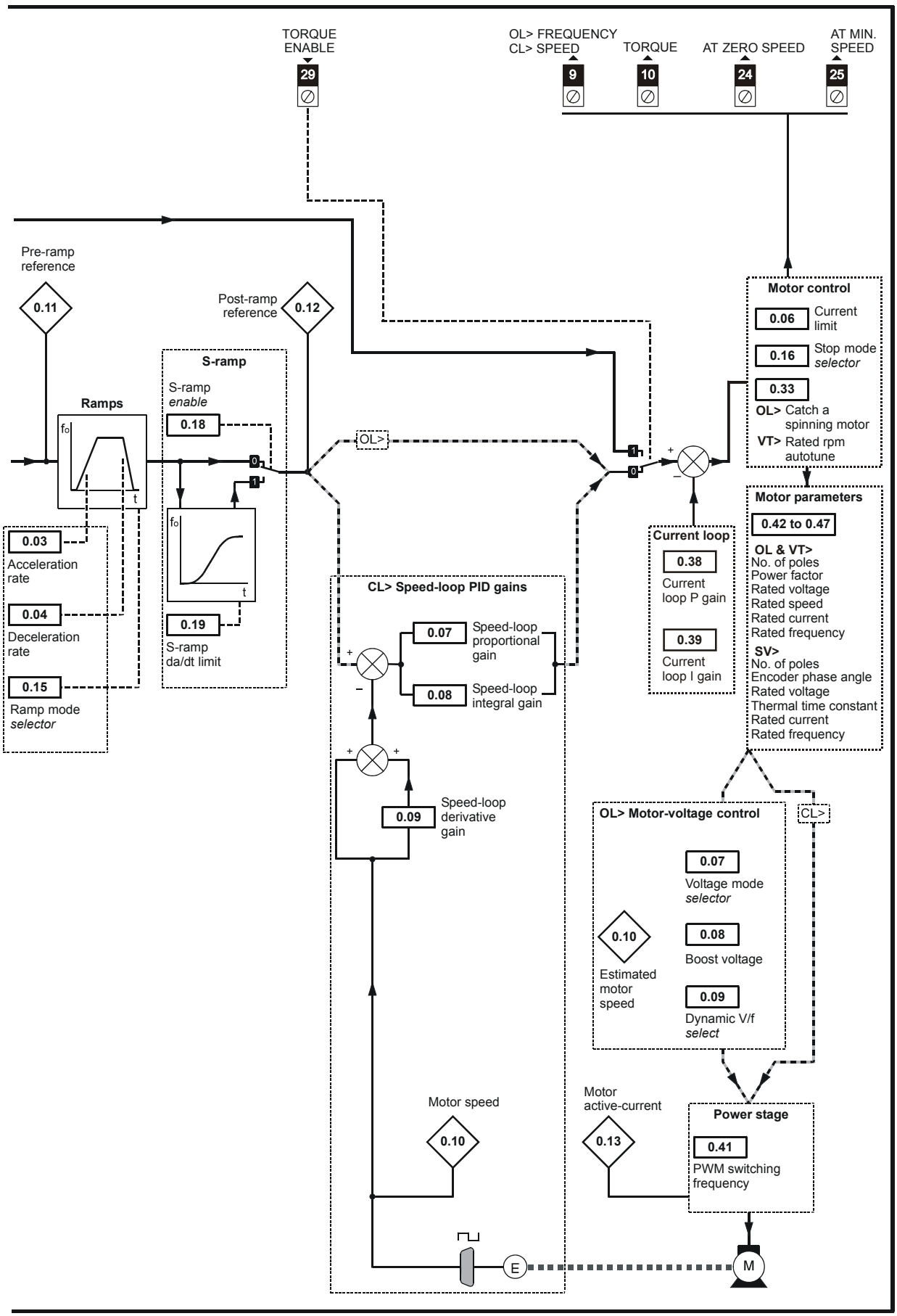
Figure 6-4 Macro 4 Torque control logic diagram



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>
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

6.6 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.	

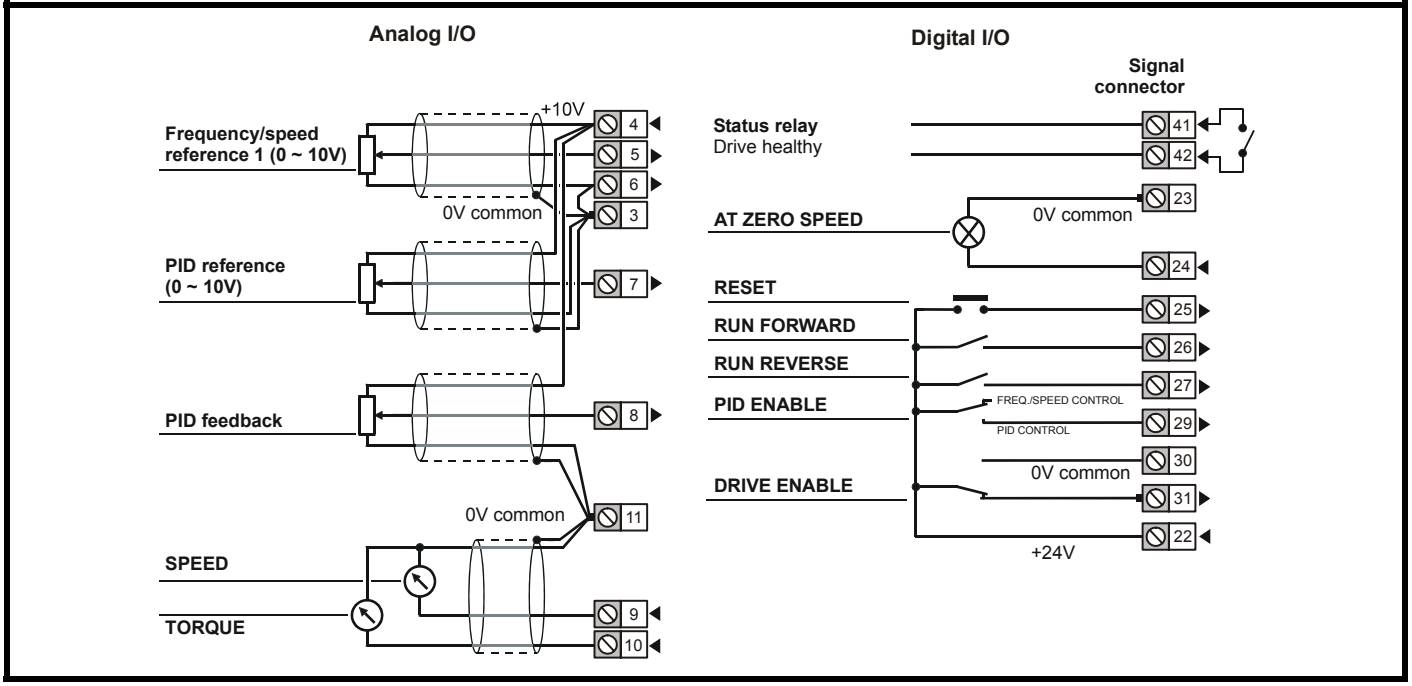


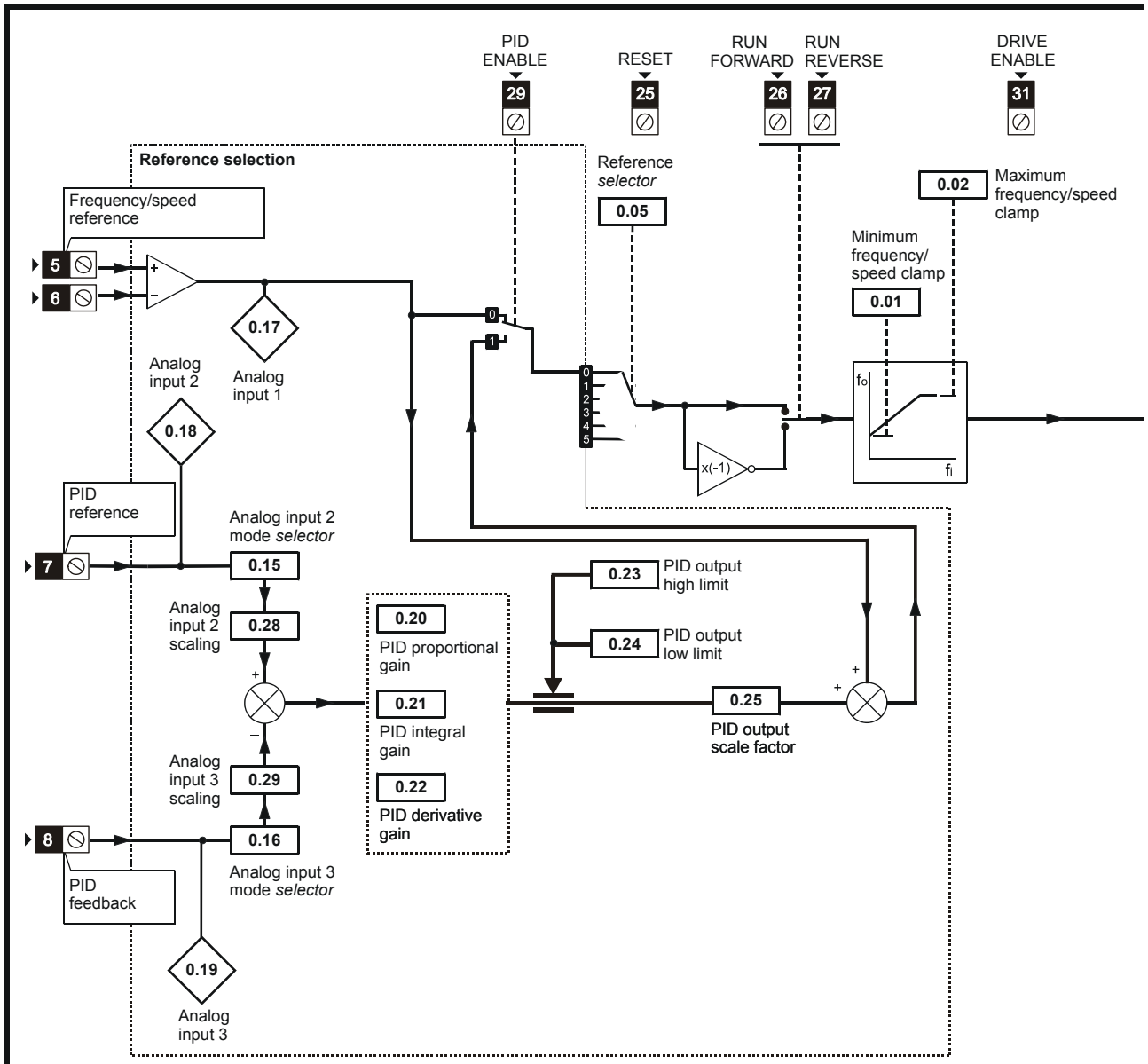
Table 6-10 Macro 5 menu 0 programmable parameters

Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
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

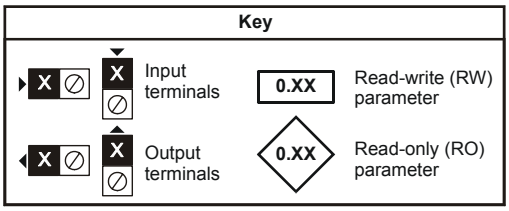
Parameter		Value	
		OL	CL
7.10	Analog input 1 destination	Pr **0.00**	
7.14	Analog input 2 destination	Pr **1.27**	
7.18	Analog input 3 destination	Pr **1.28**	
8.26	T29 digital input 6 destination	Pr **14.08**	
8.39	T28 and T29 digital input auto selection disable	On (1)	
11.01	Define Pr **0.11**	Pr **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**	

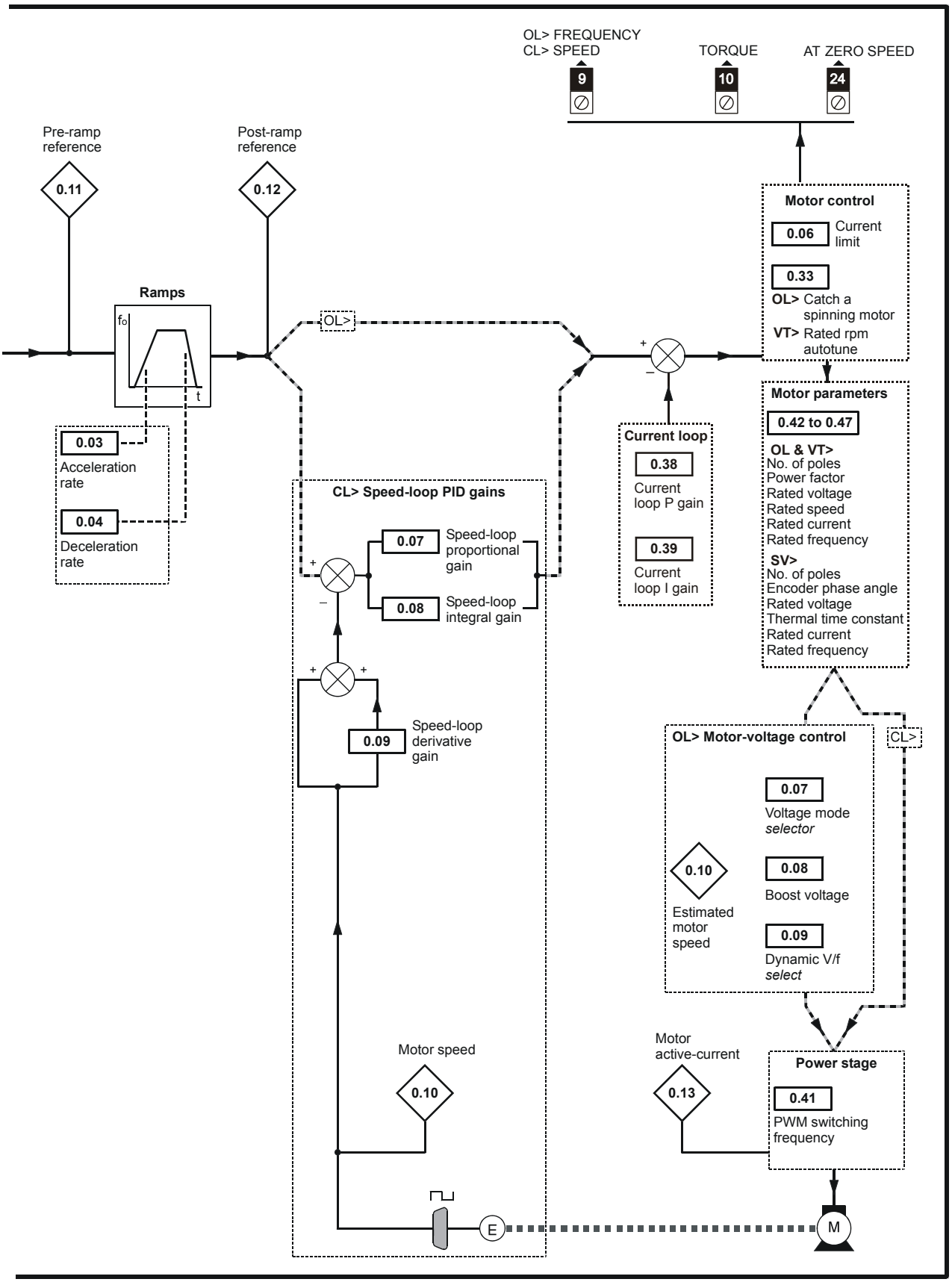
Figure 6-5 Macro 5 PID control logic diagram



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
fo
t
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
Current loop
0.38
Current loop P gain
0.39
Current loop I gain
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
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

6.7 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.	

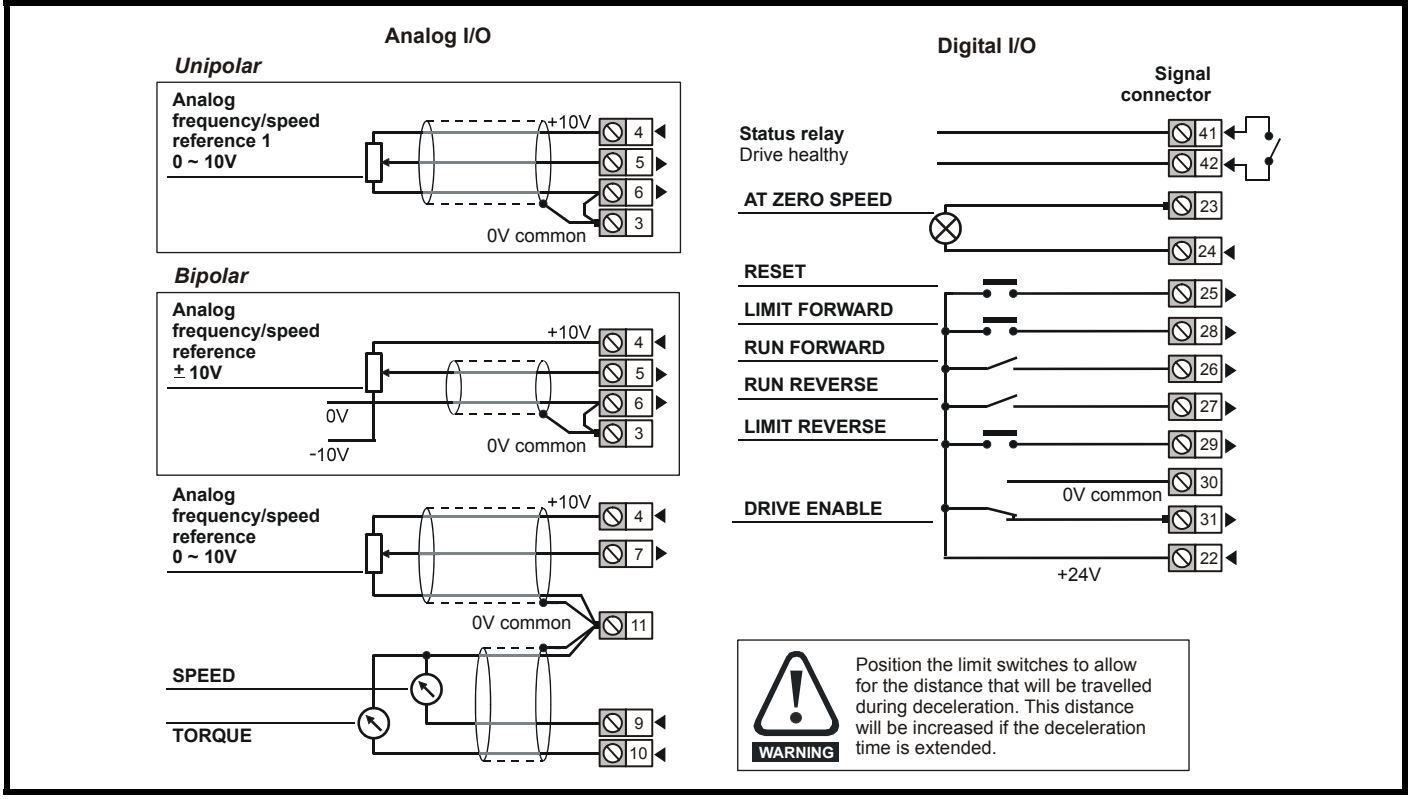


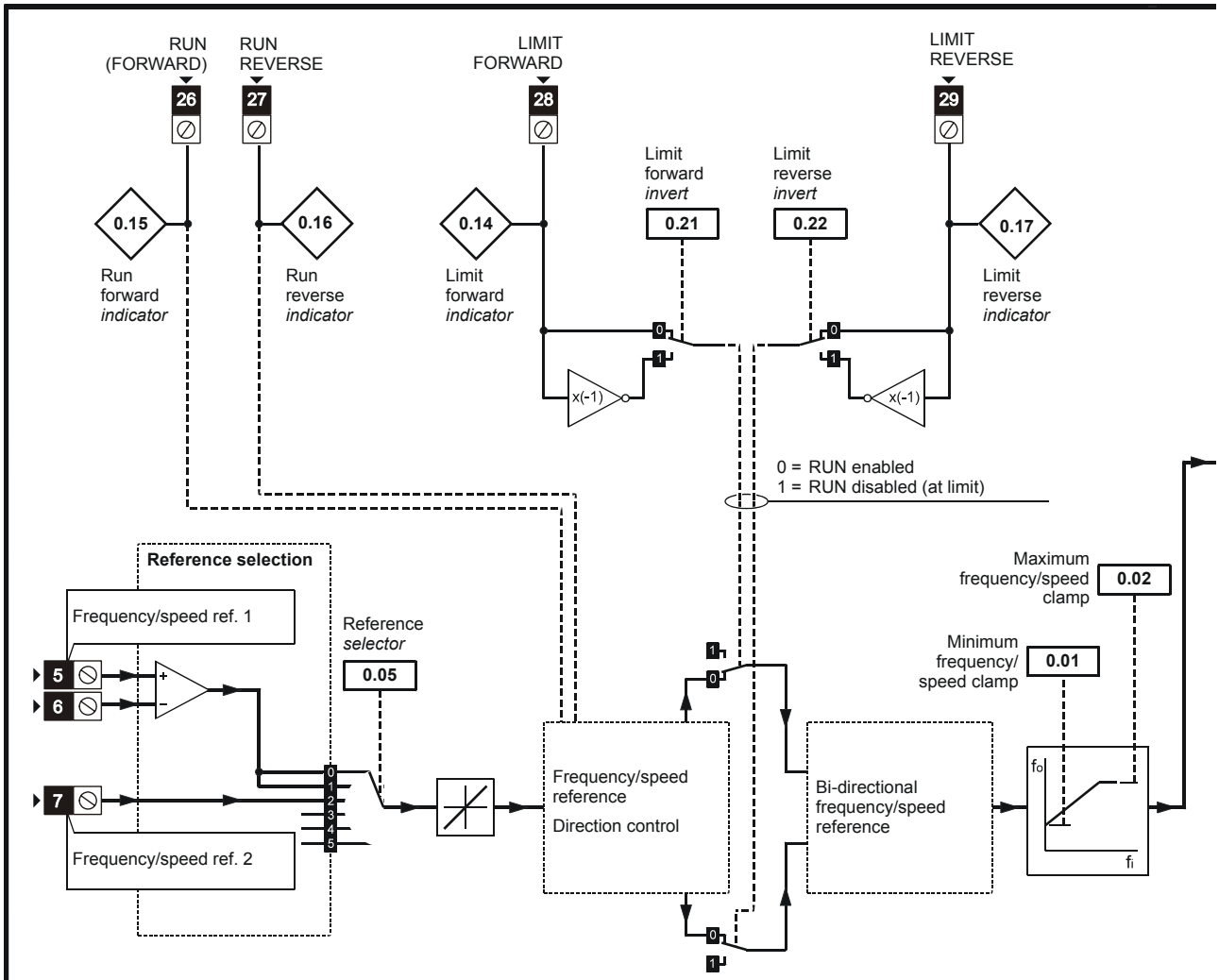
Table 6-12 Macro 6 menu 0 programmable parameters

Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
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

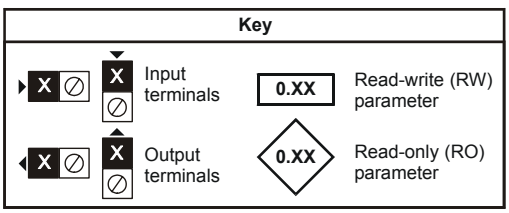
Parameter		Value	
		OL	CL
1.10	Bipolar select	On (1)	
2.04	Ramp mode	FASt	
2.22	Deceleration rate 2	1.0	2.0
8.39	T28 & T29 digital input auto selection disable	On (1)	
8.25	T28 digital input 5 destination	Pr **6.35**	
8.26	T29 digital input 6 destination	Pr **6.36**	
9.04	Logic function 1 source 1	Pr **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**	

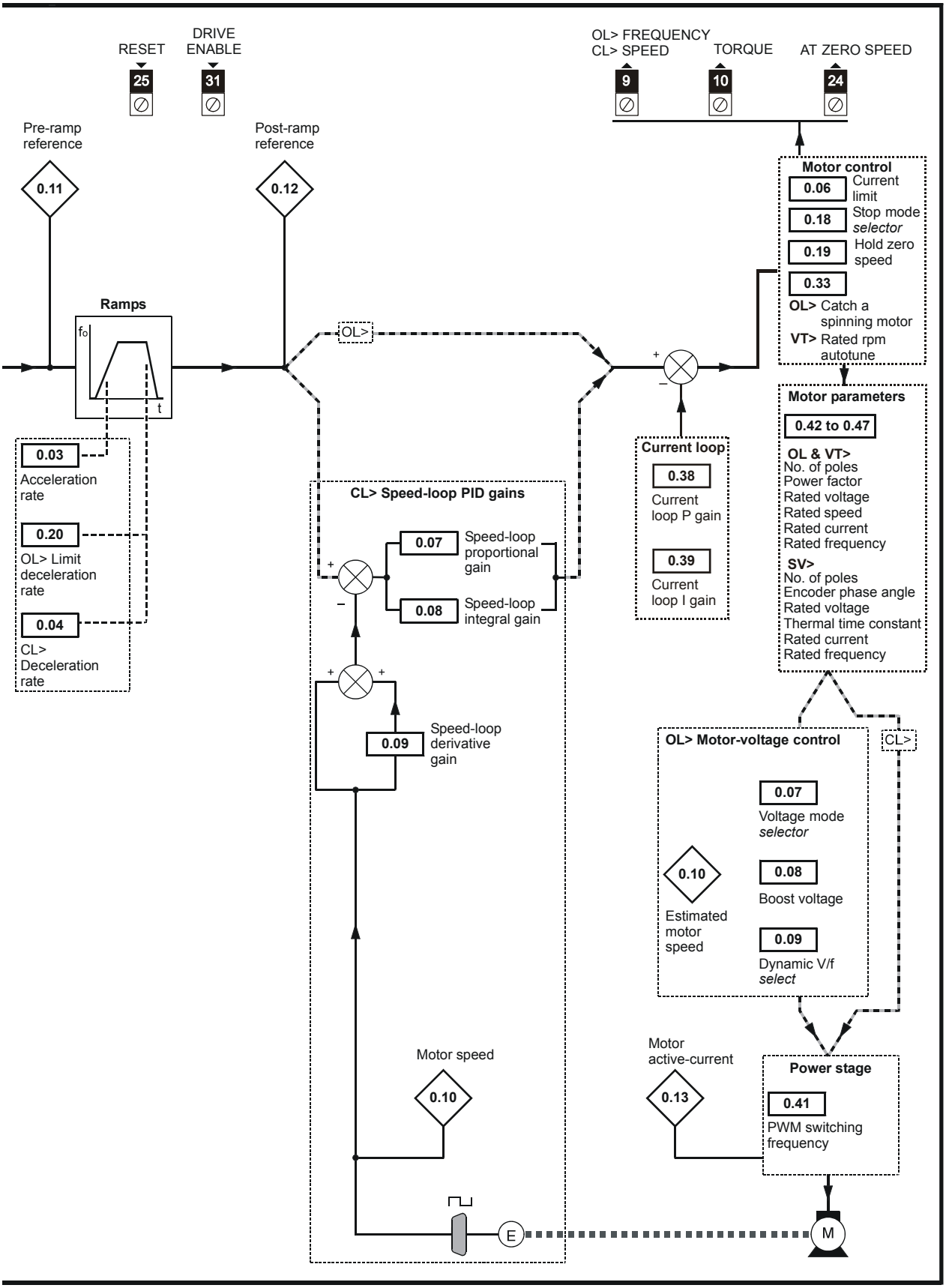
Figure 6-6 Macro 6 Axis limit control logic diagram



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
25
DRIVE ENABLE
31
OL> FREQUENCY
CL> SPEED
9
TORQUE
10
AT ZERO SPEED
24
Pre-ramp reference
0.11
Post-ramp reference
0.12
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
Ramps
fo
t
OL>
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
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
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

6.8 Macro 7 - Brake control

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.

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.	

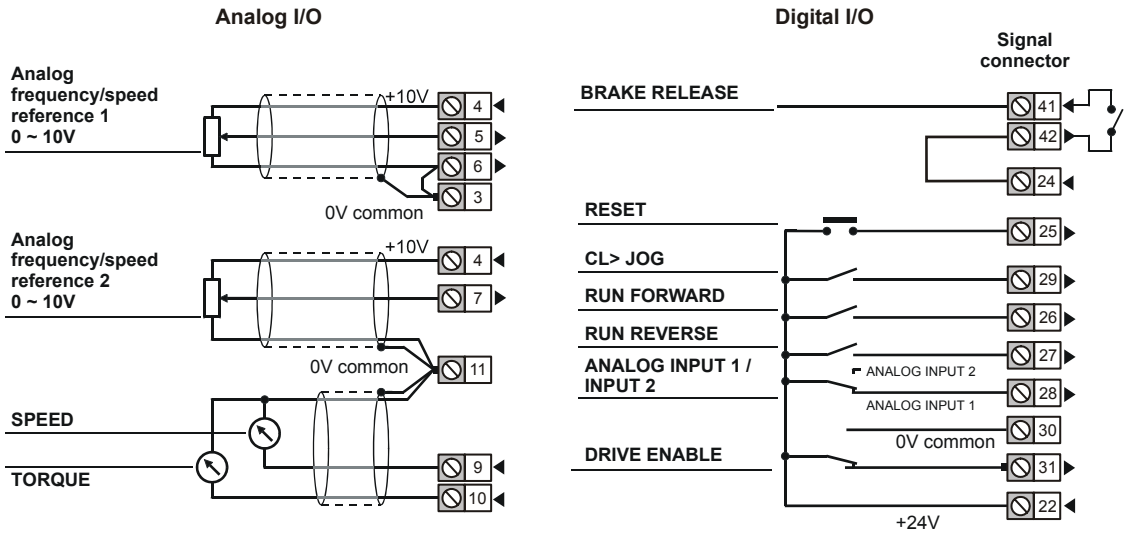


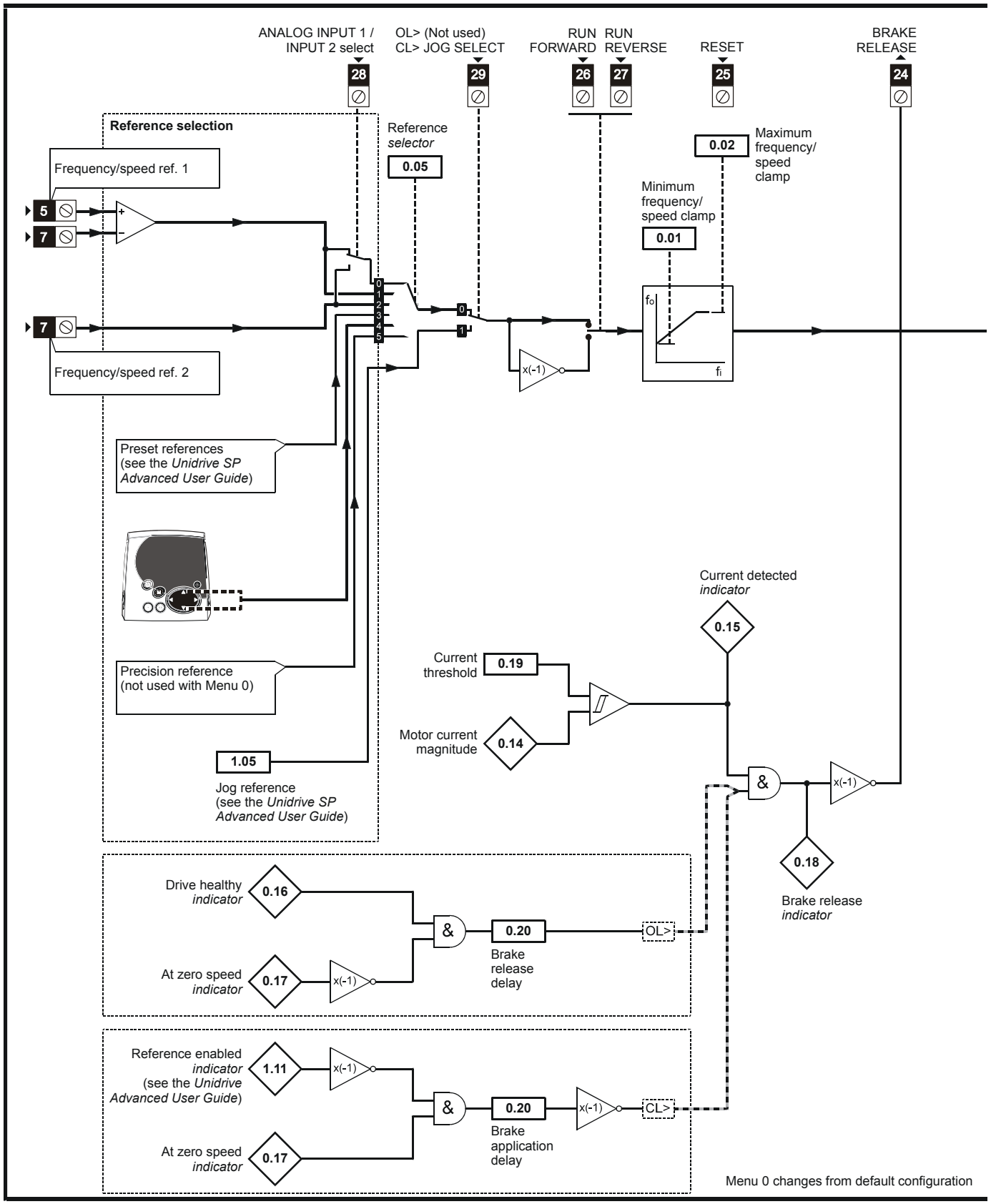
Table 6-14 Macro 7 menu 0 programmable parameters

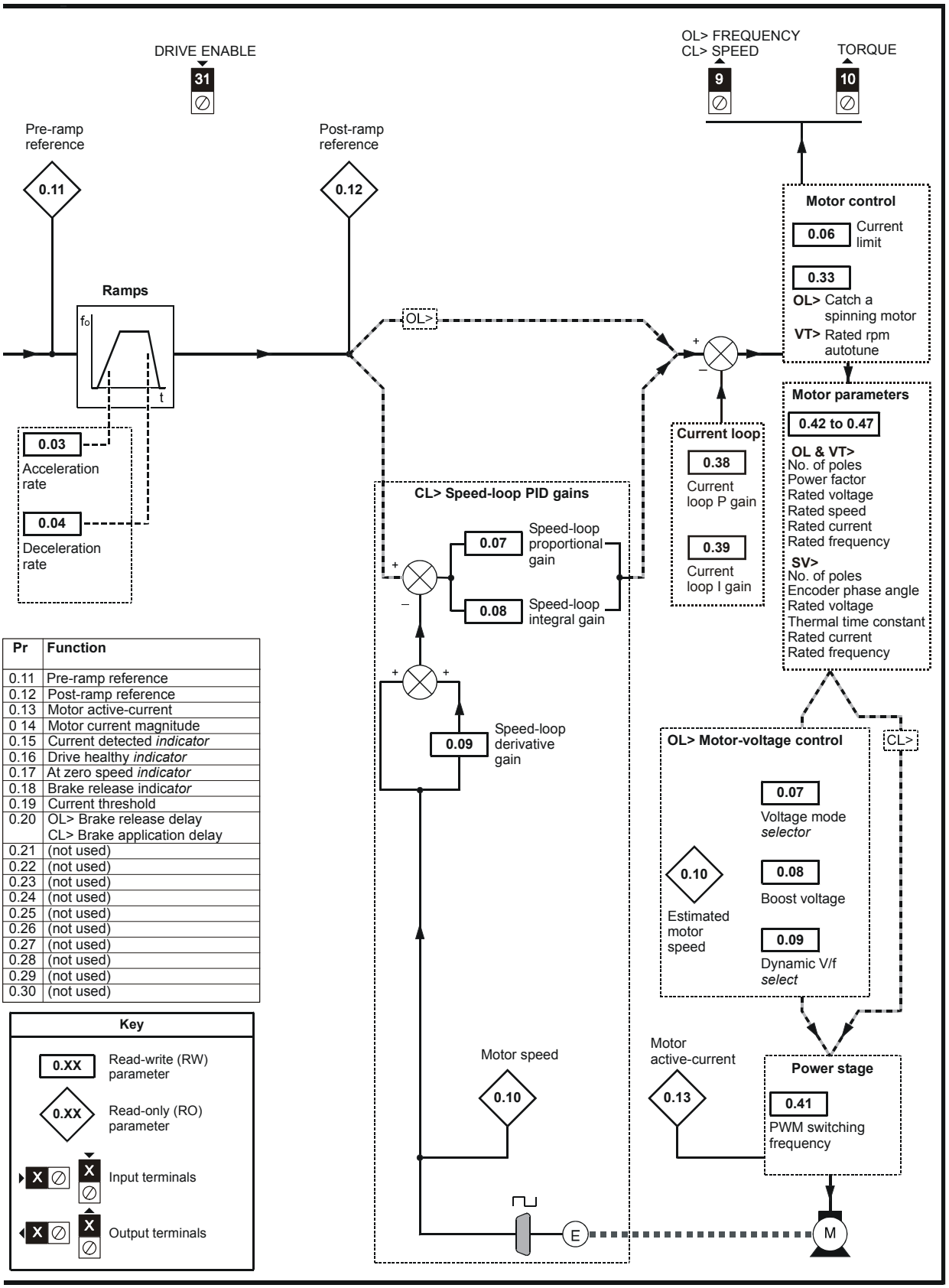
Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
0.11	Pre-ramp reference	{**1.03**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}	±SPEED_FREQ_MAX Hz/rpm					RO	Bi			PT	
0.13	Active current	{**4.02**}	±DRIVE_CURRENT_MAX A					RO	Bi	FI	NC	PT	
0.14	Current 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 healthy	{**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	CL
2.04	Ramp mode	FASt	
3.05	Zero speed threshold	2.0	2
5.27	Enable slip compensation	OFF (0)	
6.08	Hold zero speed	On (1)	
8.11	T24 I/O invert	On (1)	
8.21	T24 digital I/O source / destination	Pr **9.01**	
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	Pr **10.00**	
12.05	Threshold detector 1 hysterisis	Pr **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 indic*ator*
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)

Key

0.XX — Read-write (RW) parameter

0.XX — Read-only (RO) parameter

Input terminals

Output terminals

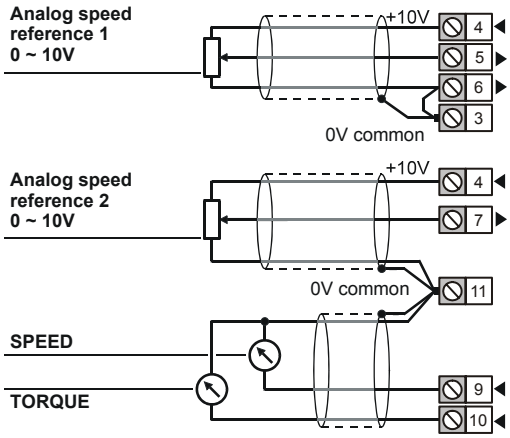
6.9 Macro 8 - Digital Lock

Macro 8	Motorised potentiometer

Only available in closed loop vector or servo operating modes.

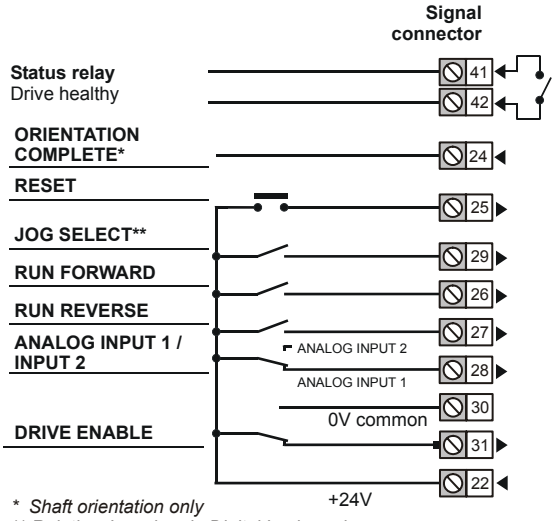
Digital lock: The drive operates as a slave in a closed loop master-slave system. The slave motor is digitally locked to the master motor.
Shaft orientation: The motor speed is controlled in the same way as for default operation, but the motor shaft can be orientated to a specified angular position before and/or after running the motor.

Analog I/O



	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

Digital I/O



** Shaft orientation only*
*** Relative Jog when in Digital Lock mode*

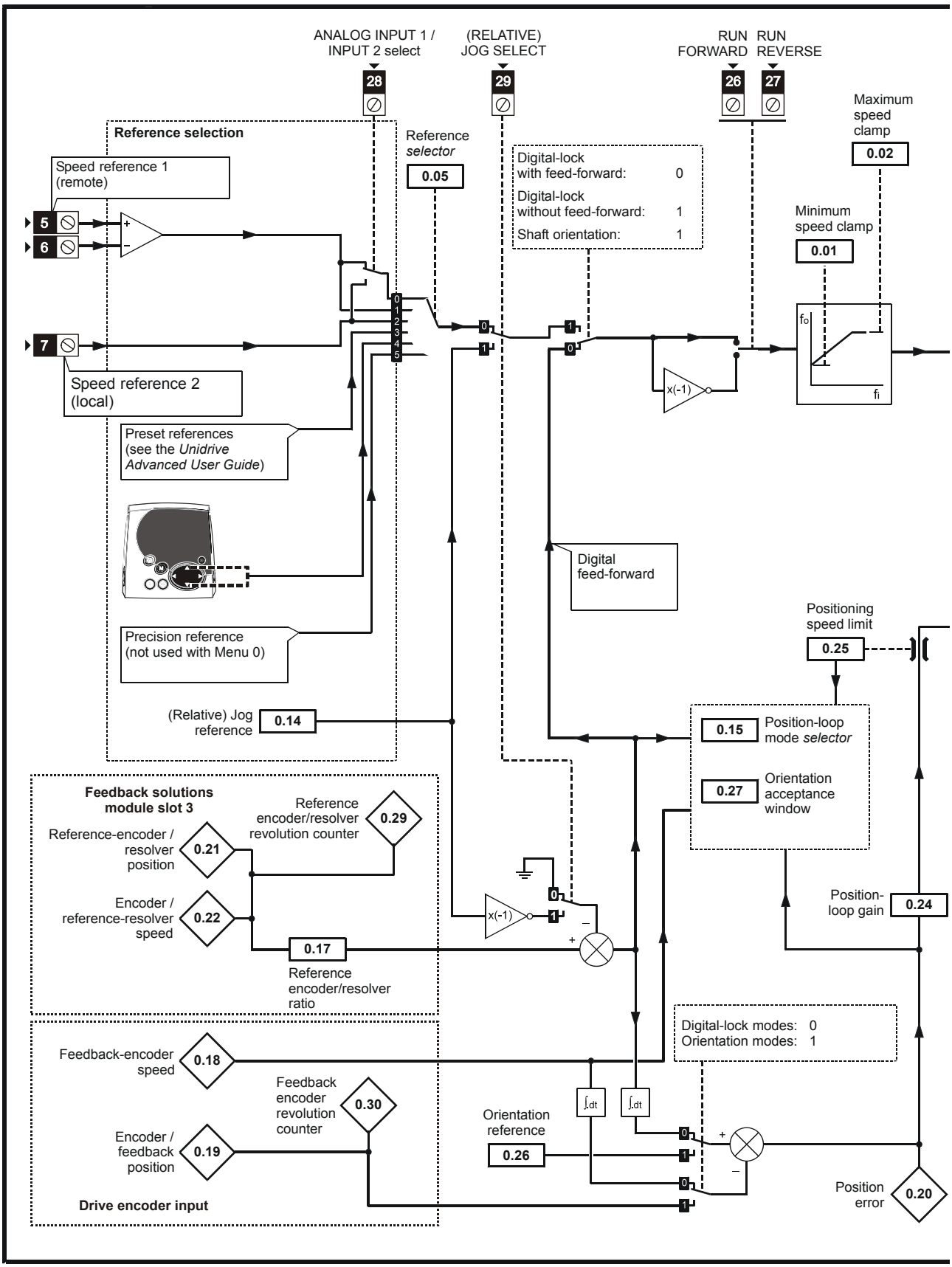
Table 6-16 Macro 8 menu 0 programmable parameters

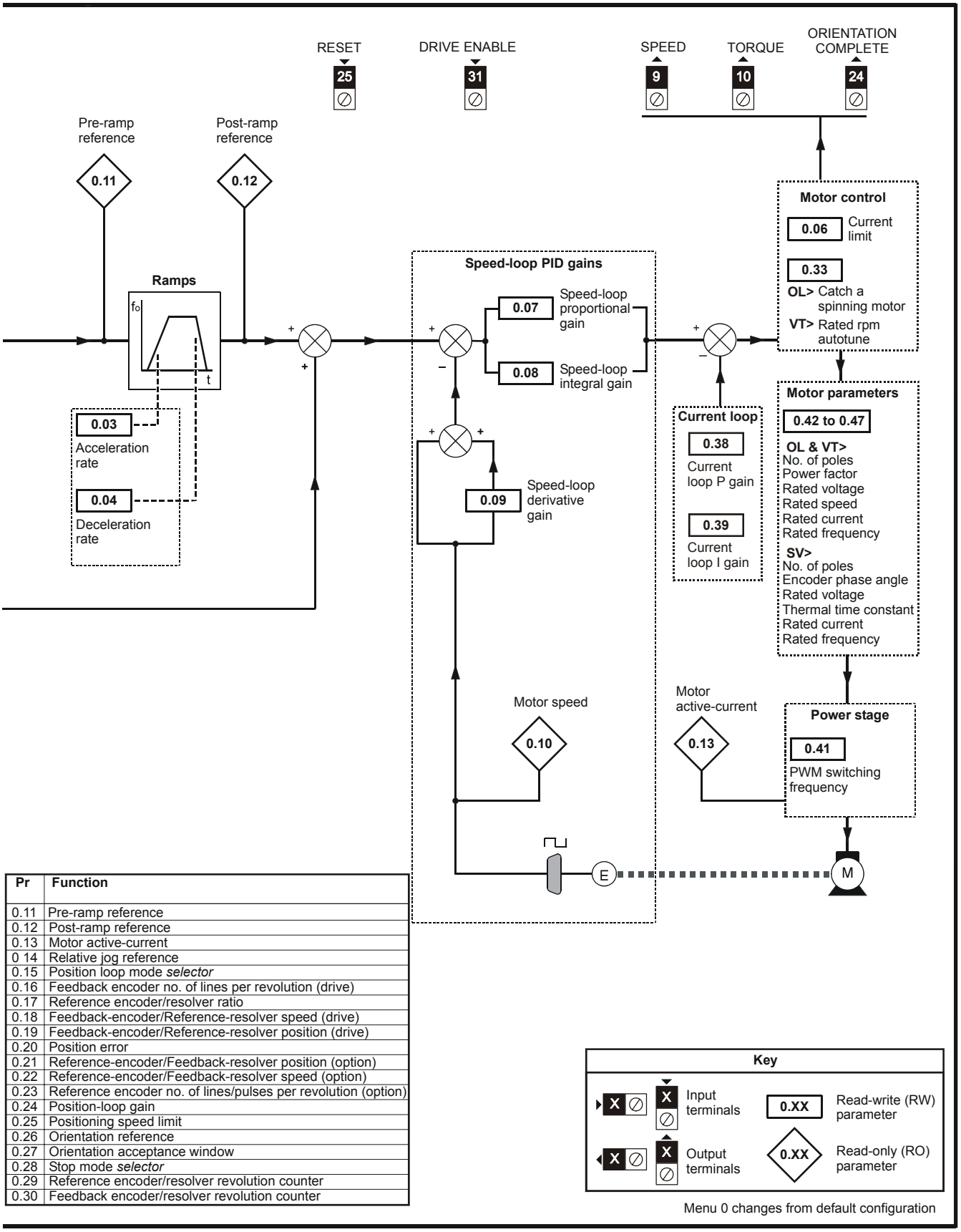
Parameter			Range(⇳)		Default(⇨)			Type					
			OL	CL	OL	VT	SV						
0.11	Pre-ramp reference	{**1.03**}		±SPEED_FREQ_MAX Hz/rpm				RO	Bi		NC	PT	
0.12	Post ramp reference	{**2.01**}		±SPEED_FREQ_MAX Hz/rpm				RO	Bi			PT	
0.13	Active current	{**4.02**}		±DRIVE_CURRENT_MAX A				RO	Bi	FI	NC	PT	
0.14	Relative 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)		Position controller disabled (0)		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 **13.18**
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 **x.05**
11.12	Define Pr **0.22**	Pr **x.03**
11.13	Define Pr **0.23**	Pr **x.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 **x.04**
11.20	Define Pr **0.30**	Pr **3.28**
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 485 is supported directly by connecting the transmit and receive channels together.
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, 57600, 115200

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 reponse

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

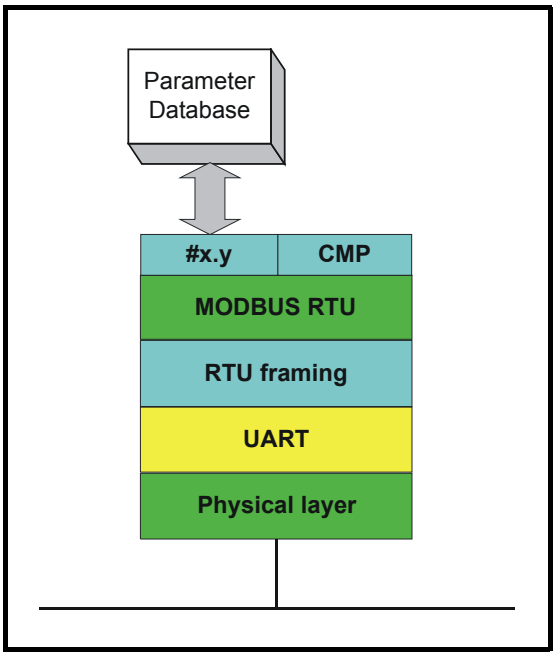
		ASCII code	Ctl code
STX	Start of text	02	B
ETX	End of text	03	C
EOT	End of transmission	04	D
ENQ	Enquiry	05	E
ACK	Acknowledge	06	F
BS	Back space	08	H
NAK	Not acknowledge	15	U

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.

The CMP protocol is also supported using a vendor specific function code. The CMP protocol is provided on some CT products for program download, program debug, advanced diagnostics, etc.



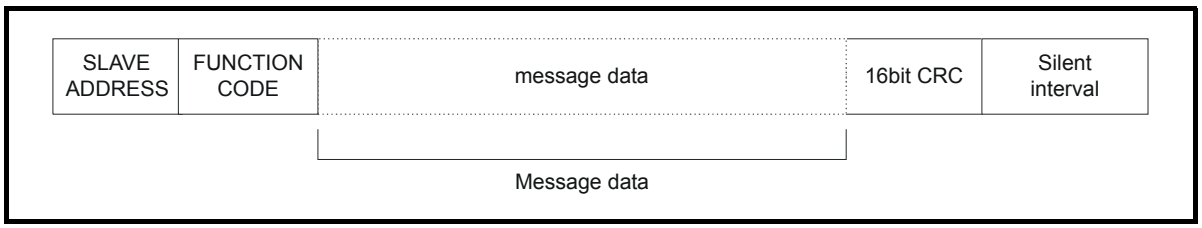
7.2.1 MODBUS RTU

Physical layer

Attribute	Description
Normal physical layer for multi-drop operation	RS485 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

RTU framing

The frame has the following basic format

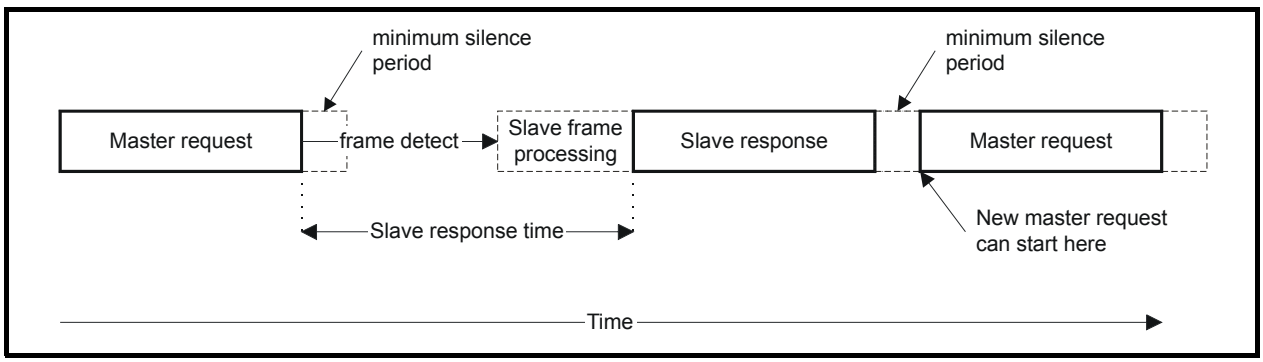


The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without 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 behaviour 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:			
#1.2	40102	101	
#1.0	40100	99	
#0.1	40001	0	
#70.0	47000	6999	

Data types

The MODBUS protocol specification defines registers as 16bit signed integers. All CT devices support this data size.

Refer to the section 7.2.9 *Extended data types* on page 344 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	0x12345678L	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
40	CMP encapsulated protocol Non-standard function code

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

FC6 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 0x6
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 0x6
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

FC40 CMP

Encapsulated CMP protocol. This non-standard function code is used to transfer the CT standard CTNet Message Protocol (CMP).

Table 7-9 Master request

Byte	Description
0	Slave node address 1 through 247 0 is global
1	Function code 0x40
2	CMP destination port
3	CMP destination sub-node address
4	CMP opcode
5	CMP status
6	CMP PID
7	CMP data field of 'n' bytes
7+n	CRC LSB
8+n	CRC MSB

Table 7-10 Slave response

Byte	Description
0	Slave node address 1 through 247 0 is global
1	Function code 0x40
2	CMP source port
3	CMP source sub node address
4	CMP opcode
5	CMP status
6	CMP PID
7	CMP data field of 'n' bytes
7+n	CRC LSB
8+n	CRC MSB

7.2.7 FC40 message routing capability

The FC40 encapsulated protocol includes extra destination fields to be used for message routing between nodes on different networks. The combination of Slave Node Address, CMP Destination Port and CMP Destination Sub-Node Address allow a RTU slave to decide whether to process a received message or retransmit the message through another port onto a different communications network. When a node receives a message addressed to itself (Slave Node Address matches the actual node address), if the CMP Destination Port has the value 0, the nodes processes the message locally; if the CMP Destination Port is non-zero, the node should attempt to re-transmit the message to another node.

While particular implementations may vary, this section uses an example to illustrate how the extra destination port and sub-node addresses can be used to enable message routing.

Unidrive SP / SM-Applications Message Routing Example

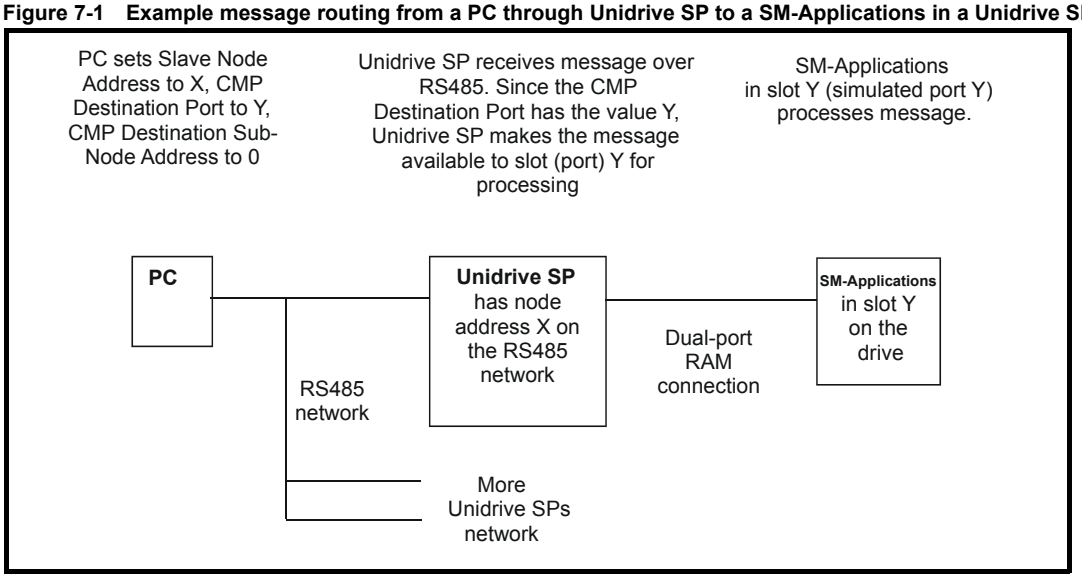
Unidrive SP can hold up to three options in slots 1, 2 or 3. For the purposes of message routing, these slots are treated as ports 1, 2 and 3 on Unidrive SP.

The Unidrive SP/ SM-Applications combination message routing falls into 2 categories:

1. Routing of a CT Modbus RTU by Unidrive SP to a SM-Applications in one of the Unidrive SP options slots.
   In this example, a PC wishes to communicate with a SM-Applications option located in option slot Y (where Y = 1, 2 or 3) in a Unidrive SP with node address X on an RS485 network.
   The PC sets the Slave Node Address to X, the CMP Destination Port to Y and the CMP Destination Sub-Node Address field to 0 in the CT Modbus RTU message and transmits the message over an RS485 network connecting the PC and Unidrive SP.
   The Unidrive SP receives the message and notices that the CMP Destination Port has the value Y - Unidrive SP does not process the

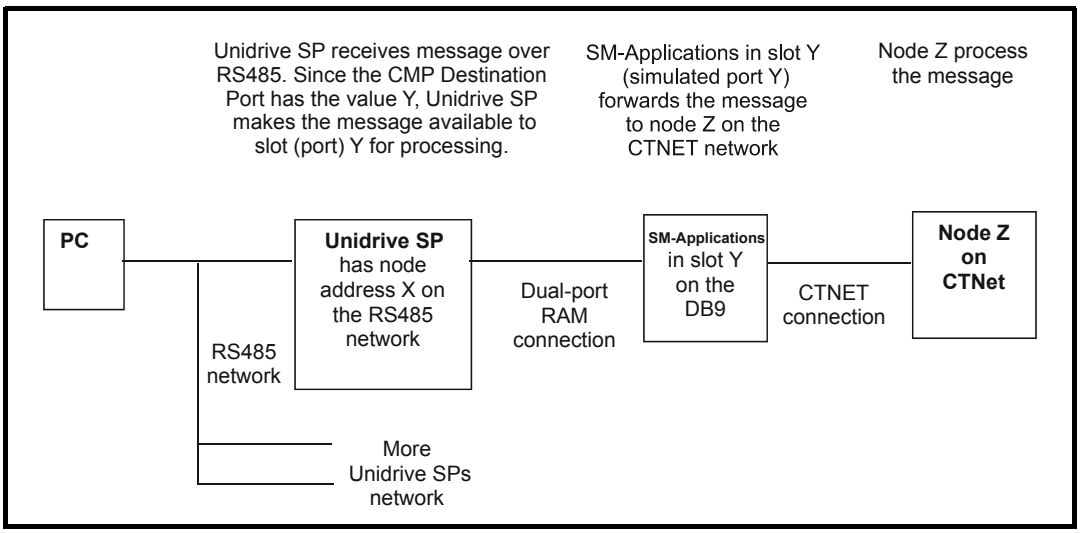
message but forwards the message for processing by the SM-Applications in slot (port) Y.
SM-Applications notices that the CMP Destination Sub-Node Address field is 0 and so processes the message and returns a response.

Figure 7-1 Example message routing from a PC through Unidrive SP to a SM-Applications in a Unidrive SP option slot



2. Routing of a CT Modbus RTU by Unidrive SP to a SM-Applications in one of the Unidrive SP options slots and then re-routing by the SM-Applications onto a CTNet network.
In this example, a PC wishes to communicate with node Z on a CTNET network connected to a SM-Applications option located in option slot Y (where Y = 1, 2 or 3) in a Unidrive SP with node address X on an RS485 network.
The PC sets the Slave Node Address to X, the CMP Destination Port to Y and the CMP Destination Sub-Node Address field to Z in the CT Modbus RTU message and transmits the message over a RS485 network connecting the PC and Unidrive SP.
The Unidrive SP receives the message and notices that the CMP Destination Port has the value Y - Unidrive SP does not process the message but forwards the message for processing by the SM-Applications in slot (port) Y.
SM-Applications notices that the CMP Destination Sub-Node Address field has the value Z and so transmits the CMP portion of the message over its CTNET connection to node Z.
Node Z receives and processes the message and returns a CMP response to the SM-Applications. SM-Applications constructs a suitable CT Modbus RTU response using the CMP response and sends the reconstructed RTU message back to the PC via Unidrive SP.

Figure 7-2 Example message routing from a PC through Unidrive SP and SM-Applications to a CTNet node



7.2.8 Communications timeouts

When a CT Modbus RTU master sends a message to a slave, the master should use a timeout to detect a missing response from a slave. Ideally, a variable timeout will be used based on the number of hops a CT Modbus RTU message makes between the master and its eventual destination. For example, in the Unidrive SP/ SM-Applications re-routing scenarios shown in the previous section, when a PC sends a message to SM-Applications one hop is performed (through Unidrive SP) to reach the SM-Applications; when a PC sends a message via through Unidrive SP and then SM-Applications onto CTNet, two hops are performed.

In practice a master may not be able to handle variable timeouts in such a fashion. If this is the case a single timeout should be used which is large enough to cater for the longest route to a destination. The recommended timeouts for use with a specific product are given in the specific product user guides.

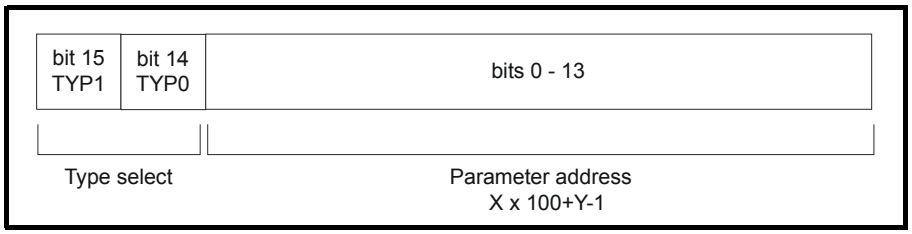
7.2.9 Extended data types

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 16bit and 32bit registers. To permit the master to select the desired 16bit or 32bit 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	IEEE794 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 #20.1 through #20.4 as 32bit parameters using FC03 from node 8:

Table 7-11 Master request

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x40	Start register address #20.01 (0x4000 + 201 - 1) = 16584 = 0x40C8
3	0xC8	
4	0x00	Number of 16bit registers to read #20.1 through #20.4 is 4x32bit registers = 8x16bit registers
5	0x08	
6	CRC LSB	
7	CRC MSB	

Table 7-12 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		#20.01 data
7-10		#20.02 data
11-14		#20.03 data
15-18		#20.04 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 extent 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 #20.1 is a 32 bit parameter with a value of 0x12345678, #20.2 is a 16 bit parameter with a value of 0xABCD, and #20.2 is a 16 bit parameter with a value of 0x0123.

Read	Start register address	Number of 16bit registers	Response	Comments
#20.1	200	1	0x5678	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#20.1	16584	2	0x12345678	Full 32bit access
#20.1	16584	1	Exception 2	Number of words must be even for 32bit access
#20.2	201	1	0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of data
#20.2	16585	2	0xFFFFABCD	32bit access to a 16bit register will return 32bit sign extended data
#20.3	16586	2	0x00000123	32bit access to a 16bit register will return 32bit sign extended data
#20.1-#20.2	200	2	0x5678, 0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#20.1-#20.2	16584	4	0x12345678, 0xFFFFABCD	Full 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 extent the written value, therefore, the effective range of this type of write will be ±32767.

Examples, if #20.1 has a range of ±100000, and #20.2 has a range of ±10000.

Write	Start register address	Number of 16bit registers	Data	Comments
#20.1	200	1	0x1234	Standard 16 bit write to a 32bit register. Value written = 0x00001234
#20.1	200	1	0xABCD	Standard 16 bit write to a 32bit register. Value written = 0xFFFFABCD
#20.1	16584	2	0x00001234	Value written = 0x00001234
#20.2	201	1	0x0123	Value written = 0x0123
#20.2	16585	2	0x00000123	Value written = 0x00000123

7.2.10 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.

7.2.11 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.

7.2.12 Device compatibility parameters

All devices have the following compatibility parameters defined:

Parameter	Description
Device ID	Unique device identification code
Minimum slave response time	
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 used with the MAx range electronic nameplate system. 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 fitted 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.)

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	0.1Hz	0.001Hz	0.1rpm	0.001rpm

*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
Analogue input 1	16 bits plus sign*	16 bits plus sign*
Analogue input 2 / 3	10 bit plus sign	10 bit plus sign

*16 bit plus sign as a speed reference, resolution = Pr **7.26** x 10^6 otherwise

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%
Resolution: 10 bit plus sign
Full scale resolution is equivalent to 222% drive rated current (OI.AC trip level)

9.6 Bandwidth

Speed loop: 150Hz
Current loop: t.b.c.

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