



# *Advanced User Guide*

# **Affinity**

Building Automation  
HVAC/R drive

Part Number: 0474-0011-02  
Issue: 2



[www.controltechniques.com](http://www.controltechniques.com)

## General Information

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

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

All rights reserved. No parts of this guide may be reproduced or transmitted in any form or by any means, electrical or mechanical including photocopying, recording or by an information storage or retrieval system, without permission in writing from the publisher.

## Drive and Building Automation Network (BAN) Interface software version

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

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

The software version of the Building Automation Network (BAN) Interface can be checked by looking at Pr **17.02** and Pr **17.51**. The software version takes the form of xx.yy.zz, where Pr **17.02** displays xx.yy and Pr **17.51** displays zz.

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

## Environmental statement

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

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

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

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

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

# Contents

<b>1</b>	<b>Parameter structure.....</b>	<b>5</b>
1.1	Menu 0 .....	5
1.2	Advanced menus .....	8
1.3	Solutions Modules .....	8
<b>2</b>	<b>Keypad and display .....</b>	<b>9</b>
2.1	Understanding the display .....	9
2.1.1	BA-Keypad (LCD) .....	9
2.2	Keypad operation .....	9
2.2.1	Control buttons .....	9
2.3	Status mode .....	10
2.4	Parameter view mode .....	10
2.5	Edit mode .....	10
2.6	Parameter access level and security .....	12
2.6.1	Access Level .....	12
2.6.2	Changing the Access Level .....	12
2.6.3	User Security .....	12
2.7	Alarm and trip display .....	13
2.8	Keypad control mode .....	13
2.9	Drive reset .....	13
2.10	Second motor parameters .....	13
<b>3</b>	<b>Parameter x.00 .....</b>	<b>14</b>
3.1	Parameter x.00 reset .....	14
3.2	Saving parameters in drive EEPROM .....	14
3.3	Loading defaults .....	15
3.4	SMARTCARD transfers .....	15
3.5	Display non-default values or destination parameters .....	15
<b>4</b>	<b>Typical parameter description format .....</b>	<b>16</b>
4.1	Parameter ranges and variable maximums: .....	17
4.1.1	Default .....	19
4.1.2	Second motor parameter .....	19
4.1.3	Update rate .....	19
4.2	Sources and destinations .....	20
4.2.1	Sources .....	20
4.2.2	Destinations .....	20
4.2.3	Sources and destinations .....	20
4.3	Update rates .....	20
4.3.1	Speed reference update rate .....	21
4.3.2	Hard speed reference update rate .....	21
4.3.3	Torque reference update rate .....	21
<b>5</b>	<b>Advanced parameter descriptions.....</b>	<b>22</b>
5.1	Overview .....	22
5.2	Feature look-up table .....	23
5.3	Menu 1: Frequency/speed reference .....	26
5.3.1	Hand / Off / Auto .....	37
5.4	Menu 2: Ramps .....	40
5.5	Menu 3: Speed feedback and speed control .....	49
5.6	Menu 4: Torque and current control .....	60
5.6.1	Open-loop .....	61
5.6.2	RFC .....	62
5.6.3	Parameter descriptions .....	64
5.7	Menu 5: Motor control .....	77
5.8	Menu 6: Sequencer and clock .....	95
5.9	Menu 7: Analog I/O .....	111
5.10	Menu 8: Digital I/O .....	122
5.11	Menu 9: Programmable logic, motorized pot and binary sum .....	130
5.12	Menu 10: Status and trips .....	140

5.13	Menu 11: General drive set-up .....	159
5.14	Menu 12: Threshold detectors, variable selectors and brake control function .....	172
5.14.1	External Rectifier (BAMC/U) Monitor .....	177
5.14.2	Brake control function .....	177
5.15	Menu 13: Not used .....	184
5.16	Menu 14: Advanced process PID .....	186
5.17	Menus 15 and 16: Solutions Module slots .....	200
5.18	Menu 17: Building Automation Interface .....	201
5.19	Menu 18: Application menu 1 .....	207
5.20	Menu 19: Application menu 2 .....	208
5.21	Menu 20: Application menu 3 .....	209
5.22	Menu 21: Second motor parameters .....	210
5.23	Menu 22: Additional menu 0 set-up .....	217
5.24	32 bit parameters .....	218
5.24.1	Drive parameters .....	218
5.24.2	Solutions Module parameters .....	218
<b>6</b>	<b>PC communications protocol .....</b>	<b>219</b>
6.1	ANSI communications protocol .....	219
6.1.1	Introduction .....	219
6.1.2	Physical layer and UART .....	219
6.1.3	Reading a parameter .....	219
6.1.4	Writing to a parameter .....	219
6.1.5	Drive address .....	220
6.1.6	Short commands .....	220
6.1.7	Summary of control characters .....	220
6.2	CT Modbus RTU specification .....	221
6.2.1	MODBUS RTU .....	221
6.2.2	Slave address .....	221
6.2.3	MODBUS registers .....	222
6.2.4	Data consistency .....	222
6.2.5	Data encoding .....	222
6.2.6	Function codes .....	222
6.2.7	Extended data types .....	223
6.2.8	Exceptions .....	224
6.2.9	CRC .....	225
6.2.10	Device compatibility parameters .....	225
<b>7</b>	<b>Building Automation Network .....</b>	<b>226</b>
7.1	Introduction .....	226
7.2	BACnet .....	226
7.3	Metasys N2 .....	230
7.3.1	Introduction .....	230
7.3.2	Analog Inputs .....	230
7.3.3	Binary Inputs .....	231
7.3.4	Analog outputs .....	232
7.3.5	Binary Outputs .....	232
7.3.6	Internal Float Values .....	233
7.3.7	Metasys N2 commands .....	233
7.3.8	Change of state .....	233
<b>8</b>	<b>Performance .....</b>	<b>234</b>
8.1	Digital speed reference .....	234
8.2	Analog reference .....	234
8.3	Analog outputs .....	234
8.4	Digital inputs and outputs .....	234
8.5	Current feedback .....	235
8.6	Bandwidth .....	235
8.6.1	Speed loop .....	235
8.6.2	Current loop .....	235
<b>9</b>	<b>Rotor Flux Control (RFC) mode .....</b>	<b>236</b>
9.1	Introduction .....	236
9.2	Setting up the RFC mode .....	236
9.3	Further Tuning .....	236

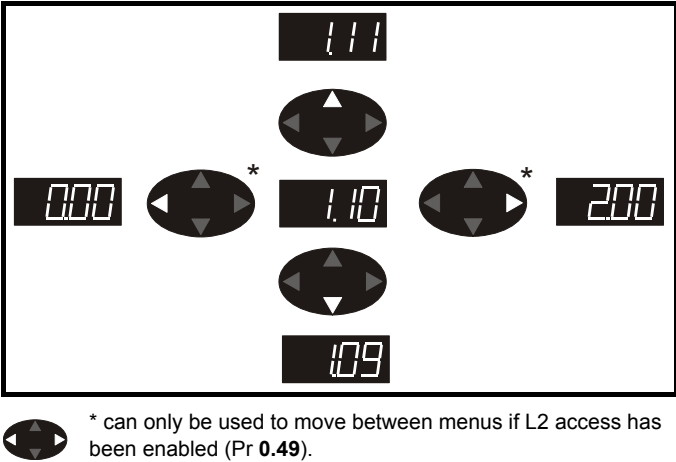


# 1 Parameter structure

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 12.

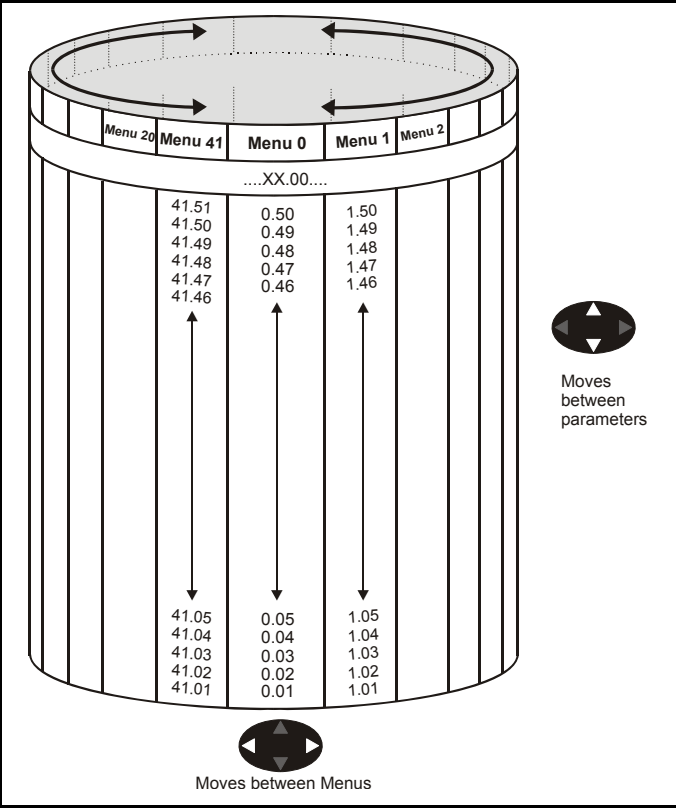
Figure 1-1 Parameter navigation



The menus and parameters roll over in both directions; i.e. if the last parameter is displayed, a further press will cause the display to rollover and show the first parameter.

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

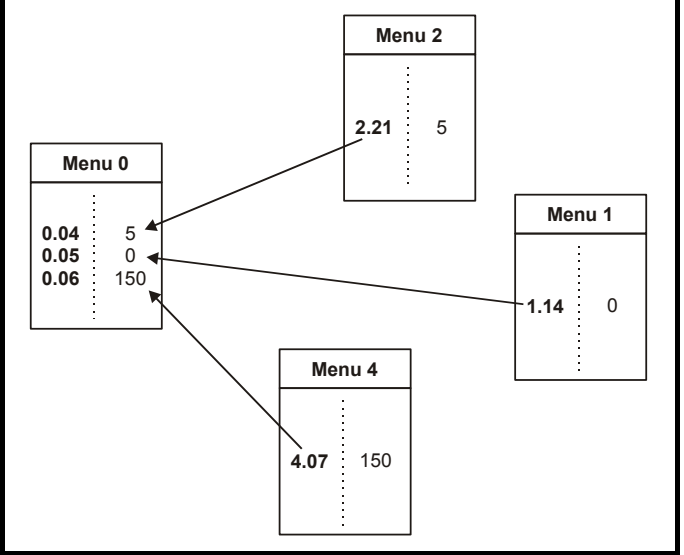
Figure 1-2 Menu structure



## 1.1 Menu 0

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

Figure 1-3 Menu 0 cloning



Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. All the parameters in menu 0 appear in other menus in the drive (denoted by {...}).

Menus 11 and 22 can be used to change most of the parameters in menu 0. Menu 0 can also contain up to 59 parameters by setting up menu 22.

**Table 1-1 Menu 0 parameters**

Parameter			Range(⇅)		Default(⇒)	
			OL	RFC	OL	RFC
0.00	xx.00	{x.00}	0 to 32,767		0	
0.01	Minimum reference clamp	{1.07}	±3,000.0Hz	±SPEED_LIMIT_MAX Hz/rpm	0.0	
0.02	Maximum reference clamp	{1.06}	0 to 3,000.0Hz	SPEED_LIMIT_MAX Hz/rpm	EUR> 50.0 USA> 60.0	EUR> 1,500.0 USA> 1800.0
0.03	Acceleration rate	{2.11}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	EUR> 40.0 USA> 33.3	EUR> 13.333 USA> 11.111
0.04	Deceleration rate	{2.21}	0.0 to 3,200.0 s/100Hz	0.000 to 3,200.000 s/1,000rpm	EUR> 40.0 USA> 33.3	EUR> 13.333 USA> 11.111
0.05	Reference select	{1.14}	A1.A2 (0), A1.Pr (1), A2.Pr (2), Pr (3), PAd (4), Prc (5)		A1.A2 (0)	
0.06	Current limit	{4.07}	0 to CURRENT_LIMIT_MAX %		110	
0.07	OL> Voltage mode select	{5.14}	Ur_S (0), Ur (1), Fd (2), Ur_Auto (3), Ur_I (4), SrE (5)		Fd (2)	
	RFC> Speed controller P gain	{3.10}		0.0000 to 6.5535 1/rad s <sup>-1</sup>		0.0300
0.08	OL> Voltage boost	{5.15}	0.0 to 25.0% of motor rated voltage		Size 1 to 3: 3.0 Size 4 & 5: 2.0 Size 6: 1.0	
	RFC> Speed controller I gain	{3.11}		0.00 to 655.35 1/rad		0.10
0.09	OL> Dynamic V/F	{5.13}	OFF (0) or On (1)		OFF (0)	
	RFC> Speed controller D gain	{3.12}		0.00000 to 0.65535 (s)		0.00000
0.10	OL> Estimated motor speed	{5.04}	±180,000 rpm			
	RFC> Motor speed	{3.02}		±SPEED_MAX rpm		
0.11	Drive output frequency	{5.01}	±SPEED_FREQ_MAX Hz	±1250 Hz		
0.12	Total motor current	{4.01}	0 to DRIVE_CURRENT_MAX A			
0.13	Percentage load	{4.20}	±USER_CURRENT_MAX %			
0.14	Ramp mode select	{2.04}	FASt (0) Std (1) Std.hV (2)	FASt (0) Std (1)	Std (1)	
0.15	Sleep/wake threshold	{6.53}	±SPEED_FREQ_MAX Hz/rpm		0.0	
0.16	Sleep/wake delay time	{6.54}	0.0 to 250.0 s		10.0	
0.17	RFC> Current demand filter 1	{4.12}		0.0 to 25.0 ms		0.0
0.18	Spin start boost	{5.40}	0.0 to 10.0		1.0	
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)		4-20 (4)	
0.20	Analog input 2 destination	{7.14}	Pr 0.00 to Pr 50.99		Pr 1.37	
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)	
0.22	Date	{6.16}	0 to 311299			
0.23	Time	{6.17}	0.00 to 23.59			
0.24	Date/Time selector	{6.19}	0 to 5		3	
0.25	Date format	{6.20}	Std (0), Std.ds (1), US (2), US.ds (3)		EUR> Std (0), USA> US (2)	
0.26	Low load detection level	{4.27}	0.0 to 100.0 %		0.0	
0.27	Low load detection speed / frequency threshold	{4.28}	0.0 to +SPEED_FREQ_MAX Hz/rpm		0.0	
0.28	Trip on abnormal load detection	{4.29}	OFF (0) or On (1)		OFF (0)	
0.29	SMARTCARD parameter data	{11.36}	0 to 999		0	
0.30	Parameter cloning	{11.42}	nonE (0), rEAd (1), Prog (2), AutO (3), boot (4)		nonE (0)	
0.31	Drive rated voltage	{11.33}	200 (0), 400 (1), 575 (2), 690 (3) V			
0.32	Drive current scaling	{11.32}	0.00 to 9999.99A			
0.33	Catch a spinning motor	{6.09}	0 to 3	0 to 1	0	1
0.34	User security code	{11.30}	0 to 999		0	
0.35	PC comms mode	{11.24}	AnSI (0), rTU (1), Lcd (2)		rTU (1)	
0.36	PC 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)	
0.37	PC comms address	{11.23}	0 to 247		1	
0.38	Hold zero speed / Motor pre-heat enable	{6.08}	OFF (0) or On (1)		OFF (0)	
0.39	Motor pre-heat current magnitude	{6.52}	0 to 100 %		0	
0.40	Autotune	{5.12}	0 to 2	0 to 4	0	
0.41	Maximum switching frequency	{5.18}	3 (0), 4 (1), 6 (2), 8 (3), 12 (4), 16 (5) kHz		3 (0)	

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

Parameter			Range(⇅)		Default(⇄)	
			OL	RFC	OL	RFC
0.42	No. of motor poles	{5.11}	0 to 60 (Auto to 120 pole)		0 (Auto)	
0.43	Motor rated power factor	{5.10}	0.000 to 1.000		0.850	
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	
0.45	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
0.46	Motor rated current	{5.07}	0 to RATED_CURRENT_MAX A		Drive rated current [11.32]	
0.47	Rated frequency	{5.06}	0 to 3,000.0 Hz	0 to 1,250.0 Hz	EUR> 50.0 USA> 60.0	
0.48	Operating mode selector	{11.31}	OPEn LP (1), RFC (2),		OPEn LP (1)	RFC (2)
0.49	Security status	{11.44}	L1 (0), L2 (1), Loc (2)			
0.50	Software version	{11.29}	1.00 to 99.99			
0.51	Positive logic select	{8.29}	OFF (0) or On (1)		On (1)	
0.52	Timer 1 start date	{9.35}	0 to 311299		0	
0.53	Timer 1 start time	{9.36}	0.00 to 23.59		0.00	
0.54	Timer 1 stop date	{9.37}	0 to 311299		0	
0.55	Timer 1 stop time	{9.38}	0.00 to 23.59		0.00	
0.56	Timer 1 repeat function	{9.39}	0 to 6		0	
0.57	Timer 1 enable	{9.40}	OFF (0) or On (1)		OFF (0)	
0.58	Timer 1 destination	{9.43}	Pr 0.00 to Pr 50.99		Pr 0.00	

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

Coding	Attribute
OL	Open loop
rfc	RFC
{X.XX}	Cloned / copied advanced parameter
RW	Read/write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter: 'On' or 'OFF' on the display
Bi	Bipolar parameter
Uni	Unipolar parameter
Txt	Text: the parameter uses text strings instead of numbers.
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: This parameter selects the destination of an input or logic function.
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. However, the value will be transferred if only the current rating is different and the file is a differences from default type file.
NC	Not cloned / copied: not transferred to or from SMARTCARDS during cloning.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs. Power-down save parameters are also saved in drive EEPROM when the user initiates a parameter save.

## 1.2 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. These are accessible via the keypad, drive serial comms and Solutions Modules. Advanced menu parameters can only be 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	Not used
14	Advanced process PID
15	Slot 1 Solutions Module menu
16	Slot 2 Solutions Module menu
17	Building Automation Network
18	User application menu 1 (saved in drive EEPROM)
19	User application menu 2 (saved in drive EEPROM)
20	User application menu 3 (not saved in drive EEPROM)
21	Second motor map
22	Additional menu 0 set-up

## 1.3 Solutions Modules

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

## 2 Keypad and display

### 2.1 Understanding the display

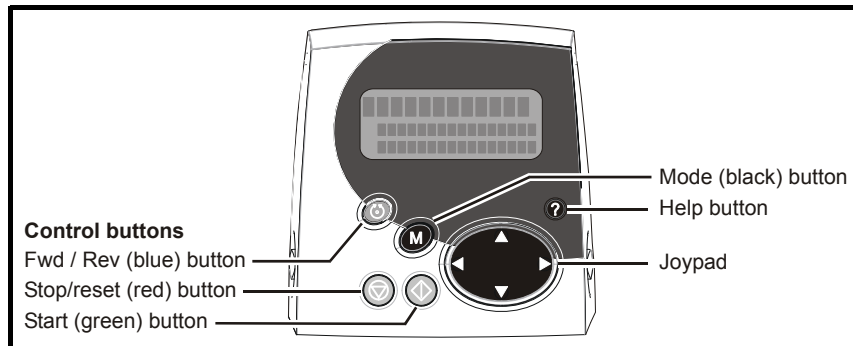
#### 2.1.1 BA-Keypad (LCD)

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 2-1 BA-Keypad**



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

### 2.2 Keypad operation

#### 2.2.1 Control buttons

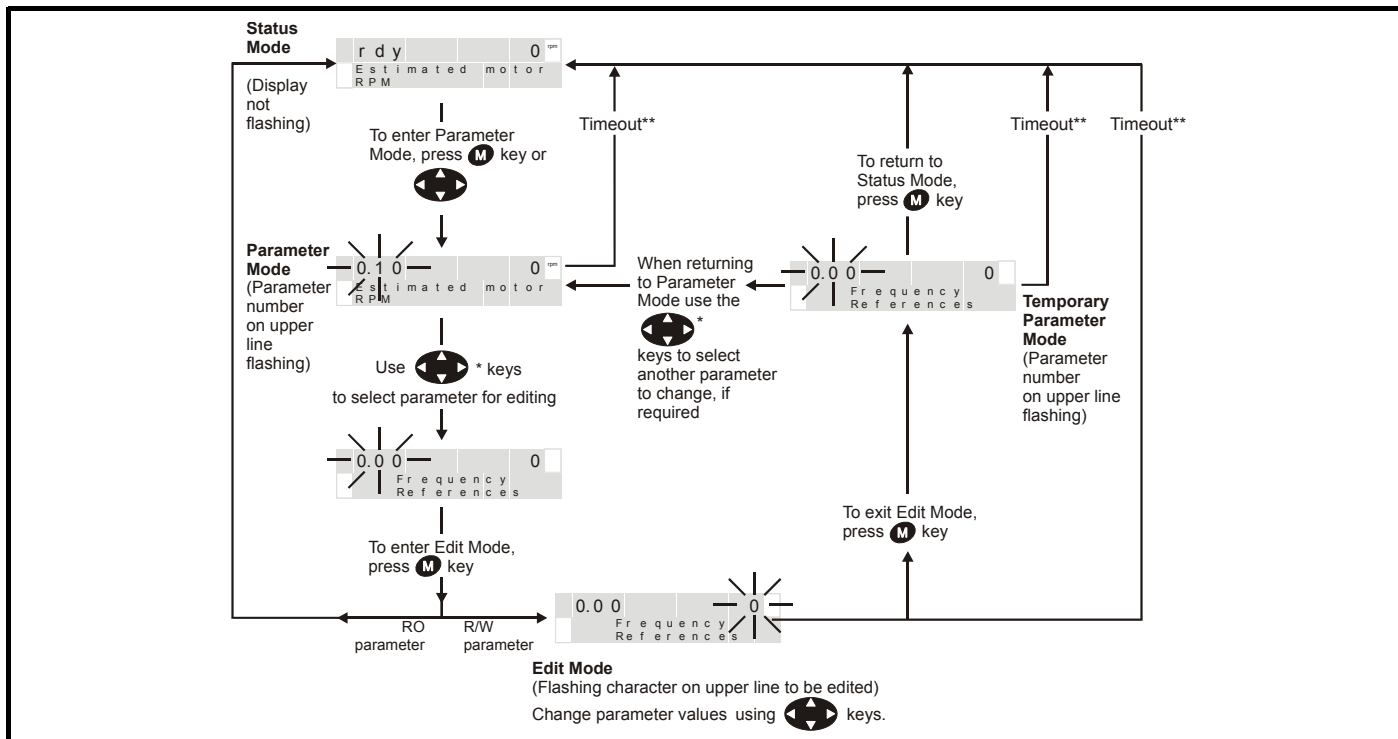
The keypad consists of:

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 select Hand / Off / Auto modes
4. Help button - 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 drive parameters are accessed as shown in Figure 2-2.

**Figure 2-2 Display modes**



## 2.3 Status mode

In status mode, the first row displays a four letter mnemonic on the left indicating the status of the drive together with the parameter last viewed or edited on the right.

State	Upper row
Inhibited: enable input is inactive	inh
Ready: enable closed, but inverter not active	rdy
Stopped: inverter active, but holding zero speed/frequency	stop
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
Tripped: drive is tripped	trip
Drive is running with Hand / Off / Auto disabled	run
Drive is running in Auto mode	auto
Drive is running in Hand mode	hand
Drive is stopped	off

## 2.4 Parameter view mode

In this mode the first row shows the menu.parameter number on the left and the parameter value on the right. The second row gives a parameter value range of -9,999,999 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 41 is reached. A single Right key action when Menu 41 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 41. 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 when using 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.

The BA-Keypad contains two menus, menu 40 and menu 41. The parameters in these menus are listed Table 2-1 on page 11.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

**Table 2-1 Menu 40 parameter descriptions**

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

**Table 2-2 Menu 41 parameter descriptions**

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

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar
Bit	Bit parameter	Txt	Text string	FI	Filtered	DE	Destination
NC	Not cloned / copied	RA	Rating dependent	PT	Protected	US	User save
PS	Power down save						

For more information about the BA Keypad, see the SM-Keypad Plus User Guide.

## 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 22) in addition to menu 0.

The User Security determines whether the access to the user is read only or read write.

Both the User Security and Parameter Access Level can operate independently of each other as shown in the table below:

Parameter Access Level	User Security	Menu 0 status	Advanced menus status
L1	Open	RW	Not visible
L1	Closed	RO	Not visible
L2	Open	RW	RW
L2	Closed	RO	RO

RW = Read / write access RO = Read only access

The default settings of the drive are Parameter Access Level L1 and user Security Open, i.e. read / write access to Menu 0 with the advanced menus not visible.

### 2.6.1 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**

Pr 0.00			
Pr 0.01			
Pr 0.02			
Pr 0.03			
Pr 0.49			
Pr 0.50			

**L2 access selected - All parameters visible**

Pr 0.00	Pr 1.00	.....	Pr 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

### 2.6.2 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 22)

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 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

**User security closed - All parameters: Read Only access (except Pr 0.49 and Pr 11.44)**

Pr 0.00	Pr 1.00	.....	Pr 21.00	Pr 22.00
Pr 0.01	Pr 1.01	.....	Pr 21.01	Pr 22.01
Pr 0.02	Pr 1.02	.....	Pr 21.02	Pr 22.02
Pr 0.03	Pr 1.03	.....	Pr 21.03	Pr 22.03
		.....		
		.....		
Pr 0.49	Pr 1.49	.....	Pr 21.30	Pr 22.28
Pr 0.50	Pr 1.50	.....	Pr 21.31	Pr 22.29

### Setting User Security

Enter a value between 1 and 999 in Pr 0.34 and press the **M** button; the security code has now been set to this value. In order to activate the security, the Access level must be set to Loc in Pr 0.49. When the drive is reset, the security code will have been activated and the drive returns to Access Level L1. The value of Pr 0.34 will return to 0 in order to hide the security code. At this point, the only parameter that can be changed by the user is the Access Level Pr 0.49.

### Unlocking User Security

Select a read write parameter to be edited and press the **M** button, the upper display will now show CodE. Use the arrow buttons to set the security code and press the **M** button.

With the correct security code entered, the display will revert to the parameter selected in edit mode.

If an incorrect security code is entered the display will revert to parameter view mode.

To lock the User Security again, set Pr 0.49 to Loc and press the **⏮** reset button.

### Disabling User Security.

Unlock the previously set security code as detailed above. Set Pr 0.34 to 0 and press the **M** button. The User Security has now been disabled, and will not have to be unlocked each time the drive is powered up to allow read / write access to the parameters.



## 2.7 Alarm and trip display

An alarm can flash alternately with the data displayed on the second row when one of the following conditions occur. If action is not taken to eliminate the alarm, except "Auto tune", "Lt" and "PLC", the drive may eventually trip. Alarms flash once every 640ms except "PLC" which flashes once every 10s. Alarms are not displayed when a parameter is being edited.

Alarm string	Alarm condition
br.rS	Braking resistor (Pr <b>10.39</b> > 75.0% and the braking IGBT is active)
OVLd	Motor overload (Pr <b>4.20</b> > 75% and the drive output current > Pr <b>5.07</b> )
hot	Heatsink or control board alarms are active
Auto tune	Auto tune in progress
Lt	Indicates that a limit switch is active and that it is causing the motor to be stopped (i.e. forward limit switch with forward reference etc.)
PLC	On-board PLC program is running

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

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

## 2.8 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
rfc	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 operable, 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 therefore the parameters must be re-programmed as required and saved in EEPROM.

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

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

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

## 2.10 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 'mot 2' is displayed on the bottom left.

### 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 <b>10.16</b> = 0) and 48V supply is not active (Pr <b>6.44</b> = 0).
1001	Save parameters under all conditions
1070	Reset all Solutions Modules
1233	Load standard defaults
1244	Load US defaults
1253	Change drive mode with standard defaults
1254	Change drive mode with US defaults
1255	Change drive mode with standard defaults (excluding menus 15 to 20)
1256	Change drive mode with US defaults (excluding menus 15 to 20)
2001	Transfer drive parameter to a card and create a bootable difference from default SMARTCARD block with data block number 1 and clear Pr <b>11.42</b> . If data block 1 exists it is over written.
3yyy	Transfer drive EEPROM data to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive ladder program to SMARTCARD block number yyy
6yyy	Transfer SMARTCARD data block yyy to the drive
7yyy	Erase SMARTCARD data block yyy
8yyy	Compare drive parameters with block yyy
9555	Clear SMARTCARD warning suppression flag
9666	Set SMARTCARD warning suppression flag
9777	Clear SMARTCARD read-only flag
9888	Set SMARTCARD read-only flag
9999	Erase SMARTCARD
*12000	Display non-default values only
*12001	Display destination parameters only

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

#### 3.1 Parameter x.00 reset

When an action is started by setting Pr **x.00** to one of the above values and initiating a drive reset this parameter is cleared when the action is completed successfully. If the action is not started, e.g. because the drive is enabled and an attempt is made to load defaults, etc., Pr **x.00** is not cleared and no trip is produced.

If the action is started and then fails for some reason, a trip is always produced and Pr **x.00** is not cleared. It should be noted that parameter saves etc. can also be initiated with the cloning parameter (Pr **11.42**). If actions that can be initiated by either parameter are started and then completed successfully, Pr **x.00** and Pr **11.42** are cleared if they have a value less than 3.

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

#### 3.2 Saving parameters in drive EEPROM

Drive parameters are saved to the drive EEPROM by setting Pr **x.00** to 1000 or 1001 and initiating a drive reset. In addition to user saved parameters, power down save parameters are also saved by these actions and/or by changing the drive mode, but not by any other actions that result in parameters being saved to drive EEPROM (i.e. loading defaults). Power down save parameters are not saved at power down unless the drive is supplied from a normal line power supply, thereby giving the user the option of saving these parameters when required.

When the parameter save is complete, Pr **x.00** is reset to zero by the drive. Care should be taken when saving parameters because this action can take between 400ms and several seconds depending on how many changes are stored in the EEPROM. If the drive is powered down during a parameter save it is possible that data may be lost. When the drive is operating from a normal line power supply then it will stay active for a short time after the power is removed, however, if the drive is being powered from a 24V control supply, or it is being operated from a low voltage battery supply, the drive will power down very quickly after the supply is removed. The drive provides two features to reduce the risk of data loss when the drive is powered down:-

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

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

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

8. As these parameters are not saved if the power is removed unless the drive is supplied with a normal line power supply, this ensures that the power down save parameters are always stored correctly for the new drive mode. The first time parameters are saved after the change of drive mode, however the save will take slightly longer than a normal parameter save.
9. When an Solutions Modules is changed for a different type in a slot, or a module is inserted when one was not present previously or a module is removed the EEPROM is forced to re-initialise itself on the next parameter saves. On the first parameter save one bank is cleared and then written to, and on the next parameter save the other bank is cleared and re-written. Each of these parameter saves takes slightly longer than a normal parameter save.

### 3.3 Loading defaults

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

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

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

Pr	Description	Default	Modes	Voltage rating
<b>1.06</b>	Max reference clamp	60.0Hz	Open-loop	All
<b>1.06</b>	Max reference clamp	1800rpm	RFC	All
<b>2.08</b>	Standard ramp volts	775V	Open-loop, RFC	400V
<b>5.06</b>	Rated frequency	60.0Hz	Open-loop	All
<b>5.08</b>	Rated load rpm	1800rpm	Open-loop	All
<b>5.08</b>	Rated load rpm	1770rpm	RFC	All
<b>5.09</b>	Rated voltage	460V	Open-loop, RFC	400V
<b>6.20</b>	Date format	US (2)	Open-loop, RFC	All
<b>21.01</b>	M2 Max reference clamp	60.0Hz	Open-loop	All
<b>21.01</b>	M2 Max reference clamp	1800rpm	RFC	All
<b>21.06</b>	M2 Rated frequency	60.0Hz	Open-loop	All
<b>21.09</b>	M2 Rated voltage	460V	Open-loop, RFC	400V

### 3.4 SMARTCARD transfers

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

### 3.5 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 Typical parameter description format

In the sections which follow, typical parameter descriptions are given for each advanced parameter set. Each parameter has its own detailed information block as shown here.

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

The first row gives the menu parameter number and name. The other rows describe 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 it via the keypad.

The following types of parameter are possible:

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

**RFC** - The control strategy is rotor flux oriented vector control with closed-loop current operation for induction motors without position feedback.

### Coding

#### NOTE

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

The coding defines the attributes of the parameter as follows:

Coding	Attribute
Bit	1 bit parameter
SP	Spare: not used
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: indicates that this parameter can be a destination parameter.
Txt	Text: the parameter uses text strings instead of numbers.
VM	Variable maximum: the maximum of this parameter can vary.
DP	Decimal place: indicates the number of decimal places used by this parameter.
ND	No default: when defaults are loaded (except when the drive is manufactured or on EEPROM failure) this parameter is not modified.
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. However, the value will be transferred if only the current rating is different and the file is a differences from default type file.
NC	Not cloned / copied: not transferred to or from SMARTCARDS during cloning / copying.
NV	Not visible: not visible on the keypad.
PT	Protected: cannot be used as a destination.
US	User save: saved in drive EEPROM when the user initiates a parameter save.
RW	Read/write: can be written by the user.
BU	Bit default one/unsigned: Bit parameters with this flag set to one have a default of one (all other bit parameters have a default of zero. Non-bit parameters are unipolar if this flag is one.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs. Power-down save parameters are also saved in drive EEPROM when the user initiates a parameter save.

## 4.1 Parameter ranges and variable maximums:

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

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

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, RFC 40000.0rpm]	<b>Maximum speed (RFC mode) reference or frequency (open-loop mode) reference</b> If Pr 1.08 = 0: SPEED_FREQ_MAX = Pr 1.06 If Pr 1.08 = 1: SPEED_FREQ_MAX is Pr 1.06 or – Pr 1.07 whichever is the largest (If the second motor map is selected Pr 21.01 is used instead of Pr 1.06 and Pr 21.02 instead of Pr 1.07)
SPEED_LIMIT_MAX [40000.0rpm]	<b>Maximum applied to speed reference limits</b> In RFC mode SPEED_LIMIT_MAX = 40,000rpm.
SPEED_MAX [40000.0rpm]	<b>Maximum speed</b> This maximum is used for some speed related parameters in menu 3. To allow headroom for overshoot etc. the maximum speed is twice the maximum speed reference. $SPEED\_MAX = 2 \times SPEED\_FREQ\_MAX$
RATED_CURRENT_MAX [9999.99A]	<b>Maximum motor rated current</b> $RATED\_CURRENT\_MAX = 1.36 \times K_C$ . The motor rated current can be increased above $K_C$ up to a level not exceeding $1.36 \times K_C$ . (Maximum motor rated current is the maximum normal duty current rating.) The actual level varies from one drive size to another, refer to Table 4-2.
DRIVE_CURRENT_MAX [9999.99A]	<b>Maximum drive current</b> The maximum drive current is the current at the over current trip level and is given by: $DRIVE\_CURRENT\_MAX = K_C / 0.45$
AC_VOLTAGE_SET_MAX [690V]	<b>Maximum output voltage set-point</b> Defines the maximum motor voltage that can be selected. 200V drives: 240V, 400V drives: 480V 575V drives: 575V, 690V drives: 690V
AC_VOLTAGE_MAX [930V]	<b>Maximum AC output voltage</b> This maximum has been chosen to allow for maximum AC voltage that can be produced by the drive including quasi-square wave operation as follows: $AC\_VOLTAGE\_MAX = 0.78 \times dc\_VOLTAGE\_MAX$ 200V drives: 325V, 400V drives: 650V, 575V drives: 780V, 690V drives: 930V
dc_VOLTAGE_SET_MAX [1150V]	<b>Maximum dc voltage set-point</b> 200V rating drive: 0 to 400V, 400V rating drive: 0 to 800V 575V rating drive: 0 to 955V, 690V rating drive: 0 to 1150V
dc_VOLTAGE_MAX [1190V]	<b>Maximum DC bus voltage</b> The maximum measurable DC bus voltage. 200V drives: 415V, 400V drives: 830V, 575V drives: 990V, 690V drives: 1190V

Maximum	Definition
MOTOR1_CURRENT_LIMIT_MAX [1000.0%]	<p><b>Maximum current limit settings for motor map 1</b> This maximum current limit setting is the maximum applied to the current limit parameters in motor map 1.</p> <p><b>Open Loop</b></p> $\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + \text{PF}^2 - 1\right]}}{\text{PF}} \times 100\%$ <p>Where: The Maximum current is either 1.1 x drive rating or 1.5 x K<sub>C</sub> if the motor rated current set in Pr <b>5.07</b> is more than the drive current scaling given by Pr <b>11.32</b>. Motor rated current is given by Pr <b>5.07</b> PF is motor rated power factor given by Pr <b>5.10</b></p> <p><b>RFC</b></p> $\text{Maximum current limit} = \frac{\sqrt{\left[\left[\frac{\text{Maximum current}}{\text{Motor rated current}}\right]^2 + \cos(\varphi_1)^2 - 1\right]}}{\cos(\varphi_1)} \times 100\%$ <p>Where: The Maximum current is either 1.1 x drive rating or 1.75 x K<sub>C</sub> if the motor rated current set in Pr <b>5.07</b> is more than or equal to the drive current scaling given by Pr <b>11.32</b>. Motor rated current is given by Pr <b>5.07</b> <math>\varphi_1 = \cos^{-1}(\text{PF}) - \varphi_2</math>. This is measured by the drive during an autotune. See Menu 4 in the <i>Advanced User Guide</i> for more information regarding <math>\varphi_2</math>. PF is motor rated power factor given by Pr <b>5.10</b></p>
MOTOR2_CURRENT_LIMIT_MAX [1000.0%]	<p><b>Maximum current limit settings for motor map 2</b> This maximum current limit setting is the maximum applied to the current limit parameters in motor map 2. The formulae for MOTOR2_CURRENT_LIMIT_MAX are the same for MOTOR1_CURRENT_LIMIT_MAX except that Pr <b>5.07</b> is replaced with Pr <b>21.07</b> and Pr <b>5.10</b> is replaced with Pr <b>21.10</b>.</p>
TORQUE_PROD_CURRENT_MAX [1000.0%]	<p><b>Maximum torque producing current</b> This is used as a maximum for torque and torque producing current parameters. It is MOTOR1_CURRENT_LIMIT_MAX or MOTOR2_CURRENT_LIMIT_MAX depending on which motor map is currently active.</p>
USER_CURRENT_MAX [1000.0%]	<p><b>Current parameter limit selected by the user</b> The user can select a maximum for Pr <b>4.08</b> (torque reference) and Pr <b>4.20</b> (percentage load) to give suitable scaling for analog I/O with Pr <b>4.24</b>. 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 <b>4.24</b></p>
POWER_MAX [9999.99kW]	<p><b>Maximum power in kW</b> The maximum power has been chosen to allow for the maximum power that can be output by the drive with maximum AC output voltage, maximum controlled current and unity power factor. Therefore: <math>\text{POWER\_MAX} = \sqrt{3} \times \text{AC\_VOLTAGE\_MAX} \times \text{DRIVE\_CURRENT\_MAX}</math></p>

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

**Table 4-2 Maximum motor rated current (sizes 1 to 6)**

Model	Kc	Maximum normal duty current rating A
BA1201	4.3	5.2
BA1202	5.8	6.8
BA1203	7.5	9.6
BA1204	10.6	11
BA2201	12.6	15.5
BA2202	17.0	22.0
BA2203	25.0	28.0
BA3201	31.0	42.0
BA3202	42.0	54.0
BA4201	56.0	68.0
BA4202	68.0	80.0
BA4203	80.0	104.0
BA1401	2.1	2.8
BA1402	3.0	3.8
BA1403	4.2	5.0
BA1404	5.8	6.9
BA1405	7.6	8.8
BA1406	9.5	11.0
BA2401	13.0	15.3
BA2402	16.5	21.0
BA2403	23.0	29.0
BA3401	32.0	35.0
BA3402	40.0	43.0
BA3403	46.0	56.0
BA4401	60.0	68.0
BA4402	74.0	83.0
BA4403	96.0	104.0
BA5401	124.0	138.0
BA5402	156.0	168.0
BA6401	154.2	202.0
BA6402	180.0	236.0
BA3501	4.1	5.4
BA3502	5.4	6.1
BA3503	6.1	8.4
BA3504	9.5	11.0
BA3505	12.0	16.0
BA3506	18.0	22.0
BA3507	22.0	27.0
BA4601	19.0	22.0
BA4602	22.0	27.0
BA4603	27.0	36.0
BA4604	36.0	43.0
BA4605	43.0	52.0
BA4606	52.0	62.0

Model	Kc	Maximum normal duty current rating A
BA5601	63.0	84.0
BA5602	85.0	99.0
BA6601	85.7	125.0
BA6602	107.1	144.0
BAMD12X1	133.7	192
BAMD12X2	164.5	248
BAMD12X3	214.2	312
BAMD12X4	248.5	350
BAMA14X1	154.2	202
BAMA14X2	180.0	236
BAMD14X1	154.2	202
BAMD14X2	180.0	246
BAMD14X3	205.7	290
BAMD14X4	248.5	330
BAMA16X1	85.7	125
BAMA16X2	107.1	144
BAMD16X1	85.7	125
BAMD16X2	107.1	144
BAMD16X3	123.4	168
BAMD16X4	144.0	192

#### 4.1.1 Default

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

#### 4.1.2 Second motor parameter

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

#### 4.1.3 Update rate

Defines the rate at which the parameter data is written by the drive (write) or read and acted upon by the drive (read). Where background update rate is specified, the update time depends on the drive processor load. Generally the update time is between 2ms and 30ms, however, the update time is significantly extended when loading defaults, changing drive mode, transferring data to/from a SMARTCARD, or transferring blocks of parameters or large CMP data blocks to/from the drive (not a Solutions Module) via the drive serial comms port.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

## 4.2 Sources and destinations

### 4.2.1 Sources

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

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

### 4.2.2 Destinations

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

1. If the parameter number in the destination pointer parameter does not exist then the output value has no effect.
2. If the destination parameter is protected then the output value has no effect.
3. If the function output is a bit value (i.e. a digital input) the destination parameter value does not operate in the same way as a source described above, but is always either 0 or 1 depending on the state of the function output whether the destination parameter is a bit parameter or not.

## 4.3 Update rates

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

3.03	Speed error															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	R W	BU	PS
			1			1	1	1		1		1				
Range	RFC							±SPEED_MAX rpm								
Update rate	4ms write															

Some parameters have an increased update in special circumstances.

4. If the function output is not a bit value (i.e. analog input) and the destination parameter is not a bit parameter, the destination value is given by (function output x destination parameter maximum) / 100%. Generally the result is rounded down to the nearest unit, but other rounding effects may occur depending on the internal scaling of the particular source function (rounded down to nearest unit). Pr **1.36** and Pr **1.37** are a special case. The scaling shown in the description of parameter Pr **1.08** is used when any non-bit type quantity is routed to these parameters.
5. If the function output is not a bit value and the destination parameter is a bit value, the destination value is 0 if the function output is less than 50% of its maximum value, otherwise it is 1.
6. If more than one destination selector is routed to the same destination, the value of the destination parameter is undefined. The drive checks for this condition where the destinations are defined in any menu except menus 15 to 17. If a conflict occurs a dEST trip occurs that cannot be reset until the conflict is resolved.

### 4.2.3 Sources and destinations

1. Bit and non-bit parameters may be connected to each other as sources or destinations. The scaling is as described previously.
2. All new source and destination routing only changes to new set-up locations when the drive is reset.

When a destination pointer parameter within the drive or a dumb Solutions Modules (SM-I/O plus) is changed the old destination is written to zero, unless the destination change is the result of loading defaults or transferring parameters from a SMARTCARD. When defaults are loaded the old destination is set to its default value. When parameters are loaded from a SMARTCARD the old destination retains its old value unless a SMARTCARD value is written to it.



Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

#### 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 250 $\mu$ s 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.

#### 4.3.2 Hard speed reference update rate

The normal update rate for the hard speed reference is 4ms, however it is possible to reduce the sample time to 250 $\mu$ s 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.

#### 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 250 $\mu$ s by selecting the reference from particular sources, but only in RFC mode. 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 description**

Menu number	Description
0	Commonly used basic set up parameters for quick / easy programming
1	Frequency / speed reference
2	Ramps
3	Speed feedback and speed control
4	Torque and current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
9	Programmable logic, motorized pot and binary sum
10	Status and trips
11	General drive set-up
12	Threshold detectors and variable selectors
13	Not used
14	Advanced process PID
15, 16	Solutions Module slots
17	Building Automation Network
18	Application menu 1
19	Application menu 2
20	Application menu 3
21	Second motor parameters
22	Additional Menu 0 set-up

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

**Table 5-2 Key to parameter coding**

Coding	Attribute
RW	Read/write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter. 'On' or 'OFF' on the display
Bi	Bipolar parameter
Uni	Unipolar parameter
Txt	Text: the parameter uses text strings instead of numbers.
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: This parameter selects the destination of an input or logic function.
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS, when the rating of the destination drive is different from the source drive and the file is a parameter file. However, the value will be transferred if only the current rating is different and the file is different to the default file type.
NC	Not cloned / copied: not transferred to or from SMARTCARDS during cloning / copying.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs or when the user initiates a parameter save.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

## 5.2 Feature look-up table

Feature	Parameter number (Pr)												
Acceleration rates	2.10	2.11 to 2.19	2.32	2.33	2.34	2.02							
Analog speed reference 1	1.36	7.10	7.01	7.07	7.08	7.09	7.25	7.26	7.30				
Analog speed reference 2	1.37	7.14	1.41	7.02	7.11	7.12	7.13	7.28	7.31				
Analog I/O	Menu 7												
Analog input 1	7.01	7.07	7.08	7.09	7.10	7.25	7.26	7.30					
Analog input 2	7.02	7.11	7.12	7.13	7.14	7.28	7.31						
Analog input 3	7.03	7.15	7.16	7.17	7.18	7.29	7.32						
Analog output 1	7.19	7.20	7.21	7.33									
Analog output 2	7.22	7.23	7.24										
Application menu	Menu 18	Menu 19	Menu 20										
At speed indicator bit	3.06	3.07	3.09	10.06	10.05	10.07							
Auto reset	10.34	10.35	10.36	10.01									
Autotune	5.12	5.17	5.23	5.24	5.25	5.10	5.29	5.30					
Binary sum	9.29	9.30	9.31	9.32	9.33	9.34							
Bipolar speed	1.10												
Brake control	12.40 to 12.48												
Braking	10.11	10.10	10.30	10.31	6.01	2.04	2.02	10.12	10.39	10.40			
Building Automation Network	Menu 17												
Catch a spinning motor	6.09												
Cloning	11.42	11.36 to 11.40											
Coast to stop	6.01												
Comms	11.23 to 11.26												
Cost - per kWh electricity	6.24	6.25	6.26	6.27	6.28								
Current controller	4.13	4.14											
Current feedback	4.01	4.02	4.17	4.04	4.12	4.20	4.23	4.24	4.26	10.08	10.09	10.17	
Current limits	4.05	4.06	4.07	4.18	4.15	4.19	4.16	5.07	5.10	10.08	10.09	10.17	
DC bus voltage	5.05	2.08											
dc injection braking	6.06	6.07	6.01										
Deceleration rates	2.20	2.21 to 2.29	2.04	2.35 to 2.37	2.02			2.08	6.01	10.30	10.31	10.39	
Defaults	11.43	11.46											
Digital I/O	Menu 8												
Digital I/O read word	8.20												
Digital I/O T24	8.01	8.11	8.21	8.31									
Digital I/O T25	8.02	8.12	8.22	8.32									
Digital I/O T26	8.03	8.13	8.23	8.33									
Digital input T27	8.04	8.14	8.24										
Digital input T28	8.05	8.15	8.25	8.39									
Digital input T29	8.06	8.16	8.26	8.39									
Digital output T22	8.08	8.18	8.28										
Direction	10.13	6.30	6.31	1.03	10.14	2.01	3.02	8.03	8.04	10.40			
Display timeout	11.41												
Drive active	10.02	10.40											
Drive current scaling	5.07	11.32											
Drive derivative	11.28												
Drive OK	10.01	8.27	8.07	8.17	10.36	10.40							
Dynamic performance	5.26												
Dynamic V/F	5.13												
Enable	6.15	8.09	8.10										
External trip	10.32	8.10	8.07										
Fan speed	6.45												
Fast disable	6.29												
Filter change	6.21	6.22											
Fire mode	1.53	1.54											
Frequency reference selection	1.14	1.15											
Hard speed reference	3.22	3.23											
High stability space vector modulation	5.19												
I/O sequencer	6.04	6.30	6.31	6.32	6.33	6.34	6.42	6.43	6.41				
Inertia compensation	2.38	5.12	4.22	3.18									
Jog reference	1.05	2.19	2.29										
Keypad operating mode	1.52												
Keypad reference	1.17	1.14	1.43	1.51	6.12	6.13							
Kt	5.32												

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

Feature	Parameter number (Pr)												
Limit switches	6.35	6.36											
Line power supply loss	6.03	10.15	10.16	5.05									
Logic function 1	9.01	9.04	9.05	9.06	9.07	9.08	9.09	9.10					
Logic function 2	9.02	9.14	9.15	9.16	9.17	9.18	9.19	9.20					
Low load detection	4.20	4.27	4.28	4.20	10.6								
Low voltage supply	6.44	6.46											
Maximum speed	1.06												
Menu 0 set up	11.01 to 11.22		Menu 22										
Minimum speed	1.07	10.04											
Modules - number of	11.35												
Motor map	5.06	5.07	5.08	5.09	5.10	5.11							
Motor map 2	Menu 21		11.45										
Motor pre-heat	6.08	6.52											
Motorized potentiometer	9.21	9.22	9.23	9.24	9.25	9.26	9.27	9.28					
Offset speed reference	1.04	1.38	1.09										
Onboard PLC	11.47 to 11.51												
Open collector digital outputs	8.30												
Open loop vector mode	5.14	5.17	5.23										
Operating mode	0.48	11.31											
Output	5.01	5.02	5.03	5.04									
Overspeed threshold	3.08												
PID controller	Menu 14												
Positive logic	8.29												
Power up parameter	11.22	11.21											
Precision reference	1.18	1.19	1.20	1.44									
Preset speeds	1.15	1.21 to 1.28		1.16	1.14	1.42	1.45 to 1.48		1.50				
Programmable logic	Menu 9												
Quasi square operation	5.20												
Ramp (accel / decel) mode	2.04	2.08	6.01	2.02	2.03	10.30	10.31	10.39					
Real time clock	6.16	6.17	6.18	6.19	6.20								
Regenerating	10.10	10.11	10.30	10.31	6.01	2.04	2.02	10.12	10.39	10.40			
Relay output	8.07	8.17	8.27										
Reset	10.33	8.02	8.22	10.34	10.35	10.36	10.01						
RFC mode	3.24	3.42	4.12	5.40									
S ramp	2.06	2.07											
Sample rates	5.18												
Security code	11.30	11.44											
Serial comms	11.23 to 11.26												
Skip speeds	1.29	1.30	1.31	1.32	1.33	1.34	1.35						
Sleep mode	6.53	6.54											
Slip compensation	5.27	5.08											
SMARTCARD	11.36 to 11.40		11.42										
Software version	11.29	11.34											
Speed controller	3.10 to 3.17		3.19	3.20	3.21								
Speed feedback	3.02	3.03	3.04										
Speed reference selection	1.14	1.15	1.49	1.50	1.01								
Status word	10.40												
Supply	6.44	5.05	6.46										
Switching frequency	5.18	5.35	7.34	7.35									
Thermal protection - drive	5.18	5.35	7.04	7.05	7.06	7.32	7.35	10.18					
Thermal protection - motor	4.15	5.07	4.19	4.16	4.25	7.15							
Thermistor input	7.15	7.03											
Threshold detector 1	12.01	12.03 to 12.07											
Threshold detector 2	12.02	12.23 to 12.27											
Time - filter change	6.21	6.22											
Time - powered up log	6.16	6.17	6.19	6.20									
Time - run log	6.16	6.17	6.19	6.20									
Timer functions	9.35 to 9.53												
Torque	4.03	4.26	5.32										
Torque mode	4.08	4.11	4.09	4.10									
Trip detection	10.37	10.38	10.20 to 10.29										
Trip log	10.20 to 10.29		10.41 to 10.60		6.28	6.49							
Under voltage	5.05	10.16	10.15										
V/F mode	5.15	5.14											
Variable selector 1	12.08 to 12.15												

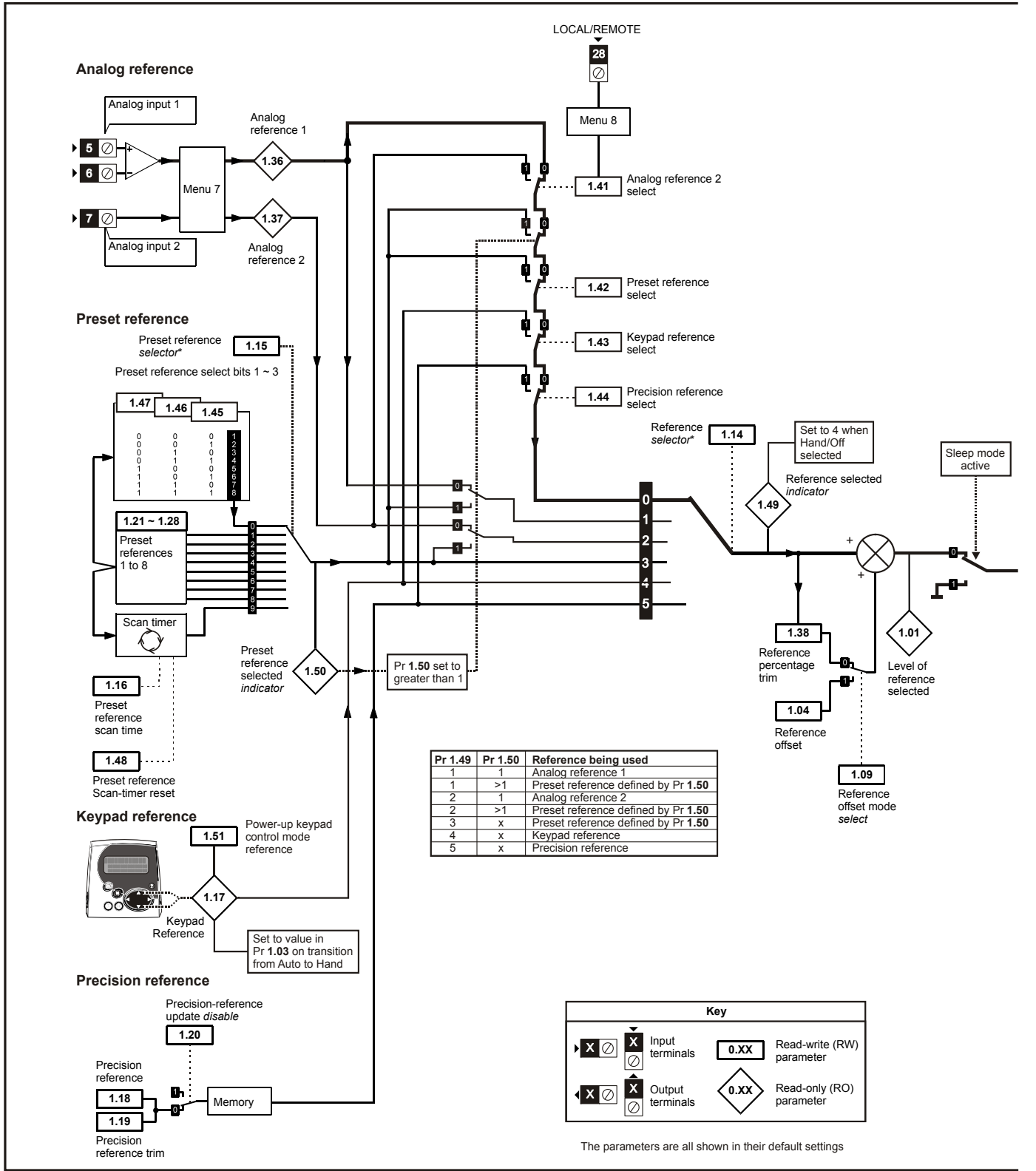
Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

Feature	Parameter number (Pr)												
Variable selector 2	12.28 to 12.35												
Voltage controller	5.31												
Voltage mode	5.14	5.17	5.23	5.15									
Voltage rating	11.33	5.09	5.05										
Voltage supply	6.44	6.46	5.05										
Warning	10.19	10.12	10.17	10.18	10.40								
Zero speed indicator bit	3.05	10.03											

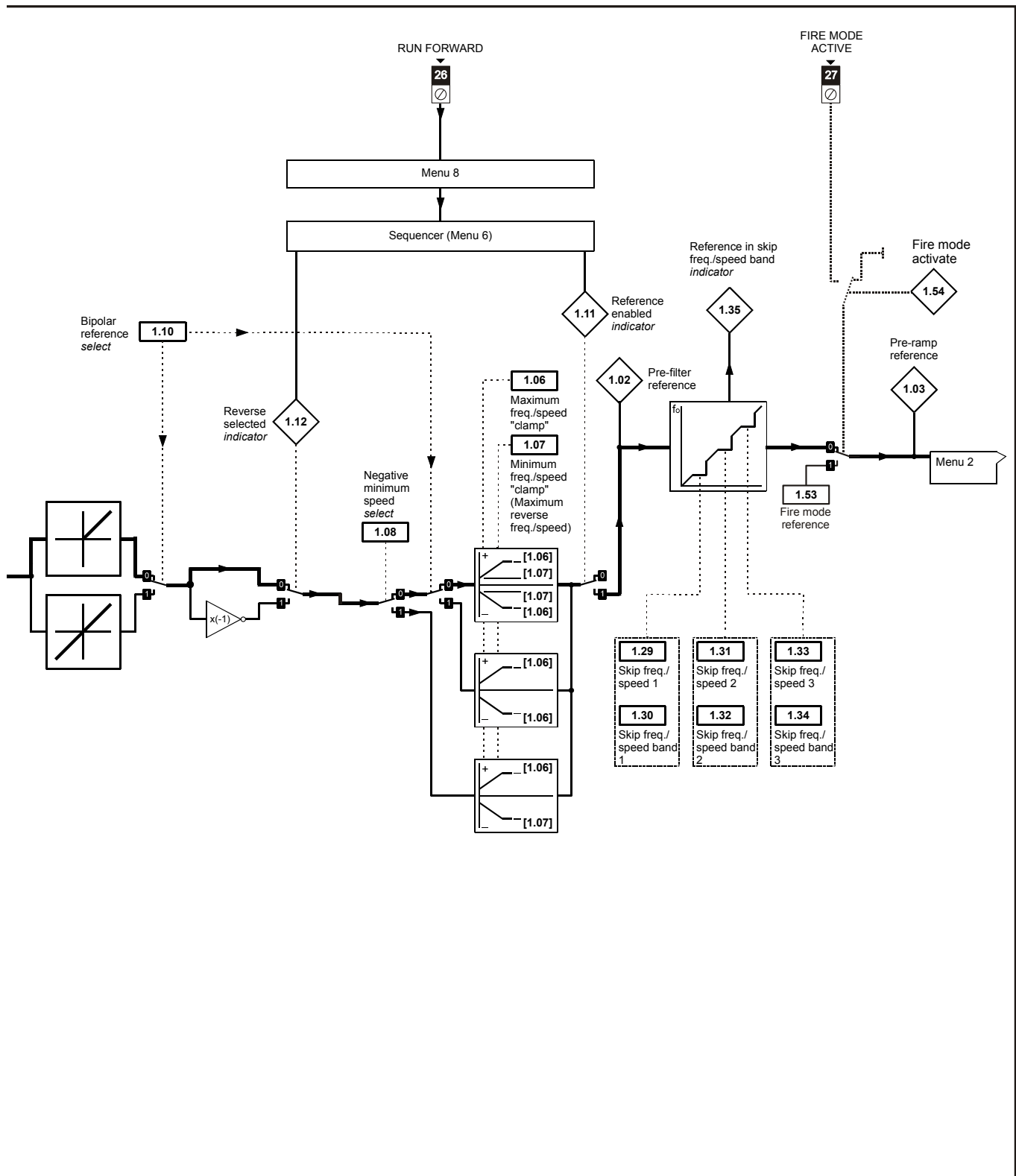
5.3 Menu 1: Frequency/speed reference

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

Figure 5-1 Menu 1 logic diagram



\*Refer to Pr 1.14 on page 31.



1.01	Frequency/speed reference selected															
Drive modes	Open-loop, RFC															
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, RFC								±SPEED_FREQ_MAX Hz/rpm							
Update rate	4ms write															

1.02	Pre-skip filter reference															
Drive modes	Open-loop, RFC															
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, RFC, RFC								±SPEED_FREQ_MAX Hz/rpm							
Update rate	4ms write															

1.03	Pre-ramp reference															
Drive modes	Open-loop, RFC															
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, RFC								±SPEED_FREQ_MAX Hz/rpm							
Update rate	4ms write															

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

See Pr 1.09 on page 30.

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

Reference used for jogging. See section 5.8 *Menu 6: Sequencer and clock* on page 95 for details on when the jog mode can be activated.



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

See below.

1.07	Minimum reference clamp																
Drive modes	Open-loop, RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
							1					1	1	1			
	RFC: VM = 1																
Range	Open-loop RFC								±3,000.0 Hz* ±SPEED_LIMIT_MAX rpm*								
Default	Open-loop, RFC								0.0								
Second motor parameter	Open-loop, RFC								Pr <b>21.02</b>								
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	RFC
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

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

The variable maximum limit for reference parameters, SPEED\_FREQ\_MAX, is defined as:

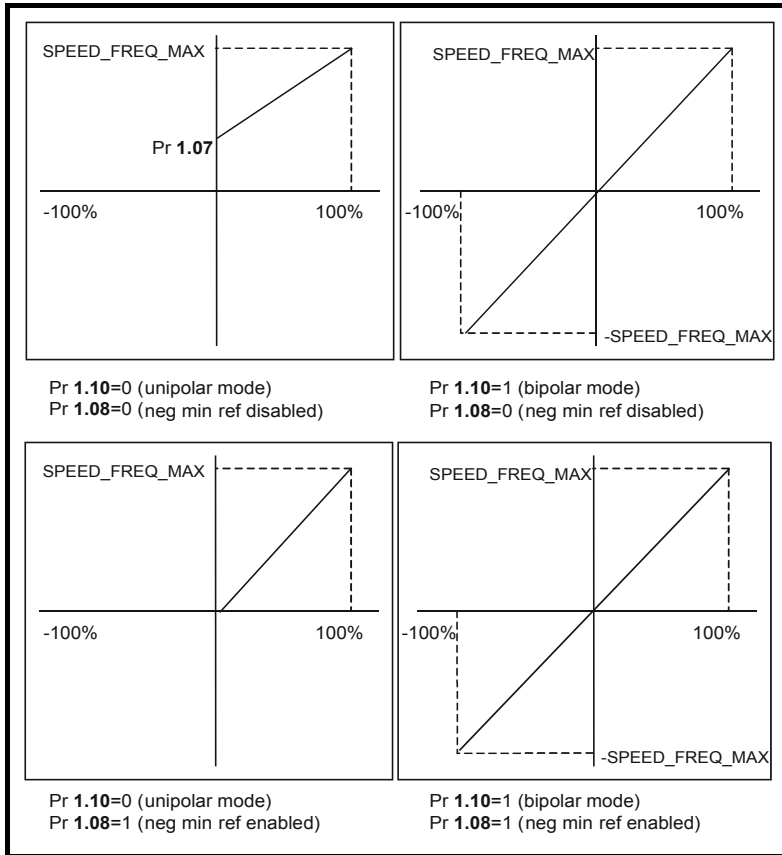
If Pr 1.08 = 0: SPEED\_FREQ\_MAX = Pr 1.06

If Pr 1.08=1: SPEED\_FREQ\_MAX is Pr 1.06 or -Pr 1.07 whichever is the largest

(If the second motor map is selected Pr 21.01 is used instead of Pr 1.06 and Pr 21.02 instead of Pr 1.07)

## Analog input scaling

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



## Reference limits

With reference to the block diagram for Menu 1 (Figure 5-1 on page 26) the following table shows the limits applied to the reference by various blocks in the reference system. It should be noted that the minimum limit in the main reference limits block changes when either the jog reference or velocity feedforward references are active. When one of these is active: if Pr 1.08 = 0 the minimum = -Pr 1.06 [-Pr 21.01 for motor map2], if Pr 1.08 = 1 the minimum = -Pr 1.07 [-Pr 21.02 for motor map 2].

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

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

When this parameter is 0 the reference is given by

$$\text{Pr 1.01} = \text{selected reference} \times (100 + \text{Pr 1.38}) / 100$$

and when this parameter is 1 the reference is given by

$$\text{Pr 1.01} = \text{selected reference} + \text{Pr 1.04}$$

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

See Pr 1.08 on page 29.

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

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

1.14	Reference selector															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 5							
Default	Open-loop, RFC								0 (A1.A2)							
Second motor parameter	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 9							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0 to 400.0 s								
Default	Open-loop, RFC							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, RFC															
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, RFC								±SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop, RFC								0.0							
Update rate	4ms read															

The drive can be controlled from the keypad if Pr 1.14 is set to 4. 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 down, the rate of change of keypad reference increases with time. The units used for displaying the keypad reference for different modes are given below.

Mode	Unit
Open loop	Hz
RFC	rpm

See also Pr 1.51 on page 36 (*Power-up keypad control mode reference*).

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

See below.

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

#### Open loop

The frequency reference resolution is restricted to 0.1Hz from normal parameters, however 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.

#### RFC

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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	Background read															

When this bit is 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1		
Range	Open-loop, RFC								±SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC: DP = 0															
Range	Open-loop RFC								0.0 to 3,000.0 Hz 0 to 40,000 rpm							
Default	Open-loop RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC: DP = 0															
Range	Open-loop RFC								0.0 to 25.0 Hz 0 to 250 rpm							
Default	Open-loop RFC								0.5 5							
Update rate	Background read															

Three skip references are available to prevent continuous operation at a speed which 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, with 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, RFC															
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1						
Range	Open-loop, RFC								±SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop, RFC								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 29.

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

See Pr 1.09 on page 30.

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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

Menu 1	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
--------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

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 31 and Pr 1.15 on page 32)

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 32 for more information.

1.48	Reference timer reset flag															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							1 to 5								
Update rate	4ms write															

Indicates the reference currently selected.

1.50	Preset reference selected indicator															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								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



### 5.3.1 Hand / Off / Auto

1.52	Enable hand/off/auto keypad operating mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC							0 to 3								
Default	Open-loop, RFC							1								
Update rate	Background read															

Hand / Off / Auto functions are enabled if Pr 1.52 is set to a non-zero value, otherwise the keypad buttons are allocated as follows:

- Blue  - Forward/Reverse
- Green  - Run
- Red  - Reset

When Hand / Off / Auto functions are enabled (Pr 1.52 set to either 1, 2 or 3), then the keypad buttons will be allocated as follows:

- Blue  - Auto
- Green  - Hand
- Red  - Off/Reset

The value in Pr 1.52 selects Hand/Off/Auto mode on power-up as shown in Table 5-3.

**Table 5-3 Hand/Off/Auto mode**

Pr 1.52	Power up
0	Hand/Off/Auto disabled
1	Auto Mode
2	Off Mode
3	See table Table 5-4

**Table 5-4 Power-up modes if Pr 1.52 = 3**

Power-down	Power-up
Hand	Off
Off	Off
Auto	Auto

#### Auto

In Auto mode, the reference for the motor speed/frequency will be selected by the value set in Pr 0.05.

#### Hand

The speed/frequency reference Pr 0.05 is automatically set to keypad reference. The motor speed is determined by the value in the keypad control mode reference Pr 1.17, which can be adjusted by pressing the Up/Down arrows on the keypad.

When Hand is selected from Auto, Pr 1.17 will be set to the value of the *Pre-ramp reference* (Pr 1.03) on mode transition, so the current motor speed is maintained.

If Hand mode is selected from Off mode, the motor will ramp up to the speed determined by the value in Pr 1.17.

#### Off

In Off mode, the motor will be stopped. The speed/frequency reference (Pr 0.05) is automatically set to keypad reference, allowing the value in the *keypad control mode reference* (Pr 1.17) to be modified by pressing the Up/Down arrow keys. If Hand mode is then subsequently selected, the motor will ramp up to the speed determined by the value in Pr 1.17.

1.53	Fire mode reference															
Drive modes	Open-loop, RFC															
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, RFC								-SPEED_FREQ_MAX to +SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop RFC								0.0Hz 0.0rpm							
Update rate	Background read															

1.54	Fire mode activate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1						
Default	Open-loop, RFC								0							
Update rate	Background read															

Emergency ventilation or fire mode allows for the purging of air from a structure during a fire. It is enabled if Pr 1.53 is set to a non zero value and activated when Pr 1.54 is set to one. When activated, the pre-ramp reference (Pr 1.03) is set to the value of Pr 1.53 and the normal drive controls are overridden as follows:

1. Drive enable is only controlled by the Enable input (Pr 6.15). The control word (Pr 6.43) cannot be used to disable the drive.
2. The internal run command is forced to be active. The normal drive sequencing bits (Pr 6.30 to Pr 6.34) and the control word have no effect.
3. The limit switch functions (Pr 6.35 and Pr 6.36) have no effect and will not stop the motor.
4. The hard speed reference is forced to zero. The hard speed reference should not be used when fire mode is likely to be activated as this will cause an abrupt change of speed.
5. The hand/off/auto function is disabled. If this system is in the hand state when fire mode is activated it will be forced to the off state, in order that the hand state is not active when fire mode is de-activated.
6. Keypad mode is disabled.
7. All latching mode states are reset.


If the fire mode activate parameter is subsequently set to zero the drive returns to normal operation. The fire mode activate parameter does not have the RW attribute set, and so it must be controlled from a digital input. This prevents fire mode from being enabled via the keypad, serial comms or a correctly functioning Solutions Modules.

If the drive is in the tripped state when fire mode is activated, the trip is reset and thereafter only the trips listed in the table below can be initiated while fire mode is active.

Trip number	String	Cause of trip
2	OU	DC bus over-voltage
3	OI.AC	AC instantaneous over-current
4	OI.br	Braking resistor instantaneous over current
5	PS	Drive power supply fault
8	PS.10V	10V user power supply overload
9	PS.24V	24V internal power supply overload
21	O.ht1	Power device over temperature based on thermal model
31	EEF	EEPROM failure
36	SAVE.Er	User parameter save error
37	PSAVE.Er	Power down save parameter error
103	Oibr.P	Power module braking IGBT over current
104	OIAC.P	Power module over current detected from the module output currents
105	Oht2.P	Power module heatsink over temperature
106	OU.P	Power module DC bus over-voltage
107	Ph.P	Power module phase loss detection
108	PS.P	Power module power supply fail
109	OIdc.P	Power module over current detected from on state voltage monitoring
110	Unid.P	Power module unidentified trip
200	SL1.HF	Slot 1 Solutions Module failure
205	SL2.HF	Slot 2 Solutions Module failure
210	SL3.HF	Slot 3 Solutions Module failure
217 to 232	HF17 to HF32	Hardware faults

Most of the trips included in the table are initiated in hardware and cannot be prevented in fire mode. These can be reset using the auto-reset function. The number of reset attempts can be set to a value from 1 to 5, or set to infinite attempts - see Pr 10.34, **Number of auto-reset attempts** on page 155 for details.

SLx.HF trips are allowed because these provide a watchdog function for most Solutions Modules and cannot be reset. HF17 to HF32 are hardware related faults that will prevent the drive from operating and cannot be reset. EEF, SAVE.Er and PSAVE.Er indicate that the parameter data taken from EEPROM is incorrect at power-up, and so the drive cannot run.



It is possible for the drive to become damaged when operating in fire mode because some of the drive thermal protection trips are disabled.

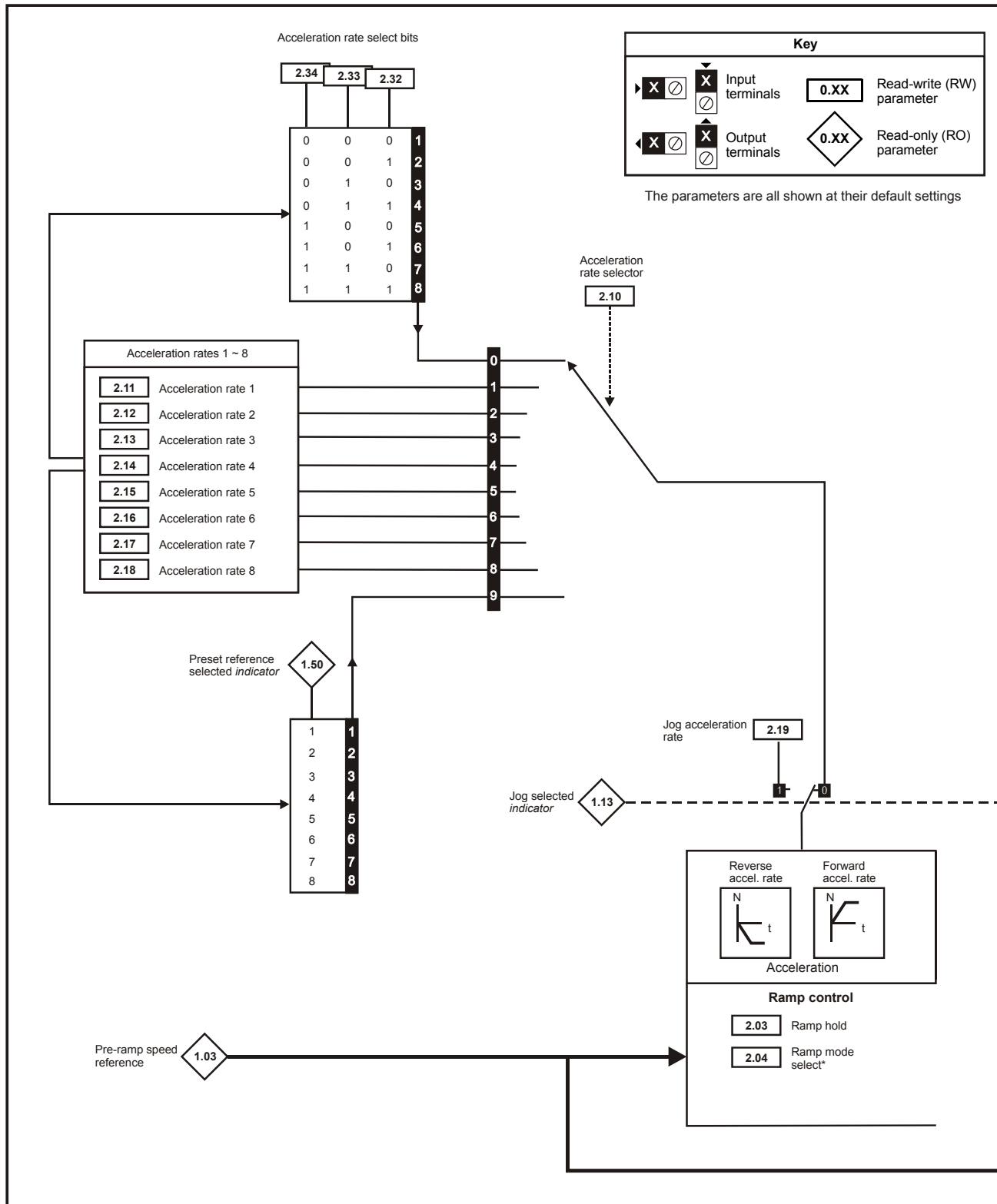
**CAUTION**

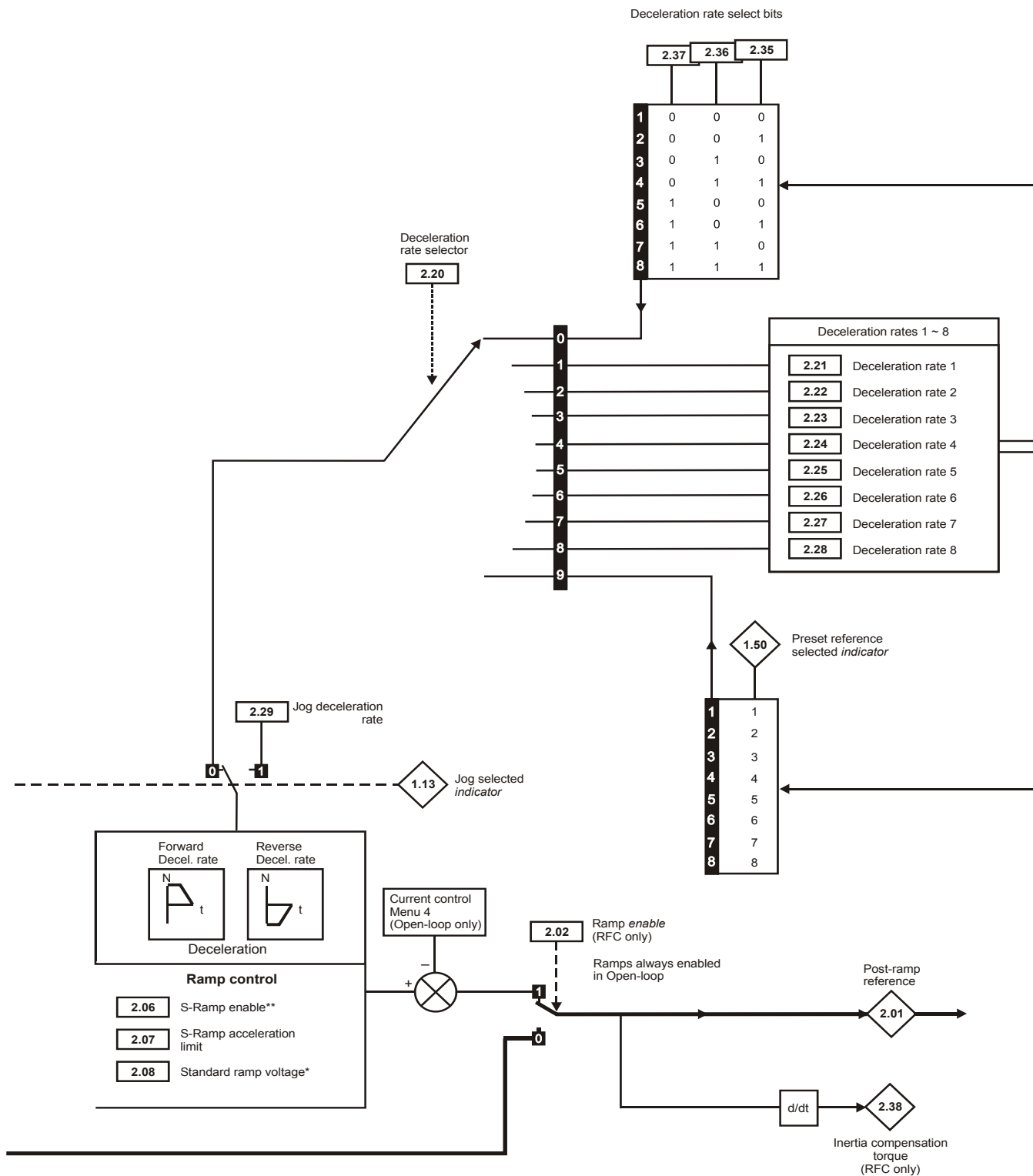


## 5.4 Menu 2: Ramps

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

**Figure 5-2 Menu 2 logic diagram**





\* For more information refer to Pr 2.04 on page 42.

\*\* For more information refer to Pr 2.06 on page 43.

2.01	Post ramp reference															
Drive modes	Open-loop, RFC															
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, RFC								±SPEED_FREQ_MAX Hz/rpm							
Update rate	4ms write															

2.02	Ramp enable															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	RFC								1							
Update rate	4ms read															

2.03	Ramp hold															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								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.

2.04	Ramp mode select															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop RFC								0 to 2 0 to 1							
Default	Open-loop, RFC								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 under some unusual circumstances in open-loop mode (i.e. with highly inductive supplies), for the motor to reach a low speed in standard ramp mode, but not completely stop. It is also possible if the drive attempts to stop the motor with an overhauling load in any mode, that the motor will not stop when standard ramp mode or fast ramp mode is used.

If the drive is in the deceleration state, the rate of fall of the frequency or speed is monitored. If this does not fall for 10 seconds, the drive forces the frequency or the speed reference to zero. This only applies when the drive is in the deceleration state, and not when the reference is simply set to zero. If the speed or frequency reference is set to zero with an overhauling or very high inertia load, then the drive may not decelerate.

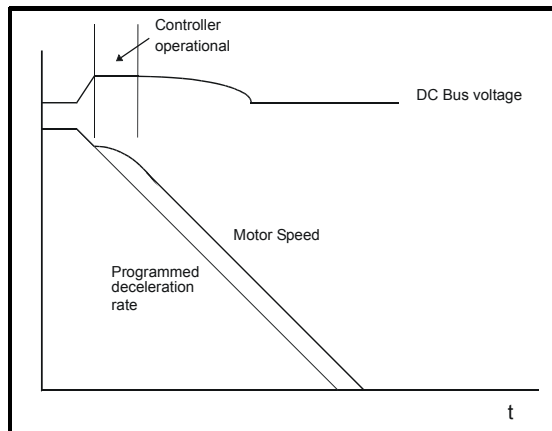
#### 0: Fast ramp

Fast ramp is used where the deceleration follows the programmed deceleration rate subject to current limits.

#### 1: Standard ramp

Standard ramp is used during deceleration if the voltage rises to the standard ramp level (Pr 2.08). It causes a controller to operate, the output of which changes the demanded load current in the motor. As the controller regulates the DC bus voltage, the motor deceleration increases as the speed approaches zero speed. When the motor deceleration rate reaches the programmed deceleration rate, the controller ceases to operate and the drive continues to decelerate at the programmed rate.

If the standard ramp voltage (Pr 2.08) is set lower than the nominal DC bus level, the drive will not decelerate the motor, but it will coast to a 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 (RFC mode). 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								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 mode, the acceleration ramp used by the S ramp function is reset to zero.

2.07	S ramp acceleration limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC: DP = 3															
Range	Open-loop RFC							0.0 to 300.0 s <sup>2</sup> /100Hz 0.000 to 100.000 s <sup>2</sup> /1,000rpm								
Default	Open-loop RFC							3.1 1.500								
Update rate	Background read															

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

### Frequency (Open-loop mode)

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

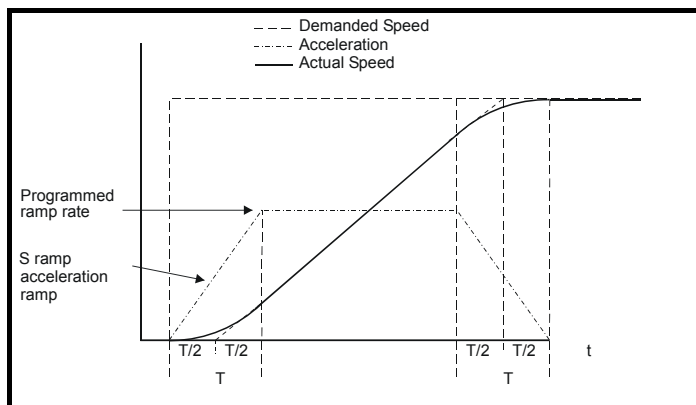
where A is the selected ramp rate in s / 100Hz

### Speed (RFC)

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

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

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



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

### Frequency (Open-loop mode)

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

where:

A is the selected ramp rate in s / 100Hz

J is parameter Pr 2.07, the S ramp acceleration limit in s<sup>2</sup> / 100Hz

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

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

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

### Speed (RFC)

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

where:

A is the selected ramp rate in s / 1000rpm

J is Pr 2.07, the S ramp acceleration limit in s<sup>2</sup> / 1000rpm

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

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

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

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

2.08	Standard ramp voltage															
Drive modes	Open-loop, RFC															
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, RFC								0 to dc _VOLTAGE_SET_MAX V							
Default	Open-loop, RFC								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 a rest, and if it is set too high and no braking resistor is used, the drive may indicate 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  $\sqrt{2}$ .



2.09	Deceleration failure detection															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

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

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

2.10	Acceleration rate selector															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 9							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC: DP = 3															
Range	Open-loop RFC							0.0 to 3,200.0 s/100Hz 0.000 to 3,200.000 s/1000rpm								
Default	Open-loop RFC							EUR> 40.0, USA> 33.0 EUR> 13.333, USA> 11.111								
Second motor parameter	Open-loop, RFC							Pr 21.04 for Pr 2.11 only								
Update rate	4ms read															

#### RFC

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

#### Open-loop

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

2.19	Jog acceleration rate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFCL: DP = 3															
Range	Open-loop							0.0 to 3200.0 s/100Hz								
	RFC							0.000 to 3200.000 s/1000rpm								
Default	Open-loop							0.2								
	RFC							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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 9							
Default	Open-loop, RFC								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 an external control. The ramp rate selected depends on the binary code generated by these bits as follows:

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

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

2.21	Deceleration rate 1															
2.22	Deceleration rate 2															
2.23	Deceleration rate 3															
2.24	Deceleration rate 4															
2.25	Deceleration rate 5															
2.26	Deceleration rate 6															
2.27	Deceleration rate 7															
2.28	Deceleration rate 8															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC: DP = 3															
Range	Open-loop RFC								0.0 to 3,200.0 s/100Hz 0.000 to 3,200.000 s/1000rpm							
Default	Open-loop RFC								EUR> 40.0, USA> 33.0 EUR> 13.333, USA> 11.111							
Second motor parameter	Open-loop, RFC								Pr 21.05 for Pr 2.21 only							
Update rate	4ms read															

#### RFC

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

#### Open-loop

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

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

The jog deceleration rate is only used when the drive is changing speed (when 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Update rate	4ms read															

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

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

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

## 5.5 Menu 3: Speed feedback and speed control

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.

Drive mode section	Menu 3 functions
Open-loop	Frequency slaving "Zero speed" and "at speed" detectors
RFC	Speed feedback, speed controller "Zero speed", "at speed" and overspeed detectors

### Frequency/Speed accuracy and resolution

#### Digital reference resolution

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

#### Analog reference resolution

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

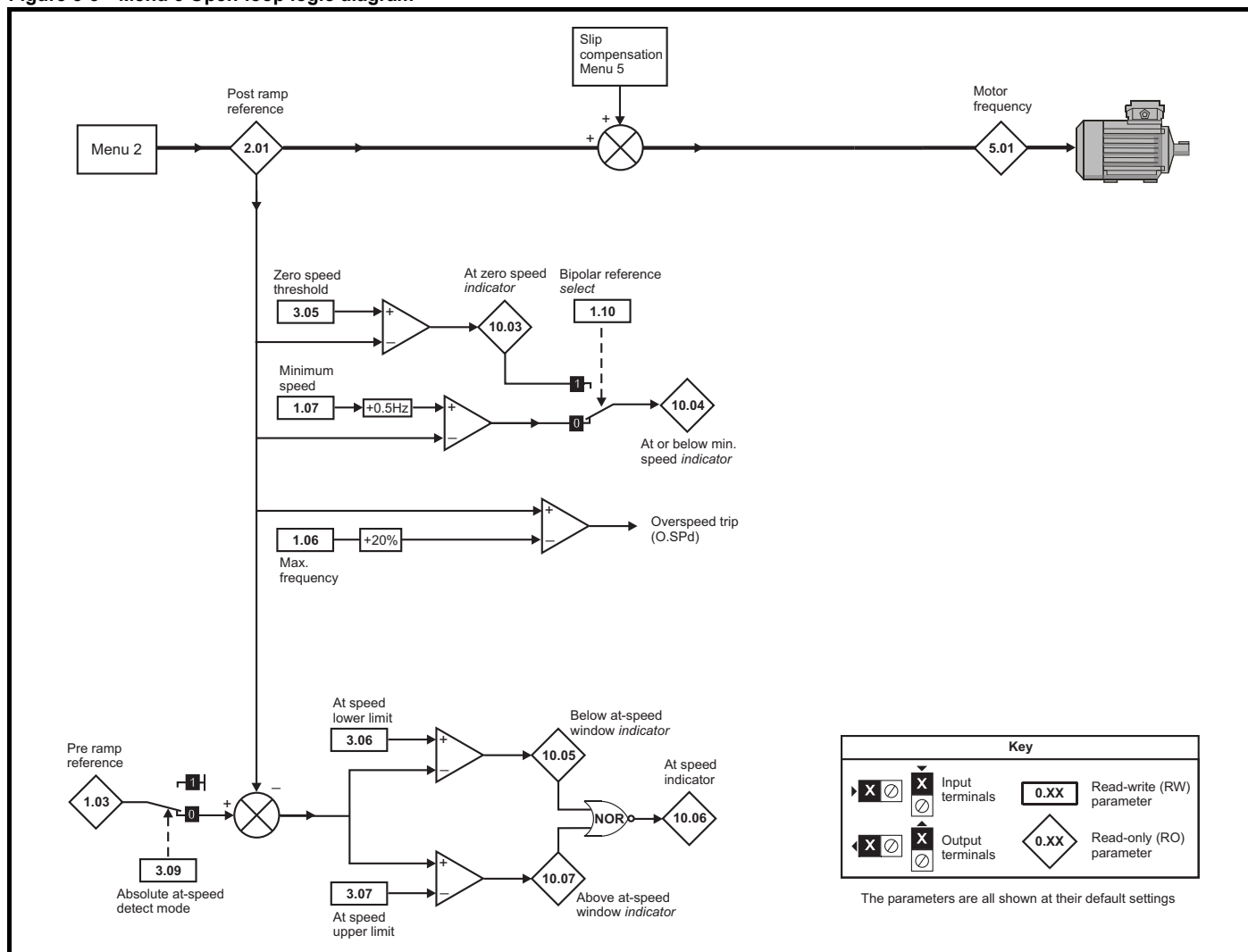
In RFC mode the resolution from analog input 1 is better than 16 bits plus sign provided the speed reference is routed via Pr **1.36**, Pr **1.37** or Pr **3.22** in high speed update mode. The resolution from analog inputs 2 or 3 is 10 bits plus sign.

#### Accuracy

The absolute frequency and speed accuracy depends on the accuracy of the crystal used with the drive microprocessor. The accuracy of the crystal is 100ppm, and so the absolute frequency/speed accuracy is 100ppm (0.01%) of the reference, when a preset speed is used. If an analog input is used the absolute accuracy is further limited by the absolute accuracy and non-linearity of the analog input.

## Parameter descriptions: Open-loop

Figure 5-3 Menu 3 Open-loop logic diagram



3.05	Zero speed threshold															
Drive modes	Open-loop, RFC															
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, RFC															
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, RFC															
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, RFC															
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

$$(|\text{Pr } 1.03| - \text{Pr } 3.06) \leq |\text{Pr } 2.01| \leq (|\text{Pr } 1.03| + \text{Pr } 3.07)$$

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

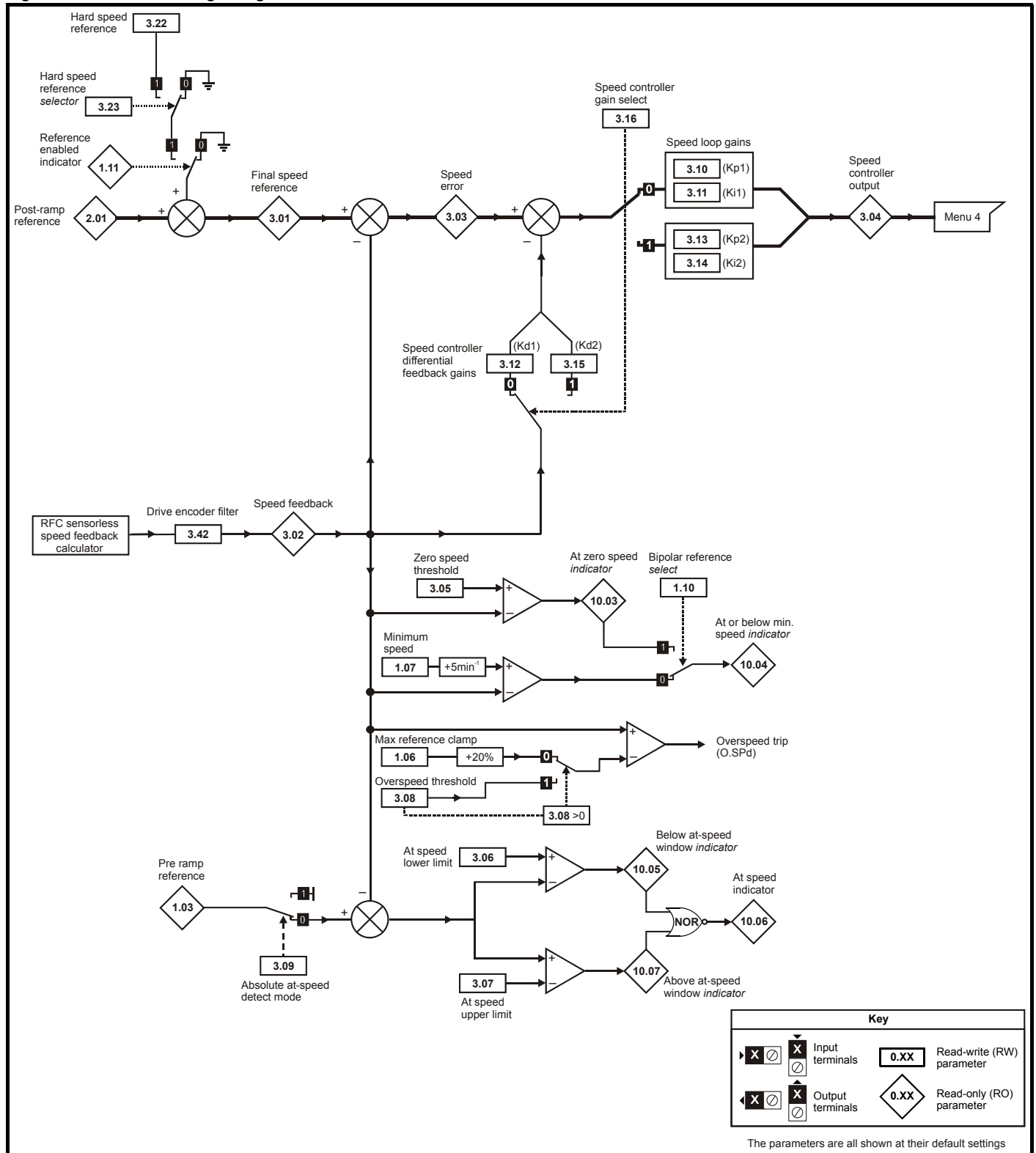
If Pr 3.09 = 1 absolute window mode is used and the "at speed" condition is true if

$$\text{Pr } 3.06 \leq |\text{Pr } 2.01| \leq \text{Pr } 3.07$$

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.

## Parameter descriptions: RFC

Figure 5-4 Menu 3 RFC logic diagram





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

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

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

The speed feedback is derived from the sensorless feedback calculation.

3.03	Speed error															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	RFC								±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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	RFC								±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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC								0 to 200 rpm							
Default	RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC								0 to 40,000 rpm							
Default	RFC								50							
Update rate	Background read															

3.07	At speed upper limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC							0 to 40,000 rpm								
Default	RFC							50								
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

$$(|\text{Pr } 1.03| - \text{Pr } 3.06) \leq |\text{Pr } 3.02| \leq (|\text{Pr } 1.03| + \text{Pr } 3.07)$$

(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

$$\text{Pr } 3.06 \leq |\text{Pr } 3.02| \leq \text{Pr } 3.07$$

3.08	Overspeed threshold															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC							0 to 40,000 rpm								
Default	RFC							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.

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

See Pr 3.06 and Pr 3.07 on page 54.

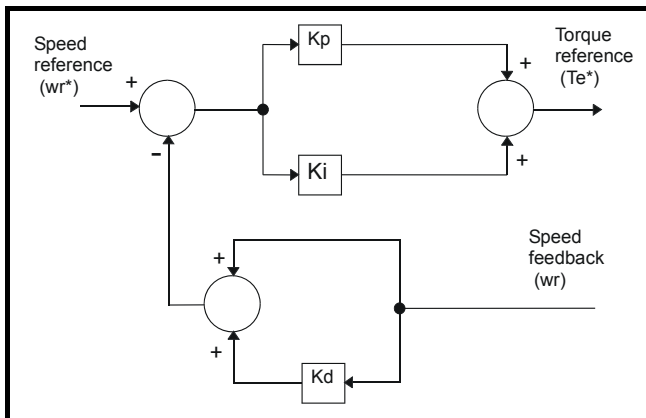
3.10	Speed controller proportional gain (Kp1)															
3.13	Speed controller proportional gain (Kp2)															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							4						1	1	1	
Range	RFC								0.0000 to 6.5335 (1/ rad s <sup>-1</sup> )							
Default	RFC								0.0300							
Second motor parameter	RFC								Pr 21.17							
Update rate	Background read															

3.11	Speed controller integral gain (Ki1)															
3.14	Speed controller integral gain (Ki2)															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	RFC							0.00 to 653.35 s/rad s <sup>-1</sup>								
Default	RFC							0.10								
Second motor parameter	RFC							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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5						1	1	1	
Range	RFC							0.00000 to 0.65335 s <sup>-1</sup> /rad s <sup>-1</sup>								
Default	RFC							0.00000								
Second motor parameter	RFC							Pr 21.19								
Update rate	Background read															

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

The following diagram shows a generalized 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.

### Integral gain (Ki)

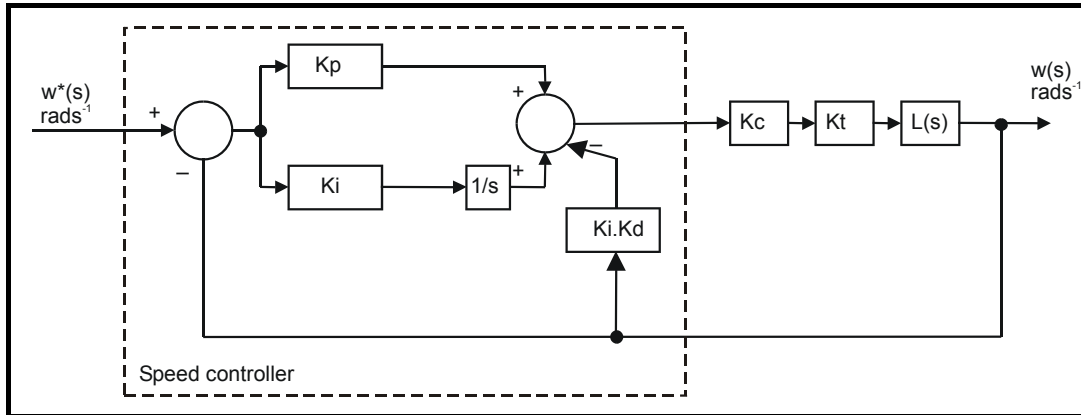
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time, and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level, and increases the stiffness 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  $\sum(K_i \times \text{error})$ , 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  $\times K_d \times K_i$  is greater than 170.

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



Where:

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

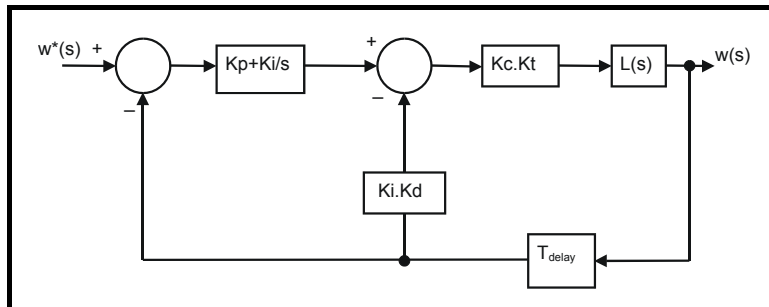
$K_t$  is the torque constant of the motor (i.e. torque in Nm per amp of torque producing current). This value is normally available for a servo motor from the manufacturer, however for induction motors the value must be calculated from:-

$$K_t = \text{Motor rated torque} / \text{Motor rated torque producing current}$$

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

$L(s)$  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, speed measurement and control delays. These delays, which can be approximated with a simple unity gain transport delay ( $T_{\text{delay}}$ ) as shown below, should be taken into account for more accurate results.



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

Gain	Conversion from previous internal units to new SI units
Kp	$K_{p\_old} / 17103$
Ki	$K_{i\_old} / 94.41$
Kd	$K_{d\_old} / 46376$

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

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

#### 0: user set-up

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

#### 1: Bandwidth set-up

If bandwidth based set-up is required, the following parameters must be set correctly: Pr 3.20 = required bandwidth, Pr 3.21 = required damping factor, Pr 3.18 = motor + load inertia (it is possible to measure the load inertia as part of the auto-tuning process, see Pr 5.12 on page 84), Pr 5.32 = motor torque per amp.

$$K_i = J / (K_c \times K_t) \times (2\pi \times \text{Bandwidth} / K_{bw})^2 = \text{Pr } 3.18 / (K_c \times \text{Pr } 5.32) \times (2\pi \times \text{Pr } 3.20 / K_{bw})^2$$

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

$$K_p = 2\xi \sqrt{[(K_i \times J) / (K_c \times K_t)]} = 2\xi \sqrt{[(\text{Pr } 3.11 \times \text{Pr } 3.18) / (K_c \times \text{Pr } 5.32)]}$$

#### 2: Compliance angle set-up

If compliance angle based set-up is required the following parameters must be set correctly: Pr 3.19 = required compliance angle, Pr 3.21 = required damping factor, Pr 3.18 = motor + load inertia (it is possible to measure the load inertia as part of the auto-tuning process, see Pr 5.12 on page 84), Pr 5.32 = motor torque per amp.

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

$$K_p = 2\xi \sqrt{[(K_i \times J) / (K_c \times K_t)]} = 2\xi \sqrt{[(\text{Pr } 3.11 \times \text{Pr } 3.18) / (K_c \times \text{Pr } 5.32)]}$$

#### 3: Kp gain times 16

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

3.18	Motor and load inertia															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5						1	1	1	
Range	RFC							0.00000 to 90.00000 kg m <sup>2</sup>								
Default	RFC							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 54) and to provide torque feed-forwards during acceleration when required. (see Pr 4.11 on page 69) (It is possible to measure the inertia as part of the auto-tune process, see Pr 5.12 on page 84).

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

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

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

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

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

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

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

3.23	Hard speed reference selector															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	RFC								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 or from an analog input. The hard speed reference is selected when Pr 3.23 = 1.

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

Pr 3.24 can only be set to 3 (RFC mode) - Closed loop vector without position feedback with no maximum limit.

A filter with a 4ms time constant/filter is automatically included in the speed feedback, as this is required for this system to operate correctly. Particularly when operating above rated speed it may be necessary to include further filtering (Pr 4.12 set to a value between 1.0 and 5.0ms) to achieve stable operation.

3.42	Drive encoder filter															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC								0 to 5 (0 to 16 ms)							
Default	RFC								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 hence 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.

This parameter also defines a filter on the output of the speed estimator which is used as the speed feedback. A filter with a 4ms time constant/filter is always present on the output of the speed estimator, but this filter may be extended as follows: 0 = 4ms, 1 = 8ms, 2 = 16ms, 3 = 32ms, 4 = 64ms, 5 = 128ms. The output of the speed estimator can include some ripple, which increases as the drive passes into field weakening, and the filter can be used to remove this ripple. This is particularly useful when using standard ramp or spinning start with a low friction high inertia load, and can prevent over voltage trips when the drive has no braking resistor.

## 5.6 Menu 4: Torque and current control

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

Level	x Rated drive current
Over-current trip	1/0.45 = 2.22
Open-loop peak limit	1.75
RFC	1.75
Open-loop maximum standard operating current	1.5
Current scaling (Kc)	1.0
Maximum Normal Duty current rating	≤1.36*
Maximum motor rated current	≤1.36*

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

The motor rated current (defined by Pr 5.07 or Pr 21.07), may be increased above the drive current scaling up to the maximum Normal Duty rated current. When the motor rated current is above the drive current scaling, the drive always provides a motor protection scheme that is intended for variable torque applications (see Pr 4.16 on page 72 for more details). The maximum rated current is the maximum rated current allowed for Normal Duty operation.

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

**Table 5-5 Current ratings**

200V				400V				575V				690V			
Model	Current scaling (Kc)	Drive current scaling	Max Normal Duty rated current	Model	Current scaling (Kc)	Drive current scaling	Max Normal Duty rated current	Model	Current scaling (Kc)	Drive current scaling	Max Normal Duty rated current	Model	Current scaling (Kc)	Drive current scaling	Max Normal Duty rated current
BA1201	4.3	4.3	5.2	BA1401	2.1	2.1	2.8	BA3501	4.1	4.1	5.4	BA4601	18	18	22
BA1202	5.8	5.8	6.8	BA1402	3.0	3.0	3.8	BA3502	5.4	5.4	6.1	BA4602	22	22	27
BA1203	7.5	7.5	9.6	BA1403	4.2	4.2	5.0	BA3503	6.1	6.1	8.4	BA4603	27	27	36
BA1204	10.6	10.6	11	BA1404	5.8	5.8	6.9	BA3504	9.5	9.5	11	BA4604	36	36	43
BA2201	12.6	12.6	15.5	BA1405	7.6	7.6	8.8	BA3505	12	12	16	BA4605	43	43	52
BA2202	17	17	22	BA1406	9.5	9.5	11	BA3506	18	18	22	BA4606	52	52	62
BA2203	25	25	28	BA2401	13	13	15.3	BA3507	22	22	27	BA5601	62	62	84
BA3201	31	31	42	BA2402	16.5	16.5	21					BA5602	84	84	99
BA3202	42	42	54	BA2403	23	25	29					BA6601	85.7	100	125
BA4201	56	56	68	BA3401	32	32	35					BA6602	107.1	125	144
BA4202	68	68	80	BA3402	40	40	43					BAMA16X1	85.7	100	125
BA4203	80	80	104	BA3403	46	46	56					BAMA16X1	107.1	125	144
BA5201	105	105	130	BA4401	60	60	68					BAMD16X1	85.7	100	125
BA5202	130	130	154	BA4402	74	74	83					BAMD16X1	107.1	125	144
BAMD12X1	133.7	156	192	BA4403	96	96	104					BAMD16X1	123.4	144	168
BAMD12X2	164.5	192	248	BA5401	124	124	138					BAMD16X1	144.0	168	192
BAMD12X3	214.2	250	312	BA5402	156	156	168								
BAMD12X4	248.5	290	350	BA6401	154.2	180	205								
				BA6402	180	210	236								
				BAMA14X1	154.2	180	202								
				BAMA14X2	180.0	210	236								
				BAMD14X1	154.2	180	202								
				BAMD14X2	180.0	210	246								
				BAMD14X3	205.7	246	290								
				BAMD14X4	248.5	290	330								



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

### Current scaling (Kc)

Kc is the sum of Kc for all the modules.

### Maximum drive current scaling

Maximum drive current scaling =  $0.95 \times \text{Sum of maximum drive current scaling for all the modules.}$

### Maximum rated current

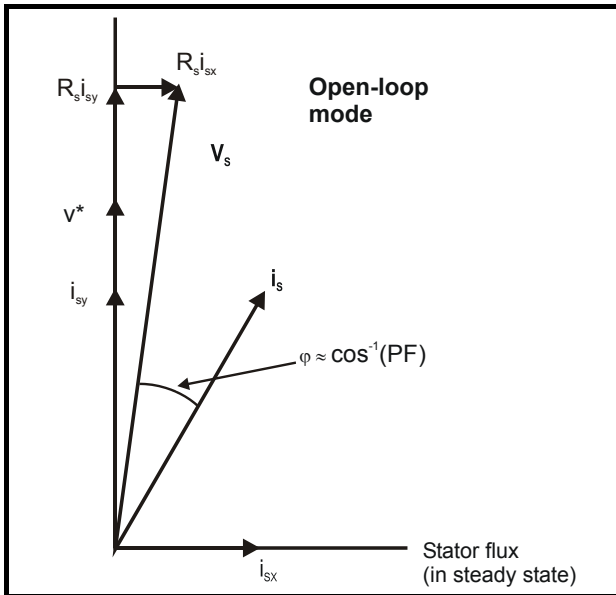
Maximum rated current =  $0.95 \times \text{Sum of maximum normal duty rated current for all the modules.}$

## 5.6.1 Open-loop

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

DRIVE\_CURRENT\_MAX is full scale current feedback, i.e.  $Kc / 0.45$ .

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



### Definitions:

- $v_s$  = motor terminal voltage vector
- $i_s$  = motor current vector
- $i_{sy}$  = y axis component of current
- $i_{sx}$  = x axis component of current
- $v^*$  = 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%):

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

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  $(1.5 \times Kc)$  when the rated current set by Pr 5.07 (or Pr 21.07 if motor map 2 is selected) is less than or equal to the Drive currentscaling, otherwise it is  $(1.1 \times \text{Maximum motor rated current})$ .

For example, with a motor of the same rating as the drive and a power factor of 0.85, the maximum current limit is 113.6%.

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 the 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 =  $\sqrt{(1 - \text{power factor}^2)} \times \text{motor rated current}$

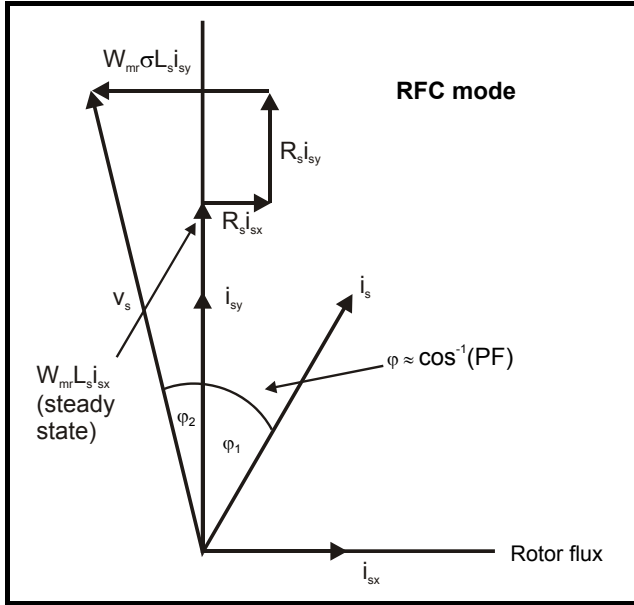
In this mode of operation the drive only requires the motor rated current and the power factor at rated load to set up the maximum current limits, scale the current limits correctly and calculate the rated active and magnetizing currents. The user may enter the nameplate values in Pr 5.07 and Pr 5.10 respectively, and the drive will operate satisfactorily. Alternatively the drive can perform an auto-tune test on the motor to measure the power factor at rated load by measuring  $R_s$  (stationary test),  $\sigma L_s$  (stationary test), and  $L_s$  (rotating test). See Pr 5.12 on page 84 for details.

### 5.6.2 RFC

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.  $K_c / 0.45$ .

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



#### Definitions:

$v_s$  = motor terminal voltage vector

$i_s$  = motor current vector

$i_{sy}$  = y axis component of current

$i_{sx}$  = x axis component of current

MOTOR1\_CURRENT\_LIMIT\_MAX is used as the maximum for some parameters such as the user current limits. The magnetizing current ( $i_{sx}$ ) 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%):

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

Where:

Motor rated current is given by Pr 5.07

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

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  $(1.75 \times K_c)$  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 drive current scaling, otherwise it is  $(1.1 \times \text{Maximum rated current})$ .

$\varphi_1$  can be derived directly by the drive auto-tune. However, if the auto-tune is not carried out  $\varphi_1$  is derived from  $\varphi_2$  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  $\varphi_2$  is given by the following equation.

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

Where:

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

$f_R$  is the rated frequency (Pr 5.06)

$\sigma L_s$  is the transient inductance (H) (Pr 5.24 / 1000)

$V_R$  is the rated voltage (Pr 5.09)

$I_{sxR}$  and  $I_{syR}$  are the currents in the x and y axes of the Rotor Flux Reference frame under rated load

$I_{sxR}$  and  $I_{syR}$  are derived as  $I_{sxR} = \text{Pr } 5.07 \times \sqrt{(1 - \text{Pr } 5.10^2)}$  and  $I_{syR} = \text{Pr } 5.07 \times \text{Pr } 5.10$  for the purposes of calculating  $\varphi_2$ . This calculation gives a result that is reasonably accurate for most purposes.

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

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

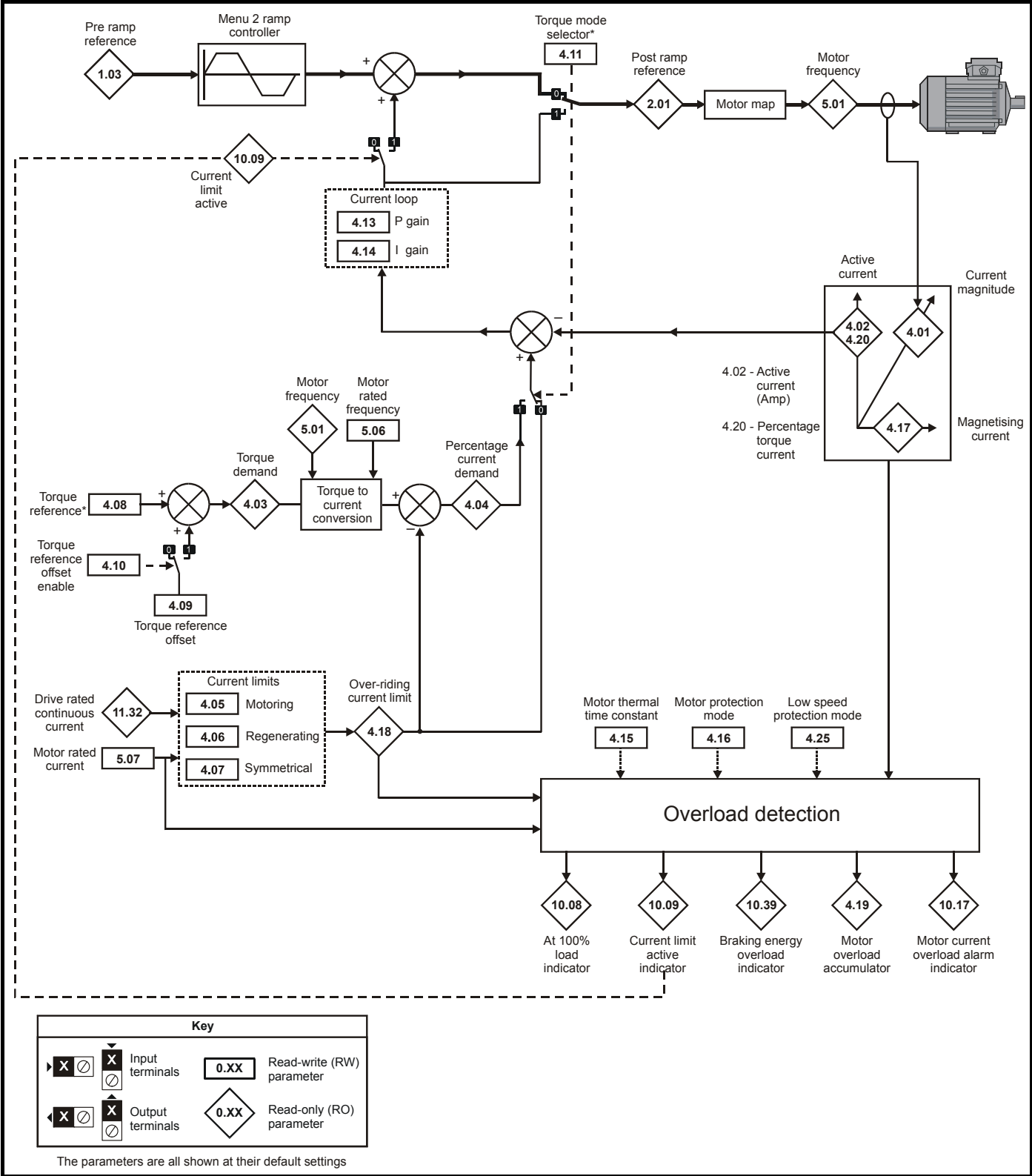
In this mode of operation the drive requires the following parameters to set the maximum current limits, scale the current limits correctly and calculate the rated active and magnetising currents.

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

5.6.3 Parameter descriptions

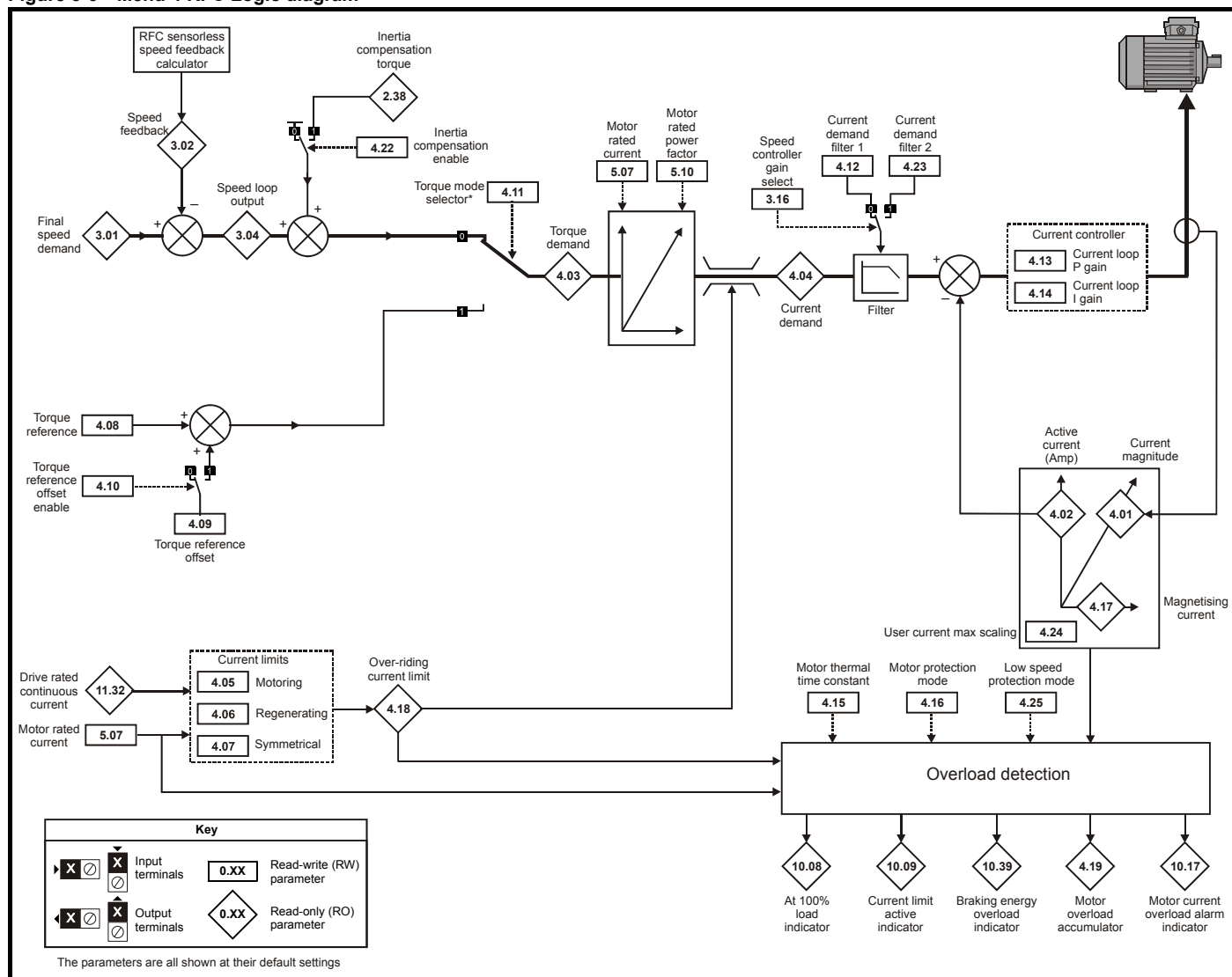
Parameter descriptions: Open-loop

Figure 5-5 Menu 4 Open-loop logic diagram



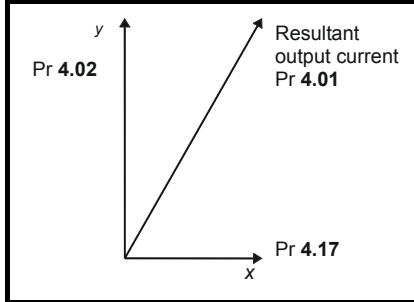
## Parameter descriptions: RFC

Figure 5-6 Menu 4 RFC Logic diagram



4.01	Current magnitude															
Drive modes	Open-loop, RFC															
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, RFC								0 to DRIVE_CURRENT_MAX A							
Update rate	4ms write															

This parameter is the rms 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. The reactive current is the magnetizing or flux producing current for a motor drive.

4.02	Active current															
Drive modes	Open-loop, RFC															
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, RFC								±DRIVE_CURRENT_MAX A							
Update rate	4ms write															

#### Open-loop and RFC

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 RFC mode 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.

4.03	Torque demand															
Drive modes	Open-loop, RFC															
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, RFC								±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.

#### RFC

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, RFC															
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, RFC								±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:

$$\text{Pr 4.04} = \text{Pr 4.03} \times \text{frequency} / \text{rated frequency}$$

The current demand is subject to the current limits.

#### RFC

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.

$$\text{Pr 4.04} = \text{Pr 4.03} \times \text{flux} / \text{rated flux}$$

4.05	Motoring current limit															
Drive modes	Open-loop, RFC															
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, RFC								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Open-loop, RFC								110.0*							
Second motor parameter	Open-loop, RFC								Pr <b>21.27</b>							
Update rate	Background read															

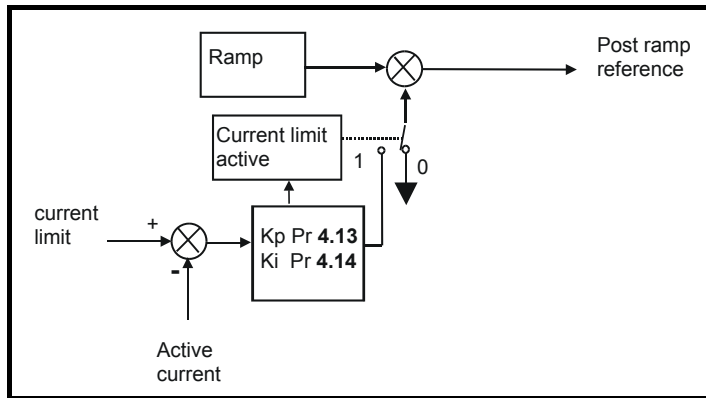
4.06	Regen current limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Open-loop, RFC								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Open-loop, RFC								110.0*							
Second motor parameter	Open-loop, RFC								Pr <b>21.28</b>							
Update rate	Background read															

4.07	Symmetrical current limit															
Drive modes	Open-loop, RFC															
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, RFC								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Open-loop, RFC								110.0*							
Second motor parameter	Open-loop, RFC								Pr <b>21.29</b>							
Update rate	Background read															

\* These are the maximum default values. If the variable maximum of this parameter (MOTOR1\_CURRENT\_LIMIT\_MAX) gives a lower value with the default value of Motor rated current (Pr 5.07) the default of this parameter is at the lower value.

## Open-loop

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



The current limits are compared with the active current, and if the current exceeds a limit the error value passes through the PI controller to give a frequency component which is used to modify the ramp output. The direction of the modification is always to reduce the frequency to zero if the active current is over the motoring limit, or to increase the frequency towards the maximum if the current is over the regenerating limit. Even when the current limit is active the ramp still operates, therefore the proportional and integral gains (Pr 4.13 and Pr 4.14) must be high enough to counter the effects of the ramp. See Pr 4.13 and Pr 4.14 on page 70 for gain setting.

## RFC

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.

4.08	Torque reference															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	2						1	1		
Range	Open-loop, RFC								±USER_CURRENT_MAX %							
Default	Open-loop, RFC								0.00							
Update rate	4ms read															

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

The torque offset is added to the torque reference when Pr 4.10 is 1. 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.

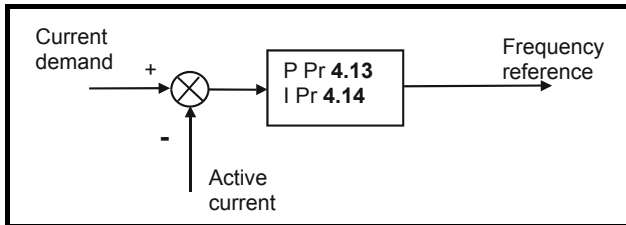
4.10	Torque offset select															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms read															



4.11	Torque mode selector																
Drive modes	Open-loop, RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
													1	1	1		
Range	Open-loop, RFC								0 to 1								
Default	Open-loop, RFC								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  $\pm \text{SPEED\_FREQ\_MAX}$ .



#### RFC

When this parameter is set to 1, the ramps are not active while the drive is in the run state. When the drive is taken out of the run state but not disabled, the appropriate stopping mode is used. It is recommended that coast stopping or stopping without ramps is 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.

4.12	Current demand filter 1															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	RFC								0.0 to 25.0 ms							
Default	RFC								0.0							
Update rate	Background read															

This filter introduces a lag in the speed loop, and therefore the speed loop gains may need to be reduced to maintain stability as the filter time constant is increased. Alternative time constants/filters 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, RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
													1	1	1		
Range	Open-loop, RFC								0 to 30,000								
Default	Drive voltage rating:								200V	400V	575V	690V					
	Open-loop,								20	20	20	20					
	RFC								75	150	180	215					
Second motor parameter	RFC								Pr <b>21.22</b>								
Update rate	Background read																

4.14	Current controller Ki gain															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 30,000							
Default	Drive voltage rating:								200V	400V	575V	690V				
	Open-loop,								40	40	40	40				
	RFC								1,000	2,000	2,400	3,000				
Second motor parameter	RFC								Pr <b>21.23</b>							
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 at which field weakening begins. The proportional term is inherent in the loop. The integral term must be increased sufficiently 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 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.

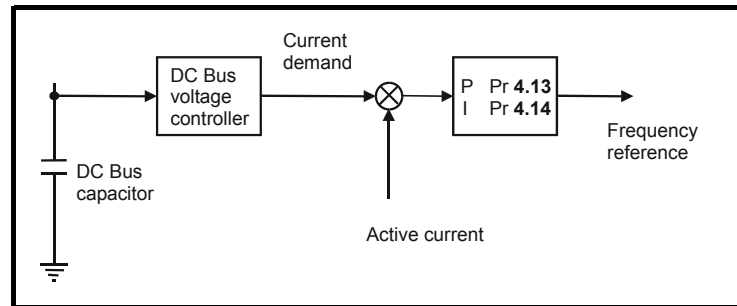
A system has been included to prevent regulation because of the opposite actions of the ramps and the current limit. This can reduce the actual level that the current limit becomes active by 12.5%. This still allows the current to increase up to the current limit set by the user. However the current 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.

It should now be possible to 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 stabilizing effect provided that the drive is not required to operate in torque control mode.

## RFC

The proportional gain Kp (Pr 4.13) is the most critical value in controlling the performance of the current controllers. Either the value can be set by auto-tuning (see Pr 5.12), or it can be set by the user so that:-

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

Where:

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

L is the motor inductance. For a servo motor this is half the phase to phase inductance that is normally specified by the manufacturer. For an induction motor this is the per phase transient inductance (σLs). This is the inductance value stored in Pr 5.24 after the auto-tune test is carried out.

I<sub>fs</sub> is the peak full scale current feedback = Kc x √2 / 0.45. Where Kc is the current scaling for each size of drive.

V<sub>fs</sub> is the maximum DC bus voltage.

Therefore:

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

Where:

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

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

Drive voltage rating	V <sub>fs</sub>	K
200V	415V	2,322
400V	830V	1,161
575V	990V	973
690V	1190V	809

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

$$K_i = K_p \times 256 \times T / \tau_m$$

where

τ<sub>m</sub> is the motor time constant/filter (L / R).

R is the per phase stator resistance of the motor (i.e. half the resistance measured between two phases).

Therefore

$$K_i = (K \times L \times K_c) \times 256 \times 167\mu s \times R / L \\ = 0.0427 \times K \times R \times K_c$$

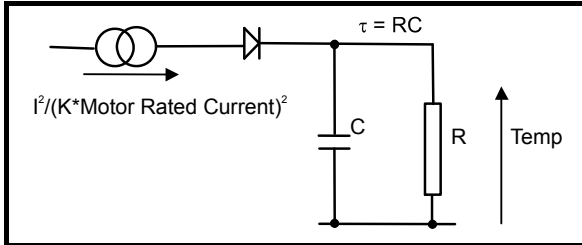
The above equations give the gain values that are calculated by the auto-tune system, and these should give the best response at all switching frequencies with minimal overshoot. If necessary the gains can be adjusted to improve performance as follows:

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

4.15	Thermal time constant/filter															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0.0 to 3000.0							
Default	Open-loop, RFC								89.0							
Second motor parameter	Open-loop, RFC								Pr <b>21.16</b>							
Update rate	Background read															

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

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

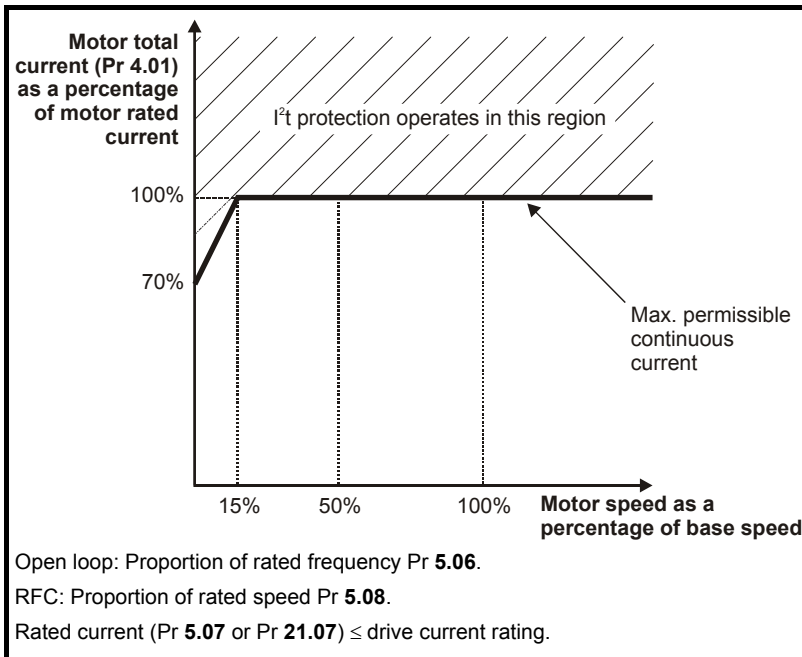


The temperature of the motor as a percentage of maximum temperature, with a constant current magnitude of  $I$ , constant value of  $K$  and constant value of motor rated current (set by Pr 5.07 or Pr 21.07) after time  $t$  is given by

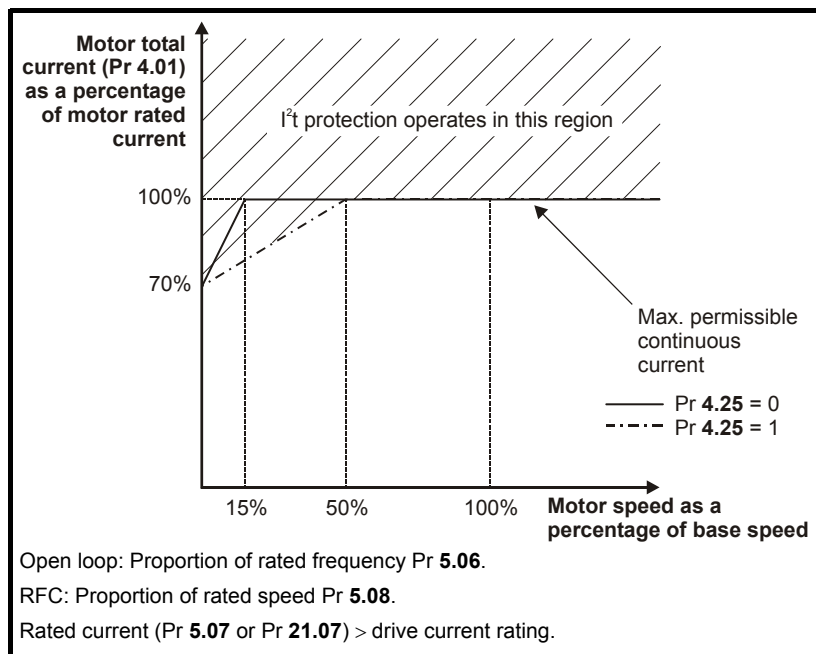
$$\text{Temp} = [I^2 / (K \times \text{Motor rated current})^2] (1 - e^{-t/\tau}) \times 100\%$$

This assumes that the maximum allowed motor temperature is produced by  $K \times \text{Motor rated current}$  and that  $\tau$  is the thermal time constant/filter of the point in the motor that reaches its maximum allowed temperature first.  $\tau$  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/filter 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 drive current scaling then Pr 4.25 can be used to select 2 alternative protection characteristics (see diagram below). If Pr 4.25 is 0 the characteristic is for a motor which can operate at rated current over the whole speed range. Induction motors with this type of characteristic normally have forced cooling. If Pr 4.25 is 1 the characteristic is intended for motors where the cooling effect of motor fan reduces with reduced motor speed below half of rated speed. The maximum value for  $K$  is 1.05, so that above the knee of the characteristics the motor can operate continuously up to 105% current.



The maximum value for  $K$  is 1.01, so that above the knee of the characteristics the motor can operate continuously up to 101% current.



When the estimated temperature 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  $(K - 0.05) \times 100\%$  when the temperature is 100%. The current limit is set back to the user defined level when the temperature falls below 95%.

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

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

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

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

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

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

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

4.17	Reactive current															
Drive modes	Open-loop, RFC															
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, RFC								±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, RFC															
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, RFC								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, RFC															
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, RFC								0 to 100.0 %							
Update rate	Background write															

See Pr 4.16 on page 72.

4.20	Percentage load															
Drive modes	Open-loop, RFC															
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, RFC								±USER_CURRENT_MAX %							
Update rate	Background write															

#### Open-loop, RFC

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.

4.22	Inertia compensation enable															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	RFC								0							
Update rate	Background read															

If this parameter is set to 1, 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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	RFC								0.0 to 25.0 ms							
Default	RFC								0.0							
Update rate	Background read															

The current demand filter time constant/filter is defined by this parameter if the speed gain select (Pr 3.16) is 1.

4.24	User current maximum scaling															
Drive modes	Open-loop, RFC															
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, RFC								0.0 to TORQUE_PROD_CURRENT_MAX %							
Default	Open-loop RFC								165.0* 175.0*							
Update rate	Background read															

\* These are the maximum default values. If the variable maximum of this parameter (TORQUE\_PROD\_CURRENT\_MAX which is defined by MOTOR1\_CURRENT\_LIMIT\_MAX or MOTOR2\_CURRENT\_LIMIT\_MAX depending on which motor map is active) gives a lower value with the default value of Motor rated current (Pr 5.07 or Pr 21.07) default of this parameter is at the lower value.

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

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

See Pr 4.16 on page 72.

#### NOTE

Pr 4.25 is always set to 1

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:

$$\text{Pr 4.26} = \text{Pr 4.20} \times \text{rated frequency} / \text{frequency}$$

4.27	Low load detection level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC								0.0 to 100.0%							
Default	Open-loop, RFC								0.0							
Update rate	Background read															

4.28	Low load detection speed / frequency threshold															
Drive modes	Open-loop, RFC															
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, RFC								0.0 to SPEED_FREQ_MAX Hz/rpm							
Default	Open-loop, RFC								0.0							
Update rate	Background read															

4.29	Trip on abnormal load detection															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1													1		
Default	Open-loop, RFC								0							
Update rate	Background read															

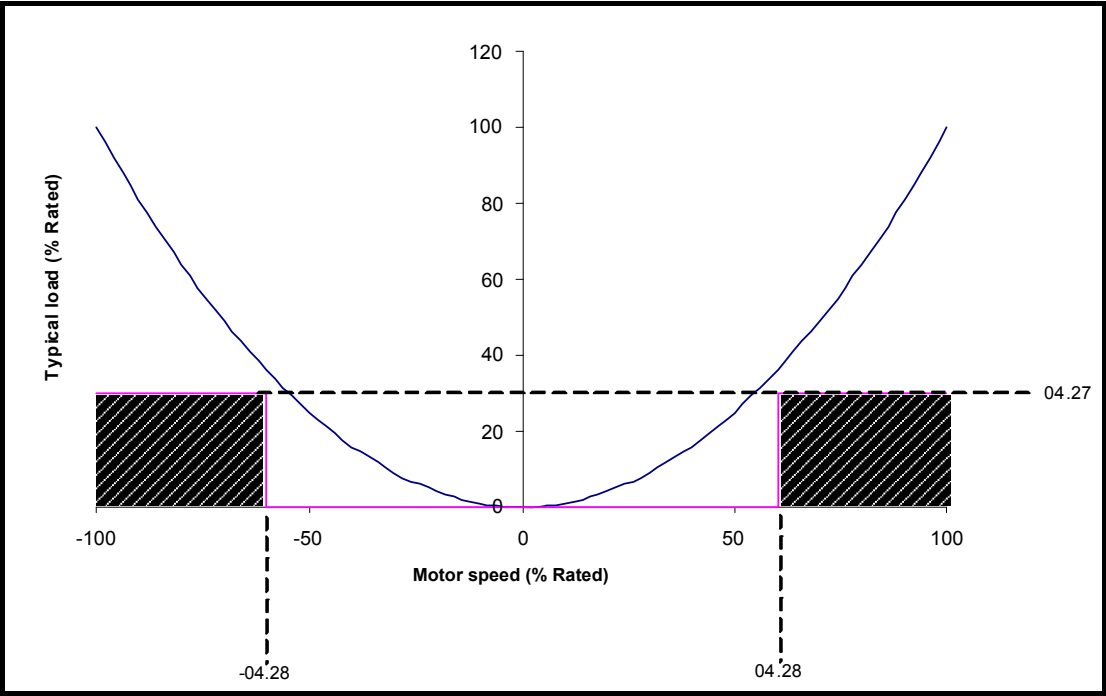
The low load detection function is provided so that loss of load can be detected and the necessary action taken. The low load detection function is disabled if Pr 4.27 is set to zero.

In order that the detector can be used with typical fan and pump load characteristics (i.e. where the load is relatively light at low motor speed), the detector is only active when the output frequency or speed is above the level defined by Pr 4.28. The motor must also be at the required speed (i.e. not accelerating or decelerating), so Pr 10.06 (At Speed) must be 1 for the low load detector to be active.

Once the detector is active, the low load condition is detected when Pr 4.20 (percentage load) falls below Pr 4.27, so the condition for detecting low load is given by:

$$(Pr\ 10.06 = 1) \text{ AND } (|Output\ frequency\ or\ speed| > Pr\ 4.28) \text{ AND } (Pr\ 4.20 < Pr\ 4.27)$$

If Pr 4.29 is zero when low load is detected, then a "Load" warning message is displayed on the keypad. If Pr 4.29 is 1 then a drive trip is initiated. The diagram below shows a typical fan load and operating areas (shaded), where the low load detection is active.

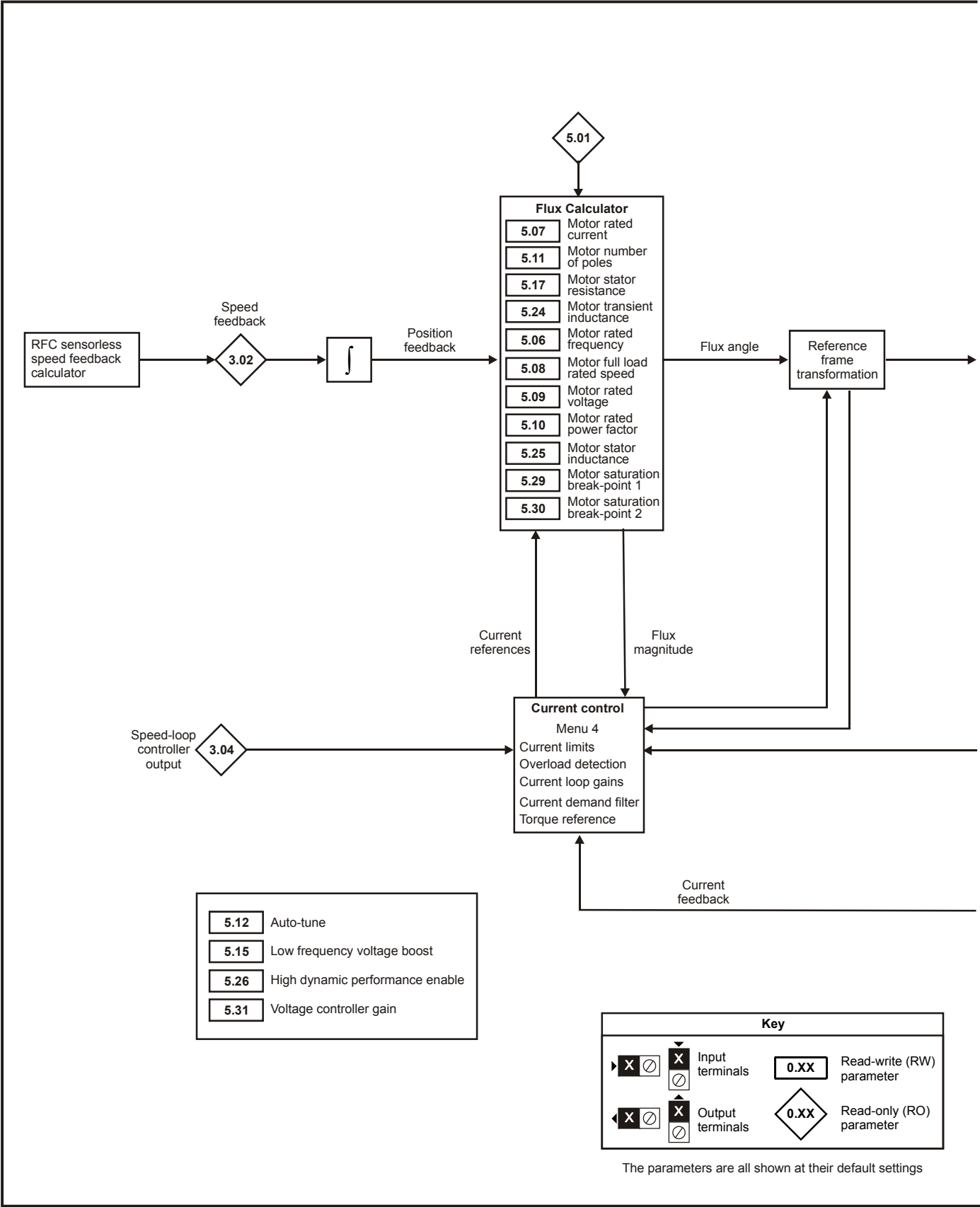


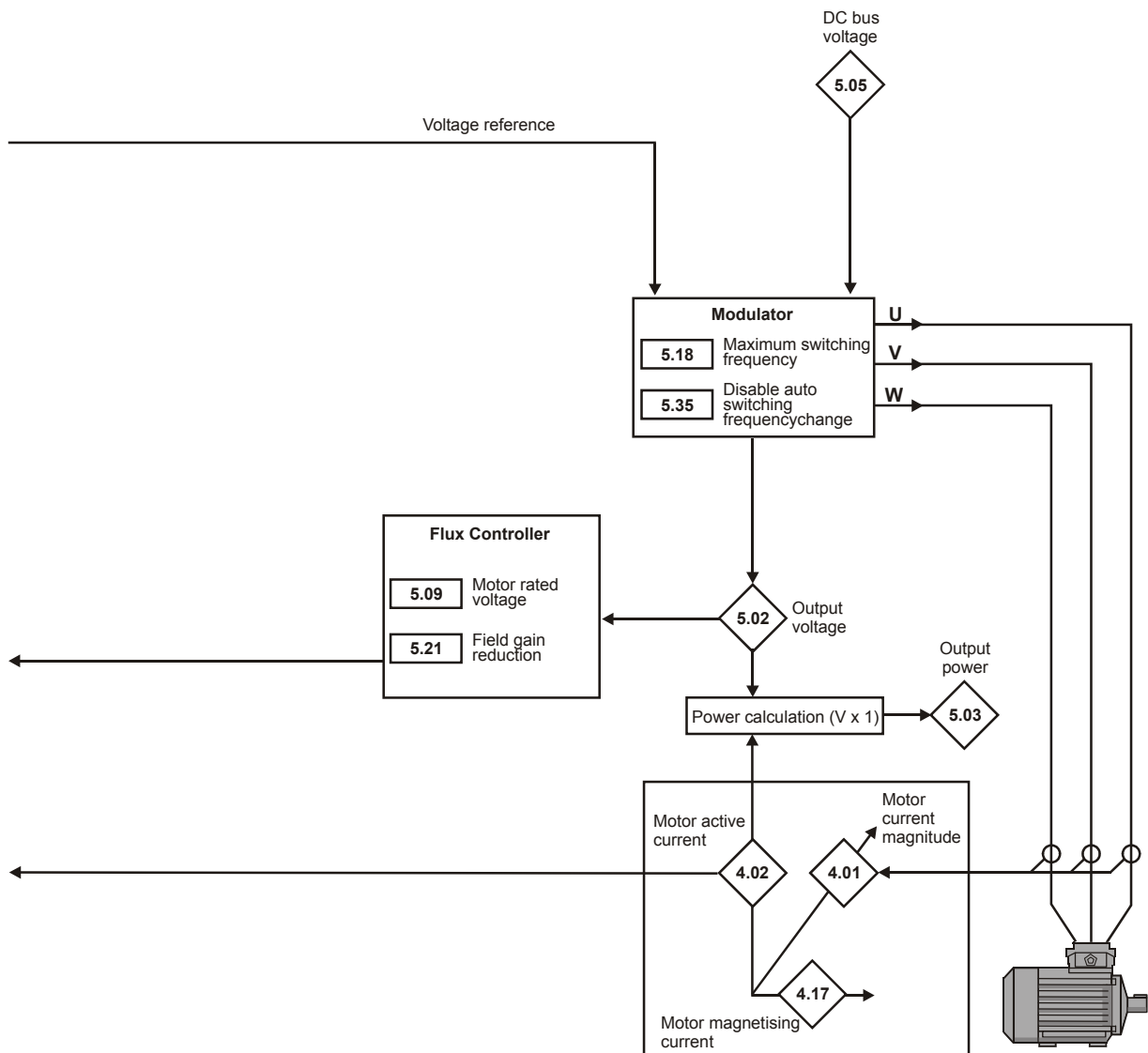




RFC

Figure 5-8 Menu 5 RFC logic diagram





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

#### Open-loop

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

#### RFC

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.

5.02	Output voltage															
Drive modes	Open-loop, RFC															
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, RFC								0 to AC_VOLTAGE_MAX V							
Update rate	Background write															

This is the modulus of the rms line to line voltage at the inverter output at the drive output frequency.

5.03	Output power															
Drive modes	Open-loop, RFC															
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, RFC								±POWER_MAX kW							
Update rate	Background write															

#### Open-loop and RFC mode

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).

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:

$$\text{rpm} = 60 \times \text{frequency} / \text{no. of pole pairs}$$

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, RFC															
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, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop RFC							0 to 3000.0 Hz 0 to 1250.0 Hz								
Default	Open-loop, RFC							EUR: 50.0 Hz, USA: 60.0 Hz								
Second motor parameter	Open-loop, RFC							Pr <b>21.06</b>								
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 82). 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 82).

#### RFC

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 82). The test frequency used for the rotating auto-tune test is  $\frac{2}{3} \times$  Pr **5.06**.

5.07	Motor rated current															
Drive modes	Open-loop, RFC															
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, RFC								0 to RATED_CURRENT_MAX A							
Default	Open-loop, RFC								Drive current scaling (i.e. the value of Pr 11.32)							
Second motor parameter	Open-loop, RFC								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
RFC	Current limits Motor thermal protection Vector control algorithm

5.08	Rated load rpm / Rated speed															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
	RFC DP=2															
Range	Open-loop, RFC								0 to 180,000 rpm 0.00 to 40,000.00 rpm							
Default	Open-loop, RFC								EUR: 1,500, USA: 1,800 EUR: 1450.00, USA: 1,770.00							
Second motor parameter	Open-loop, RFC								Pr <b>21.08</b>							
Update rate	Background read															

#### Open loop

The rated load rpm is used with the motor rated frequency and number of poles to calculate the rated slip of induction machines in Hz.

$$\text{rated slip (Hz)} = \text{rated motor frequency} - (\text{no. of pole pairs} \times \text{motor full load rpm} / 60) \\ = \text{Pr 5.06} - ((\text{Pr 5.11} / 2) \times \text{Pr 5.08} / 60)$$

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 value 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.

#### RFC

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.

5.09	Rated voltage															
Drive modes	Open-loop, RFC															
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, RFC							0 to AC_VOLTAGE_SET_MAX V								
Default	Open-loop, RFC							200V rating drive: 230V 400V rating drive: EUR: 400V, USA: 480V 600V rating drive: 575V 690V rating drive: 690V								
Second motor parameter	Open-loop, RFC							Pr <b>21.09</b>								
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.

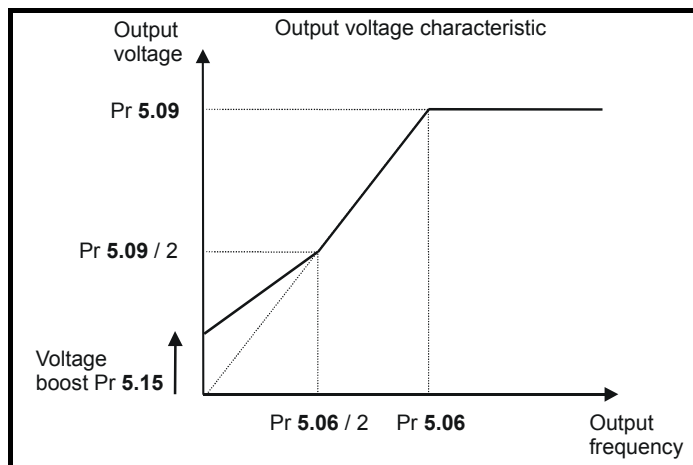
#### Open-loop vector mode: Ur\_S, Ur or Ur\_I

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.

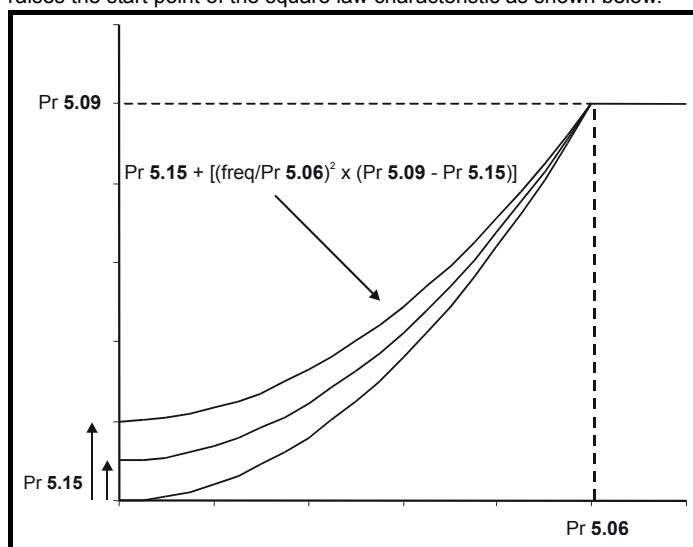
### Fixed boost mode: Fd

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.



### RFC

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.

In order 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.

Accordingly 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 84), and in the calculations required for automatic optimization of the rated motor slip. It is important therefore, that the correct rated voltage for the motor is used.

In some applications it may be necessary to restrict the voltage applied to the motor to a level lower than the nameplate rated voltage of the motor. In this case the rated frequency (Pr 5.06) must be adjusted to maintain the ratio of rated voltage and frequency given on the motor nameplate. The rated frequency will then be different to the nameplate value, and so the rated speed must be changed from the nameplate value to give the correct rated slip.

5.10	Rated power factor															
Drive modes	Open-loop, RFC															
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, RFC							0.000 to 1.000								
Default	Open-loop, RFC							0.850								
Second motor parameter	Open-loop, RFC							Pr <b>21.10</b>								
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 magnetizing current of the motor. The rated active current is used extensively to control the drive, and the magnetizing current is used in vector mode Rs compensation. It is important that this parameter is set up correctly.

#### RFC

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 magnetizing 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC							0 to 60 (Auto to 120 POLE)								
Default	Open-loop, RFC							0 (Auto)								
Second motor parameter	Open-loop, RFC							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.

#### RFC

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.

5.12	Autotune															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, RFC								0 to 2 0 to 4							
Default	Open-loop, RFC								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 RFC mode 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 RFC 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 has successfully completed, the drive is disabled and will enter the inhibit state.

The motor can only be restarted if the enable is removed either from the enable input if Pr 6.15 is set to zero, or by using control word (Pr 6.42). 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 ( $\sigma L_s$ )	Pr 5.24		

All the above 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  $\frac{2}{3}$  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.

### RFC

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 ( $\sigma L_s$ )	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 the above parameters can be set by the user. The motor set-up is constantly recalculated in the background task, therefore modifying these parameters even after auto-tune will affect the performance of the drive. The auto-tune test can be used to overwrite the user or default settings as described below. It should be noted that the current loop gains (Pr 4.13 and 4.14) are not updated as part of any test if either the stator resistance or the transient inductance for the active motor map are zero.

### 1. Stationary test

- A stationary test is performed to measure the stator resistance (Pr 5.17)
- Pr 5.17 is saved to EEPROM.
- A stationary test is performed to measure the transient inductance (Pr 5.24). When this test is complete the current loop gains (Pr 4.13 and Pr 4.14) are over-written with the correct values based on the calculations given in Menu 4. A moderately accurate value of  $\phi_1$  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  $\frac{2}{3}$  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  $\frac{3}{4}$  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  $\frac{1}{4}$ ,  $\frac{1}{2}$  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 has completed. It should be noted that the value changes back to zero within a few hundred milliseconds of being set to 4 by the user.

### Open-loop, RFC

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 motor did not reach the required speed	RFC 3
tunE2	The motor could not be stopped	RFC 3
tunE3	The calculated inertia is out of range	RFC 3
tunE7	Motor poles or encoder lines set up incorrectly. A trip is initiated if the speed is not within $\pm 6.25\%$ of the expected no load speed just after the motor has ramped up to speed. This trip will not occur if the motor poles are set to more than 12.	RFC 2
tunE	Auto-tune stopped before completion	All
rS*	Stator resistance too high	Open-loop 1, 2 RFC 1

\*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 65.000 $\Omega$ . The maximum measurable value for a particular drive size can be calculated from the following formula.

$$R_{s_{max}} = dc\_VOLTAGE\_MAX \times 0.45 / (Kc \times \sqrt{2})$$

where Kc is the current scaling factor for the drive

5.13	Dynamic V to F / flux optimise select															
Drive modes	Open-loop, RFC															
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

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  $| \text{active current} | < 0.7 \times \text{rated active current}$

motor rated frequency =  $\text{Pr } 5.06 \times (2 - (\text{active current} / (0.7 \times \text{rated active current})))$

else if  $| \text{active current} | \geq 0.7 \times \text{rated active current}$

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.

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								2							
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).

#### 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0.0 to 25.0 % of motor rated voltage								
Default	Open-loop, RFC							See below								
Update rate	Background read															

Voltage boost is used in fixed boost mode and square law mode for Open-loop mode, and also during the rotating auto-tune test in RFC mode. In open-loop mode, the default is dependant on the frame size as given in the table below.

Drive sizes	Default
BA1xxx, BA2xxx, BA3xxx	3.0%
BA4xxx, BA5xxx	2.0%
BA6xxx, BAMxxxx	1.0%

5.17	Stator resistance															
Drive modes	Open-loop, RFC															
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, RFC							0.0 to 65.000								
Default	Open-loop, RFC							0.00								
Second motor parameter	Open-loop, RFC							Pr 21.12								
Update rate	Background read															

Pr 5.17 shows the stator resistance of the motor. The units vary with the drive size to ensure that the full range of likely resistances can be represented with suitable resolution. The table below shows the units. Therefore 1.000 in the parameter represents the resistance shown in the units column.

Drive size	Units
BA1xxx to BA5xxx	1 Ohm
BA6xxx, BAMxxxx	0.01 Ohms

5.18	Maximum switching frequency															
Drive modes	Open-loop, RFC															
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, RFC								0 to 5 (3, 4, 6, 8, 12, 16 kHz)*							
Default	Open-loop, RFC								0 (3 kHz)							
Update rate	Background read															

\*The maximum switching frequency available is limited for some drive sizes as shown in Table 5-6 below.

**Table 5-6 maximum switching frequency**

200V	kHz	400V	kHz	575V	kHz	690V	kHz
BA1201	16	BA1401	16	BA3501	8	BA4601	8
BA1202	16	BA1402	16	BA3502	8	BA4602	8
BA1203	16	BA1403	16	BA3503	8	BA4603	8
BA1204	16	BA1404	16	BA3504	8	BA4604	8
BA2201	16	BA1405	16	BA3505	8	BA4605	8
BA2202	16	BA1406	16	BA3506	8	BA4606	8
BA2203	16	BA2401	16	BA3507	8	BA5601	8
BA3201	12	BA2402	16			BA5602	8
BA3202	12	BA2403	16			BA6601	6
BA4201	8	BA3401	16			BA6602	6
BA4202	8	BA3402	16			BAMA16X1	6
BA4203	8	BA3403	12			BAMA16X2	6
BA5201	8	BA4401	8			BAMD16X1	6
BA5202	8	BA4402	8			BAMD16X2	6
BAMD12X1	6	BA4403	8			BAMD16X3	6
BAMD12X2	6	BA5401	8			BAMD16X4	6
BAMD12X3	6	BA5402	8				
BAMD12X4	6	BA6401	6				
		BA6402	6				
		BAMA14X1	6				
		BAMA14X2	6				
		BAMD14X1	6				
		BAMD14X2	6				
		BAMD14X3	6				
		BAMD14X4	6				

This parameter defines the required switching frequency. The drive may automatically reduce the actual switching frequency (without changing this parameter) if the power stage becomes too hot. The switching frequency can reduce from 12kHz to 6kHz to 3kHz, or 16kHz to 8kHz to 4kHz. An estimate of the IGBT junction temperature is made, based on the heatsink temperature and an instantaneous temperature drop using the drive output current and switching frequency.

The estimated IGBT junction temperature is displayed in Pr 7.34. If the temperature exceeds 135°C, the switching frequency is reduced (if this is possible i.e >4kHz) and this mode is enabled (see Pr 5.35 on page 94).

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.h1 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	RFC
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
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.

As the rated voltage parameter is increased for a given DC bus voltage, the modulation depth is also increased. Therefore if the rated voltage is set to a level higher than the supply voltage the point at which pulse dropping, over-modulation and quasi-square operation each begin, may occur at a frequencies below the rated frequency.

5.21	Field gain reduction															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	RFC 0															
Update rate	Background read															

A suitable field controller gain is automatically set by the drive from the motor parameters. However by setting this parameter to 1, it is possible to reduce this gain by a factor of 2 if instability problems occur above base speed.

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															

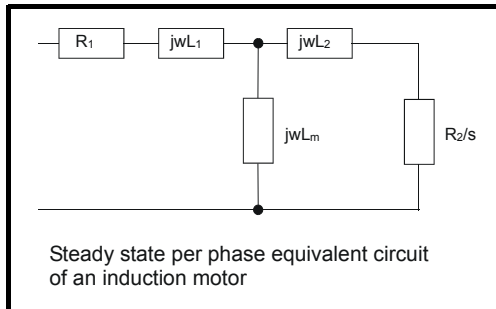
Due to various effects in the drive inverter, a voltage offset must be produced before any current flows. To obtain good performance at low frequencies where the machine terminal voltage is small, this offset must be taken into account. The value shown in Pr 5.23 is this offset given in line to line 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 87).

5.24	Transient inductance ( $\sigma L_s$ )															
Drive modes	Open-loop, RFC															
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, RFC								0.000 to 500.000 mH							
Default	Open-loop, RFC								0.000							
Second motor parameter	Open-loop, RFC								Pr <b>21.14</b>							
Update rate	Background read															

#### Open-loop, RFC

With reference to the diagram below, the transient inductance is defined as

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



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 RFC mode.

5.25	Stator inductance (L <sub>s</sub> )															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2		1				1	1	1	
Range	RFC								0.00 to 5000.00 mH							
Default	RFC								0.00							
Second motor parameter	RFC								Pr <b>21.24</b>							
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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	RFC								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 Pr 5.08 is set to a value other than zero or synchronous speed.

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

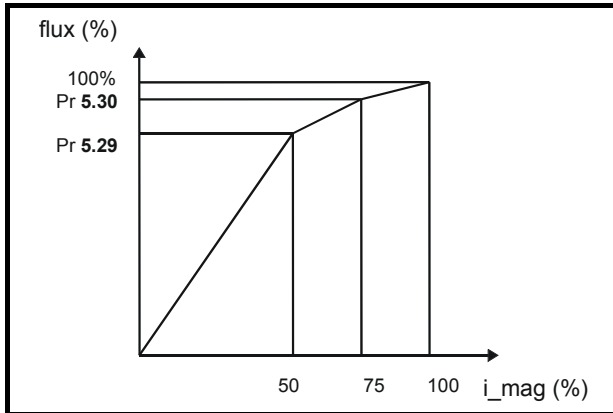
When the flux in the motor is reduced below its rated level, the level of torque producing current required for a given amount of shaft torque is higher than the rated level. In speed control the compensation prevents gain reduction at higher speeds. In torque control the compensation maintains the torque 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 1. 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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC							0 to 100 % of rated flux								
Default	RFC							50								
Second motor parameter	RFC							Pr <b>21.25</b>								
Update rate	Background read															



5.30	Motor saturation breakpoint 2																
Drive modes	RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
													1	1	1		
Range	RFC							0 to 100 % of rated flux									
Default	RFC							75									
Second motor parameter	RFC							Pr <b>21.26</b>									
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 30							
Default	Open-loop, RFC								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	RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
RFC							2	1							1	
Range	RFC								0.00 to 500.00 NmA <sup>-1</sup>							
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).

## RFC

The drive calculates the motor torque per amp of active current using the motor parameters as shown below assuming a motor efficiency of 90%.

$$K_t = \frac{\sqrt{3} \times V_{rated} \times I_{rated} \times \text{Rated power factor} \times \text{Efficiency}}{\text{Rated speed (rad s}^{-1}\text{)} \times \text{Rated active current}}$$

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

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.

5.35	Disable auto-switching frequency change															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC 0															
Update rate	Background read															

The drive thermal protection scheme (see Pr 5.18 on page 89), 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 1. If the feature is disabled, the drive trips immediately when the IGBT temperature is too high.

5.37	Actual switching frequency															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Open-loop, RFC 0 to 7															
Update rate	Background write															

Pr 5.37 shows the actual switching frequency used by the inverter. The maximum switching frequency is set with parameter Pr 5.18, but this may be reduced by the drive if automatic switching frequency changes are allowed (Pr 5.35=1). Pr 5.37 also indicates if the sample time for the current controllers have been reduced to allow for RFC mode.

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

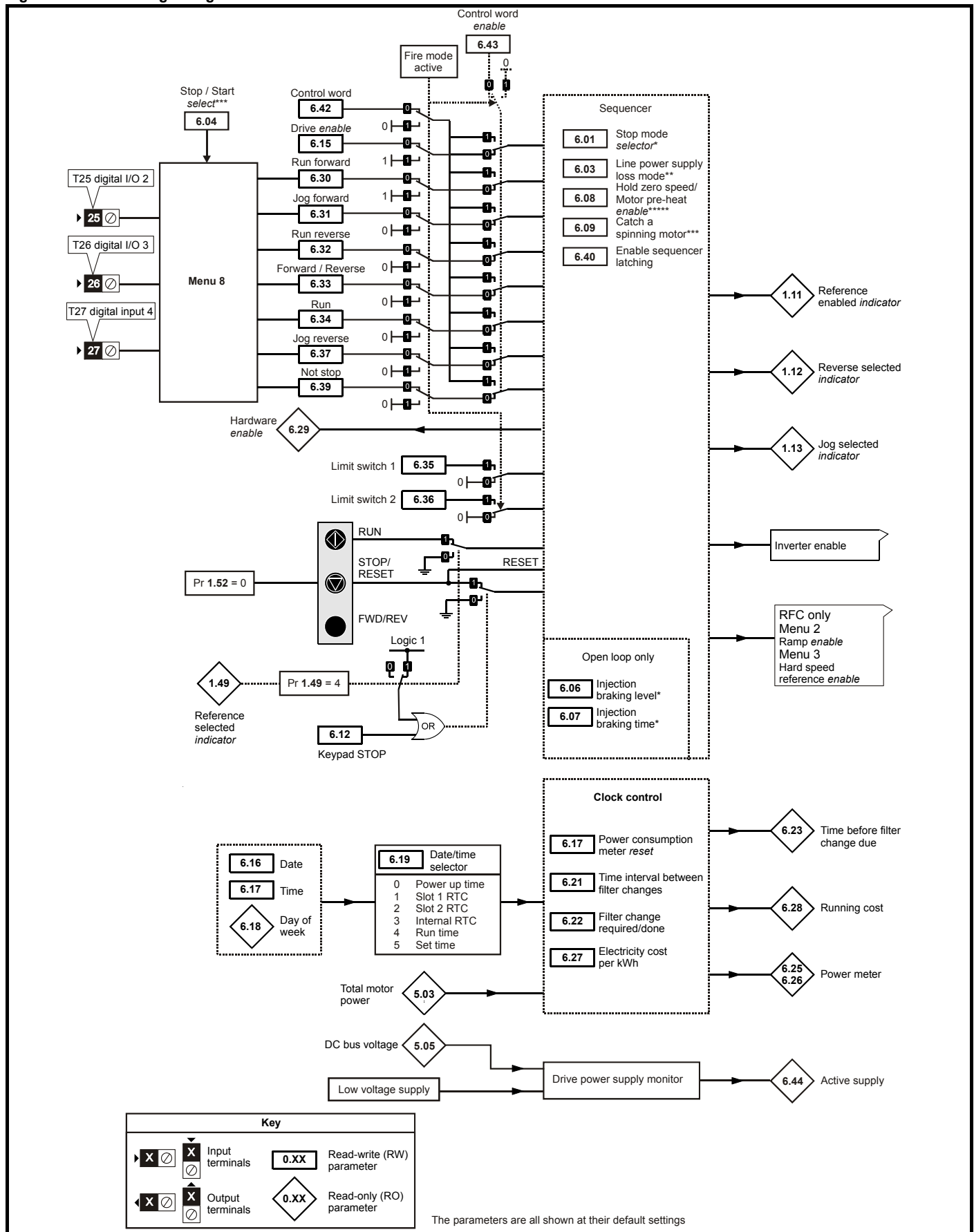
5.40	Spin start boost															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC 0.0 to 10.0															
Default	Open-loop, RFC 1.0															
Update rate	Background read															

If Pr 6.09 is set to enable the catch a spinning motor function in open-loop mode or RFC mode without position feedback (RFC mode) (Pr 3.24 = 1 or 3), this parameter will define a scaling function used by the algorithm which detects the speed of the motor.

It is likely that for smaller motors the default value of 1.0 is suitable, but for larger motors this parameter may need to be increased. If the value of this parameter is too large, the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small, the drive will detect the motor speed as zero even if the motor is spinning.

## 5.8 Menu 6: Sequencer and clock

Figure 5-9 Menu 6 logic diagram



6.01	Stop mode																
Drive modes	Open-loop, RFC																
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
					1								1	1	1		
Range	Open-loop RFC								0 to 5 0 to 2								
Default	Open-loop, RFC								1 1								
Update rate	Background read																

#### Open-loop

Stopping is in two distinct phases: decelerating to stop, and stopped.

Stopping Mode	Phase 1	Phase 2	Comments
0: Coast	Inverter disabled	Drive cannot be re-enabled for 1s	Delay in phase 2 allows rotor flux to decay.
1: Ramp	Ramp down to zero frequency	Wait for 1s with inverter enabled	
2: Ramp followed by dc injection	Ramp down to zero frequency	Inject dc at level specified by Pr 6.06 for time defined by Pr 6.07	
3: dc injection with zero speed detection	Low frequency current injection with detection of low speed before next phase.	Inject dc at level specified by Pr 6.06 for time defined by Pr 6.07	The drive automatically senses low speed and therefore it adjusts the injection time to suit the application. If the injection current level is too small, the drive will not sense low speed (normally a minimum of 50-60% is required).
4: Timed dc injection braking stop	Inject dc at level specified by Pr 6.06 for time specified by Pr 6.07.	No phase 2.	
5: Disable	Inverter disabled	No phase 2.	Allows the drive to be immediately disabled and then re-enabled again immediately if required.

Once modes 3 or 4 have begun, the drive must go through the ready state before being restarted either by stopping, tripping or being disabled. If this parameter is set to 5 (Disable stopping mode), the disable stopping mode is used when the run command is removed, and will allow the drive to be started immediately by reapplying the run command. However, if the drive is disabled by removing the drive enable (i.e. via the secure disable input or the drive enable (Pr 6.15), then the drive cannot be re-enabled for 1s.

#### RFC

Only one stopping phase exists, and the ready state is entered as soon as the single stopping action is complete. It should be noted that the stop condition is detected when the speed feedback is below the zero speed threshold (Pr 3.05) for at least 16ms. If the speed is not stable, it is possible that the stop condition may not be detected. In this case the system should be made more stable or alternatively the zero speed threshold should be raised.

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

If coast stop is selected, the inverter is inhibited immediately when the run command is removed. If however hold zero speed is also selected (Pr 6.08 = 1), then the inverter will be re-enabled to hold zero speed. The result is that the inverter is disabled for one sample and then enabled to ramp the motor to a stop. If coast stop is required Pr 6.08 should be set to zero to disable hold zero speed.

If stop with ramp is selected, the relevant ramp rate is used to stop the motor even if Pr 2.02 is set to zero to disable ramps.

The motor can be stopped with position orientation after stopping. This mode is selected with the position controller mode (Pr 13.10). When this mode is selected Pr 6.01 has no effect.

6.03	Line power loss mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								0							
Update rate	Background read															

#### 0: dis

There is no line power 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. This will reset itself if the voltage rises again above VuuRestart as shown in Table 5-7  *Voltages and voltage ratings* on page 97.

#### 1: Stop

##### Open-loop

The action taken by the drive is the same as for ride through mode except the ramp-down rate is at least as fast as the deceleration ramp setting, and the drive will continue to decelerate and stop even if the line power is re-applied. If normal or timed injection braking is selected, the drive will use ramp mode to stop on loss of line power. If ramp stop followed by injection braking is selected, the drive will ramp to a stop and then attempt to apply dc injection. If the line supply is reapplied the drive restarts after it reaches the ready state provided the necessary controls are still active to initiate a start.

##### RFC

The speed reference is set to zero and the ramps are disabled allowing the drive to decelerate the motor to a stop under current limit. If the line power 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 enter a UU trip before the motor has stopped. If the line power is reapplied the drive restarts after it reaches the ready state provided the necessary controls are still active to initiate a start.

#### 2: ride.th

The drive detects line power loss when the DC bus voltage falls below Vml<sub>1</sub>. The drive then enters a mode where a closed-loop controller attempts to hold the DC bus level at Vml<sub>2</sub>. This causes the motor to decelerate at a rate that increases as the speed falls. If the line power is re-applied, it will force the DC bus voltage above the detection threshold Vml<sub>3</sub> and the drive will continue to operate normally. The output of the line power 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 70 for set-up details.

**Table 5-7 Voltages and voltage ratings**

Voltage level	200V drive	400V drive	575V drive	690V drive
Vuu	175	350	500	500
Vml <sub>1</sub>	205*	410*	540*	540*
Vml <sub>2</sub>	Vml <sub>1</sub> - 10V	Vml <sub>1</sub> - 20V	Vml <sub>1</sub> - 25V	Vml <sub>1</sub> - 25V
Vml <sub>3</sub>	Vml <sub>1</sub> + 10	Vml <sub>1</sub> + 15	Vml <sub>1</sub> + 50	Vml <sub>1</sub> + 50
Vuu Restart	215	425	590	590

\* Vml<sub>1</sub> is defined by Pr 6.48. The values given in the table are the default values.

6.04	Start/stop logic select															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 4							
Default	Open-loop, RFC								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 (Pr 8.22)	T26 (Pr 8.23)	T27 (Pr 8.24)	Pr 6.40
0	Pr 6.29*	Pr 6.30 Run Forward	Pr 6.32 Run Reverse	0 (non latching)
1	Pr 6.39 Not stop	Pr 6.30 Run Forward	Pr 6.32 Run Reverse	1 (latching)
2	Pr 6.29*	Pr 6.34 Run	Pr 6.33 Fwd /Rev	0 (non latching)
3	Pr 6.39 Not stop	Pr 6.34 Run	Pr 6.33 Fwd/Rev	1 (latching)
4	User prog	User prog	User prog	User prog

\* Pr 6.29 can be used as a fast disable parameter. See Pr 6.29 on page 103 for more information.

6.06	Injection braking level															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1		1				1	1	1	
Range	Open-loop							0 to 150.0 %								
Default	Open-loop							100.0 %								
Update rate	Background read															

Defines the current level used during dc injection braking as a percentage of motor rated current as defined by Pr 5.07.

6.07	Injection braking time															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop							0.0 to 25.0 s								
Default	Open-loop							1.0								
Update rate	Background read															


Defines the time of injection braking during phase 1 with stopping modes 3 and 4 (see Pr 6.01 on page 96) for injection braking stop.

6.08	Hold zero speed / Motor pre-heat enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

Pre-heat mode is enabled if Pr 6.08 is set to a 1 and Pr 6.52 is set to a value greater than zero. When the run command is removed and the motor has reached standstill, the drive applies a percentage (determined by the value in Pr 6.52) of the motor rated current. When pre-heat is active, then the keypad displays the status "Heat".

Hold zero speed is enabled if Pr 6.08 is set to a one and Pr 6.52 is set to zero. When the run command is removed and the motor has reached standstill, the drive continues to apply the magnetizing current. The level of magnetizing current cannot be modified. When hold zero speed is active, then the keypad displays the status "StoP".

The drive cannot be switched between hold zero speed and pre-heat mode if any one of these modes is active. The drive should either be disabled or running in order to change the mode.



The value in Pr 6.52 should not be set too high because it could damage the motor or cause the motor thermal protection to operate and trip the drive.

6.09	Catch a spinning motor																
Drive modes	Open-loop, RFC																
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
													1	1	1		
Range	Open-loop								3								
	RFC								1								
Default	Open-loop								0								
	RFC								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.

Using the default parameters, the length of the test is approximately 200ms. However if the motor has a short rotor time constant/filter (usually found in smaller motors) the time may be shorter. The drive will set the test time automatically if the motor parameters including the rated load rpm, are set up correctly for the motor.

For the test to operate correctly, it is important that the stator resistance (Pr 5.17, Pr 21.12) is set up correctly. This applies even if fixed boost (Fd) or square law (SrE) voltage mode is being used. The test uses the rated magnetizing current of the motor during the test, therefore the rated current (Pr 5.07, Pr 21.07 and Pr 5.10, Pr 21.10) and power factor should be set to values close to those of the motor, although these parameters are not as critical as the stator resistance. For larger motors, it may be necessary to increase Pr 5.40 (spin start boost) from its default value of 1.0 for the drive to successfully detect the motor speed.

It should be noted that a stationary lightly loaded motor with low inertia may move slightly during the test. The direction of the movement is undefined. Restrictions may be placed on the direction of this movement and on the frequencies detected by the drive as follows:

Pr 6.09	Function
0	Disabled
1	Detect all frequencies
2	Detect positive frequencies only
3	Detect negative frequencies only

#### RFC

When the drive is enabled with this bit at zero, the post ramp reference (Pr 2.01) starts at zero and ramps to the required reference. When the drive is enabled with this parameter at one, the post ramp reference is set to the motor speed. When RFC mode is used feedback and catch a spinning motor is not required, this parameter should be set to zero as this avoids unwanted movement of the motor shaft when zero speed is required. When RFC mode is used with larger motors, it may be necessary to increase Pr 5.40 (spin start boost) from its default value of 1.0 for the drive to successfully detect the motor speed.

6.12	Enable stop key															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

This parameter permanently enables the Stop key on the drive such that the drive will always stop when the Stop key is pressed. If keypad mode is selected this has no effect because the Stop key is automatically enabled.

The sequencer logic has been designed so that pressing the Stop key (whether the Stop key is enabled or not), does not make the drive change from a stopped to a running condition. As the Stop key is also used to reset trips, this means that if the Stop key is pressed when the drive is tripped, the trip will be reset but the drive does not start. (This does not apply to the UU trip which cannot be reset by the user, but is automatically reset when the DC bus voltage is high enough).

Preventing the drive from starting when the stop key is pressed is implemented as follows:-

#### Sequencer latching not enabled (Pr 6.40=0)

If the Stop key is pressed when the Stop key is enabled (Pr 6.12=1), or when the drive is tripped the sequencer run is removed, and so the drive stops or remains stopped respectively. The sequencer run can only then be reapplied after at least one of the following conditions occurs:-

1. Run forward, Run reverse and Run sequencing bits all zero
2. OR the drive is disabled via Pr 6.15 or Pr 6.29
3. OR Run forward and Run reverse are both active and have been for 60ms.
4. OR The drive is in the UU state.

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

#### Sequencer latching enabled (Pr 6.40=1)

If the Stop key is pressed when the stop key is enabled (Pr 6.12=1) or when the drive is tripped the sequencer run is removed, and so the drive stops or remains stopped respectively. The sequencer run can only then be reapplied after at least one of the following conditions occurs.

1. Run forward, Run reverse and Run sequencing bits all zero after the latches
2. OR Not stop sequencing bit is zero
3. OR the drive is disabled via Pr 6.15 or Pr 6.29
4. OR Run forward and Run reverse are both active and have been for 60ms.
5. OR The drive is in the UU state.

The drive can then be restarted by activating the necessary bits to give a normal start. Note that Run forward and Run reverse together will reset the stop key condition, but the latches associated with Run forward and Run reverse must then be reset before the drive can be restarted. It should be noted that holding the Run key and pressing the Stop key to reset the drive without stopping does not apply unless keypad reference mode is selected.

Menu 6	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
--------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

6.15	Drive enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Open-loop, RFC								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	Date															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1		1	1	
Default	Open-loop, RFC							0 to 311299								
Update rate	Background read/write															

6.17	Time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1		1	1	
Default	Open-loop, RFC							0.0 to 23.59								
Update rate	Background read/write															

6.18	Day of week															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Default	Open-loop, RFC							0 to 6								
Update rate	Background write															

6.19	Date / Time selector															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 5							
Default	Open-loop, RFC								3							
Update rate	Background read															



6.20	Date format															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 3							
Default	Open-loop, RFC								EUR > 0 (Std), USA > 2 (US)							
Update rate	Background read															

The value of Pr 6.19 determines the data displayed in Pr 6.16 and Pr 6.17 as shown in the table below:

Pr 6.19	Data displayed in Pr 6.16 and Pr 6.17
0	Drive powered-up time: Date and time starts from zero at each power-up
1	Date and time from real time clock in slot 1 Solutions Module. If the module does not support this feature or no module is installed in slot 1, then the date and time will be zero
2	Date and time from real time clock in slot 2 Solutions Module. If the module does not support this feature or no module is installed in slot 2, then the date and time will be zero
3	Date and time from internal real time clock
4	Drive running time: Time that the drive inverter has been active since it was manufactured
5	Set date and time: Date and time can be adjusted and written to all Solutions Modules installed which support real time clock

Pr 6.16 shows the date in the format ddmmyy (Pr 6.20 = 0 or 1) or mmddyy (Pr 6.20 = 2 or 3). Pr 6.17 shows the time in hh.mm format.

If Pr 6.19 is set to 0 or 4 then the date and time start from zero, the days roll over after 30, and the months roll over after 11.

The day of the week displayed in Pr 6.18 is zero unless Pr 6.19 is set to 1, 2 or 3.

To adjust the date/time, set Pr 6.19 to 5. Enter date/time in Pr 6.16 and Pr 6.17. The date/time will be written to the internal real time clock and any Solutions Module installed that supports real time clock functions.

The drive date and time (Pr 6.16 and Pr 6.17) are used for the date/times associated with the trip log (Pr 10.41 to Pr 10.60) and timer functions (Pr 9.35 to Pr 9.43).

If Pr 6.19 is changed, then a reset must be initiated for the change to take place, otherwise the originally selected clock will be used for the trip log and timer functions.

If Pr 6.19 is changed and a reset is initiated then the trip log times are cleared and the repeat period for the timers (Pr 9.39, Pr 9.49) set to zero, disabling the timers.

Daylight saving time is enabled if Pr 6.20 is set to 1 (Std) or 3 (US) and has the following effect:

Pr value	Pr string	Date format
0	Std	ddmmyy
1	Std.ds	ddmmyy with an extra hour added for daylight saving
2	US	mmddyy
3	US.ds	mmddyy with an extra hour added for daylight saving

The value in Pr 6.18 denotes the day of week as shown in the following table.

Pr value	Day of week
0	Sunday
1	Monday
2	Tuesday
3	Wednesday
4	Thursday
5	Friday
6	Saturday

6.21	Time between filter changes															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1			1	1	1	
Range	Open-loop, RFC							0 to 30,000 hrs								
Default	Open-loop, RFC							0								
Update rate	Background read															

6.22	Filter change required / change done															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1		1		
Default	Open-loop, RFC								0							
Update rate	Background read/write															

6.23	Time before filter change due															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	1
Range	Open-loop, RFC							0 to 30,000 hrs								
Update rate	Background read															

To enable the feature which indicates to the user when a filter change is due, Pr 6.21 should be set to the time between filter changes and Pr 6.22 set to 1 and back to 0. When the drive is running, Pr 6.23 is reduced each time the runtime timer hour increments until Pr 6.23 reaches 0, at which point Pr 6.22 is set to 1 to inform the user that a filter change is required. When the user has changed the filter, resetting Pr 6.22 to 0 will indicate to the drive that the change has been done and Pr 6.23 will be reloaded with the value of Pr 6.21. Pr 6.23 can be updated with the value of Pr 6.21 at any time by setting and clearing this parameter manually.

6.24	Reset energy meter															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	Background read															

If this parameter is one the energy meter (Pr 6.25 and Pr 6.26) is reset and held at zero.

6.25	Energy meter: MWh															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				1
Range	Open-loop, RFC								±999.9 MWh							
Update rate	Background write															

6.26	Energy meter: kWh															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				1
Range	Open-loop, RFC							±99.99 kWh								
Update rate	Background write															

Pr 6.25 and Pr 6.26 form the energy meter that indicates the net energy supplied to/from the drive in kWh (i.e. energy supplied by the drive - energy fed back to the drive). For motor control modes a positive value indicates net transfer of energy from the drive to the motor. The energy meter is reset and held at zero when Pr 6.24 is one.

If the maximum or minimum of Pr 6.25 is reached, the parameter does not roll over, but is instead clamped at the maximum or minimum value.

6.27	Electricity cost per kWh															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0.0 to 600.0 currency units per kWh								
Default	Open-loop, RFC							0								
Update rate	Background read															

When this parameter is set up correctly for the local currency, Pr 6.28 will give an instantaneous read out of running cost.

6.28	Running cost															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1				
Range	Open-loop, RFC								±32,000							
Update rate	Background write															

Instantaneous read out of the cost/hour of running the drive. This requires Pr 6.27 to be set up correctly.

6.29	Hardware enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1		1				
Update rate	4ms write															

This bit shows whether the drive is in the enable state or not.

Generally this will reflect the state of the enable input and shows the same value as Pr 8.09. However, the disabled state can be forced by other functions within the drive. Pr 8.09 will always follow the enable input state but the Pr 6.29 will be held at zero, indicating that the drive is forced into the disable state by the following:

1. A digital input is routed to this parameter as described below to provide a fast disable and the input forces this parameter to zero.
2. Any of the following trips are active: OI.AC, PS.10V, PS.24V, OI.Br, OV.

If the destination of one of the drive digital I/O (Pr 8.21 to Pr 8.26) is set to Pr 6.29 and the I/O is set as an input, the state of the input does not affect the value of this parameter as it is protected, however it does provide a fast disable function. The drive enable input to the drive (T31) disables the drive in hardware by removing the gate drive signals from the inverter IGBT's and also disables the drive via the software system.

When the drive is disabled by de-activating the drive enable input there can be a delay of up to 20ms. However, if a digital I/O is set up to provide the fast disable function it is possible to disable the drive within 600us of de-activating the input. To do this the enable signal should be connected to both the drive enable (T31) and to the digital I/O selected for the fast disable function. The state of the digital I/O including the effect of its associated invert parameter is ANDed with the drive enable to enable the drive.

6.30	Sequencing bit: Run forward															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.31	Sequencing bit: Jog															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.32	Sequencing bit: Run reverse															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.33	Sequencing bit: Forward/reverse															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.34	Sequencing bit: Run															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

During normal operation, the sequencer is 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, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	250μs read															

6.36	Reverse limit switch															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								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 RFC mode 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

#### RFC

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, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.39	Sequencing bit: Not stop															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.40	Enable sequencer latching															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

6.41	Drive event flags															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, RFC								0 to 65535							
Default	Open-loop, RFC								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.

#### 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, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, RFC								0 to 32,767							
Default	Open-loop, RFC								0							
Update rate	Bits 0 –7: 4ms read, Bits 8-15: Background read															

6.43	Control word enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC 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.

Bit	Function	Equivalent parameter
0	Drive enable	Pr 6.15
1	Run forward	Pr 6.30
2	Jog	Pr 6.31
3	Run reverse	Pr 6.32
4	Forward/reverse	Pr 6.33
5	Run	Pr 6.34
6	Not stop	Pr 6.39
7	Auto/manual	
8	Analog/Preset reference	Pr 1.42
9	Jog reverse	Pr 6.37
10	Reserved	
11	Reserved	
12	Trip drive	
13	Reset drive	Pr 10.33
14	Keypad watchdog	

#### Bits 0-7 and bit 9: sequencing control

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

#### Bit 8: Analog/preset reference

When the control word is enabled (Pr 6.43) bit 8 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) The state of bit 8 is written to Pr 1.42. With default drive settings this selects analog reference 1 (bit8 = 0) or preset reference 1 (bit8 = 1). If any other drive parameters are routed to Pr 1.42 the value of Pr 1.42 is undefined.

#### Bit12: Trip drive

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

#### Bit 13: Reset drive

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

#### Bit 14: Keypad watchdog

When the control word is enabled (Pr 6.43) bit 14 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) A watchdog is provided for an external keypad or other device where a break in the communication link must be detected. The watchdog system can be enabled and/or serviced if bit 14 of the control word is changed from zero to one with the control word enabled. Once the watchdog is enabled it must be serviced at least once every second or an "SCL" trip occurs. The watchdog is disabled when an "SCL" trip occurs, and so it must be re-enabled when the trip is reset. It should be noted that when data is transferred from a SMARTCARD to the drive there may be a delay of up to 1.5s for the comms to respond. Once the comms starts to respond again normally the watchdog will not time-out for a further 2s even if it is not serviced. This period is allowed for the system connected to the comms port to recover if required and to begin servicing the watchdog again.

6.44	Active supply															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

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

#### 0: Normal high voltage supply

The drive is operating in normal high voltage supply mode.

##### BA1xxx, BA2xxx, BA3xxx:

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

##### BA4xxx, BA5xxx, BA6xxx, BAMxxxx

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

#### 1: Low voltage dc supply

The drive is operating in low voltage dc supply mode.

##### BA1xxx, BA2xxx, BA3xxx:

The drive is using the low voltage auxiliary power input to derive the power circuit supplies (i.e. gate drives, fans, etc). The main power terminals can be connected to a different supply of any voltage up to the maximum normal supply level. All parameters voltage based parameters are calculated from the auxiliary supply level and not the supply from the main power terminals. If the auxiliary supply and the main supply are different, then these parameters will not be correct. Parameters that are saved at power-down are not saved when the power is removed in this mode.

##### BA4xxx and larger:

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

For all sizes of drive in low voltage battery mode, 24V must also be supplied via the 24V control board power supply input. The drive will operate normally except that line power loss detection is disabled, the braking IGBT will only operate when the drive is enabled, and the voltage levels contained in the following table are used instead of the normal high voltage levels whatever the voltage rating of the drive.

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

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

6.45	Force cooling fan to run at full speed															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Update rate	Background read															

The drive thermal model system normally controls the fan speed, however the fan can be forced to operate at full speed if this parameter is set to 1. When this is set to 1 the fan remains at full speed until 10s after this parameter is set to zero.

#### NOTE

When the drive is in the UU state, the fan always runs at minimum speed.

6.46	Nominal low voltage dc supply															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	48 to 48 for BA1xxx drives 48 to 72 for BA2xxx and BA3xxx drives 48 to 72 for all other 200V drives 48 to 96 for all other 400V and 690V drives															
Default	Open-loop, RFC								48							
Update rate	Background read															

This parameter defines the nominal supply voltage when operating in low voltage mode. The parameter is used to define the braking IGBT switching threshold and the over voltage trip level for low voltage battery mode (see Pr 6.44).

6.47	Disable line power/phase loss detection from input rectifier															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

#### BA1xxx, BA2xxx and BA3xxx

Drives in these sizes ranges have a diode rectifier input stage with no direct monitoring system. Line power loss and phase loss detection is derived from the DC bus voltage. This parameter has no effect.

#### BA4xxx, BA5xxx and BA6xxx

Drives in these sizes ranges have an active rectifier input stage that is used to control DC bus charging. Line power loss and phase loss detection is derived from the DC bus voltage. The only status information taken from the input rectifier stage is an over temperature indication which gives an Oht4 trip if active. This parameter has no effect on this feature. When the control system is leaving the line power loss ride through condition (ACUU) it is important that no load is applied to the input rectifier until it is fully active. This feature can be disabled by setting this parameter to one.

#### BAMxxxx

Drives in this size range have an active rectifier input stage that is used to control DC bus charging. Line power and phase loss detection is derived from the DC bus voltage, but additional monitoring is provided by the input rectifier controller as follows:

1. An over temperature indication from a single module or any module operating in parallel causes an Oht4.P trip if it is present for more than 0.5s. This feature is not affected by this parameter.
2. A phase loss indication from a single module or any module operating in parallel causes a PH.P trip if it is present for more than 0.5s. If this parameter is set to one, the drive is operating in regen mode or the drive is operating from a low voltage supply this feature is disabled.
3. A line power loss indication from any, but not all modules operating in parallel, causes a PH.P trip if this condition is present for more than 0.5s. If this parameter is set to one, the drive is operating in regen mode or the drive is operating from a low voltage supply this feature is disabled.

When the control system is leaving the line power loss ride through condition (ACUU) it is important that no load is applied to the input rectifier until it is fully active. This feature can be disabled by setting this parameter to one.

The active rectifier status signals are monitored in one of the following ways:

1. When BAMAxix drives are connected in parallel, the status of the individual rectifiers is monitored through the parallel module control interface system.
2. When BAMDxxx drives are connected in parallel, the status of the individual rectifiers is combined and is monitored when the combined status signals are connected to power module one.
3. When an external rectifier is used, these monitoring features are provided via digital I/O terminals using the rectifier monitoring feature of the variable selector blocks (see menu 12).

6.48	Line power loss ride through detection level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Open-loop, RFC								0 to dc_VOLTAGE_SET_MAX V							
Default	Open-loop, RFC								200V rated drive 205							
									400V rated drive 410							
									575V rated drive 540							
									690V rated drive 540							
Update rate	Background read															

The line power loss detection level can be adjusted using this parameter. If the value is reduced below the default value the default value is used by the drive. If the level is set too high so that line power loss detection becomes active under normal operating conditions the motor will coast to a stop.



6.49	Enable date / time in trip log															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								1							
Update rate	Background read															

The drive retains a log in Pr 10.20 to Pr 10.29 of the last 10 trips that have occurred. The state of Pr 6.49 determines whether date and time or module number, associated with the trip, is stored (see Table 5-8).

**Table 5-8 Trip log definition**

Trip number	Trip code	Pr 6.49 = 1		Pr 6.49 = 0
		Date	Time	Module number
Trip 1	10.20	10.41	10.42	10.42
Trip 2	10.21	10.43	10.44	10.44
Trip 3	10.22	10.45	10.46	10.46
Trip 4	10.23	10.47	10.48	10.48
Trip 5	10.24	10.49	10.50	10.50
Trip 6	10.25	10.51	10.52	10.52
Trip 7	10.26	10.53	10.54	10.54
Trip 8	10.27	10.55	10.56	10.56
Trip 9	10.28	10.57	10.58	10.58
Trip 10	10.29	10.59	10.60	10.60

Trip 1 is the most recent trip or the current trip if the drive is in a trip condition, and trip 10 is the oldest trip.

The date and time for Pr 10.41 to 10.59 are taken from the values in Pr 6.16 and Pr 6.17.

The value in Pr 6.19 determines if power-up time, drive running time or real time clock is logged.

If any parameter between Pr 10.20 and Pr 10.29 inclusive is read by serial communications, then the trip number in Table 5-13 *Trip indications* on page 143 is the value transmitted.

When power modules are connected in parallel, various trips can be initiated from the power modules themselves. To aid identification of the source of the trip the module number of the source can be stored in the module number and trip time log (Pr 10.42 to Pr 10.60). If the drive is a single module drive (BA1xxx to BA6xxx), the module number that is stored is normally zero. However, a BAMAXxxx or BAMDXxxx drive is installed with the interface circuits normally intended for parallel operation, so if a BAMAXxxx or BAMDXxxx drive is used as a single module then a module number of 1 is stored.

If Pr 6.49 is zero the module number is stored in the module number and trip time log. If this parameter is one, either the powered-up clock or run time clock is stored in the module number and trip time log as defined by Pr 6.28. It should be noted that changing this parameter clears the trip, and module number and trip time logs.

6.50	Drive comms state															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Default	Open-loop,RFC								0 to 2							
Update rate	Background write															

The drive comms system 128 bytes buffer used with ANSI or Modbus rtu protocols via the 485 connector can be controlled by an Solutions Module under certain circumstances. This parameter shows which node has control of the buffer (0 (drv) = drive, 1 (Slot1) = Solutions Modules in slot 1, etc. If an Solutions Modules has control of the buffer the drive will use an alternative buffer for 485 comms and the following restrictions will apply:

1. Comms messages via the 485 port are limited to a maximum of 32 bytes
2. The 6 pin keypad port will operate correctly with an LED keypad, but it will no longer operate with an LCD keypad
3. Modbus messages using the CMP protocol can only route messages to nodes within the drive. It will not be possible for these to be routed further, i.e. via CT Net on an SM Applications module.

6.51	External rectifier not active															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1													1		
Default	Open-loop,RFC								0							
Update rate	1ms read															

When a drive with an internal rectifier is used this parameter should be left at zero. For a drive with an active external rectifier (used to control DC bus charging), this parameter should be the destination of the output of a variable selector set up for external rectifier monitoring. This allows the monitoring block to prevent the drive from leaving the main loss ride through mode until the rectifier is fully active and phased forwards. If this feature is not used, the line power loss ride through mode ends as soon as the DC bus voltage is above the line power loss detection level. The rectifier may still be phasing forwards, and the application of load at this point may cause the DC bus voltage to fall back below the line power loss detection level again.

6.52	Motor pre-heat current magnitude															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop,RFC								0 to 100%							
Default	Open-loop,RFC								0							
Update rate	Background read															

Refer to Pr 6.08

6.53	Sleep / wake threshold															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop RFC								0 to 50.0 Hz 0.0 to 1500.0 rpm							
Default	Open-loop,RFC								0.0							
Update rate	Background read															

6.54	Sleep / wake delay time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC								0 to 250.0s							
Default	Open-loop,RFC								10.0s							
Update rate	Background read															

Sleep/wake mode automatically stops the motor if it is running at a low and inefficient speed. It is enabled when Pr 6.53 is set to a non zero value, and activated when the absolute value of the frequency/speed reference Pr 1.01 remains below the sleep threshold Pr 6.53 for the time period set in Pr 6.54.

When sleep/wake mode is activated, the internal drive run command is removed and the motor stops. The motor restarts when Pr 1.01 remains above the sleep threshold Pr 6.53 for the time period set in Pr 6.54.

If the PID functions are being used then sleep mode can be delayed by setting the PID pre-boost level (Pr 14.28) and maximum boost time (Pr 14.29) to non-zero values.

Sleep/wake mode cannot be activated when the keypad reference mode is selected (i.e. Pr 1.49 = 4).

If bipolar mode is disabled (i.e. Pr 1.10 = 0), then negative values of the reference selected (Pr 1.01) are treated as zero when compared to the sleep threshold.

## 5.9 Menu 7: Analog I/O

### Hardware

The drive has three analog inputs (AI1 to AI3) and two analog outputs (AO1 and AO2). Each input and 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.

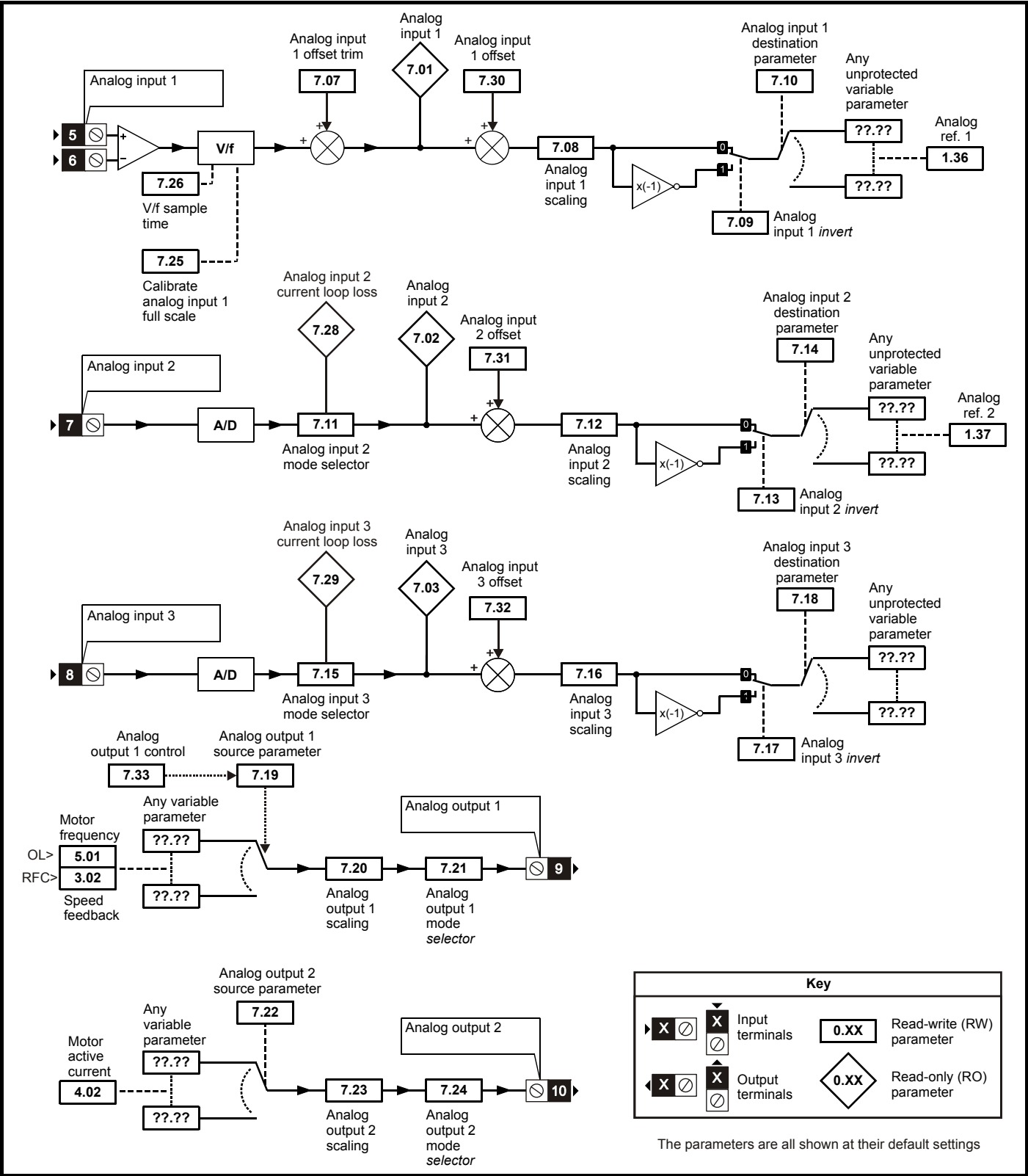
Input destination	RFC mode sample rate
Pr 1.36 - Analog reference	250µs (AI1 subject to window filter. See Pr 7.26 on page 119)
Pr 1.37 - Analog reference	250µs (AI1 subject to window filter. See Pr 7.26 on page 119)
Pr 3.19 - Hard speed ref	250µs (AI1 subject to window filter. See Pr 7.26 on page 119)
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	(RFC modes only) 10.0V = SPEED_MAX
Pr 4.02 - torque prod current	10.0V = Kc / 0.45 where Kc is the current scaling factor for the drive
Pr 4.17 - magnetising current	10.0V = Kc / 0.45
Pr 5.03 - output power	(RFC modes only) The output is the product of the active current and the voltage component in phase with the active current (v <sub>sy</sub> x i <sub>sy</sub> ). 10V would be produced when: Active current = Kc / 0.45 Peak phase voltage in phase with the active current = dc_VOLTAGE_MAX / 2

Figure 5-10 Menu 7 logic diagram



7.01	T5/6 analog input 1 level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC								±100.00 %							
Update rate	4ms write															

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

7.02	T7 analog input 2 level															
7.03	T8 analog input 3 level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				
Range	Open-loop, RFC								±100.0 %							
Update rate	4ms write															

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

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

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

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

7.04	Power circuit temperature 1															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							-128 to 127°C								
Update rate	Background write															

7.05	Power circuit temperature 2															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							-128 to 127°C								
Update rate	Background write															

7.06	Control board temperature															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							-128 to 127°C								
Update rate	Background write															

For drive sizes BA1xxx to BA5xxx two temperatures are available from the power circuit. These are displayed in Pr 7.04 and Pr 7.05. For drive size BA6xxx and BAMxxxx, three temperatures are available from the power circuit. These are displayed in Pr 7.04, Pr 7.05 and Pr 7.36. If BAMxxxx drives consist of more than one parallel power module, the temperatures displayed are the highest value from any of the parallel modules.

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

**Table 5-9 Power stage temperature 1 (Pr 7.04) in °C**

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
BA0xxx	77	72	75
BA1xxx	110	105	100
BA2xxx	115	110	100
BA3xxx	120	115	100
BA4xxx	72	67	68
BA5xxx	72	67	68
BA6xxx	92	87	85
BAMAxxxx	92	87	85
BAMDxxxx	96	91	88

Additional monitoring is used with drives size BA6xxx and BAMAxxxx to detect failure of the power stage cooling fan. If this fan fails, the monitoring point used to derive power stage temperature 1 that is nearest the fan, will raise the temperature above its normal level, but not above the trip temperature for the power stage. This is detected and can initiate an Oht2 trip. The trip thresholds are shown below.

Drive size	Trip temperature
BA6xxx	67
BAMAxxxx	67
BAMDxxxx	71

**Table 5-10 Power stack temperature 2 (Pr 7.05) in °C**

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
BA0xxx	83	78	80
BA1xxx	92	87	85
BA2xxx	100	95	95
BA3xxx	98	93	94
BA4xxx	78	73	72
BA5xxx	78	73	72
BA6xxx	78	73	72
BAMAxxxx	78	73	72
BAMDxxxx	78	73	72

**Table 5-11 Power stack temperature 3 (Pr 7.36) in °C**

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
BA0xxx	105	100	100
BA1xxx	N/A	N/A	N/A
BA2xxx	N/A	N/A	N/A
BA3xxx	N/A	N/A	N/A
BA4xxx	N/A	N/A	N/A
BA5xxx	N/A	N/A	N/A
BA6xxx	85	80	80
BAMAxxxx	85	80	80
BAMDxxxx	125	100	120

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

#### Drive cooling fan

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

1. If Pr 6.45 = 1 the fan is at full speed for at least 10s.
2. If a Solutions Module indicates that it is overheating, the fan will run at full speed for at least 10s.
3. For drive sizes BA1xxx to BA2xxx the fan is at full speed if the drive is enabled and the highest power circuit temperature (Pr 7.04 or Pr 7.05) or the temperature calculated for the case of the IGBT package exceed the threshold for the drive. The fan is at its low speed if this temperature falls 5°C below the threshold, or the drive is disabled and the temperature is below the alarm level for Pr 7.04 and Pr 7.05.
4. For drive sizes BA3xxx to BA6xxx, the fan speed is controlled above its minimum level if the drive is enabled, and the highest power circuit temperature (Pr 7.04, Pr 7.05 or Pr 7.36) or the temperature calculated for the case of the IGBT package exceed the lower threshold for the drive. The maximum fan speed is reached when the highest of these temperatures exceeds the upper threshold. The fan is at its minimum speed if the drive is disabled and the temperature is below the alarm level for Pr 7.04, Pr 7.05 and Pr 7.36. The thresholds are given in the table below in °C :

Drive size	Fan threshold	Lower fan threshold	Upper fan threshold
BA0xxx	N/A	N/A	N/A
BA1xxx	60	N/A	N/A
BA2xxx	60	N/A	N/A
BA3xxx	N/A	55	70
BA4xxx	N/A	55	62
BA5xxx	N/A	55	62
BA6xxx	N/A	55	65
BAMAxxxx	N/A	55	65
BAMDxxxx	N/A	55	65

7.07	T5/6 analog input 1 offset trim															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, RFC								±10.000 %							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	Background read															

7.09	T5/6 analog input 1 invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

7.10	T5/6 analog input 1 destination															
Drive modes	Open-loop, RFC															
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, RFC							Pr <b>0.00</b> to Pr <b>50.99</b>								
Default	Open-loop, RFC							Pr <b>1.36</b>								
Update rate	Read on drive reset															

7.11	T7 analog input 2 mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 6							
Default	Open-loop, RFC								4							
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	

In modes 2 and 4, the destination parameter is at a value equivalent to 0.0% when the input current is less than 4mA. In modes 3 and 5 the destination parameter is at a value equivalent to 100.0% when the input current is less than 4mA.

7.12	T7 analog input 2 scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	Background read															

7.13	T7 analog input 2 invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

7.14	T7 analog input 2 destination															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 1.37							
Update rate	Read on drive reset															



7.15	T8 analog input 3 mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 9							
Default	Open-loop, RFC								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	

In modes 2 and 4 the destination parameter is at a value equivalent to 0.0% when the input current is less than 4mA. In modes 3 and 5 the destination parameter is at a value equivalent to 100.0% when the input current is less than 4mA.

7.16	T8 analog input 3 scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	Background read															

7.17	T8 analog input 3 invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

7.18	T8 analog input 3 destination															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on drive reset															

7.19	T9 analog output 1 source															
Drive modes	Open-loop, RFC															
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, RFC							Pr <b>0.00</b> to Pr <b>50.99</b>								
Default	Open-loop RFC							Pr <b>5.01</b> Pr <b>3.02</b>								
Update rate	Background read															

7.20	T9 analog output 1 scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 4.000								
Default	Open-loop, RFC							1.000								
Update rate	Background read															

7.21	T9 analog output 1 mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC							0 to 3								
Default	Open-loop, RFC							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

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

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

If high speed update mode is selected and the source for the output is one of the parameters designated for high speed analog output operation (see start of this section), the output is updated at a higher rate with special scaling. If the parameter selected is not designated for this mode, the output is updated at the normal rate. If speed feedback or power is selected for high speed mode for both analog output 1 and analog output 2, the setting is ignored for analog output 2. If the high speed mode is selected the output is always a voltage signal.

7.22	T10 analog output 2 source															
Drive modes	Open-loop, RFC															
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, RFC							Pr 0.00 to Pr 50.99								
Default	Open-loop, RFC							Pr 4.02								
Update rate	Read on drive reset															

7.23	T10 analog output 2 scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 4.000								
Default	Open-loop, RFC							1.000								
Update rate	Background read															

7.24	T10 analog output 2 mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC							0 to 3								
Default	Open-loop, RFC							0								
Update rate	Background read															

The following modes are available for the analog outputs.

Parameter value	Parameter string	Mode
0	VOLt	Voltage mode
1	0-20	0 - 20mA
2	4-20	4 - 20mA
3	H.Spd	High speed update mode

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

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

If high speed update mode is selected, and the source for the output is one of the parameters designated for high speed analog output operation (see start of this section), the output is updated at a higher rate with special scaling. If the parameter selected is not designated for this mode, the output is updated at the normal rate. If speed feedback or power is selected for high speed mode for both analog output 1 and analog output 2, the setting is ignored for analog output 2. If the high speed mode is selected the output is always a voltage signal.

7.25	Calibrate T5/6 analog input 1 full scale															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0 to 8.0 ms								
Default	Open-loop, RFC							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 250 $\mu$ s. It should be noted that if this input is not used as a speed reference (Pr 1.36, Pr 1.37) or as a hard speed reference (Pr 3.22) the sample time affects the resolution. The nominal resolution is given by Pr 7.26 x 500 x 10, therefore the default setting gives approximately 11 bit resolution.

7.28	T7 analog input 2 current loop loss															
7.29	T8 analog input 3 current loop loss															
Drive modes	Open-loop, RFC															
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 -analog input 3) is set to one if the current falls below 3mA. If the current is above 3mA with these modes or another mode is selected the respective bit is set to zero.

7.30	T5/6 analog input 1 offset															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1		
Range	Open-loop, RFC							±100.00 %								
Default	Open-loop, RFC							0.00								
Update rate	Background read															

7.31	T7 analog input 2 offset															
7.32	T8 analog input 3 offset															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Open-loop, RFC								±100.0 %							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC								±200 °C							
Update rate	Background write															

The IGBT junction temperature is displayed in this parameter is the sum of the power circuit 1 temperature (Pr 7.04) and a thermal model of the drive power stage. The 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 89).

7.35	Drive thermal protection accumulator															
Drive modes	Open-loop, RFC															
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, RFC								0 to 100 %							
Update rate	Background write															

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

7.36	Power circuit temperature 3															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							-128 to 127 °C								
Update rate	Background write															

An additional thermal monitoring point is provided in BA6xxx and BAMxxxx drives. The temperature is displayed in this parameter in degrees C. See Pr 7.04 to Pr 7.06 for more details.

If this temperature exceeds 135°C, the switching frequency is reduced provided that this feature has not been reached. The switching frequency can be reduced from 12kHz to 6kHz to 3kHz, or from 16kHz to 8kHz to 4kHz. If at any time the calculated IGBT junction temperature exceeds 145°C the drive initiates an Ohtl.trip. Once the switching frequency has been reduced the drive will attempt to restore the switching frequency every 20ms if the higher switching frequency will not take the IGBT temperature above 135°C.

## 5.10 Menu 8: Digital I/O

The drive has eight digital I/O terminals (T22, T24 to T29 and the relay) plus an enable input.

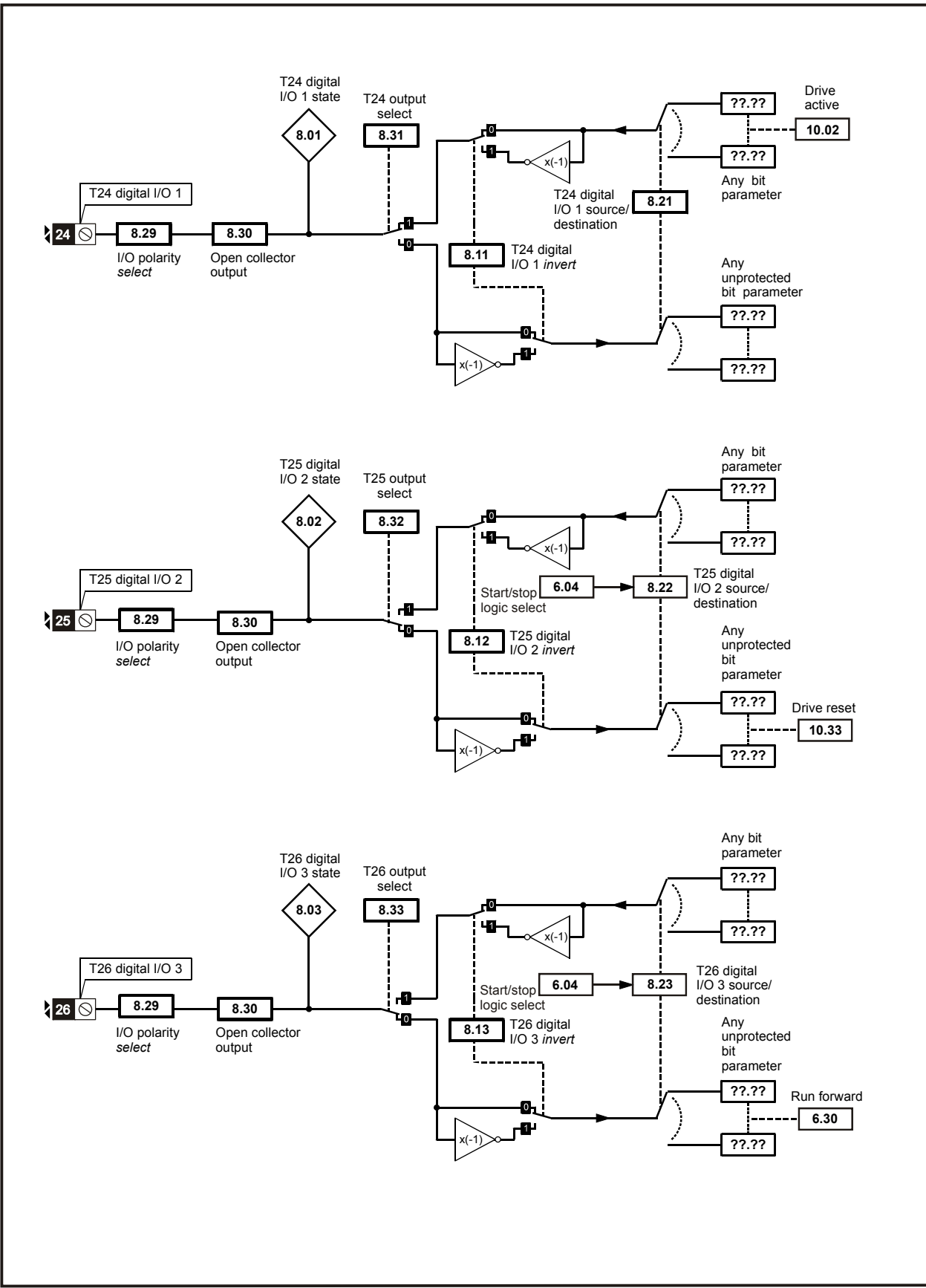
Each input has the same parameter structure. The digital inputs are sampled every 4ms except when inputs are routed to the limit switches Pr **6.35** and Pr **6.36** when the sample time is reduced to 250µs.

The digital input hardware (excluding the drive enable input) introduces a further 100µs delay. The secure disable input hardware gives a typical delay of 8ms (maximum 20ms). The digital outputs are updated every 4ms. Any changes to the source/destination parameters only become effect after drive reset is activated.

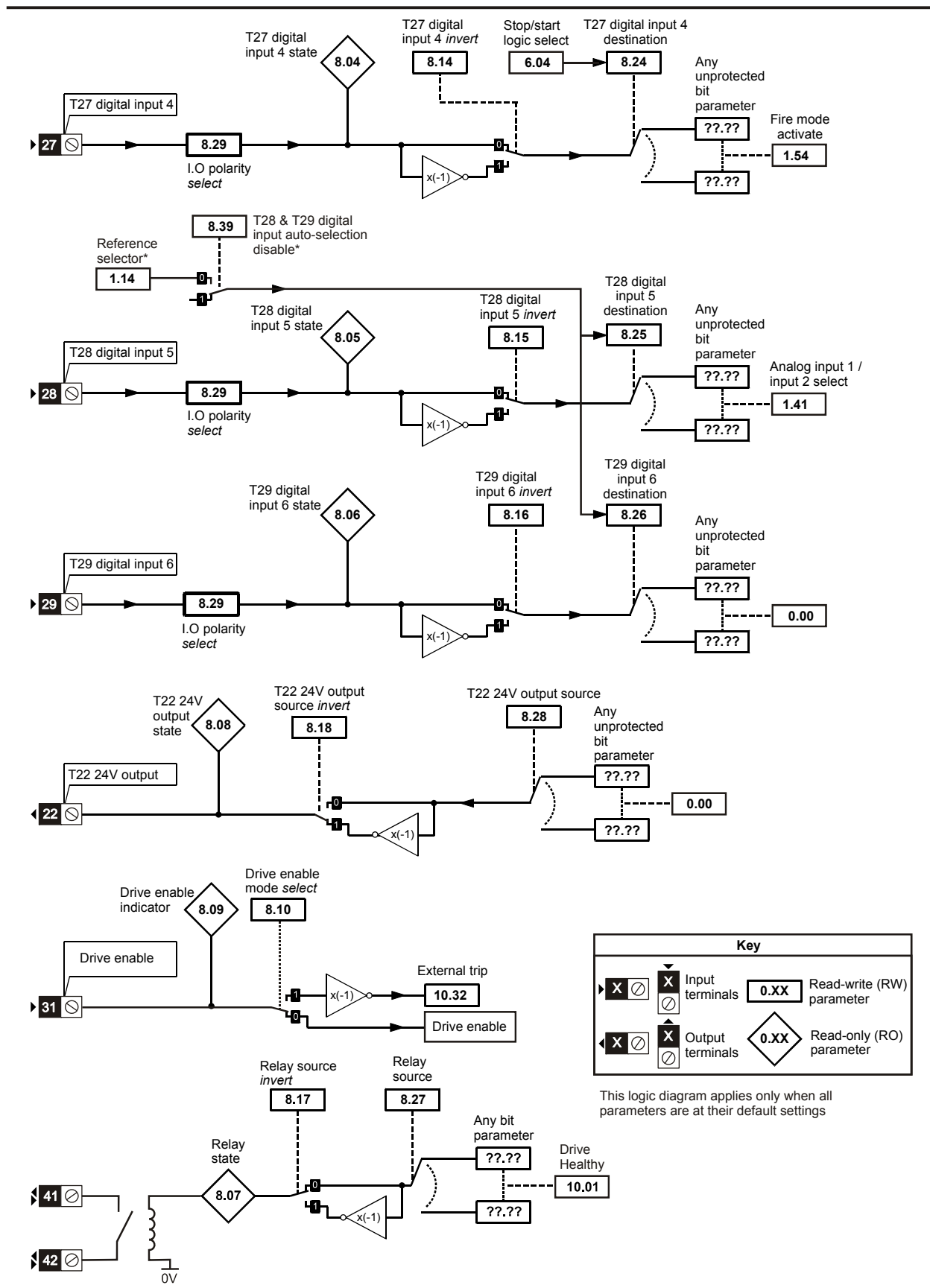
I/O	Sample rate	Function
T24 to T26	4ms	Digital input or output
T27 to T29	4ms	Digital input
Relay	Background	
T22	Background	24V output



Figure 5-11 Menu 8 logic diagram







## Open-loop, RFC

Table 5-12

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 10.02 - Drive active	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 1.54 - Fire mode activate		
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 0.00		
T41 / 42 Relay	Pr 8.07	Pr 8.17	0	Pr 8.27	Pr 10.01 – Drive ok		
T22 24V output	Pr 8.08	Pr 8.18	1	Pr 8.28	Pr 0.00		
T31 Drive 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Default	Open-loop, RFC								See table							
Update rate	4ms write															

OFF (0) = Terminal inactive

On (1) = Terminal active

8.10	Drive enable mode select															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

Affinity 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								Pr 8.11 to Pr 8.17 = OFF (0), Pr 8.18 = On (1)							
Update rate	4ms read															

OFF (0) = Non-inverted

On (1) = Inverted

8.20	Digital I/O read word															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							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	Drive 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, RFC															
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, RFC								See Table 5-12 on page 126							
Range	Open-loop, RFC								Pr <b>0.00</b> to Pr <b>50.99</b>							
Update rate	Read on drive reset															

8.27	Relay source															
8.28	T22 24V output source															
Drive modes	Open-loop, RFC															
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, RFC								See Table 5-12 on page 126							
Range	Open-loop, RFC								Pr 0.00 to Pr 50.99							
Update rate	Read on drive reset															

8.29	Positive logic select															
Drive modes	Open-loop, RFC															
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, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								Pr 8.31 = On (1), Pr 8.32 and Pr 8.33 = OFF (0)							
Update rate	Background read															

OFF (0) = Terminal is an input

On (1) = Terminal is an output

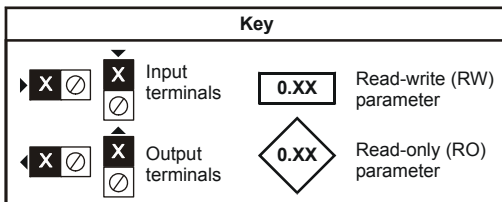
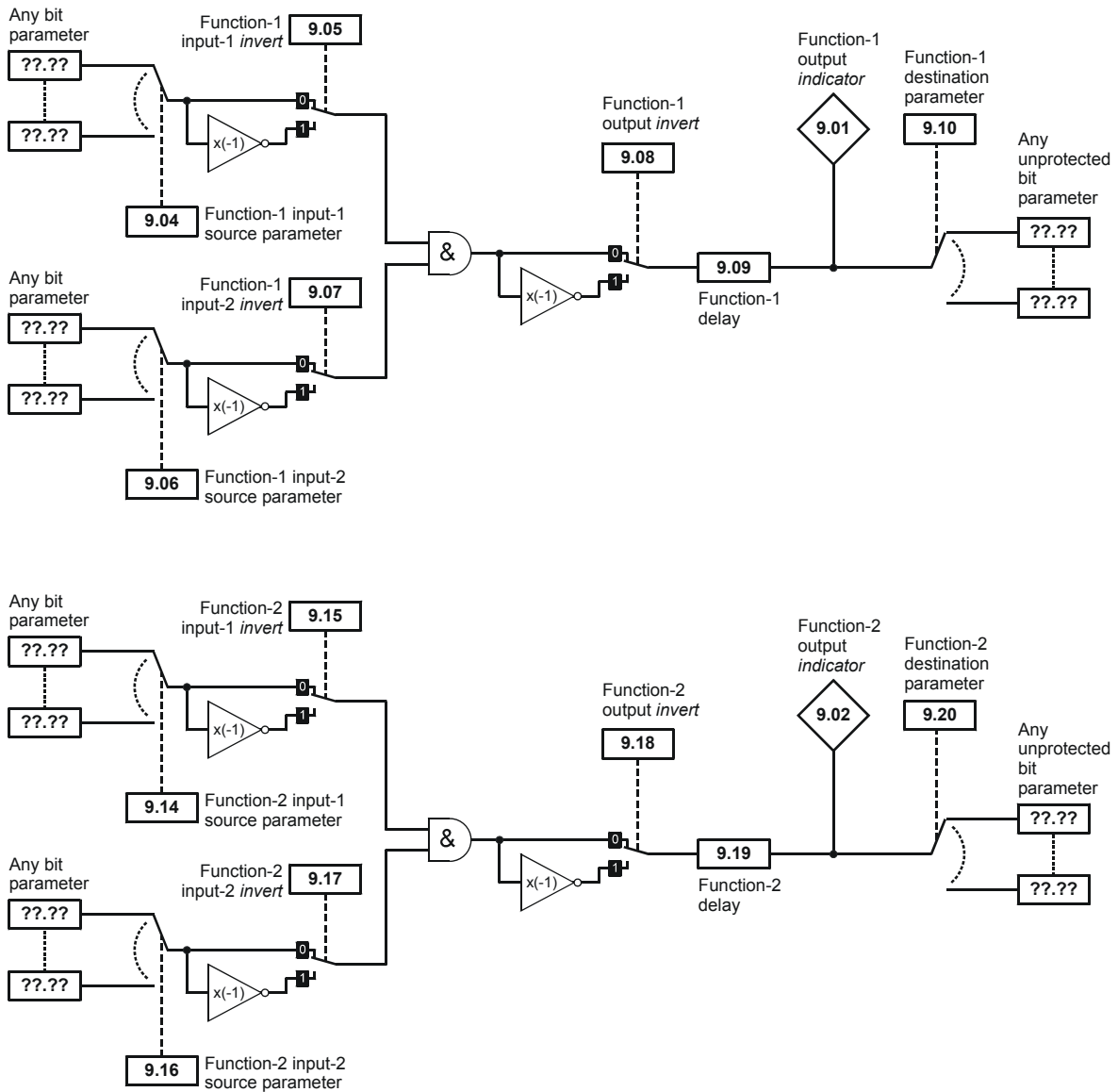
8.39	T28 & T29 digital input auto-selection disable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								On (1)							
Update rate	Background read															

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 0.00
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

## 5.11 Menu 9: Programmable logic, motorized pot and binary sum

Figure 5-12 Menu 9 logic diagram



The parameters are all shown at their default settings

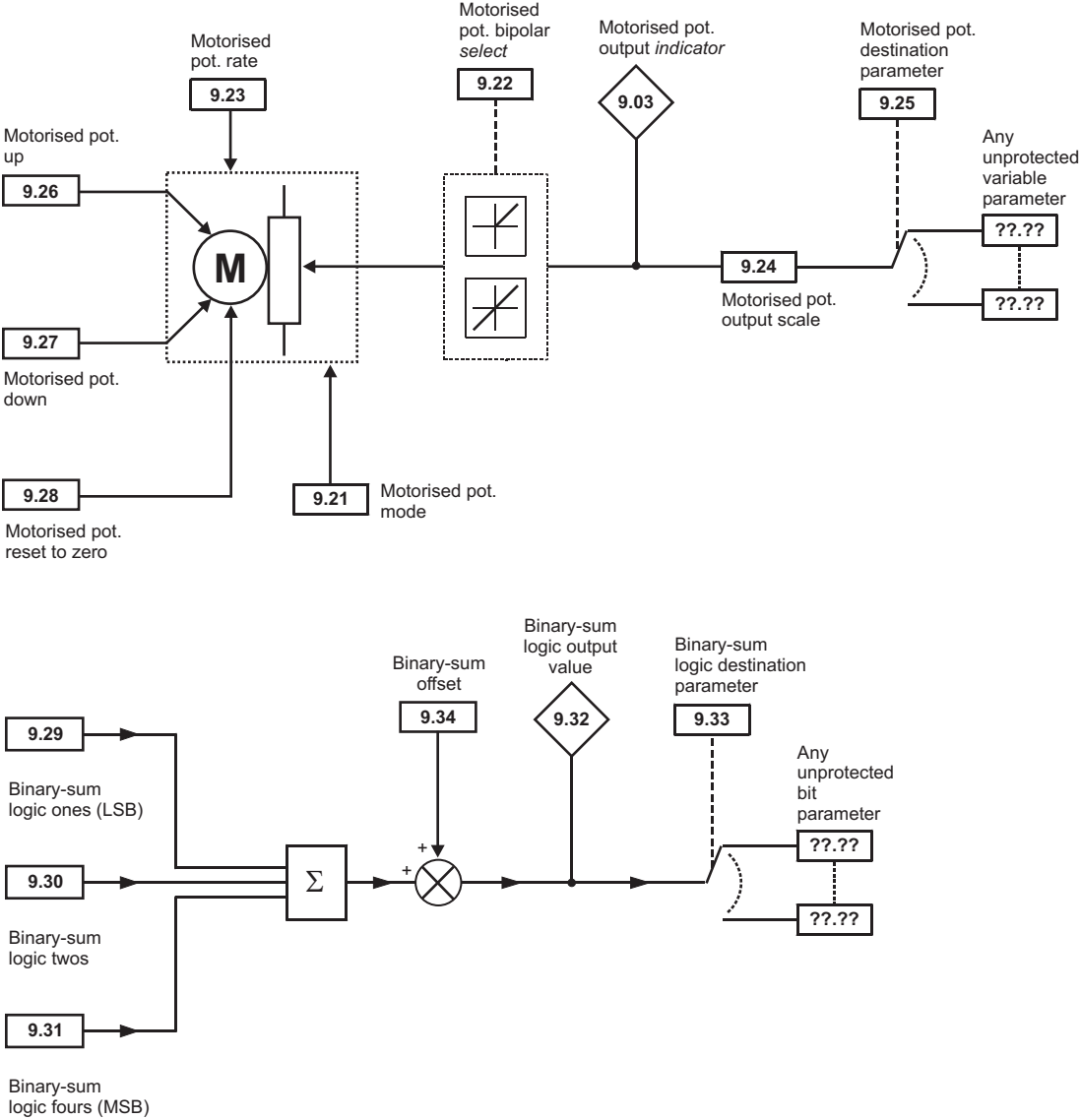
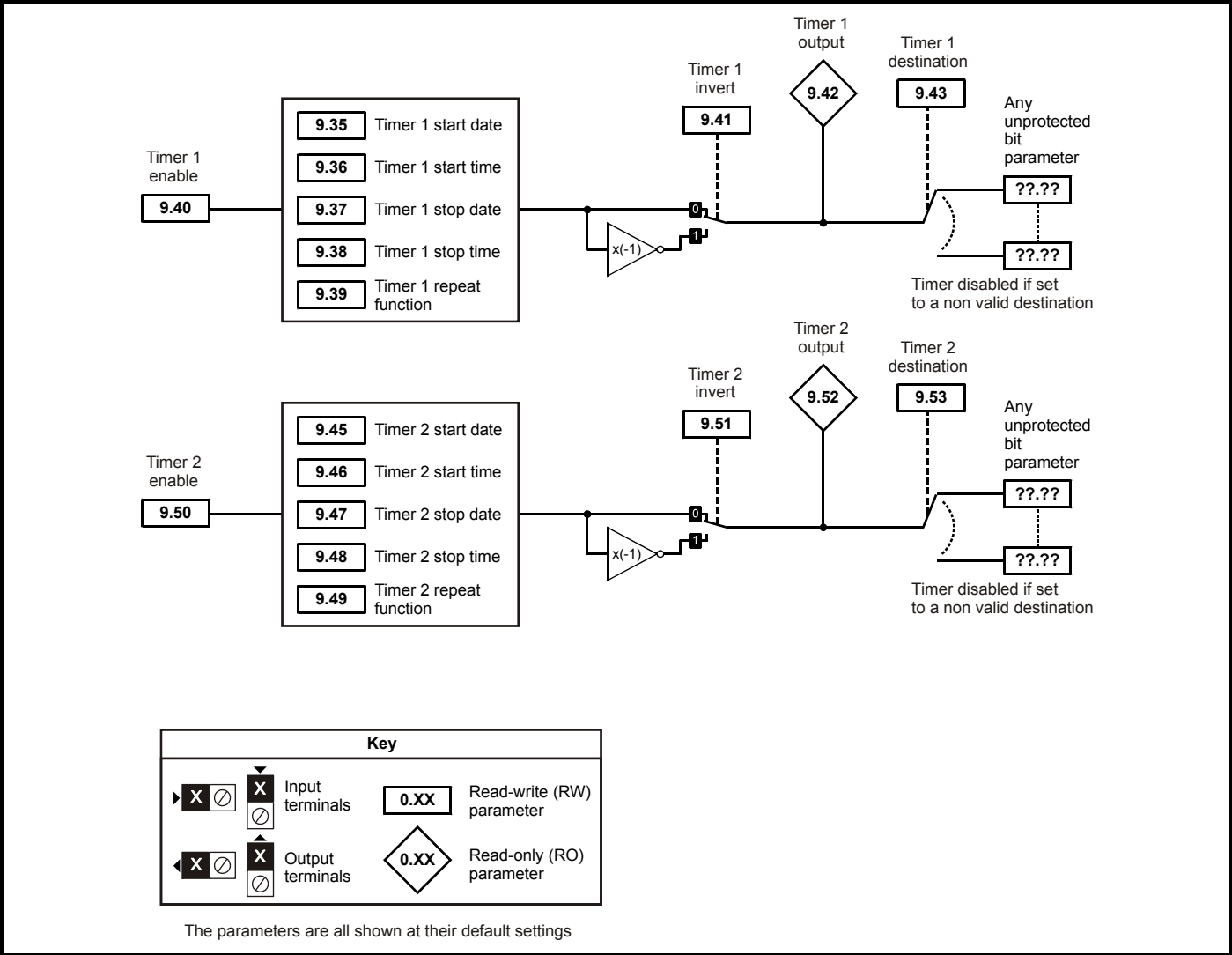


Figure 5-13 Menu 9 logic diagram: Timers



Menu 9 contains 2 logic block functions (which can be used to produce any type of 2 input logic gate, with or without a delay), a motorized pot function, a binary sum block and two timers. 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms x number of menu 9 or 12 functions active write															

9.03	Motorized pot output															
Drive modes	Open-loop, RFC															
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, RFC								±100.00 %							
Update rate	4ms x number of menu 9 or 12 functions active write															

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



9.04	Logic function 1 source 1															
9.14	Logic function 2 source 1															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

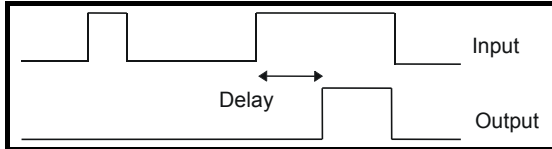
9.06	Logic function 1 source 2															
9.16	Logic function 2 source 2															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

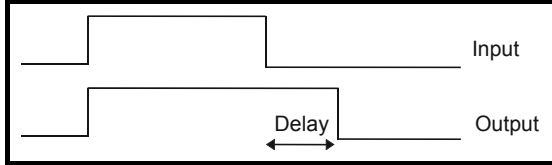
9.08	Logic function 1 output invert															
9.18	Logic function 2 output invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Coding	RW, Bit, US															
Default	Open-loop, RFC								0							
Update 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Open-loop, RFC								±25.0 s							
Default	Open-loop, RFC								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, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on reset															

9.21	Motorized pot mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 3							
Default	Open-loop, RFC								2							
Update rate	Background read															

The motorized pot modes are given in the following table.

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

9.22	Motorized pot bipolar select															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

When this bit is set to 0 the motorized pot output is limited to positive values only (i.e. 0 to 100.0%). Setting it to 1 allows negative outputs (i.e.  $\pm 100.0\%$ ).

9.23	Motorized pot rate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 250 s							
Default	Open-loop, RFC								20							
Update rate	Background read															

This parameter defines the time taken for the motorized pot function to ramp from 0 to 100.0%. Twice this time will be taken to adjust the output from -100.0 % to +100.0 %.

9.24	Motorized pot scale factor															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	4ms x number of menu 9 or 12 functions active read															

This parameter can be used to restrict the output of the motorized pot to operate over a reduced range so that it can be used as a trim, for example.

9.25	Motorized pot destination															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on reset															

9.26	Motorized pot up															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

9.27	Motorized pot down															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

9.28	Motorized pot reset															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

These three bits control the motorized pot. The up and down inputs increase and decrease the output at the programmed rate respectively. If both up and down are active together the up function dominates and the output increases. If the reset input is one, the motorized pot output is reset and held at 0.0%.

9.29	Binary sum ones input															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

9.30	Binary sum twos input															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

9.31	Binary sum fours input															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active read															

9.32	Binary sum output															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC								0 to 255							
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active write															

9.33	Binary sum destination																
Drive modes	Open-loop, RFC																
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, RFC							Pr 0.00 to Pr 50.99									
Default	Open-loop, RFC							Pr 0.00									
Update rate	Read on reset																

9.34	Binary sum offset															
Drive modes	Open-loop, RFC															
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, RFC								0 to 248							
Default	Open-loop, RFC								0							
Update rate	4ms x number of menu 9 or 12 functions active write															

The binary sum output is given by:

$$\text{Offset} + \text{ones input} + (2 \times \text{twos input}) + (4 \times \text{fours input})$$

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

If destination parameter maximum  $\leq (7 + \text{Offset})$ :

$$\text{Destination parameter} = \text{Binary sum output}$$

If destination parameter maximum  $> (7 + \text{Offset})$ :

$$\text{Destination parameter} = \text{Destination parameter maximum} \times \text{Binary sum output} / (7 + \text{Offset})$$

9.35	Timer 1 start date															
9.45	Timer 2 start date															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	Open-loop, RFC								0 to 311299							
Default	Open-loop, RFC								0							
Update rate	Background read															

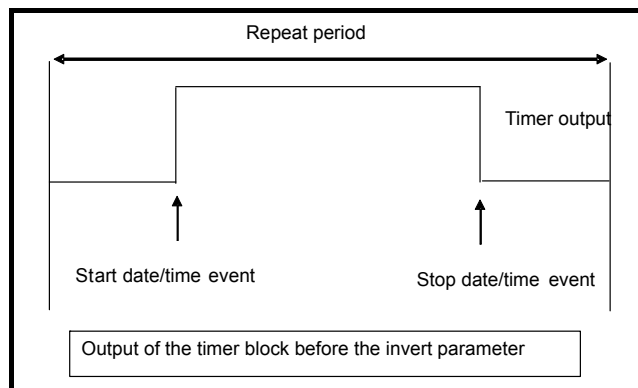
9.36	Timer 1 start time															
9.46	Timer 2 start time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Open-loop, RFC								0.00 to 23.59							
Default	Open-loop, RFC								0.00							
Update rate	Background read															

9.37	Timer 1 stop date															
9.47	Timer 2 stop date															
Drive modes	Open-loop, RFC															
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, RFC								0 to 311299							
Default	Open-loop, RFC								0							
Update rate	Background read															

9.38	Timer 1 stop time															
9.48	Timer 2 stop time															
Drive modes	Open-loop, RFC															
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, RFC								0.00 to 23.59							
Default	Open-loop, RFC								0.00							
Update rate	Background read															

9.39	Timer 1 repeat function																
9.49	Timer 2 repeat function																
Drive modes	Open-loop, RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
												1	1	1	1		
Range	Open-loop, RFC								0 to 6								
Default	Open-loop, RFC								0								
Update rate	Background read																

The state of the timer output (Pr 9.42,Pr 9.52) is on between the start and stop date/time events.



The repeat parameter (Pr 9.39, Pr 9.49) defines the length of the repeat period. Different repeat periods may be selected as shown in the table below. This also shows the data format required for the date and time parameters for each repeat period. If the stop time event is set to occur at or before the start time event or the repeat function parameter is set to zero then the output remains off.

Pr 9.39, Pr 9.49	Repeat Period	Start		Stop	
		Date	Time	Date	Time
		Pr 9.36, Pr 9.46	Pr 9.37, Pr 9.47	Pr 9.38, Pr 9.48	Pr 9.39, Pr 9.49
0	None				
1	Every hour		Minutes past each hour (0 to 59)		Minutes past each hour (0 to 59)
2	Every day		Time (hh.mm)		Time (hh.mm)
3	Every week	Day of week*	Time (hh.mm)	Day of week	Time (hh.mm)
4	Every month	Day of month (0 to 31)	Time (hh.mm)	Day of month	Time (hh.mm)
5	Every year	Date**	Time (hh.mm)	Date**	Time (hh.mm)
6	One off event	Date**	Time (hh.mm)	Date**	Time (hh.mm)

\* Day of week = 0 to 6, where 0 = Sunday, 1 = Monday etc.

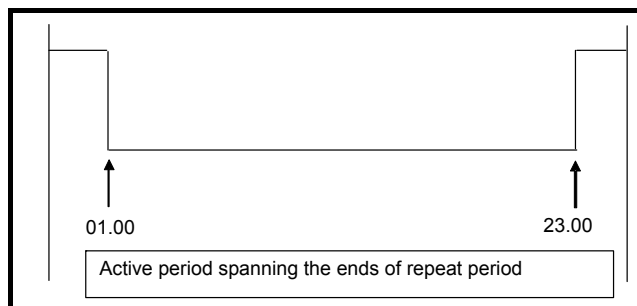
\*\* The format for Pr 9.35, Pr 9.37, Pr 9.45 and Pr 9.47 will depend upon the date format (Pr 6.20) mmddyyyy (US) or dddmyyyy (Std). If the date format is changed, then the dates set up for the start and stop dates will be invalid, so the start/stop times are reset to zero.

9.40	Timer 1 enable															
9.50	Timer 2 enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

If the timer enable parameter is off, then the timer output (Pr 9.42, Pr 9.43) is held in the off state, otherwise the output is controlled by the start and stop timer events.

9.41	Timer 1 invert															
9.51	Timer 2 invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

If the invert parameter is on, the value in the destination parameter will be the inverse of the timer output (Pr 9.42, Pr 9.43). This can be used to give an active state of zero instead of one. It can also be used to give an active state of one, but for a time period that spans the ends of the repeat period. For example if the repeat period is one day and the active time required is from 23.00 to 01.00 the next day, the stop time should be set to 23.00, the start time to 01.00 and the invert enabled. The resulting output is shown in the figure immediately below.



#### NOTE

If the enable parameter is set to 1 then the destination parameter will be 1 if the timer is disabled.

9.42	Timer 1 output															
9.52	Timer 2 output															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1				
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

This parameter indicates the state of the timer output (Pr 9.42, Pr 9.43) prior to the invert function.

9.43	Timer 1 destination															
9.53	Timer 2 destination															
Drive modes	Open-loop, RFC															
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, RFC								OFF (0)							
Update rate	Background read															

This parameter defines the address for the timer output destination. If this is not set to a valid destination parameter then the timer output will be zero.

## 5.12 Menu 10: Status and trips

10.01	Drive ok															
Drive modes	Open-loop, RFC															
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, RFC															
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, RFC															
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.

### RFC

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, RFC															
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, RFC															
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, RFC															
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

These flags are set by the speed detector in menu 3. See Pr 3.06, Pr 3.07 on page 54 and Pr 3.09 on page 54.

10.08	Load reached															
Drive modes	Open-loop, RFC															
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, RFC															
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, RFC															
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 power is being transferred from the motor to the drive.

10.11	Braking IGBT active															
Drive modes	Open-loop, RFC															
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, RFC															
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, RFC															
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

#### Open-loop

This parameter is one if the post-ramp reference (Pr 2.01) is negative, or zero if the post-ramp reference is zero or positive.

#### RFC

This parameter is one if the speed feedback (Pr 3.02) is negative, or zero if the speed feedback is zero or positive.

10.15	Line power loss															
Drive modes	Open-loop, RFC															
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 has detected line power loss from the level of the DC bus voltage. This parameter can only become active if line power loss ride through or line power loss stop modes are selected (see Pr 6.03 on page 97).

10.16	Under voltage active															
Drive modes	Open-loop, RFC															
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 97). 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

This parameter is set if the drive output current is larger than 105% of rated current (Pr 5.07) and the overload accumulator is greater than 75% to warn that if the motor current is not reduced the drive will trip on an Ixt overload. (If the rated current (Pr 5.07) is set to a level above the maximum drive current scaling (Pr 11.32) the overload alarm is given when the current is higher than 101% of rated current.)

10.18	Drive over temperature alarm															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background write															

Indicates that any of the heat sink temperatures (Pr 7.04 or Pr 7.05) or the control board temperature (Pr 7.06) are above their alarm level.

10.19	Drive warning															
Drive modes	Open-loop, RFC															
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 or Pr 10.61.




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, RFC															
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, RFC								0 to 232							
Update rate	Background write															

Contains the last 10 drive trips. Pr 10.20 is the most recent trip and Pr 10.29 the oldest. When a new trip occurs all the parameters move down one, the current trip is put in Pr 10.20 and the oldest trip is lost off the bottom of the log (descriptions of the trips are given in Table 5-13 below). A time stamp can be stored for each trip (see Pr 10.41 to Pr 10.60). All trips are stored, including HF trips numbered from 17 to 32. (HF trips with numbers from 1 to 16 are not stored in the trip log.) UU trips are not stored unless the drive is running when the trip occurs. Any trip can be initiated by the actions described or by writing the relevant trip number to Pr 10.38. If any trips shown as user trips are initiated the trip string is "txxx", where xxx is the trip number.

For drives BA4xxx and larger some trips are detected and initiated by the power module hardware (trips 101 -109). These are indicated by ".P" at the end of the trip string. If the drive is a multi-module drive the number of the module that has caused the trip can be stored (see Pr 10.41 to Pr 10.60).

**Table 5-13 Trip indications**

Trip	Diagnosis
<b>C.Acc</b>	<b>SMARTCARD trip: SMARTCARD Read / Write fail</b>
185	Check SMARTCARD is installed / located correctly Ensure SMARTCARD is not writing data to data location 500 to 999 Replace SMARTCARD
<b>C.boot</b>	<b>SMARTCARD trip: The menu 0 parameter modification cannot be saved to the SMARTCARD because the necessary file has not been created on the SMARTCARD</b>
177	A write to a menu 0 parameter has been initiated via the keypad with Pr 11.42 set to auto(3) or boot(4), but the necessary file on the SMARTCARD has not been created Ensure that Pr 11.42 is correctly set and reset the drive to create the necessary file on the SMARTCARD Re-attempt the parameter write to the menu 0 parameter
<b>C.bUSY</b>	<b>SMARTCARD trip: SMARTCARD can not perform the required function as it is being accessed by a Solutions Module</b>
178	Wait for the Solutions Module to finish accessing the SMARTCARD and then re-attempt the required function
<b>C.Chg</b>	<b>SMARTCARD trip: Data location already contains data</b>
179	Erase data in data location Write data to an alternative data location
<b>C.cPr</b>	<b>SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different</b>
188	Press the red  reset button
<b>C.dAt</b>	<b>SMARTCARD trip: Data location specified does not contain any data</b>
183	Ensure data block number is correct
<b>C.Err</b>	<b>SMARTCARD trip: SMARTCARD data is corrupted</b>
182	Ensure the card is located correctly Erase data and retry Replace SMARTCARD
<b>C.Full</b>	<b>SMARTCARD trip: SMARTCARD full</b>
184	Delete a data block or use different SMARTCARD
<b>cL2</b>	<b>Analog input 2 current loss (current mode)</b>
28	Check analog input 2 (terminal 7) current signal is present (4-20mA, 20-4mA)

Menu 10	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode																												
Trip	Diagnosis																																				
cL3	Analog input 3 current loss (current mode)																																				
29	Check analog input 3 (terminal 8) current signal is present (4-20mA, 20-4mA)																																				
CL.bit	Trip initiated from the control word (Pr 6.42)																																				
35	Disable the control word by setting Pr 6.43 to 0 or check setting of Pr 6.42																																				
ConF.P	The number of power modules installed no longer matches the value stored in Pr 11.35																																				
111	Ensure that all power modules are correctly connected Ensure that all power modules have powered up correctly Ensure that the value in Pr 11.35 matches the number of power modules connected																																				
C.OPtn	SMARTCARD trip: Solutions Modules installed are different between source drive and destination drive																																				
180	Ensure correct Solutions Modules are installed Ensure Solutions Modules are in the same Solutions Module slot Press the red  reset button																																				
C.Prod	SMARTCARD trip: The data blocks on the SMARTCARD are not compatible with this product																																				
175	Erase all data on the SMARTCARD by setting Pr xx.00 to 9999 and pressing the red  reset button Replace SMARTCARD																																				
C.rdo	SMARTCARD trip: SMARTCARD has the Read Only bit set																																				
181	Enter 9777 in Pr xx.00 to allow SMARTCARD Read / Write access Ensure the drive is not writing to data locations 500 to 999 on the card																																				
C.rtg	SMARTCARD trip: The voltage and/or current rating of the source and destination drives are different																																				
186	<div>Drive rating dependent parameters (parameters with the RA coding) are likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will not be transferred to the destination drive by SMARTCARDS when the rating of the destination drive is different from the source drive and the file is a parameter file. Drive rating dependent parameters will only be transferred if the current rating is different and the file is a 4yyy type (differences from default) file.</div> <div>Press the red  reset button</div> <div>Drive rating parameters are:</div> <table><thead><tr><th>Parameter</th><th>Function</th></tr></thead><tbody><tr><td>2.08</td><td>Standard ramp voltage</td></tr><tr><td>4.05/6/7, 21.27/8/9</td><td>Current limits</td></tr><tr><td>4.24</td><td>User current maximum scaling</td></tr><tr><td>5.07, 21.07</td><td>Motor rated current</td></tr><tr><td>5.09, 21.09</td><td>Motor rated voltage</td></tr><tr><td>5.10, 21.10</td><td>Rated power factor</td></tr><tr><td>5.17, 21.12</td><td>Stator resistance</td></tr><tr><td>5.18</td><td>Switching frequency</td></tr><tr><td>5.23, 21.13</td><td>Voltage offset</td></tr><tr><td>5.24, 21.14</td><td>Transient inductance</td></tr><tr><td>5.25, 21.24</td><td>Stator inductance</td></tr><tr><td>6.06</td><td>dc injection braking current</td></tr><tr><td>6.48</td><td>Line power supply loss ride through detection level</td></tr></tbody></table> <div>The above parameters will be set to their default values.</div>									Parameter	Function	2.08	Standard ramp voltage	4.05/6/7, 21.27/8/9	Current limits	4.24	User current maximum scaling	5.07, 21.07	Motor rated current	5.09, 21.09	Motor rated voltage	5.10, 21.10	Rated power factor	5.17, 21.12	Stator resistance	5.18	Switching frequency	5.23, 21.13	Voltage offset	5.24, 21.14	Transient inductance	5.25, 21.24	Stator inductance	6.06	dc injection braking current	6.48	Line power supply loss ride through detection level
Parameter	Function																																				
2.08	Standard ramp voltage																																				
4.05/6/7, 21.27/8/9	Current limits																																				
4.24	User current maximum scaling																																				
5.07, 21.07	Motor rated current																																				
5.09, 21.09	Motor rated voltage																																				
5.10, 21.10	Rated power factor																																				
5.17, 21.12	Stator resistance																																				
5.18	Switching frequency																																				
5.23, 21.13	Voltage offset																																				
5.24, 21.14	Transient inductance																																				
5.25, 21.24	Stator inductance																																				
6.06	dc injection braking current																																				
6.48	Line power supply loss ride through detection level																																				
C.TyP	SMARTCARD trip: SMARTCARD parameter set not compatible with drive																																				
187	Press the reset button Ensure destination drive type is the same as the source parameter file drive type																																				
dESt	Two or more parameters are writing to the same destination parameter																																				
199	Set Pr xx.00 = 12001 check all visible parameters in the menus for duplication																																				
EEF	EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.																																				
31	This trip can only be cleared by loading default parameters and saving parameters																																				

Trip	Diagnosis
<b>Et</b>	<b>External trip</b>
<b>6</b>	Check terminal 31 signal Check value of Pr <b>10.32</b> Enter 12001 in Pr <b>xx.00</b> and check for parameter controlling Pr <b>10.32</b> Ensure Pr <b>10.32</b> or Pr <b>10.38</b> (=6) are not being controlled by serial comms
<b>HF01</b>	<b>Data processing error: CPU address error</b>
	Hardware fault - return drive to supplier
<b>HF02</b>	<b>Data processing error: DMAC address error</b>
	Hardware fault - return drive to supplier
<b>HF03</b>	<b>Data processing error: Illegal instruction</b>
	Hardware fault - return drive to supplier
<b>HF04</b>	<b>Data processing error: Illegal slot instruction</b>
	Hardware fault - return drive to supplier
<b>HF05</b>	<b>Data processing error: Undefined exception</b>
	Hardware fault - return drive to supplier
<b>HF06</b>	<b>Data processing error: Reserved exception</b>
	Hardware fault - return drive to supplier
<b>HF07</b>	<b>Data processing error: Watchdog failure</b>
	Hardware fault - return drive to supplier
<b>HF08</b>	<b>Data processing error: Level 4 crash</b>
	Hardware fault - return drive to supplier
<b>HF09</b>	<b>Data processing error: Heap overflow</b>
	Hardware fault - return drive to supplier
<b>HF10</b>	<b>Data processing error: Router error</b>
	Hardware fault - return drive to supplier
<b>HF11</b>	<b>Data processing error: Access to EEPROM failed</b>
	Hardware fault - return drive to supplier
<b>HF12</b>	<b>Data processing error: Main program stack overflow</b>
	Hardware fault - return drive to supplier
<b>HF13</b>	<b>Data processing error: Software incompatible with hardware</b>
	Hardware or software fault - return drive to supplier
<b>HF17</b>	<b>Multi-module system thermistor short circuit or open circuit</b>
<b>217</b>	Hardware fault - return drive to supplier
<b>HF18</b>	<b>Multi-module system interconnect cable error</b>
<b>218</b>	Hardware fault - return drive to supplier
<b>HF19</b>	<b>Temperature feedback multiplexing failure</b>
<b>219</b>	Hardware fault - return drive to supplier
<b>HF20</b>	<b>Power stage recognition: serial code error</b>
<b>220</b>	Hardware fault - return drive to supplier
<b>HF21</b>	<b>Power stage recognition: unrecognized frame size</b>
<b>221</b>	Hardware fault - return drive to supplier
<b>HF22</b>	<b>Power stage recognition: multi module frame size mismatch</b>
<b>222</b>	Hardware fault - return drive to supplier
<b>HF23</b>	<b>Power stage recognition: multi module voltage rating mismatch</b>
<b>223</b>	Hardware fault - return drive to supplier
<b>HF24</b>	<b>Power stage recognition: unrecognised drive size</b>
<b>224</b>	Hardware fault - return drive to supplier

Menu 10	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
<b>Trip</b>	<b>Diagnosis</b>								
<b>HF25</b>	<b>Current feedback offset error</b>								
<b>225</b>	Hardware fault - return drive to supplier								
<b>HF26</b>	<b>Soft start relay failed to close, soft start monitor failed or braking IGBT short circuit at power up</b>								
<b>226</b>	Hardware fault - return drive to supplier								
<b>HF27</b>	<b>Power stage thermistor 1 fault</b>								
<b>227</b>	Hardware fault - return drive to supplier								
<b>HF28</b>	<b>Power stage thermistor 2 fault, or internal fan fault (size 3)</b>								
<b>228</b>	Hardware fault - return drive to supplier								
<b>HF29</b>	<b>Control board thermistor fault</b>								
<b>229</b>	Hardware fault - return drive to supplier								
<b>HF30</b>	<b>dc CT wire break trip from power module</b>								
<b>230</b>	Hardware fault - return drive to supplier								
<b>HF31</b>	<b>Internal capacitor bank fan failure (size 4 and larger) or a module has not powered up in a multi-module parallel drive</b>								
<b>231</b>	Check the AC or dc power supply to all modules in a multi-module parallel drive If the AC or dc power supply is present, or if this is a single drive, then there is a hardware fault - return drive to the supplier								
<b>HF32</b>	<b>Power stage - Identification and trip information serial code error</b>								
<b>232</b>	Hardware fault - return drive to the supplier								
<b>It.AC</b>	<b>Output current overload timed out (<math>I^2t</math>) - accumulator value can be seen in Pr 4.19</b>								
<b>20</b>	Ensure the load is not jammed / sticking Check the load on the motor has not changed Ensure rated speed parameter is correct (RFC)								
<b>It.br</b>	<b>Braking resistor overload timed out (<math>I^2t</math>) – accumulator value can be seen in Pr 10.39</b>								
<b>19</b>	Ensure the values entered in Pr 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								
<b>LOAD</b>	<b>Low load detected</b>								
<b>38</b>	Check mechanical motor coupling								
<b>O.CtL</b>	<b>Drive control board over temperature</b>								
<b>23</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Check ambient temperature Reduce drive switching frequency								
<b>O.ht1</b>	<b>Power device over temperature based on thermal model</b>								
<b>21</b>	Reduce drive switching frequency Reduce duty cycle Decrease acceleration / deceleration rates Reduce motor load								
<b>O.ht2</b>	<b>Heatsink over temperature</b>								
<b>22</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load								

Trip	Diagnosis
<b>Oht2.P</b>	<b>Power module heatsink over temperature</b>
<b>105</b>	Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load
<b>O.ht3</b>	<b>Drive over-temperature based on thermal model</b>
<b>27</b>	The drive will attempt to stop the motor before tripping. If the motor does not stop in 10s the drive trips immediately. Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce duty cycle Reduce motor load
<b>Oht4.P</b>	<b>Power module rectifier over temperature or input snubber resistor over temperature (size 4 and above)</b>
<b>102</b>	Check for supply imbalance Check for supply disturbance such as notching from a dc drive Check enclosure / drive fans are still functioning correctly Check enclosure ventilation paths Check enclosure door filters Increase ventilation Decrease acceleration / deceleration rates Reduce drive switching frequency Reduce duty cycle Reduce motor load
<b>OI.AC</b>	<b>Instantaneous output over current detected: peak output current greater than 225%</b>
<b>3</b>	Acceleration /deceleration rate is too short. If seen during autotune reduce voltage boost Pr <b>5.15</b> Check for short circuit on output cabling Check integrity of motor insulation Is motor cable length within limits for that frame size? Reduce the values in speed loop gain parameters – Pr <b>3.10</b> , Pr <b>3.11</b> and Pr <b>3.12</b> (RFC mode) Reduce the values in current loop gain parameters - Pr <b>4.13</b> and Pr <b>4.14</b> (RFC mode)
<b>OIAC.P</b>	<b>Power module over current detected from the module output currents</b>
<b>104</b>	Acceleration /deceleration rate is too short. If seen during autotune reduce voltage boost Pr <b>5.15</b> Check for short circuit on output cabling Check integrity of motor insulation Is motor cable length within limits for that frame size? Reduce the values in speed loop gain parameters – Pr <b>3.10</b> , Pr <b>3.11</b> and Pr <b>3.12</b> (RFC mode) Reduce the values in current loop gain parameters - Pr <b>4.13</b> and Pr <b>4.14</b> (RFC mode)
<b>OI.br</b>	<b>Braking transistor over-current detected: short circuit protection for the braking transistor activated</b>
<b>4</b>	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
<b>OIbr.P</b>	<b>Power module braking IGBT over current</b>
<b>103</b>	Check braking resistor wiring Check braking resistor value is greater than or equal to the minimum resistance value Check braking resistor insulation
<b>OldC.P</b>	<b>Power module over current detected from IGBT on state voltage monitoring</b>
<b>109</b>	Vce IGBT protection activated. Check motor and cable insulation.
<b>O.Ld1</b>	<b>Digital output overload: total current drawn from 24V supply and digital outputs exceeds 200mA</b>
<b>26</b>	Check total load on digital outputs (terminals 24, 25, 26)and +24V rail (terminal 22)

Menu 10	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode															
Trip	Diagnosis																							
O.SPd	Motor speed has exceeded the over speed threshold																							
7	Increase the over speed trip threshold in Pr 3.08 (RFC mode) 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 (RFC mode)																							
OV	DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds																							
2	Increase deceleration ramp (Pr 0.04) Decrease braking resistor value (staying above the minimum value) Check nominal AC supply level Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by dc drives Check motor insulation <table><tr><td>Drive voltage rating</td><td>Peak voltage</td><td>Maximum continuous voltage level (15s)</td></tr><tr><td>200</td><td>415</td><td>410</td></tr><tr><td>400</td><td>830</td><td>815</td></tr><tr><td>575</td><td>990</td><td>970</td></tr><tr><td>690</td><td>1190</td><td>1175</td></tr></table> If the drive is operating in low voltage dc mode the overvoltage trip level is 1.45 x Pr 6.46.									Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)	200	415	410	400	830	815	575	990	970	690	1190	1175
Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)																						
200	415	410																						
400	830	815																						
575	990	970																						
690	1190	1175																						
OV.P	Power module DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds																							
106	Increase deceleration ramp (Pr 0.04) Decrease braking resistor value (staying above the minimum value) Check nominal AC supply level Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by dc drives Check motor insulation <table><tr><td>Drive voltage rating</td><td>Peak voltage</td><td>Maximum continuous voltage level (15s)</td></tr><tr><td>200</td><td>415</td><td>410</td></tr><tr><td>400</td><td>830</td><td>815</td></tr><tr><td>575</td><td>990</td><td>970</td></tr><tr><td>690</td><td>1190</td><td>1175</td></tr></table> If the drive is operating in low voltage dc mode the overvoltage trip level is 1.45 x Pr 6.46.									Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)	200	415	410	400	830	815	575	990	970	690	1190	1175
Drive voltage rating	Peak voltage	Maximum continuous voltage level (15s)																						
200	415	410																						
400	830	815																						
575	990	970																						
690	1190	1175																						
PAd	Keypad has been removed when the drive is receiving the speed reference from the keypad																							
34	Install keypad and reset Change speed reference selector to select speed reference from another source																							
PH	AC voltage input phase loss or large supply imbalance detected																							
32	Ensure all three phases are present and balanced Check input voltage levels are correct (at full load) <div>NOTE</div> Load level must be between 50 and 100% for the drive to trip under phase loss conditions. The drive will attempt to stop the motor before this trip is initiated.																							
PH.P	Power module phase loss detection																							
107	Ensure all three phases are present and balanced Check input voltage levels are correct (at full load)																							
PS	Internal power supply fault																							
5	Remove any Solutions Modules and reset Hardware fault - return drive to supplier																							
PS.10V	10V user power supply current greater than 10mA																							
8	Check wiring to terminal 4 Reduce load on terminal 4																							
PS.24V	24V internal power supply overload																							
9	The total user load of the drive and Solutions Modules has exceeded the internal 24V power supply limit. The user load consists of the drive's digital outputs and the SM-I/O Plus digital outputs. <ul style="list-style-type: none"><li>• Reduce load and reset</li><li>• Provide an external 24V &gt;50W power supply</li><li>• Remove any Solutions Modules and reset</li></ul>																							
PS.P	Power module power supply fail																							
108	Remove any Solutions Modules and reset Hardware fault - return drive to supplier																							



Trip	Diagnosis																
<b>PSAVE.Er</b>	<b>Power down save parameters in the EEPROM are corrupt</b>																
37	Indicates that the power was removed when power down save parameters were being saved. The drive will revert back to the power down parameter set that was last saved successfully. Perform a user save (Pr <b>xx.00</b> to 1000 or 1001 and reset the drive) or power down the drive normally to ensure this trip does or occur the next time the drive is powered up.																
<b>rS</b>	<b>Failure to measure resistance during autotune or when starting in open loop vector mode 0 or 3</b>																
33	Check motor power connection continuity																
<b>SAVE.Er</b>	<b>User save parameters in the EEPROM are corrupt</b>																
36	Indicates that the power was removed when user parameters were being saved. The drive will revert back to the user parameter set that was last saved successfully. Perform a user save (Pr <b>xx.00</b> to 1000 or 1001 and reset the drive) to ensure this trip does or occur the next time the drive is powered up.																
<b>SCL</b>	<b>Drive RS485 serial comms loss to remote keypad</b>																
30	Reinstall the cable between the drive and keypad Check cable for damage Replace cable Replace keypad																
<b>SLX.dF</b>	<b>Solutions Module slot X trip: Solutions Module type installed in slot X changed</b>																
204,209	Save parameters and reset																
<b>SL3.dF</b>	<b>Building automation interface slot trip</b>																
214	Module typed changed																
<b>SLX.Er</b>	<b>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</b>																
202,207	Check value in Pr <b>15/16.50</b> . See the <i>Diagnostics</i> section in the relevant Solutions Module User Guide for more information.																
<b>SL3.Er</b>	<b>Building automation interface: Module has detected a fault</b>																
212	Check value in Pr <b>17.50</b> . The following table lists the possible error codes. <table border="1"> <thead> <tr> <th>Error code</th><th>Trip Description</th></tr> </thead> <tbody> <tr> <td>0</td><td>No trip</td></tr> <tr> <td>10</td><td>Module operating system error</td></tr> <tr> <td>20</td><td>Real time clock error</td></tr> <tr> <td>30</td><td>IP54 cooling fan power supply fault</td></tr> <tr> <td>40</td><td>Drive to Solutions Modules interface error</td></tr> <tr> <td>50</td><td>Building Automation Network error</td></tr> <tr> <td>74</td><td>Building Automation Network PCB over-temperature</td></tr> </tbody> </table>	Error code	Trip Description	0	No trip	10	Module operating system error	20	Real time clock error	30	IP54 cooling fan power supply fault	40	Drive to Solutions Modules interface error	50	Building Automation Network error	74	Building Automation Network PCB over-temperature
Error code	Trip Description																
0	No trip																
10	Module operating system error																
20	Real time clock error																
30	IP54 cooling fan power supply fault																
40	Drive to Solutions Modules interface error																
50	Building Automation Network error																
74	Building Automation Network PCB over-temperature																
<b>SLX.HF</b>	<b>Solutions Module slot X trip: Solutions Module X hardware fault</b>																
200,205	Ensure Solutions Module is installed correctly Return Solutions Module to supplier																
<b>SL3.HF</b>	<b>Building automation interface: Module hardware fault</b>																
210	Ensure Solutions Module is installed correctly Return Solutions Module to supplier																
<b>SLX.nF</b>	<b>Solutions Module slot X trip: Solutions Module has been removed</b>																
203,208	Ensure Solutions Module is installed correctly Reinstall Solutions Module Save parameters and reset drive																
<b>SL3.nF</b>	<b>Building automation interface: Module has been removed</b>																
213	Ensure Solutions Module is installed correctly Reinstall Solutions Module Save parameters and reset drive																
<b>SL.rtd</b>	<b>Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect</b>																
215	Press reset. If the trip persists, contact the supplier of the drive.																
<b>SLX.tO</b>	<b>Solutions Module slot X trip: Solutions Module watchdog timeout</b>																
201,206	Press reset. If the trip persists, contact the supplier of the drive.																

Trip	Diagnosis
<b>SL3.tO</b>	<b>Building automation interface: Module watchdog timeout</b>
211	Press reset. If the trip persists, contact the supplier of the drive.
<b>t040 to t089</b>	<b>User defined trip</b>
40 to 89	Onboard PLC program must be interrogated to find the cause of this trip
<b>t099</b>	<b>User defined trip</b>
99	Onboard PLC program must be interrogated to find the cause of this trip
<b>t101</b>	<b>User defined trip</b>
101	Onboard PLC program must be interrogated to find the cause of this trip
<b>t112 to t160</b>	<b>User defined trip</b>
112 to 160	Onboard PLC program must be interrogated to find the cause of this trip
<b>t168 to t174</b>	<b>User defined trip</b>
168 to 174	Onboard PLC program must be interrogated to find the cause of this trip
<b>t216</b>	<b>User defined trip</b>
216	Onboard PLC program must be interrogated to find the cause of this trip
<b>th</b>	<b>Motor thermistor trip</b>
24	Check motor temperature Check thermistor continuity Set Pr 7.15 = VOLT and reset the drive to disable this function
<b>thS</b>	<b>Motor thermistor short circuit</b>
25	Check motor thermistor wiring Replace motor / motor thermistor Set Pr 7.15 = VOLT and reset the drive to disable this function
<b>tunE*</b>	<b>Autotune stopped before completion</b>
18	The drive has tripped out during the autotune The red stop key has been pressed during the autotune The Enable signal (terminal 31) was active during the autotune procedure
<b>tunE1*</b>	<b>Required speed could not be reached during the inertia test (see Pr 5.12)</b>
11	Ensure the motor is free to turn i.e. brake was released
<b>tunE2*</b>	<b>Motor could not be stopped during the inertia test (see Pr 5.12)</b>
12	Check motor cable wiring is correct
<b>tunE3*</b>	<b>Measured inertia out of range (see Pr 5.12)</b>
13	Check motor cable wiring is correct
<b>tunE7*</b>	<b>Motor number of poles set incorrectly</b>
17	Check lines per revolution for feedback device Check the number of poles in Pr 5.11 is set correctly
<b>Unid.P</b>	<b>Power module unidentified trip</b>
110	Check all interconnecting cables between power modules Ensure cables are routed away from electrical noise sources
<b>UP ACC</b>	<b>Onboard PLC program: cannot access Onboard PLC program file on drive</b>
98	Disable drive - write access is not allowed when the drive is enabled Another source is already accessing Onboard PLC program - retry once other action is complete
<b>UP div0</b>	<b>Onboard PLC program attempted divide by zero</b>
90	Check program
<b>UP OFL</b>	<b>Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)</b>
95	Check program
<b>UP ovr</b>	<b>Onboard PLC program attempted out of range parameter write</b>
94	Check program
<b>UP PAr</b>	<b>Onboard PLC program attempted access to a non-existent parameter</b>
91	Check program

Trip	Diagnosis		
UP ro	Onboard PLC program attempted write to a read-only parameter		
92	Check program		
UP So	Onboard PLC program attempted read of a write-only parameter		
93	Check program		
UP udF	Onboard PLC program un-defined trip		
97	Check program		
UP uSEr	Onboard PLC program requested a trip		
96	Check program		
UV	DC bus under voltage threshold reached		
1	Check AC supply voltage level		
	Drive voltage rating (Vac)	Under voltage threshold (Vdc)	UV reset voltage (Vdc)
	200	175	215V
	400	330	425V
	575 & 690	435	590V

\*If a tunE through tunE3 trip occurs, then after the drive is reset the drive cannot be made to run unless it is disabled via the Enable input (terminal 31), drive enable parameter (Pr 6.15) or the control word (Pr 6.42 and Pr 6.43).

Table 5-14 Serial communications look-up table

No.	Trip	No.	Trip	No.	Trip
1	UV	40 to 89	t040 to t089	182	C.Err
2	OV	90	UP div0	183	C.dAt
3	OI.AC	91	UP PAr	184	C.FULL
4	OI.br	92	UP ro	185	C.Acc
5	PS	93	UP So	186	C.rtg
6	Et	94	UP ovr	187	C.TyP
7	O.SPd	95	UP OFL	188	C.cPr
8	PS.10V	96	UP uSEr	189	Reserved
9	PS.24V	97	UP udF	190	Reserved
10	Reserved	98	UP ACC	191	Reserved
11	tunE1	99	t099	192	Reserved
12	tunE2	100		193	Reserved
13	tunE3	101	t101	194	Reserved
14	Reserved	102	Oht4.P	195	Reserved
15	Reserved	103	OIbr.P	196	Reserved
16	Reserved	104	OIAC.P	197	Reserved
17	tuneE7	105	Oht2.P	198	Reserved
18	tuneE	106	OV.P	199	DEST
19	It.br	107	PH.P	200	SL1.HF
20	It.AC	108	PS.P	201	SL1.tO
21	O.ht1	109	OldC.P	202	SL1.Er
22	O.ht2	110	Unid.P	203	SL1.nF
23	O.CtL	111	ConF.P	204	SL1.dF
24	th	112 to 160	t112 to t160	205	SL2.HF
25	thS	161	Reserved	206	SL2.tO
26	O.Ld1	162	Reserved	207	SL2.Er
27	O.ht3	163	Reserved	208	SL2.nF
28	cL2	164	Reserved	209	SL2.dF
29	cL3	165	Reserved	210	SL3.HF
30	SCL	166	Reserved	211	SL3.tO
31	EEF	167	Reserved	212	SL3.Er
32	PH	168 to 174	t168 to t174	213	SL3.nF
33	rS	175	C.Prod	214	SL3.dF
34	PAd	176	Reserved	215	SL.rtd
35	CL.bit	177	C.boot	216	t216
36	SAVE.Er	178	C.bUSY	217	HF17
37	PSAVE.Er	179	C.Chg	218	HF18
38	LOAD	180	C.OPtn	219	HF19
39	Reserved	181	C.RdO	220 to 232	HF20 to HF32

Trips can be grouped into the following categories. It should be noted that a trip can only occur when the drive is not tripped or is already tripped but with a trip with a lower priority number.

Priority	Category	Trips	Comments
1	Hardware faults	HF01 to HF16	These indicate fatal problems and cannot be reset. The drive is inactive after one of these trips and the display shows HFxx.
2	Non-resetable trips	HF17 to HF32, SL1.HF, SL2.HF, SL3.HF	Cannot be reset.
3	EEF trip	EEF	Cannot be reset unless a code to load defaults is first entered in Pr <b>x.00</b> or Pr <b>11.43</b> .
4	SMARTCARD trips	C.Boot, C.Busy, C.Chg, C.Optn, C.RdO, C.Err, C.dat, C.FULL, C.Acc, C.rtg, C.Typ, C.cpr, C.Prod	SMARTCARD trips have priority 5 during power up.
5	Normal trips with extended reset	OI.AC, OI.br, OIAC.P, OIbr.P, OidC.P	Can be reset after 10.0s
5	Normal trips	All other trips not included in this table	
5	Non-important trips	Old1, cL2, cL3, SCL	If bit 0 of Pr <b>10.37</b> is 1 the drive will stop before tripping.
5	Phase loss	PH	The drive attempts to stop before tripping.
5	Drive over-heat based on thermal model	O.ht3	The drive attempts to stop before tripping, but if it does not stop within 10s the drive will automatically trip.
6	Self resetting trips	UV	Under voltage trip cannot be reset by the user, but is automatically reset by the drive when the supply voltage is with specification.

Unless otherwise stated, trips cannot be reset until 1.0s after the trip has been accepted by the drive.

#### Power module trips

Trips 101 to 110 are power module trips that are initiated by the drive power electronics module, or modules for a multi-module parallel drive. The trip identifier for each of these trips is in the form "xxxx.P". If the drive is a single module drive, and does not use the power interface intended for parallel operation, (BA4xxx to BA6xxx only) OldC.P, Oht4.P and Unid.P power module trip are possible. When the trip string is displayed the trip source module number is not displayed and the module number stored in the "module number and trip time log" is zero.

If the drive is a multi-module parallel drive or a single module drive using the power interface intended for parallel operation (BAMAxxxx and BAMDxxxx) all the power module trips are possible, the trip source module is displayed with the trip string and the module number is stored in the log. A PH.P trip is initiated if some, but not all parallel modules detect line supply loss via their input stage to ensure that the input stages of the remaining modules are not overloaded.

If line power loss is detected by all modules then the normal line power loss system based on DC bus monitoring is used. A PH.P trip occurs if any modules detect phase loss via their input stage. The normal phase loss system which detects phase loss from DC bus voltage ripple cannot be used in case different phases have been lost by different modules or if the system is a 12 pulse or higher system.

#### Braking IGBT control

The braking IGBT continues to operate even when the drive is not enabled (except if the active supply is a low voltage supply, see Pr **6.44**), but is only disabled if any of the following trips occurs or would occur if another trip had not already become active: OI.br, PS, It.br or OV or any HFXx trip.

#### UV trip

It should be noted that although the UV trip operates in a similar way to all other trips, all drive functions can still operate, but the drive cannot be enabled. The following differences apply to the UV trip:

1. Power down save user parameters are saved when UV trip is activated except when the main high voltage supply is not active (Pr **6.44** = 1).
2. The UV trip is self-resetting when the DC bus voltage rises above the drive restart voltage level. If another trip is active instead of UV at this point, the trip is not reset.
3. The drive can change between using the main high voltage supply and low voltage battery supply only when the drive is in the under voltage condition (Pr **10.16** = 1). The UV trip can only be seen as active if another trip is not active in the under voltage condition.
4. When the drive is first powered up a UV trip is initiated if the supply voltage is below the restart voltage level and another trip is not active. This does not cause save power down save parameters to be saved at this point.

**Table 5-15 Hardware fault trips**

HF fault code	Reason for trip
01	CPU address error
02	DMAC address error
03	Illegal instruction
04	Illegal slot instruction
05	Undefined exception
06	Reserved exception
07	Watchdog failure
08	Level 4 crash
09	Heap overflow
10	Router error
11	Access to the EEPROM failed or incorrect EEPROMs installed.
12	Main program stack overflow
13	The drive firmware is not compatible with the drive hardware
14-16	Not used
17	Reserved
18	Reserved
19	Power circuit temperature feedback multiplexor failure
20	Power circuit - identification code error
21	Power circuit - unrecognized frame size
22	Reserved
23	Reserved
24	Power circuit - unrecognized drive size
25	Current feedback offset error
26	Soft start relay failed to close, or soft start monitor failed, or braking IGBT short circuit at power-up
27	Power circuit thermistor 1 fault
28	Power circuit thermistor 2 or 3 fault / Internal fan fault for some drive sizes.
29	Control board thermistor fault
30	dc CT wired break trip from power module
31	Internal capacitor fan failure from power module
32	Power stage - a module has not powered up in a multi-module parallel drive

10.30	Full power braking time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC								0.00 to 400.00 s							
Default	Open-loop, RFC								See below							
Update rate	Background read															

For BA1xxx and BA2xxx drives the default value is a suitable value for standard braking resistors that can be mounted within the drive heatsink as given in the table below. For larger drives the default is 0.00.

Drive voltage rating	Size 1 and 2
200V	0.09s
400V	0.02s
575V and 690V	N/A

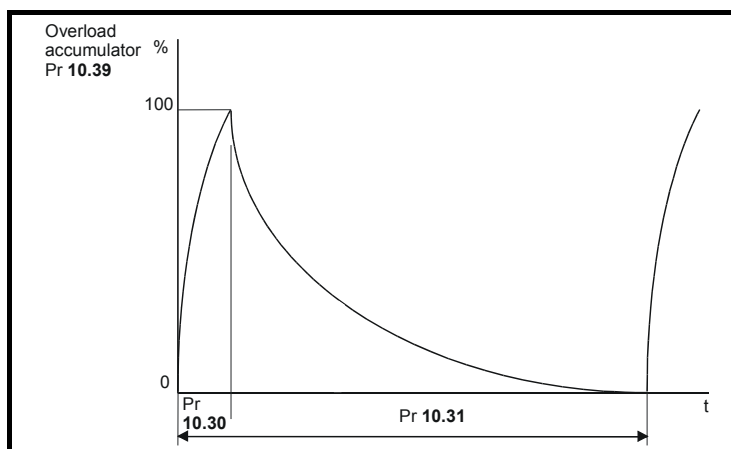
This parameter defines the time period that the braking resistor installed can stand full braking volts without damage. The setting of this parameter is used in determining the braking overload time.

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

10.31	Full power braking period															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0.0 to 1500.0 s								
Default	Open-loop, RFC							BA1xxx and BA2xxx: 3.3s Larger drive sizes: 0.0s								
Update rate	Background read															

This parameter defines the time between periods when the braking IGBT is on for the full power braking time so that the average power in the resistor does not exceed the rating of the resistor. If Pr 10.30 is 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. Under the conditions shown the resistor is heating up just to 100% of its rated temperature during each braking period.



Assuming that the full power braking time is much shorter than the full power braking period i.e.  $Pr\ 10.30 < Pr\ 10.31 / 10$  (which is normally the case) the values for Pr 10.30 and Pr 10.31 can be calculated as follows:

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

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),  $T_{on} = E \times R / \text{Full braking volts}^2$

If the average power rating of the resistor is not to be exceeded in the cycle shown in the diagram above.

The average power in the resistor is given by,  $P_{av} = P_{on} \times T_{on} / T_p$

Where:

$T_p$  is the full power braking period

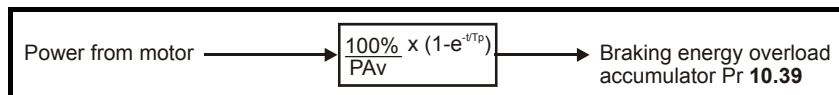
$P_{on} = E / T_{on}$

Therefore  $P_{av} = E / T_p$

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

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

If the profile of the power flowing from the motor is known, then the instantaneous temperature can be calculated at any point by simulating the braking resistor with the model shown below.



The temperature of the resistor is monitored by the braking energy accumulator (Pr 10.39). When this parameter reaches 100% the drive will trip if bit 1 of Pr 10.37 is 0, or will disable the braking IGBT until the accumulator falls below 95% if bit 1 Pr 10.37 is 1. The second option is intended for applications with parallel connected 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Open-loop, RFC								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	Number of auto-reset attempts															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 6							
Default	Open-loop, RFC								0							
Update rate	Background read															

10.35	Auto-reset delay															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0.0 to 600.0 s								
Default	Open-loop, RFC							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. If the number of attempts is set to 6 (inF) then the number of attempts will be infinite. Pr 10.35 defines the time between the trip and the auto reset (this time is always at least 10s for OI.AC, OI.br trips, etc.). The reset count is only incremented when the trip is the same as the previous trip, otherwise it is reset to 0. When the reset count reaches the programmed value, any further trip of the same value will not cause an auto-reset. If there has been no trip for 5 minutes then the reset count is cleared. Auto reset will not occur on a UU, Et, EEf or HFxx trips. When a manual reset occurs the auto reset counter is reset to zero.

10.36	Hold drive ok until last attempt															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

If this parameter is 0 then Pr **10.01** (Drive ok) is cleared every time the drive trips regardless of any auto-reset that may occur. When this parameter is set the 'Drive ok' indication is not cleared on a trip if an auto-reset is going to occur.

10.37	Action on trip detection															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 15							
Default	Open-loop, RFC								0							
Update rate	Background read															

Each bit in this parameter has the following functions:

Bit	Function
0	Stop on non-important trips
1	Disable braking IGBT trips
2, 3	Reserved

#### Stop on non-important trips

If bit 0 is set to zero then the drive simply trips when a non-important trip occurs. Non-important trips are: th, ths, Old1, cL2, cL3, SCL. If bit 0 is set to one the drive will stop before tripping when one of these trips is initiated, except in Regen mode where the drive trips immediately.

#### Disable braking IGBT trips

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

10.38	User trip															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 255							
Default	Open-loop, RFC								0							
Update rate	Background read															

When a value other than zero is written to the user trip parameter the actions described in the following table are performed. The drive immediately writes the value back to zero. If the value is not included in the table a trip is initiated with the same trip number as the value provided the drive is not already tripped.

Action	Values written to 10.38	Trip code
No action	1	UU
	31	EEF
	200	SL1.HF
	205	SL2.HF
	210	SL3.HF
	217-245	HFx
Drive reset	100	
Clear trip and trip time logs	255	



10.39	Braking energy overload accumulator															
Drive modes	Open-loop, RFC															
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, RFC								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 154. Zero indicates the resistor is close to ambient and 100% is the maximum temperature (trip level). A br.rS warning is given if this parameter is above 75% and the braking IGBT active.

10.40	Status word															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							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 date															
10.43	Trip 1 date															
10.45	Trip 2 date															
10.47	Trip 3 date															
10.49	Trip 4 date															
10.51	Trip 5 date															
10.53	Trip 6 date															
10.55	Trip 7 date															
10.57	Trip 8 date															
10.59	Trip 9 date															
Drive modes	Open-loop, RFC															
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, RFC								0 to 31.12 Days. Month*							
Update rate	Background read															

\* See Pr 6.19 for details of date format

10.42	Trip 0 time or power module number															
10.44	Trip 1 time or power module number															
10.46	Trip 2 time or power module number															
10.48	Trip 3 time or power module number															
10.50	Trip 4 time or power module number															
10.52	Trip 5 time or power module number															
10.54	Trip 6 time or power module number															
10.56	Trip 7 time or power module number															
10.58	Trip 8 time or power module number															
10.60	Trip 9 time or power module number															
Drive modes	Open-loop, RFC															
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, RFC								0.00 to 23.59 hours.minutes							
Update rate	Background read															

If Pr 6.49 = 1, then Pr 10.41 to Pr 10.60 are used to store the date and time associated with trip x in the trip log (Pr 10.2x). The data stored depends upon the setting of Pr 6.20 as follows:

Pr 6.20	Trip x date	Trip x time
0	0	Drive powered up time
1	Date (RTC Option slot 1)	Time (RTC Option slot 1)
2	Date (RTC Option slot 2)	Time (RTC Option slot 2)
3	Date (Onboard RTC)	Time (Onboard RTC)
4	0	Drive running time

If Pr 6.49 = 0, then Pr 10.41 to Pr 10.60 are used to store the module number if the trip has been initiated by the power module hardware (trip numbers 101 to 110, HF30 and HF31). The trip number is stored in the "Trip x time or power module number" parameter and the "Trip x date parameter" is set to zero. If the drive has only one power module, and this module is not using the power interface intended for parallel operation, then Pr 10.41 to Pr 10.60 are always zero. If the drive has more than one parallel power module, or is a single module drive using the power interface intended for parallel operation (BAMDxxxx / BAMAXxxx), then module values stored can be used to identify the power module that initiated the trip.

Pr 10.41 to Pr 10.60 are cleared if any of the following occurs:

- Pr 6.49 =1, Pr 6.19 is changed and the drive reset
- Pr 6.49 =1 and date format (Pr 6.20) is changed
- Pr 6.49 is changed

10.61	Low load detected alarm															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1				1				
Range	Open-loop, RFC								0							
Update rate	Background write															

This parameter is one when the low load condition is detected. (See Pr 4.27 to Pr 4.29).

## 5.13 Menu 11: General drive set-up

11.01	Parameter 0.11 set-up															
11.02	Parameter 0.12 set-up															
11.03	Parameter 0.13 set-up															
11.04	Parameter 0.14 set-up															
11.05	Parameter 0.15 set-up															
11.06	Parameter 0.16 set-up															
11.07	Parameter 0.17 set-up															
11.08	Parameter 0.18 set-up															
11.09	Parameter 0.19 set-up															
11.10	Parameter 0.20 set-up															
11.11	Parameter 0.21 set-up															
11.12	Parameter 0.22 set-up															
11.13	Parameter 0.23 set-up															
11.14	Parameter 0.24 set-up															
11.15	Parameter 0.25 set-up															
11.16	Parameter 0.26 set-up															
11.17	Parameter 0.27 set-up															
11.18	Parameter 0.28 set-up															
11.19	Parameter 0.29 set-up															
11.20	Parameter 0.30 set-up															
Drive modes	Open-loop, RFC															
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, RFC								Pr 1.00 to Pr 50.99							
Default	Open-loop, RFC								See Table 5-16							
Update rate	Background read															

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

**Table 5-16 Default settings:**

Parameter	Menu 0	Open-loop	RFC
Pr 11.01	Pr 0.11	Pr 5.01	Pr 5.01
Pr 11.02	Pr 0.12	Pr 4.01	Pr 4.01
Pr 11.03	Pr 0.13	Pr 4.20	Pr 4.20
Pr 11.04	Pr 0.14	Pr 2.04	Pr 2.04
Pr 11.05	Pr 0.15	Pr 6.53	Pr 6.53
Pr 11.06	Pr 0.16	Pr 6.54	Pr 6.54
Pr 11.07	Pr 0.17	Pr 0.00	Pr 4.12
Pr 11.08	Pr 0.18	Pr 5.40	Pr 5.40
Pr 11.09	Pr 0.19	Pr 7.11	Pr 7.11
Pr 11.10	Pr 0.20	Pr 7.14	Pr 7.14
Pr 11.11	Pr 0.21	Pr 7.15	Pr 7.15
Pr 11.12	Pr 0.22	Pr 6.16	Pr 6.16
Pr 11.13	Pr 0.23	Pr 6.17	Pr 6.17
Pr 11.14	Pr 0.24	Pr 6.19	Pr 6.19
Pr 11.15	Pr 0.25	Pr 6.20	Pr 6.20
Pr 11.16	Pr 0.26	Pr 4.27	Pr 4.27
Pr 11.17	Pr 0.27	Pr 4.28	Pr 4.28
Pr 11.18	Pr 0.28	Pr 4.29	Pr 4.29
Pr 11.19	Pr 0.29	Pr 11.36	Pr 11.36
Pr 11.20	Pr 0.30	Pr 11.42	Pr 11.42

Menu 11	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

11.21	Parameter 0.30 scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 9.999								
Default	Open-loop, RFC							1.000								
Update rate	Background read															

This parameter may be used to scale the value of Pr **0.30** seen via the 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 using the keypad, it reverts to its un-scaled value during editing.

11.22	Parameter displayed at power-up															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 0.59							
Default	Open-loop, RFC								Pr 0.10							
Update rate	Background read															

This parameter defines which menu 0 parameter is displayed on power-up.

11.23	Serial address															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								00 to 247							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								1							
Update rate	Background read															

This parameter defines the communications protocol used by the 485 comms port on the drive. This parameter may be changed using the drive keypad, or a Solutions Module or by using the comms interface itself. If it is changed via the comms interface, the response to the command uses the original protocol. The master should wait at least 20ms before sending a new message using the new protocol. (Note: ANSI uses 7 data bits, 1 stop bit and even parity; Modbus RTU uses 8 data bits, 2 stops bits and no parity.)

Parameter value	String	Comms mode
0	AnSI	ANSIx3.28 protocol
1	rtU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but only with BA keypad

### ANSI3.28 protocol

Full details of the CT implementation of ANSI3.28 are given in Chapter 6 *PC communications protocol* on page 219.

### Modbus RTU protocol

Full details of the CT implementation of Modbus RTU are given in Chapter 6 *PC communications protocol* on page 219.

The protocol provides the following facilities:

- Drive parameter access with basic Modbus RTU
- The protocol supports access to 32 bit floating point parameters

The following product specific limitations apply:

- Maximum slave response time when accessing the drive is 100ms.
- Maximum number of 16 bit registers which can be written to or read from the drive itself is limited to 16.
- Maximum number of 16 bit registers which can be written to or read from a Solutions Module or by using a Solutions Module - see Solutions Module User Guide.
- The communications buffer can hold a maximum of 128bytes.

### Modbus RTU protocol, but with BA Keypad only

This setting is used for disabling comms access when the BA Keypad is used as a hardware key. See the SM-Keypad Plus User Guide for more information.

11.25	Baud rate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 9							
Default	Open-loop, RFC								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, a Solutions Module or by using 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 250 ms							
Default	Open-loop,RFC								2							
Update rate	Background read															

There will always be a finite delay between the end of a message from the host (master), and the time at which the host is ready to receive the response from the drive (slave). The drive does not respond until at least 1ms after the message has been received from the host, allowing 1ms for the host to change from transmit to receive mode. This initial delay can be extended using Pr 11.26 if required for both ANSI and Modbus RTU protocols.

Menu 11	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

Pr 11.26	Action
0	The transmit buffers are turned on and data transmission begins immediately after the initial delay ( $\geq 1\text{ms}$ )
1	The transmit buffers are turned on after the initial delay ( $\geq 1\text{ms}$ ) and data transmission begins after 1ms.
2 or more	The transmit buffers are turned on after the initial delay ( $\geq 1\text{ms}$ ) a delay of at least the time specified in Pr 11.26 and data transmission begins 1ms later.

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

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

11.28	Drive derivative															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							0 to 16								
Update rate	Write at power-up															

If this parameter is zero, the drive is a standard product. If this parameter is non-zero, then the product is a derivative product. Derivatives can have different defaults from the standard product and restrictions on the values allowed for some parameters.

11.29	Software version															
Drive modes	Open-loop, RFC															
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, RFC								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, RFC															
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, RFC							0 to 999								
Default	Open-loop, RFC							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 keypad. When this parameter is read using a keypad and security is locked, it appears as zero. The security code can be modified using 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 keypad.

11.31	User drive mode															
Drive modes	Open-loop, RFC															
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, RFC								1 to 2							
Default	Open-loop								1							
	RFC								2							
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, after which 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	RFC	RFC

11.32	Drive current scaling															
Drive modes	Open-loop, RFC															
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, RFC								0.00 to 9999.99 A							
Update rate	Write at power-up															

See section 5.6 *Menu 4: Torque and current control* on page 60 for more details.

11.33	Drive voltage rating															
Drive modes	Open-loop, RFC															
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, RFC							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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	Open-loop, RFC								0 to 10							
Default	Open-loop, RFC								0							
Update rate	Background read															

This parameter can be used to initiate a ConF.P trip if the number of power modules actually connected together in a multi-module drive is different from the expected number. This can be used for example to determine if the control connection between modules has been disconnected. If Pr 11.35 is set to the default value of zero this feature is disabled, and ConF.P trips will not occur. If the feature is required, Pr 11.35 should be set to the actual number of power modules available and the parameters should be saved. When the drive subsequently powers up, the number of power modules is checked and if the actual number of modules is different from Pr 11.35 a ConF.P trip is initiated.

11.36	SMARTCARD parameter data previously loaded															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1		1	1		1	
Range	Open-loop, RFC								0 to 999							
Default	Open-loop, RFC								0							
Update rate	Background write															

This parameter shows the number of the data block last parameter or difference from default data block transferred from a SMARTCARD to the drive.

11.37	SMARTCARD data number															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, RFC								0 to 1003							
Default	Open-loop, RFC								0							
Update rate	Background read															

Data blocks are stored on a SMARTCARD with header information including a number to identify the block. The header information also includes the type of data stored in the block (i.e. the file type) and the drive mode (if this parameter is not the same as the default data), and the version number and a checksum. This data can be viewed through Pr 11.38 to Pr 11.40 by increasing or decreasing Pr 11.37. This parameter jumps between the data numbers of the data blocks present on the card. If this parameter is increased above the highest data block on the card it can have the special values given below:

1000 - shows the space left on the card for data blocks in 16 byte pages.

1001 - shows the total space available on the card for data blocks in 16 byte pages.

1002 - shows the state of the read-only (bit 0) and warning suppression flags (bit 1).

1003 - shows the product identifier.

It should be noted that 16 bytes are reserved at the beginning and the end of the card which cannot be used to hold data. Therefore, a 4096 byte card has 4064 bytes (254 x 16 byte pages) available to hold data. Compatible cards from 4Kbytes to 512Kbytes may be used with the drive. The first 16 bytes on the card hold the card header information, including the read-only flag which can be set to make the whole card read-only, plus the warning suppression flag which can be set to prevent C.rtg and C.Optn trips when data is transferred to the drive from a card. The card header also contains the product identifier which is described later.

The actions of erasing a card, erasing a file, creating a new file, changing a menu 0 parameter, or inserting a new card will set Pr 11.37 to 0.



Various SMARTCARD actions can be initiated via Pr **x.00** or the cloning (Pr **11.42**) and resetting of the drive as given in the table below:

Code	Action
<b>x.00</b> = 2001	Transfer drive parameters as difference from defaults to a bootable SMARTCARD block with block number 1. (This will clear data block 1 on the card if it already exists.)
<b>x.00</b> = 3yyy	Transfer drive parameters to a SMARTCARD block number yyy as a parameter file
<b>x.00</b> = 4yyy	Transfer drive data to a SMARTCARD block number yyy as difference from defaults file
<b>x.00</b> = 5yyy	Transfer drive user program to SMARTCARD block number yyy
<b>x.00</b> = 6yyy	Transfer SMARTCARD data block yyy to the drive
<b>x.00</b> = 7yyy	Erase SMARTCARD data block yyy
<b>x.00</b> = 8yyy	Compare drive parameters with block yyy
<b>x.00</b> = 9555	Clear SMARTCARD warning suppression flag
<b>x.00</b> = 9666	Set SMARTCARD warning suppression flag
<b>x.00</b> = 9777	Clear SMARTCARD read-only flag
<b>x.00</b> = 9888	Set SMARTCARD read-only flag
<b>x.00</b> = 9999	Erase SMARTCARD
Pr <b>11.42</b> = Read	Transfer SMARTCARD data block 1 to the drive provided it is a parameter file
Pr <b>11.42</b> = Prog	Transfer drive parameters to a SMARTCARD block number one as a parameter file
Pr <b>11.42</b> = Auto Pr <b>11.42</b> = boot	Transfer drive parameters to a SMARTCARD block with data block number 1 as a parameter file provided Pr <b>11.42</b> has been changed since power-up.

The data and the format of the data, is different depending on the method used to store it on a SMARTCARD. The different formats are described below. In addition to data transfers, a compare function is also provided.

If 8yyy is entered in Pr **x.00** and the drive is reset, data block yyy on the SMARTCARD is compared with the data in the drive. If the compare is successful, Pr **x.00** is set to 0. If the compare fails, a trip is initiated and parameter **x.00** is not cleared. This function can be used with all data block types except the option type (18).

#### Parameter file type data block

This type of data block is created when 3xxx in Pr **x.00**, the cloning parameter (Pr **11.42**) or auto/boot mode is used to initiate the transfer. The data block (referred to as a parameter file), contains the complete data from all user save (US) parameters, except those with the NC coding bit set. Parameter RAM is used as the source for this information. Power-down save (PS) are not saved to the SMARTCARD. When the data is transferred back to a drive, it is transferred to the drive RAM and then to the drive EEPROM. A parameter save is not required to retain the data after power-down. Before the data is taken from the card, defaults are loaded in the destination drive using the same default code as was last used in the source drive.

#### Difference from defaults type data block

This type of data block is created when 4xxx in Pr **x.00** is used to initiate the transfer. This data block format (referred to a difference from defaults file), is different depending on the software version.

The data held in the data block has changed between different software versions as follows:

Parameters with the following attributes: NC=0 (clonable) and US=1 (user save), and menu 20 parameters except Pr **20.00** if they are different from their default value. If a parameter is a user save (US), but has no default (ND) it is saved on the card whatever its value.

It is possible to transfer parameters between drives with each of the software version dependant formats, however, the data block compare function does not work with data produced by the different formats.

The data density is not as high as a parameter file type data block, but in most cases the number of differences from default is small and the data blocks are therefore smaller. This method can be used for example for creating drive macros. Parameter RAM is used as the source of this information.

When the data is transferred back to a drive, using 6yyy in Pr **x.00**, it is transferred to the drive RAM and then to the drive EEPROM. A parameter save is not required to retain the data after power-down.

#### Onboard Application Lite user program data blocks

This type of data block is created when 5xxx in Pr **x.00** is used to initiate the transfer. The Onboard Application Lite user program from a drive, may be transferred to/from internal flash memory, or from/to a SMARTCARD. If the user program is transferred from a drive with no program loaded, the block is still created on the card but contains no data. If this is then transferred to a drive, the drive will then have no user program.

When transferring data between drives the following should be noted:

#### Parameter transfer failure

When parameter or default difference data is transferred to the drive, the parameters are automatically saved to drive EEPROM. If the transfer from the card fails for any reason, the drive generates the appropriate trip. If the failure occurs after the transfer has begun, it is possible that some, but not all the parameters will have been updated with the card data. However if the transfer fails, the parameters are not saved to drive EEPROM, therefore only the RAM values will be incorrect. If the drive is powered down and then powered up again, the original drive parameters will be restored.

#### Read-only function

Data blocks with numbers from 1 to 499 can be created or erased by the user. Data block with numbers 500 and above are read-only and cannot be created or erased by the user. The whole card may also be protected from writing or erasing by setting the read-only flag. If the card or a data block on the card is read-only, then the operation to erase the whole card is disabled.

### Changing the drive mode

If the destination drive has a different drive mode to the parameters on the card, the drive mode will be changed by the action of transferring parameters from the card to the drive. The only exception is that the mode cannot be changed to a mode that is not allowed for the particular derivative of the drive, e.g. Regen mode is not allowed with the Unidrive ES derivative. If an attempt is made to change to a disallowed mode, the drive produces a C.Typ trip.

### Different voltage ratings

If the voltage rating of the source and destination drive are different, then the parameters are transferred with the exception of rating dependent parameters (RA attribute set, see table below), which are left at their default values. In this case a C.rtg trip is displayed as a warning that this has happened. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

Parameter number	Function
Pr 2.08	Standard ramp voltage
Pr 4.05 - Pr 4.07, Pr 21.27- Pr 21.29	Current limits
Pr 4.24	User current maximum scaling
Pr 5.07, Pr 21.07	Motor rated current
Pr 5.09, Pr 21.09	Motor rated voltage
Pr 5.10, Pr 21.10	Rated power factor
Pr 5.17, Pr 21.12	Stator resistance
Pr 5.18	Switching frequency
Pr 5.23, Pr 21.13	Voltage offset
Pr 5.24, Pr 21.14	Transient inductance
Pr 5.25, Pr 21.24	Stator inductance
Pr 6.06	dc injection braking current
Pr 6.48	Mains loss ride through detection level

### Different Solutions Modules installed

If the categories of the Solutions Modules installed to the source drive are different to the destination drive, the parameters are transferred with the exception of the parameters in the menus of the modules that are different. These parameters are left at their default values. In this case a C.Optn trip is given as a warning. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

### Different current rating with a parameter file type data block

If the current ratings of the source and destination drive are different and the parameters stored as a parameter file (not differences from default), then rating dependant parameters are set to their defaults and a C.rtg trip is produced as described above where the voltage ratings are different. It is possible to suppress this warning trip for any data transfer to the drive, including a boot transfer at power-up by setting the warning suppression flag for the whole card.

### Different current rating with difference from defaults type data block

If the current ratings of the source and destination drives are different, but the parameters are stored as a difference from defaults file, the rating dependant parameters are transferred from the card to the drive and the appropriate maximums are applied. The C.rtg is still produced unless it is suppressed. To ensure that the performance of the destination drive is similar to that of the source drive, the speed controller gains and current controller gains are scaled as shown in the table below. Note that the gain scaling is only applied when the data block number is less than 500.

Drive modes	Gains	Scaling applied
RFC	Speed controller gains	x Source Pr 11.32 / Destination Pr 11.32
RFC	Current controller gains	x Destination Pr 11.32 / Source Pr 11.32

### Effects of variable maximums if ratings or options are different

It should be noted that if ratings of the source and destination drives are different, or if the Solutions Modules installed to the source and destination drives are different, it is possible that some parameters with variable maximums may be limited, and may not have the same values as on the card. For example, the user current maximum scaling (Pr 4.24) is rating dependent and could be set to its default value when it is transferred between drives of different ratings, but this could also affect the torque reference (Pr 4.08) as this uses Pr 4.24 as its maximum.

### Unexpected rating changes

Some drive ratings may change between software versions. These changes will cause a C.rtg trip when parameters are transferred between drives of different software versions where the rating has changed.

## Product identifier

When a SMARTCARD is used with any of the following software versions, it must have the correct product identifier in the card header to give full functionality with the drive. The product identifier is written to the card when the whole card is erased. If the software version is earlier than those given above, the product identifier is set to 255 otherwise the following values are used:

Product	Product Identifier
Unidrive SP (standard)	255
Commander GP20	1
Digitax ST	2
Affinity	3

If the identifier does not match the drive product and the card contains data blocks, a C.Prod trip is produced. Also if the following functions are initiated, a C.Acc trip is produced and the card or drive data is not affected: erase file, transfer data block from card to drive, or transfer data block from drive to card. It is still possible to use Pr 11.37 to browse information about the whole card (i.e. Pr 11.37 = 1000 to 1003), but it is not possible to see the data block information (i.e. Pr 11.37 < 1000). It is also possible to change the card header information (i.e. read-only flag and warning suppression flag). This feature allows the read-only flag to be cleared so that a card can be erased for use with the product that performs the card erase.

If the card does not contain any data blocks (i.e. an erased card), and the identifier does not match that of the drive, then the drive will automatically change the identifier on the card to match when it is first inserted.

11.38	SMARTCARD data type/mode															
Drive modes	Open-loop, RFC															
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, RFC								0 to 18							
Update rate	Background write															

Gives 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, 1000 to 1003	Data from EEPROM
1		Reserved	
2	3OpEn.LP	Open-loop mode parameters	
3	3rfc	RFC mode parameters	
4 to 5		Reserved	
6 to 8	3Un	Unused	Defaults last loaded and differences
9		Reserved	
10	4OpEn.LP	Open-loop mode parameters	
11	4rfc	RFC mode parameters	
12 to 13		Reserved	
14 to 16	4Un	Unused	
17	LAddEr	Onboard PLC program	
18	Option	A Solutions Module file	
19		Reserved	

11.39	SMARTCARD data version															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Open-loop, RFC								0 to 9,999							
Default	Open-loop, RFC								0							
Update rate	Background read/write															

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

Menu 11	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

11.40	SMARTCARD data checksum															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							0 to 65,335								
Update rate	Background write															

Gives the checksum of the data block space left on the card, the total space on the card for the card flags see Pr 11.37 for details.

11.41	Status mode time-out															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 250 s							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1					1			*	1	1	
Range	Open-loop, RFC								0 to 4							
Default	Open-loop, RFC								0							
Update rate	Background read															

\* Modes 1 and 2 are not US (i.e. not saved when drive parameters are saved), mode 3 and 4 are US.

Therefore this parameter can only be saved to EEPROM if it has a value of 0, 3 or 4.

### Reading (1)

Setting Pr 11.42 to 1 and resetting the drive, will transfer the data from the card into the drive parameter and then the drive EEPROM, provided data block 1 exists and is a parameter file for the current drive mode. All SMARTCARD trips apply. When the action is complete this parameter is automatically reset to zero.

### Programming (2)

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

### Auto (3)

Changing Pr 11.42 to 3 and resetting the drive, will save the complete parameter set from the drive parameters to the card, i.e. equivalent to writing 3001 to Pr x.00. If the data block already exists it is automatically overwritten. If the card is removed when Pr 11.42 is set to 3, Pr 11.42 will be set to 0. The action of setting Pr 11.42 to 0 when a card is removed forces the user to change Pr 11.42 back to 3 if auto mode is still required. The user will need to set Pr 11.42 to 3 and reset the drive to write the complete parameter set to the new card.

When a parameter in menu zero is changed via the keypad and a card is installed, the parameter is saved to both the drive EEPROM and the card. Only the new value of the modified parameter is written to the EEPROM and the card. If Pr 11.42 was not cleared automatically when a card was removed, then when a new card is inserted which contains data block 1, the modified parameter would be written to the existing data block 1 on the new card and the rest of the parameters in this data block may not be the same as those in the drive.

When Pr 11.42 is equal to 3 and the parameters in the drive are saved, the card is also updated, therefore the card becomes a copy of the drive parameters. At power up, if Pr 11.42 is set to 3, the drive will save the complete parameter set to the card. This is done to ensure that if a card is inserted while the drive is powered down, the new card will have the correct data after the drive is powered up again.

### Boot (4)

When Pr 11.42 is set 4, the drive operates in the same way as with Pr 11.42 set to 3 and automatically creates a copy of it parameters on a SMARTCARD. Pr 11.42 has the NC (not clonable) attribute, and so it does not have a value stored on a SMARTCARD in the normal way. However, when data is transferred to a card from the source drive, the value of this parameter is held in the header of parameter or difference from default file type data blocks so that the destination drive can detect when boot transfer is required on power-up (i.e. the source drive had this parameter set to 4). If a card is present at power up, and it has Pr 11.42 stored as 4 in the header of a parameter file or difference from default file as data block 1 then the following actions are taken.

1. The parameters from data block 1 are transferred to the drive and then saved in drive EEPROM.
2. If data block 2 exists and is type 17 the user program from this data block is transferred to the drive.
3. Parameter Pr 11.42 is set to zero after the data transfer is complete.

It is possible to create a difference from default bootable file by setting parameter Pr **x.00** to 2001 and resetting the drive. This type of file causes the drive to behave in the same way at power-up as a file created with boot mode set up with Pr **11.42**. The difference from default file has the added advantage of including menu 20 parameters. A bootable difference from default file can only be created in one operation and parameters cannot be added as they are saved via menu zero.

When the drive is powered up it detects which Solutions Modules are installed before loading parameters from a SMARTCARD which has been set up for boot mode. If a new Solutions Module has been installed since the last time the drive was powered up, the drive produces a SLx.dF trip and then proceeds to transfer the parameters from the SMARTCARD. If the parameter data in the card includes the parameters for the newly installed Solutions Module, then these are also transferred to the drive. Once the transfer is complete, the drive parameters are automatically saved to the drive EEPROM. The SLx.dF trip can be reset either by resting the drive or power recycling. Because the parameters are transferred to the drive after detecting the Solutions Modules, it is possible to fit the required Solutions Modules to a drive (corresponding to the modules installed when the SMARTCARD data was stored) and transfer the parameters to the drive including those for the Solutions Modules.

11.43	Load defaults															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1					1				1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								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, RFC															
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, RFC								0 to 2							
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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	Background read															

When this bit is set to 1, 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1		1	
Range	Open-loop, RFC								0 to 2,000							
Default	Open-loop, RFC								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. 1233, 1244, etc.

11.47	Drive Onboard Application Lite Ladder Program Enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								2							
Update rate	Background read															

This parameter is used to start and stop the drive Onboard PLC program.

Value	Description
0	Halt the Drive Onboard Application Lite ladder Program.
1	Run the Drive Onboard Application Lite ladder Program (if installed). Any out-of-range parameter writes attempted will be clipped to the maximum / minimum values valid for that parameter before being written.
2	Run the drive Onboard Application Lite ladder Program (if installed). Any out-of-range parameter writes attempted will cause a drive trip.

11.48	Drive Onboard PLC program status															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							-128 to +127								
Update rate	Background write															

The Drive Onboard Application Lite Ladder Program Status parameter indicates to the user the actual state of the drive Onboard Application Lite Ladder Program. (Not installed / running / stopped / tripped).

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

11.49	Drive Onboard application lite ladder programming events															
Drive modes	Open-loop, RFC															
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, RFC								0 to 65,535							
Update rate	Background write															

The Drive Onboard Application Lite Ladder Programming Events parameter, holds the number of times an Onboard Application Lite Ladder program download has taken place, and is set to 0 by default on dispatch from the factory. If the Drive Onboard Application Lite Ladder Programming Events is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value. This parameter is not altered when defaults are loaded.

11.50	Drive Onboard Application Lite Ladder Program Average Scan Time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC								0 to 65,535 ms							
Update rate	Onboard Application Lite Ladder program execution period															

This parameter is updated once per second or once per Onboard PLC program scan whichever is the longest. If more than one program scan occurs within the one second update period, the parameter shows the average scan time. If the program scan time is longer than one second, the parameter shows the time for the last program scan.

11.51	Drive Onboard Application Lite Ladder Program first run															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Range	Open-loop, RFC								0 or 1							
Update rate	Onboard Application Lite Ladder program execution period															

The Drive Onboard Application Lite Ladder Program first run parameter is set for the duration of the first ladder diagram scan from the ladder diagram stopped state. This enables the user to perform any required initialization every time the ladder diagram is run. This parameter is set every time the ladder is stopped.

5.14 Menu 12: Threshold detectors, variable selectors and brake control function

Menu 12 includes two threshold detectors which produce logic signals depending on the level of a variable value with respect to a threshold, and two variable selectors which allow two input parameters to be selected or combined to produce a variable output. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. A function is active if one or more sources are routed to a valid parameter.

Figure 5-14 Menu 12 logic diagram

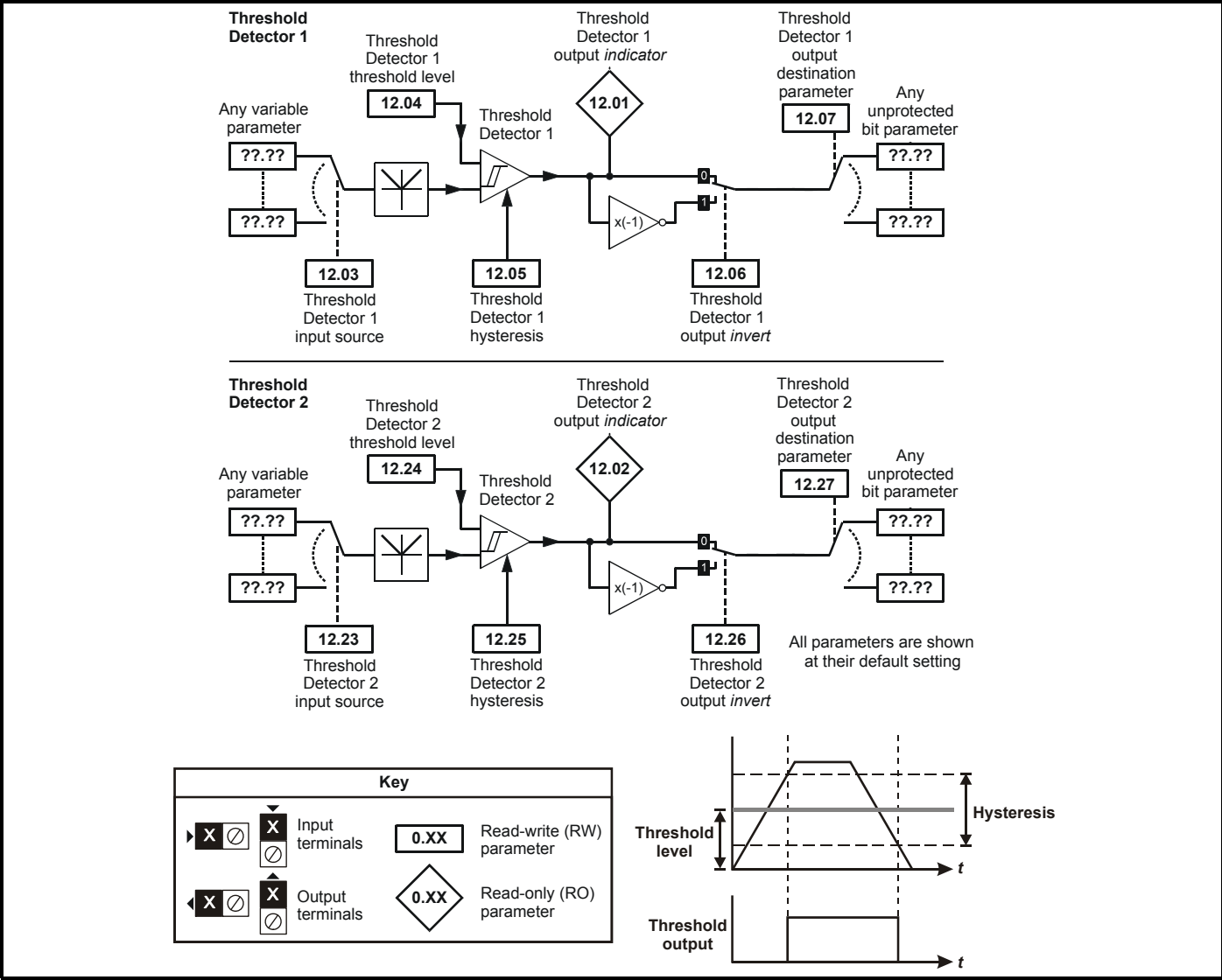
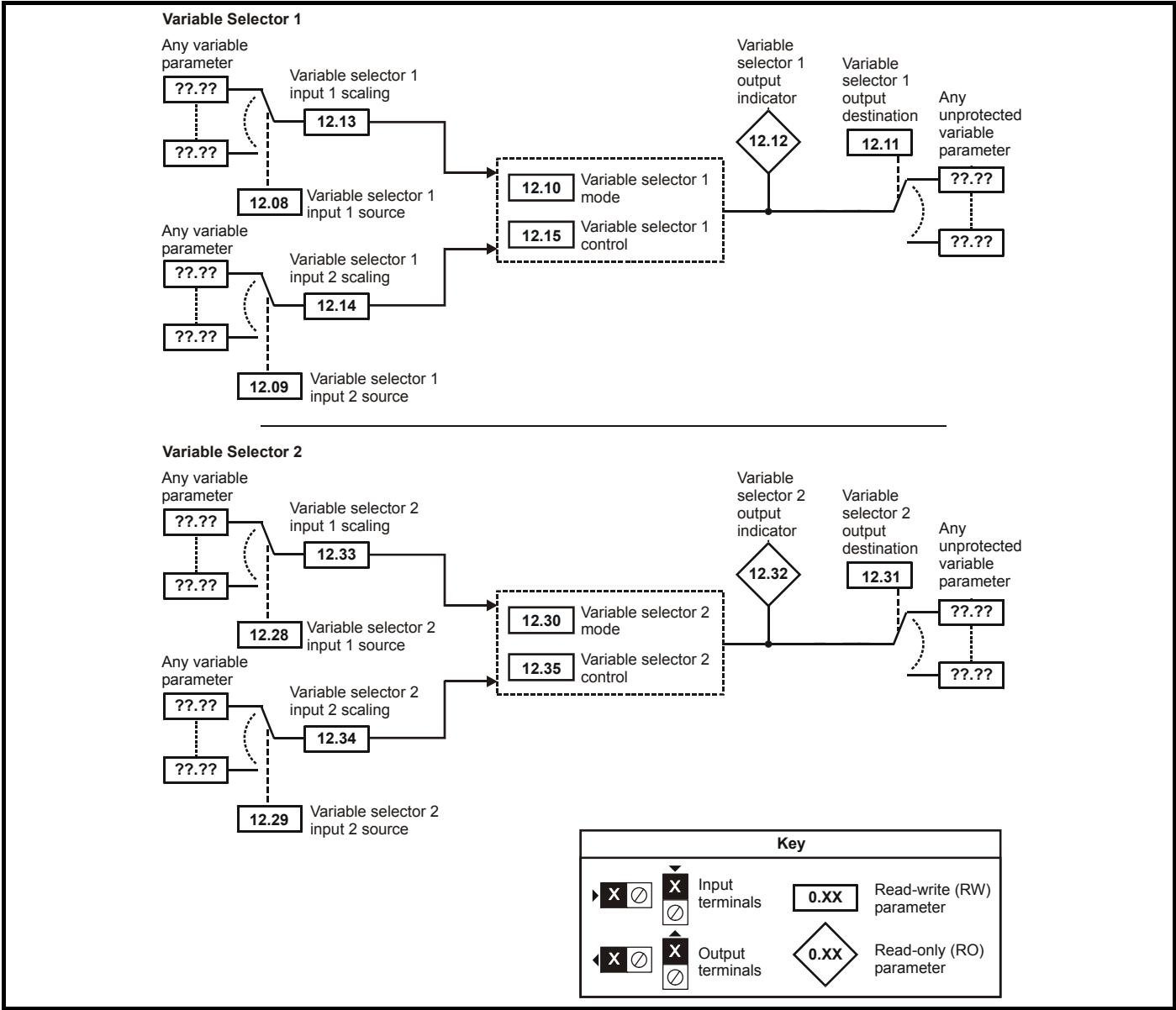




Figure 5-15 Menu 12 Logic diagram (continued)



Menu 12	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

12.01	Threshold detector 1 output															
12.02	Threshold detector 2 output															
Drive modes	Open-loop, RFC															
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, RFC															
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, RFC							Pr 0.00 to Pr 21.51								
Default	Open-loop, RFC							Pr 0.00								
Update rate	Read on reset															

12.04	Threshold detector 1 level															
12.24	Threshold detector 2 level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC							0.00 to 100.00 %								
Default	Open-loop, RFC							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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC								0.00 to 25.00 %							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								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, RFC															
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, RFC								Pr 0.00 to Pr 21.51							
Default	Open-loop, RFC								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, RFC															
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, RFC								Pr 0.00 to Pr 21.51							
Default	Open-loop, RFC								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, RFC															
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, RFC								Pr 0.00 to Pr 21.51							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on reset															

12.10	Variable selector 1 mode															
12.30	Variable selector 2 mode															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 11							
Default	Open-loop, RFC								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, RFC															
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, RFC								Pr 0.00 to Pr 21.51							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on reset															

12.12	Variable selector 1 output															
12.32	Variable selector 2 output															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC								±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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, RFC								±4.000							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Open-loop, RFC								±4.000							
Default	Open-loop, RFC								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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC								0.00 to 100.00							
Default	Open-loop, RFC								0.00							
Update rate	Background															

The variable selectors allow two source values (defined by Pr 12.08, Pr 12.28 and Pr 12.09, Pr 12.29) to be combined as defined by the mode (Pr 12.10, Pr 12.30) to produce an output (Pr 12.12, Pr 12.32) which can be routed to the destination parameter (defined by Pr 12.11, Pr 12.31). The actions of the variable selector are defined by the mode parameter as given below. If the mode parameter is changed or the variable selector is disabled because neither source is routed to a valid parameter, all internal state variables (i.e. time constant/filter accumulator, etc.) within the selector are reset.

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/filter	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 <sup>2</sup> / 100.0 control = 0.03: output = input1 <sup>3</sup> / 100.0 <sup>2</sup> control has any other value: output = input1
10		Reserved
11	External rectifier monitor	See section 5.14.1 below

### 5.14.1 External Rectifier (BAMC/U) Monitor

This mode is intended to monitor an external rectifier system (BAMC/U) to provide over temperature monitoring, phase loss detection and mains loss detection. The variable selector inputs should be routed to digital inputs on the drive or a Solutions Module, which are connected to the (BAMC/U) rectifier status outputs. The external rectifier monitor produces a number of actions depending on the state of the inputs as given in the table below.

The healthy/OK state becomes active immediately both inputs are high, but the other states only become active when the required inputs have been active for at least 0.5s. The high state is defined as a value greater than, or equal to half the source maximum, and the low state is defined as a value less than half the source maximum (with the scaling parameters set to 1.000). If digital inputs are used as the sources, and the scaling parameters are 1.000, high is therefore defined as 1, and low is defined as 0. The variable selector output gives 0% if the rectifier is healthy/OK otherwise it gives 100%.

The output should be routed to Pr 6.51 (rectifier not active), in order that the drive is not allowed to leave the main loss condition if the rectifier is not fully phased forwards.

Input 1 (Pr 12.08, Pr 12.28)	Input 2 (Pr 12.09, Pr 12.29)	State	Trip	Output (Pr 12.09, Pr 12.29)
High	High	healthy/OK	None	0%
High	Low	Over temperature	Oht4.P trip	100%
Low	High	Phase Loss	PH.P trip	100%
Low	Low	Mains Loss	None	100%

For more information about Oht4.P and PH.P trips, refer to the *Affinity Modular Drive User Guide*.

### 5.14.2 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 (RFC mode). 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, RFC															
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).



**WARNING**

The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

12.41	Brake controller enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC								0 to 3							
Default	Open-loop, RFC								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 (RFC mode), Pr 13.04 and Pr 13.10 (RFC mode if Pr 12.49 = 1).

#### 1 = rel

The brake controller is enabled with I/O set up to control the brake via the relay output T41/42. Drive ok is re-routed to digital I/O 2 (T25).

#### 2 = d IO

The brake controller is enabled with I/O set up to control the brake via digital I/O 2 (T25).

#### 3 = User

The brake controller is enabled, but no parameters are set to select the brake output.

The following tables show the automatic parameter changes that occur to set up digital I/O2 (T25) and the relay output (T41/42) after drive reset when Pr 12.41 has been changed. The changes are done in two stages: the first stage restores the I/O used as defined by the initial setting of Pr 12.41, and the second stage sets up the I/O as defined by the new setting of Pr 12.41.

#### Stage 1: Restore I/O

Initial setting in Pr 12.41	Pr 8.12 (Invert)	Pr 8.22 (Source / destination)	Pr 8.32 (Input/ output)	Pr 8.17 (Invert)	Pr 8.27 (Source)
0	No action				
1	0	Pr <b>10.33</b>	0	0	Pr <b>10.01</b>
2	0	Pr <b>10.33</b>	0	No action	
3	No action				

#### Stage 2: Set-up I/O

New setting in Pr 12.41	Pr 8.12 (Invert)	Pr 8.22 (Source / destination)	Pr 8.32 (Input/ output)	Pr 8.17 (Invert)	Pr 8.27 (Source)
0	No action				
1	0	Pr <b>10.01</b>	1	0	Pr <b>12.40</b>
2	0	Pr <b>12.40</b>	1	No action	
3	No action				



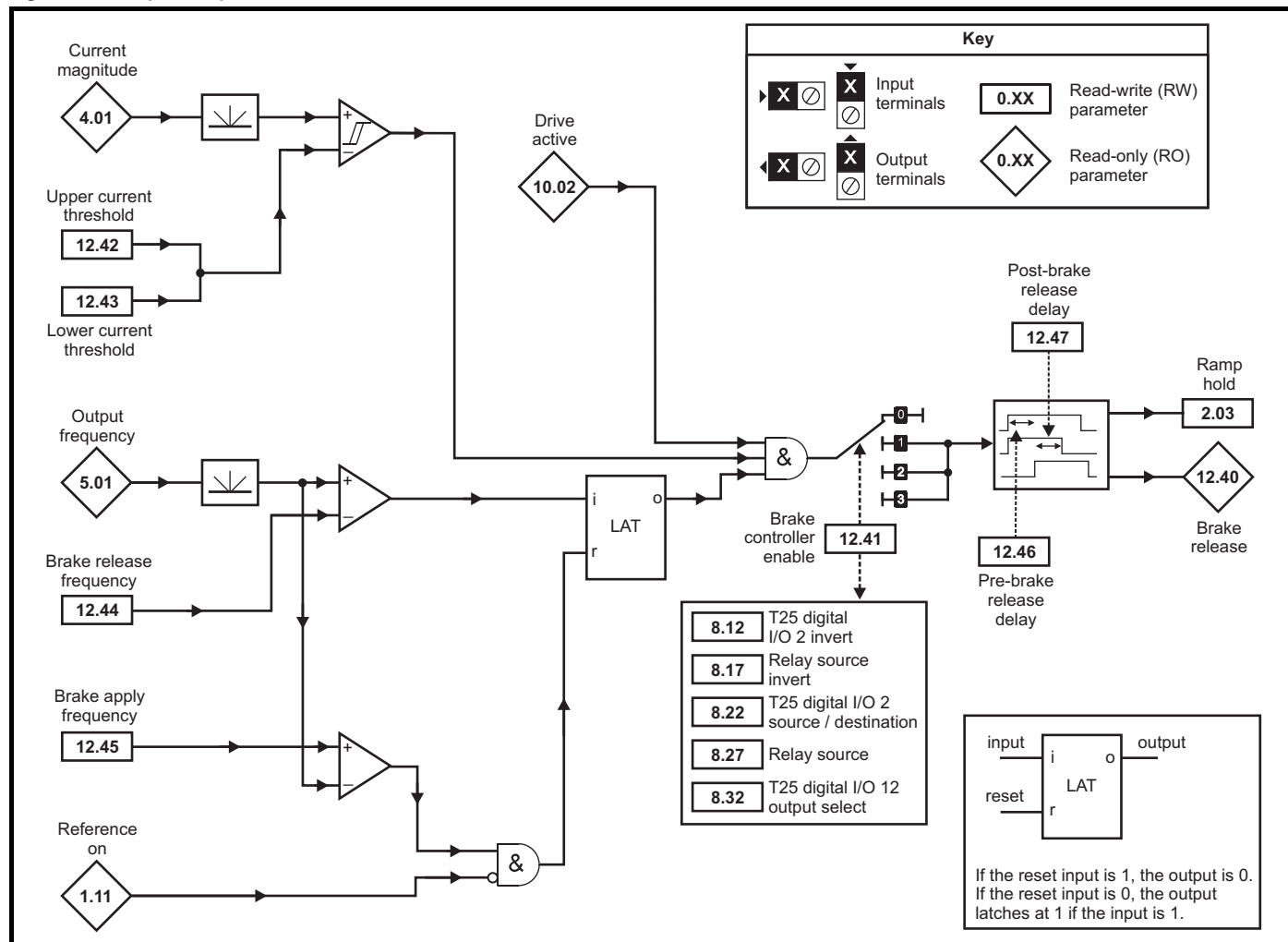
The brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.



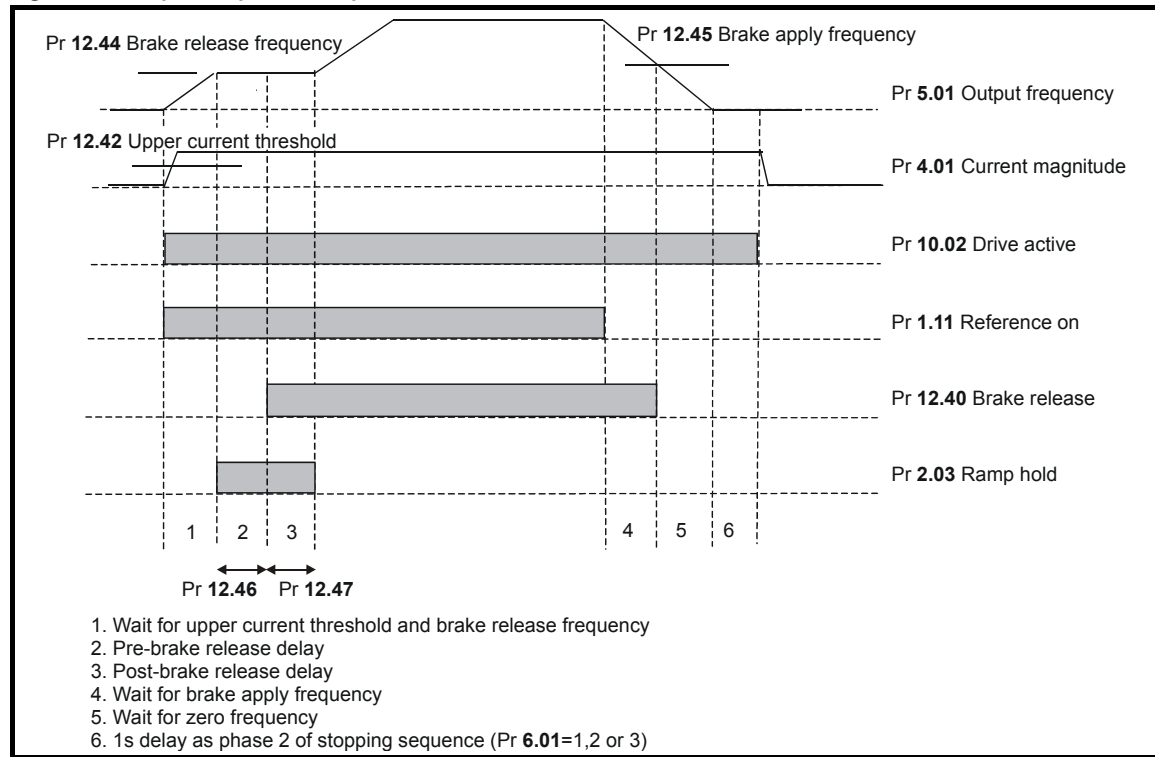
The control terminal relay can be selected as an output to release a brake. If a drive is set up in this manner and a drive replacement takes place, prior to programming the drive on initial power up, the brake may be released. When drive terminals are programmed to non default settings the result of incorrect or delayed programming must be considered. The use of a SMARTCARD in boot mode or an SM-Applications module can ensure drive parameters are immediately programmed to avoid this situation.

## Open-loop

Figure 5-16 Open-loop brake function



**Figure 5-17 Open-loop brake sequence**



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 establish 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 which indicates that there is magnetizing current and sufficient torque producing current in the motor to deliver the required amount of torque when the brake is released.

The output of the comparator remains active after this level has been reached, unless the current subsequently falls below the lower threshold which should be set to the required level to detect the condition where the motor has been disconnected from the drive. If the lower threshold is set greater or equal to the upper threshold, the upper threshold applies 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 which is likely to occur under the highest expected load that is applied to the motor when the brake is released.

12.45	Brake apply frequency															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop							0.0 to 20.0 Hz								
Default	Open-loop							2.0								
Update rate	Background read															

The brake apply frequency threshold is used to ensure that the brake is applied before the motor frequency reaches zero, and to prevent the motor rotating in the reverse direction due to an overhauling load, for example during the brake apply time. If the frequency falls below this threshold, but the motor is not required to stop (i.e. reversing direction without stopping), provided the Reference on parameter (Pr 1.11) remains at one, the brake is not applied. This prevents the brake from activating and de-activating as the motor passes through zero speed.

12.46	Pre-brake release delay															
Drive modes	Open-loop															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop							0.0 to 25.0 s								
Default	Open-loop							1.0								
Update rate	Background read															

The pre-brake release delay is used to allow time for the motor torque to reach the required level before the brake is released. This time should allow for the motor flux to reach a significant proportion of the rated level (2 or 3 times the rotor time constant/filter 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.

## RFC

Figure 5-18 RFC brake function

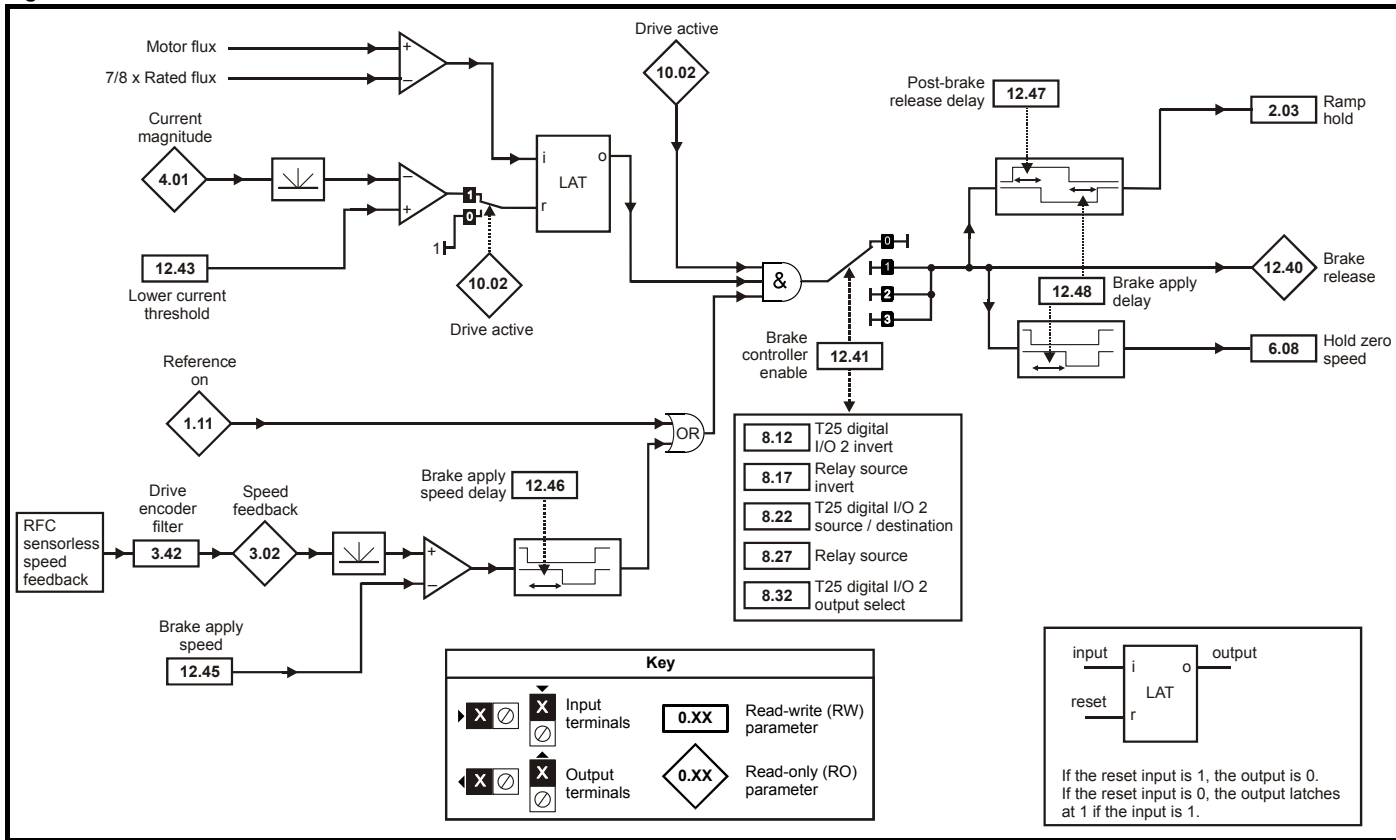
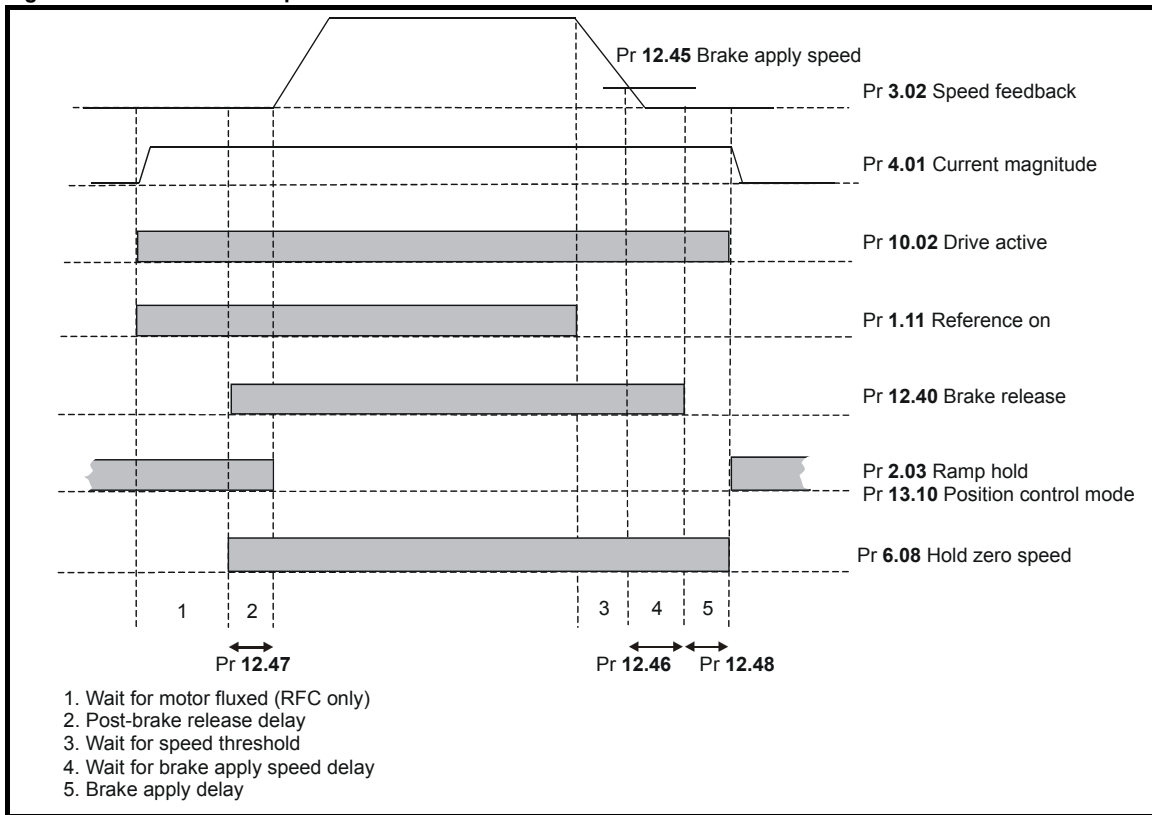


Figure 5-19 RFC brake sequence



12.43	Low current threshold															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 200 %							
Default	Open-loop, RFC								10							
Update rate	Background read															

If the current magnitude falls below the lower current threshold the brake is applied immediately. The lower threshold should be set to the required level to detect the condition where the motor has been disconnected from the drive. If this parameter is set to zero, the loss of current will not cause the brake to be applied. However, the flux detection and current threshold latch will be reset when the drive is disabled.

12.45	Brake apply speed															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	RFC								0 to 200 rpm							
Default	RFC								5							
Update rate	Background read															

When stopping, the drive reference can be removed (i.e. Pr 1.11 = 0), but the brake will remain energized (open) until the motor has remained at a speed below the brake apply speed for the delay defined by Pr 12.46. The delay prevents rapid activation and de-activation of the brake when fine control of a motor is required close to zero speed.

12.46	Brake apply speed delay															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	RFC								0.0 to 25.0 s							
Default	RFC								1.0							
Update rate	Background read															

See Pr 12.45.

12.47	Post-brake release delay															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	RFC								0.0 to 25.0 s							
Default	RFC								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	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	RFC								0.0 to 25.0 s							
Default	RFC								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.

Menu 13	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

5.15    **Menu 13: Not used**

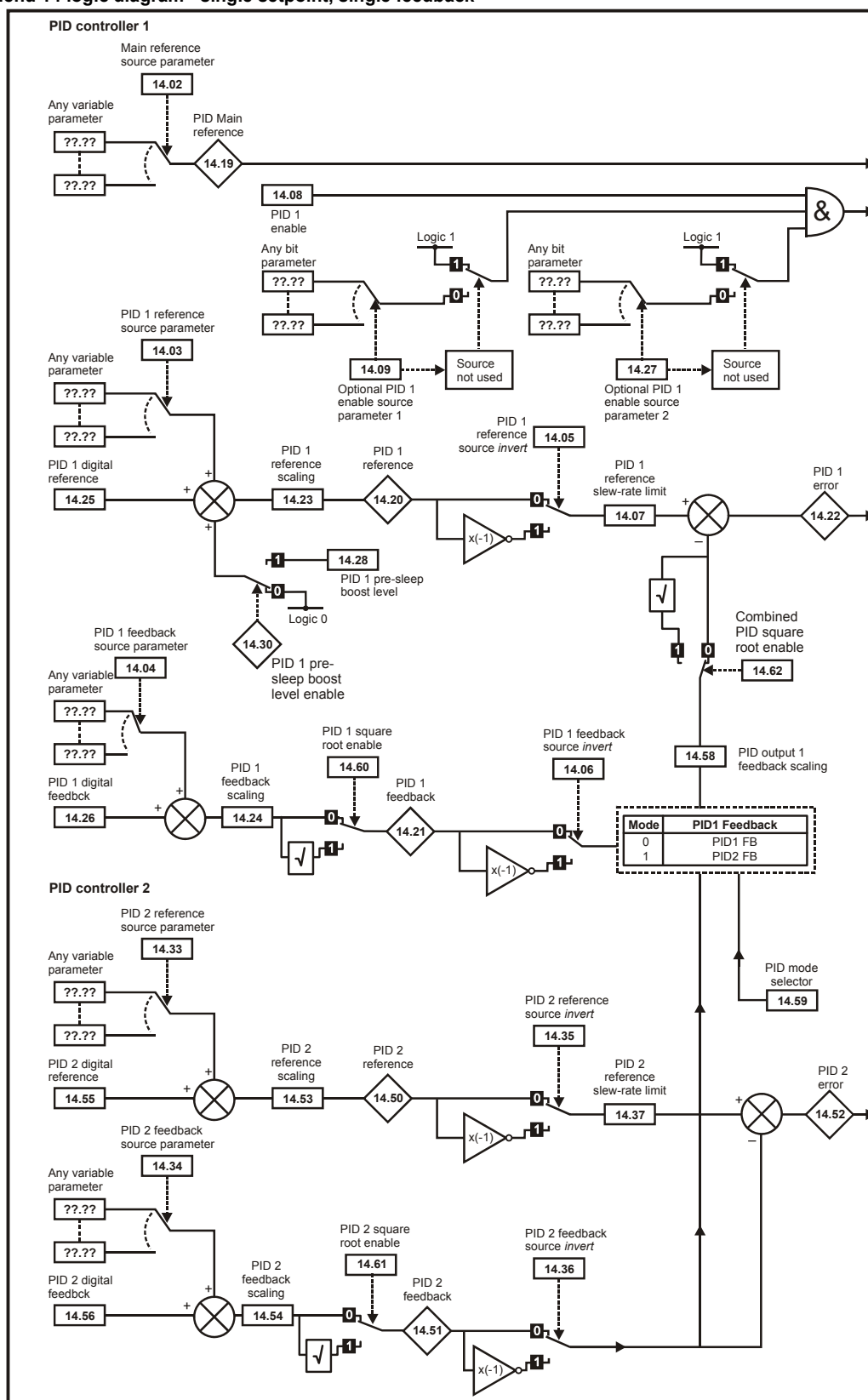
Menu 13 is not used by the Affinity drive but Pr **13.00** is available and provides Pr **x.00** functions (See Chapter 3)

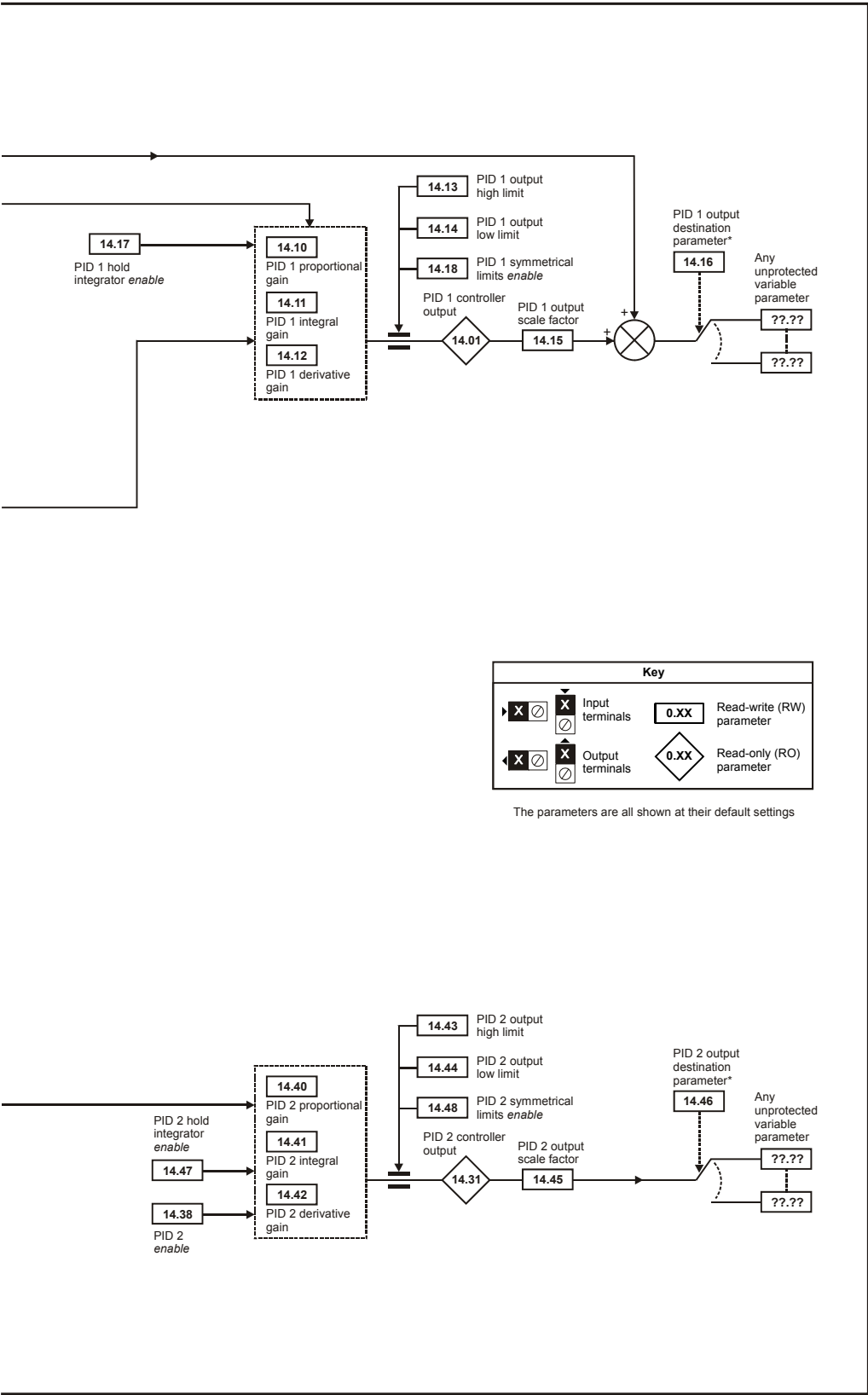


## 5.16 Menu 14: Advanced process PID

This menu contains two PID controllers. The PID controllers may be used independently or combined for complex applications. The sample rate of the PID controller is 4ms.

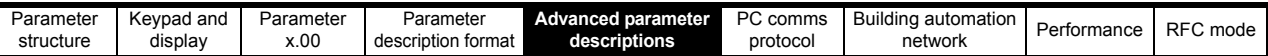
Figure 5-20 Menu 14 logic diagram - single setpoint, single feedback



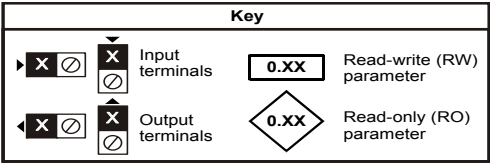
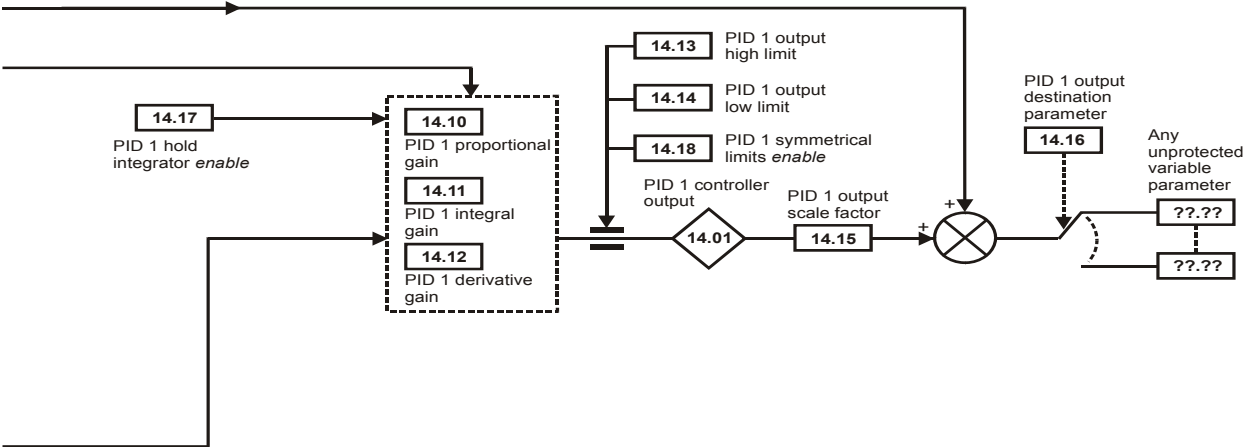


\*The PID controller is only enabled if Pr 14.16 is set to a non Pr xx.00 and unprotected destination parameter.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------







The parameters are all shown at their default settings

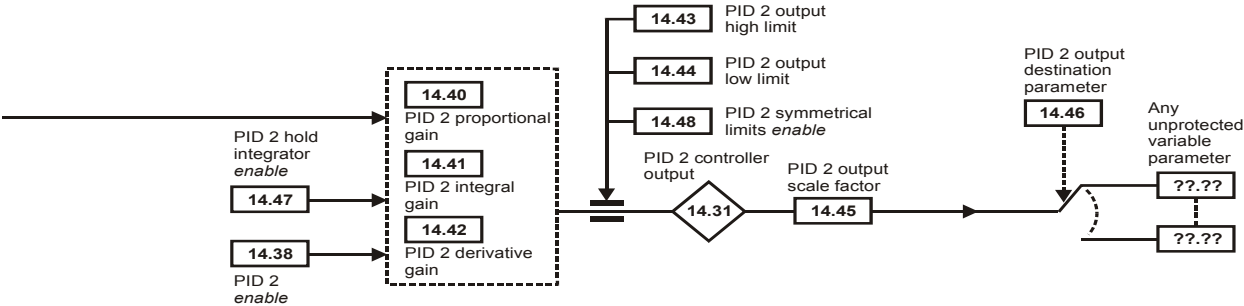
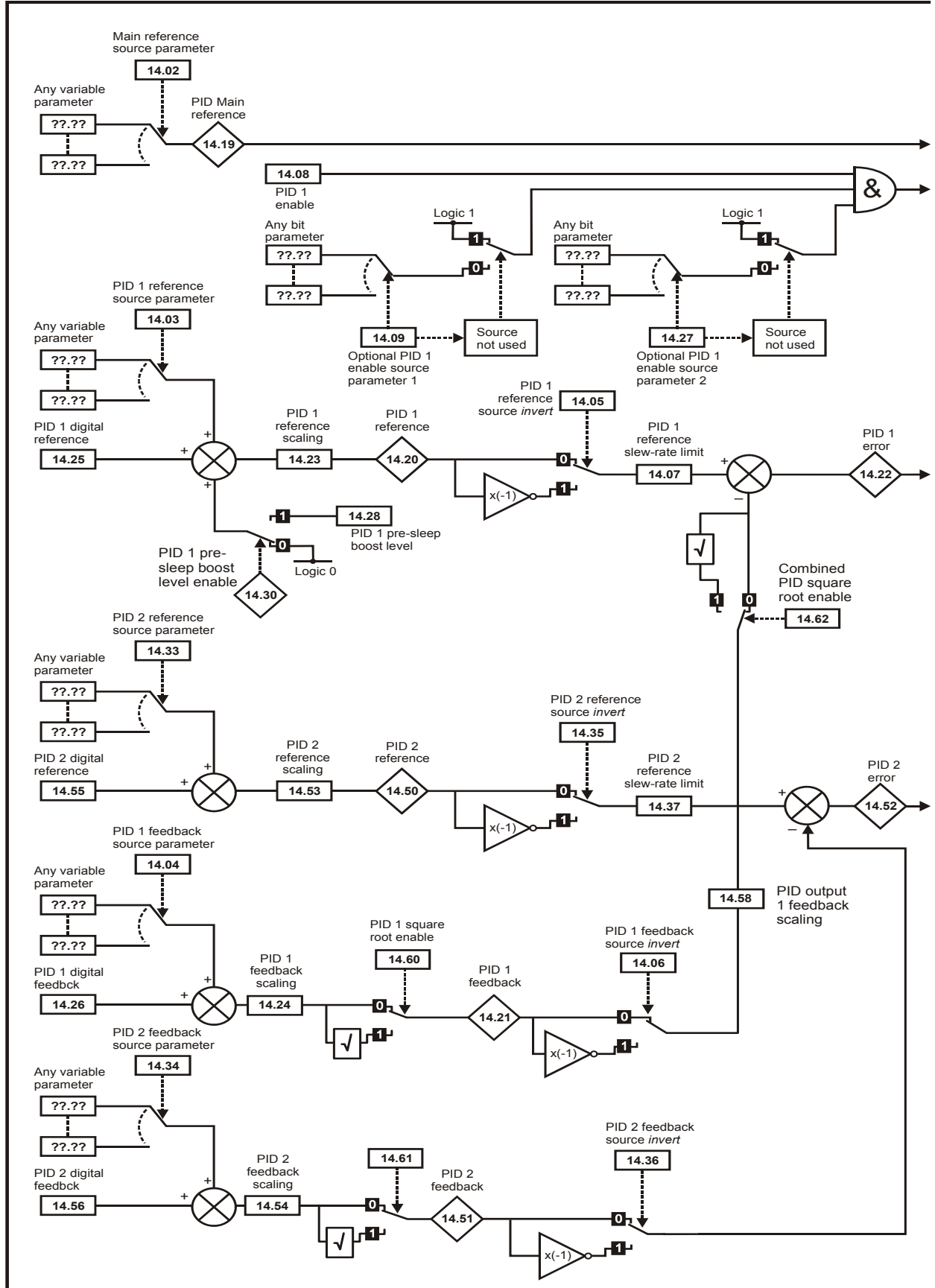
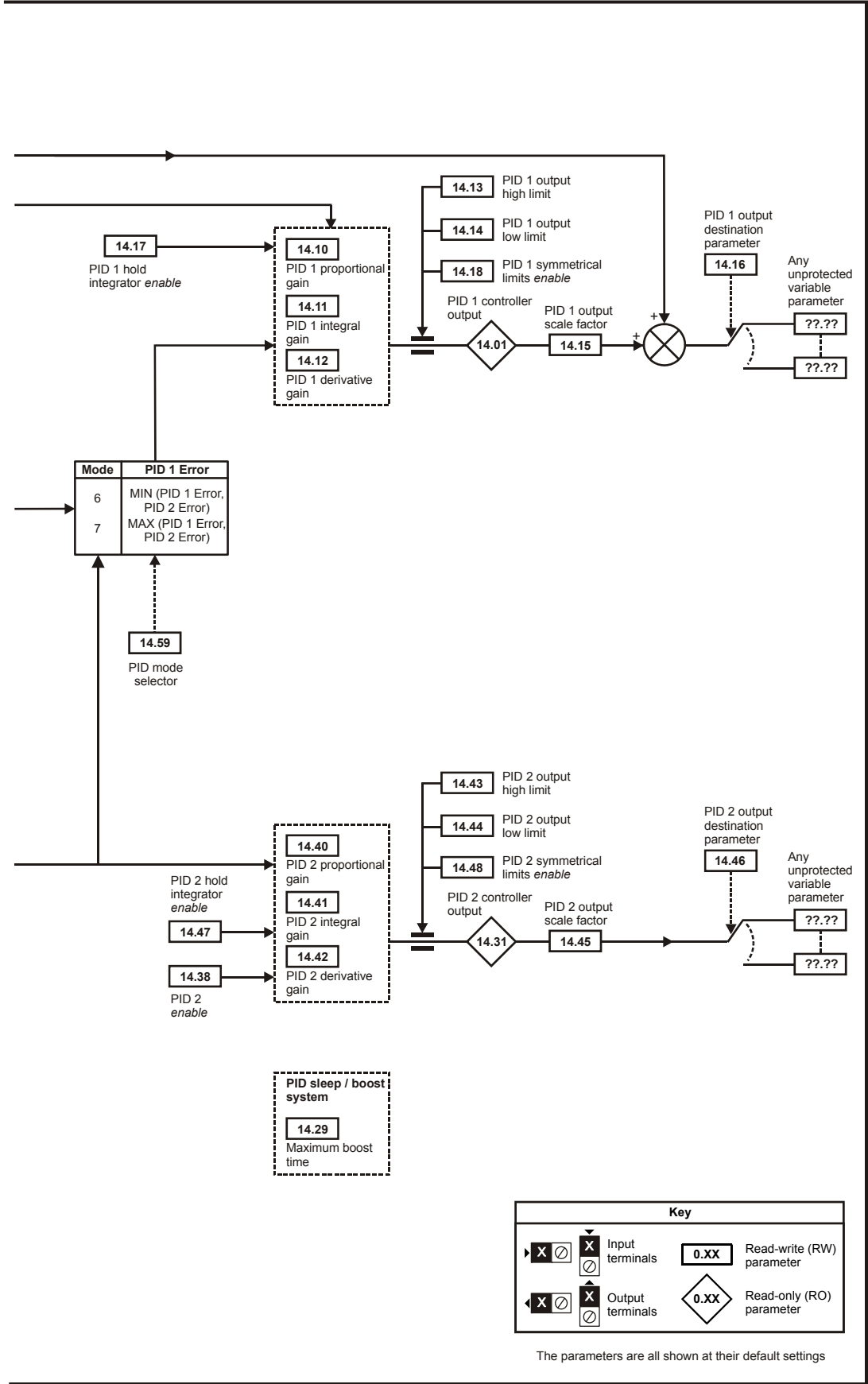


Figure 5-22 Menu 14 Logic diagram - dual setpoint, dual feedback





14.01	PID 1 Output															
14.31	PID 2 Output															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC								-100.00 to 100.00%							
Update rate	4ms read															

The PID output is derived from the following algorithm:

Output = Error x [Kp + Ki/s + Kds/(0.064s + 1)] where:

- Error (Pr 14.22, Pr 14.52) = Reference (Pr 14.20, Pr 14.50) - Feedback (Pr 14.21, Pr 14.51)
- Kp = proportional gain (Pr 14.10, Pr 14.40)
- Ki = integral gain (Pr 14.11, Pr 14.41)
- Kd = differential gain (Pr 14.12, Pr 14.42)

Therefore with an error of 100% and Kp=1.000, the output produced by the proportional term is 100%. With an error of 100% and Ki=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 Kd=1.000, the output produced by the differential term will be 100%. A filter with a 64ms time constant is applied to the differential term to reduce noise.

The output Pr 14.01 (Pr 14.31) is limited by the values in Pr 14.13 (Pr 14.43) upper limit and Pr 14.14 (Pr 14.44) lower limit. Scaling can be applied before this value is sent to the location defined by destination parameter Pr 14.16 (Pr 14.46) by setting Pr 14.15 (Pr 14.45) to a value other than one.

14.02	PID main reference source parameter															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 0.00							
Update rate	Read on reset															

14.03	PID 1 reference source parameter															
14.33	PID 2 reference source parameter															
Drive modes	Open-loop, RFC															
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, RFC							Pr 0.00 to Pr 50.99								
Default	Open-loop, RFC							Pr 0.00								
Update rate	Read on reset															

The PID reference Pr 14.20 (Pr 14.50) is the sum of the digital reference Pr 14.25 (Pr 14.55) and the value from the location defined by the source parameter Pr 14.03 (Pr 14.33). Before the reference is applied to the controller algorithm, it can be scaled by setting Pr 14.23 (Pr 14.53) to a value other than one and/or inverted by setting Pr 14.05 (Pr 14.35) =1.

14.04	PID 1 feedback source parameter															
14.34	PID 2 feedback source parameter															
Drive modes	Open-loop, RFC															
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, RFC							Pr 0.00 to Pr 50.99								
Default	Open-loop, RFC							Pr 0.00								
Update rate	Read on reset															

The feedback Pr 14.21 (Pr 14.51) is the sum of the digital feedback Pr 14.26 (Pr 14.56) and the value from the location defined by the source parameter Pr 14.04 (Pr 14.34). Before the reference is applied to the controller algorithm, it can be scaled by setting Pr 14.24 (Pr 14.54) to a value other than one and/or inverted by setting Pr 14.06 (Pr 14.36) =1.

14.05	PID 1 reference invert															
14.35	PID 2 reference invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

14.06	PID 1 feedback invert															
14.36	PID 2 feedback invert															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

14.07	PID 1 reference slew-rate limit															
14.37	PID 2 reference slew-rate limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC								0.00 to 3200.0s							
Default	Open-loop, RFC								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 1 enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	4ms read															

PID 1 is enabled when Pr 14.08 = 1 both the parameter sources defined by Pr 14.09 and Pr 14.27 to have a value of one (the source value for Pr 14.09 or Pr 14.27 appears as one if the parameter is set to 0.0). By default Pr 14.09 is set to 10.01 (drive ok) so that PID 1 controller is disabled if the drive is tripped. When the PID controller is disabled, the output is zero and all the internal state variables (i.e. integrator accumulator etc.) are held at zero.

14.09	PID 1 optional enable source parameter 1															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 10.01							
Update rate	Read on reset															

To enable the PID controller, the drive must be ok (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 1 proportional gain															
14.40	PID 2 proportional gain															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	Background read															

14.11	PID 1 integral gain															
14.41	PID 2 integral gain															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								0.500							
Update rate	Background read															

14.12	PID 1 differential gain															
14.42	PID 2 differential gain															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								0.000							
Update rate	Background read															

14.13	PID 1 output upper limit															
14.43	PID 2 output upper limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC								0.00 to 100.00 %							
Default	Open-loop, RFC								100.00%							
Update rate	Background read															

14.14	PID 1 output lower limit															
14.44	PID 2 output lower limit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1		
Range	Open-loop, RFC								±100.00 %							
Default	Open-loop, RFC								-100.00							
Update rate	Background read															

If Pr 14.18 (Pr 14.48) is zero, the upper limit Pr 14.13 (Pr 14.43) defines the maximum positive output for the PID Controller and the lower limit defines the minimum positive or maximum negative output. If symmetrical limits are selected, i.e. Pr 14.18 (Pr 14.48) =1, then the upper limit defines the maximum positive or negative magnitude for the PID output. When any of the limits is active, then the integrator accumulator is held.

14.15	PID 1 output scaling															
14.45	PID 2 output scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC								0.000 to 4.000							
Default	Open-loop, RFC								1.000							
Update rate	4ms read															

14.16	PID 1 output destination parameter															
14.46	PID 2 output destination parameter															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2						1	1	1	
Range	Open-loop, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								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 1 integrator hold															
14.47	PID 2 integrator hold															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1	1	
Default	Open-loop, RFC								0							
Update rate	4ms read															

When this parameter is set to zero 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 1 symmetrical limit enable															
14.48	PID 2 symmetrical limit enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Open-loop, RFC								0							
Update rate	Background read															

Refer to Pr 14.13 (Pr 14.43) and Pr 14.14 (Pr 14.44).

14.19	PID main reference															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC							±100.00 %								
Update rate	4ms write															

The value on the main reference is added to PID 1 output after scaling has been applied.

14.20	PID 1 reference															
14.50	PID 2 reference															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC							±100.00 %								
Update rate	4ms write															

14.21	PID 1 feedback															
14.51	PID 2 feedback															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC							±100.00 %								
Update rate	4ms write															

14.22	PID 1 error															
14.52	PID 2 error															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC							±100.00 %								
Update rate	4ms write															

14.23	PID 1 reference scaling															
14.53	PID 2 reference scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 4.000								
Default	Open-loop, RFC							1.000								
Update rate	4ms read															

14.24	PID 1 feedback scaling															
14.54	PID 2 feedback scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 4.000								
Default	Open-loop, RFC							1.000								
Update rate	4ms read															



14.25	PID 1 feedback reference															
14.55	PID 2 feedback reference															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2			1				1		
Range	Open-loop, RFC								±100.00 %							
Default	Open-loop, RFC								0.00%							
Update rate	4ms read															

14.26	PID 1 digital feedback															
14.56	PID 2 digital feedback															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2			1				1		
Range	Open-loop, RFC								±100.00 %							
Default	Open-loop, RFC								0.00%							
Update rate	4ms read															

14.27	PID 1 optional enable source parameter 2															
Drive modes	Open-loop, RFC															
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, RFC								Pr 0.00 to Pr 50.99							
Default	Open-loop, RFC								Pr 0.00							
Update rate	4ms write															

See Pr 14.08.

14.28	PID 1 pre-sleep boost level															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Open-loop, RFC								±100.00 %							
Default	Open-loop, RFC								0.00%							
Update rate	Background read															

14.29	Maximum boost time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC								0.0 to 250.0s							
Default	Open-loop, RFC								0.0s							
Update rate	Background read															

Menu 14	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

14.30	PID 1 pre-sleep boost level enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Default	Open-loop, RFC								0							
Update rate	4ms read															

If PID is used to control the motor output via Menu 1 and sleep mode is enabled, the drive will automatically stop the motor when the output drops below the sleep/wake threshold. The feedback may then fall causing the output and hence the feedback to rise again. Setting Pr **14.28** and Pr **14.29** to non zero values results in the value in Pr **14.28** being added to the PID reference for a length of time defined in Pr **14.29** when the drive attempts to enter sleep mode. This will reduce the frequency of the transitions into sleep mode. Pr **14.30** indicates when the boost system is enabled.

14.38	PID 2 enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 2							
Default	Open-loop, RFC								0							
Update rate	4ms read															

<b>Parameter Value</b>	<b>PID Enable state</b>
0	PID 2 disabled; output is zero and integrator reset to zero
1	PID 2 enabled
2	PID 2 enable state follows PID 1 enable state

14.58	PID 1 Feedback output scaling															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Open-loop, RFC							0.000 to 4.000								
Default	Open-loop, RFC							1.000								
Update rate	4ms read															

If Pr **14.58** is set a value greater than zero, then the following algorithm is applied to PID 1 feedback.

- Square root function output = Sign(Feedback) x 100.00% x 14.58 x v(|Feedback| / 100.00%)  
where Sign(Feedback) is 1 if the feedback is positive or -1 if the feedback is negative.

If Pr **14.58** is set to 0.000 then this feature is disabled and the feedback remains unchanged.

14.59	PID mode selector															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC							0 to 7								
Default	Open-loop, RFC							0								
Update rate	Background read															

**Normal mode (Pr 14.59 is between 0 and 5)**

The two PID controllers operate independently. The feedback for PID2 is always from the PID2 feedback input. The feedback for PID1 is as given in the following table.

Pr 14.59	Final PID1 feedback
0	PID1 feedback
1	PID2 feedback
2	PID1 feedback + PID2 feedback
3	Lowest of PID1 feedback and PID2 feedback
4	Highest of PID1 feedback and PID2 feedback
5	(PID1 feedback + PID2 feedback) / 2

#### Dual Zone Mode (Pr 14.59 is 6 or 7)

When PID mode 6 or 7 is selected the controller operates in a dual zone mode. In this mode, the reference and feedback quantities from each PID controller are used to calculate two controller errors. These two errors are then checked and the zone with the larger or smaller absolute value of error (depending upon mode selected) is used as the error signal to the PID1 controller.

Pr 14.59	Final PID1 feedback	PID1 Error
6	PID1 feedback	Lowest of  PID1 Error  or  PID2 Error
7	PID1 feedback	Highest of  PID1 Error  or  PID2 Error

14.60	PID 1 Square root enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Range	Open-loop, RFC								OFF (0) or On (1)							
Default	Open-loop, RFC															
Update rate	Background read															

14.61	PID 2 Square root enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Range	Open-loop, RFC								OFF (0) or On (1)							
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

14.62	Combined square root enable															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Range	Open-loop, RFC								OFF (0) or On (1)							
Default	Open-loop, RFC								OFF (0)							
Update rate	Background read															

## 5.17 Menus 15 and 16: Solutions Module slots

Pr **x.00** and Pr **x.01** are always present in menus 15 and 16. Pr **x.01** indicates which type of module is present (0 = no module installed). When a module is installed, the drive provides the relevant menu (menu 15 for slot 1, 16 for slot 2 and) depending on the Solutions Module installed. The possible categories are shown Table 5-17.

**Table 5-17 Solutions Modules available for use with Affinity drives**

Solutions Module ID	Module	Category
0	No module installed	
201	SM-I/O Plus	Automation (I/O Expansion)
204	SM-I/O PELV	
205	SM-I/O 24V Protected	
206	SM-I/O 120V	
207	SM-I/O Lite	
208	SM-I/O 32	
301	SM-Applications	Automation (Applications)
302	SM-Applications Lite	
304	SM-Applications Lite Plus	
305	SM-Applications Lite V2	
401	SM-LON	Fieldbus
403	SM-PROFIBUS DP	
404	SM-INTERBUS	
406	SM-CAN	
407	SM-Devicenet	
408	SM-CANopen	
409	SM-SERCOS	
410	SM-Ethernet	
421	SM-EtherCAT	

Most modules include a processor and parameters are updated by the processor in the Solutions Module. Conversely, dumb modules do not contain a processor and hence all parameters are updated by the drive processor.

Dumb Solutions Module parameters are read/written by the drive background task or at the combined update time for time critical parameters. The combined update time depends on the number and type of dumb Solutions Module installed to the drive. For each Solutions Module the update rate of these parameters is specified as 4ms, 8ms, etc. The combined update time is the total of the update times for all dumb Solutions Module installed.

For example, if a module with 4ms update time and a module with 8ms are installed to the drive, then the combined update time for the time critical parameters of each module is 12ms.

In the parameter tables, the update time added by the type of module is given, for example 8ms for the SM-I/O Plus.

When parameters are saved by the user in the drive EEPROM, the option code of the currently installed module is saved in EEPROM. If the drive is subsequently powered-up with a different module installed, or no module installed where a module was previously installed, the drive gives a Slot.dF trip. The menu for the relevant slot appears for the new module category with the default parameter values for the new category. The new parameters values are not stored in EEPROM until the user performs a parameter save.

### Parameters common to all categories

Parameter	Range(⇅)	Default(⇒)	Type					
<b>x.01</b> Solutions Module ID	0 to 599		RO	Uni			PT	US
<b>x.02</b> Solutions Module software version	0.00 to 99.99		RO	Uni		NC	PT	
<b>x.50</b> Solutions Module error status	0 to 255		RO	Uni		NC	PT	
<b>x.51</b> Solutions Module software sub-version	0 to 99		RO	Uni		NC	PT	

## 5.18 Menu 17: Building Automation Interface

17.01	ID number															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Open-loop, RFC															
Default	Open-loop, RFC								402							
Update rate	4ms write															

The ID code for the Building Automation Interface is 402.

17.02	Software version															
Drive modes	Open-loop, RFC															
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, RFC								0 to 99.99							
Update rate	N/A															

Pr 17.02 and Pr 17.51 display the firmware version in the form xx.yy.zz where xx.yy is Pr 17.02 and zz is Pr 17.51.

17.03	MAC / Node address															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 65535							
Default	Open-loop, RFC								1							
Update rate	Read on reset															

Protocol	Allowable MAC Address Values	
	Minimum	Maximum
Modbus RTU	1	247
BACnet ( see note 1)	0	127
MetaSys N2	1	255

If a MAC address is selected that is greater than, or less than those allowed by the currently selected protocol, then the actual address used will be the maximum valid address value.

17.04	Baud rate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Range	Open-loop, RFC								0 to 127							
Default	Open-loop, RFC								0							
Update rate	N/A															

This selects the baud rate used for network communication.

Menu 17	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

17.04 Value	Baud rate (bps)
0	Protocol default value (see table below)
1	1200
2	2400
3	4800
4	9600
5	19200
6	38400
7	57600
8	76800
>8	Protocol default value (see table below)

The default value for each protocol is as follows: -

Protocol	Default baud rate (bps)
Modbus RTU	19200
BACnet	9600
MetaSys N2	9600

17.05	Building Automation Network protocol															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 65535							
Default	Open-loop, RFC								0							
Update rate	Read on reset															

This selects the protocol used for the Building Automation Network as follows:

Pr 17.05	Protocol	Reference section
0	Disabled	
1	Modbus RTU	6.2
2	BACnet	7.2
3	MetaSys N2 IOopen	7.3

If a value greater than 3 is entered for Pr 17.05 then the Building Automation Network is disabled.

17.06	Received message counter															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Open-loop, RFC							0 to 9999								
Default	Open-loop, RFC							0								
Update rate	Background write															

This parameter displays the number of valid messages that have been received using the currently selected building automation protocol. If the communications settings are configured correctly then this counter will count each time a message is received, therefore if the value remains constant then there is likely to be an error in either the configuration or the wiring to the communications port.

The received message counter is reset to in the following circumstances: -

1. When another message is received after 9999 prior valid messages have been received.
2. Upon power up.

17.07	MS/TP maximum master MAC address															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 3000							
Default	Open-loop, RFC								127							
Update rate	Read on reset															

### BACnet use only

This is highest address that the drive will use when looking for the next master on the network with which token passing can be achieved. If a value greater than 127 is entered then the value used will be 127.

17.10	Device object identifier															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, RFC								32768 to -32767							
Default	Open-loop, RFC								0							
Update rate	Read on reset															

If this parameter is zero, then the MAC/Node address selected in parameter Pr 17.03 will be used as the object identifier for the BACnet device, otherwise the device object identifier will be the value specified here.

If the node address is also set to zero then the Device Object Identifier value will be set to 1.

17.12	Communications lost detection timeout															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, RFC								32768 to -32767							
Default	Open-loop, RFC								0							
Update rate	Read on reset															

This is the period of time in seconds that the drive will wait to see a valid communications frame on the building automation network before taking the action specified in Pr 17.13.

If the value specified is less than or equal to five, then the timeout period will be adjusted to be 5 seconds. Care must be taken to ensure that this parameter is not set to a time less than the minimum time period between frames on the network.

17.13	Communications loss action															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, RFC								32768 to -32767							
Default	Open-loop, RFC								0							
Update rate	Read on reset															

Pr 17.13	Action	Comment
0	Do nothing	The drive will continue as it was before communications was lost
1	Trip the drive	The drive will trip when communications is lost
2	Move to a fixed speed	Preset speed 8 is used to define this speed, see below
183	Reserved	Do not select this value.

The move to fixed speed option will only operate if the drive is configured to use preset speed 1 as the reference at the time communications are lost. Every time there is a transition from the communications healthy state to the communications lost state, the reference value set in preset speed 8, will be transferred to preset speed 1, causing the drive to run at the speed defined in preset speed 8.

The drive will continue to run at this speed until such time as the user manually changes preset speed 1 via the keypad, or communications resume and a new speed reference is provided via the building automation network.

Menu 17	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

17.35	CRC errors															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1				1			1	
Range	Open-loop, RFC							0 to +2 <sup>31</sup> -1								
Update rate	Background write															

If an error is detected in the message header or body, then this count is incremented by one and the message disposed of. This parameter should remain constant when the connection to the Building Automation Network is operating correctly.

The CRC error count is reset to zero under the following circumstances:-

1. When another CRC error is detected after 32767 prior errors.
2. Upon power up.
3. After the last successfully received message.
4. After building automation protocol is changed.

17.38	Data format															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1					1	1	1	
Range	Open-loop, RFC							0 to 255								
Default	Open-loop, RFC							0								
Update rate	Background read															

This selects the data transmission format used for the selected protocol.

17.38	Description			
	Start Bits	Data Bits	Parity	Stop Bits
0	Protocol default value			
1	1	8	None	1
2	1	8	None	2
3	1	8	Even	1
4	1	8	Odd	1
>4	Protocol default value			

The default value when Pr 17.38 is set to 0 OR >4 is as follows:-

Protocol	Description			
	Start bits	Data bits	Parity	Stop bits
Modbus RTU	1	8	None	2
BACnet	1	8	None	1
MetaSys N2	1	8	None	1



17.39	Response turn-around time															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1					1	1	1	
Range	Open-loop, RFC							0 to 255ms								
Default	Open-loop, RFC							5ms								
Update rate	Read on reset															

#### Modbus RTU Only

There will always be a finite delay between the end of a message from the host (master), and the time at which the host is ready to receive the response from the drive (slave). The drive does not respond until at least 1ms after the message has been received from the host, allowing 1ms for the host to change from transmit to receive mode. This initial delay can be extended using Pr 17.39 if required.

Pr 17.39	Action
0	The transmitters are turned on and data transmission begins immediately after the initial delay ( $\geq 1$ ms).
1	The transmitters are turned on after the initial delay ( $\geq 1$ ms) and data transmission begins 1ms later.
2 or more	The transmitters are turned on after a delay of at least the time specified in Pr 17.39 and data transmission begins 1ms later.
184	Reserved. Do not select this value.

17.44	Real-time clock battery low															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC							0 to 255								
Update rate	Read on reset															

The real-time clock backup battery is checked upon power up and after a drive reset to determine if it should be changed. The conditions requiring battery replacement are when all power has been lost to the real-time clock while the drive was un-powered or that the battery voltage has fallen below 2.5Vdc.

If this parameter is 1 then the real-time clock backup battery should be replaced at the earliest opportunity.

If the battery is low, the real-time clock will continue to operate as long as the drive remains powered.

If the time-synchronization features of are also being used then the user may never notice nor care that the battery has failed.

17.45	Communications OK flag															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1		1				
Range	Open-loop, RFC								0 to 255							
Update rate	Read on reset															

This parameter has a value of 1 when the building automation network communications are healthy and zero when the communications lost detection determines that an error has occurred; this is determined differently for BACnet and MetaSys as follows: -

#### BACnet

The network is monitored for the presence of an active token; should this token disappear for the time specified in parameter Pr 17.12 the drive will take the action configured in parameter Pr 17.13.

#### MetaSys

The network is monitored for any message. Receipt of a valid message (regardless of intended destination) will be seen as communications being healthy. If no valid message is received within time specified in Pr 17.12 the drive will take the action configured in parameter Pr 17.13. It is important to ensure that a message is placed onto the network within the configured time-out period to prevent spurious drive operation

Menu 17	Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------	---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

17.50	Error status															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1					1	
Range	Open-loop, RFC							0 to 255								
Update rate	Background write															

If the Solutions Module detects a fault, then the drive will trip with an SL3.Er trip. The source of the trip can then be discovered from the error code written into Pr 17.50.

Possible error codes are shown in the table below: -

Pr 17.50	Description
0	No error
10	Solutions Module operating system error
20	Real-time clock error
30	IP54 cooling fan power supply fault
40	Drive to Solutions Module interface error
50	Building Automation Network error
74	Solutions Module PCB over-temperature

17.51	Software sub version															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Open-loop, RFC								0 to 99							
Update rate	Written on power up															

See Pr 17.02.

## 5.19 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

18.02 to 18.10	Application menu 1 read-only integer															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

18.11 to 18.30	Application menu 1 read-write integer															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

18.31 to 18.50	Application menu 1 read-write bit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	N/A															

## 5.20 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

19.02 to 19.10	Application menu 2 read-only integer															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

19.11 to 19.30	Application menu 2 read-write integer															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

19.31 to 19.50	Application menu 2 read-write bit															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Open-loop, RFC								0							
Update rate	N/A															

## 5.21 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, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1*				1		
Range	Open-loop, RFC								-32,768 to 32,767							
Default	Open-loop, RFC								0							
Update rate	N/A															

20.21 to 20.40	Application menu 3 read-write long integer															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1*				1		
Range	Open-loop, RFC								-2 <sup>31</sup> to 2 <sup>31</sup> -1							
Default	Open-loop, RFC								0							
Update rate	N/A															

\*Menu 20 parameters are non-clonable and cannot be saved in a full parameter type data block but these parameters can be saved in a difference from defaults type data block if they are not at their default value.

## 5.22 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 'mot 2' is displayed in the bottom left hand side of the display. For more information about a particular parameter, see the equivalent normal motor map 1 parameter.

21.01	Maximum reference clamp															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC = VM															
Range	Open-loop RFC								0 to 3,000.0Hz SPEED_LIMIT_MAX rpm							
Default	Open-loop RFC								EUR: 50.0, USA: 60.0 EUR: 1,500.0, USA: 1,800.0							
Normal parameter	Open-loop, RFC								Pr <b>1.06</b>							
Update rate	Background read															

21.02	Minimum reference clamp															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1					1	1	1		
	RFC = VM															
Range	Open-loop RFC							±3,000.0 Hz * ±SPEED_LIMIT_MAX rpm								
Default	Open-loop, RFC							0.0								
Normal parameter	Open-loop, RFC							Pr <b>1.07</b>								
Update rate	Background read															

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

01.08	01.10	Open-loop	RFC
(Neg min ref enable)	(Bipolar mode enable)		
0	0	0 to 01.06	0 to 21.01
0	1	0	0
1	0	-3000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm
1	1	-3000 to 0Hz*	-SPEED_LIMIT_MAX to 0 rpm

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

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, RFC																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
							1						1	1	1		
	RFC DP = 3																
Range	Open-loop RFC							0.0 to 3200.0 s/100Hz 0.000 to 3200.000 s/1000rpm									
Default	Open-loop RFC							EUR: > 40.0, USA: > 33.3 EUR: > 13.333, USA: > 11.111									
Normal parameter	Open-loop, RFC							Pr 2.11									
Update rate	Background read																

21.05	Deceleration rate															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
	RFC DP = 3															
Range	Open-loop RFC							0.0 to 3200.0 s/100Hz 0.000 to 3200.000 s/1000rpm								
Default	Open-loop RFC							EUR: > 40.0, USA: > 33.3 EUR: > 13.333, USA: > 11.111								
Normal parameter	Open-loop, RFC							Pr 2.21								
Update rate	Background read															

21.06	Rated frequency															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop RFC							0 to 3000.0 Hz 0 to 1250.0 Hz								
Default	Open-loop, RFC							EUR: 50.0, USA: 60.0								
Normal parameter	Open-loop, RFC							Pr <b>5.06</b>								
Update rate	Background read															

21.07	Rated current															
Drive modes	Open-loop, RFC															
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, RFC								0 to RATED_CURRENT_MAX A							
Default	Open-loop, RFC								RATED_CURRENT_MAX (Pr 11.32)							
Normal parameter	Open-loop, RFC								Pr 5.07							
Update rate	Background read															

21.08	Rated load rpm															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
	RFC DP=2															
Range	Open-loop, RFC							0 to 180,000 rpm 0.00 to 40,000.00 rpm								
Default	Open-loop, RFC							1500 1450.00								
Normal parameter	Open-loop, RFC							Pr <b>5.08</b>								
Update rate	Background read															

21.09	Rated voltage															
Drive modes	Open-loop, RFC															
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, RFC								0 to AC_VOLTAGE_SET_MAX V							
Default	Open-loop, RFC								200V rating drive: 230V 400V rating drive: EUR: 400V, USA: 460V 575V rating drive: 575V 690V rating drive: 690V							
Normal parameter	Open-loop, RFC								Pr <b>5.09</b>							
Update rate	Level 4 read															



21.10	Rated power factor															
Drive modes	Open-loop, RFC															
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, RFC							0.000 to 1.000								
Default	Open-loop, RFC							0.850								
Normal parameter	Open-loop, RFC							Pr <b>5.10</b>								
Update rate	Background read															

21.11	Number of motor poles															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Open-loop, RFC							0 to 60 (Auto to 120 POLE)								
Default	Open-loop, RFC							0 (Auto)								
Normal parameter	Open-loop, RFC							Pr <b>5.11</b>								
Update rate	Background read															

21.12	Stator resistance															
Drive modes	Open-loop, RFC															
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, RFC							0.000 to 65.000								
Default	Open-loop, RFC							0.000								
Normal parameter	Open-loop, RFC							Pr 5.17								
Update rate	Background read															

Pr 21.12 shows the stator resistance of the motor. The units vary with the drive size to ensure that the full range of likely resistances can be represented with suitable resolution. The table below shows the units. Therefore 1.000 in the parameter represents the resistance shown in the units column.

Drive size	Units
BA1xxx to BA5xxx	1 Ohm
BA6xxx, BAMxxxx	0.01 Ohms

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 <b>5.23</b>								
Update rate	Background read															

21.14	Transient inductance ( $\sigma L_s$ )															
Drive modes	Open-loop, RFC															
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, RFC							0.000 to 500.000 mH								
Default	Open-loop, RFC							0.000								
Normal parameter	Open-loop, RFC							Pr <b>5.24</b>								
Update rate	Background read															

21.15	Motor 2 active															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Normal motor parameter	Open-loop, RFC							Pr 21.15								
Update rate	Background write															

Pr 21.15 does not have an equivalent normal motor parameter, but is displayed when motor 2 is active.

21.16	Thermal time constant/filter															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Open-loop, RFC							0.0 to 3000.0								
Default	Open-loop, RFC							89.0								
Normal motor parameter	Open-loop, RFC							Pr 4.15								
Update rate	Background read															

21.17	Speed controller Kp gain															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							4						1	1	1	
Range	RFC								0.00 to 6.5335 (1/rad s <sup>-1</sup> )							
Default	RFC								0.0300							
Normal motor parameter	RFC								Pr <b>3.10</b>							
Update rate	Background read															

21.18	Speed controller Ki gain															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	RFC							0.00 to 653.35 s/rad s <sup>-1</sup>								
Default	RFC							0.10								
Normal motor parameter	RFC							Pr 3.11								
Update rate	Background read															

21.19	Speed controller Kd gain															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							5							1	1	1
Range	RFC								0.00000 to 0.65335 s <sup>-1</sup> / rad s <sup>-1</sup>							
Default	RFC								0.00000							
Normal motor parameter	RFC								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.

21.22	Current controller Kp gain															
Drive modes	Open-loop, RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Open-loop, RFC								0 to 30,000							
Default	Drive voltage rating:								200V	400V	575V	690V				
	Open-loop,								20	20	20	20				
	RFC								75	150	180	215	45	90	110	
Normal parameter	Open-loop, RFC								Pr 4.13							
Update rate	Background read															

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

21.24	Stator inductance (L <sub>s</sub> )															
Drive modes	RFC															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2		1				1	1	1	
Range	RFC								0.00 to 5,000.00 mH							
Default	RFC								0.00							
Normal parameter	RFC								Pr <b>5.25</b>							
Update rate	Background read															

[illegible][illegible][illegible][illegible][illegible]

\*These are the maximum default values. If the variable maximum of this parameter (MOTOR2\_CURRENT\_LIMIT\_MAX) gives a lower value with the default value of Motor rated current (Pr **21.07**) the default of this parameter is at the lower value.

## 5.23 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, RFC															
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, RFC								Pr 1.00 to Pr 21.51							
Default	Open-loop, RFC								See Table 5-18							
Update rate	Background read															

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

**Table 5-18 Menu 22 default settings**

Parameter	Menu 0 parameter	Open-loop	RFC
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 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 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 8.29
Pr 22.22	Pr 0.52		Pr 9.35
Pr 22.23	Pr 0.53		Pr 9.36
Pr 22.24	Pr 0.54		Pr 9.37
Pr 22.25	Pr 0.55		Pr 9.38
Pr 22.26	Pr 0.56		Pr 9.39
Pr 22.27	Pr 0.57		Pr 9.40
Pr 22.28	Pr 0.58		Pr 9.43
Pr 22.29	Pr 0.59		Pr 0.00

It should be noted that if the parameter values saved in the drive EEPROM or on a SMARTCARD are all zero for menu 22, the drive will automatically load defaults for this menu when the drive is powered up, or the parameters are transferred from the SMARTCARD. This ensures that defaults are used for this menu if the saved parameters are from a software version which did not include this menu.

## 5.24 32 bit parameters

All parameters in the drive are 1 bit, 16 bit or 32 bit. This section identifies all the 32 bit parameters in the drive and Solutions Modules.

### 5.24.1 Drive parameters

The table below contains all the 32 bit parameters present in the drive for all four modes of operation (open loop, RFC).

**Table 5-19 32 bit drive parameters**

Menu	32-bit parameters							
Menu 1	Pr 1.01	Pr 1.02	Pr 1.03	Pr 1.04	Pr 1.06	Pr 1.07	Pr 1.17	Pr 1.18
	Pr 1.21	Pr 1.22	Pr 1.23	Pr 1.24	Pr 1.25	Pr 1.26	Pr 1.27	Pr 1.28
	Pr 1.36	Pr 1.37	Pr 1.39					
Menu 2	Pr 2.01	Pr 2.07	Pr 2.11	Pr 2.12	Pr 2.13	Pr 2.14	Pr 2.15	Pr 2.16
	Pr 2.17	Pr 2.18	Pr 2.19	Pr 2.21	Pr 2.22	Pr 2.23	Pr 2.24	Pr 2.25
	Pr 2.26	Pr 2.27	Pr 2.28	Pr 2.29				
Menu 3	Pr 3.01	Pr 3.02	Pr 3.03	Pr 3.10	Pr 3.18	Pr 3.22		
Menu 4	Pr 4.01	Pr 4.02	Pr 4.08	Pr 4.17				
Menu 5	Pr 5.01	Pr 5.03	Pr 5.04	Pr 5.07	Pr 5.08	Pr 5.24	Pr 5.25	
Menu 11	Pr 11.32							
Menu 20	Pr 20.21	Pr 20.22	Pr 20.23	Pr 20.24	Pr 20.25	Pr 20.26	Pr 20.27	Pr 20.28
Menu 21	Pr 20.29	Pr 20.30	Pr 20.31	Pr 20.32	Pr 20.33	Pr 20.34	Pr 20.35	Pr 20.36
	Pr 20.37	Pr 20.38	Pr 20.39	Pr 20.40				
	Pr 21.01	Pr 21.02	Pr 21.04	Pr 21.05	Pr 21.07	Pr 21.08	Pr 21.14	Pr 21.24

Some of the parameters listed above are only 32 bit parameters in certain modes. Below is a table listing these parameters and the modes in which they are 32 bit parameters.

Parameter	Modes in which the parameter is 32 bit
Pr 3.01	RFC
Pr 3.03	RFC
Pr 3.18	RFC
Pr 4.08	Open Loop, RFC

### 5.24.2 Solutions Module parameters

Some Solutions Modules contain 32 bit parameters. Below is a table listing these parameters and the modules in which they are 32 bit parameters.

**Table 5-20 32 bit Solutions Module parameters**

Parameter	Solutions modules in which the parameter is 32 bit
Pr x.35	All Fieldbus modules

## 6 PC communications protocol

### 6.1 ANSI communications protocol

#### 6.1.1 Introduction

Affinity 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 Affinity.

#### 6.1.2 Physical layer and UART

Attribute	Description
Physical layer	2 wire EIA485
Bit stream	Standard UART asynchronous symbols with Non Return to Zero (NRZ)
Symbol	Each symbol consists of: 1 start bit 7 data bits (ASCII) 1 parity bit (even parity) 1 stop bit
Baud rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400

#### 6.1.3 Reading a parameter

The command to read a parameter is:

EOT	End of transmission (Ctl D)
A1	Drive address: 1 <sup>st</sup> digit
A1	Drive address: 1 <sup>st</sup> digit
A2	Drive address: 2 <sup>nd</sup> digit
A2	Drive address: 2 <sup>nd</sup> digit
M1	Menu number: 1 <sup>st</sup> digit
M2	Menu number: 2 <sup>nd</sup> digit
P1	Parameter number: 1 <sup>st</sup> digit
P2	Parameter number: 2 <sup>nd</sup> 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: 1 <sup>st</sup> digit
M2	Menu number: 2 <sup>nd</sup> digit
P1	Parameter number: 1 <sup>st</sup> digit
P2	Parameter number: 2 <sup>nd</sup> digit
D1	Data: 1 <sup>st</sup> digit
D2	Data: 2 <sup>nd</sup> 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, either a 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 =  $M1 \wedge M2 \wedge P1 \wedge P2 \wedge D1 \wedge D2 \wedge \dots \wedge Dn \wedge ETX$ . The checksum is an unsigned 8 bit value and if the checksum is less than 32 then 32 is added to the calculated checksum.

#### 6.1.4 Writing to a parameter

The command to write to a parameter is:

EOT	End of transmission (Ctl D)
A1	Drive address: 1 <sup>st</sup> digit
A1	Drive address: 1 <sup>st</sup> digit
A2	Drive address: 2 <sup>nd</sup> digit
A2	Drive address: 2 <sup>nd</sup> digit
STX	Start of text (Ctl B)
M1	Menu number: 1 <sup>st</sup> digit
M2	Menu number: 2 <sup>nd</sup> digit
P1	Parameter number: 1 <sup>st</sup> digit
P2	Parameter number: 2 <sup>nd</sup> digit
D1	Data: 1 <sup>st</sup> digit
D2	Data: 2 <sup>nd</sup> 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 =  $M1 \wedge M2 \wedge P1 \wedge P2 \wedge D1 \wedge D2 \wedge \dots \wedge Dn \wedge ETX$ . The checksum is an unsigned 8 bit value and if the checksum is less than 32 then 32 is added to the calculated checksum.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

### 6.1.5 Drive address

The drive only acts on received messages which contain a drive address if the whole drive address or drive group address, matches the whole address or the group address in the message, or if the address in the message is 0 (i.e. a global message). Global or group addressing allows data to be written to more than one drive with one command. The drive does not give a response to a global or group write message. Although it is possible to perform a global or group read, this would result in messages crashing if more than one drive responds to the command.

Drive address	Message address	Command	Action
7.8	7.8	Read	Read
7.8	7.8	Write	Write
7.8	7.0	Read	Read
7.8	7.0	Write	Write with no response
7.8	0.0	Read	Read
7.8	0.0	Write	Write with no response

### 6.1.6 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: 1 <sup>st</sup> digit
M2	Menu number: 2 <sup>nd</sup> digit
P1	Parameter number: 1 <sup>st</sup> digit
P2	Parameter number: 2 <sup>nd</sup> digit
D1	Data: 1 <sup>st</sup> digit
D2	Data: 2 <sup>nd</sup> 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 the drive address first digit, drive address second 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.

### 6.1.7 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



## 6.2 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.

### 6.2.1 MODBUS RTU

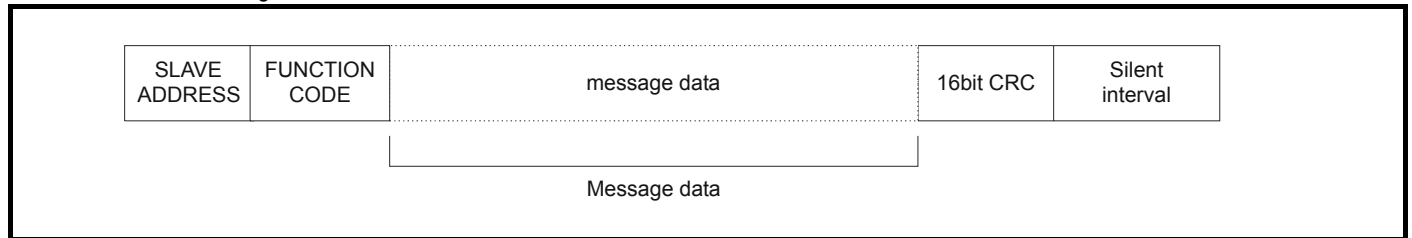
#### Physical layer

Attribute	Description
Normal physical layer for multi-drop operation	EIA485 2 wire
Bit stream	Standard UART asynchronous symbols with Non Return to Zero (NRZ)
Symbol	Each symbol consists of:- 1 start bit 8 data bits (transmitted least significant bit first) 2 stop bits*
Baud rates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200

\*The drive will accept a packet with 1 or 2 stop bits, but will always transit 2 stop bits

#### RTU framing

The frame has the following basic format

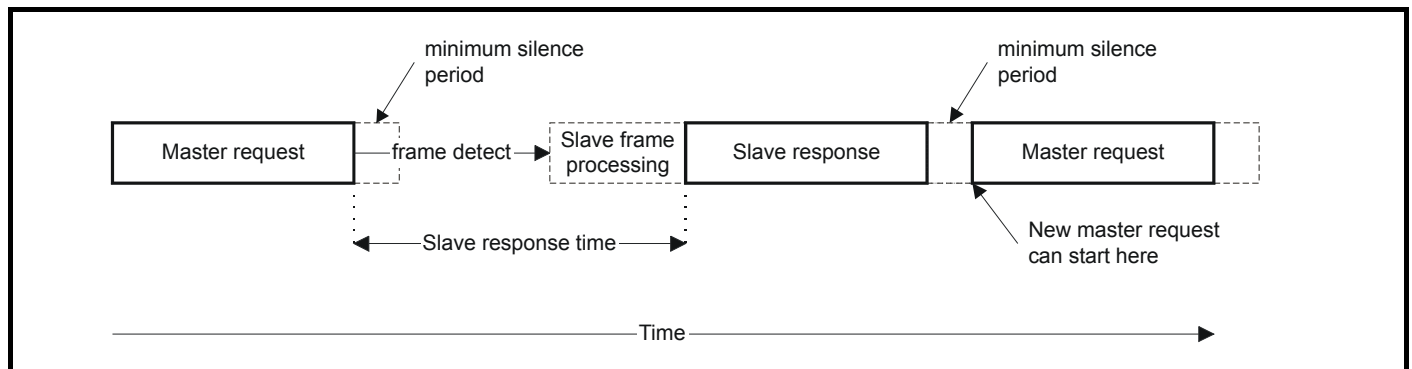


The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without 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 than 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 plus transmission time for the response.



### 6.2.2 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.

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

## 6.2.3 MODBUS registers

The MODBUS register address range is 16bit (65536 registers) which at the protocol level is represented by indexes 0 through 65535.

### PLC registers

Modicon PLCs typically define 4 register 'files' each containing 65536 registers. Traditionally, the registers are referenced 1 through 65536 rather than 0 through 65535. The register address is therefore decremented on the master device before passing to the protocol.

File type	Description
1	Read only bits ("coil")
2	Read / write bits ("coil")
3	Read only 16bit register
4	Read / write 16bit register

The register file type code is NOT transmitted by MODBUS, and all register files can be considered to map onto a single register address space. However, specific function codes are defined in MODBUS to support access to the "coil" registers.

All standard CT drive parameters are mapped to register file '4' and the coil function codes are not required.

### CT parameter mapping

All CT products are parameterized using the #menu.param notation. Indexes 'menu' and 'param' are in the range 0 through 99. The #menu.param is mapped into the MODBUS register space as menu\*100 + param.

To correctly map the parameters at the application layer, the slave device increments the received register address. The consequence of this behavior is that #0.0 cannot be accessed.

CT parameter	MODBUS PLC register	Register address (protocol level)	Comments
#X.Y	40000 + X x 100 + Y	X x 100 + Y - 1	#0.0 cannot be accessed
<b>Examples:</b>			
#1.02	40102	101	
#1.00	40100	99	
#0.01	40001	0	
#20.00	42000	1999	

### Data types

The MODBUS protocol specification defines registers as 16bit signed integers. All CT devices support this data size.

Refer to the section 6.2.7 *Extended data types* on page 223 for detail on accessing 32bit register data.

## 6.2.4 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.

## 6.2.5 Data encoding

MODBUS RTU uses a 'big-endian' representation for addresses and data items (except the CRC, which is 'little-endian'). This means that when a numerical quantity larger than a single byte is transmitted, the MOST significant byte is sent first. So for example

16 - bits    0x1234            would be    0x12    0x34  
32 - bits    0x12345678        would be    0x12    0x340x560x78

## 6.2.6 Function codes

The function code determines the context and format of the message data. Bit 7 of the function code is used in the slave response to indicate an exception.

The following function codes are supported:

Code	Description
3	Read multiple 16bit registers
6	Write single register
16	Write multiple 16bit registers
23	Read and write multiple 16bit registers

### FC03 Read multiple

Read a contiguous array of registers. The slave imposes an upper limit on the number of registers, which can be read. If this is exceeded the slave will issue an exception code 2.

**Table 6-1 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 6-2 Slave response**

Byte	Description
0	Slave source node address
1	Function code 0x03
2	Length of register data in read block (in bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

### FC06 Write single register

Writes a value to a single 16bit register. The normal response is an echo of the request returned after the register contents have been written. The register address can correspond to a 32bit parameter, but only 16 bits of data can be sent.

**Table 6-3 Master request**

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

**Table 6-4 Slave response**

Byte	Description
0	Slave source node address
1	Function code 0x06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

### 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 6-5 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 6-6 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 6-7 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 6-8 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

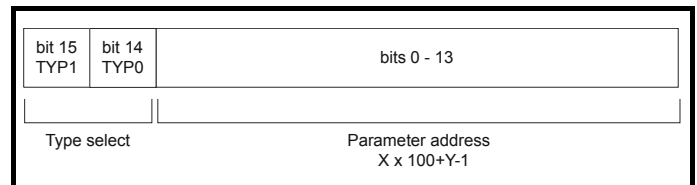
### 6.2.7 Extended data types

Standard MODBUS registers are 16bit and the standard mapping maps a single #X.Y parameter to a single MODBUS register. To support 32bit data types (integer and float), the MODBUS multiple read and write services are used to transfer a contiguous array of 16bit registers.

Slave devices typically contain a mixed set of 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	IEEE754 standard Not supported on all slaves
11	Reserved	

If a 32bit data type is selected, then the slave uses two consecutive 16bit MODBUS registers (in 'big endian'). The master must also set the correct 'number of 16bit registers'.

Example: read #20.21 through #20.24 as 32bit parameters using FC03 from node 8:

**Table 6-9 Master request**

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x47	Start register address #20.21
3	0xE4	(16384 + 2021 - 1) = 18404 = 0x47E4
4	0x00	Number of 16bit registers to read
5	0x08	#20.21 through #20.24 is 4x32bit registers = 8x16bit registers
6	CRC LSB	
7	CRC MSB	

**Table 6-10 Slave response**

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x10	Length of data (bytes) = 4x32bit registers = 16bytes
3-6		#20.21 data
7-10		#20.22 data
11-14		#20.23 data
15-18		#20.24 data
19	CRC LSB	
20	CRC MSB	

### Reads when actual parameter type is different from selected

The slave will send the least significant word of a 32 bit parameter if that parameter is read as part of a 16 bit access.

The slave will sign/extend the least significant word if a 16 bit parameter is accessed as a 32 bit parameter. The number of 16 bit registers must be even during a 32 bit access.

Example: If #1.28 is a 32 bit parameter with a value of 0x12345678, #1.29 is a signed 16 bit parameter with a value of 0xABCD, and #1.30 is a signed 16 bit parameter with a value of 0x0123.

Read	Start register address	Number of 16bit registers	Response	Comments
#1.28	127	1	0x5678	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#1.28	16511*	2	0x12345678	Full 32bit access
#1.28	16511*	1	Exception 2	Number of words must be even for 32bit access
#1.29	128	1	0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of data
#1.29	16512*	2	0xFFFFABCD	32bit access to a 16bit register will return 32bit sign extended data
#1.30	16513*	2	0x00000123	32bit access to a 16bit register will return 32bit sign extended data
#1.28 - #1.29	127	2	0x5678, 0xABCD	Standard 16 bit access to a 32bit register will return low 16bit word of truncated data
#1.28 - #1.29	16511*	4	0x12345678, 0xFFFFABCD	Full 32bit access

\*For 32 bit access, bit 14 is set

### Writes when actual parameter type is different from selected

The slave will permit the writing of a 32 bit value to a 16 bit parameter, provided the 32 bit value is within the normal range of the 16 bit parameter.

The slave will permit the writing of a 16 bit value to a 32 bit parameter. The slave will sign extend the written value, therefore, the effective range of this type of write will be  $\pm 32767$ .

Examples, if #1.28 has a range of  $\pm 100000$ , and #1.29 has a range of  $\pm 10000$ .

Write	Start register address	Number of 16bit registers	Data	Comments
#1.28	127	1	0x1234	Standard 16 bit write to a 32bit register. Value written = 0x00001234
#1.28	127	1	0xABCD	Standard 16 bit write to a 32bit register. Value written = 0xFFFFABCD
#1.28	16511	2	0x00001234	Value written = 0x00001234
#1.29	128	1	0x0123	Value written = 0x0123
#1.29	16512	2	0x00000123	Value written = 0x00000123

### 6.2.8 Exceptions

The slave will respond with an exception response if an error is detected in the master request. If a message is corrupted and the frame is not received or if 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.

### 6.2.9 CRC

The CRC is a 16bit cyclic redundancy check using the standard CRC-16 polynomial  $x^{16} + x^{15} + x^2 + 1$ . The 16bit CRC is appended to the message and transmitted LSB first.

The CRC is calculated on ALL the bytes in the frame.

### 6.2.10 Device compatibility parameters

All devices have the following compatibility parameters defined:

Parameter	Description
Device ID	Unique device identification code.
Minimum slave response time	The minimum delay between the end of a message from the master and the time at which the master is ready to receive a response from the slave.
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.

# 7 Building Automation Network

## 7.1 Introduction

The Affinity Building Automation Network (BAN) Interface supports the following communication protocols:

- Modbus RTU (see section 6.2)
- BACnet
- Metasys N2

## 7.2 BACnet

The tables in the following sections describe the BACnet objects that are available on the drive. The device object is also produced when queried by a master on the network.

The number of objects available is variable depending upon which Solutions Modules are installed. Object identifiers are allocated in the following order:

1. Drive
2. Module in slot 1
3. Module in slot 2

The Present Value property of each of the objects can be accessed in the manner indicated in the right-hand column of each of the object tables. The three access types are as follows:

Code	Type	Description
RO	Read only	The present value of these objects can only be read
RW	Read/write	The present value property of these objects can be both read from and written to. Writes from different BACnet devices will overwrite each other
C	Commanded	The present value property of these objects can be both read from and written to. Writes are accompanied by a priority level in the range 1 to 16, the underlying drive parameter is set to the value written at the highest priority level

The supported properties for each of the supported object types are given in the table below:

Object Property	Binary input	Binary output	Binary value	Analog input	Analog output	Analog value
Object_Identifier	✓	✓	✓	✓	✓	✓
Object_Name	✓	✓	✓	✓	✓	✓
Object_Type	✓	✓	✓	✓	✓	✓
Present_Value	✓	✓	✓	✓	✓	✓
Status_Flags	✓	✓	✓	✓	✓	✓
Event_State	✓	✓	✓	✓	✓	✓
Reliability	✓	✓	✓	✓	✓	✓
Out_Of_Service	✓	✓	✓	✓	✓	✓
Units	x	x	x	✓	✓	✓
Priority_Array	x	✓	✓	x	✓	✓
Relinquish_Default	x	✓	✓	x	✓	✓
Polarity*	✓	✓	x	x	x	x

\*The polarity property is read-only for all objects that support it, and can only be changed via the invert parameter associated with the input/output represented by the object.

### Analog input objects

Object ID (AI <i>n</i> )	Object name	Description	Present value access mode
1	Drive analog input 1	Analog input 1 on drive (Pr 7.01)	RO
2	Drive analog input 2	Analog input 2 on drive (Pr 7.02)	RO
3	Drive analog input 3	Analog input 3 on drive (Pr 7.03)	RO
4	Module x analog input 1	The first available analog input on a Solutions Module.	RO
↓	↓	↓	↓
<i>n</i>	Module x analog input <i>n</i>	The <i>n</i> <sup>th</sup> available analog input on a Solutions Module	RO

### Analog output objects

To control an analog output via BACnet the source parameter for the output must be set to a read/write parameter on menu 18. (Pr 18.11 to Pr 18.30 are acceptable).

Object ID (AO <i>n</i> )	Object name	Description	Present value access mode
1	Drive analog output 1	Analog output 1 on drive	C
2	Drive analog output 2	Analog output 2 on drive	C
3	Module x analog output 1	The first available analog output on a Solutions Module	C
↓	↓	↓	↓
<i>n</i>	Module x analog output 1	The first available analog output on a Solutions Module	C

Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

The following list describes the Device Object properties supported on the BAN interface with Affinity.

**Table 7-1 Device Object properties**

Device Object Property
APDU-timeout
Application software version
Database revision
Firmware revision
Local date
Local time
Max-APDU-length-accepted
Model name
Number of APDU retries
Object identifier
Object-list
Object-name
Object-type
Protocol object types supported
Protocol-version
Segmentation-supported
System-status
Vendor-identifier
Vendor-name

17	Energy meter (KWH)	Energy meter (kWh) (Pr <b>6.26</b> )	RO
18	PID 1 digital reference	Digital reference for PID 1 (Pr <b>14.25</b> )	C
19	PID 1 digital feedback	Digital feedback for PID 1 (Pr <b>14.26</b> )	C
20	PID 1 reference	Sum of all reference inputs to PID 1 (Pr <b>14.20</b> )	RO
21	PID 1 feedback	Sum of all feedback inputs to PID 1 (Pr <b>14.21</b> )	RO
22	PID 1 output	The output from PID 1 (Pr <b>14.01</b> )	RO
23	PID 2 digital reference	Digital reference for PID 2 (Pr <b>14.55</b> )	C
24	PID 2 digital feedback	Digital feedback for PID 2 (Pr <b>14.56</b> )	C
25	PID 2 reference	Sum of all reference inputs to PID 2 (Pr <b>14.50</b> )	RO
26	PID 2 feedback	Sum of all feedback inputs to PID 2 (Pr <b>14.51</b> )	RO
27	PID 2 output	The output from PID 2 (Pr <b>14.31</b> )	RO

#### Analog value objects

Object ID (AVn)	Object name	Description	Present value access mode
1	Drive parameter	The drive parameter to read/write	RW
2	Parameter value	The new value for the parameter, or the value read from the parameter	RW
3	Parameter read/write	Whether the parameter should be read or written (1 = write, 2 = read)	RW
4	Speed reference	The required output frequency/speed reference (Pr <b>1.21</b> )	C
5	Maximum speed reference	The maximum reference clamp value (Pr <b>1.06</b> )	RW
6	Output current	Motor output current magnitude (Pr <b>4.01</b> )	RO
7	Output torque	Motor output torque (Pr <b>4.20</b> ) as a percentage of full load	RO
8	Output frequency	Drive output frequency (Pr <b>5.01</b> )	RO
9	Output speed	Motor speed (Pr <b>5.04</b> )	RO
10	Output power	Drive output power (Pr <b>5.03</b> )	RO
11	Drive status word	Drive status word (Pr <b>10.40</b> )	RO
12	User trip parameter	User trip (Pr <b>10.38</b> )	RW
13	Last trip	Last drive trip (Pr <b>10.20</b> )	RO
14	Filter change (dt)	Time between filter changes (Pr <b>6.21</b> )	RW
15	Time to next filter change	Time before filter change due (Pr <b>6.23</b> )	RO
16	Energy meter (MWH)	Energy meter (MWh) (Pr <b>6.25</b> )	RO

#### Binary input objects

Object ID (BIn)	Object name	Description	Present value access mode
1	Drive digital input 1	Digital input 1 on drive (bi-dir Pr <b>8.01</b> )	RO
2	Drive digital input 2	Digital input 2 on drive (bi-dir Pr <b>8.02</b> )	RO
3	Drive digital input 3	Digital input 3 on drive (bi-dir Pr <b>8.03</b> )	RO
4	Drive digital input 4	Digital input 4 on drive (bi-dir Pr <b>8.04</b> )	RO
5	Drive digital input 5	Digital input 5 on drive (bi-dir Pr <b>8.05</b> )	RO
6	Drive digital input 6	Digital input 6 on drive (bi-dir Pr <b>8.06</b> )	RO
7	Drive digital input 7	Drive enable input (Pr <b>8.09</b> )	RO
8	Module x digital input 1	The first available digital input on a Solutions Module	RO
↓	↓	↓	↓
n	Module x digital input n	The nth available digital input on a Solutions Module	RO

## Binary output objects

To control a binary output via BACnet the source parameter for the output must be set to a read/write bit parameter on menu 18. (Pr 18.31 to Pr 18.50 are acceptable).

Object ID (BOn)	Object name	Description	Present value access mode
1	Drive digital output 1	Digital output 1 on drive (bi-dir Pr 8.01)	C
2	Drive digital output 2	Digital output 2 on drive (bi-dir Pr 8.02)	C
3	Drive digital output 3	Digital output 3 on drive (bi-dir Pr 8.03)	C
4	Drive digital output 4	24V Output (Pr 8.08)	C
5	Drive digital output 5 (R)	Drive relay (Pr 8.07)	C
6	Module x digital output 1	The first available digital output on a Solutions Module	C
↓	↓	↓	↓
n	Module x digital output n	The nth available digital output on a Solutions Module	C

## Binary value objects

Object ID (BVn)	Object name	Description	Present value access mode
1	Reset energy meter	Reset drive energy meter (Pr 6.24)	RW
2	Filter change required	Filter change required/done (Pr 6.22)	RW
3	Drive run forward	Run forward (Pr 6.30)	C
4	Drive OK	Drive OK indication (Pr 10.01)	RO
5	Drive warning	Drive warning/alarm state (Pr 10.19)	RO
6	Drive reset	Drive reset (Pr 10.33)	RW



Parameter structure	Keypad and display	Parameter x.00	Parameter description format	Advanced parameter descriptions	PC comms protocol	Building automation network	Performance	RFC mode
---------------------	--------------------	----------------	------------------------------	---------------------------------	-------------------	-----------------------------	-------------	----------

**Table 7-2 BACnet protocol implementation conformance statement**

<b>Date</b>		7th March 2011					
<b>Vendor Name</b>		Control Techniques					
<b>Product Name</b>		Affinity Variable Speed Drive					
<b>Product Model Number</b>		Affinity (All models)					
<b>Applications Software Version</b>	n/a	<b>Firmware Revision</b>	V01.03.08		<b>BACnet Protocol Revision</b>	4	
<b>BACnet Standardized Device Profile (Annex L)</b>			<input type="checkbox"/>	BACnet Operator Workstation (B_OWS)			
			<input type="checkbox"/>	BACnet Building Controller (B-BC)			
			<input type="checkbox"/>	BACnet Advanced Application Controller (B-AAC)			
			<input checked="" type="checkbox"/>	BACnet Application Specific Controller (B-ASC)			
			<input type="checkbox"/>	BACnet Smart Sensor (B-SS)			
			<input type="checkbox"/>	BACnet Smart Actuator (B-SA)			
<b>Supported BACnet Interoperability Building Blocks (Annex K)</b>			DS-RP-B, DS-WP-B, DM-DDB-B, DM-DCC-B, DM-RD-B, DM-TS-B, DM-DOB-B				
<b>Segmentation Capability</b>			<input type="checkbox"/>	Able to transmit segmented messages		Window Size _____	
			<input type="checkbox"/>	Able to receive segmented messages		Window Size _____	
<b>Standard Object Types Supported</b>			See BACnet Objects section				
<b>Data Link Layer Options</b>			<input type="checkbox"/>	BACnet IP, (Annex J)			
			<input type="checkbox"/>	BACnet IP, (Annex J), Foreign Device			
			<input type="checkbox"/>	ISO 8802-3, Ethernet (Clause 7)			
			<input type="checkbox"/>	ANSI/ATA 878.1, 2.5Mb. ARCNET (Clause 8)			
			<input type="checkbox"/>	ANSI/ATA 878.1, EIA-485 ARCNET (Clause 8)			
			<input checked="" type="checkbox"/>	MS/TP master (Clause 9), baud rates : 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800			
			<input type="checkbox"/>	MS/TP slave (Clause 9), baud rates : 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800			
			<input type="checkbox"/>	Point-To-Point, EIA 232 (Clause 10)			
			<input type="checkbox"/>	Point-To-Point, modem (Clause 10)			
			<input type="checkbox"/>	LonTalk, (Clause 11)			
			<input type="checkbox"/>	Other			
<b>Device Address Binding Supported</b>			<input type="checkbox"/>	Yes	<input checked="" type="checkbox"/>	No	
<b>Networking Options</b>			<input type="checkbox"/>	Router, Clause 6			
			<input type="checkbox"/>	Annex H, BACnet Tunnelling Router over IP			
			<input type="checkbox"/>	BACnet/IP Broadcast Management Device (BBMD)			
			<input type="checkbox"/>	BBMD supports registration by Foreign Devices		<input type="checkbox"/>	Yes
<input type="checkbox"/>					<input type="checkbox"/>	No	
<b>Character Sets Supported</b>							
Indicating support for multiple character sets does not imply that they can all be supported simultaneously							
<input checked="" type="checkbox"/>	ANSI X3.4		<input type="checkbox"/>	IBM™/Microsoft™ DBCS		<input type="checkbox"/>	ISO 8859-1
<input type="checkbox"/>	ISO 10646 (UCS-2)		<input type="checkbox"/>	ISO 10646 (UCS-4)		<input type="checkbox"/>	JIS C 6226

## 7.3 Metasys N2

### 7.3.1 Introduction

The sections below detail the Metasys N2 regions, points, commands, alarms and warnings supported by the Affinity drive.

The supported region types are listed in the table below.

Region	Name	Description
1	Analog Inputs	Drive numeric parameters that are read-only
2	Binary Inputs	Drive bit parameters that are read-only
3	Analog Outputs	Drive numeric parameters that are read-write
4	Binary Outputs	Drive bit parameters that are read-write and read-only
5	Internal Float Values	Used for non cyclic access
6	Internal Integer Values	Not supported
7	Internal Byte Values	Not supported

Within each region, there may be up to 256 points that can be accessed over the network. The points available in the drive are detailed in the sections below.

The "Protocol level point list" should be used for the direct communications by client software, and the "Controller level point list" should be used for the controllers such as the "Johnson Controls N2 master Controller", "SlotServer's Metasys N2 module", etc.

### 7.3.2 Analog Inputs

Analog input points are numeric parameters (real) that are read-only. An analog input cannot be written to but can be overridden.

#### NOTE

The drive only supports integer parameters with an implied decimal point. Any such parameter returned by a Metasys query will be in IEEE floating point (not the internal representation in the drive).

Protocol level point list	Controller level point list	Description	Parameter	Access
0	1	Motor output current magnitude	Pr 4.01	RO
1	2	Motor output torque % full load	Pr 4.20	RO
2	3	Drive output frequency	Pr 5.01	RO
3	4	Motor Speed	Pr 5.04	RO
4	5	Drive output power	Pr 5.03	RO
5	6	Drive status word	Pr 10.40	RO
6	7	Last drive trip	Pr 10.20	RO
7	8	Time to next filter change	Pr 6.23	RO
8	9	Energy meter (MWh)	Pr 6.25	RO
9	10	Energy meter (kWh)	Pr 6.26	RO
10	11	Sum of all reference inputs to PID 1	Pr 14.20	RO
11	12	Sum of all feedback inputs to PID 1	Pr 14.21	RO
13	13	The output from PID 1	Pr 14.01	RO
13	14	Sum of all reference inputs to PID 2	Pr 14.50	RO
14	15	Sum of all feedback inputs to PID 2	Pr 14.51	RO
15	16	The output from PID 2	Pr 14.31	RO
16	17	Analogue input 1 on drive	Pr 7.01	RO
17	18	Analogue input 2 on drive	Pr 7.02	RO
18	19	Analogue input 3 on drive	Pr 7.03	RO
19*	20	Analogue input 4 on I/O Plus – slot 1	Pr 15.40	RO
20*	21	Analogue input 5 on I/O Plus – slot 1	Pr 15.44	RO
21*	22	Analogue input 4 on I/O Plus – slot 2	Pr 16.40	RO
22*	23	Analogue input 5 on I/O Plus – slot 2	Pr 16.44	RO

\*Only available if I/O Solutions Modules are fitted on the drive. The number of available I/O's will vary depending on the type of I/O Solutions Modules installed.

**Table 7-3 Supported attributes for analog inputs**

Attribute	Name	Commands
1	Object configuration	Read, Write
2	Object Status	Read
3	Analog Input Value	Read, Override
8	Low Alarm Limit	Read, Write
9	Low Warning Limit	Read, Write
10	High Warning Limit	Read, Write
11	High Alarm Limit	Read, Write
12	Differential	Read, Write

### 7.3.3 Binary Inputs

Binary input points are drive bit parameters that are read-only. A binary input cannot be written to but can be overridden.

Protocol level point list	Controller level point list	Description	Parameter	Access
0	1	Filter change required/done	Pr <b>6.22</b>	RO
1	2	Drive healthy indication	Pr <b>10.01</b>	RO
2	3	Drive warning/alarm state	Pr <b>10.19</b>	RO
3	4	Digital Input 1 on drive (bi-directional)	Pr <b>8.01</b>	RO
4	5	Digital Input 1 on drive (bi-directional)	Pr <b>8.02</b>	RO
5	6	Digital Input 1 on drive (bi-directional)	Pr <b>8.03</b>	RO
6	7	Digital Input 1 on drive	Pr <b>8.04</b>	RO
7	8	Digital Input 1 on drive	Pr <b>8.05</b>	RO
8	9	Digital Input 1 on drive	Pr <b>8.06</b>	RO
9	10	Drive enable state	Pr <b>8.09</b>	RO
10*	11	Digital Input/Output 1 on I/O Plus – slot 1	Pr <b>15.09</b>	RO
11*	12	Digital Input/Output 2 on I/O Plus – slot 1	Pr <b>15.10</b>	RO
12*	13	Digital Input/Output 3 on I/O Plus – slot 1	Pr <b>15.03</b>	RO
13*	14	Digital Input 4 on I/O Plus – slot 1	Pr <b>15.04</b>	RO
14*	15	Digital Input 5 on I/O Plus – slot 1	Pr <b>15.05</b>	RO
15*	16	Digital Input 6 on I/O Plus – slot 1	Pr <b>15.06</b>	RO
16*	17	Digital Input/Output 1 on I/O Plus – slot 2	Pr <b>16.09</b>	RO
17*	18	Digital Input/Output 2 on I/O Plus – slot 2	Pr <b>16.10</b>	RO
18*	19	Digital Input/Output 3 on I/O Plus – slot 2	Pr <b>16.03</b>	RO
19*	20	Digital Input 4 on I/O Plus – slot 2	Pr <b>16.04</b>	RO
20*	21	Digital Input 5 on I/O Plus – slot 2	Pr <b>16.05</b>	RO
21*	22	Digital Input 6 on I/O Plus – slot 2	Pr <b>16.06</b>	RO

**Table 7-4 Attributes supported for Binary inputs**

Attribute	Name	Commands
1	Object Configuration	Read, Write
2	Object Status	Read, Override

### 7.3.4 Analog outputs

#### NOTE

The drive only supports integer parameters with an implied decimal point. Any such parameter returned by a Metasys query will be in IEEE floating point (not the internal representation in the drive).

Protocol level point list	Controller level point list	Description	Parameter	Access
0	1	Preset Speed Reference 1	Pr 1.21	RW
1	2	Maximum reference clamp	Pr 1.06	RW
2	3	User trip	Pr 10.38	RW
3	4	Time between Filter Changes	Pr 6.21	RW
4	5	PID 1 Digital	Pr 14.25	RW
5	6	PID 1 Digital	Pr 14.26	RW
6	7	PID 1 Digital	Pr 14.55	RW
7	8	PID 1 Digital	Pr 14.56	RW
8	9	Analogue Output 1 on Drive	Pr 7.19	RW
9	10	Analogue Output 2 on Drive	Pr 7.22	RW
10*	11	Analogue output 3 on I/O Plus – slot 1	Pr 15.48	RW
11*	12	Analogue output 3 on I/O Plus – slot 2	Pr 16.48	RW

\*Only available if I/O Solutions Modules are fitted on the drive. The number of available I/Os will vary depending on the type of I/O Solutions Modules.

**Table 7-5 Attributes supported for Analog Outputs**

Attribute	Name	Commands
1	Object Configuration	Read, Write
2	Object Status	Read
3	Current Value	Read, Override

### 7.3.5 Binary Outputs

Binary output points are drive bit parameters that have read/write access. The output is updated by using a Metasys write command. Reading a binary output will return its current state.

Protocol level point list	Controller level point list	Description	Parameter	Access
0	1	Sequencing Bit – Run Forward	Pr 6.30	RW
1	2	Drive Reset	Pr 10.38	W
2	3	Reset energy meter	Pr 6.24	RW
3	4	Digital Input 1 on drive (bi-directional)	Pr 8.01	RO
4	5	Digital Input 2 on drive (bi-directional)	Pr 8.02	RO
5	6	Digital Input 3 on drive (bi-directional)	Pr 8.03	RO
6	7	24 Volt Output State	Pr 8.08	RO
7	8	Relay State Indicator	Pr 8.07	RO
8*	9	Digital Input/Output 1 on I/O Plus – slot 1	Pr 15.21	RO
9*	10	Digital Input/Output 1 on I/O Plus – slot 1	Pr 15.22	RO
10*	11	Digital Input/Output 1 on I/O Plus – slot 1	Pr 15.23	RO
11*	12	Relay 1 on I/O Plus – slot 1	Pr 15.27	RO
12*	13	Relay 2 on I/O Plus – slot 1	Pr 15.28	RO
13*	14	Digital Input/Output 1 on I/O Plus – slot 2	Pr 16.21	RO
14*	15	Digital Input/Output 1 on I/O Plus – slot 2	Pr 16.22	RO
15*	16	Digital Input/Output 1 on I/O Plus – slot 2	Pr 16.23	RO
16*	17	Relay 1 on I/O Plus – slot 2	Pr 16.27	RO
17*	18	Relay 1 on I/O Plus – slot 2	Pr 16.28	RO

\*Only available if I/O Solutions Modules are fitted on the drive. The number of available I/Os will vary depending on the type of I/O Solutions Modules.

**Table 7-6 Attributes supported for Binary Outputs**

Attribute	Name	Commands
1	Object Configuration	Read, Write
2	Object Status	Read, Override

### 7.3.6 Internal Float Values

Internal float values are read/write internal parameters used to implement a generic parameter access method allowing access to any drive parameter.

Point	Description	Access
0	Parameter (specified as a float e.g. 1.25 = Pr 1.25)	RW
1	Value (specified as a float value)	RW
2	Read/Write command code 0 = Idle 1 = Write 2 = Read	RW

**Table 7-7 Attributes supported for Internal Float Values**

Attribute	Name	Commands
1	Object Status	Read
2	Current Value	Read, Override

### 7.3.7 Metasys N2 commands

The Metasys commands supported by Affinity are listed in the table below.

Metasys commands
Synch time command
Poll without ack message
Read analog input command
Read binary input command
Read analog output command
Read binary output command
Read internal parameter command
Write analog input command
Write binary input command
Write analog output command
Write binary output command
Write internal parameter command
Override analog input command
Override binary input command
Override analog output command
Override binary output command
Override internal parameter command
Override release request
Identify device type command

Affinity supports the COS (change of state) feature for all supported points (except internal float values). The drive constantly queries the points and any that have changed from the stored current value will be flagged in the status byte as having changed state.

Table 7-8 lists the conditions which cause a change of state to be detected.

**Table 7-8 Change of state**

Point type	Region	COS Detection Conditions
Analog Inputs	1	Current value transitions into one of four alarm/warning regions (high alarm, high warning, low warning, low alarm) or current value transitions back to normal
Binary Inputs	2	Current bit changes logic state.
Analog Outputs	3	Current value changes by .001%
Binary Outputs	4	Current bit changes logic state.
Internal Float Values	5	Not applicable

When the polling command appears, the flagged point will be returned in the status reply message. Transmission of the status reply will clear the change of state indication.

### 7.3.8 Change of state

## 8 Performance

### 8.1 Digital speed reference

Table 8-1 Accuracy and resolution

	Open loop		RFC	
	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

### 8.2 Analog reference

Table 8-2 Update rates

		Open Loop				RFC			
		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 8-3 Resolution

	Open loop	RFC
Analog input 1	16 bits plus sign*	16 bits plus sign*
Analog input 2 / 3	10 bit plus sign	10 bit plus sign

\*16 bit plus sign as a speed reference, resolution = Pr 7.26 x 500 x 10<sup>3</sup>.

### 8.3 Analog outputs

Table 8-4 Analog outputs

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 RFC mode.

### 8.4 Digital inputs and outputs

Table 8-5 Response times

Switching frequency	Terminals	Open loop		RFC	
		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

## 8.5 Current feedback

Accuracy: 5% worst case, 2% typical

Resolution: 10 bit plus sign

Full scale resolution is equivalent to 222% drive rated current (OI.AC trip level)

## 8.6 Bandwidth

The following bandwidth values are for 12kHz PWM switching frequency:

### 8.6.1 Speed loop

The speed loop bandwidth is 160Hz

### 8.6.2 Current loop

The current loop bandwidth is 1100Hz for the 3dB point, and 400Hz for the 45° point.

1. The gain characteristic and associated 3dB point is most useful where drive is used in an application where the current controller is not included within an outer control loop.
2. The phase characteristic and associated 45° point is most useful where the current controller is used within an outer control loop such as a speed controller. The phase delay of the current controller has a limiting effect on the response of the outer loop.

## 9 Rotor Flux Control (RFC) mode

### 9.1 Introduction

Rotor Flux Control (RFC) mode, is a sub mode of closed loop vector mode on the drive. Instead of using a position feedback device, the drive uses a position estimator to determine the position of the flux in the motor. The drive uses motor currents, motor voltages and key motor parameters in a robust model of the motor to estimate flux position, flux magnitude and motor speed. The control system is exactly the same as the system used with closed loop vector with position feedback, except that in RFC mode the feedback is derived from a position estimator instead of an actual feedback device. The position estimator gives an effective resolution of 16384 lines per revolution.

RFC mode can eliminate instability when operating a large motor on light load and at low frequencies, for example in large fan applications.

### 9.2 Setting up the RFC mode

This section describes how to set up the drive to run in RFC mode.

It is recommended that the lowest possible switching frequency is used, preferably 3kHz. This is because as the switching frequency is increased, the effect of the IGBT switching dead times is greater, which reduces stability. This is more of an issue on larger drives, where the IGBT dead times are longer.

To set up the Affinity in RFC mode follow the instructions below.

Action		Detail
1	Set the drive into RFC mode	Set Pr <b>xx.00</b> to 1253 (EUR defaults) or 1254 (US defaults), set Pr <b>11.31</b> (or Pr <b>0.48</b> ) to CL VECt, and perform a drive reset.
2	Enter the motor nameplate values	Ensure all the following motor map parameters are entered into the drive using the motor nameplate. <ul style="list-style-type: none"> <li>• Motor rated frequency in Pr <b>5.06</b></li> <li>• Motor rated current in Pr <b>5.07</b></li> <li>• Motor rated speed in Pr <b>5.08</b></li> <li>• Motor rated voltage in Pr <b>5.09</b></li> </ul>
3	Select or deselect catch a spinning motor mode	If catch a spinning motor mode is not required then set Pr <b>6.09</b> to 0. If catch a spinning motor mode is required then leave Pr <b>6.09</b> at the default of 1, but depending on the size of the motor the value in Pr <b>5.40</b> may need to be adjusted. Pr <b>5.40</b> defines a scaling function used by the algorithm that detects the speed of the motor. The default value of Pr <b>5.40</b> is 1 which is suitable for small motors (<4kW). For larger motors the value in Pr <b>5.40</b> will need to be increased. Approximate values of Pr <b>5.40</b> for different motor sizes are as follows, 2 for 11kW, 3 for 55kW and 5 for 150kW. If the value of Pr <b>5.40</b> is too large the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small the drive will detect the motor speed as zero even if the motor is spinning.
4	Autotune	It is highly recommended that a rotating autotune is performed (Pr <b>5.12</b> set to 2). If a rotating autotune is not possible then a static autotune must be performed (Pr <b>5.12</b> set to 1) and the nameplate value of power factor entered into Pr <b>5.10</b>

### 9.3 Further Tuning

The position estimator used in RFC mode, has a filter with a time constant/filter of 4ms which will reduce the possible bandwidth of the speed controller compared with the bandwidth possible when position feedback is used.

This means that the speed loop integral gain will need to be lower than the value normally used when a feedback device used.

With Unidrive SP software version V01.10.00 onwards, the default of the speed loop I gain has been decreased from 1.00 to 0.10 and the P gain increased from 0.0100 to 0.0300 to enable the RFC mode to work at optimum levels with the default parameter settings. The speed loop gains should be modified to obtain the best possible performance for the application, but it is unlikely that the integral gain can be increased much above 0.50.

A filter with a 4ms time constant/filter is always present on the output of the speed estimator. This filter may be extended by setting Pr **3.42** as follows:

- 0 = 4ms
- 1 = 8ms
- 2 = 16ms
- 3 = 32ms
- 4 = 64ms
- 5 = 128ms

The output of the speed estimator can include some ripple, which increases as the drive passes into field weakening and the filter can be used to remove this ripple. This is particularly useful when using standard ramp or spinning start with a low friction high inertia load, and can prevent over voltage trips when the drive has no braking resistor. When operating above rated speed it may be necessary to include further filtering of the current demand (Pr **4.12** set to a value between 1.0 and 5.0ms) to achieve stable operation.



# Index

## Numerics

3 .....	51
4 -20mA .....	116, 117

## A

Acceleration .....	6
Acceleration rate selector .....	45
Access Level .....	12
Accuracy .....	49
Active current .....	66
Advanced menus .....	8
Advanced parameter descriptions .....	22
Alarm .....	13
Analog I/O .....	111
Analog input 1 destination .....	115
Analog input 1 level .....	113
Analog input 2 destination .....	116
Analog input 2 level .....	113
Analog input 2 mode .....	116
Analog input 3 destination .....	117
Analog input 3 level .....	113
Analog input 3 mode .....	117
Analog input objects .....	226
Analog output 1 mode .....	118
Analog output 1 source .....	118
Analog output 2 mode .....	119
Analog output 2 source .....	118
Analog output objects .....	226
Analog reference 1 .....	35
Analog reference resolution .....	49
Analog value objects .....	227
ANSI communications protocol .....	219
Application menu 1 .....	201, 207
Application menu 2 .....	208
Application menu 3 .....	209
At speed .....	140
At speed lower limit .....	50
At speed upper limit .....	51
Auto-reset attempts .....	155
Auto-tune .....	84

## B

Bandwidth .....	58
Bandwidth set-up .....	57
Baud rate .....	161
Binary input objects .....	227
Binary output objects .....	227
Binary sum .....	136
Binary value objects .....	228
Bipolar reference enable .....	31
Brake control function .....	172
Braking IGBT active .....	141
Braking resistor alarm .....	141
Braking time .....	153
Building .....	201, 226
Building Automation Network .....	226

## C

Catch a spinning motor .....	98
Closed .....	58
Coding .....	16
Compliance angle .....	57
Compliance angle set-up .....	57
Control word .....	105
Current control .....	60
Current controller Ki gain .....	70
Current controller Kp gain .....	69
Current limit .....	67
Current limit operation .....	70

## D

Damping factor .....	58
DC bus voltage .....	17, 80
Deceleration .....	6
Deceleration rate selector .....	46
Destinations .....	20
Differential feedback gain .....	55
Digital I/O 1 output select .....	128
Digital I/O 1 source/destination .....	127
Digital I/O 2 output select .....	128
Digital I/O 2 source/destination .....	127
Digital I/O 3 output select .....	128
Digital I/O 3 source/destination .....	127
Digital I/O read word .....	127
Digital input .....	122
Digital input 4 destination .....	127
Digital input 5 destination .....	127
Digital input 6 destination .....	127
Digital input auto-selection disable .....	129
Digital output .....	122
Digital reference resolution .....	49
Direction commanded .....	141
Direction running .....	142
Display .....	9
Display - special functions .....	13
Drive active .....	140
Drive enable .....	126
Drive mode .....	163
Drive ok .....	140
Drive reset .....	13, 155
Drive warning .....	142
Dynamic V to F .....	87

## E

Edit mode .....	10
Energy meter .....	102
External trip .....	155

## F

Fd .....	87
Field gain reduction .....	90
Field weakening compensation disable .....	92
Fire mode .....	37
Fixed boost .....	83, 87
Flux optimise select .....	87
Frequency/speed reference .....	26

## G

Gain select ..... 55

## H

Hard speed reference ..... 58

Hard speed reference update rate ..... 21

High dynamic performance enable ..... 91

High stability space vector modulation ..... 90

## I

IGBT junction temperature ..... 120

Inertia compensation enable ..... 74

Inertia compensation torque ..... 48

Inertia measurement ..... 86

Injection braking level ..... 98

Integral gain ..... 55

## J

Jog acceleration rate ..... 46

Jog deceleration rate ..... 47

Jog reference ..... 28

## K

Keypad ..... 9

Keypad control ..... 13

Keypad control mode reference ..... 33

## L

Limit switch ..... 104

Load reached ..... 141

Logic diagram

Menu 01 ..... 26

Menu 02 ..... 41

Menu 03 Open-loop ..... 50

Menu 03 RFC ..... 52

Menu 04 Open-loop ..... 64

Menu 04 RFC ..... 65

Menu 05 Open-loop ..... 77

Menu 05 RFC ..... 78

Menu 06 ..... 95

Menu 07 ..... 112

Menu 08 ..... 124

Menu 09 ..... 130

Menu 12 ..... 172

Menu 14 ..... 186

Logic function 1 ..... 132

Logic function 2 ..... 132

Low load ..... 75

## M

Mains loss ..... 70, 142

Mains loss mode ..... 97

Maximum reference clamp ..... 29

Menu ..... 184

Menu 0 ..... 5, 159

Menu 0 cloning ..... 5

Menu 0 parameters ..... 6

Menu 01 - Frequency/speed reference ..... 26

Menu 02 - Ramps ..... 40

Menu 03 - Slave frequency, speed feedback, speed control ..... 49

Menu 04 - Torque and current control ..... 60

Menu 05 - Motor control ..... 77

Menu 06 - Sequencer and clock ..... 95

Menu 07 - Analog I/O ..... 111

Menu 08 - Digital I/O ..... 122

Menu 09 - Programmable logic, motorised pot and binary

sum ..... 130

Menu 10 - Status and trips ..... 140

Menu 11 - General drive set-up ..... 159

Menu 12 - Threshold detectors and variable selectors ..... 172

Menu 14 - User PID controller ..... 186

Menu 15 and 16 - Solutions Module slots ..... 200

Menu 17 - Building Automation Interface ..... 201

Menu 18 - Application menu 1 ..... 201, 207

Menu 19 - Application menu 2 ..... 208

Menu 20 - Application menu 3 ..... 209

Menu 21 - Second motor parameters ..... 210

Menu 22 - Additional menu 0 set up ..... 217, 218

Menu structure ..... 5

Minimum reference clamp ..... 29

Motor 2 parameters select ..... 169

Motor control ..... 77

Motor rated current ..... 81

Motor rpm ..... 80

Motor saturation breakpoint ..... 92

Motor torque per amp (Kt) ..... 93

Motorised pot ..... 132

## N

Number of motor poles ..... 84

## O

Open collector output ..... 128

Output frequency ..... 80

Output power ..... 80

Output voltage ..... 80

Overload accumulator ..... 74

Overload alarm ..... 142

Overspeed threshold ..... 54

## P

Parameter - description format ..... 16

Parameter navigation ..... 5

Parameter security ..... 12

Parameter structure ..... 5

Parameter view mode ..... 10

Parameter x.00 ..... 14

PID controller ..... 186

Precision reference ..... 33

Preset reference selected indicator ..... 36

Preset selector ..... 32

Programmable logic ..... 130

Proportional gain ..... 54

<b>Q</b>				<b>T</b>	
Quasi-square enable .....	90			Thermal protection mode .....	72
<b>R</b>				Thermal time constant .....	71
Ramp enable .....	42			Thermistor .....	117
Ramp mode select .....	42			Threshold detector 1 .....	174
Ramps .....	40			Threshold detector 2 .....	174
Ranges .....	17			Threshold detectors .....	172
Rated frequency .....	81			Timers .....	137
Rated load rpm .....	82			Torque control .....	69
Rated power factor .....	84			Torque demand .....	66
Rated speed .....	82			Torque mode selector .....	69
Rated voltage .....	82			Torque offset .....	68
Reactive current .....	73			Torque reference .....	68
Real time clock .....	100			Transient inductance .....	91
Reference offset .....	28			<b>U</b>	
Reference selected indicator .....	36			Under voltage active .....	142
Reference selector .....	31			Update rate .....	19
Regenerating .....	141			Ur .....	87
Relay source .....	128			Ur_Auto .....	87
Resolution .....	49			Ur_I .....	87
RFC mode .....	236			Ur_S .....	87
Rotating test .....	85, 86			US defaults .....	15
Running cost .....	103			User Security .....	12
<b>S</b>				<b>V</b>	
S ramp .....	43			Variable maximums .....	17
Second motor parameters .....	13, 210			Variable selector 1 .....	175
Security .....	12			Variable selector 2 .....	175
Security code .....	162			Variable selectors .....	172
Security status .....	169			Voltage boost .....	88
Sequencer .....	95			Voltage controller .....	93
Sequencing bit .....	103			Voltage mode select .....	87
Serial communications look-up table .....	151			Voltage offset .....	87
Serial communications protocol .....	219			Voltage rating .....	163
Serial mode .....	160			<b>Z</b>	
Skip reference 1 .....	34			Zero speed .....	140
Sleep/wake mode .....	110			Zero speed threshold .....	50
Slip compensation enable .....	92				
SMARTCARD .....	164				
Software sub-version .....	163				
Software version .....	162				
Solutions Module slots .....	200				
Sources .....	20				
Speed controller .....	57				
Speed error .....	53				
Speed feedback .....	53				
Square law mode .....	83				
Stationary test .....	85, 86				
Stator inductance .....	91				
Stator resistance .....	87				
Status mode .....	10				
Status word .....	157				
Stop mode .....	96				
Switching frequency - maximum .....	89				



**0474-0011-02**