User Guide

Pump Drive F600

Model size 3 to 11

Variable speed AC drive for induction and permanent magnet motors for the control of pump control systems

Part Number: 0478-0622-01
Issue: 1

Original Instructions

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

Documentation

Manuals are available to download from the following locations: **http://www.drive-setup.com/ctdownloads**

The information contained in this manual is believed to be correct at the time of printing and does not form part of any contract. The manufacturer reserves the right to change the specification of the product and its performance, and the contents of the manual, without notice.

Warranty and Liability

In no event and under no circumstances shall the manufacturer be liable for damages and failures due to misuse, abuse, improper installation, or abnormal conditions of temperature, dust, or corrosion, or failures due to operation outside the published ratings. The manufacturer is not liable for consequential and incidental damages. Contact the supplier of the dive for full details of the warranty terms.

Environmental policy

Control Techniques Ltd operates an Environmental Management System (EMS) that conforms to the International Standard ISO 14001.

Further information on our Environmental Policy can be found at: **http://www.drive-setup.com/environment**

Restriction of Hazardous Substances (RoHS)

The products covered by this manual comply with European and International regulations on the Restriction of Hazardous Substances including EU directive 2011/65/EU and the Chinese Administrative Measures for Restriction of Hazardous Substances in Electrical and Electronic Products.

Disposal and Recycling (WEEE)

When electronic products reach the end of their useful life, they must not be disposed of along with domestic waste but should be recycled by a specialist recycler of electronic equipment. Control Techniques products are designed to be easily dismantled into their major component parts for efficient recycling. The majority of materials used in the product are suitable for recycling.

Product packaging is of good quality and can be re-used. Large products are packed in wooden crates. Smaller products are packaged in strong cardboard cartons which have a high recycled fibre content. Cartons can be re-used and recycled. Polythene, used in protective film and bags for wrapping the product, can be recycled. When preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

REACH legislation

EC Regulation 1907/2006 on the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) requires the supplier of an article to inform the recipient if it contains more than a specified proportion of any substance which is considered by the European Chemicals Agency (ECHA) to be a Substance of Very High Concern (SVHC) and is therefore listed by them as a candidate for compulsory authorisation.

Further information on our compliance with REACH can be found at: **http://www.drive-setup.com/reach**

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Registered in England and Wales. Company Reg. No. 01236886.

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How to use this guide

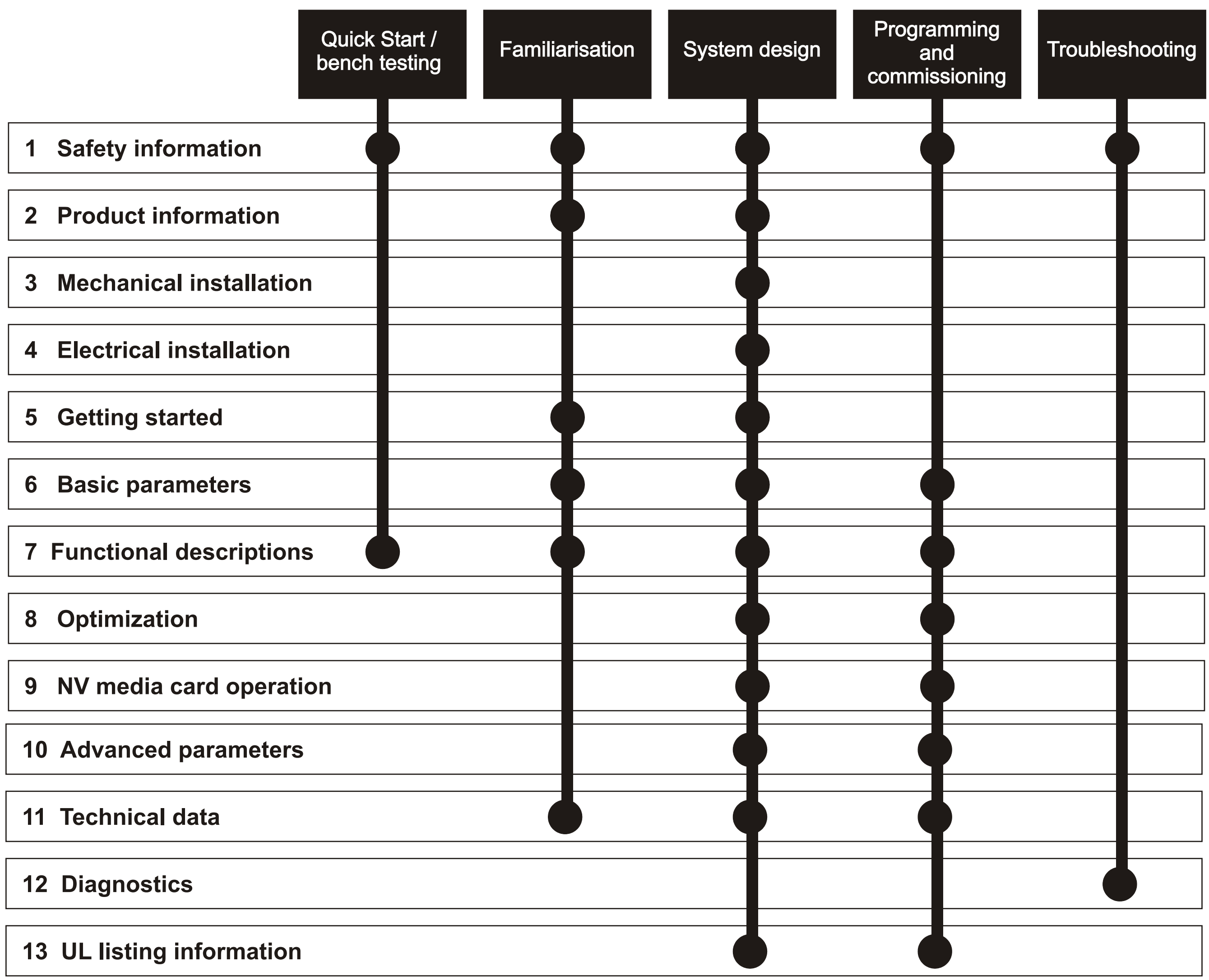
This user guide provides complete information for installing and operating the drive from start to finish.

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

NOTE

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

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



Contents

EU Declaration of Conformity

Nidec Control Techniques Ltd

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SY16 3BE

Nidec This declaration is issued under the sole responsibility of the manufacturer. The object of the declaration is in conformity with the relevant Union harmonization legislation. The declaration applies to the variable speed drive products shown below:

Model number	Interpretation	Nomenclature aaaa - bbc ddddde
aaaa	Basic series	M100, M101, M200, M201, M300, M400, M600, M700, M701, M702, F600, H300, E200, E300, HS30, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
ddddd	Current rating	Example 01000 = 100 A
e	Drive format	A = 6P Rectifier + Inverter (internal choke), D = Inverter, E = 6P Rectifier + Inverter (external choke), T = 12P Rectifier + Inverter (external choke)

The model number may be followed by additional characters that do not affect the ratings.

The variable speed drive products listed above have been designed and manufactured in accordance with the following European harmonized standards:

EN 61800-5-1:2007	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-3: 2004+A1:2012	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
EN 61000-6-2:2005	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
EN 61000-6-4: 2007+ A1:2011	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
EN 61000-3-2:2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits for harmonic current emissions (equipment input current ≤16 A per phase)
EN 61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limitation of voltage changes, voltage fluctuations and flicker in public, low voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

EN 61000-3-2:2014 Applicable where input current < 16 A. No limits apply for professional equipment where input power ≥ 1 kW.

These products comply with the Restriction of Hazardous Substances Directive (2011/65/EU), the Low Voltage Directive (2014/35/EU) and the Electromagnetic Compatibility Directive (2014/30/EU).

Jonathan Holman-White

Vice President, Technology

Date: 02/11/2020

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters.

The drives must be installed only by professional installers who are familiar with requirements for safety and EMC. Refer to the Product Documentation. An EMC data sheet is available giving detailed information. The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used.

EU Declaration of Conformity (including 2006 Machinery Directive)

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This declaration is issued under the sole responsibility of the manufacturer. The object of the declaration is in conformity with the relevant Union harmonization legislation. The declaration applies to the variable speed drive products shown below:

Model No.	Interpretation	Nomenclature aaaa - bbc dddddde
aaaa	Basic series	M300, M400, M600, M700, M701, M702, F600, H300, E200, E300, HS30, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
ddddd	Current rating	Example 01000 = 100 A
e	Drive format	A = 6P Rectifier + Inverter (internal choke), D = Inverter, E = 6P Rectifier + Inverter (external choke), T = 12P Rectifier + Inverter (external choke)

The model number may be followed by additional characters that do not affect the ratings.

This declaration relates to these products when used as a safety component of a machine. Only the Safe Torque Off function may be used for a safety function of a machine. None of the other functions of the drive may be used to carry out a safety function.

These products fulfil all the relevant provisions of the Machinery Directive 2006/42/EC and the Electromagnetic Compatibility Directive (2014/30/EU).

EC type examination has been carried out by the following notified body:

TUV Rheinland Industrie Service GmbH
Am Grauen Stein
D-51105 Köln
Germany

EC type-examination certificate numbers:
01/205/5270.01/14 dated 2014-11-11
01/205/5387.01/15 dated 2015-01-29
01/205/5383.02/15 dated 2015-04-21

Notified body identification number: 0035

The harmonized standards used are shown below:

EN 61800-5-1:2007	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-5-2:2007	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional
EN ISO 13849-1:2008	Safety of Machinery, Safety-related parts of control systems, General principles for design
EN ISO 13849-2:2008	Safety of machinery, Safety-related parts of control systems. Validation
EN 61800-3: 2004+A1:2012	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
EN 62061:2005	Safety of machinery, Functional safety of safety related electrical, electronic and programmable electronic control systems

Person authorised to complete the technical file:
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Conformity Engineer
Newtown, Powys, UK

Jonathan Holman-White
Vice President, Technology
Date: 02/11/2020
Place: Newtown, Powys, UK

IMPORTANT NOTICE

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters.

The drives must be installed only by professional installers who are familiar with requirements for safety and EMC. Refer to the Product Documentation. An EMC data sheet is available giving detailed information. The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used.

1 Safety information

1.1 Warnings, Cautions and Notes

WARNING

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

CAUTION

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

NOTE

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

1.2 Important safety information. Hazards. Competence of designers and installers

This guide applies to products which control electric motors either directly (drives) or indirectly (controllers, option modules and other auxiliary equipment and accessories). In all cases the hazards associated with powerful electrical drives are present, and all safety information relating to drives and associated equipment must be observed.

Specific warnings are given at the relevant places in this guide.

Drives and controllers are intended as components for professional incorporation into complete systems. If installed incorrectly they may present a safety hazard. The drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury. Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning/start-up and maintenance must be carried out by personnel who have the necessary training and competence. They must read this safety information and this guide carefully.

1.3 Responsibility

It is the responsibility of the installer to ensure that the equipment is installed correctly with regard to all instructions given in this guide. They must give due consideration to the safety of the complete system, so as to avoid the risk of injury both in normal operation and in the event of a fault or of reasonably foreseeable misuse.

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation of the equipment.

1.4 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses or other protection, and protective ground (earth) connections.

This guide contains instructions for achieving compliance with specific EMC standards.

All machinery to be supplied within the European Union in which this product is used must comply with the following directives:

2006/42/EC Safety of machinery.

2014/30/EU: Electromagnetic Compatibility.

1.5 Electrical hazards

The voltages used in the drive can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive. Hazardous voltage may be present in any of the following locations:

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

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

The supply must be disconnected by an approved electrical isolation device before gaining access to the electrical connections.

The STOP and Safe Torque Off functions of the drive do not isolate dangerous voltages from the output of the drive or from any external option unit.

The drive must be installed in accordance with the instructions given in this guide. Failure to observe the instructions could result in a fire hazard.

1.6 Stored electrical charge

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

1.7 Mechanical hazards

Careful consideration must be given to the functions of the drive or controller which might result in a hazard, either through their intended behaviour or through incorrect operation due to a fault. In any application where a malfunction of the drive or its control system could lead to or allow damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk - for example, an over-speed protection device in case of failure of the speed control, or a fail-safe mechanical brake in case of loss of motor braking.

With the sole exception of the Safe Torque Off function, none of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

The Safe Torque Off function may be used in a safety-related application. The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.

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

1.8 Access to equipment

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

1.9 Environmental limits

Instructions in this guide regarding transport, storage, installation and use of the equipment must be complied with, including the specified environmental limits. This includes temperature, humidity, contamination, shock and vibration. Drives must not be subjected to excessive physical force.

1.10 Hazardous environments

The equipment must not be installed in a hazardous environment (i.e. a potentially explosive environment).

1.11 Motor

The safety of the motor under variable speed conditions must be ensured.

To avoid the risk of physical injury, do not exceed the maximum specified speed of the motor.

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

The values of the motor parameters set in the drive affect the protection of the motor. The default values in the drive must not be relied upon. It is essential that the correct value is entered in the Motor Rated Current parameter.

1.12 Adjusting parameters

Some parameters have a profound effect on the operation of the drive. They must not be altered without careful consideration of the impact on the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering.

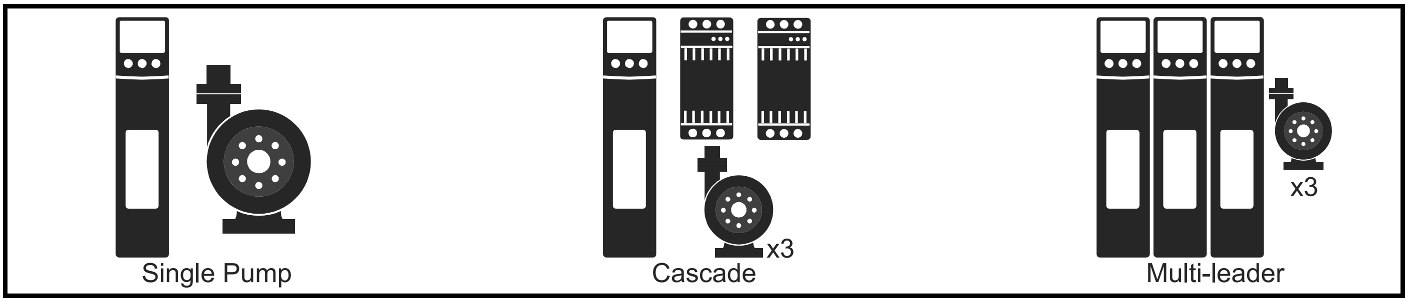
1.13 Electromagnetic compatibility (EMC)

Installation instructions for a range of EMC environments are provided in the relevant Power Installation Guide. If the installation is poorly designed or other equipment does not comply with suitable standards for EMC, the product might cause or suffer from disturbance due to electromagnetic interaction with other equipment. It is the responsibility of the installer to ensure that the equipment or system into which the product is incorporated complies with the relevant EMC legislation in the place of use.

2 Product information

2.1 Pump Drive F600 introduction

The F600 is a dedicated pump drive that supports single pump applications or more efficient parallel pump operation in a Cascade system (one drive + assist soft starters) or Multi-leader system (up to 3 drives with advanced handling). All of the features are user configurable via the keypad interface or by the F600 Guided Setup within Control Techniques' Connect PC software, available from http://controltechniques.com/support.



2.2 Overview

The operating controls for the Pump Drive F600 are Hand, Off or Auto, which may be selected from the keypad interface, digital inputs or HMI/PLC control word.

Hand mode runs the pump at a user defined fixed speed, from either a digital pre-set or an analog reference.

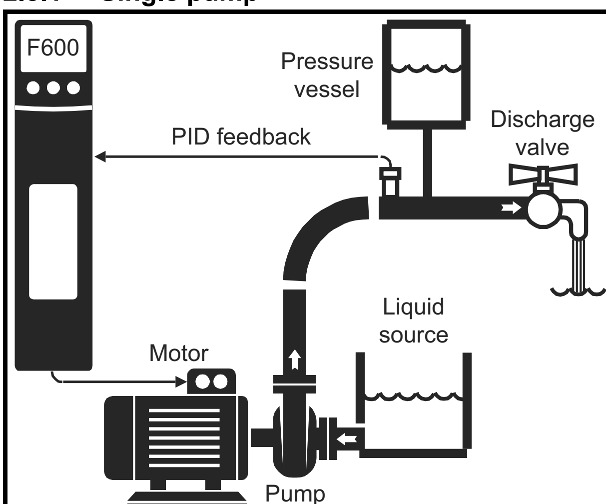
In Auto Mode, the pump starts Automatically with a start delay when the wake condition is detected, for example a pressure transducer signal goes below wake threshold. Initially, a pipe fill operation may be performed to remove air from the pipes. A PID control then regulates the system to the setpoint, e.g. for a constant pressure system, the demand pressure will be regulated by adjusting the motor speed. If the pump detects a stop condition for a defined time period, it will Automatically stop and enter the Sleeping state. There are four main stop conditions - sleep on low motor speed, software no flow detection, no flow from a flow switch and low flow from a pulsed flow meter. All four conditions can be individually enabled to suit the system requirements.

In Off Mode, Hand and or Auto are not selected, the drive will not energise the motor. This is not a safety function; the Safe Torque Off function using T29 may be used as part of a safety system if required.

In Cascade or Multi-leader parallel pumping systems, when the leader drive PID output is at maximum, additional assist F600s or soft starters are commanded to run. If the sleeping threshold is reached, additional assist F600s or soft starters are commanded to stop.

2.3 System configurations

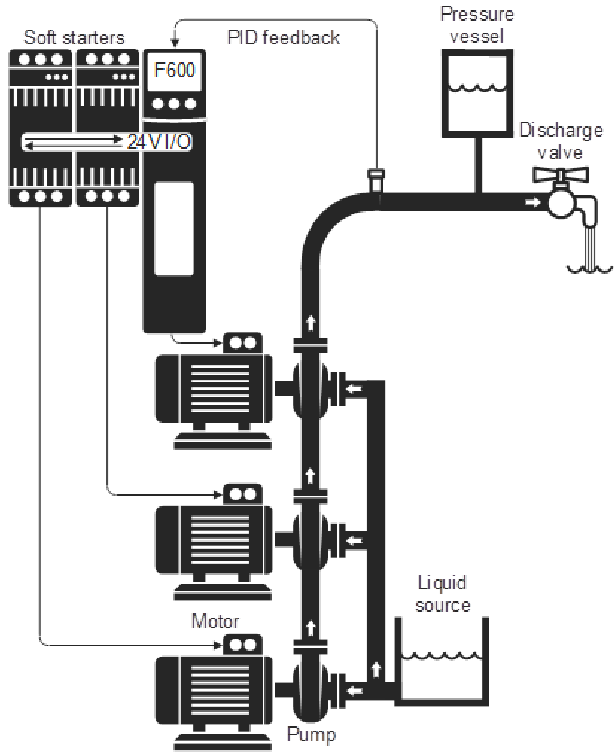
2.3.1 Single pump



This is a typical single pump layout with an F600 commanding the motor speed to maintain the PID setpoint, e.g. pressure setpoint. The main process PID, in the F600 drive, maintains constant pressure by monitoring the PID feedback and updating the motor speed as required.

Typically, the main process PID feedback transducer is a 4-20 mA device that is located close to the discharge valve. An optional pressure vessel helps to stabilise pressure when the pump starts and stops, or when the discharge valve is opened and closed.

2.3.2 Cascade pump

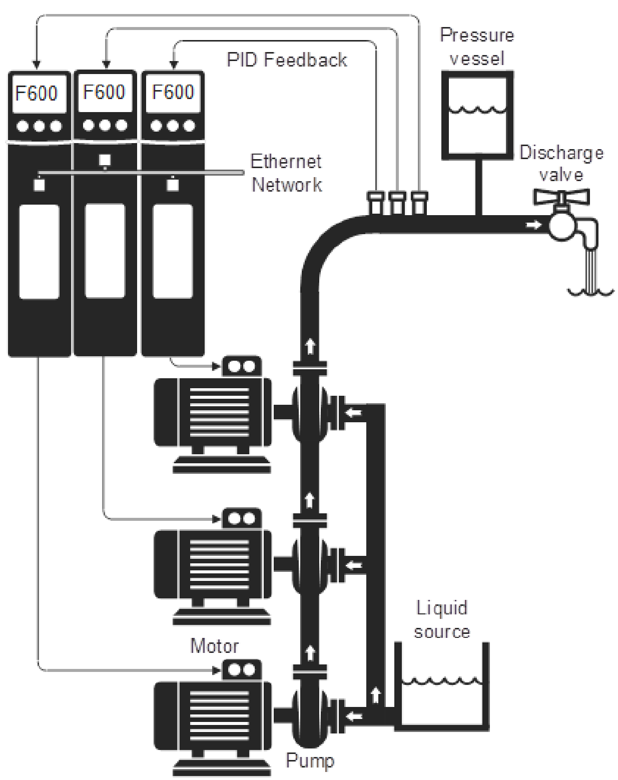


This is a typical Cascade pump layout with an F600 leader drive controlling up to 2 assist soft starters, using 24V digital I/O. The leader drive commands the motor speed to maintain the PID setpoint, e.g. pressure setpoint. The main process PID, in the F600 drive, maintains constant pressure by monitoring the PID feedback and updating the motor speed as required. If the PID output reaches its maximum, the soft starter assists will be commanded to run to increase the system output as required.

Typically, the main process PID feedback transducer is a

4-20 mA device that is located close to the discharge valve. An optional pressure vessel helps to stabilise pressure when the pump starts and stops, or when the discharge valve is opened and closed.

2.3.3 Multi-leader pump



This is a typical Multi-leader pump layout with up to 3 F600 Pump drives coordinating together over an Ethernet network. The leader drive commands the motor speed to maintain the PID setpoint, e.g. pressure setpoint. The main process PID, in the lead F600 drive, maintains constant pressure by monitoring the PID feedback and updating the motor speed as required. If the PID output reaches its maximum, the assist F600 Pump drives will be commanded to run by the system leader to increase the system output as required.

Typically, the main process PID feedback transducer is a

4-20 mA device that is located close to the discharge valve. This system will automatically reassign the leader, if required, or use the PID feedback from another drive to offer redundancy. An optional pressure vessel helps to stabilise pressure when the pump starts and stops, or when the discharge valve is opened and closed.

2.4 General pump principles

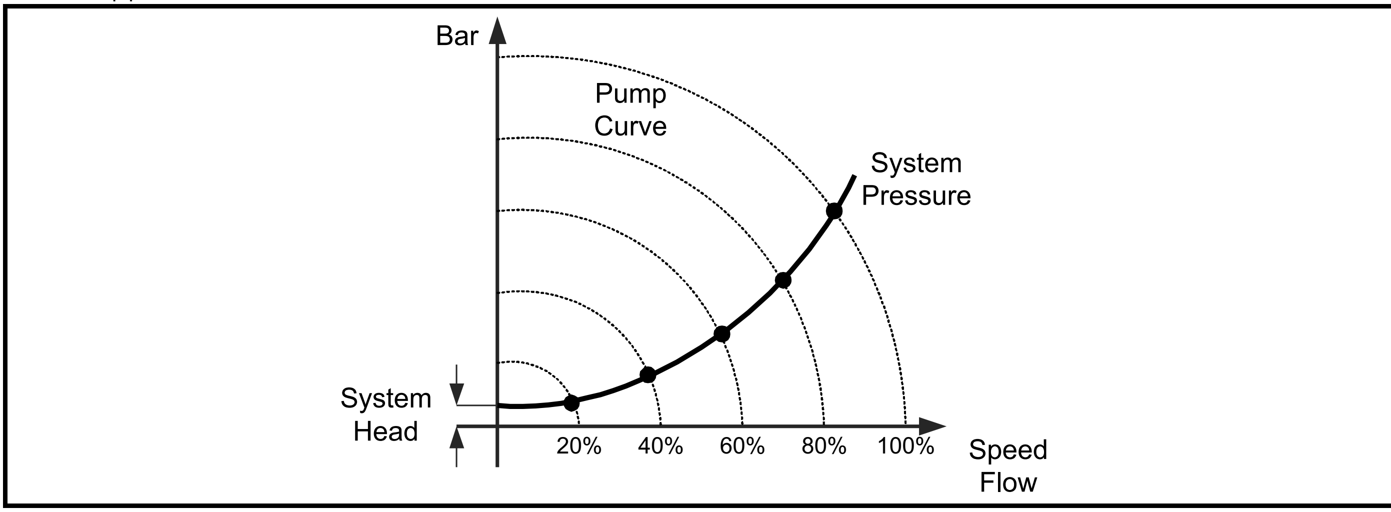
When controlling a pump with PID control, it is important to remember basic pump laws to understand the operation:

- Flow is proportional to Speed
- Pressure is proportional to $Speed^2$
- Power is proportional to $Speed^3$

Based on these laws, for a constant pressure system, we can see that pressure will increase by the motor speed squared. With PID control:

- If the actual pressure is less than the required set point, the motor speed will increase.
- If the actual pressure is greater than the required set point, the motor speed will decrease.
- The response of the PID loop is determined by the PID Proportional, Integral, and Derivative gains.

The pump, motor and drive are sized for the demand pressure and flow requirements, and pump working speed range, typically 60-100 % speed, or 30 Hz to 50 Hz with a 50 Hz motor, where the motor speed is relatively high to overcome the pressure drop or resistance to flow in the pump system distribution pipes.

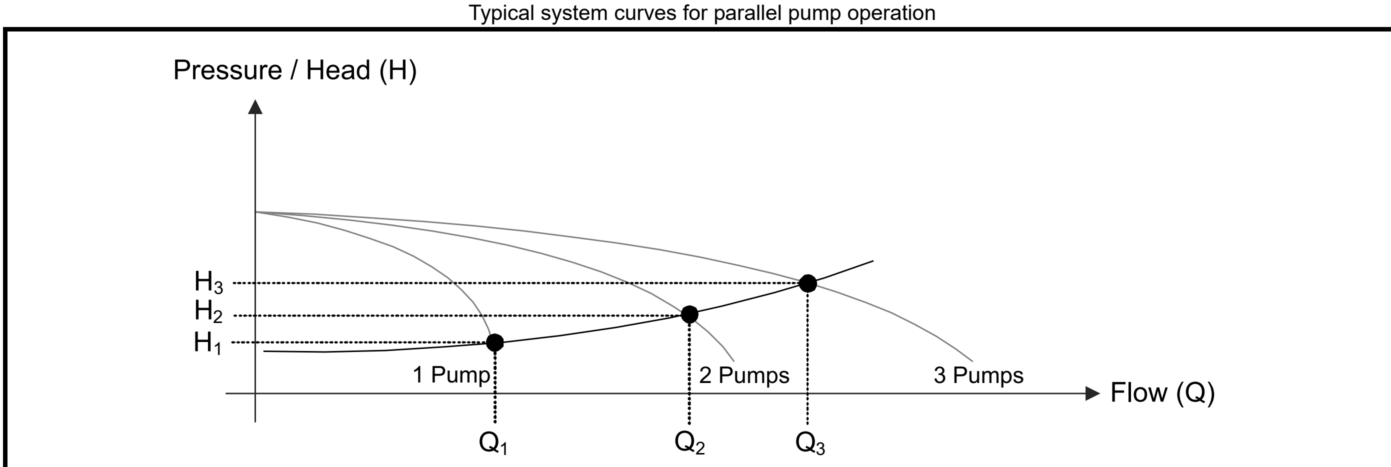


Parallel pump systems, like Cascade or Multi-leader mode, provide sequential control of multiple pumps in parallel in order to maintain a required PID setpoint with varying load demands. Pumps are often used in parallel banks to:

- Avoid motor overload
- Increased security of supply (system redundancy)
- Reduce running cost due to system load fluctuations
- Provide a wide range of control and flexibility

Contrary to commonly held beliefs, the flow does not double with the addition of a second similar pump in parallel. In fact, each successive pump adds a smaller amount to the total system pressure and flow, although the total flow is split equally between each pump.

Typical system curves for parallel pump operation

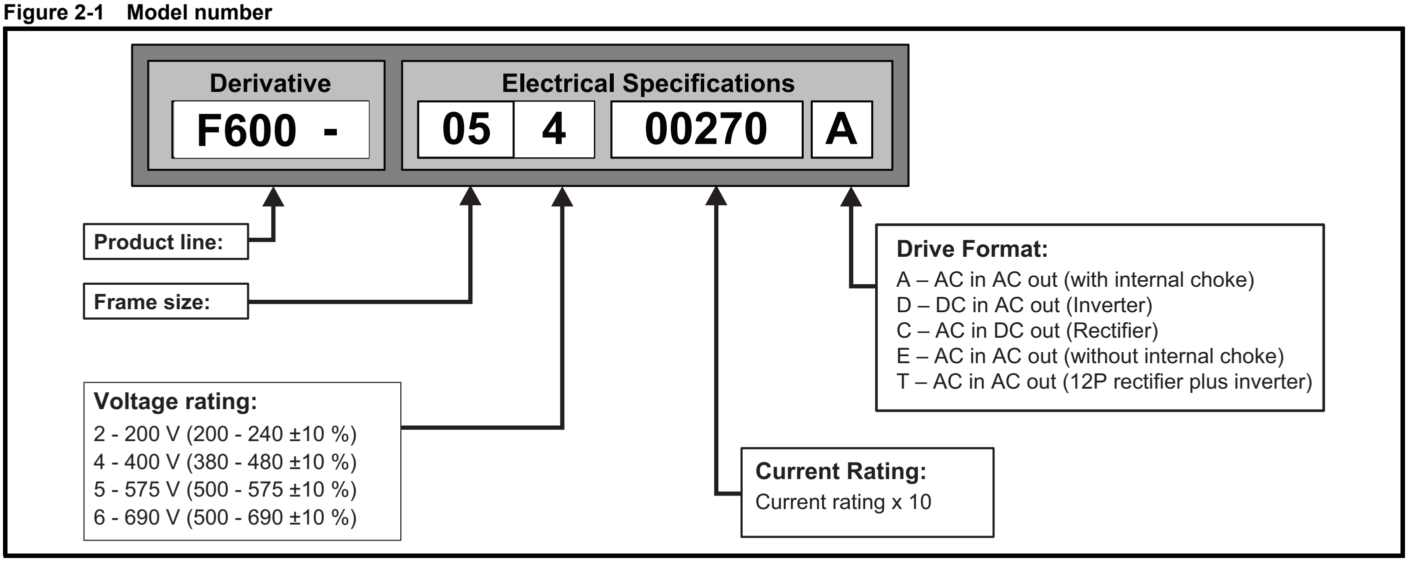


Compared to the equivalent larger pump system, the Multi-leader or Cascade parallel system has more range in control and is a more efficient system as a larger pump will be less efficient at lower speeds/flows.

2.5 Model number

The way in which the model numbers for the Pump Drive F600 range are formed is illustrated below:

Figure 2-1 Model number



* Only shown on Frame 9 and above identification label.

** For further information on the D, C or T power format models, please refer to the *Modular Installation Guide.*

NOTE

For simplicity, a Frame 9 drive with no internal choke (i.e. model 09xxxxxxE) is referred to as a Frame 9E and a Frame 9 drive with an internal choke (i.e. model 09xxxxxxA) is referred to as a Frame 9A. Any reference to Frame 9 is applicable to both sizes 9E and 9A. All Frame size 10 and 11 drives are supplied with no internal choke.

2.6 Ratings

Normal Duty

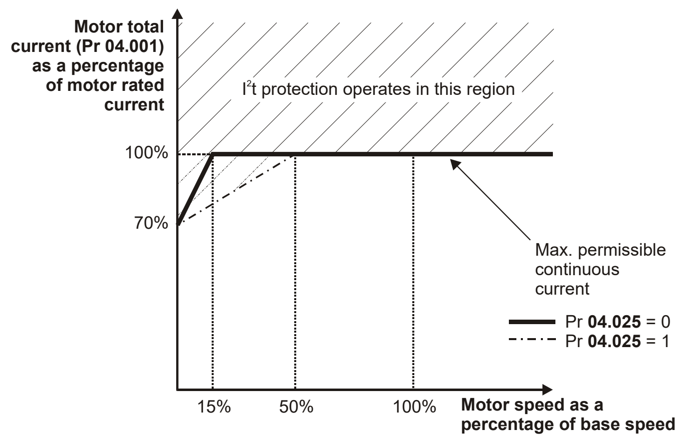
The F600 is optimized for applications which use self ventilated (TENV/TEFC) induction motors and require a low overload capability, and full torque at low speeds is not required (e.g.pumps).
Self ventilated (TENV/TEFC) induction motors require increased protection against overload due to the reduced cooling effect of the fan at low speed. To provide the correct level of protection the I^2t software operates at a level which is speed dependent. This is illustrated in the graph below.

NOTE

The speed at which the low speed protection takes effect can be changed by the setting of *Low Speed Thermal Protection Mode* Pr **04.025**.
The protection starts when the motor speed is below 15 % of base speed when Pr **04.025** = 0 (default) and below 50 % when Pr **04.025** = 1.

Operation of motor I²t protection

Motor I²t protection is fixed as shown below and is compatible with:
- Self ventilated (TENV/TEFC) induction motors



The continuous current ratings given are for maximum 40 °C (104 °F), 1000 m altitude and 3 kHz switching frequency (except where shown). Derating is required for higher switching frequencies, ambient temperature > 40 °C (104 °F) and high altitude. For further information, refer to Chapter 11 *Technical data* on page 393.

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

Model		Normal Duty			
		Maximum continuous output current	Nominal power at 230 V	Motor power at 230 V	Peak current
		A	kW	hp	A
Frame size 3	03200066	6.6	1.1	1.5	7.2
	03200080	8	1.5	2	8.8
	03200110	11	2.2	3	12.1
	03200127	12.7	3	3	13.9
Frame size 4	04200180	18	4	5	19.8
	04200250	25	5.5	7.5	27.5
Frame size 5	05200300	30	7.5	10	33
Frame size 6	06200500	50	11	15	55
	06200580	58	15	20	63.8
Frame size 7	07200750	75	18.5	25	82.5
	07200940	94	22	30	103.4
	07201170	117	30	40	128.7
Frame size 8	08201490	149	37	50	163.9
	08201800	180	45	60	198
Frame size 9	09202160	216	55	75	237.6
	09202660	266	75	100	292.6
Frame size 10	10203250	325	90	125	357.5
	10203600	360	110	150	396

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

Model		Normal Duty			
		Maximum continuous output current	**Nominal power at 400 V**	**Motor power at 460 V**	**Peak current**
		A	**kW**	**hp**	**A**
Frame size 3	03400034	3.4	1.1	1.5	3.7
	03400045	4.5	1.5	2.0	4.9
	03400062	6.2	2.2	3.0	6.8
	03400077	7.7	3.0	5.0	8.4
	03400104	10.4	4.0	5.0	11.4
	03400123	12.3	5.5	7.5	13.5
Frame size 4	04400185	18.5	7.5	10.0	20.3
	04400240	24.0	11.0	15.0	26.4
Frame size 5	05400300	30.0	15.0	20.0	33.0
Frame size 6	06400380	38.0	18.5	25.0	41.8
	06400480	48.0	22.0	30.0	52.8
	06400630	63.0	30.0	40.0	69.3
Frame size 7	07400790	79	37	50	86.9
	07400940	94	45	60	103.4
	07401120	112	55	75	123.2
Frame size 8	08401550	155	75	100	170.5
	08401840	184	90	125	202.4
Frame size 9	09402210	221	110	150	243.1
	09402660	266*	132	200	292.6
Frame size 10	10403200	320	160	250	352
	10403610	361	200	300	397.1
Frame size 11	11404370	437	225	350	480.7
	11404870	487*	250	400	535.7
	11405070	507*	280	450	557.7

* These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to section 11.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 393.

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

Model		Normal Duty			
		Maximum continuous output current	Nominal power at 575 V	Motor power at 575 V	Peak current
		A	kW	hp	A
Frame size 5	05500039	3.9	2.2	3	4.3
	05500061	6.1	4	5	6.7
	05500100	10	5.5	7.5	11
Frame size 6	06500120	12	7.5	10	13.2
	06500170	17	11	15	18.7
	06500220	22	15	20	24.2
	06500270	27	18.5	25	29.7
	06500340	34	22	30	37.4
	06500430	43	30	40	47.3
Frame size 7	07500530	53	45	50	58.3
	07500730	73	55	60	80.3
Frame size 8	08500860	86	75	75	94.6
	08501080	108	90	100	118.8
Frame size 9	09501250	125	110	125	137.5
	09501500	150	110	150	165
Frame size 10	10502000	200	150	200	220
Frame size 11	11502480	248	185	250	272.8
	11502880	288*	225	300	316.8
	11503150	315*	250	350	346.5

* These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to section 11.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 393.

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

Model		Normal Duty			
		Maximum continuous output current	Nominal power at 690 V	Motor power at 690 V	Peak current
		A	kW	hp	A
Frame size 7	07600230	23	18.5	25	25.3
	07600300	30	22	30	33
	07600360	36	30	40	39.6
	07600460	46	37	50	50.6
	07600520	52	45	60	57.2
	07600730	73	55	75	80.3
Frame size 8	08600860	86	75	100	94.6
	08601080	108	90	125	118.8
Frame size 9	09601250	125	110	150	137.5
	09601550	155	132	175	170.5
Frame size 10	10601720	172	160	200	189.2
	10601970	197	185	250	216.7
Frame size 11	11602250	225	200	250	247.5
	11602750	275*	250	300	302.5
	11603050	305*	280	400	335.5

* These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to section 11.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 393.

2.6.1 Typical short term overload limits

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

Typical values are shown in the table below for RFC (RFC-A or RFC-S) and open loop (OL) modes:

Table 2-5 Typical overload limits

Operating mode	RFC from cold	RFC from 100 %	Open loop from cold	Open loop from 100 %
Overload with motor rated current = drive rated current	110 % for 165 s	110 % for 9 s	110 % for 165 s	110 % for 9 s

Generally the drive rated current is higher than the matching motor rated current allowing a higher level of overload than the default setting. The time allowed in the overload region is proportionally reduced at very low output frequency on some drive ratings.

NOTE

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

2.7 Operating modes

Drive Operating modes

The drive operating mode is set using Pr **0.004**, by selecting either “Induction” or “Permanent magnet” and pressing the red OFF / Reset button. Selecting “Induction” sets the drive into Open-loop (OL) and RFC mode and selecting “Permanent-magnet” sets the drive into RFC-S sensorless mode, which are the most common operating modes used.

The drive supports the following operating modes:

Open-loop (OL) mode for use with an induction motor

The drive applies power to the motor at frequencies varied by the user. The motor speed is a result of the output frequency of the drive and slip due to the mechanical load.

RFC-A mode for use with an induction motor with feedback device

The drive directly controls the speed of the motor using the feedback device. The motor flux is accurately controlled to provide full torque down to zero speed.

Synchronous permanent magnet brushless motor without feedback (RFC-S sensorless mode)

Flux control is not required because the motor is self-excited by the permanent magnets which form part of the rotor. Full torque is available down to zero speed, with salient motors. Position information from the sensorless algorithm is used to ensure the output voltage is matched to the back EMF of the motor.

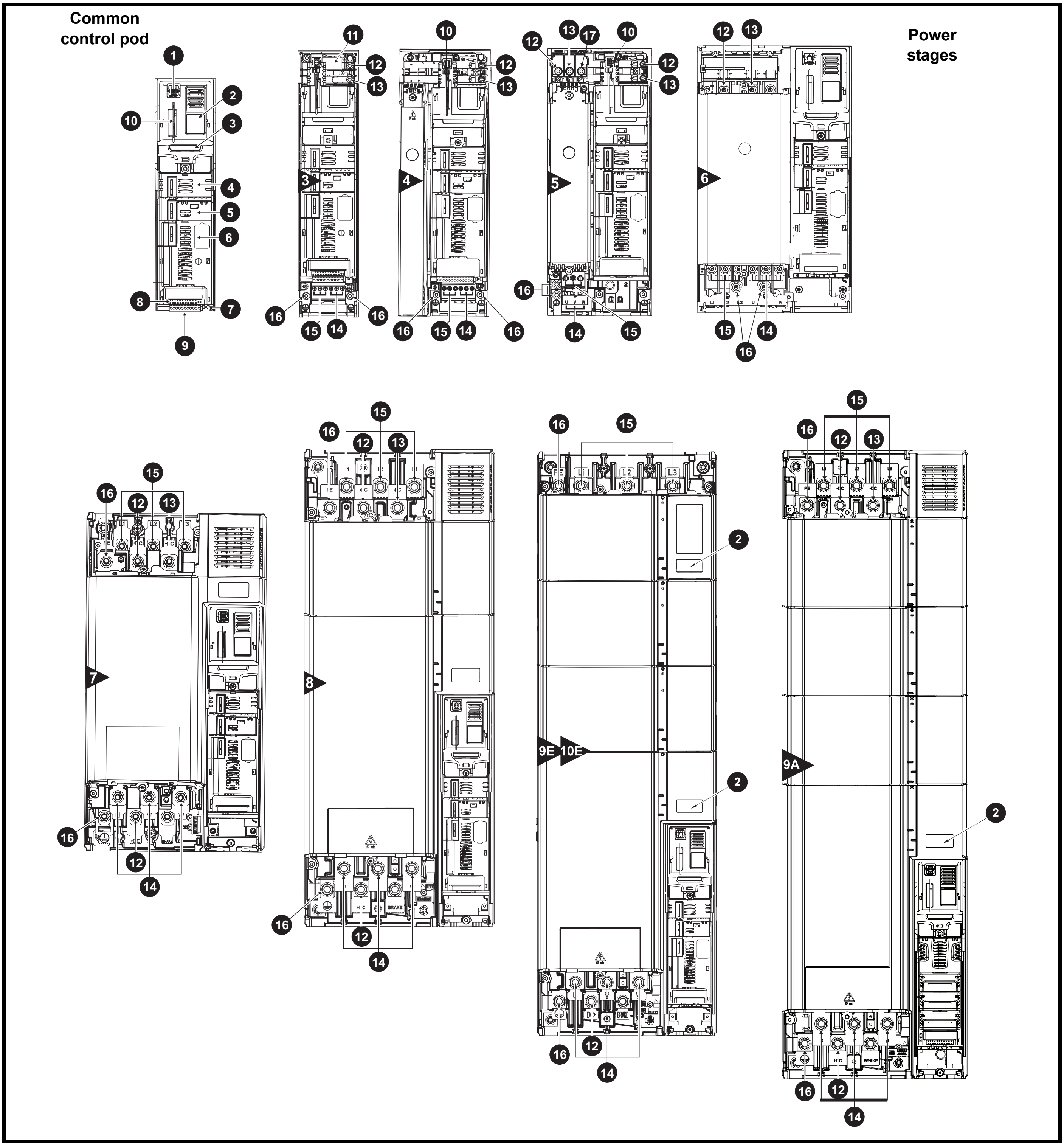
Synchronous permanent magnet brushless motor with feedback device (RFC-S feedback mode)

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

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

2.8 Drive features

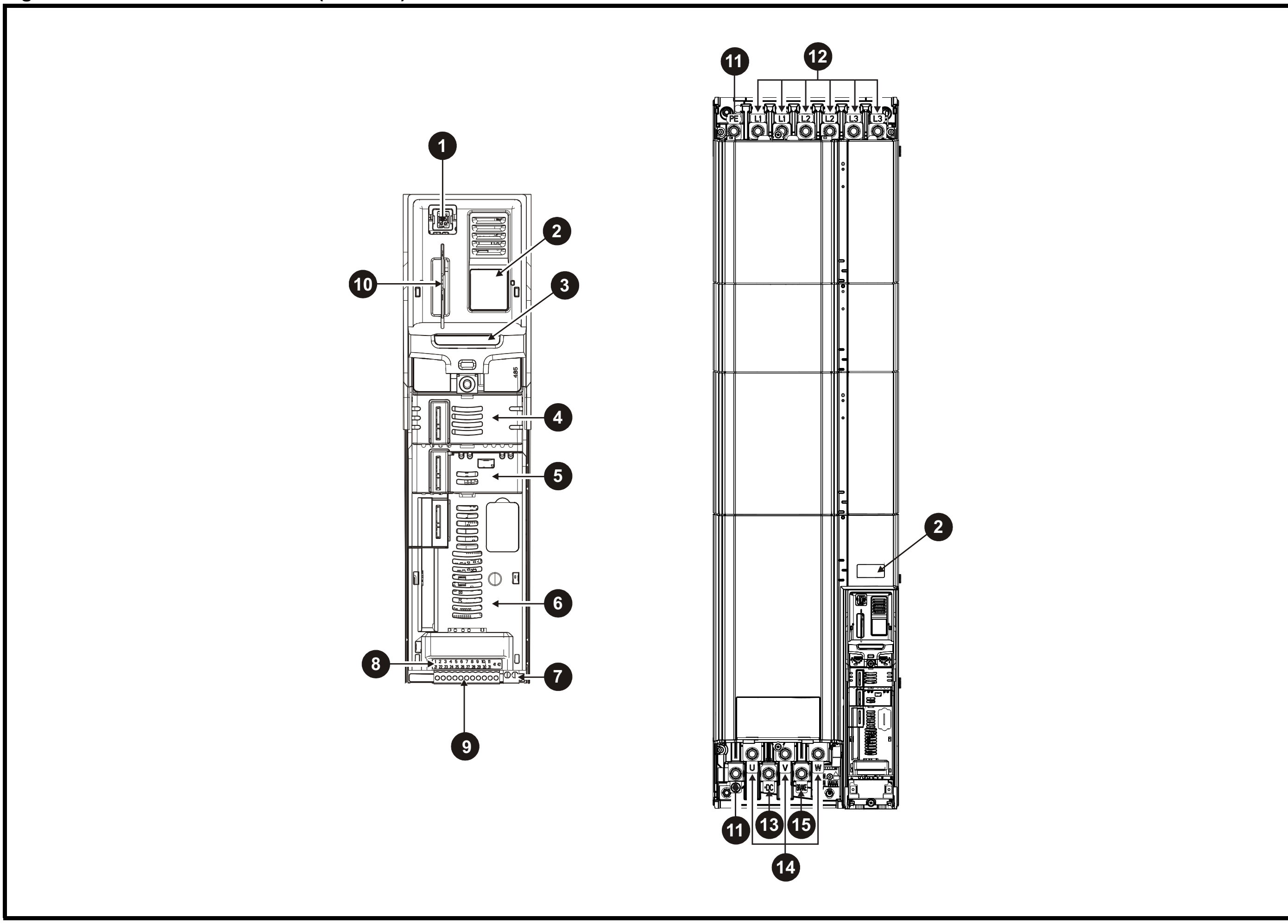
Figure 2-2 Features of the drive (size 3 to 10)



Key

1. Keypad connection
2. Rating label
3. Identification label
4. Option module slot 1
5. Option module slot 2
6. Option module slot 3
7. Relay connections
8. Control connections
9. Communications port
10. NV media card slot
11. Internal EMC filter
12. DC bus +
13. DC bus -
14. Motor connections
15. AC supply connections
16. Ground connections
17. Brake terminal

Figure 2-3 Features of the drive (size 11E)



Key

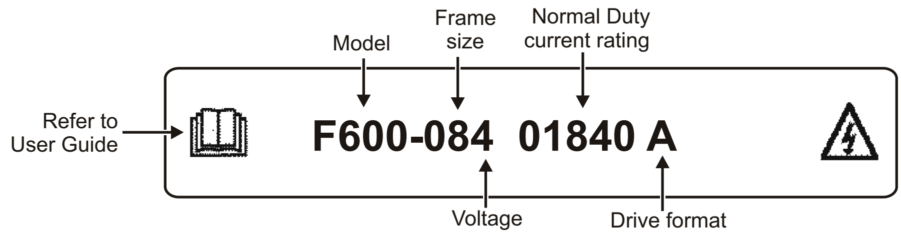
1. Keypad connection	5. Option module slot 2	9. Communications port	13. DC bus +
2. Rating label	6. Option module slot 3	10. NV media card slot	14. Motor connections
3. Identification label	7. Relay connections	11. Ground connections	15. Brake terminal
4. Option module slot 1	8. Control connections	12. AC supply connections*	

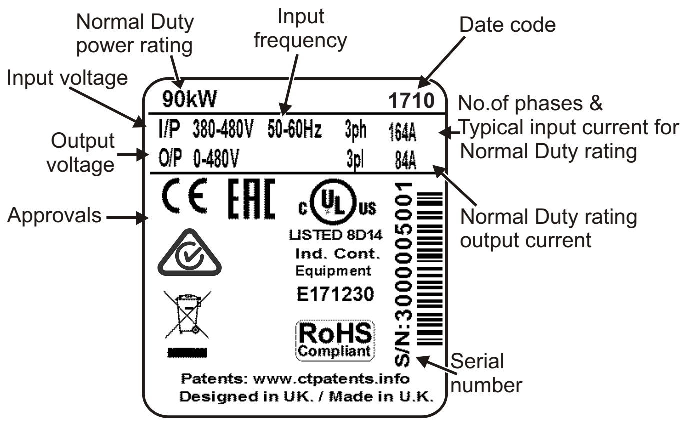
* Common AC supply connections are internally linked on the 11E 6 pulse drive.

2.9 Nameplate description

See Figure 2-2 and Figure 2-3 for location of rating labels.

Figure 2-4 Typical drive rating labels

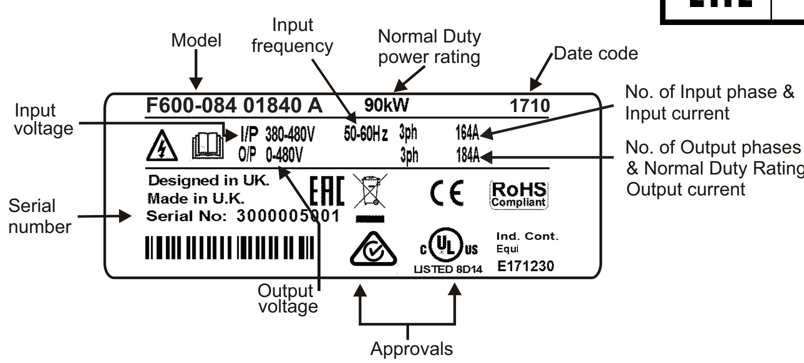




Key to approvals

CE	CE approval	Europe
RCM	RCM regulatory compliance mark	Australia
cULus	UL / cUL approval	USA & Canada
RoHS Compliant	RoHS compliant	Europe
FUNCTIONAL SAFETY cULus LISTED	Functional safety	USA & Canada
EAC	Eurasian conformity	Eurasia

Large label*



* This label is only applicable to Size 7 and above.

Refer to Figure 2-1 *Model number* on page 15 for further information relating to the labels.

NOTE

Date code format

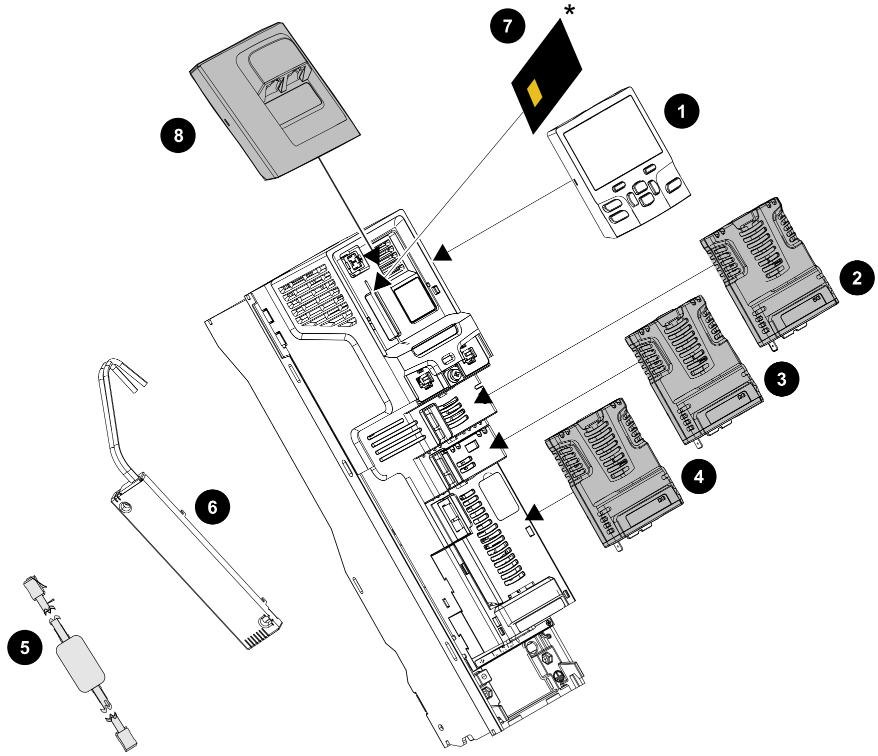
The date code is four numbers. The first two numbers indicate the year and the remaining numbers indicate the week of the year in which the drive was built.

Example:

A date code of 1710 would correspond to week 10 of year 2017.

2.10 Options

Figure 2-5 Options available with the drive



1. Keypad
2. Option module slot 1
3. Option module slot 2
4. Option module slot 3
5. CT Comms cable
6. Heatsink mounted braking resistor (size 3, 4 and 5 only)
7. NV media card
8. KI-485 comms adaptor

* For further information refer to section 9 *NV Media Card Operation* on page 317

WARNING	Be aware of possible live terminals when inserting or removing the NV media card.

All standard option modules are color-coded in order to make identification easy. All modules have an identification label on top of the module. Standard option modules can be installed to any of the available option slots on the drive. The following tables shows the color-code key and gives further details on their function.

Table 2-6 Option module identification

Type	Option module	Color	Name	Further Details
Fieldbus		N/A	KI-485 Adaptor	**EIA 485 Comms Adaptor** EIA 485 Comms adaptor provides EIA 485 communication interface. This adaptor supports 115 k Baud, node addresses between 1 to 16 and 8 1 NP M serial mode.
		Purple	SI-PROFIBUS	**Profibus option** PROFIBUS adapter for communications with the drive
		Medium Grey	SI-DeviceNet	**DeviceNet option** DeviceNet adapter for communications with the drive
		Light Grey	SI-CANopen	**CANopen option** CANopen adapter for communications with the drive
		Beige	SI-Ethernet	External Ethernet module that supports EtherNet/IP, Modbus TCP/IP and RTMoE. The module can be used to provide high speed drive access, global connectivity and integration with IT network technologies, such as wireless networking
		Yellow Green	SI-PROFINET V2	**PROFINET option** PROFINET adapter for communications with the drive Note: PROFINET V2 replaces PROFINET RT
		Brown Red	SI-EtherCAT	**EtherCAT option** EtherCAT adapter for communications with the drive
Automation (I/O expansion)		Orange	SI-I/O	**Extended I/O** Increases the I/O capability by adding the following combinations: • Digital I/O • Digital Inputs • Analog Inputs (differential or single ended) • Analog Output • Relays
Feedback		Light Brown	SI-Encoder	Incremental encoder input interface module.
		Dark Brown	SI-Universal Encoder	Additional combined encoder input and output interface supporting Incremental, SinCos, HIPERFACE, EnDAT and SSI encoders.
Automation (Applications)		Moss Green	MCi200	**Machine Control Studio Compatible Applications Processor** 2nd processor for running pre-defined and/or customer created application software.

Table 2-7 Keypad identification

Type	Keypad	Name	Further Details
Keypad		KI-HOA Keypad RTC	**LCD keypad option** Keypad with an LCD display, Hand / Off / Auto buttons and real time clock
Keypad		HOA Keypad RTC	**Remote LCD keypad option** Remotely mounted keypad with an LCD display, Hand / Off / Auto buttons and real time clock

Table 2-8 Additional options

Type	Option	Name	Further Details
Back-up		SD Card Adaptor	**SD Card Adaptor** Allows the drive to use an SD card for drive back-up
		SMARTCARD	**SMARTCARD** Used for parameter back-up with the drive

2.11 Items supplied with the drive

The drive is supplied with a copy of the *Getting Started Guide*, a safety information booklet, the Certificate of Quality and an accessory kit box including the items shown in Table 2-9.

Table 2-9 Parts supplied with the drive

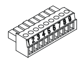
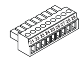
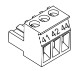
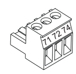
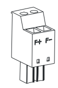
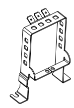
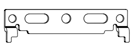
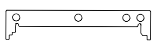
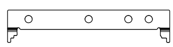
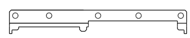
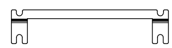
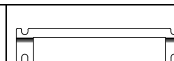
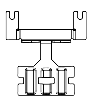
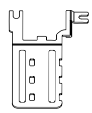
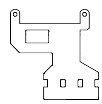
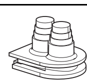
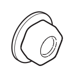
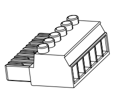
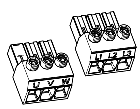
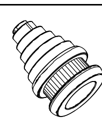
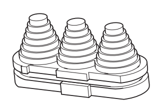
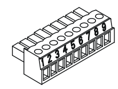
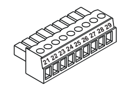
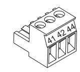
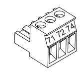
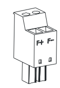
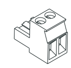
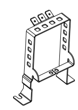
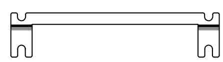
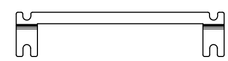
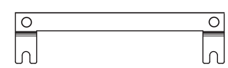
Description	Size 3	Size 4	Size 5	Size 6	Size 7	Size 8
Control connectors 1 to 9 and 21 to 29	 x 1  x 1					
Relay connector	 x 1  x 1					
24 V power supply connector				 x 1		
Grounding bracket	 x 1					
Surface mounting brackets	 x 2	 x 2	 x 2	 x 2	 x 2	 x 2
Grounding clamp	 x 1		 x 1	 x 1		
DC terminal cover grommets	 x 2					
Terminal nuts				 M6 x 11		
Supply and motor connector	 x 1		 x 1 x 1			
Finger guard grommets			 x 3	 x 2		

Table 2-10 Parts supplied with the drive (size 9A, 9E, 10E and 11E)

Description	Size 9A/9E	Size 10E	Size 11E
Control connectors 1 to 9 and 21 to 29	 x 1  x 1		
Relay connector	 x 1  x 1		
24 V power supply connectors	 x 1  x 1		
Grounding bracket	 x 1		
Surface mounting brackets	 x 2		 x 2  x 1

3 Mechanical installation

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

- Through-hole mounting
- High IP as standard or through-panel mounting
- Enclosure sizing and layout
- Option module installing
- Terminal location and torque settings

3.1 Safety information

WARNING

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

WARNING

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

WARNING

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

3.2 Planning the installation

The following considerations must be made when planning the installation:

3.2.1 Access

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

The IP (Ingress Protection) rating of the drive is installation dependent. For further information, refer to section 3.9 *Enclosing standard drive for high environmental protection* on page 62.

3.2.2 Environmental protection

The drive must be protected from:

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

NOTE

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

3.2.3 Cooling

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

For further information, refer to section 3.6 *Enclosure for standard drives* on page 57.

3.2.4 Electrical safety

The installation must be safe under normal and fault conditions. Electrical installation instructions are given in Chapter 4 *Electrical installation on page 91*.

3.2.5 Fire protection

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

For installation in the USA, a NEMA 12 enclosure is suitable.

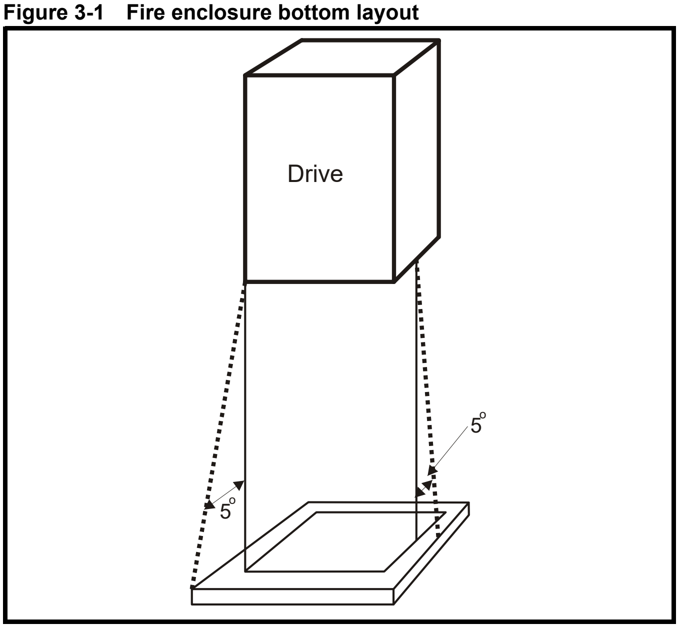
For installation outside the USA, the following (based on IEC 62109-1, standard for PV inverters) is recommended.

Enclosure can be metal and/or polymeric, polymer must meet requirements which can be summarized for larger enclosures as using materials meeting at least UL 94 class 5VB at the point of minimum thickness.

Air filter assemblies to be at least class V-2.

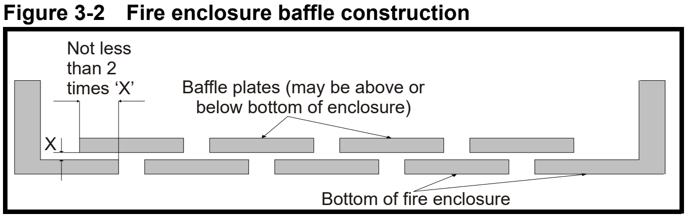
The location and size of the bottom shall cover the area shown in Figure 3-1. Any part of the side which is within the area traced out by the 5° angle is also considered to be part of the bottom of the fire enclosure.

Figure 3-1 Fire enclosure bottom layout



The bottom, including the part of the side considered to be part of the bottom, must be designed to prevent escape of burning material - either by having no openings or by having a baffle construction. This means that openings for cables etc. must be sealed with materials meeting the 5VB requirement, or else have a baffle above. See Figure 3-2 for acceptable baffle construction. This does not apply for mounting in an enclosed electrical operating area (restricted access) with concrete floor.

Figure 3-2 Fire enclosure baffle construction



3.2.6 Electromagnetic compatibility

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

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

If it is necessary to meet strict emission limits, or if it is known that electromagnetically sensitive equipment is located nearby, then full precautions must be observed. In-built into the drive, is an internal EMC filter, which reduces emissions under certain conditions. If these conditions are exceeded, then the use of an external EMC filter may be required at the drive inputs, which must be located very close to the drives. Space must be made available for the filters and allowance made for carefully segregated wiring. Both levels of precautions are covered in section 4.11 *Braking on page 116*.

3.2.7 Hazardous areas

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

3.3 Terminal cover removal

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

WARNING	**Stored charge** The drive contains capacitors that remain charged to a potentially lethal voltage after the AC and / or DC power supply has been disconnected. If the drive has been energized, the power supply must be isolated at least ten minutes before work may continue. Normally, the capacitors are discharged by an internal resistor. Under certain, unusual fault conditions, it is possible that the capacitors may fail to discharge, or be prevented from being discharged by a voltage applied to the output terminals. If the drive has failed in a manner that causes the display to go blank immediately, it is possible the capacitors will not be discharged. In this case, consult Control Techniques or their authorized distributor.

3.3.1 Removing the terminal covers

Figure 3-3 Location and identification of terminal covers (size 3 to 10)

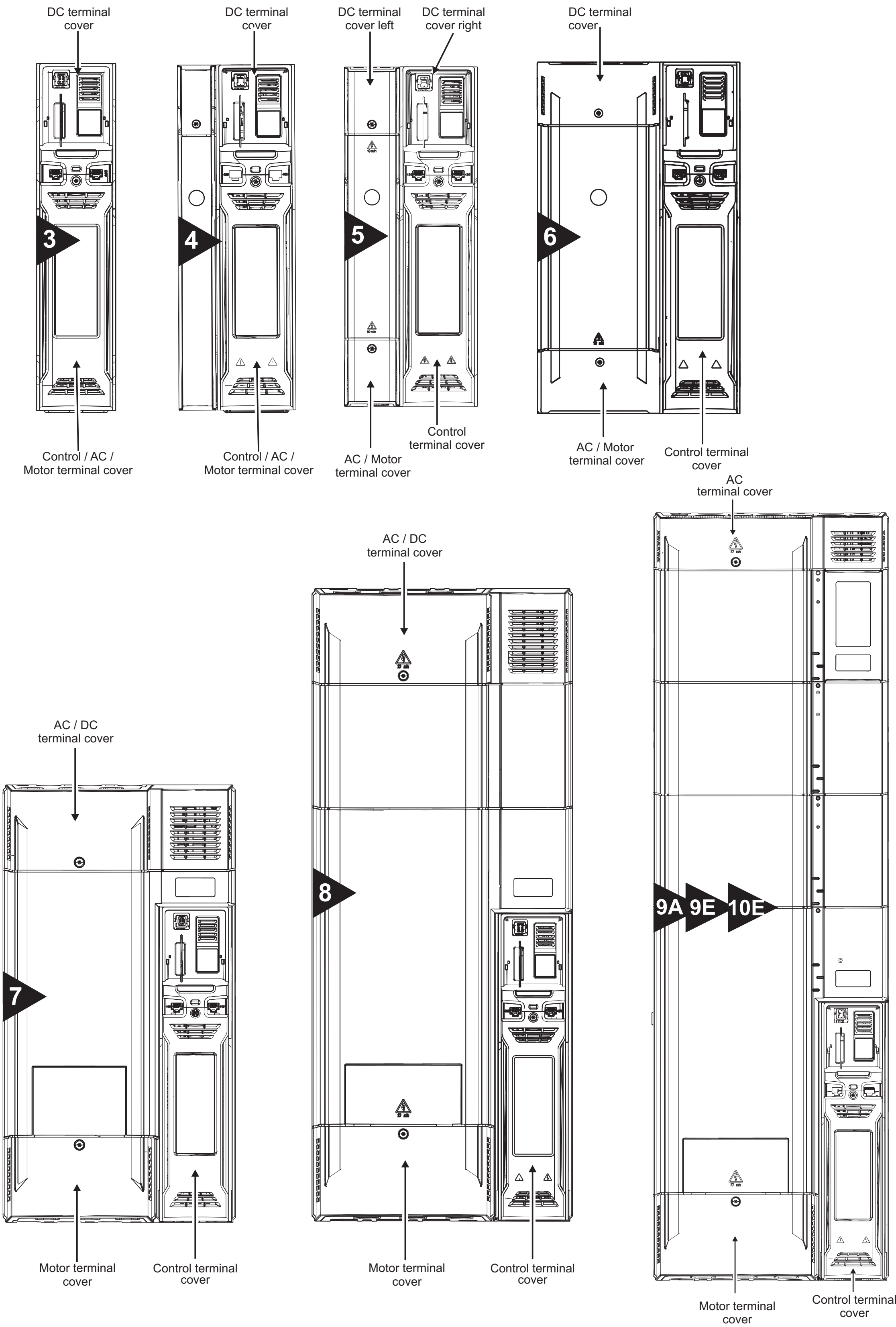


Figure 3-4 Location and identification of terminal covers (size 11)

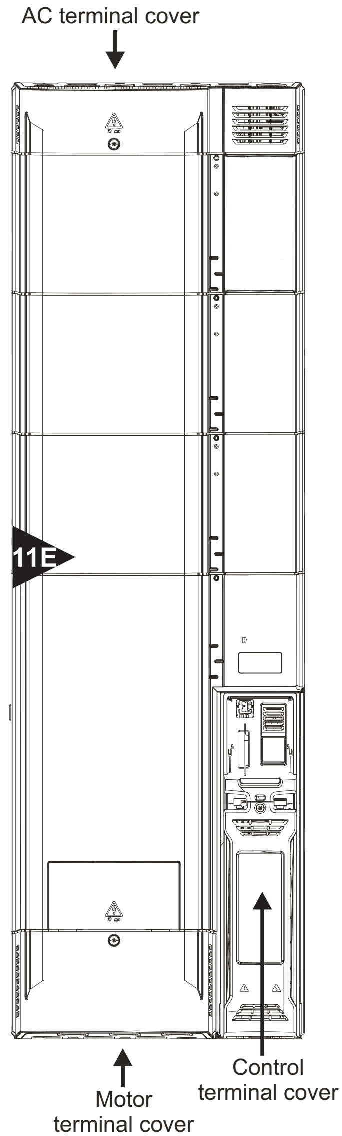
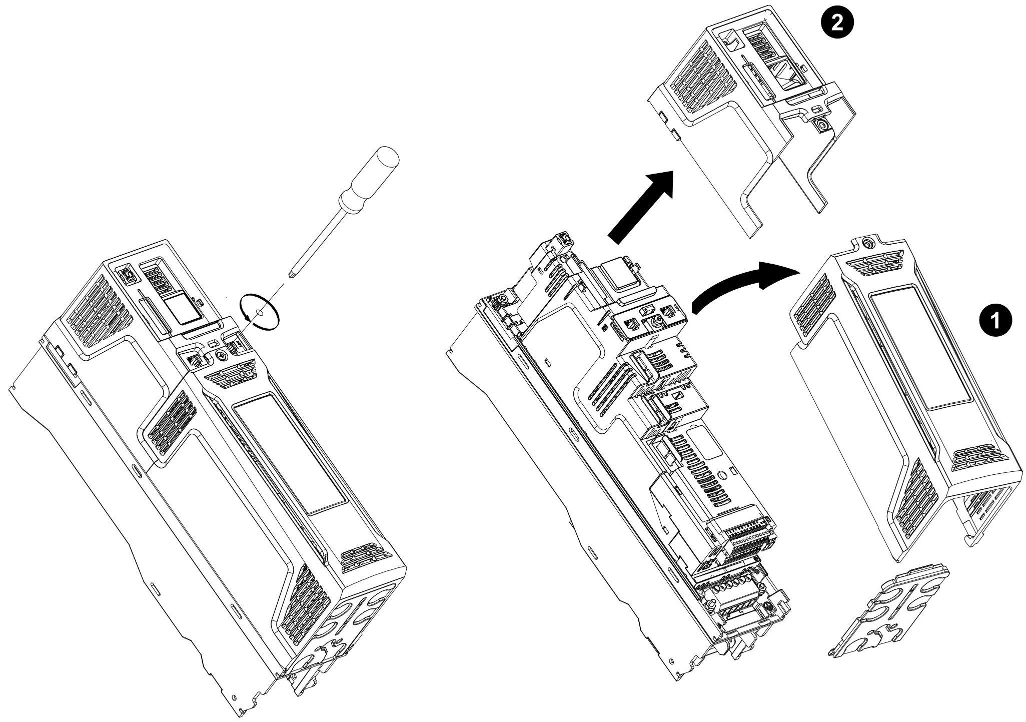


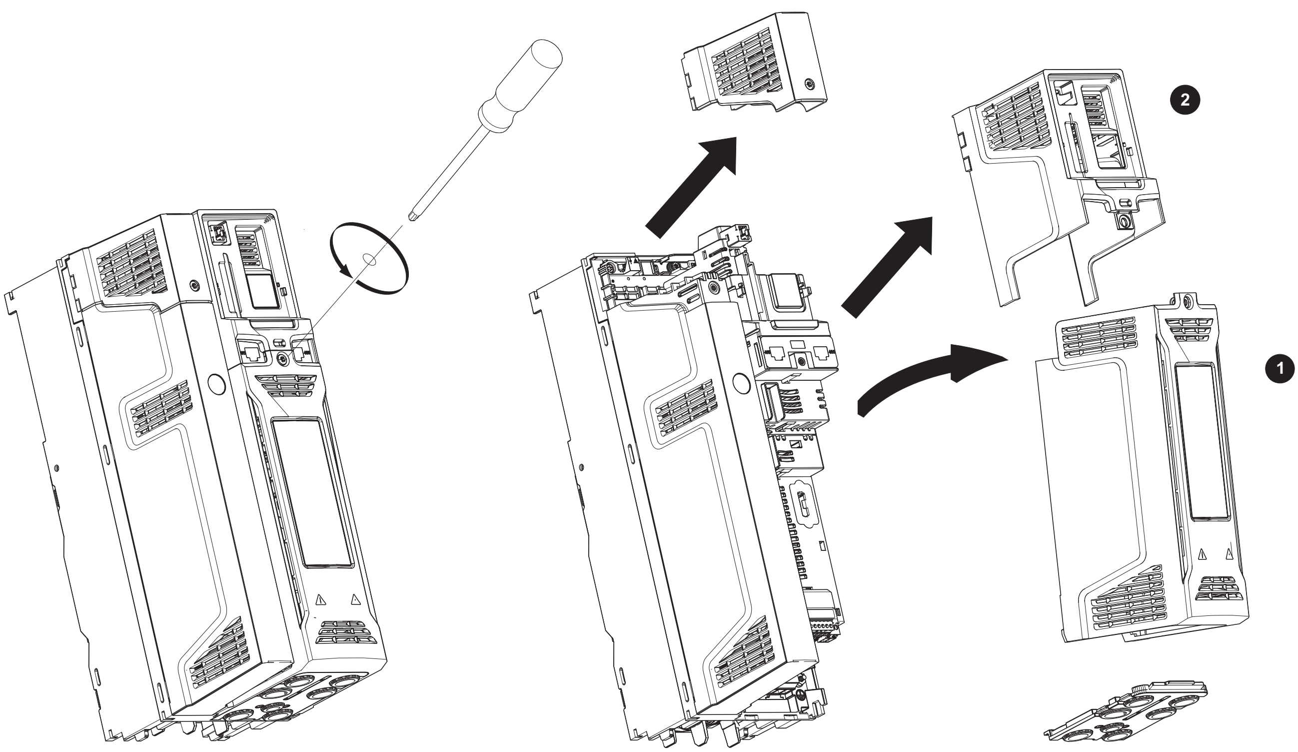
Figure 3-5 Removing the size 3 terminal covers



1. Control / AC / Motor terminal cover
2. DC cover

On size 3 drives, the Control / AC / Motor terminal cover must be removed before removal of the DC / Terminal cover. When replacing the terminal covers, the screws should be tightened to a maximum torque of 1 N m (0.7 lb ft).

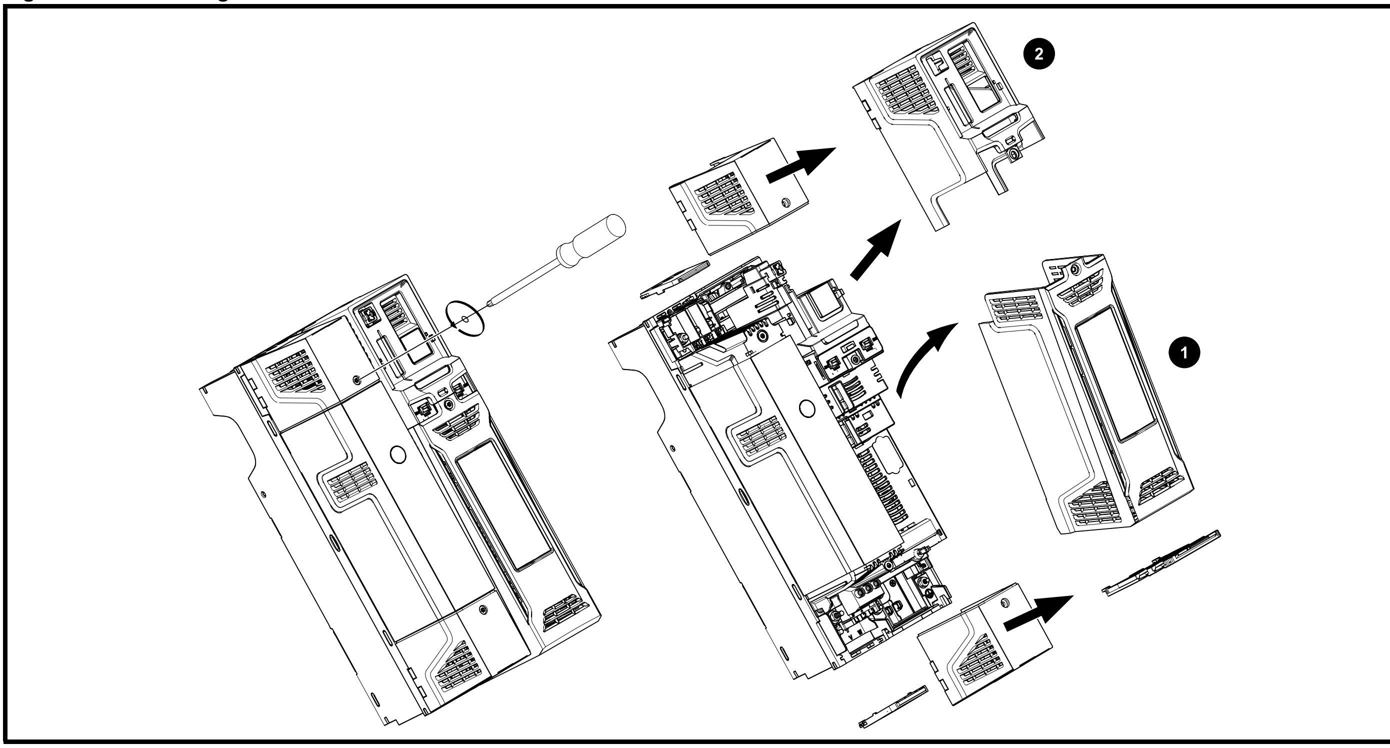
Figure 3-6 Removing the size 4 terminal covers



1. Control / AC / Motor terminal cover
2. DC cover

On size 4 drives, the Control / AC / Motor terminal cover must be removed before removal of the DC / Terminal cover. When replacing the terminal covers, the screws should be tightened to a maximum torque of 1 N m (0.7 lb ft).

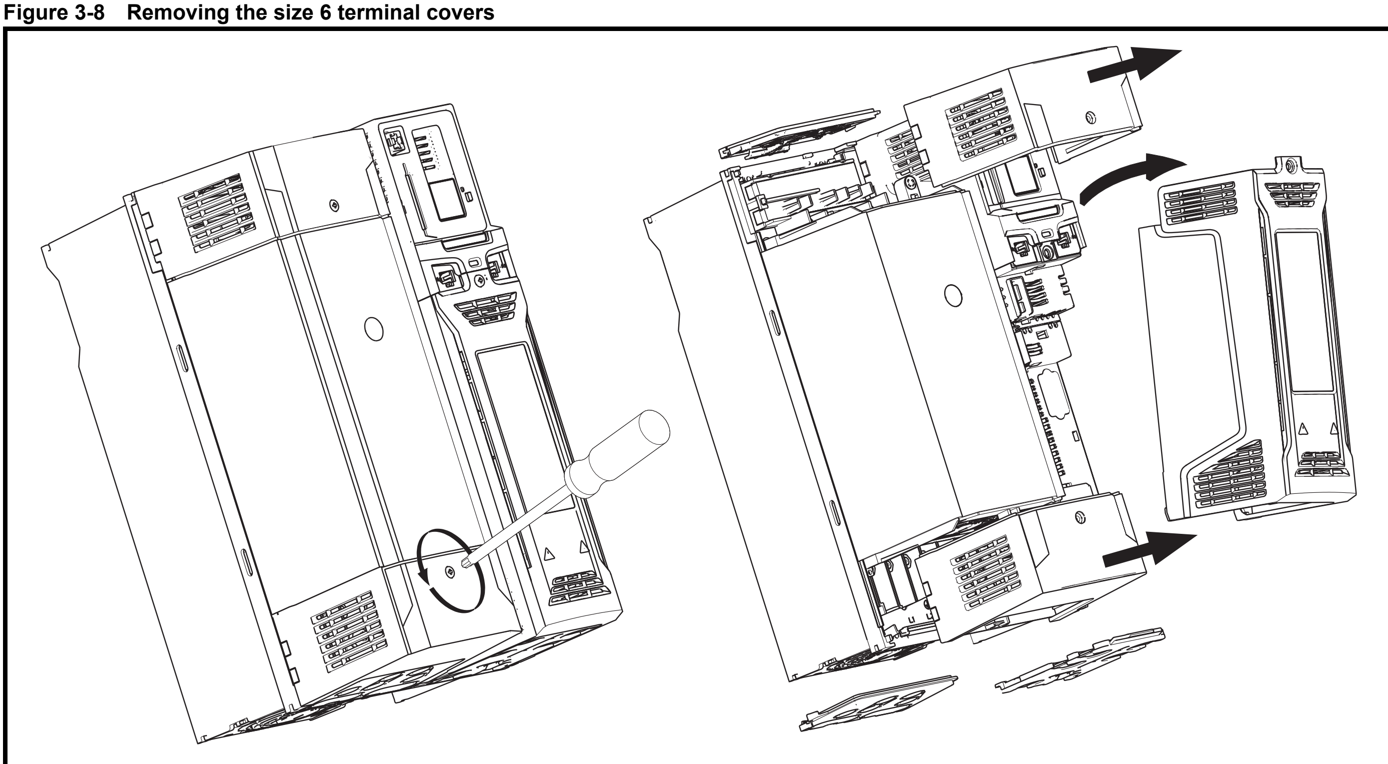
Figure 3-7 Removing the size 5 terminal covers



1. Control terminal cover
2. DC cover

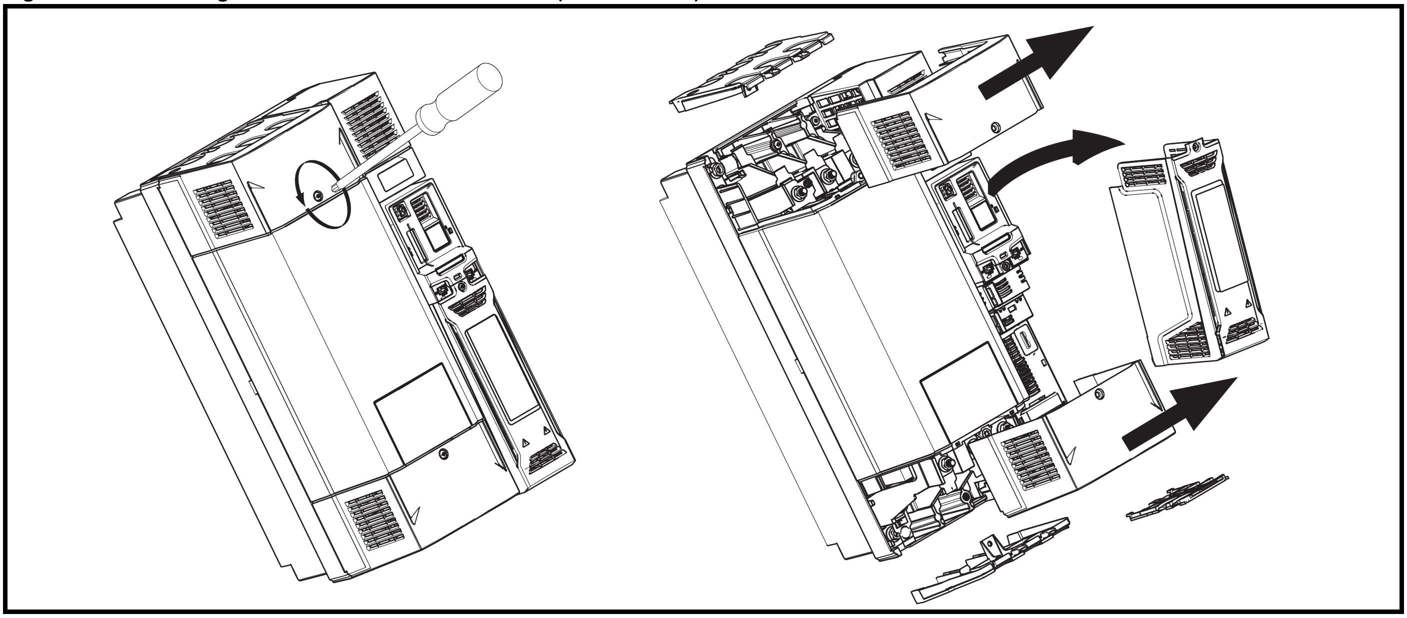
On size 5 drives, the Control terminal cover must be removed before removal of the DC / Terminal cover right. When replacing the terminal covers, the screws should be tightened to a maximum torque of 1 N m (0.7 lb ft).

Figure 3-8 Removing the size 6 terminal covers



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

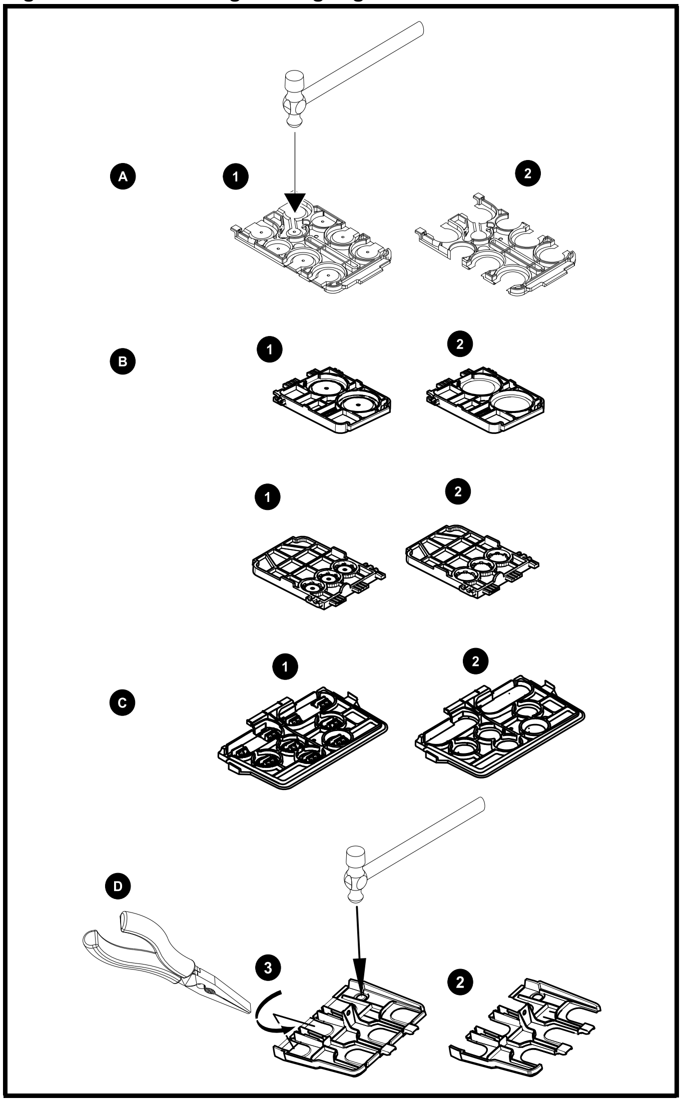
Figure 3-9 Removing the size 7 to 11 terminal covers (size 7 shown)



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

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

Figure 3-10 Removing the finger-guard break-outs



A: All sizes. B: Size 5 only. C: Size 6 only. D: Size 7 to 10.

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

Grommet kits are available for size 7 to 10 finger guards. For size 8 to 10, two versions are available allowing for either single or double cable entries.

Table 3-1 Grommet kits

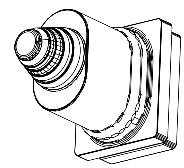
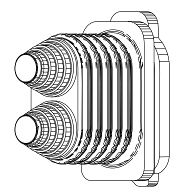
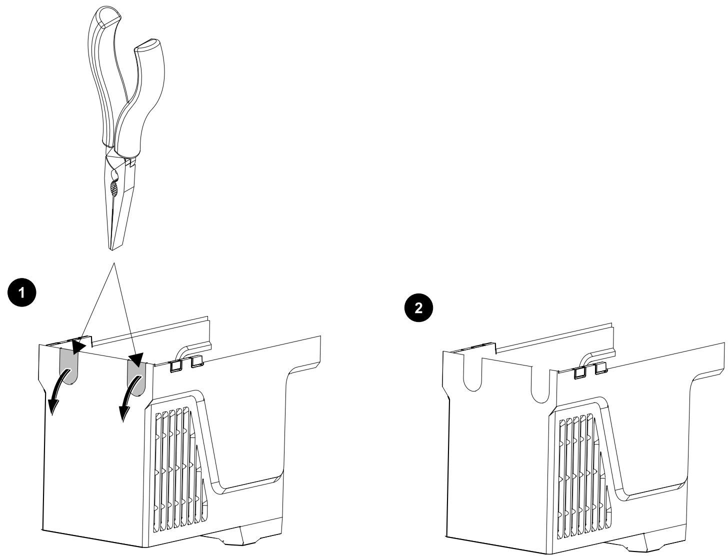
Drive size	Quantity of kits	Part number	Picture
Size 7 - Kit of 8 x single entry grommets	1	3470-0086	
Size 8 - Kit of 8 x single entry grommets	1	3470-0089	
Size 8 - Kit of 8 x double entry grommets	1	3470-0090	
Size 9E and 10E - Kit of 8 x double entry grommets	1	3470-0107	
Size 11E- Kit of 8 x double entry grommets	2		

Figure 3-11 Removing the size 3 and 4 DC terminal cover break-outs



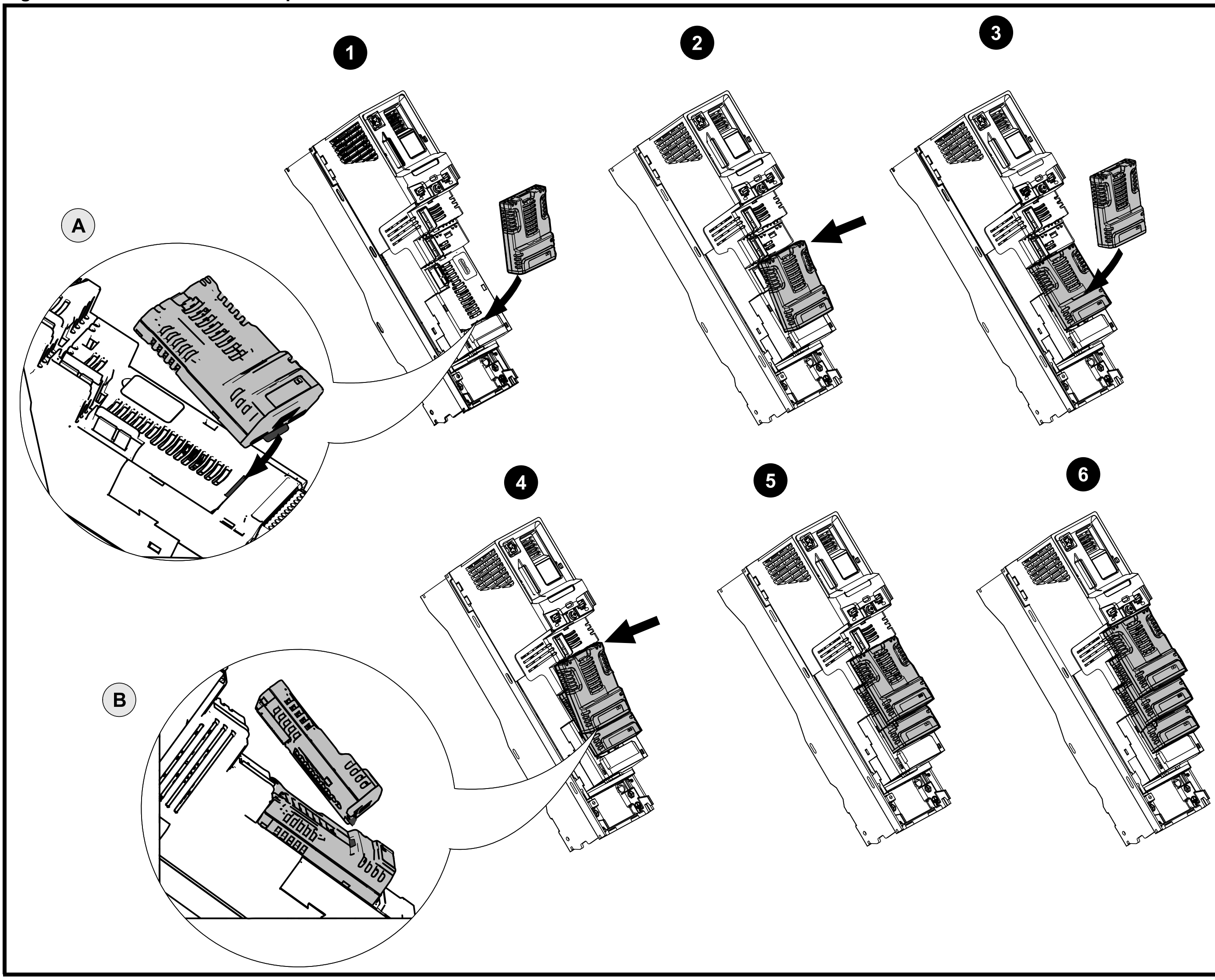
Grasp the DC terminal cover break-outs with pliers as shown (1) and pull down in the direction shown to remove. Continue until all required break-outs are removed (2). Remove any flash / sharp edges once the break-outs are removed. Use the DC terminal cover grommets supplied in the accessory box (Table 2-9 on page 26) to maintain the seal at the top of the drive.

3.4 Installing / removing option modules and keypads

CAUTION

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

Figure 3-12 Installation of an option module



Installing the first option module

NOTE

Option module slots must be used in the following order: slot 3, slot 2 and slot 1 (refer to Figure 2-2 *Features of the drive (size 3 to 10)* on page 20 for slot numbers).

- Move the option module in direction shown (1).
- Align and insert the option module tab in to the slot provided (2), this is highlighted in the detailed view (A).
- Press down on the option module until it clicks into place.

Installing the second option module

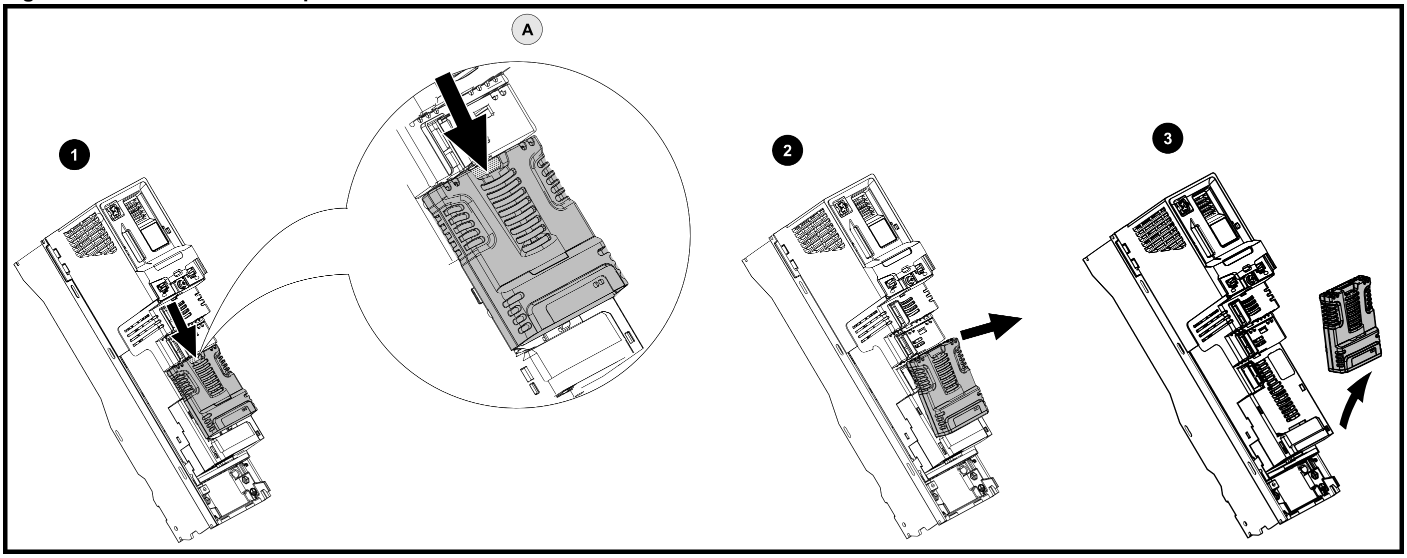
- Move the option module in direction shown (3).
- Align and insert the option module tab in to the slot provided on the already installed option module (4), this is highlighted in the detailed view (B).
- Press down on the option module until it clicks into place. Image (5) shows two option modules fully installed.

Installing the third option module

- Repeat the above process.

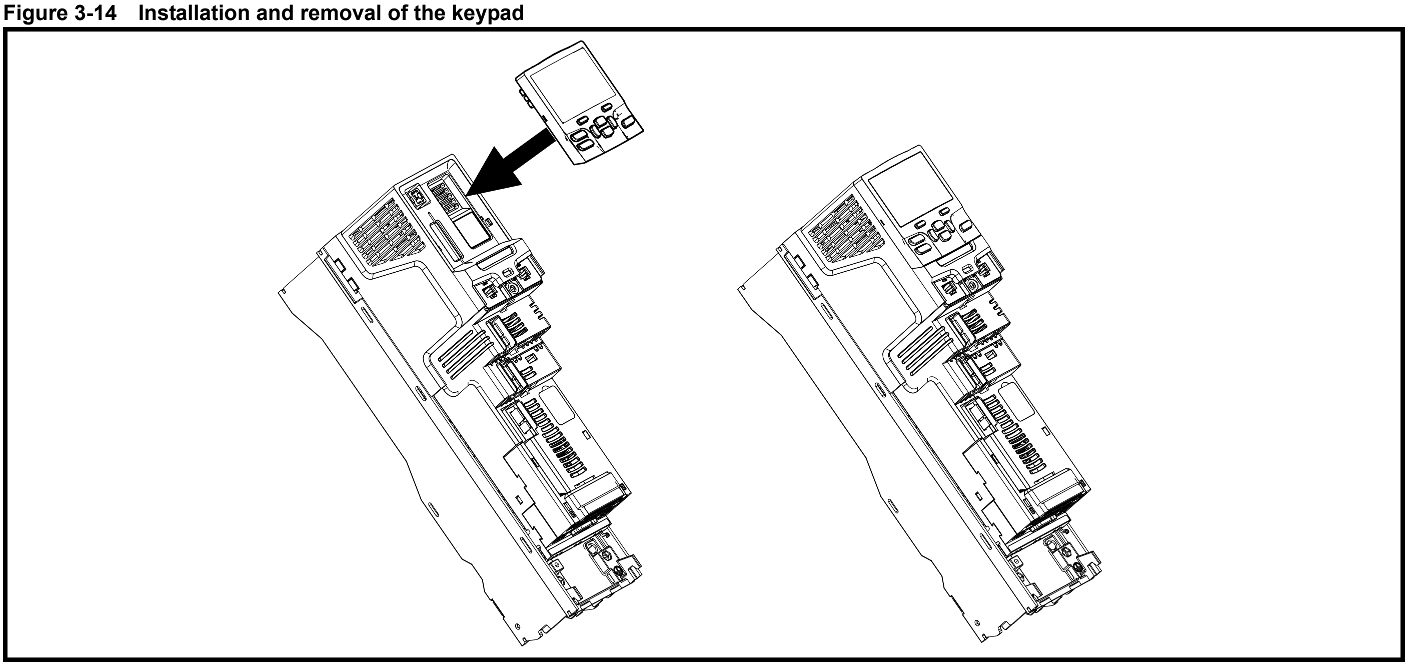
The drive has the facility for all three option module slots to be used at the same time, image (6) shows the three option modules installed.

Figure 3-13 Removal of an option module



- Press down on the tab (1) to release the option module from the drive housing, the tab is highlighted in the detailed view (A).
- Tilt the option module towards you as shown (2).
- Totally remove the option module in direction shown (3).

Figure 3-14 Installation and removal of the keypad



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

To remove, reverse the installation instructions.

NOTE

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

3.5 Dimensions and mounting methods

The drive can be either surface or through-panel mounted using the appropriate brackets. The following drawings show the dimensions of the drive and mounting holes for each method to allow a back plate to be prepared.

The Through-panel mounting kit is not supplied with the drive and can be purchased separately, below are the relevant part numbers:

Size	CT part number
3	3470-0053
4	3470-0056
5	3470-0067
6	3470-0055
7	3470-0079
8	3470-0083
9A	3470-0119
9E/10E	3470-0105
11E	3470-0126

WARNING

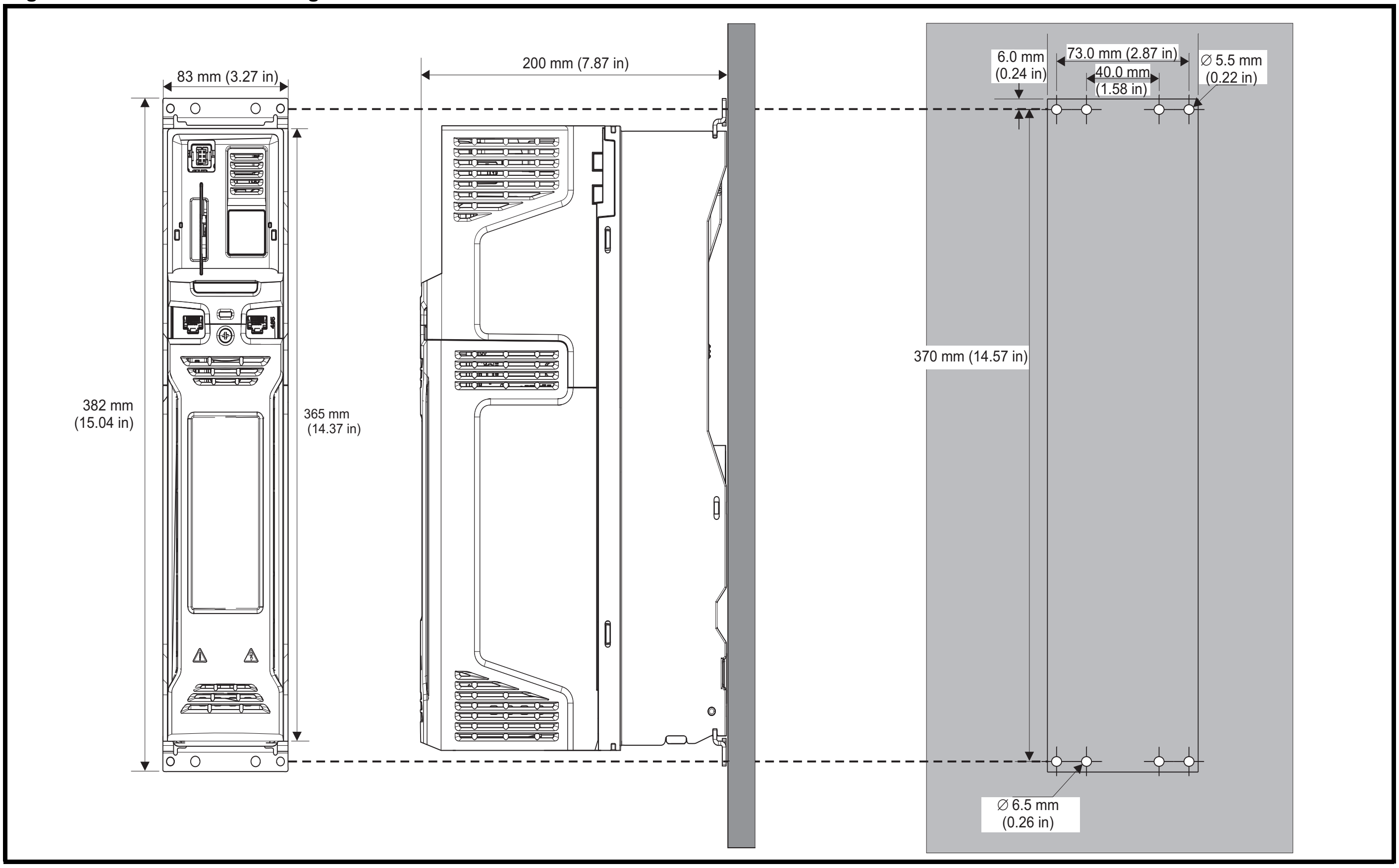
If the drive has been used at high load levels for a period of time, the heatsink can reach temperatures in excess of 70 °C (158 °F). Human contact with the heatsink should be prevented.

WARNING

Many of the drives in this product range weigh in excess of 15 kg (33 lb). Use appropriate safeguards when lifting these models. A full list of drive weights can be found in section 11.1.19 *Weights* on page 408.

3.5.1 Surface mounting

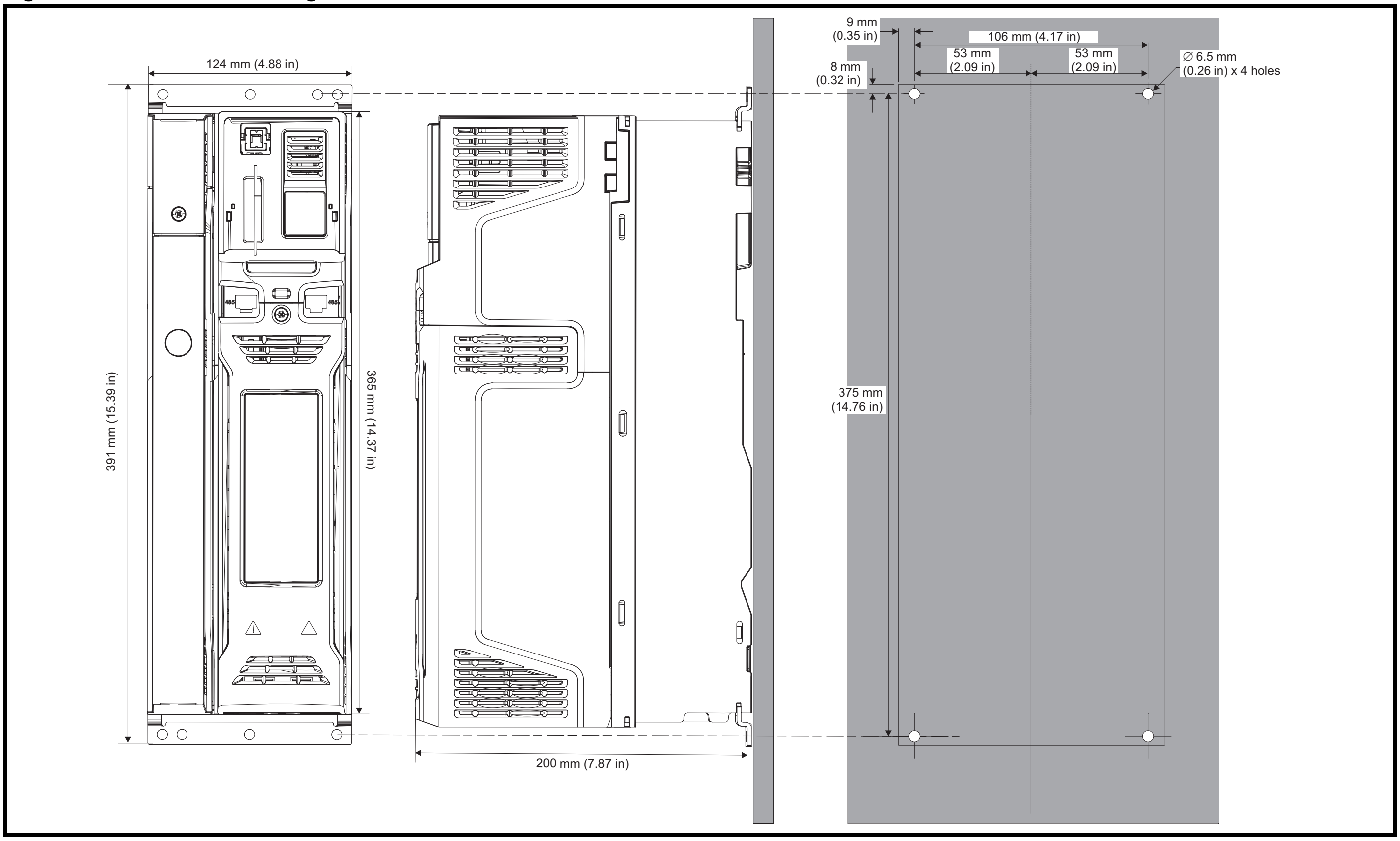
Figure 3-15 Surface mounting the size 3 drive



NOTE

Each mounting bracket contains 4 mounting holes, the outer holes (5.5 mm) x 2 should be used for mounting the drive to the backplate as this allows the heatsink fan to be replaced without removing the drive from the backplate. The inner holes (6.5 mm) x 2 are used for Unidrive SP size 1 retrofit applications. See Table 3-2 for further information.

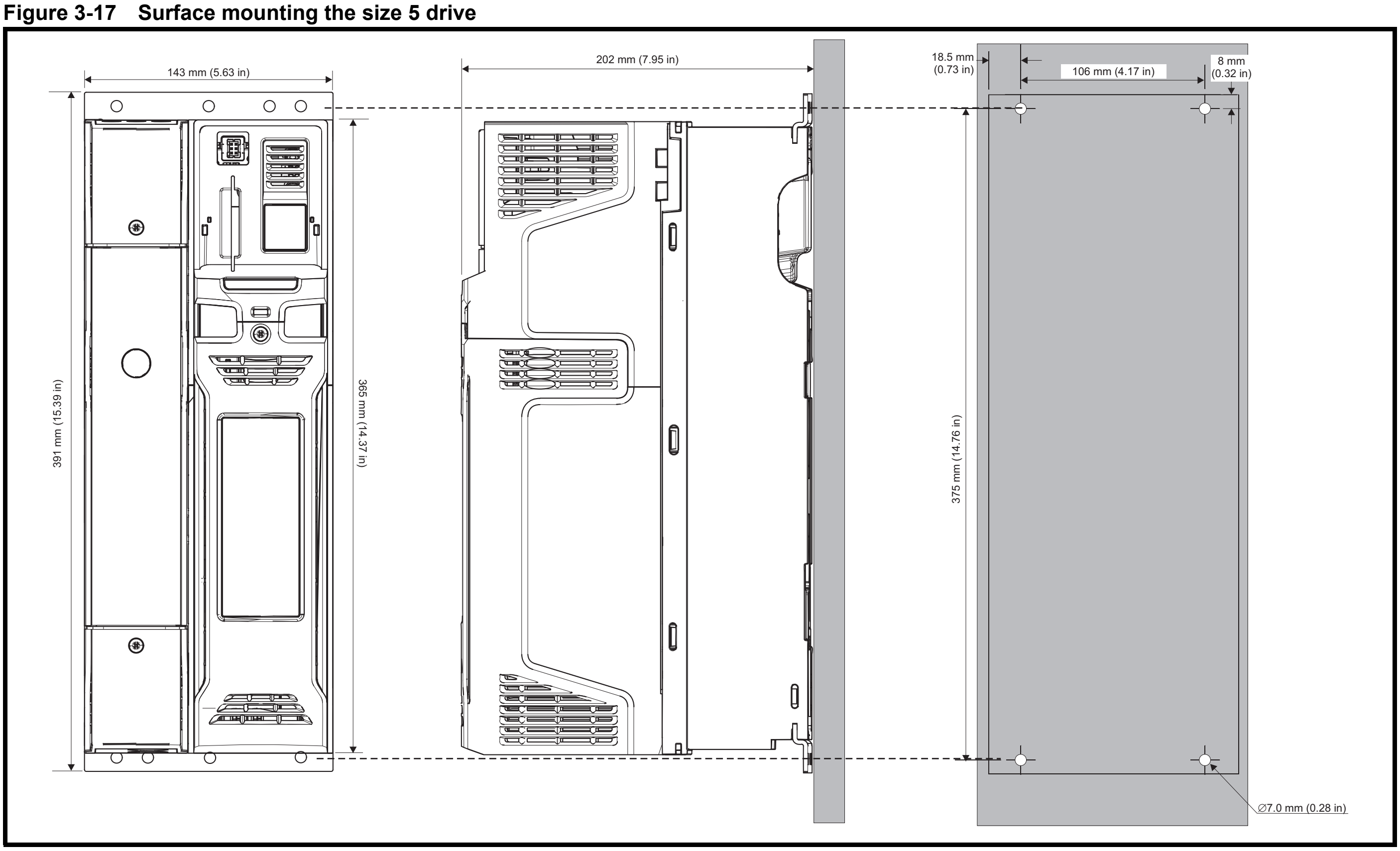
Figure 3-16 Surface mounting the size 4 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-2 for further information.

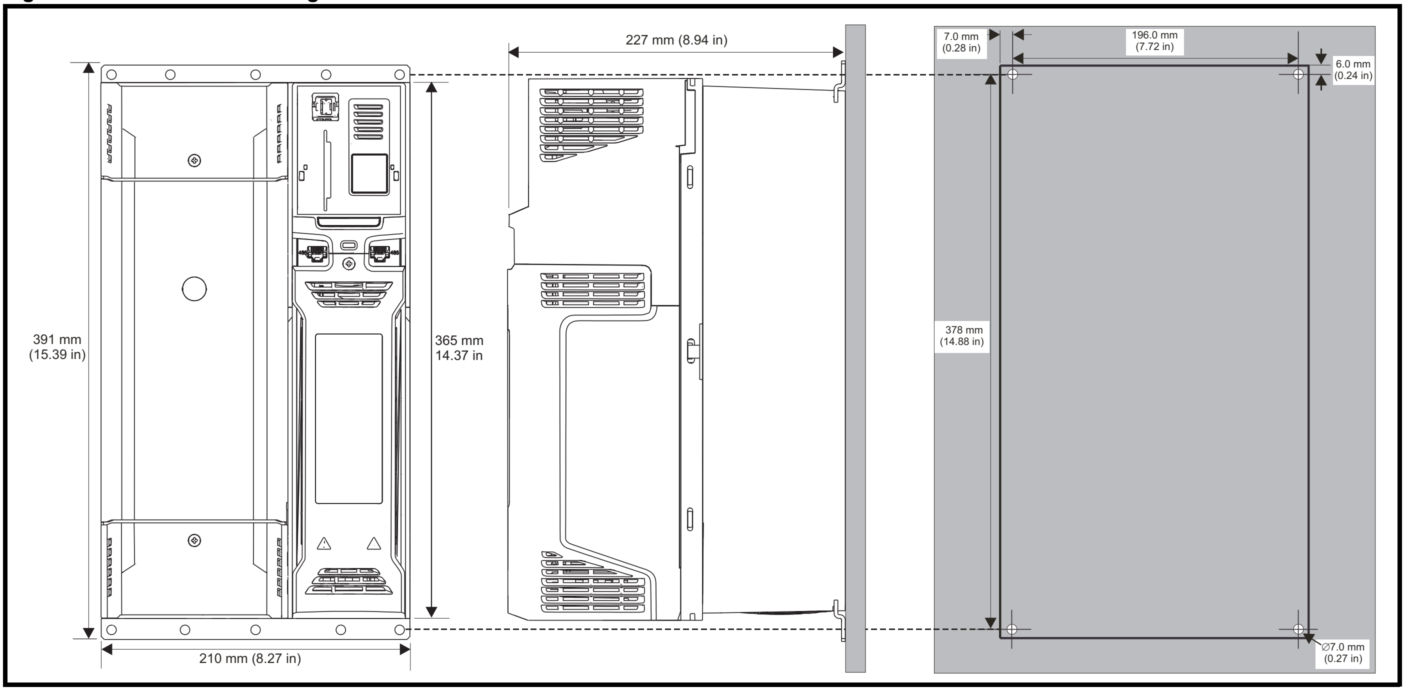
Figure 3-17 Surface mounting the size 5 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-2 for further information.

Figure 3-18 Surface mounting the size 6 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-2 for further information.

Figure 3-19 Surface mounting the size 7 drive

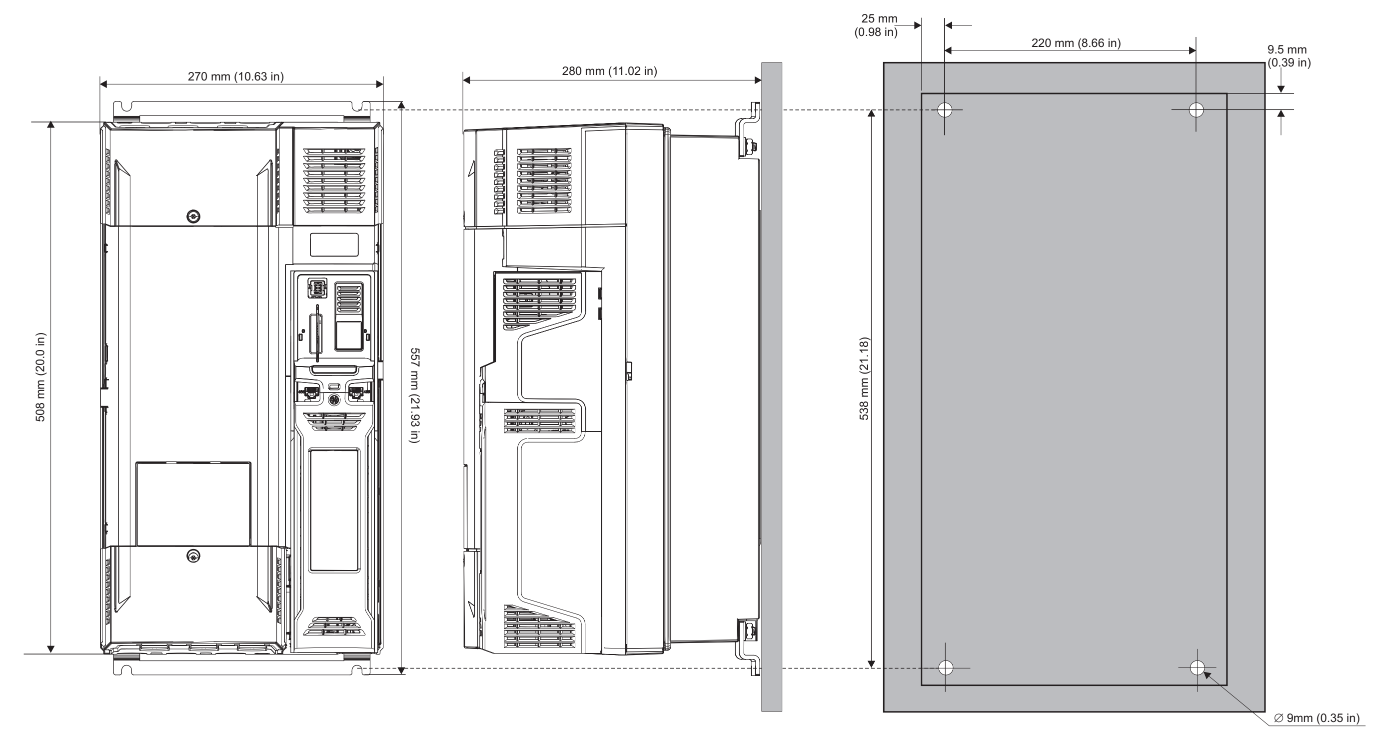


Figure 3-20 Surface mounting the size 8 drive

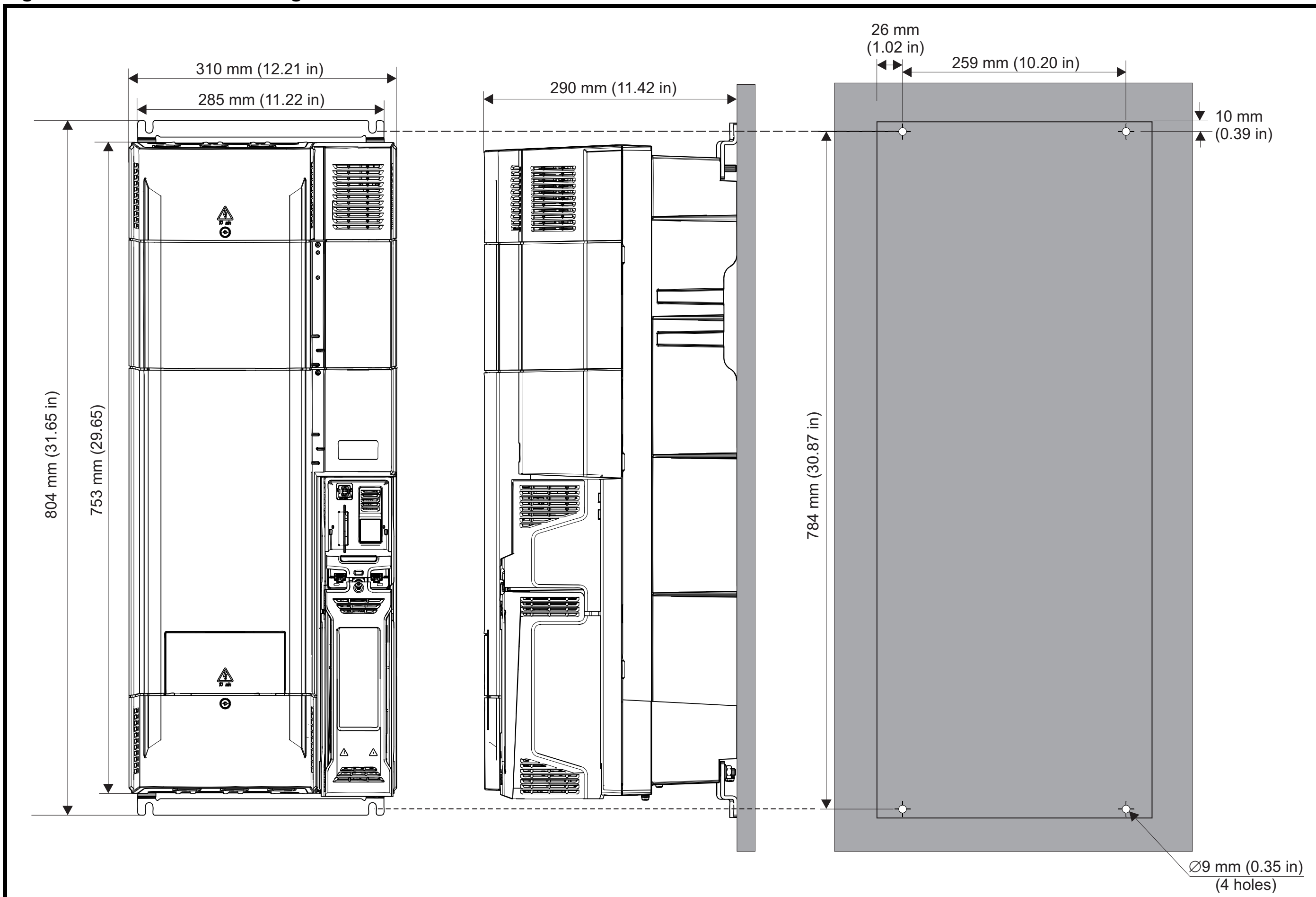


Figure 3-21 Surface mounting the size 9A drive

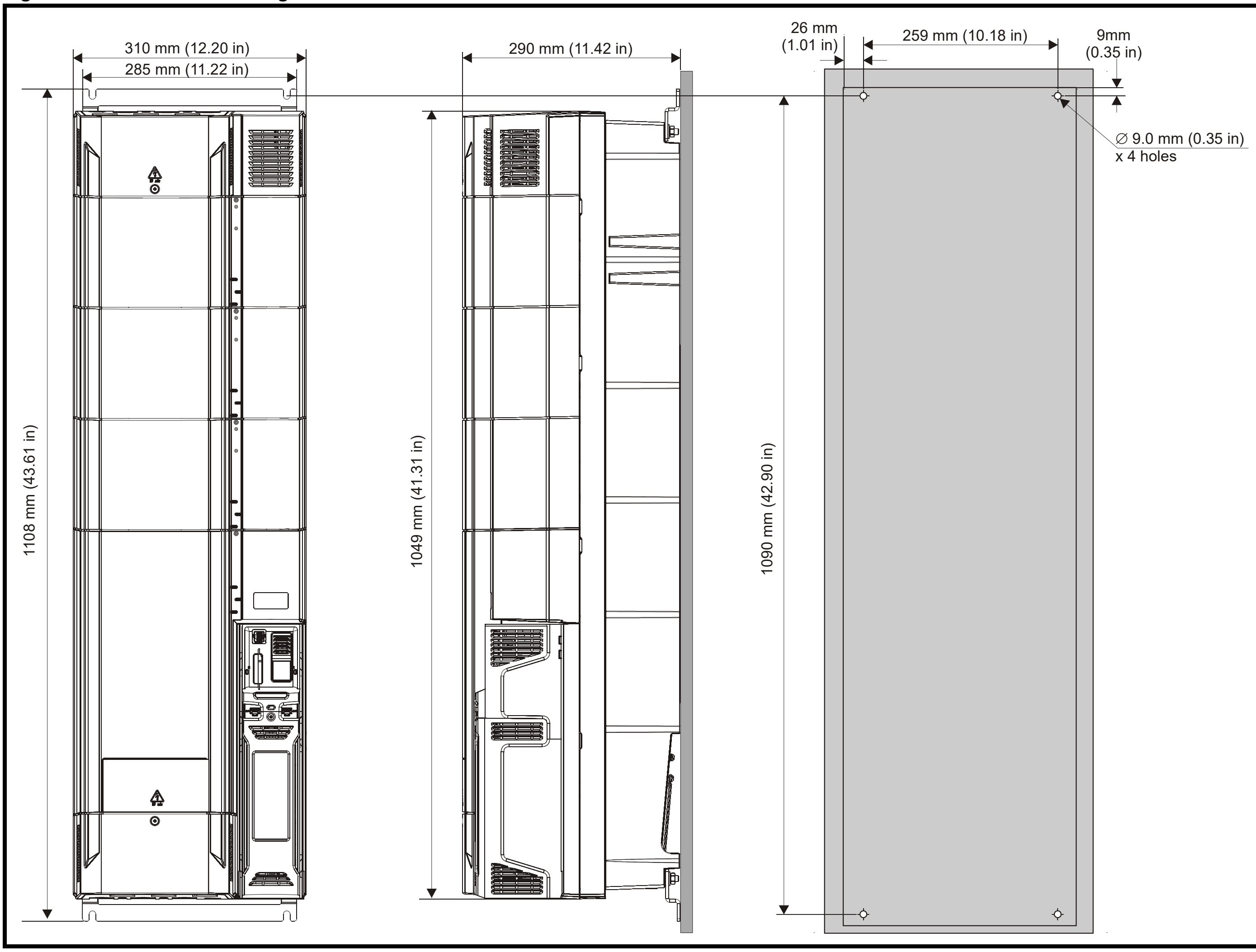


Figure 3-22 Surface mounting the size 9E and 10E

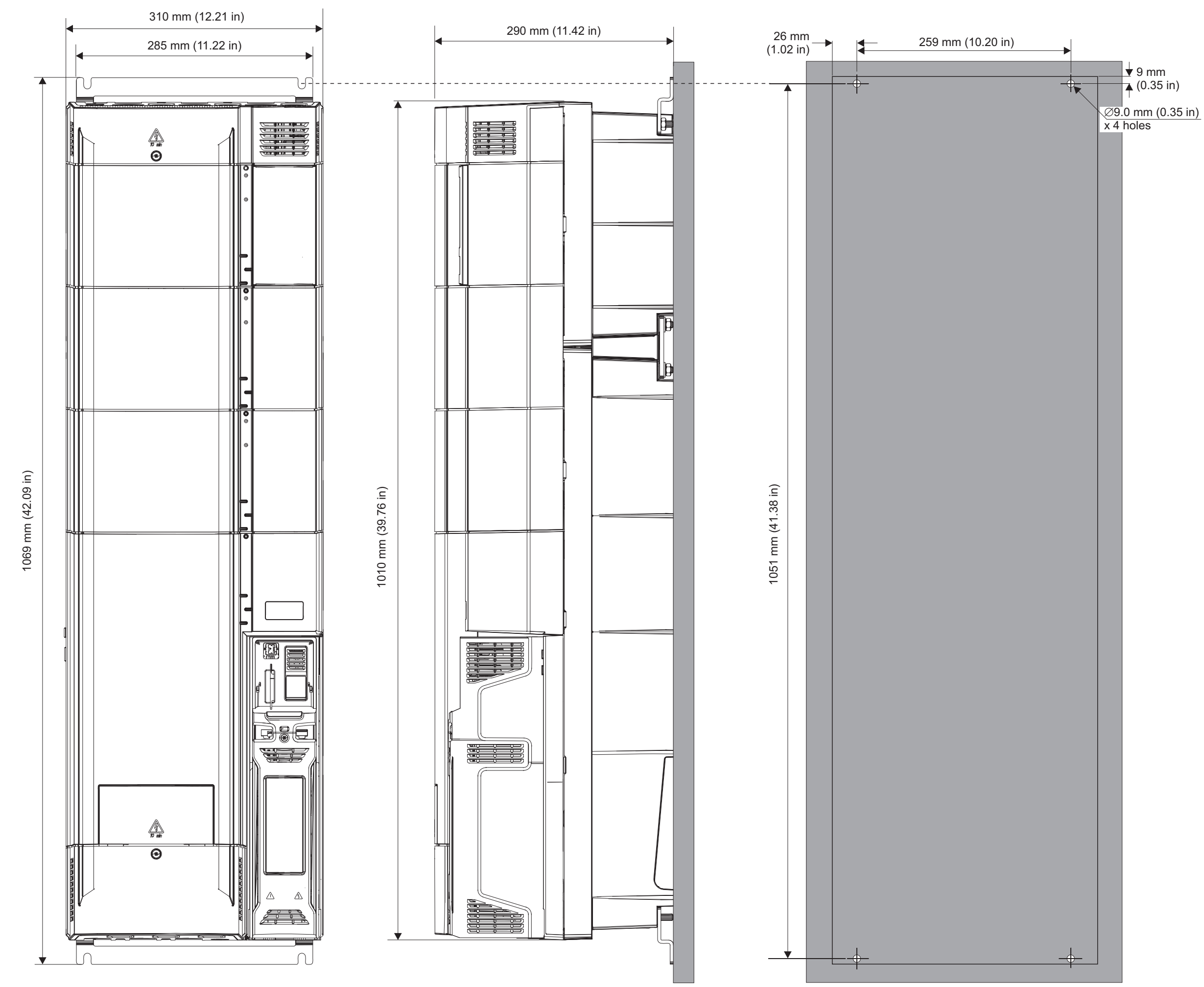
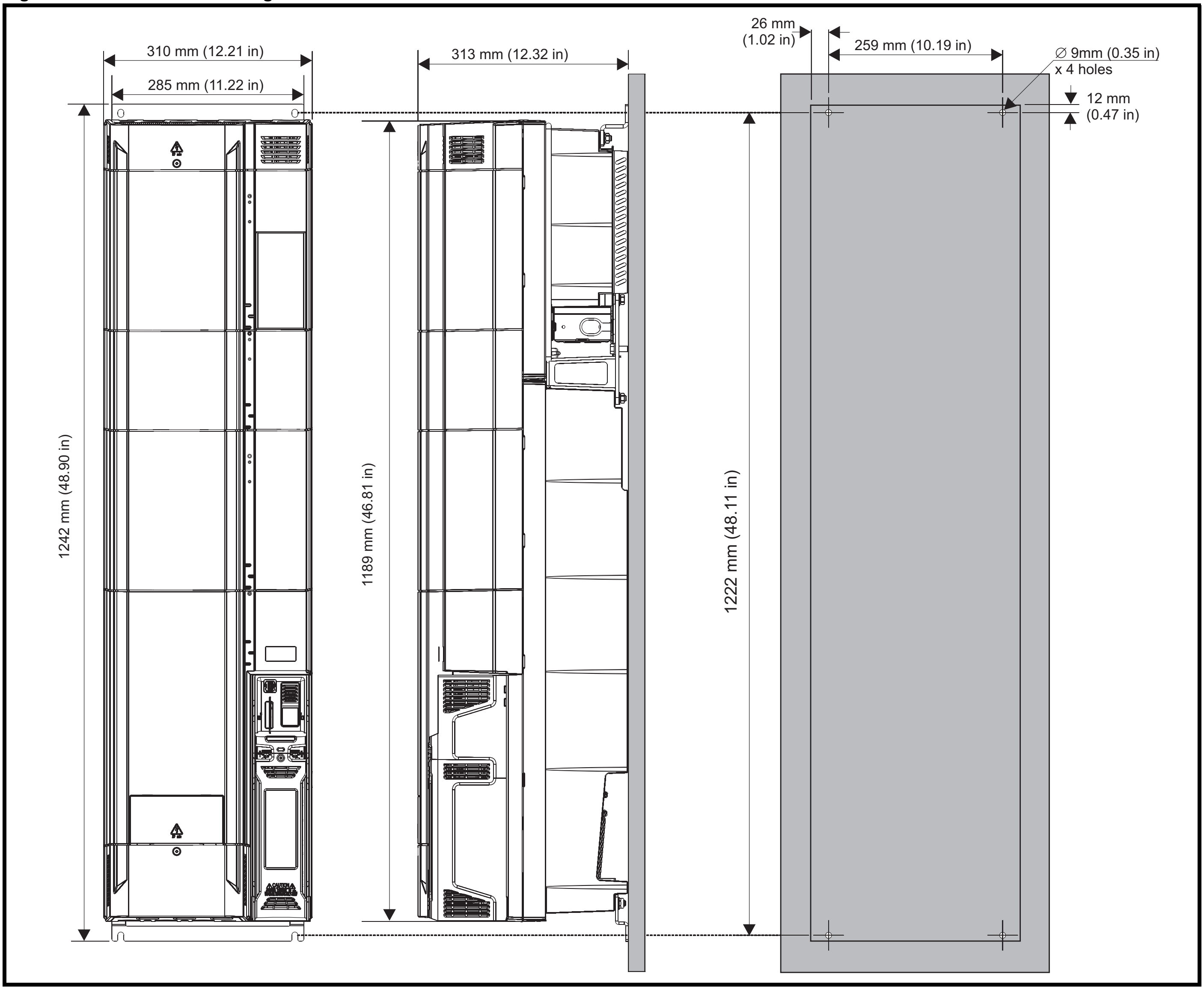


Figure 3-23 Surface mounting the size 11E



3.5.2 Through-panel mounting

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

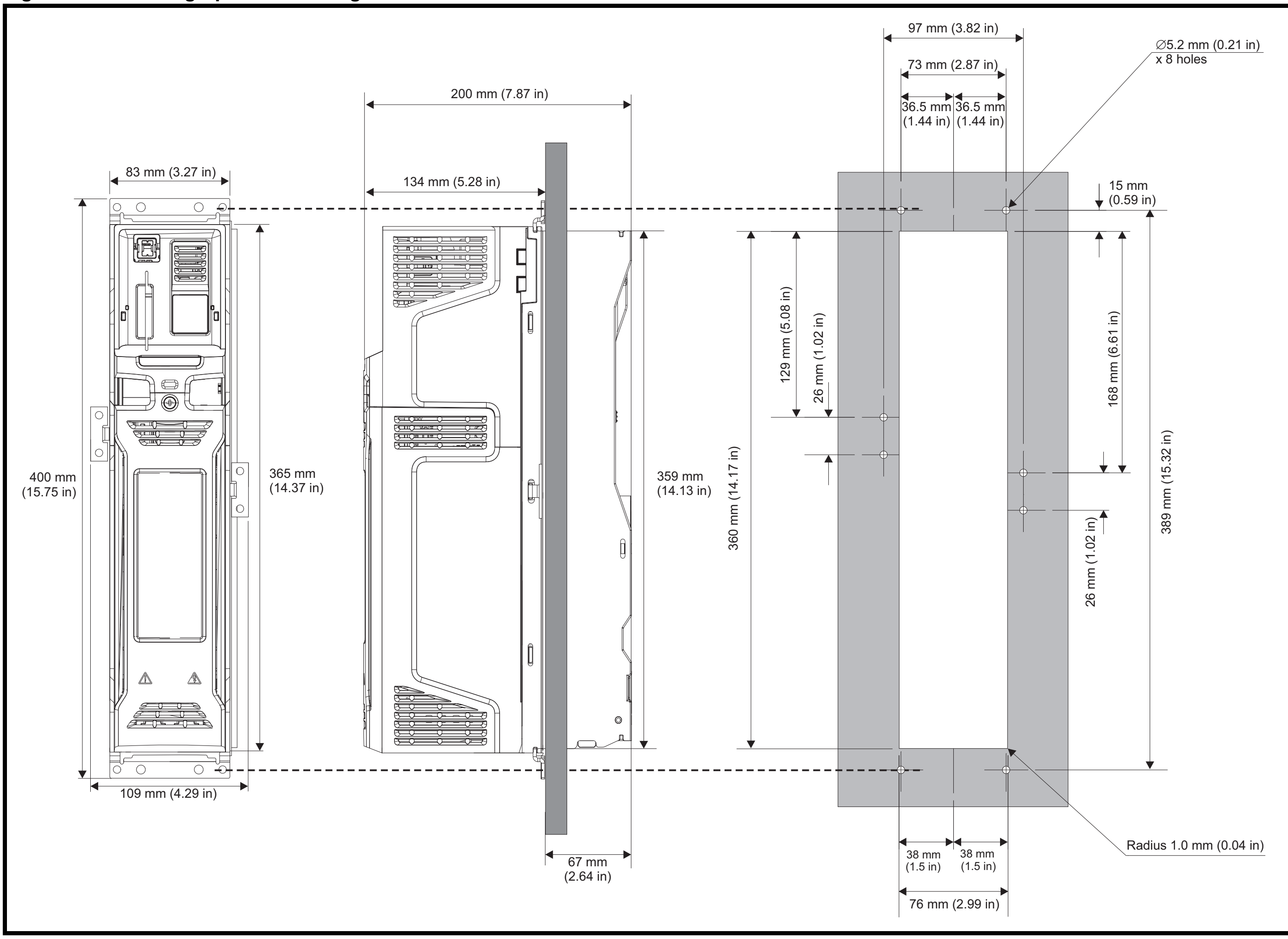


Figure 3-25 Through panel mounting the size 4 drive

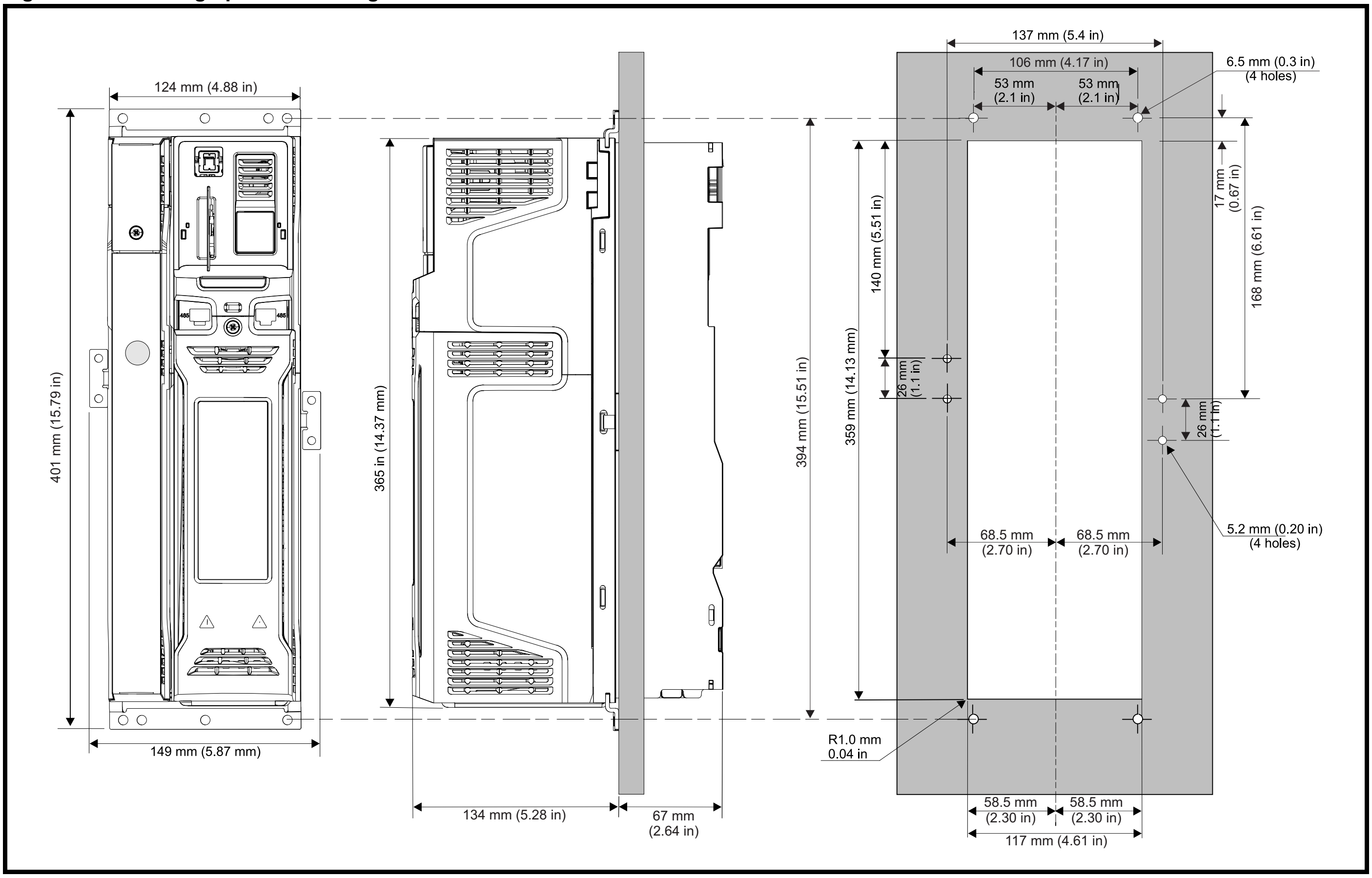


Figure 3-26 Through panel mounting the size 5 drive

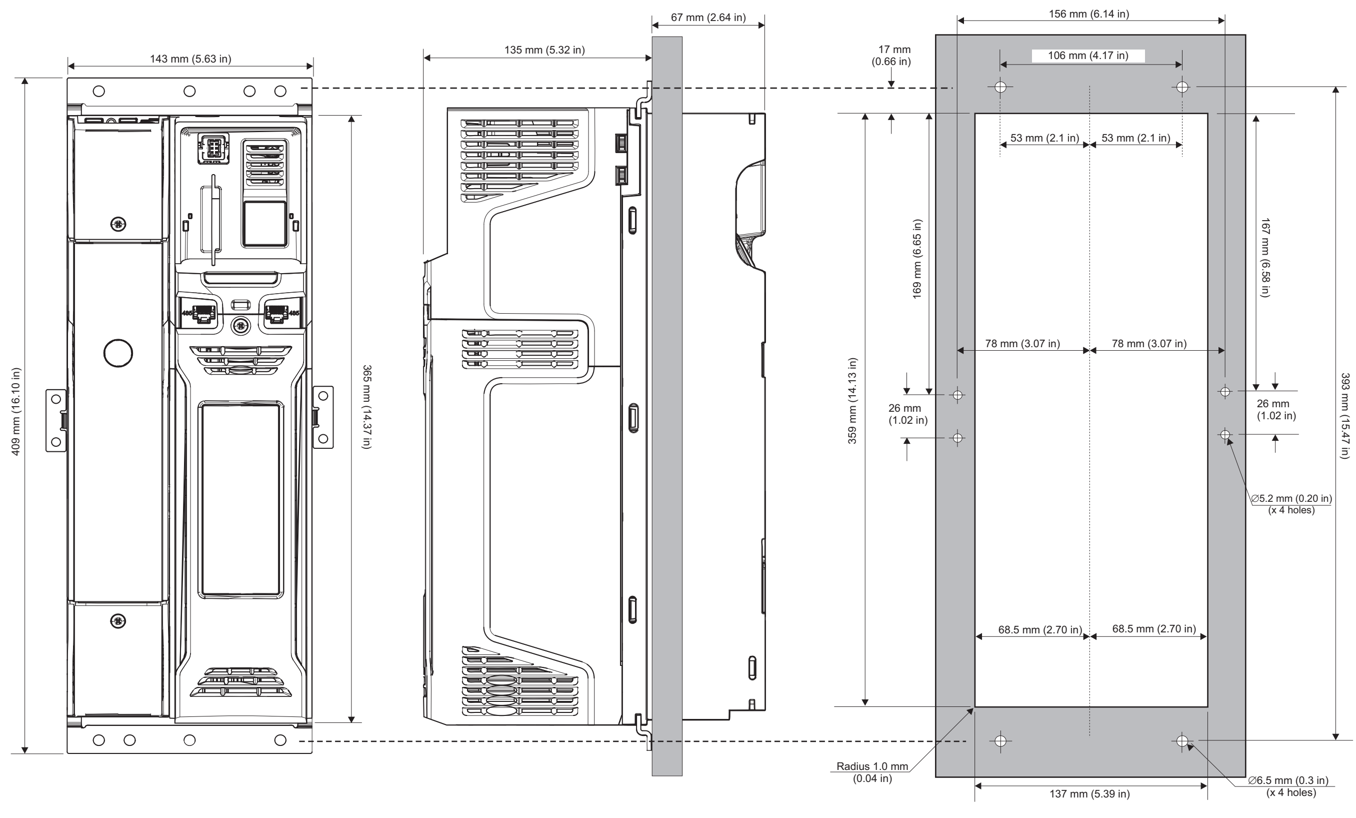
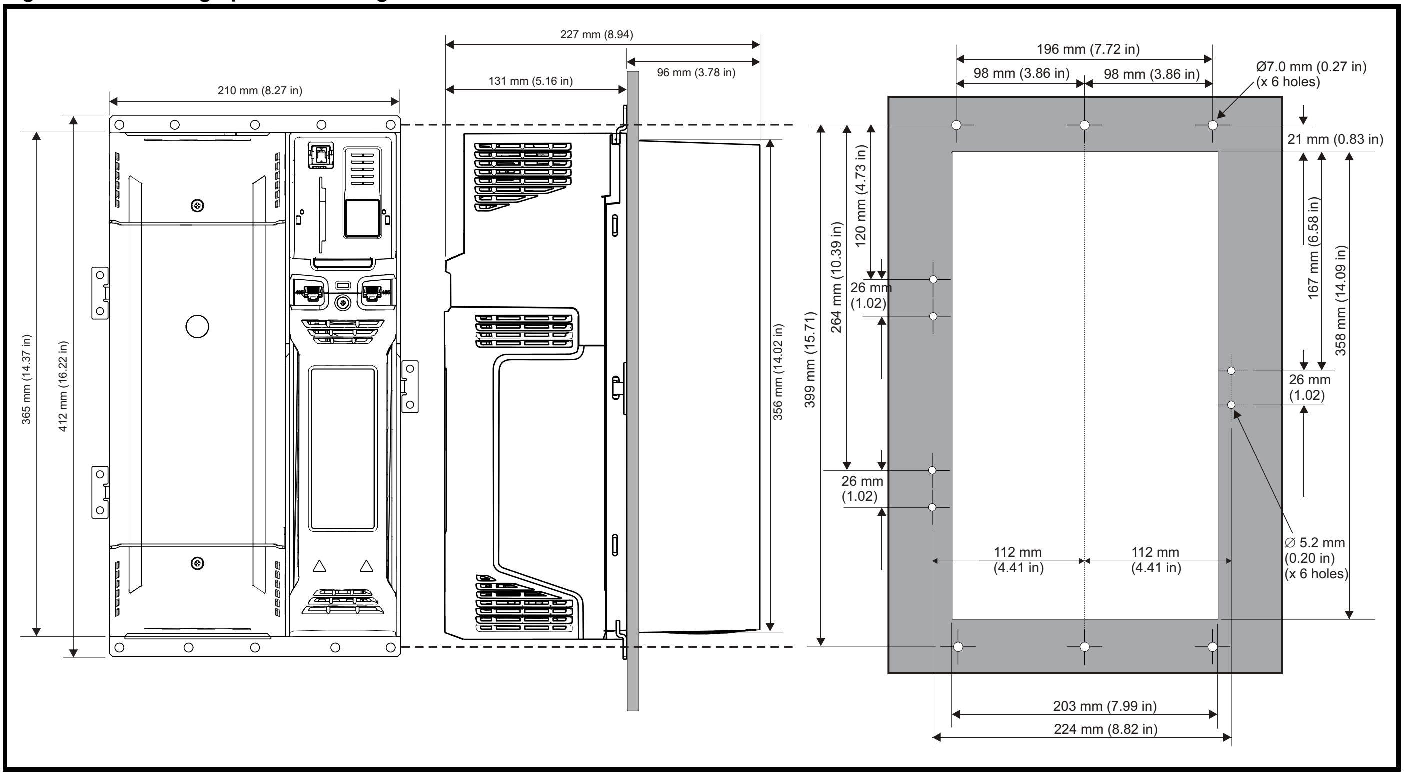


Figure 3-27 Through panel mounting the size 6 drive



NOTE

The outer holes plus the hole located in the center of the bracket are to be used for through panel mounting.

Figure 3-28 Through panel mounting the size 7 drive

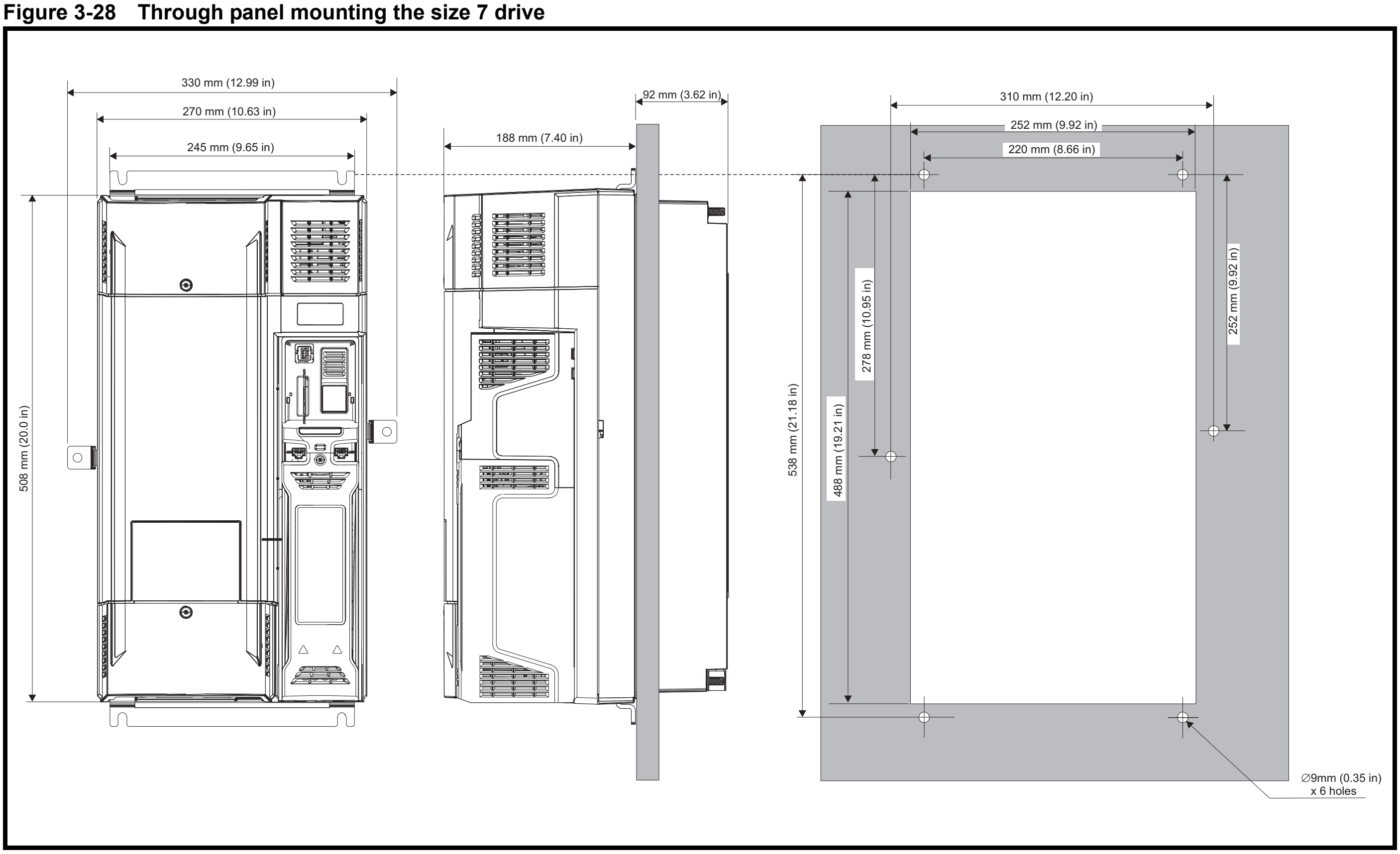


Figure 3-29 Through panel mounting the size 8 drive

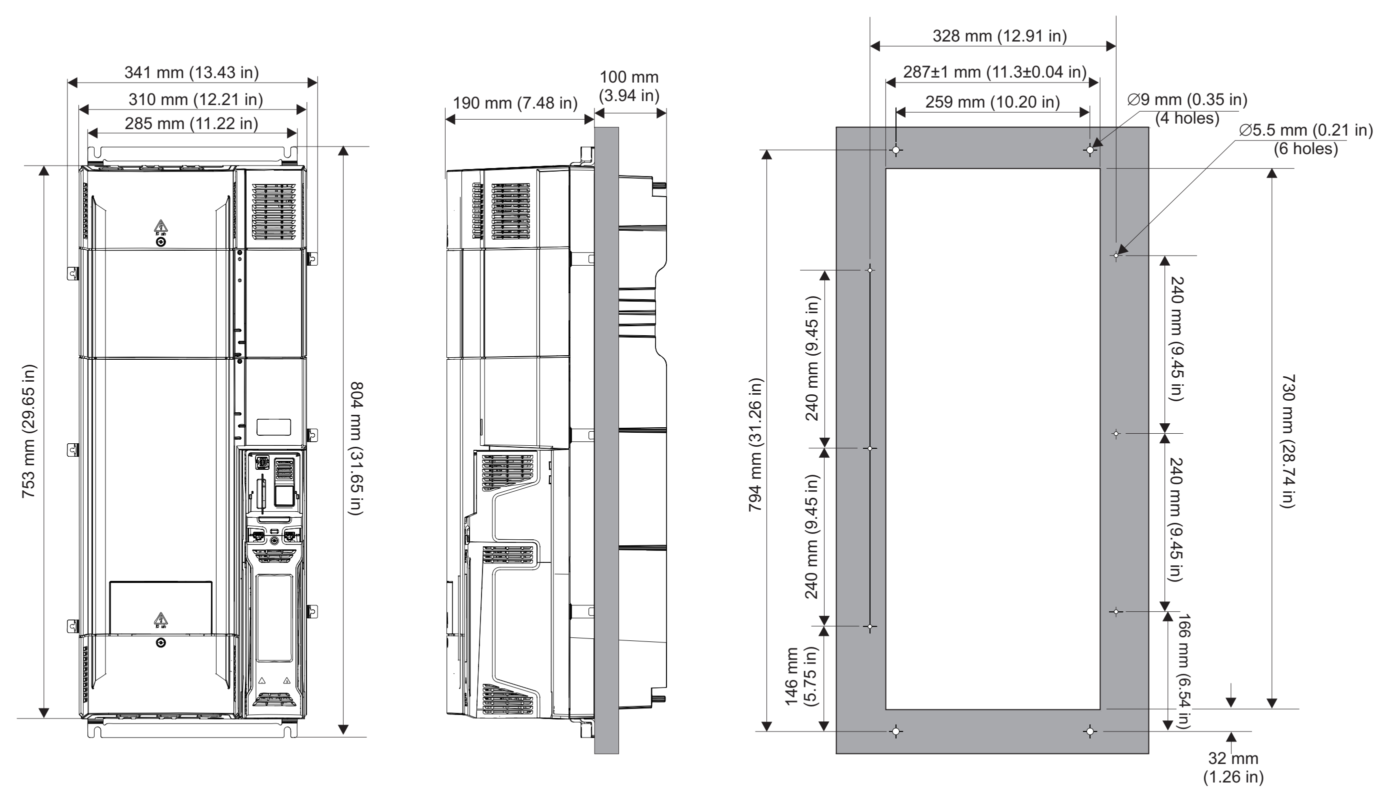


Figure 3-30 Through-panel mounting the size 9A

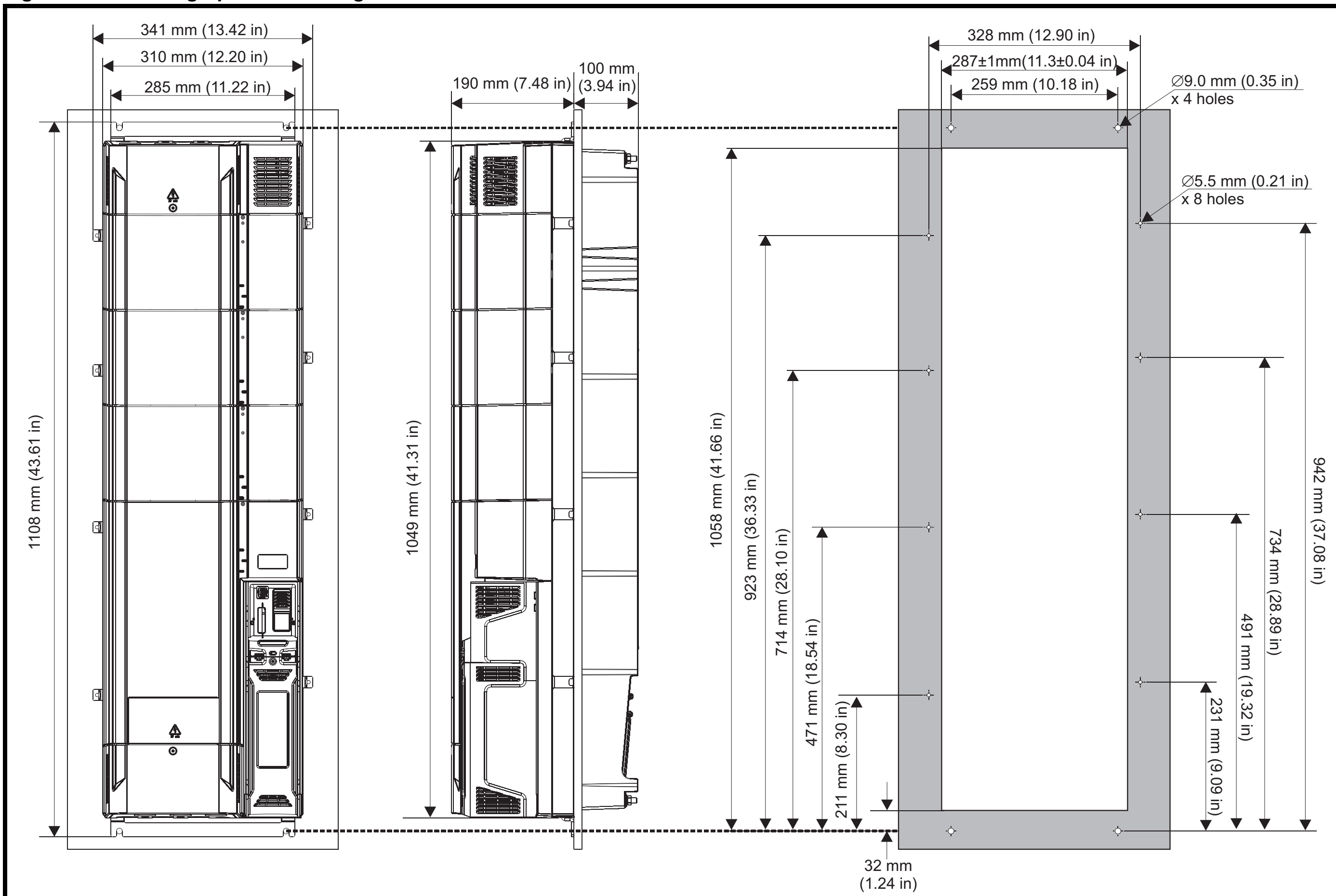


Figure 3-31 Through-panel mounting the size 9E and 10E

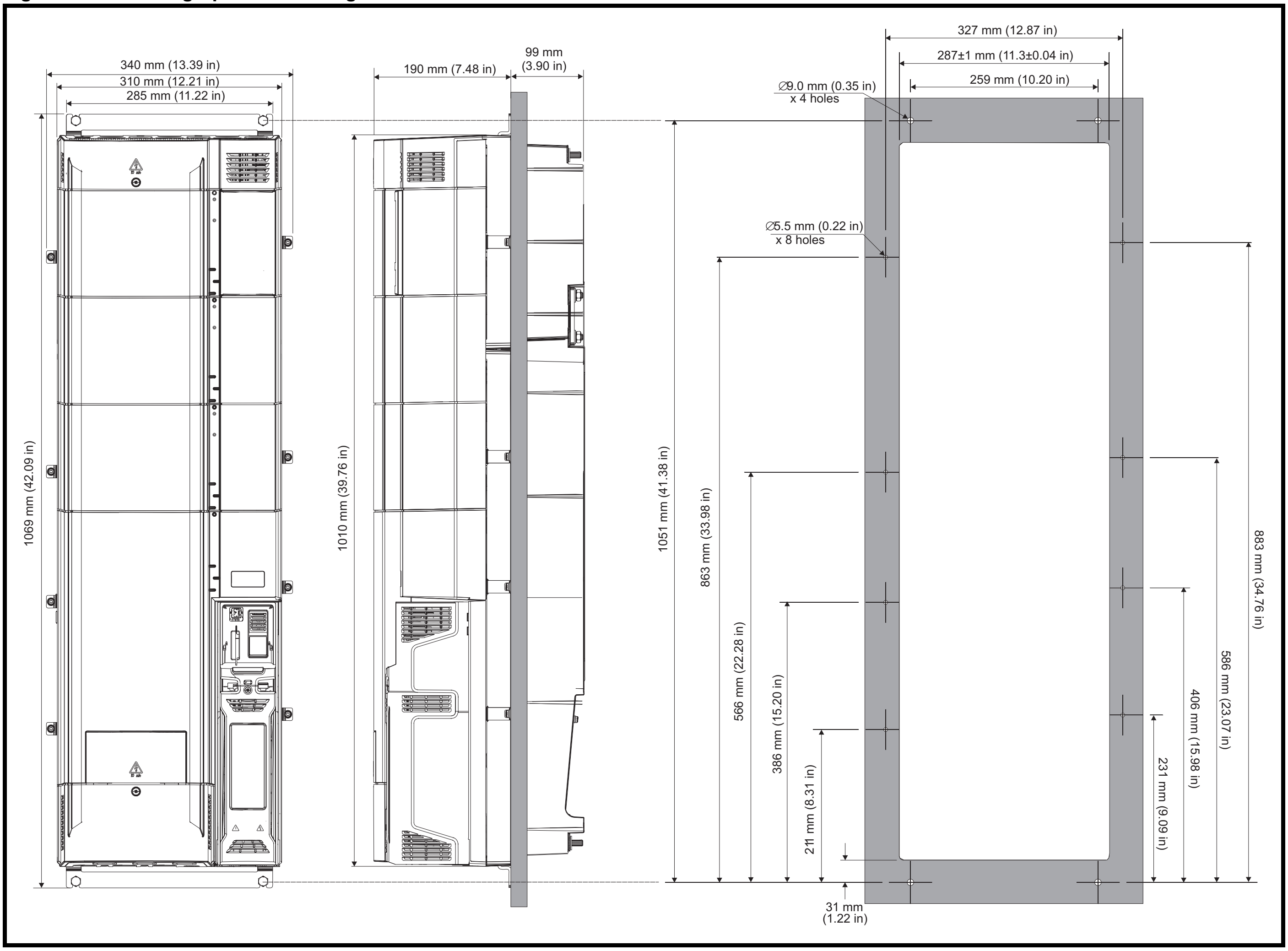
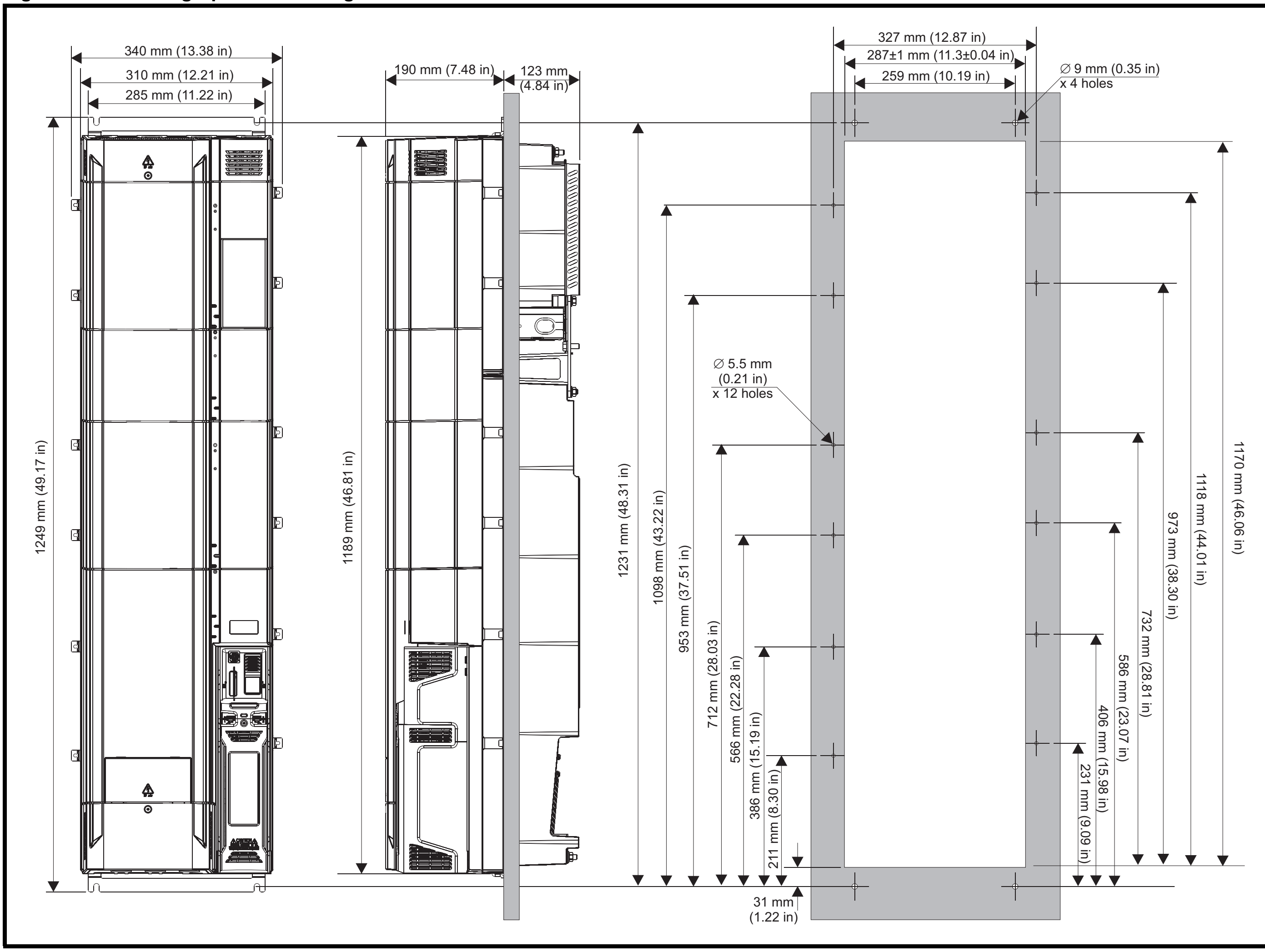
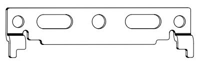
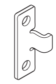
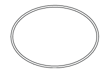
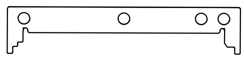
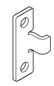
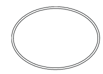
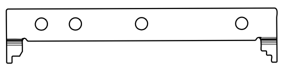
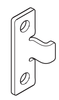
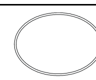
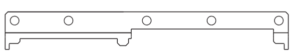
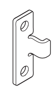
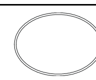
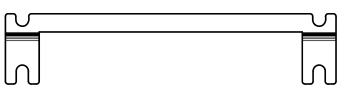
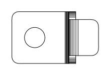
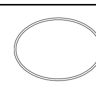
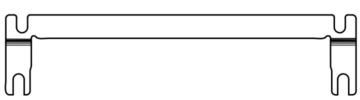
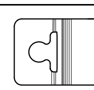
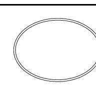
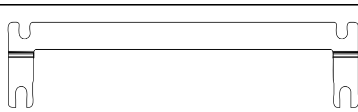
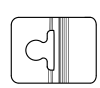
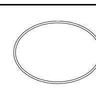


Figure 3-32 Through-panel mounting the size 11E



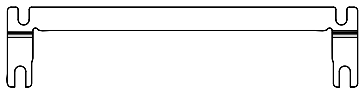
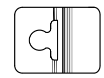
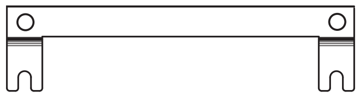
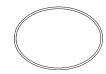
3.5.3 Mounting brackets

Table 3-2 Mounting brackets (size 3 to 10)

Frame size	Surface mounting kit (supplied with drive)	Qty	Through-panel mounting kit (option)	Qty
3	 Outer hole size: 5.2 mm (0.20 in) Centre hole / slot size: 6.2 mm (0.24 in)	x 2*	 Hole size: 5.2 mm (0.21 in)	x 2
				x 1
4	 Hole size: 6.5 mm (0.26 in)	x 2*	 Hole size: 5.2 mm (0.21 in)	x 2
				x 1
5	 Hole size: 6.5 mm (0.26 in)	x 2*	 Hole size: 5.2 mm (0.21 in)	x 2
				x 1
6	 Hole size: 6.5 mm (0.26 in)	x 2*	 Hole size: 5.2 mm (0.21 in)	x 3
				x 1
7	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 9 mm (0.35 in)	x 2
				x 1
8	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 6
				x 1
9A, 9E and 10E	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 8
				x 1

* Surface mounting brackets are also used when through-panel mounting.

Table 3-3 Mounting brackets (size 11)

Frame size	Surface mounting kit (supplied with drive)	Qty	Through-panel mounting kit (option)	Qty
11E	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 12
	 Hole size: 9 mm (0.35 in)	x 1		x 1

* Surface mounting brackets are also used when through-panel mounting.

3.6 Enclosure for standard drives

3.6.1 Recommended spacing between the drives

Figure 3-33 Recommended spacing between the drives

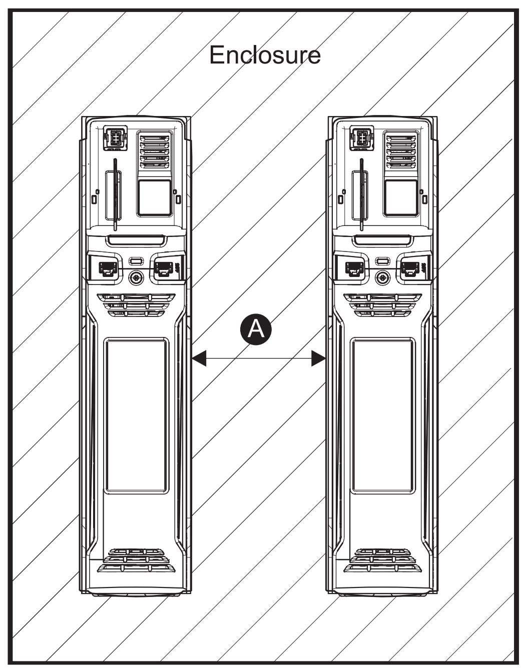


Table 3-4 Spacing required between the drives (without high IP insert)

Drive Size	Spacing (A)	
	40 °C	50 °C*
3	0 mm (0.00 in)	
4	0 mm (0.00 in)	
5	0 mm (0.00 in)	30 mm (1.18 in)
6	0 mm (0.00 in)	
7	30 mm (1.18 in)	
8	30 mm (1.18 in)	
9A/9E	60 mm (2.37 in)	
10E/11E		

* 50 °C derating applies, refer to Table 11-3 *Maximum permissible continuous output current @ 50 °C (122 °F)* on page 396.

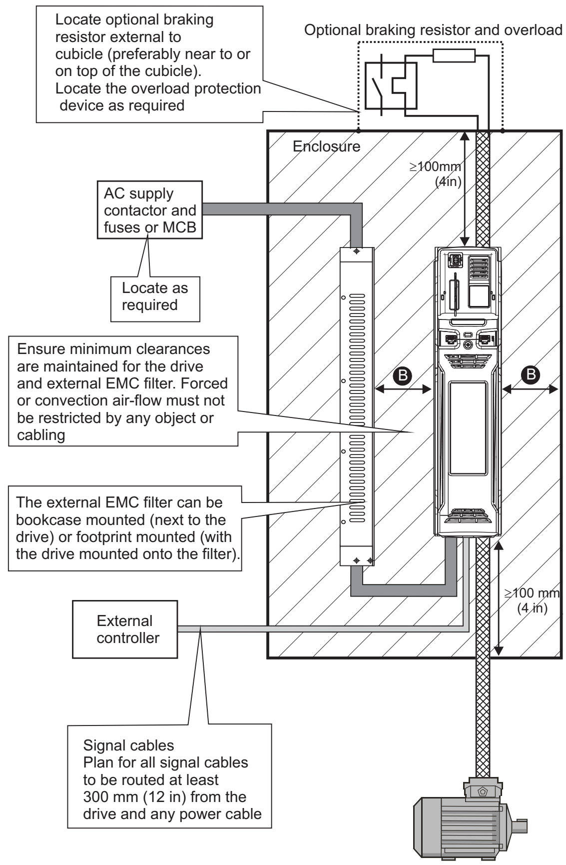
NOTE

When through-panel mounted, ideally drives should be spaced 45 mm (1.77 in) to maximize panel stiffness.

3.6.2 Enclosure layout

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

Figure 3-34 Enclosure layout (size 3 to 8)



NOTE

For EMC compliance:

1. When using an external EMC filter, one filter is required for each drive.
2. Power cabling must be at least 100 mm (4 in) from the drive in all directions

Table 3-5 Spacing required between drive / enclosure and drive / EMC filter (size 3 to 8)

Drive Size	Spacing (B)
3	0 mm (0.00 in)
4	30 mm (1.18 in)
5	
6	
7	
8	

NOTE

Drive sizes 3 to 5 can be tile mounted where limited mounting space is available. The tile mounting kit is not supplied with the drive, it can be purchased separately.

Figure 3-35 Enclosure layout (size 9 to 11)

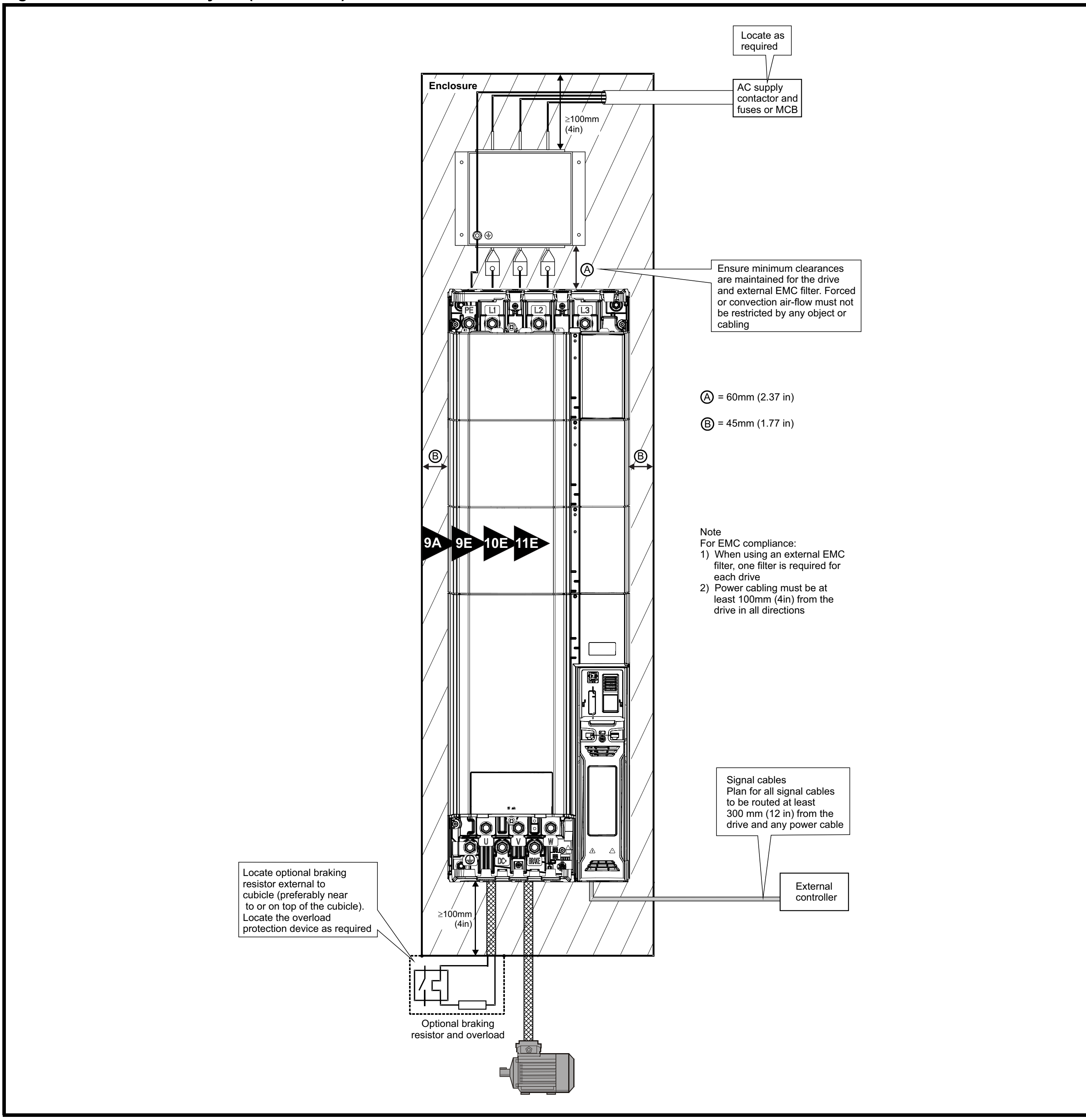


Table 3-6 Spacing required between drive / enclosure and drive (size 9 to 11)

Drive Size	Spacing (B)
9A/9E	45 mm (1.77 in)
10E/11E	

3.6.3 Enclosure sizing

1. Add the dissipation figures from section 11.1.2 *Power dissipation* on page 398 for each drive that is to be installed in the enclosure.
2. If an external EMC filter is to be used with each drive, add the dissipation figures from section 11.2.1 *EMC filter ratings* on page 424 for each external EMC filter that is to be installed in the enclosure.
3. If the braking resistor is to be mounted inside the enclosure, add the average power figures from for each braking resistor that is to be installed in the enclosure.
4. Calculate the total heat dissipation (in Watts) of any other equipment to be installed in the enclosure.
5. Add the heat dissipation figures obtained above. This gives a figure in Watts for the total heat that will be dissipated inside the enclosure.

Calculating the size of a sealed enclosure

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

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

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

Where:

A_e Unobstructed surface area in m² (1 m² = 10.9 ft²)

T_{ext} Maximum expected temperature in °C *outside* the enclosure

T_{int} Maximum permissible temperature in °C *inside* the enclosure

P Power in Watts dissipated by *all* heat sources in the enclosure

k Heat transmission coefficient of the enclosure material in W/mm²/°C

Example

To calculate the size of an enclosure for the following:

- Two drives operating at the Normal Duty rating
- External EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40 °C
- Maximum ambient temperature outside the enclosure: 30 °C

For example, if the power dissipation from each drive is 187 W and the power dissipation from each external EMC filter is 9.2 W.

Total dissipation: 2 x (187 + 9.2) =392.4 W

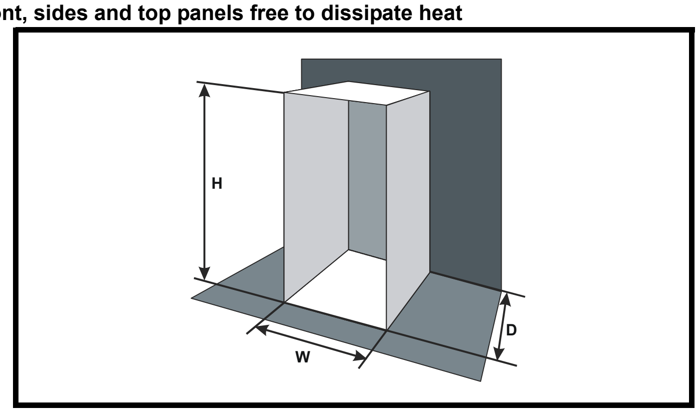
NOTE

Power dissipation for the drives and the external EMC filters can be obtained from Chapter 11 *Technical data* on page 393.

The enclosure is to be made from painted 2 mm (0.079 in) sheet steel having a heat transmission coefficient of 5.5 W/m²/°C. Only the top, front, and two sides of the enclosure are free to dissipate heat.

The value of 5.5 W/m²/°C can generally be used with a sheet steel enclosure (exact values can be obtained by the supplier of the material). If in any doubt, allow for a greater margin in the temperature rise.

Figure 3-36 Enclosure having front, sides and top panels free to dissipate heat



Insert the following values:

T_{int} 40 °C

T_{ext} 30 °C

k 5.5

P 392.4 W

The minimum required heat conducting area is then:

$$A_e = \frac{392.4}{5.5(40 - 30)}$$

= 7.135 m² (77.8 ft²) (1 m² = 10.9 ft²)

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

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

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

$$W = \frac{7.135 - (2 \times 2 \times 0.6)}{2 + 0.6}$$

=1.821 m (71.7 in)

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

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

Calculating the air-flow in a ventilated enclosure

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

Calculate the minimum required volume of ventilating air from:

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

Where:

V Air-flow in m³ per hour (1 m³/hr = 0.59 ft³/min)

T_{ext} Maximum expected temperature in °C *outside* the enclosure

T_{int} Maximum permissible temperature in °C *inside* the enclosure

P Power in Watts dissipated by *all* heat sources in the enclosure

k Ratio of $\frac{P_o}{P_I}$

Where:

P_0 is the air pressure at sea level

P_I is the air pressure at the installation

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

Example

To calculate the size of an enclosure for the following:

- Three drives operating at the Normal Duty rating
- External EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40 °C
- Maximum ambient temperature outside the enclosure: 30 °C

For example, dissipation of each drive: 101 W and dissipation of each external EMC filter: 6.9 W (max).

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

Insert the following values:

T_{int} 40 °C
T_{ext} 30 °C
k 1.3
P 323.7 W

Then:

$$V = \frac{3 \times 1.3 \times 323.7}{40 - 30}$$

= **126.2 m³/hr (74.5 ft³/min)** (1 m³/hr = 0.59 ft³/min)

3.7 Enclosure design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures

Totally enclosing or through panel mounting the drive in either a sealed cabinet (no airflow) or in a well ventilated cabinet makes a significant difference on drive cooling.

The chosen method affects the ambient temperature value (T_{rate}) which should be used for any necessary derating to ensure sufficient cooling for the whole of the drive.

The ambient temperature for the four different combinations is defined below:

1. Totally enclosed with no air flow (<2 m/s) over the drive
   $T_{rate} = T_{int} + 5$ °C
2. Totally enclosed with air flow (>2 m/s) over the drive
   $T_{rate} = T_{int}$
3. Through panel mounted with no airflow (<2 m/s) over the drive
   T_{rate} = the greater of T_{ext} +5 °C, or T_{int}
4. Through panel mounted with air flow (>2 m/s) over the drive
   T_{rate} = the greater of T_{ext} or T_{int}

Where:

T_{ext} = Temperature outside the cabinet
T_{int} = Temperature inside the cabinet
T_{rate} = Temperature used to select current rating from tables in Chapter 11 *Technical data* on page 393.

3.8 Heatsink fan operation

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

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

The heatsink fan on all sizes is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. The maximum speed at which the fan operates can be limited in Pr **06.045**. This could incur an output current derating. Refer to section 3.14.2 *Size 3 to 5 heatsink fan removal procedure* on page 83 for information on fan removal. Size 6 to 11 are also installed with a variable speed fan to ventilate the capacitor bank.

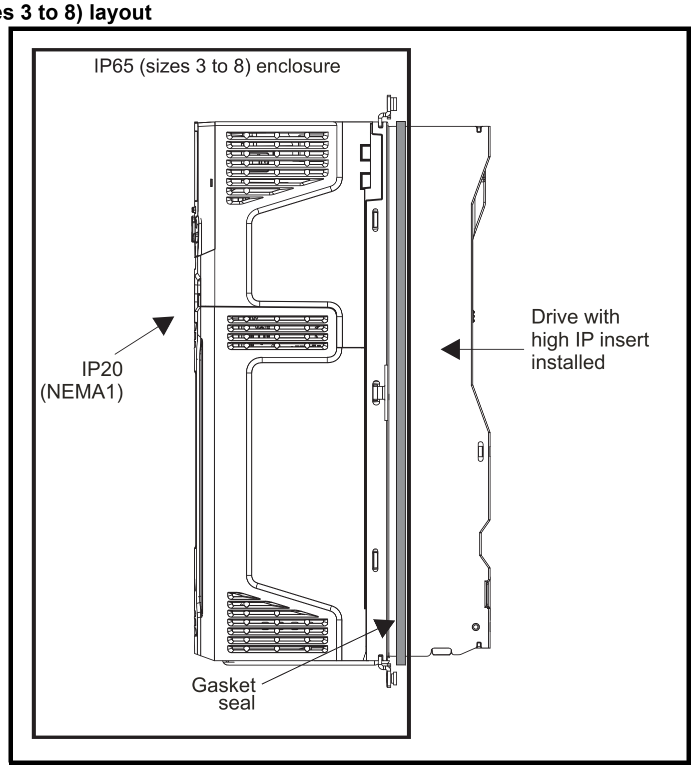
3.9 Enclosing standard drive for high environmental protection

An explanation of environmental protection rating is provided in section 11.1.9 *IP / UL Rating*.

The standard drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP65 rating (sizes 3 to 8) or IP55 (size 9, 10 and 11) (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required). Refer to section 11.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 393.

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

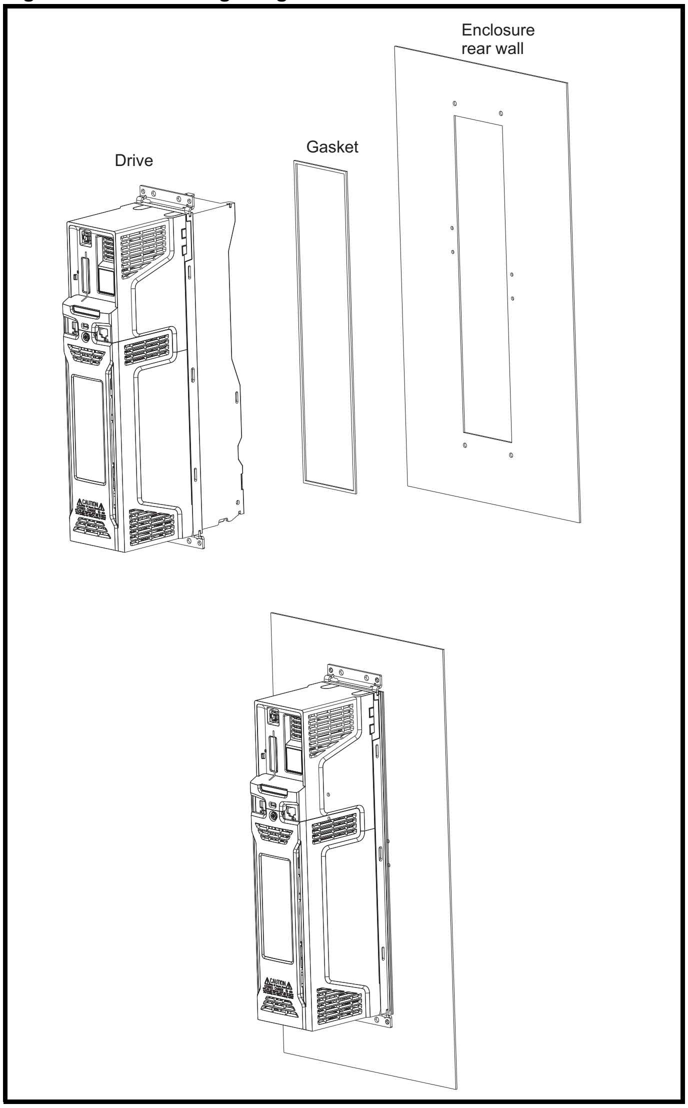
Figure 3-37 Example of IP65 (sizes 3 to 8) layout



The main gasket should be installed as shown in Figure 3-38.

On drive sizes 3, 4 and 5, in order to achieve the high IP rating at the rear of the heatsink it is necessary to seal a heatsink vent by installing the high IP insert as shown in Figure 3-40, Figure 3-41 and Figure 3-42.

Figure 3-38 Installing the gasket



To seal the space between the drive and the backplate, use two sealing brackets as shown in Figure 3-39.

Figure 3-39 Through panel mounting

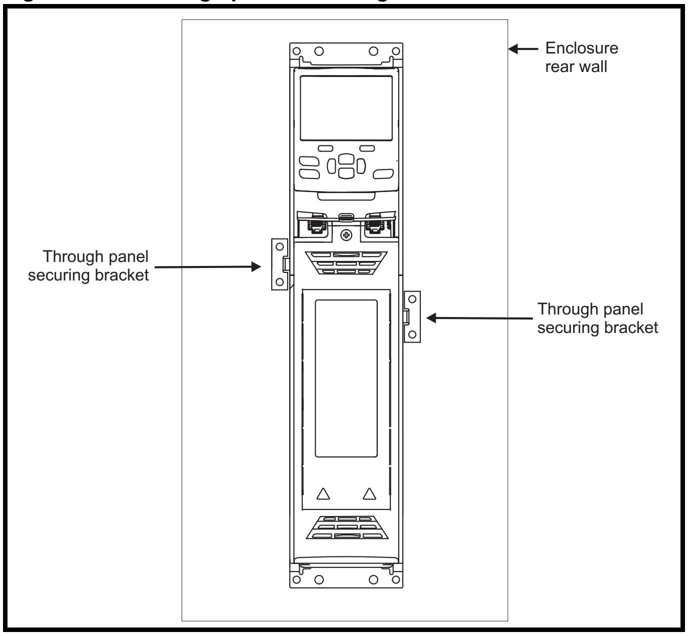
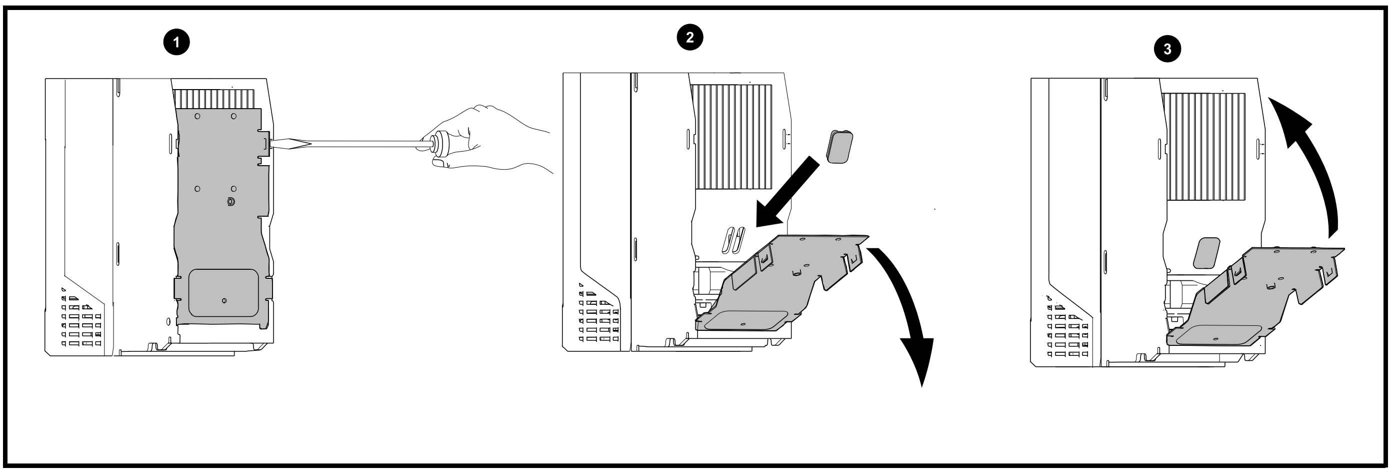


Figure 3-40 Installation of high IP insert for size 3

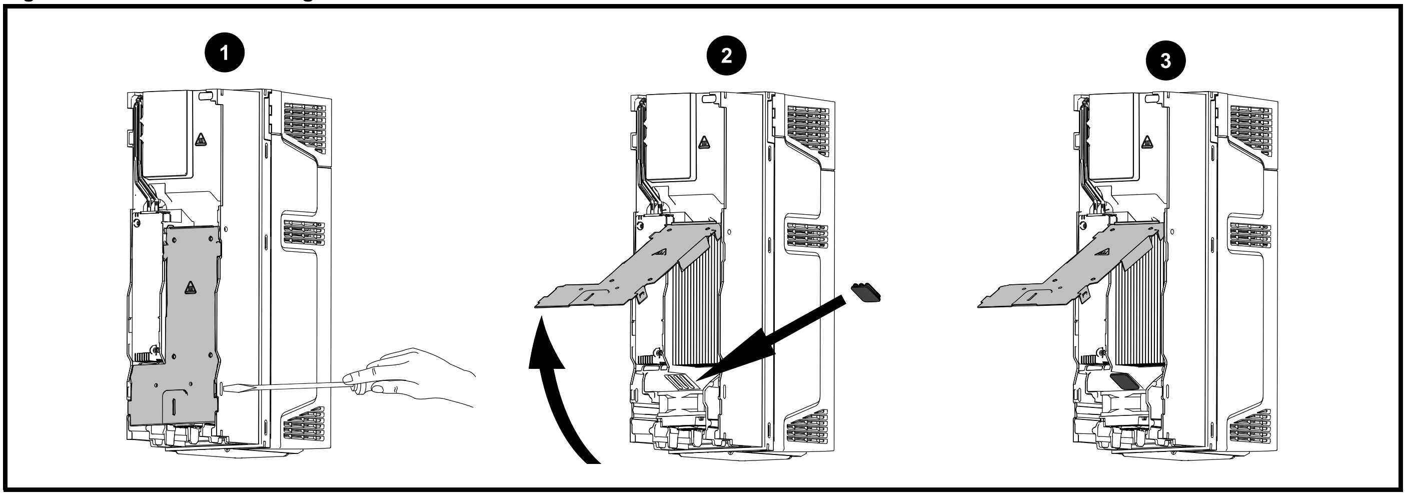


1. To install the high IP insert, firstly place a flat head screwdriver into the slot highlighted (1).
2. Pull the hinged baffle down to expose the ventilation hole, install the high IP insert into the ventilation hole in the heatsink (2). Ensure the high IP insert is securely installed by firmly pressing it into place (3).
3. Close the hinged baffle as shown (1).

To remove the high IP insert, reverse the above instructions.

The guidelines in Table 3-7 should be followed.

Figure 3-41 Installation of high IP insert for size 4

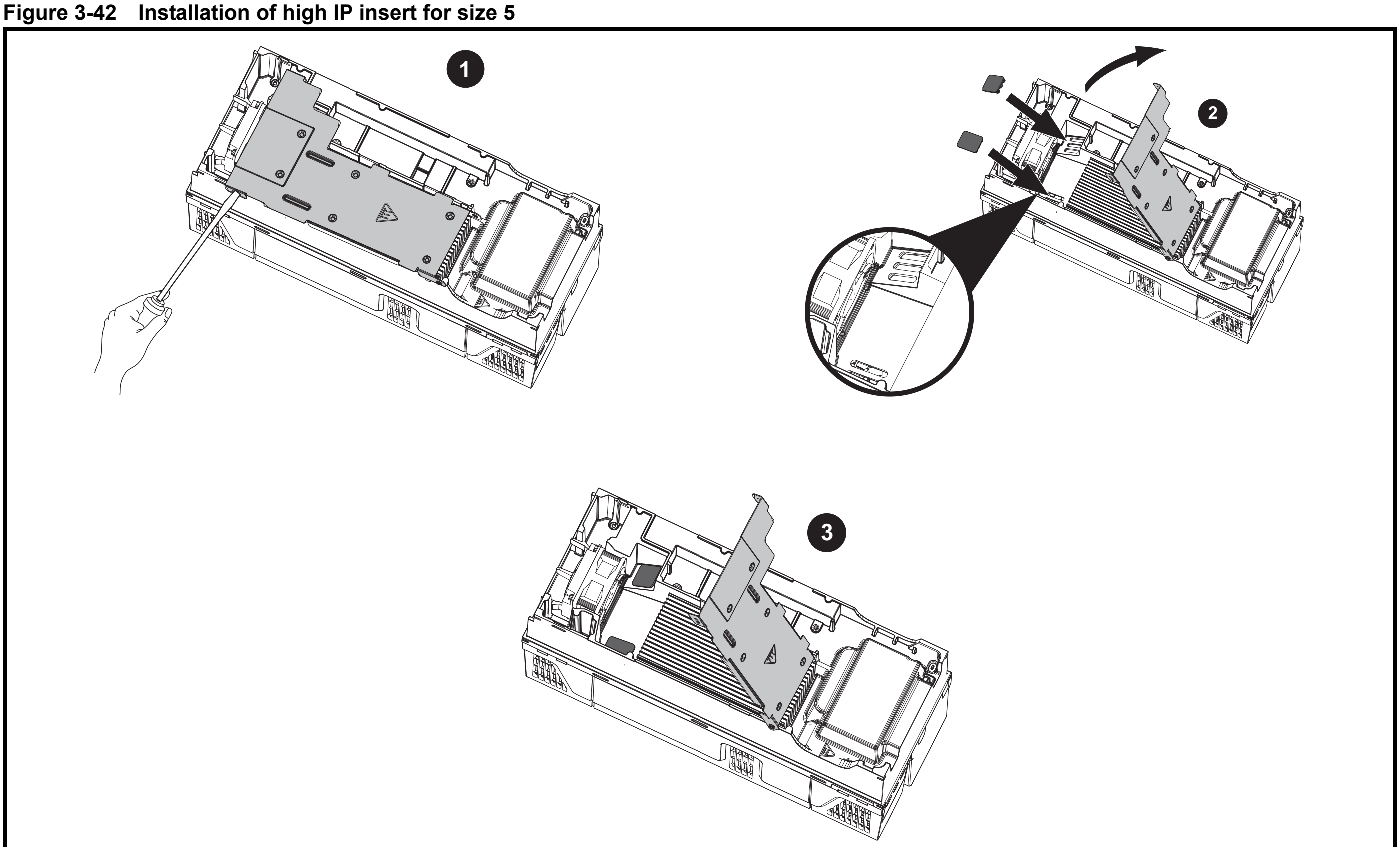


1. To install the high IP insert, firstly place a flat head screwdriver into the slot highlighted (1).
2. Pull the hinged baffle up to expose the ventilation hole, install the high IP insert into the ventilation hole in the heatsink (2).
3. Ensure the high IP insert is securely installed by firmly pressing it into place (3).
4. Close the hinged baffle as shown (1).

To remove the high IP insert, reverse the above instructions.

The guidelines in Table 3-7 should be followed.

Figure 3-42 Installation of high IP insert for size 5



1. To install the high IP insert, firstly place a flat head screwdriver into the slot highlighted (1).
2. Pull the hinged baffle up to expose the ventilation holes, install the high IP inserts into the ventilation holes in the heatsink (2).
3. Ensure the high IP inserts are securely installed by firmly pressing them into place (3).
4. Close the hinged baffle as shown (1).

To remove the high IP insert, reverse the above instructions.

The guidelines in Table 3-7 should be followed.

Table 3-7 Environment considerations

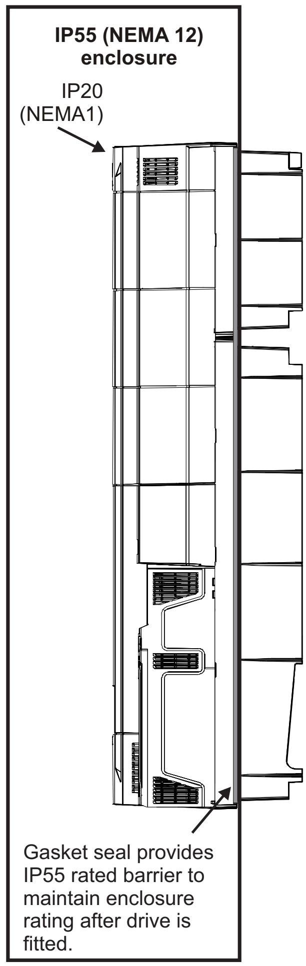
Environment	High IP insert	Comments
Clean	Not installed	
Dry, dusty (non-conductive)	Installed	Regular cleaning recommended
Dry, dusty (conductive)	Installed	
IP65 compliance	Installed	

NOTE

A current derating must be applied to the drive if the high IP insert is installed. Derating information is provided in section 11.1.1 *Power and current ratings (Derating for switching frequency and temperature)* on page 393.

Failure to do so may result in nuisance tripping.

Figure 3-43 Example of IP55 (NEMA 12) size 9 to 11 through-panel layout



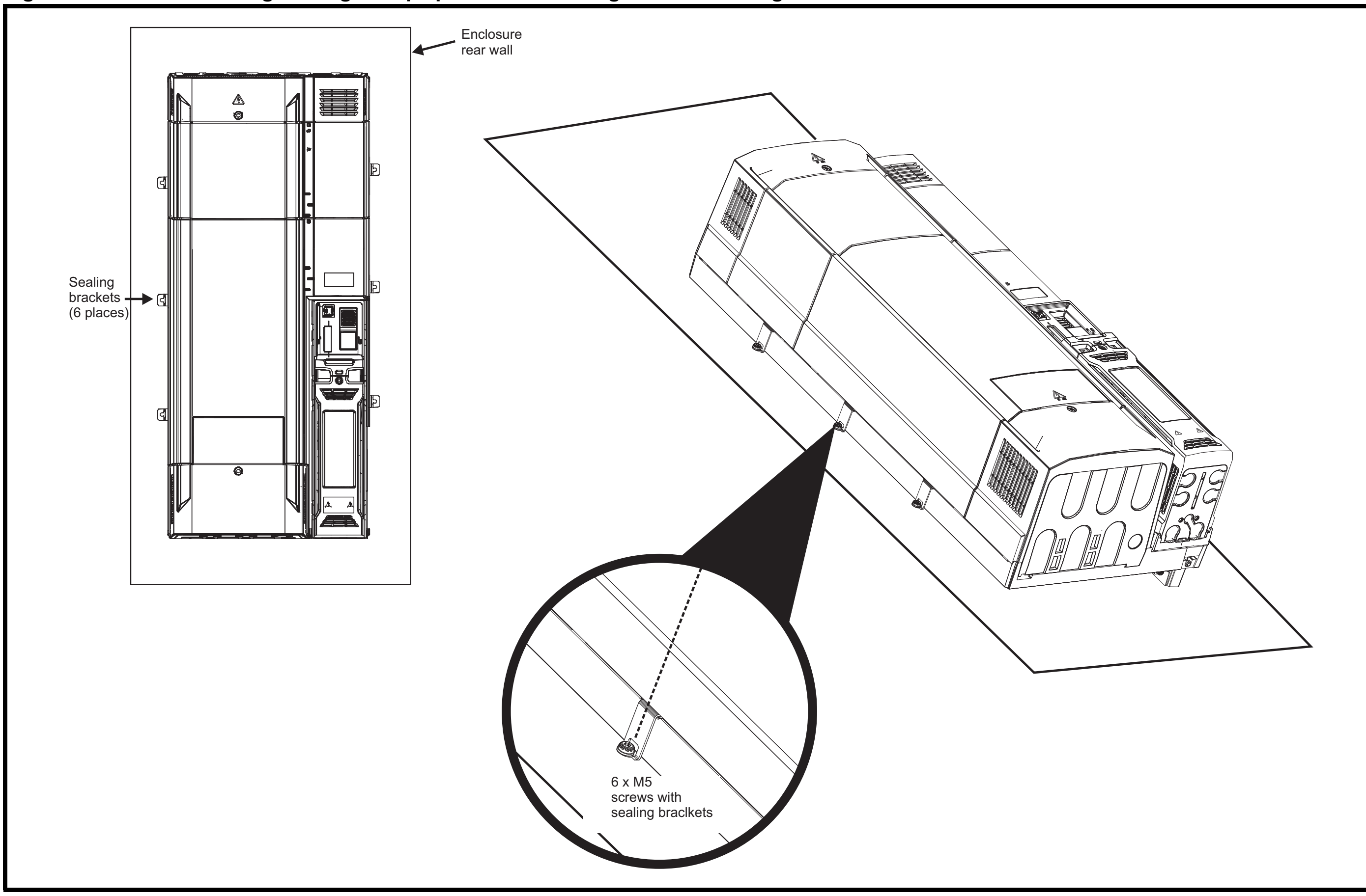
The main gasket should be installed as shown in Figure 3-38. Any screws / bolts that are used for mounting should be installed with M8 flat nylon washers to maintain a seal around the screw hole.

See Figure 3-44 on page 67, sealing clamps are supplied in the through panel mounting kit to aid compression of the gasket.

NOTE

The heatsink fans have conformal coated PCBs and have sealant at cable entry points. Dripping, splashing or sprayed water can impede the operation of the fan, therefore if the environment is such that the fan may be subjected to more than occasional dripping or sprayed water while operational, then suitable drip protection covers should be employed.

Figure 3-44 View showing sealing clamps provided in through hole mounting kit



NOTE

For detailed information regarding IP55 (NEMA 12) Through Panel Mounting see Figure 3-30 *Through-panel mounting the size 9A* on page 53, Figure 3-31 *Through-panel mounting the size 9E and 10E* on page 54 and Figure 3-32 *Through-panel mounting the size 11E* on page 55.

NOTE

When designing an IP65 or IP55 enclosure (Figure 3-37 *Example of IP65 (sizes 3 to 8) layout* on page 62), consideration should be made to the dissipation from the front of the drive.

Table 3-8 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
3	≤ 50 W
4	≤ 75 W
5	≤ 100 W
6	≤ 100 W
7	≤ 204 W
8	≤ 347 W
9A/9E/10E/11E	≤ 480 W

3.10 Heatsink mounted brake resistor

WARNING

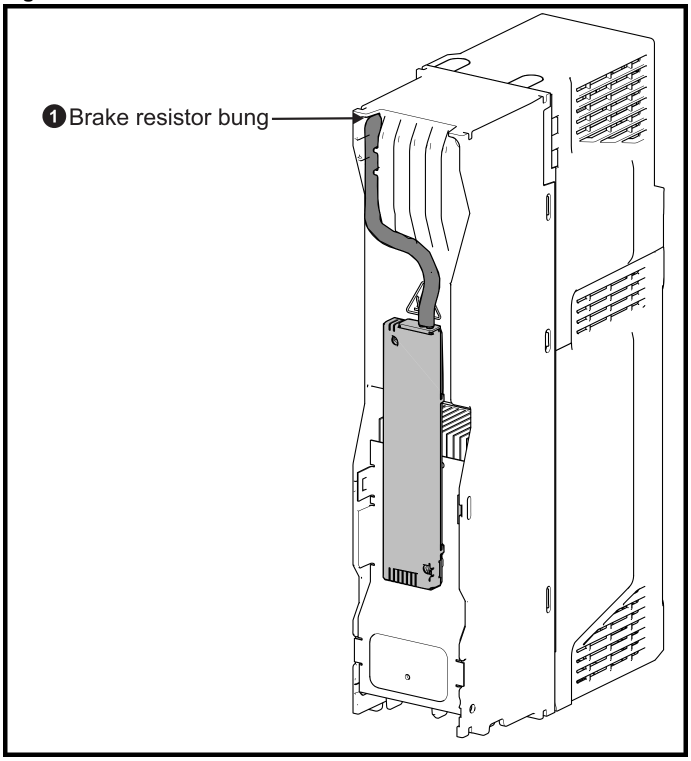
The internal / heatsink mounted braking resistors must only be used with the following drives.
Brake resistor 1220-2752 must only be used with size 3 drives. Brake resistor 1299-0003 must only be used with size 4 and 5 drives.

3.10.1 Size 3, 4 and 5 internal braking resistor

Size 3, 4 and 5 have been designed with an optional space-saving heatsink mounted resistor. The resistor can be installed within the heatsink fins of the drive. When the heatsink resistor is used, an external thermal protection device is not required as the resistor is designed such that it will fail safely under any fault conditions. The in-built software overload protection is set-up at default to protect the resistor.
The resistor is rated to IP54 (NEMA 12).

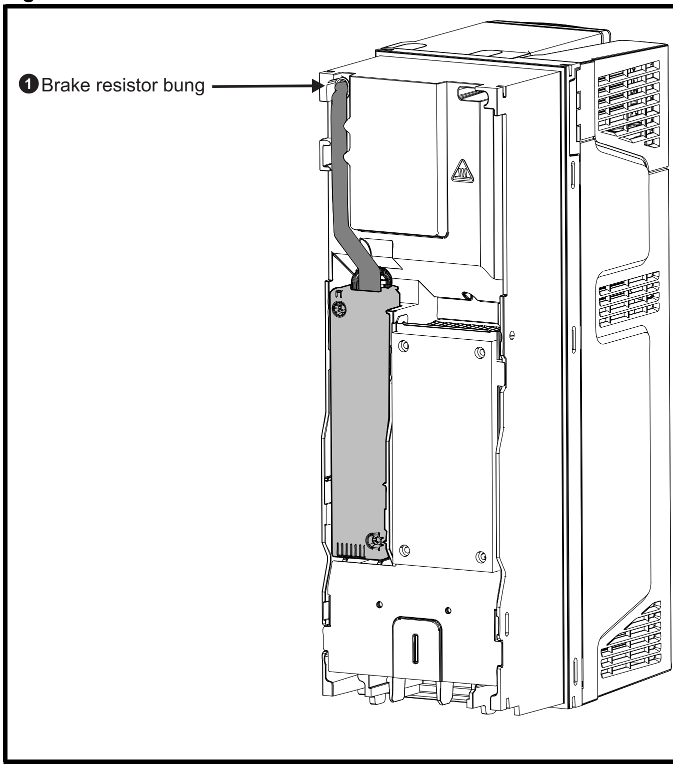
3.10.2 Internal braking resistor installation instructions

Figure 3-45 Brake resistor installation on size 3



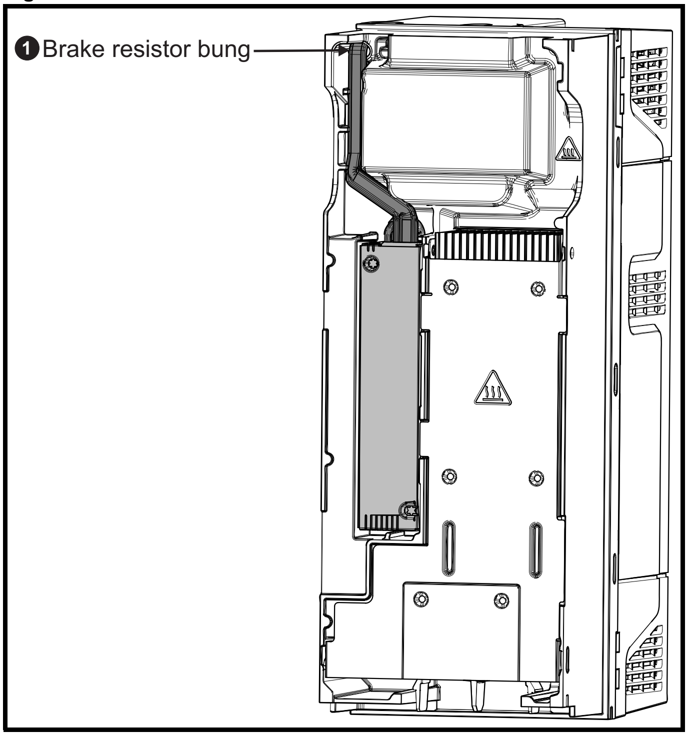
1. Remove the terminal covers as detailed in section 3.3.1 *Removing the terminal covers* on page 32.
2. Remove the internal EMC filter as shown in Figure 4-29 *Removal of the size 3 internal EMC filter* on page 123.
3. Remove the brake resistor bung (1) from the hole in the chassis, the closed end of the bung will need to be pierced so that the cable has access to be routed through.
4. Feed brake resistor bung onto outer insulation of brake resistor cable. The wider end of the bung should be inserted first.
   The Narrow end should align with end of insulation.
5. Install the braking resistor to the heatsink using the captive screws. The screws should be tighten to a maximum torque of 2 N m (1.5 lb ft).
6. Route the cables through the provided hole at the rear of the heatsink as shown in Figure 3-45 and take the cable out from the front side of the drive. Ensure the cables are routed between the fins of the heatsink, and the cables are not trapped between the heatsink fins and the resistor.
7. Crimp the cable ends and make appropriate connections. The brake terminals must be tightened to a maximum torque of 2 N m (1.5 lb ft).
8. Replace the terminal covers on the drive, tighten to a maximum torque of 1 N m (0.7 lb ft).

Figure 3-46 Brake resistor installation on size 4



1. Remove the terminal covers as detailed in section 3.3.1 *Removing the terminal covers* on page 32.
2. Remove the brake resistor bung (1) from the hole in the chassis, the closed end of the bung will need to be pierced so that the cable has access to be routed through.
3. Feed brake resistor bung onto outer insulation of brake resistor cable. The wider end of the bung should be inserted first.
   The Narrow end should align with end of insulation.
4. Install the braking resistor to the heatsink using the captive screws. The screws should be tighten to a maximum torque of 2 N m (1.5 lb ft).
5. Route the cables through the provided hole at the rear of the heatsink as shown in Figure 3-46 and take the cable out from the front side of the drive. Ensure the cables are routed between the fins of the heatsink, and the cables are not trapped between the heatsink fins and the resistor.
6. Crimp the cable ends and make appropriate connections. The brake terminals must be tightened to a maximum torque of 2 N m (1.5 lb ft).
7. Replace the terminal covers on the drive, tighten to a maximum torque of 1 N m (0.7 lb ft).

Figure 3-47 Brake resistor installation on size 5

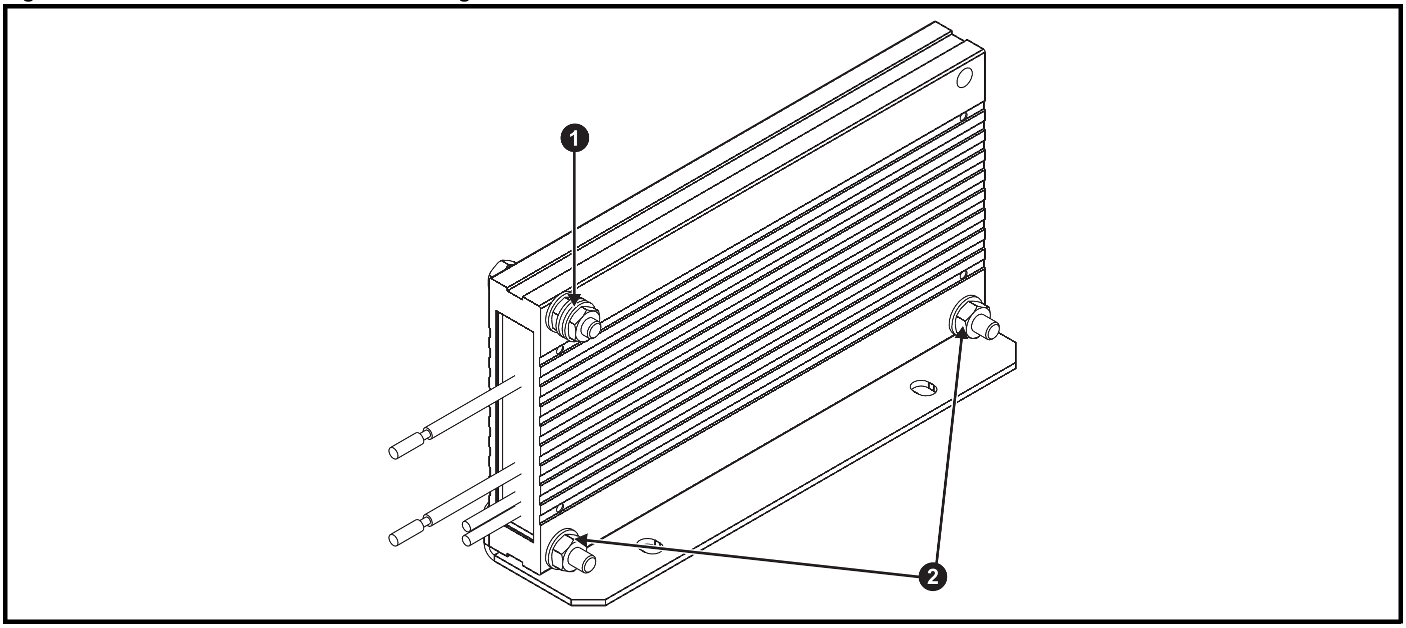


1. Remove the terminal covers as detailed in section 3.3.1 *Removing the terminal covers* on page 32.
2. Remove the brake resistor bung (1) from the hole in the chassis, the closed end of the bung will need to be pierced so that the cable has access to be routed through.
3. Feed brake resistor bung onto outer insulation of brake resistor cable. The wider end of the bung should be inserted first. The Narrow end should align with end of insulation.
4. Install the braking resistor to the heatsink using the captive screws. The screws should be tighten to a maximum torque of 2 N m (1.5 lb ft).
5. Route the cables through the provided hole at the rear of the heatsink as shown in Figure 3-46 and take the cable out from the front side of the drive. Ensure the cables are routed between the fins of the heatsink, and the cables are not trapped between the heatsink fins and the resistor.
6. Crimp the cable ends and make appropriate connections. The brake terminals must be tightened to a maximum torque of 2 N m (1.5 lb ft).
7. Replace the terminal covers on the drive, tighten to a maximum torque of 1 N m (0.7 lb ft).

3.10.3 External brake resistor

External brake resistors are available from Control Techniques for drive sizes 3 to 6. They can be mounted in the enclosure as per mounting recommendation in Figure 3-34 *Enclosure layout (size 3 to 8)* on page 58 using mounting brackets part number 6541-0187-00. Figure 3-48 below shows the brake resistor mounted on the mounting bracket. Two M4 screws and nuts (2) can be used to fix the brake resistor to the mounting bracket. One M4 nut with washer (1) is provided to use for the ground connection. The brake resistor is equipped with a thermal switch, the thermal switch should be integrated in the control circuit by the user.

Figure 3-48 Brake resistor with the mounting bracket



1. Ground connection (1 x M4 nut and washer).
2. Attaching the brake resistor to the mounting bracket (using 2 x M4 screws and nuts).

Figure 3-49 Mounting bracket dimensions

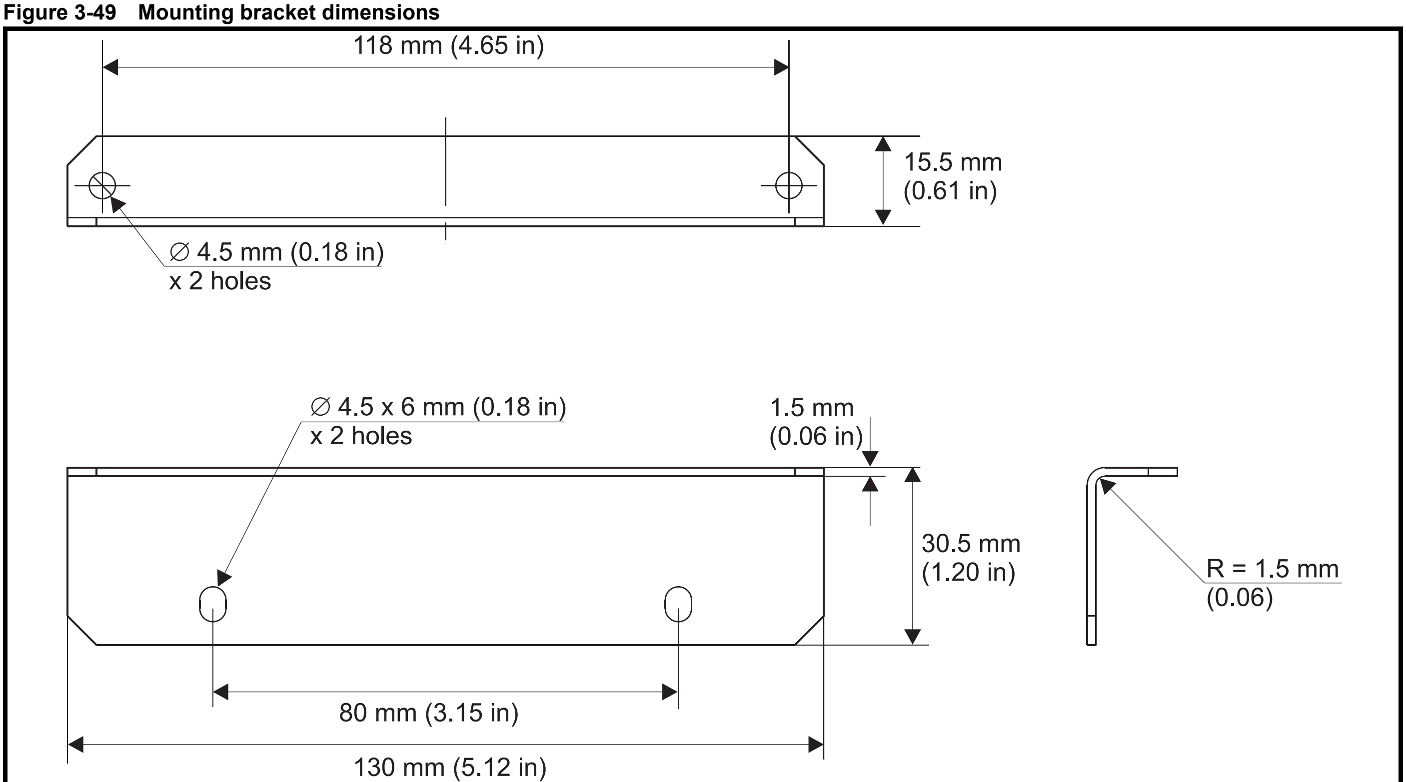
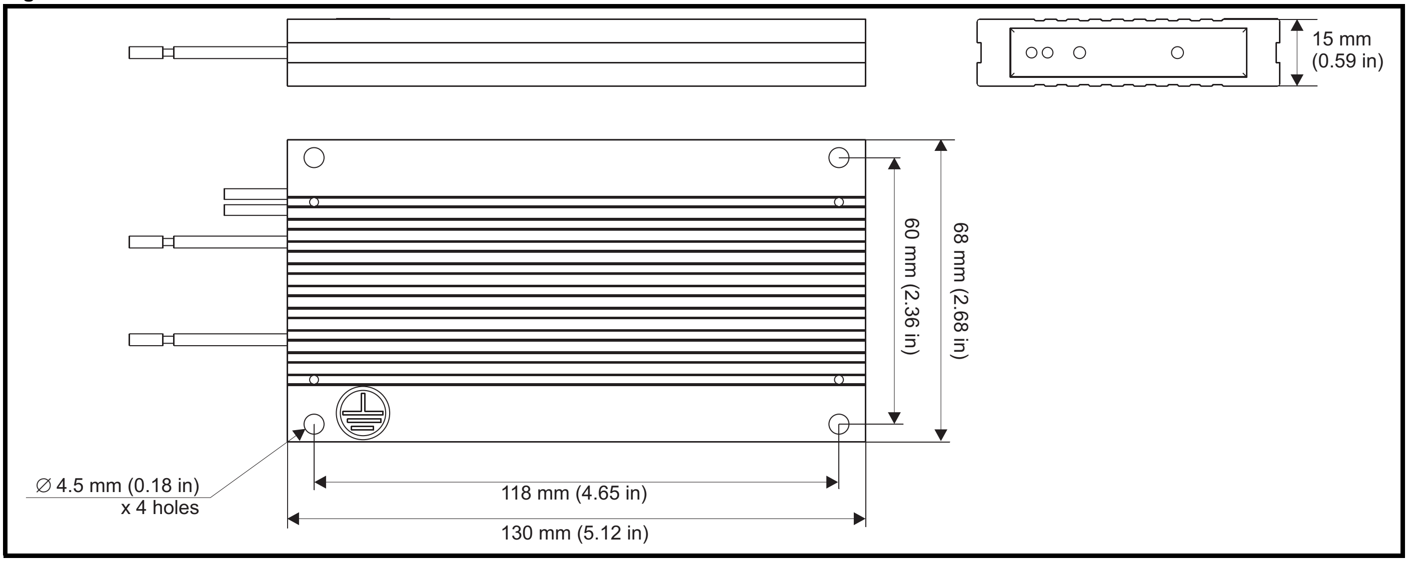


Figure 3-50 Brake resistor dimensions



3.11 External EMC filter

The external EMC filter details for each drive rating are provided in the table below.

Table 3-9 External EMC filter data

Model	CT part number	Weight	
		kg	lb
200 V			
03200066 to 03200127	4200-3230	1.9	4.20
04200180 to 04200250	4200-0272	4.0	8.82
05200300	4200-0312	5.5	12.13
06200500 to 06200580	4200-2300	6.5	14.3
07200750 to 07201170	4200-1132	6	13.2
08201490 to 08201800	4200-1972	9.6	21.1
09202160 to 09202660 (9A)	4200-3021	11	24.3
09202160 to 09202660 (9E)	4200-4460	12	26.5
10203250 to 10203600	4200-4460	12	26.5
400 V			
03400034 to 03400123	4200-3480	2.0	4.40
04400185 to 04400240	4200-0252	4.1	9.04
05400300	4200-0402	5.5	12.13
06400380 to 06400630	4200-4800	6.7	14.8
07400790 to 07401120	4200-1132	6	13.2
08401550 to 08401840	4200-1972	9.6	21.1
09402210 to 09402660 (9A)	4200-3021	11	24.25
09402210 to 09402660 (9E)	4200-4460	12	26.5
10403200 to 10403610	4200-4460	12	26.5
11404370 to 11405070	4200-0400	14.7	32.41
575 V			
05500039 to 05500100	4200-0122	5.5	12.13
06500120 to 06500430	4200-3690	7.0	15.4
07500530 to 07500730	4200-0672	6.2	13.7
08500860 to 08501080	4200-1662	9.4	20.7
09501250 to 09501500 (9A)	4200-1660	5.2	11.46
09501250 to 09501500 (9E)	4200-2210	10.3	22.7
10502000	4200-2210	10.3	22.7
11502480 to 11503150	4200-0690	16.75	36.9
690 V			
07600230 to 07600730	4200-0672	6	13.2
08600860 to 08601080	4200-1662	9.4	20.7
09601250 to 09601550 (9A)	4200-1660	5.2	11.5
09601250 to 09601550 (9E)	4200-2210	10.3	22.7
10601720 to 10601970	4200-2210	10.3	22.7
11602250 to 11603050	4200-0690	16.75	36.9

The external EMC filters for sizes 3 to 6 can be footprint mounted or bookcase mounted as shown in Figure 3-51 and Figure 3-52. The external EMC filters for sizes 7 to 11, are designed to be mounted above the drive as shown in Figure 3-53.

Mount the external EMC filter following the guidelines in section 4.12.6 *Compliance with generic emission standards* on page 127.

Figure 3-51
Footprint mounting the EMC filter

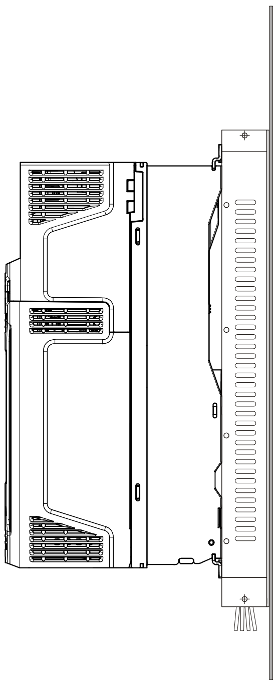


Figure 3-52
Bookcase mounting the EMC filter

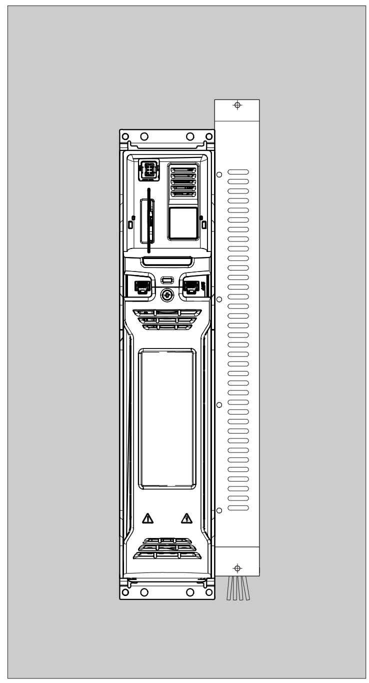


Figure 3-53
Size 7 to 11 mounting of the EMC filter

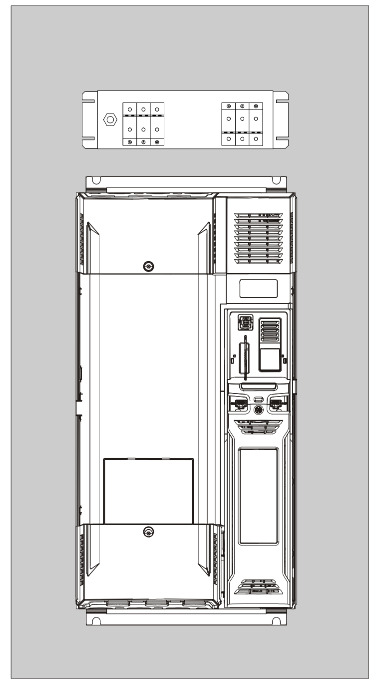
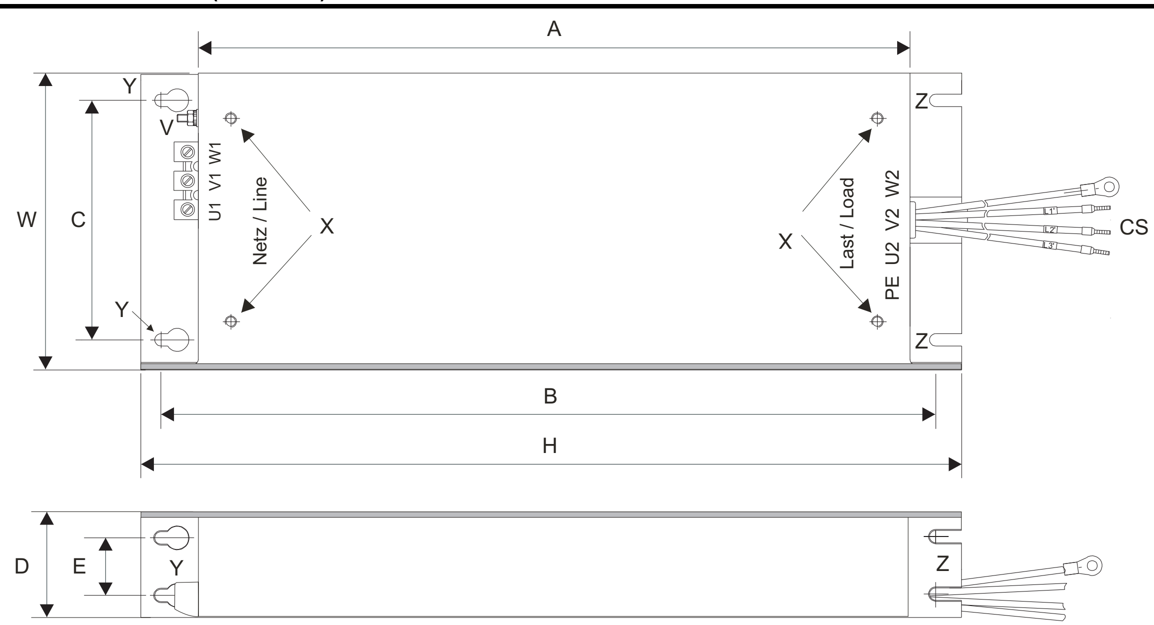


Figure 3-54 External EMC filter (size 3 to 6)



V: Ground stud

X: Threaded holes for footprint mounting of the drive

Y: Footprint mounting hole diameter

Z: Bookcase mounting slot diameter.

CS: Cable size

Table 3-10 Size 3 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-3230	384 mm (15.12 in)	414 mm (16.30 in)	56 mm (2.21 in)	41 mm (1.61 in)		426 mm (16.77 in)	83 mm (3.27 in)	M5	M5	5.5 mm (0.22 in)	5.5 mm (0.22 in)	2.5 mm² (14 AWG)
4200-3480												

Table 3-11 Size 4 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-0272	395 mm (15.55 in)	425 mm (16.73 in)	100 mm (3.94 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	123 mm (4.84 in)	M6	M6	6.5 mm (0.26 in)	6.5 mm (0.26 in)	6 mm² (10 AWG)
4200-0252												

Table 3-12 Size 5 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-0312	395 mm (15.55 in)	425 mm (16.73 in)	106 mm (4.17 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	143 mm (5.63 in)	M6	M6	6.5 mm (0.26 in)	6.5 mm (0.26 in)	10 mm² (8 AWG)
4200-0402												10 mm² (8 AWG)
4200-0122												2.5 mm² (14 AWG)

Table 3-13 Size 6 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-2300	392 mm (15.43 in)	420 mm (16.54 in)	180 mm (7.09 in)	60 mm (2.36 in)	33 mm (1.30 in)	434 mm (17.09 in)	210 mm (8.27 in)	M6	M6	6.5 mm (0.26 in)	6.5 mm (0.26 in)	16 mm² (6 AWG)
4200-4800												
4200-3690												

Figure 3-55 External EMC filter (size 7 to 8)

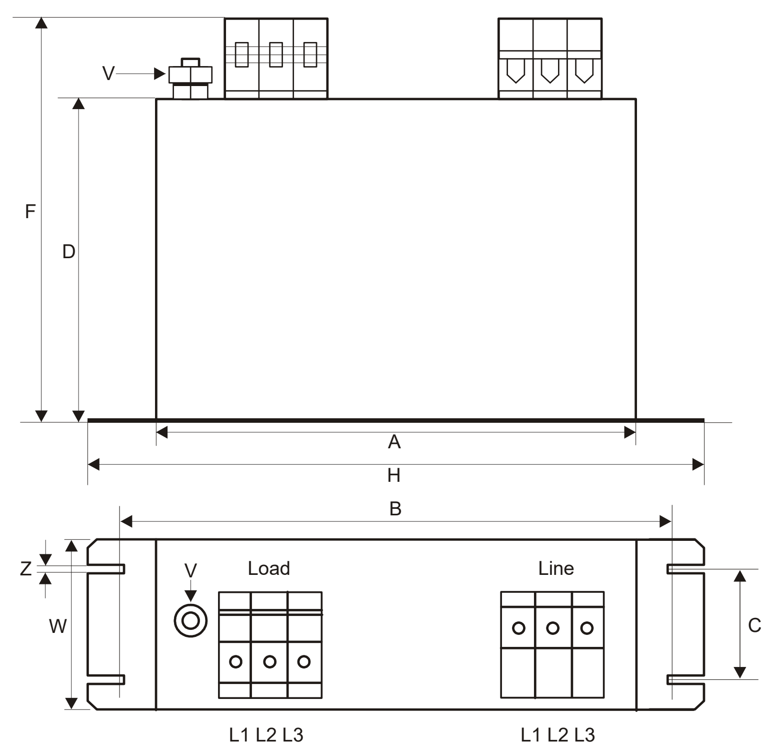


Table 3-14 Size 7 external EMC filter dimensions

CT part number	A	B	C	D	E	F	H	W	V	X	Y	Z
4200-1132	240 mm (9.45 in)	255 mm (10.04 in)	55 mm (2.17 in)	150 mm (5.90 in)		205 mm (8.07 in)	270 mm (10.63 in)	90 mm (3.54 in)	M10			6.5 mm (0.26 in)
4200-0672												

Table 3-15 Size 8 external EMC filter dimensions

CT part number	A	B	C	D	E	F	H	W	V	X	Y	Z
4200-1972 4200-1662	260 mm (10.24 in)	275 mm (10.83 in)	85 mm (3.35 in)	170 mm (6.69 in)		249 mm (9.79 in)	300 mm (11.81 in)	120 mm (4.72 in)	M10			6.5 mm (0.26 in)

Figure 3-56 External EMC filter (size 9A)

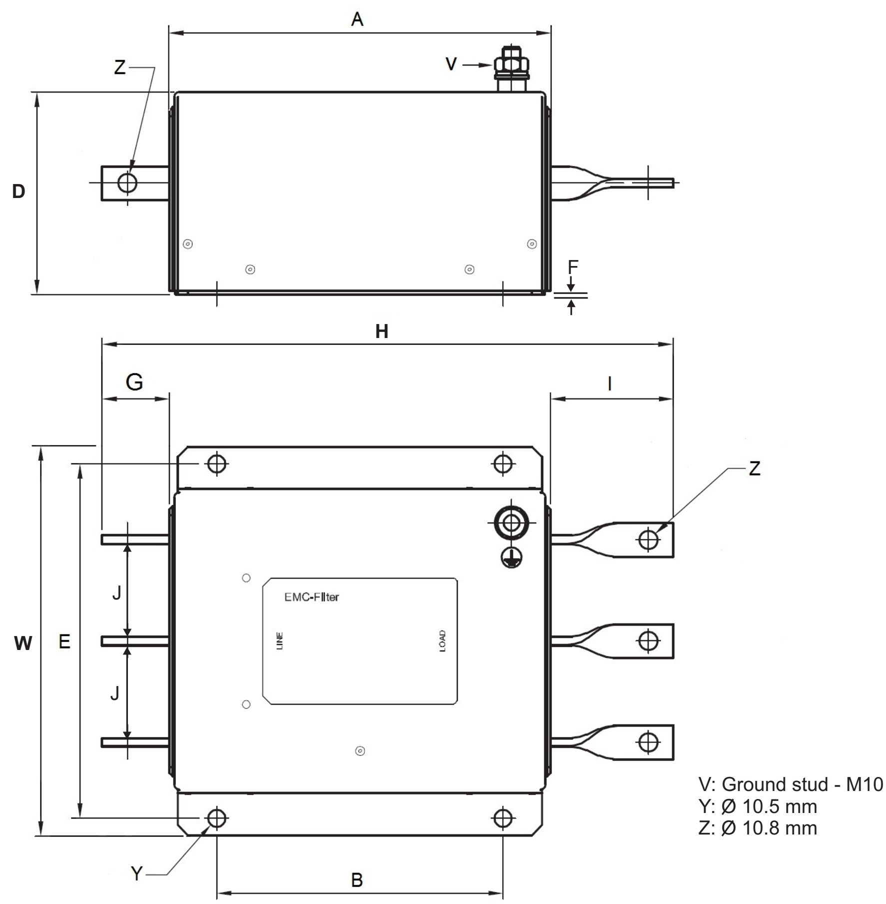


Table 3-16 Size 9A external EMC filter dimensions

CT part number	A	B	D	E	F	G	H	I	J	W
4200-3021	220 mm (8.66 in)	170 mm (6.70 in)	120 mm (4.72 in)	210 mm (8.27 in)	2 mm (0.08 in)	40 mm (1.57 in)	339 mm (13.34)	73 mm (2.87 in)	60 mm (2.36 in)	230 mm (9.06 in)
4200-1660	280 mm (11.02 in)	180 mm (7.09 in)	105 mm (4.13 in)	225 mm (8.86 in)	2 mm (0.08 in)	40 mm (1.57 in)	360 mm (14.17 in)	73 mm (2.87 in)	60 mm (2.36 in)	245 mm (9.65 in)

Figure 3-57 External EMC filter (size 9E and 10)

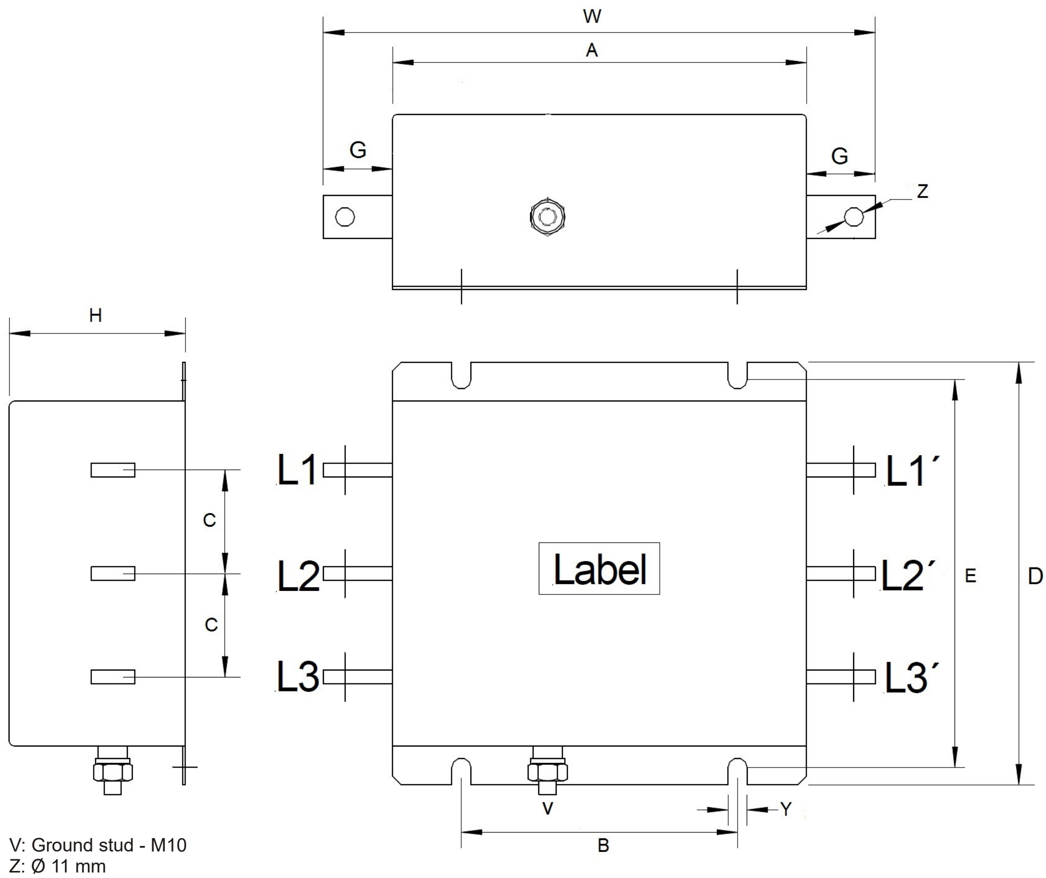


Table 3-17 Size 9E and 10 external EMC filter dimensions

CT part number	A	B	C	D	E	G	H	W	Y
4200-4460 4200-2210	280 mm (11.02)	180 mm (7.09)	57 mm (2.24 mm)	245 mm (9.65 in)	225 mm (8.86 in)	40 mm (1.57 in)	105 mm (4.13 in)	360 mm (14.7 in)	11 mm (0.43 in)

Figure 3-58 External EMC filter (size 11)

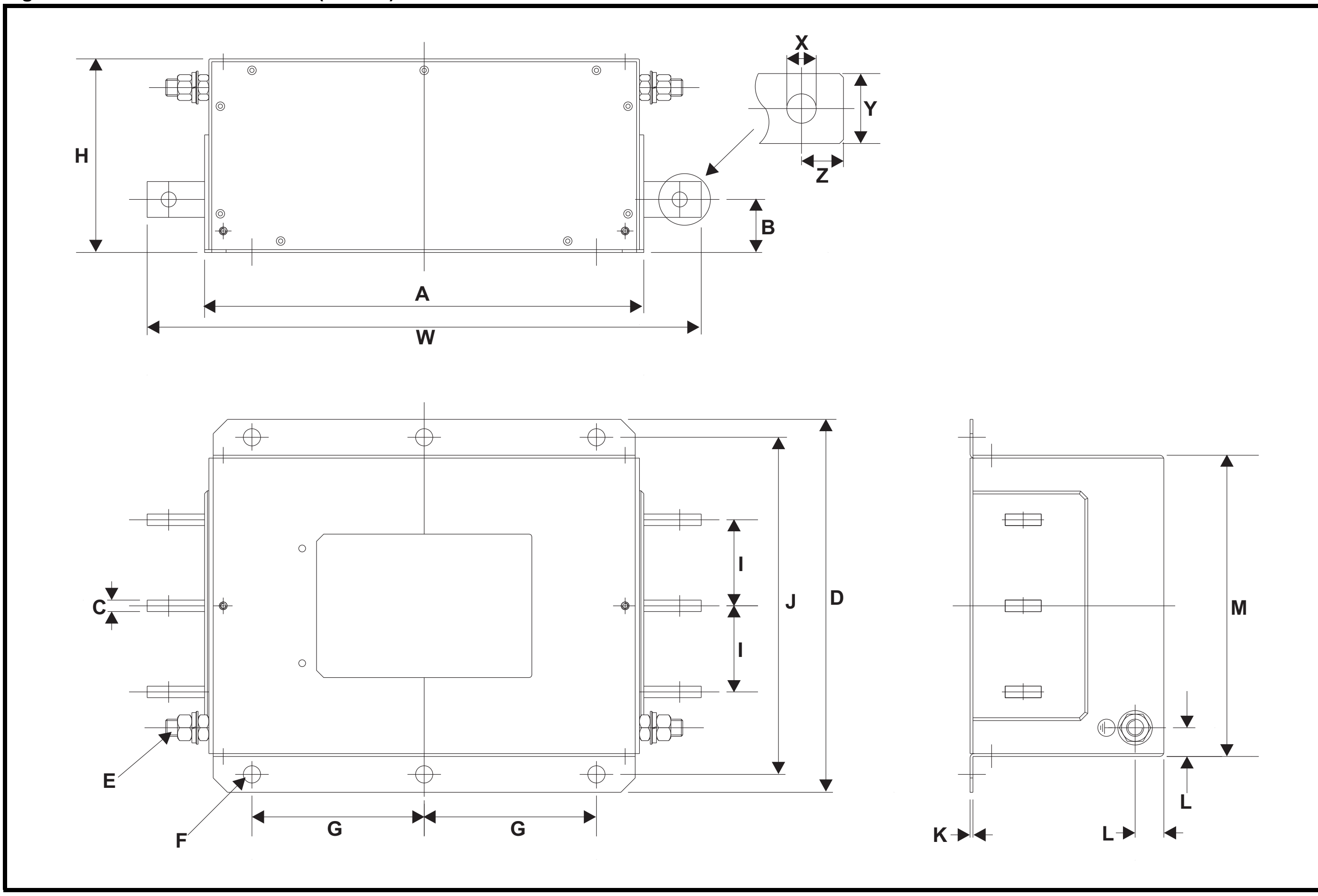


Table 3-18 Size 11 external EMC filter dimensions

CT part number	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y	Z	W
4200-0400 4200-0690	306 mm (12.05 in)	37 mm (1.46 in)	8 mm (0.32 in)	260 mm (10.2 in)	M12	12 mm (0.47 in)	120 mm (4.72 in)	135 mm (5.32 in)	60 mm (2.36 in)	235 mm (9.25 in)	2 mm (0.08 in)	20 mm (0.79 in)	210 mm (8.27 in)	10.5 mm (0.41 in)	25 mm (0.98 in)	15 mm (0.59 in)	386 mm (15.20 in)

3.12 Line reactor mounting dimensions for size 9E, 10E and 11E

Figure 3-59 Input line reactor (INLX0X) for size 9 and 10

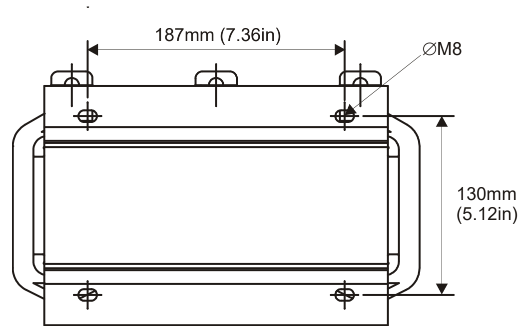
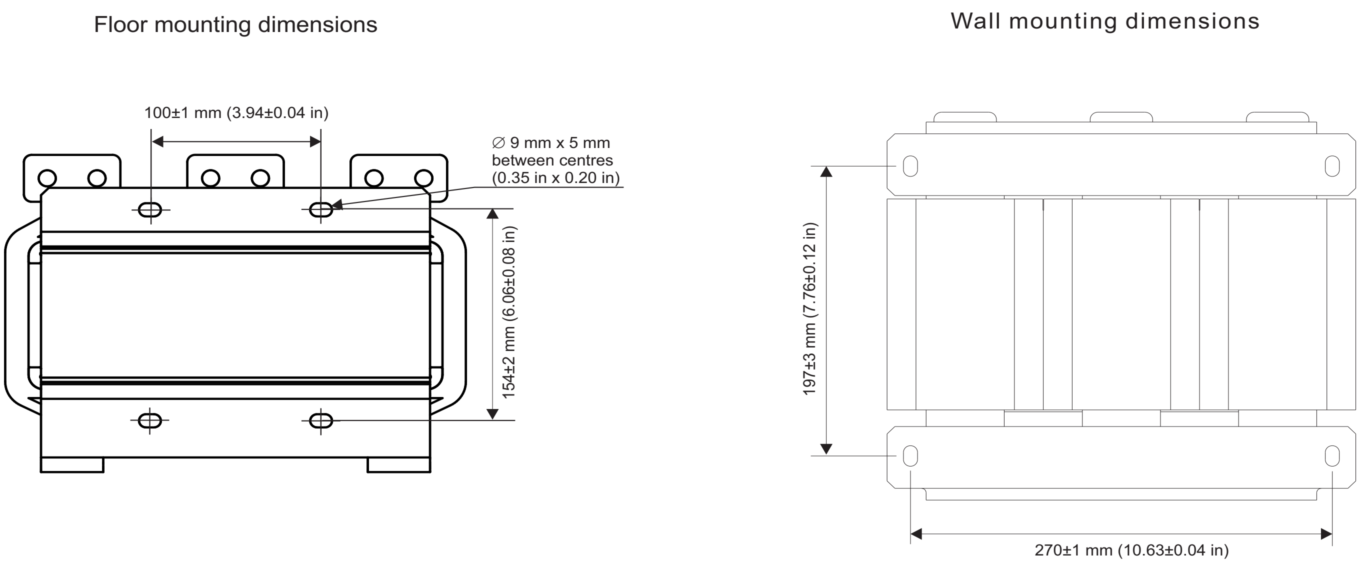


Figure 3-60 Input line reactor (INLX0X) for size 11

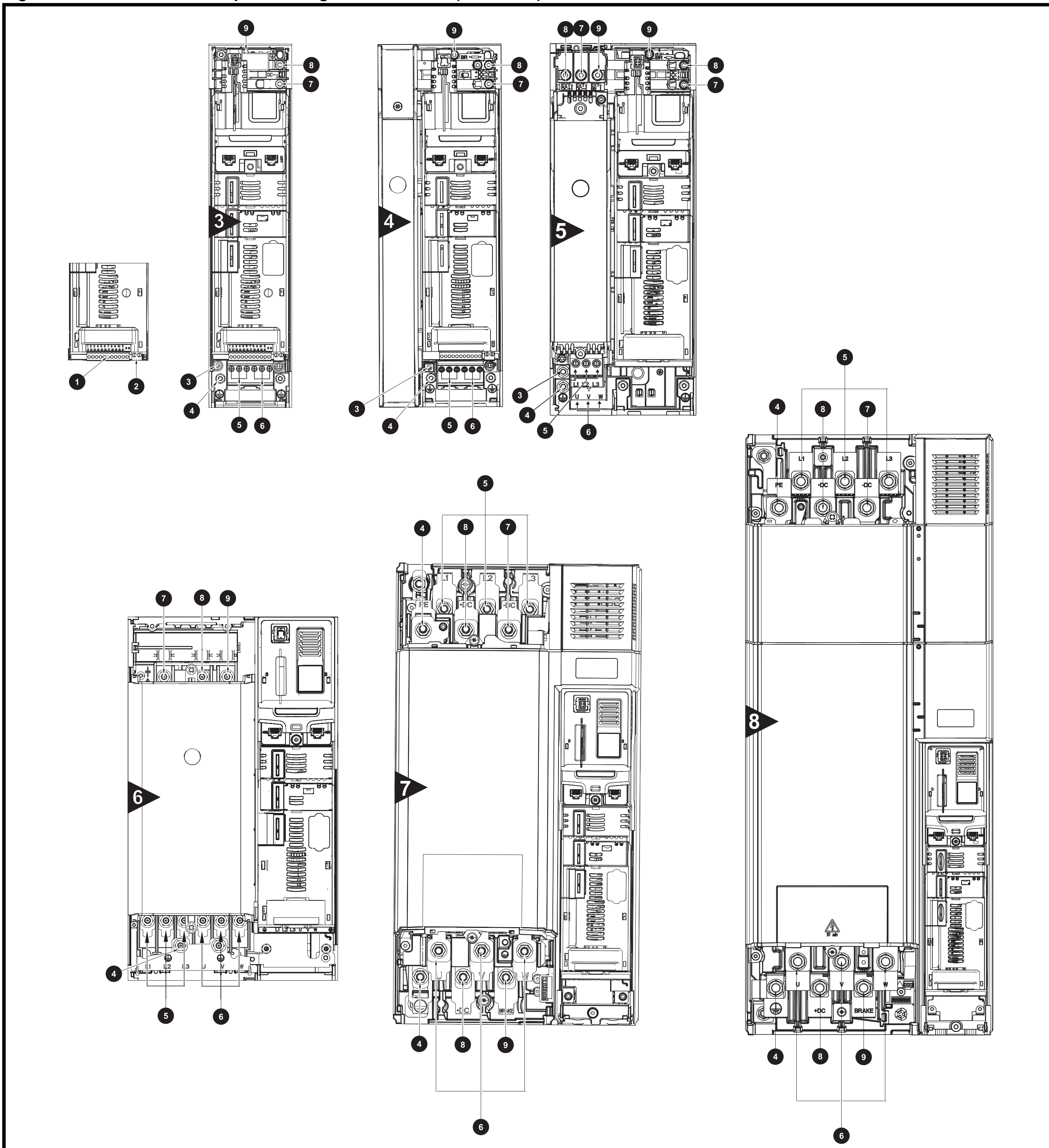


For overall dimensions and other details, refer to section 4.2.3 *Drive model and input line reactor* on page 101.

3.13 Electrical terminals

3.13.1 Location of the power and ground terminals

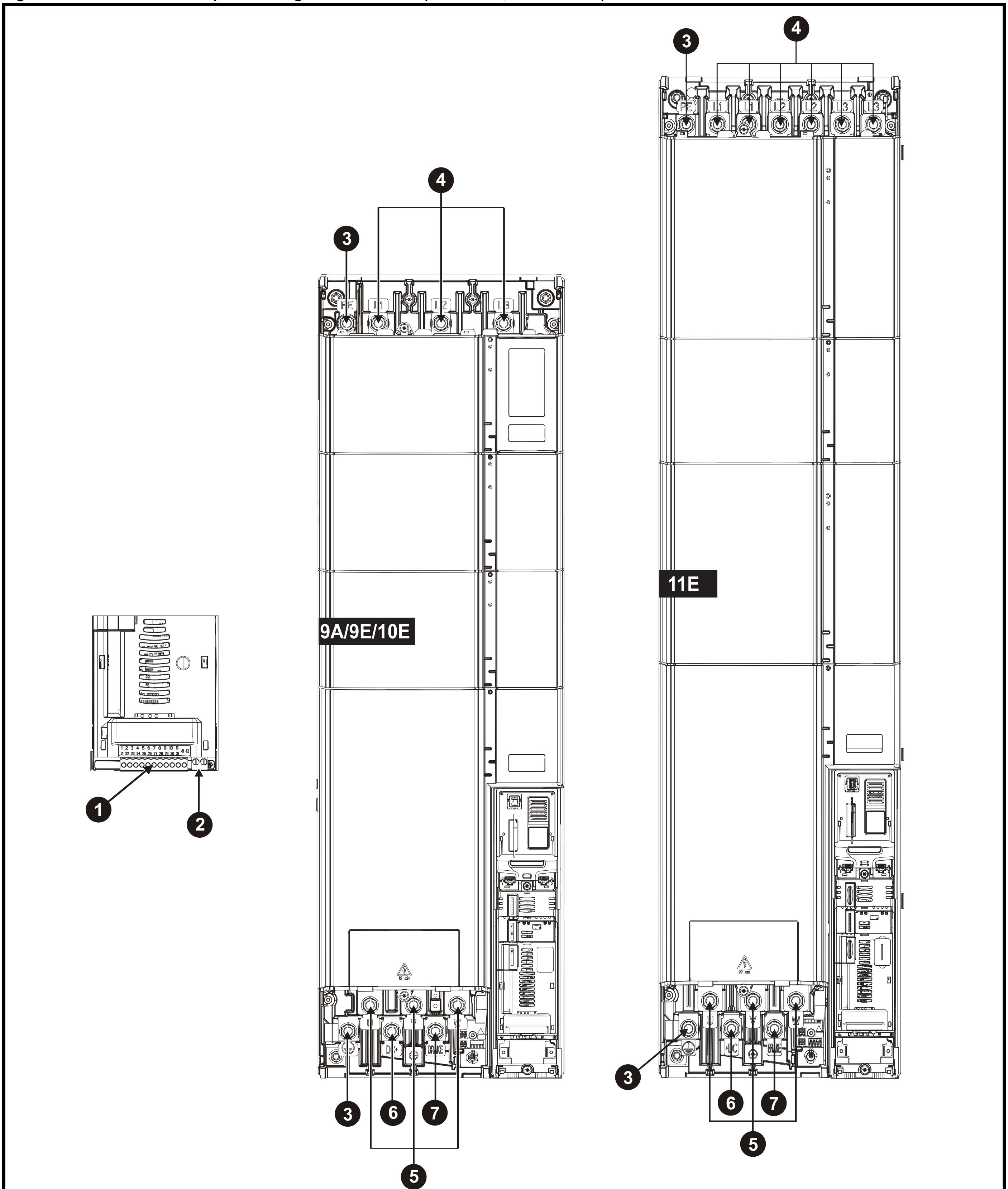
Figure 3-61 Locations of the power and ground terminals (size 3 to 8)



Key

1. Control terminals
2. Relay terminals
3. Additional ground connection
4. Ground connections
5. AC power terminals
6. Motor terminals
7. DC bus -
8. DC bus +
9. Brake terminal

Figure 3-62 Location of the power and ground terminals (size 9A/9E, 10E and 11E)



Key

1. Control terminals
2. Relay terminals
3. Ground connections
4. AC power terminals
5. Motor terminals
6. DC bus +
7. Brake terminal

3.13.2 Terminal sizes and torque settings

WARNING

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

Table 3-19 Drive power terminal data

Pump Drive F600 frame size	AC and motor terminals		DC and braking		Ground terminal	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
3 and 4	Plug-in terminal block		T20 Torx (M4)		T20 Torx (M4) / M4 Nut (7 mm AF)	
	0.7 N m (0.5 lb ft)	0.8 N m (0.6 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)
5	Plug-in terminal block		T20 Torx (M4) / M4 Nut (7 mm AF)		M5 Nut (8 mm AF)	
	1.5 N m (1.1 lb ft)	1.8 N m (1.3 lb ft)	1.5 N m (1.1 lb ft)	2.5 N m (1.8 lb ft)	2.0 N m (1.4 lb ft)	5.0 N m (3.7 lb ft)
6	M6 Nut (10 mm AF)		M6 Nut (10 mm AF)		M6 Nut (10 mm AF)	
	6.0 N m(4.4 lb ft)	8.0 N m (6.0 lb ft)	6.0 N m(4.4 lb ft)	8.0 N m (6.0 lb ft)	6.0 N m(4.4 lb ft)	8.0 N m (6.0 lb ft)
7	M8 Nut (13 mm AF)		M8 Nut (13 mm AF)		M8 Nut (13 mm AF)	
	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)
8 to 11	M10 Nut (17 mm AF)		M10 Nut (17 mm AF)		M10 Nut (17 mm AF)	
	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)

Table 3-20 Drive control and relay terminal data

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

Table 3-21 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm² (16 AWG)
	2 way relay connector	2.5 mm² (12 AWG)
3	6 way AC power connector	6 mm² (10 AWG)
4		
5	3 way AC power connector 3 way motor connector	8 mm² (8 AWG)
6	2 way low voltage power 24 V supply connector	1.5 mm² (16 AWG)
7		
8		
9A/9E		
10E/11E		

Table 3-22 External EMC filter terminal data

CT part number	Power connections			Ground connections	
	Bar hole diameter	Max cable size	Max torque	Ground stud size	Max torque
4200-1132	N/A	50 mm² (1/0 AWG)	8.0 N m (6.0lb ft)	M10	18 N m (13.3 lb ft)
4200-0672					
4200-1972		95 mm² (3/0 AWG)	20 N m (14.8 lb ft)		
4200-1662					
4200-0122		16 mm² (6 AWG)	2.3 N m (1.7 lb ft)	M6	4.8 N m (2.8 lb ft)
4200-0252			1.8 N m (1.4 lb ft)		
4200-0272					
4200-0312					
4200-0402					
4200-3230		4 mm² (12 AWG)	0.8 N m (0.59 lb ft)	M5	3.0 N m (2.2 lb ft)
4200-3480		4 mm² (12 AWG)	0.8 N m (0.59 lb ft)	M5	
4200-2300		16 mm² (6 AWG)	2.3 N m (1.70 lb ft)	M6	4.8 N m (2.8 lb ft)
4200-4800					
4200-3690					
4200-3021	10.8 mm	N/A	30 N m (22.1 lb ft)	M10	18 N m (13.3 lb ft)
4200-4460	11 mm				
4200-1660	10.8 mm				
4200-2210	11 mm				
4200-0400	10.5 mm			M12	25 N m (18.4 lb ft)
4200-0690	10.5 mm				

3.14 Routine maintenance

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

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

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

3.14.1 Real time clock battery replacement

The keypads with the real time clock feature contain a battery to ensure the clock works when the drive is powered down. The battery has a long life time but if the battery needs to be replaced or removed, follow the instructions below.

Low battery voltage is indicated by low battery symbol on the keypad display.

Figure 3-63 Keypad (rear view)

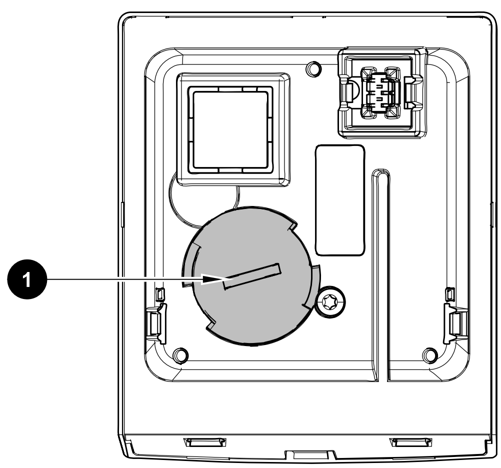


Figure 3-63 above illustrates a rear view of the keypad (KI-HOA Keypad RTC and HOA Keypad RTC).

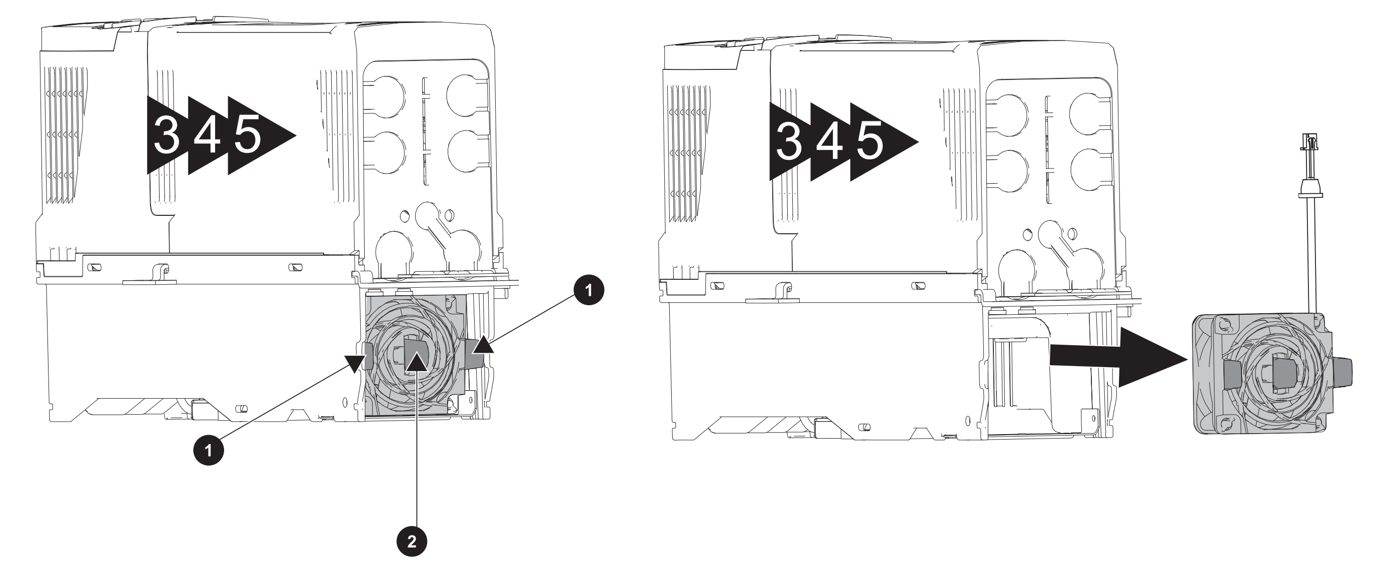
1. To remove the battery cover insert a flat head screwdriver into the slot as shown (1), push and turn anti-clockwise until the battery cover is released.
2. Replace the battery (the battery type is: CR2032).
3. Reverse point 1 above to replace battery cover.

NOTE

Ensure the battery is disposed of correctly.

3.14.2 Size 3 to 5 heatsink fan removal procedure

Figure 3-64 Removal of the size 3, 4 and 5 heatsink fan (size 3 shown)



Ensure the fan cable is disconnected from the drive prior to attempting fan removal.

1. Press the two tabs inwards to release the fan from the drive frame.
2. Using the central fan tab, withdraw the fan assembly from the drive housing.

Replace the fan by reversing the above instructions.

NOTE

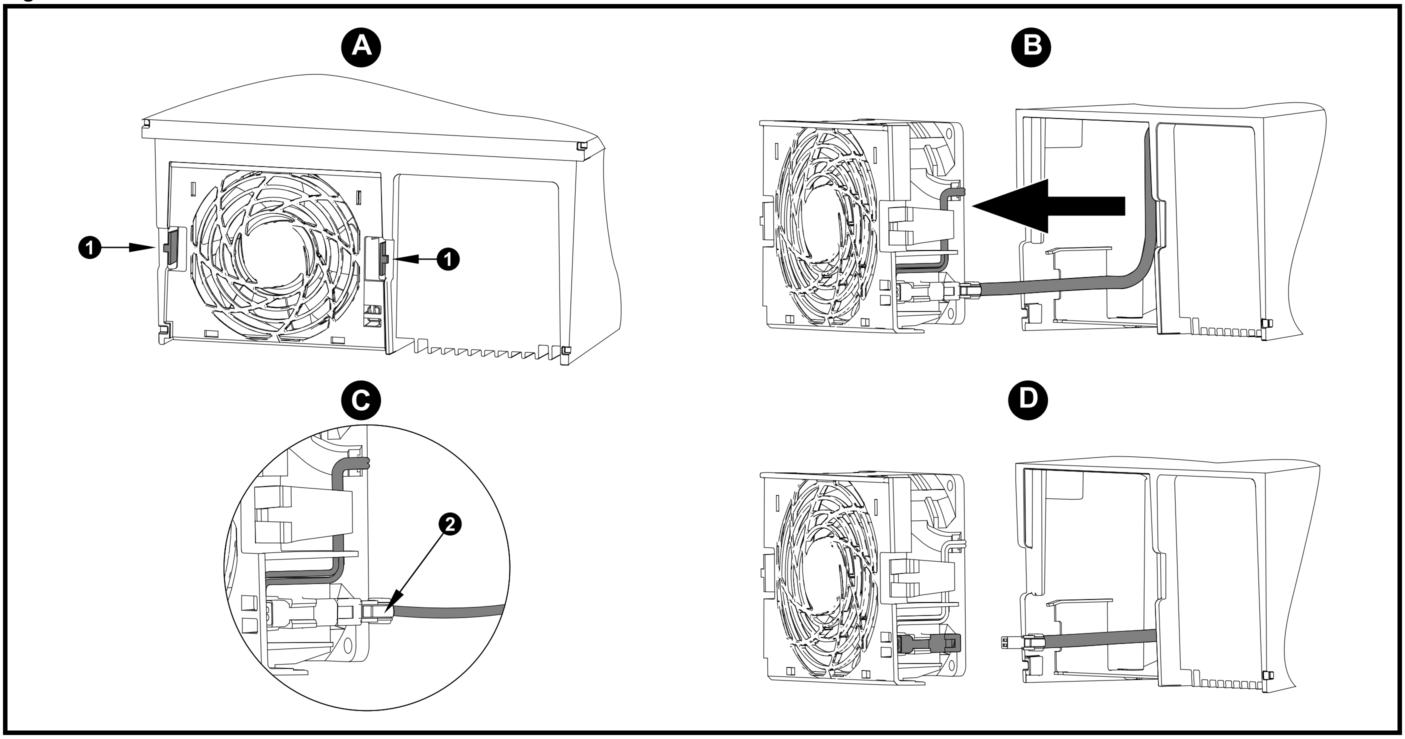
If the drive is surface mounted using the outer holes on the mounting bracket, then the heatsink fan can be replaced without removing the drive from the backplate.

Table 3-23 Size 3 to 5 heatsink fan part numbers

Model	Heatsink fan part number
Size 3	3251-0029
Size 4	3251-0245
Size 5	3251-0245

3.14.3 Size 6 heatsink fan removal procedure

Figure 3-65 Removal of the size 6 heatsink fan



A: Press the tabs (1) inwards to release the fan assembly from the underside of the drive.

B: Use the tabs (1) to withdraw the fan by pulling it away from the drive.

C: Depress and hold the locking release on the fan cable lead as shown (2).

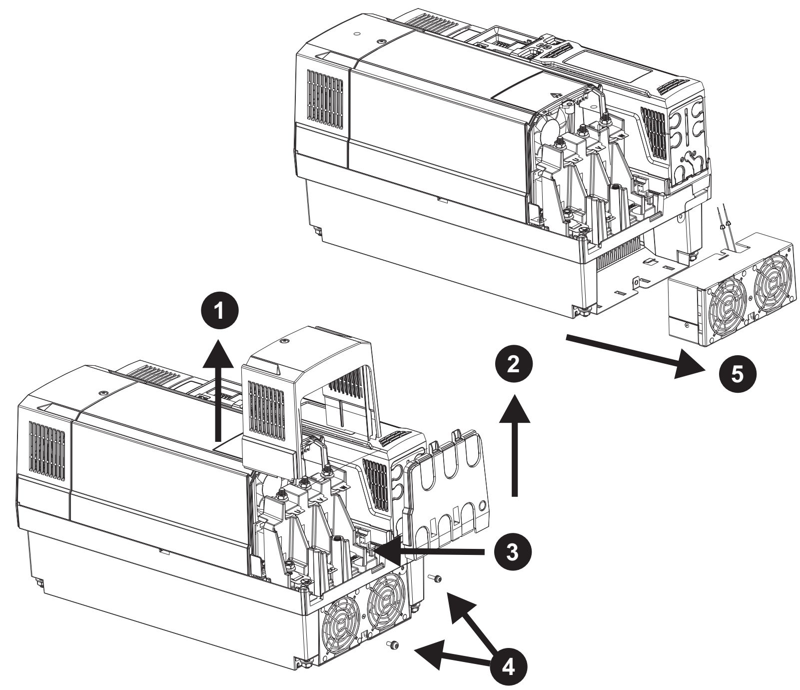
D: With the locking release depressed (2), take hold of the fan supply cable and carefully pull to separate the connectors.

Table 3-24 Size 6 heatsink fan part number

Model	Heatsink fan part number
Size 6	3251-0030

3.14.4 Size 7 heatsink fan replacement

Figure 3-66 Size 7 heatsink fan replacement



Size 7 heatsink fan removal procedure

1) Remove terminal cover

2) Remove finger guard

3) Disconnect fan cables from drive (making a note of the order) and push grommets down prior to attempting fan removal

4) Remove the mounting screws using a T20 and T25 torque driver

5) Withdraw fan housing from the drive

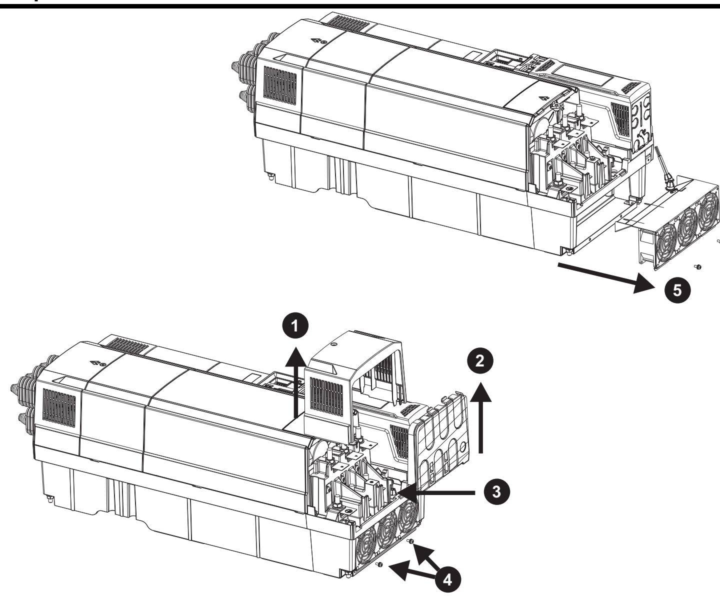
After fan(s) have been replaced, reverse the above steps to refit.

Table 3-25 Size 7 heatsink fan part number

Drive model	Heatsink fan part number
Size 7	3251-8247

3.14.5 Size 8 heatsink fan replacement

Figure 3-67 Size 8 heatsink fan replacement



Size 8 heatsink fan removal procedure

1) Remove terminal cover

2) Remove finger guard

3) Disconnect fan cables from drive (making a note of the order) and push grommet down prior to attempting fan removal

4) Remove the mounting screws using a T20 torque driver

5) Withdraw fan housing from the drive

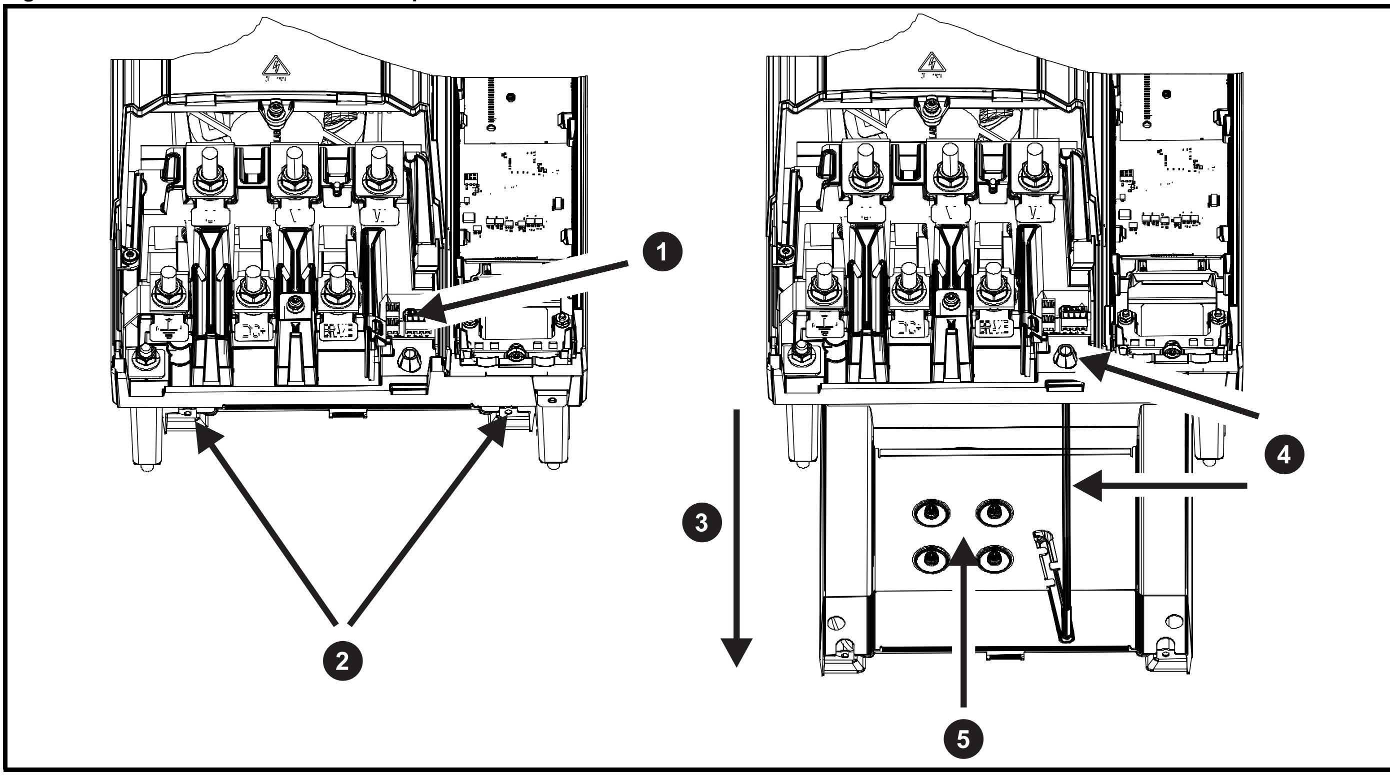
After fan(s) have been replaced, reverse the above steps to refit.

Table 3-26 Size 8 heatsink fan part number

Drive model	Heatsink fan part number
Size 8	3251-8240

3.14.6 Size 9 to 11 heatsink fan replacement

Figure 3-68 Size 9 to 11 Heatsink fan replacement



Heatsink fan removal procedure

1) Using a flat screwdriver remove the fan wires from the fan connector (making a note of the order).

2) Using a T20 Torque driver remove the two screws that retain the heatsink fan housing

3) Withdraw the heatsink fan housing from the drive in the direction shown

4) Pull the fan cable through the fan cable gland

5) Using a T20 Torque driver remove the four screws that retain the fan in the housing

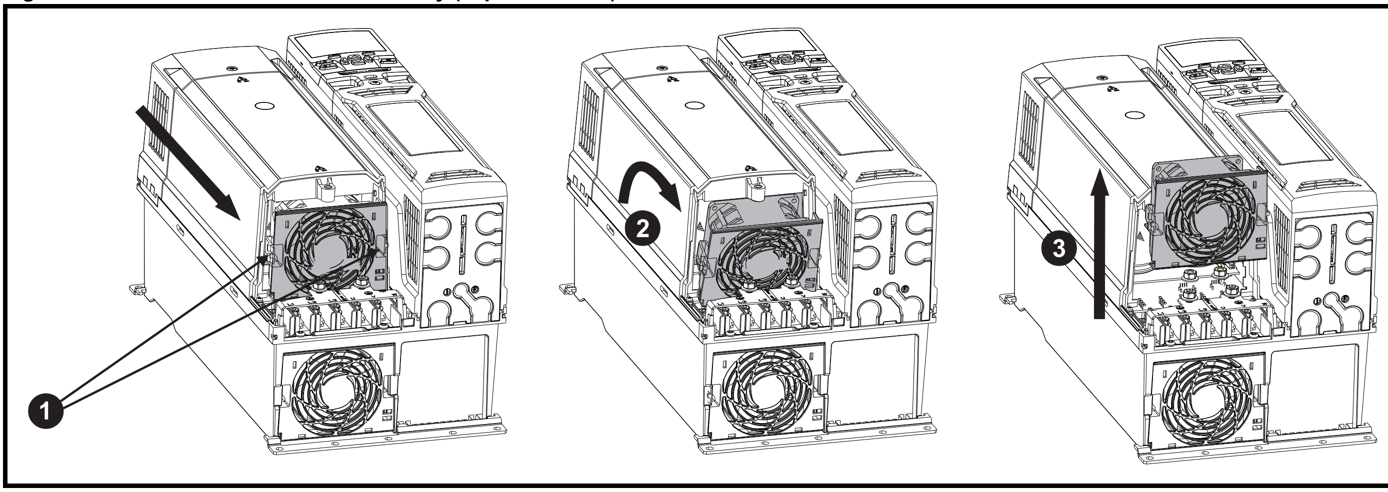
After fan has been replaced, reverse the above steps to refit.

Table 3-27 Heatsink fan part number

Drive model	Heatsink fan part number
Size 9 to 11	3251-1750

3.14.7 Size 6 auxiliary (capacitor bank) fan replacement

Figure 3-69 Removal of the size 6 auxiliary (capacitor bank) fan



- Press the tabs (1) inwards to release the fan assembly from the drive mid cover.
- Use the tabs (1) to withdraw the fan from the drive by pulling the fan assembly forward and tilting it at a slight angle (2).
- Pull the fan assembly up and away from the drive (3).
- Depress and hold the locking release on the fan cable lead.
- With the locking release depressed, take hold of the fan supply cable and carefully pull to separate the connectors.

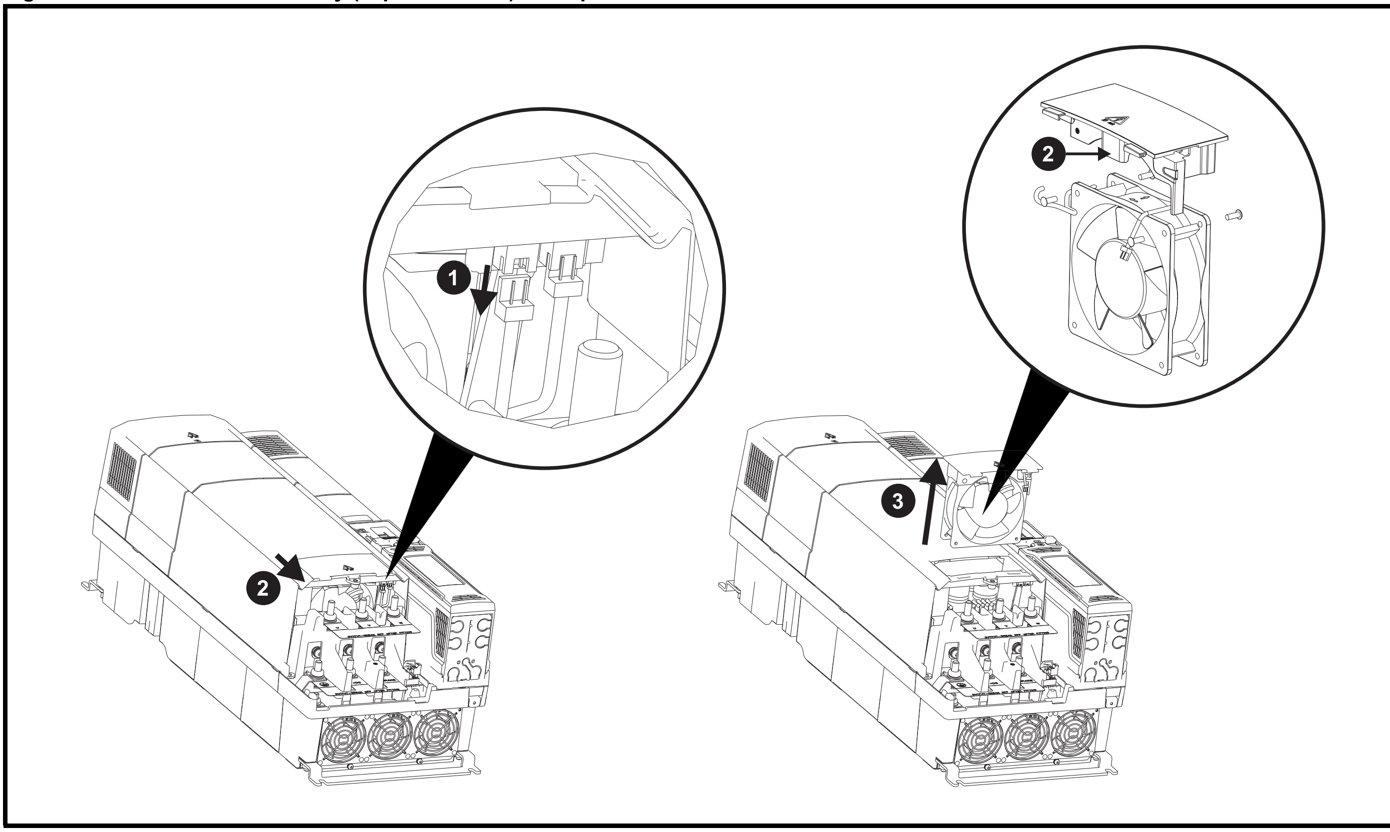
Replace the fan by reversing the above instructions.

Table 3-28 Size 6 auxiliary fan part number

Model	Auxiliary fan part number
Size 6	3251-0030

3.14.8 Size 7 to 11 auxiliary (capacitor bank) fan replacement

Figure 3-70 Size 7 to 11 auxiliary (capacitor bank) fan replacement



Size 7 to 11 auxiliary fan removal procedure

1) Disconnect the fan wiring connector shown

2) Slide fan housing in the direction shown using tongue shown in enlarged diagram of fan

3) Withdraw fan housing from the drive

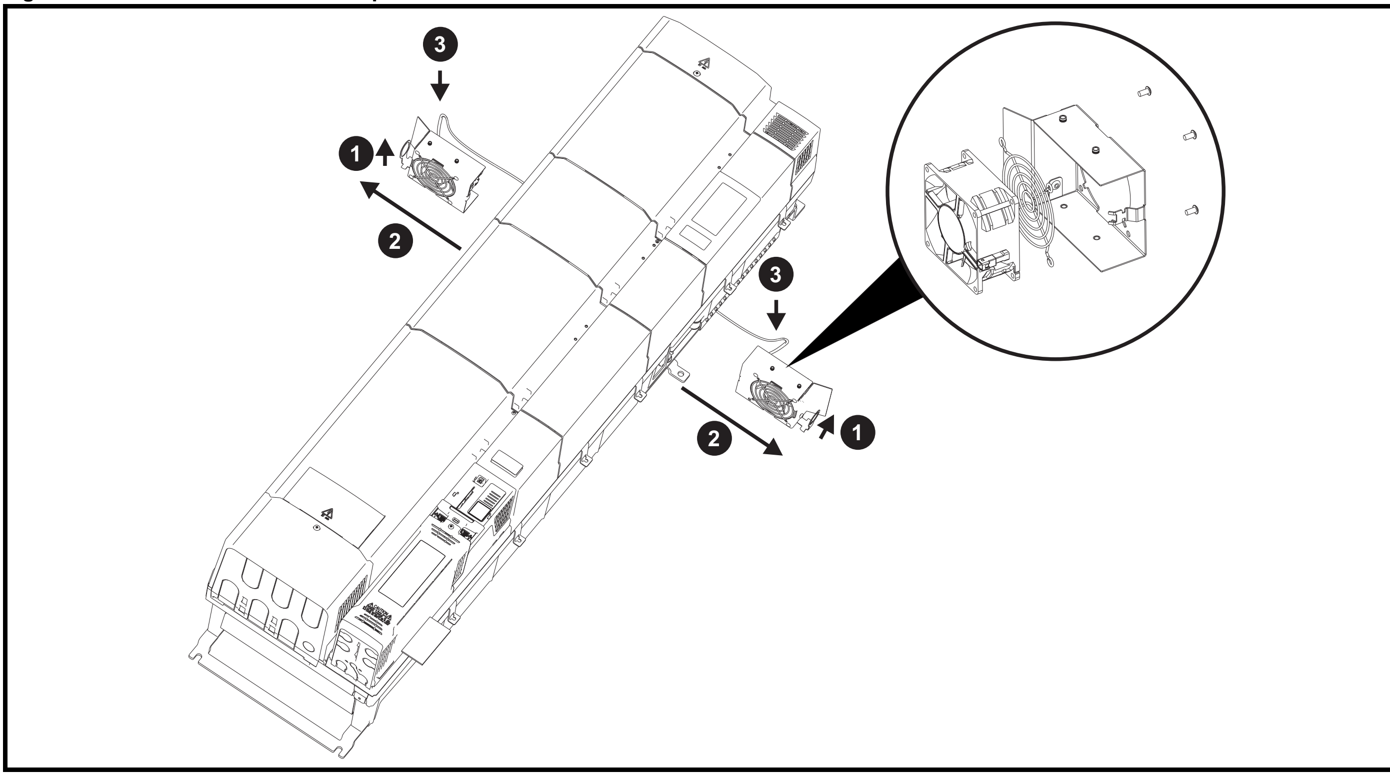
After fan has been replaced, reverse the above steps to refit.

Table 3-29 Size 7 to 11 Auxiliary (capactitor bank) fan part numbers

Drive model	Auxiliary (capacitor bank fan part number
Size 7	3251-0041
Size 8	3251-2249
Size 9, 10 and 11 (575V and 690V)	3251-0042
Size 11 (400V)	3251-1202

3.14.9 Size 11E rectifier fan replacement

Figure 3-71 Size 11E rectifier fan replacement



Size 11E rectifier fan removal procedure

1) Lift the ring eye provided

2) Pull the fan housing in the direction shown

3) Disconnect the fan wiring at the connector shown

After fans have been replaced, reverse the above steps to refit the fan housing in the rectifier (making sure the fan housing aligns correctly in the slots top and bottom).

Table 3-30 Size 11E rectifier fan part number

Drive model	Rectifier fan part number
Size 11E rectifier	3251-0030

4 Electrical installation

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

- Safe Torque Off function
- Internal EMC filter
- EMC compliance with shielding / grounding accessories
- Product rating, fusing and cabling information
- Brake resistor details (selection / ratings)

WARNING

Electric shock risk
The voltages present in the following locations can cause severe electric shock and may be lethal:
- AC supply cables and connections
- DC and brake cables, and connections
- Output cables and connections
- Many internal parts of the drive, and external option units

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

WARNING

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

WARNING

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

WARNING

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

WARNING

Stored charge
The drive contains capacitors that remain charged to a potentially lethal voltage after the AC and / or DC power supply has been disconnected. If the drive has been energized, the AC and / or DC power supply must be isolated at least ten minutes before work may continue.
Normally, the capacitors are discharged by an internal resistor. Under certain, unusual fault conditions, it is possible that the capacitors may fail to discharge,
or be prevented from being discharged by a voltage applied to the output terminals. If the drive has failed in a manner that causes the display to go blank immediately, it is possible the capacitors will not be discharged. In this case, consult Control Techniques or their authorized distributor.

WARNING

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

WARNING

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

4.1 Power connections

4.1.1 AC and DC connections

Figure 4-1 Size 3 power connections

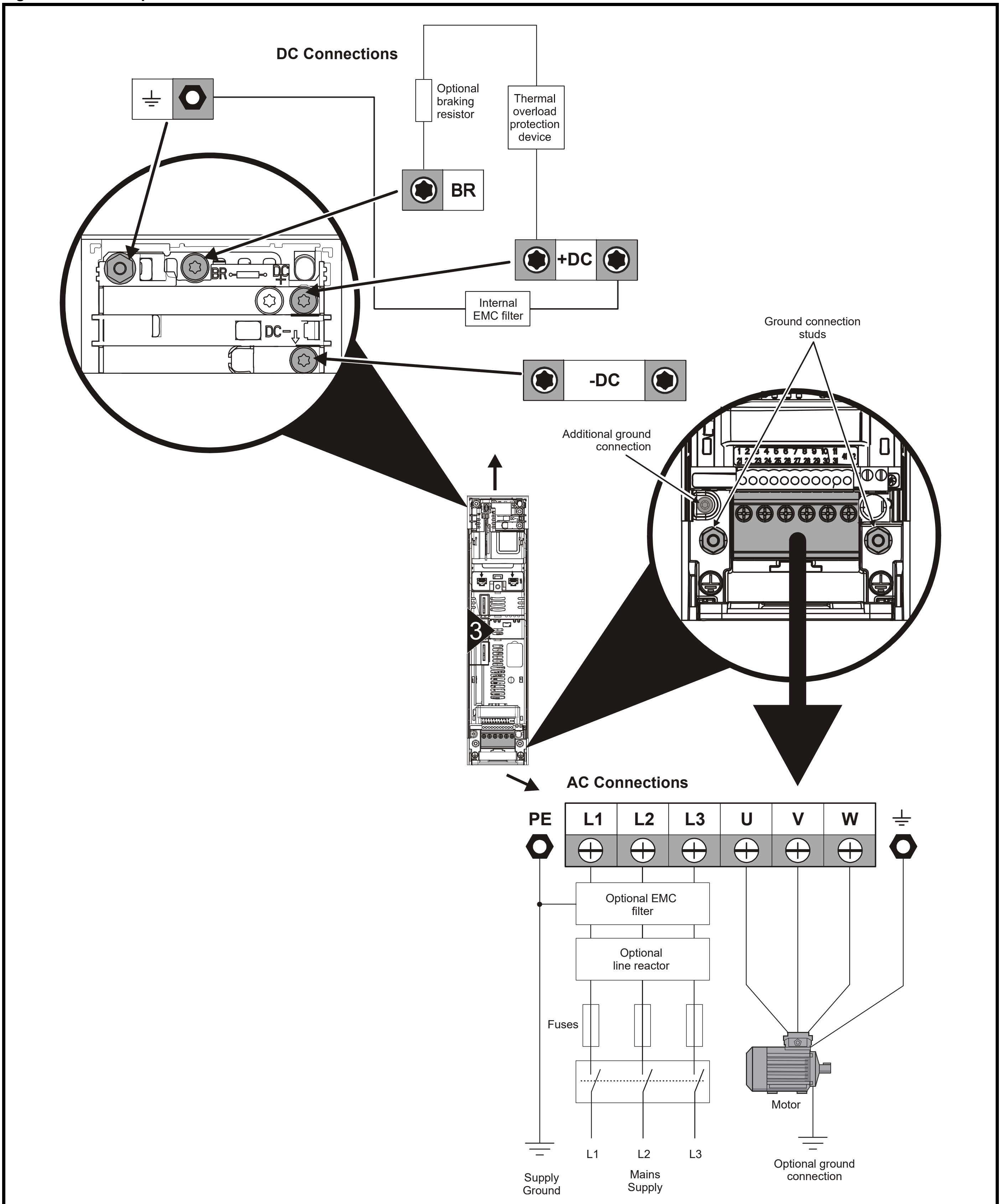


Figure 4-2 Size 4 power connections

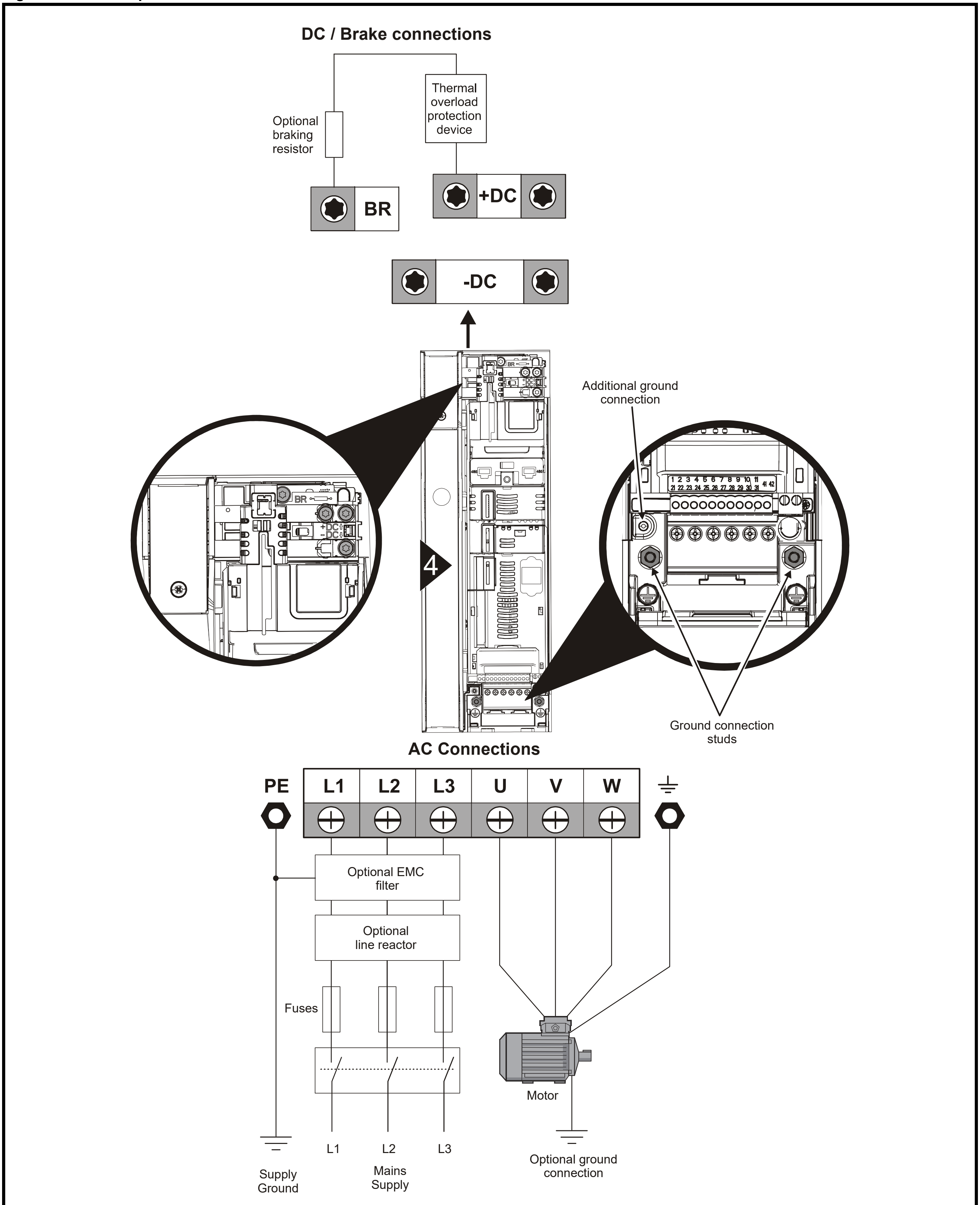
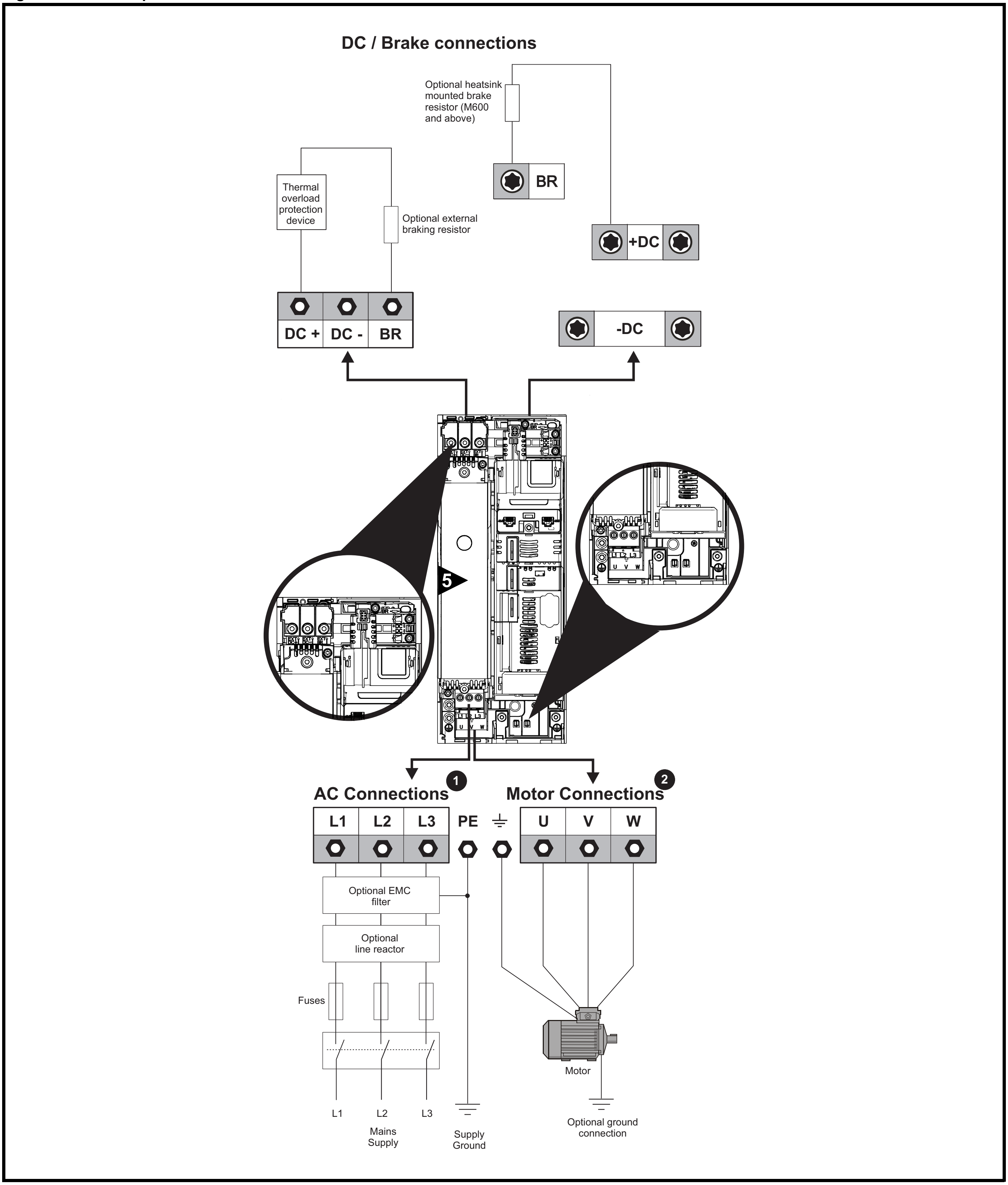


Figure 4-3 Size 5 power connections



The upper terminal block (1) is used for AC supply connection.

The lower terminal block (2) is used for Motor connection.

Figure 4-4 Size 6 power connections

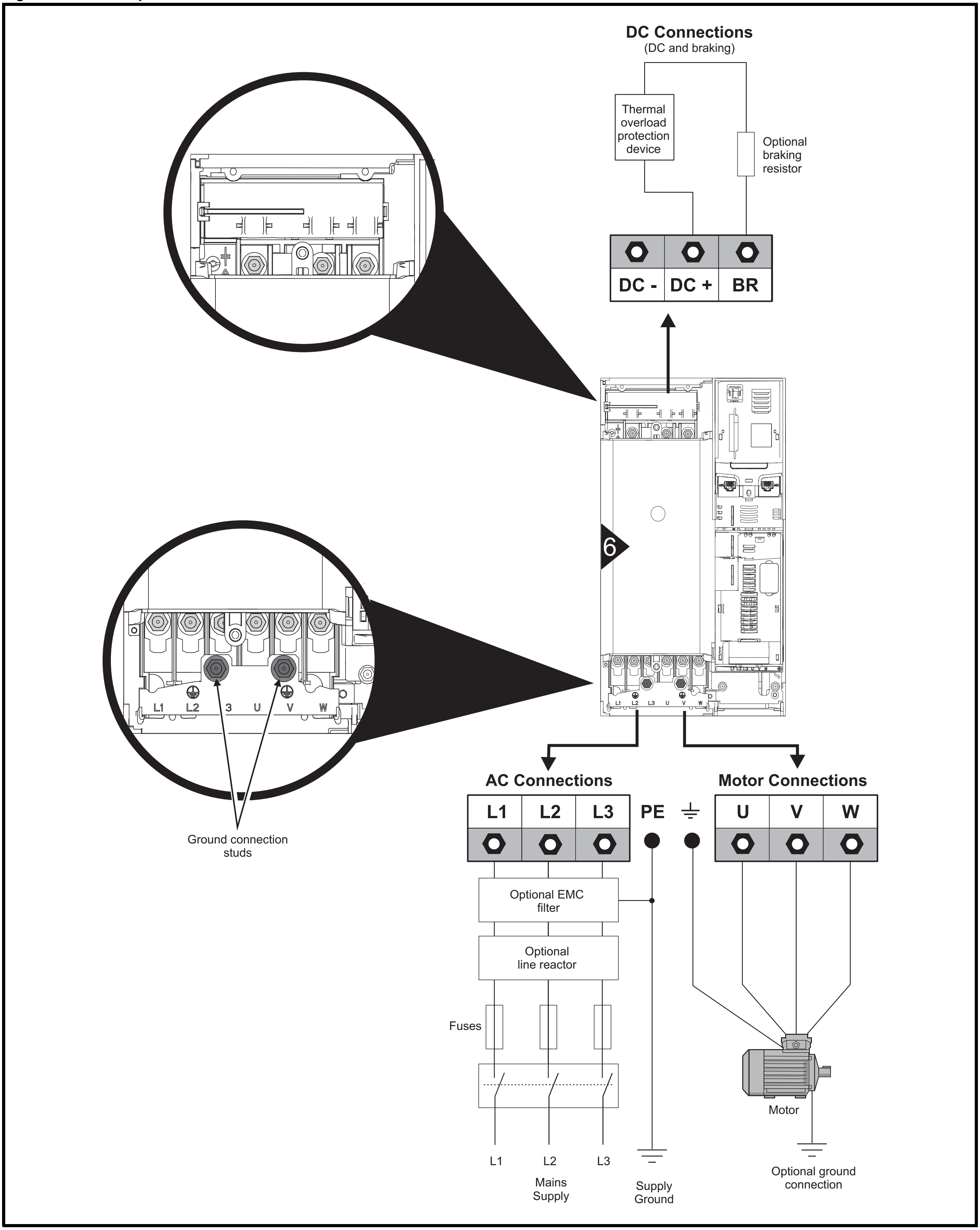


Figure 4-5 Size 7 and 8 power connections (Size 7 shown)

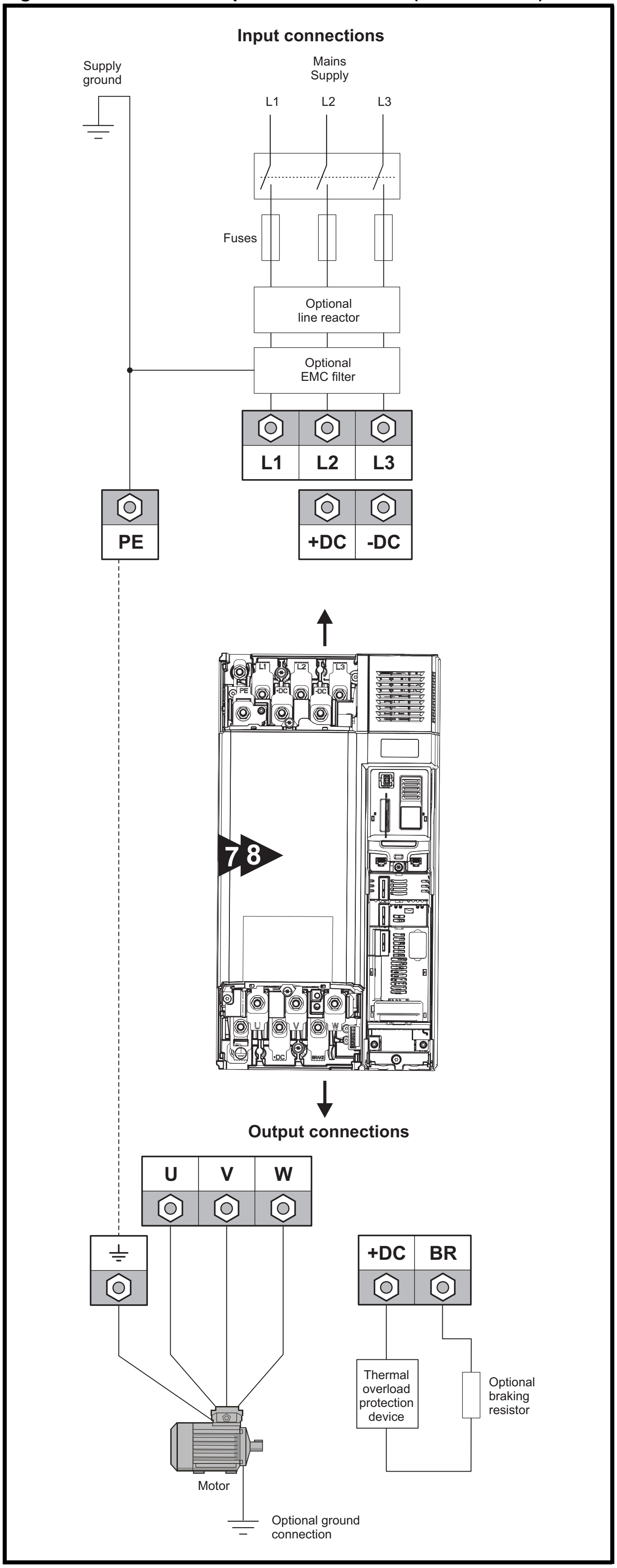


Figure 4-6 Size 9A power connections

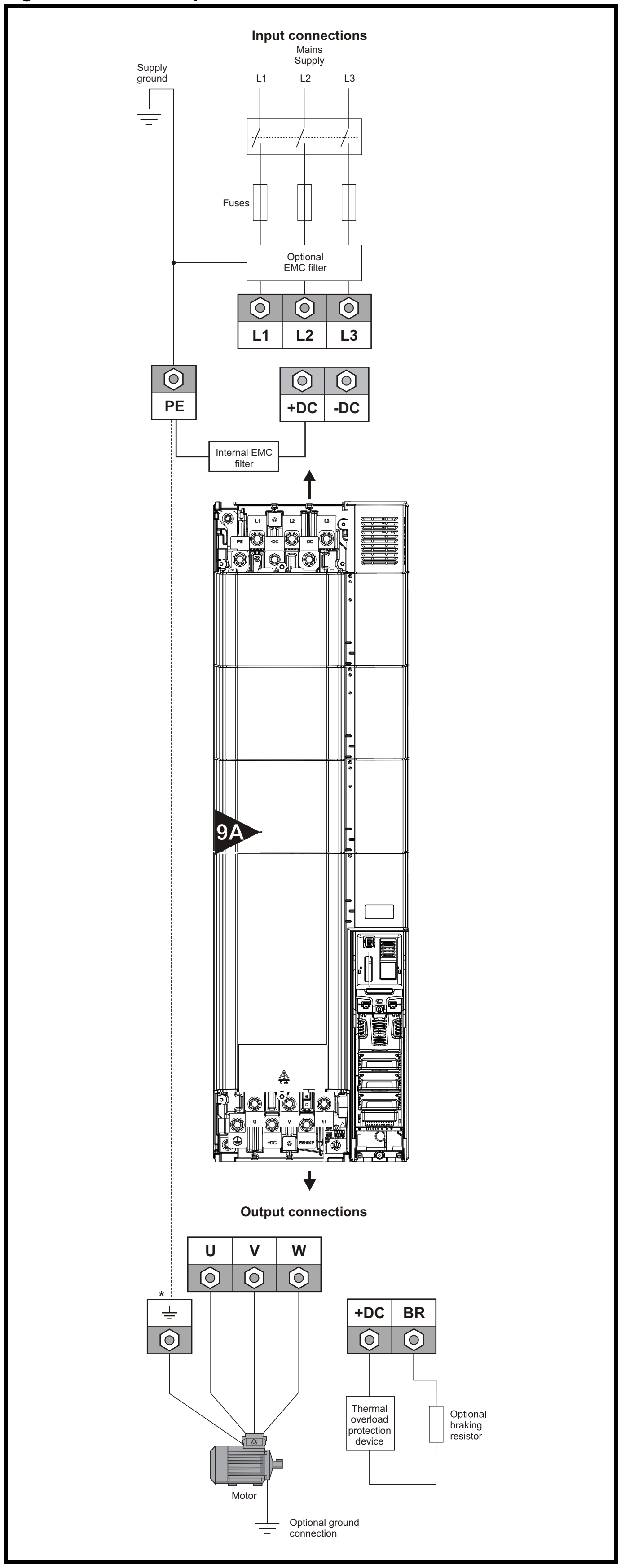
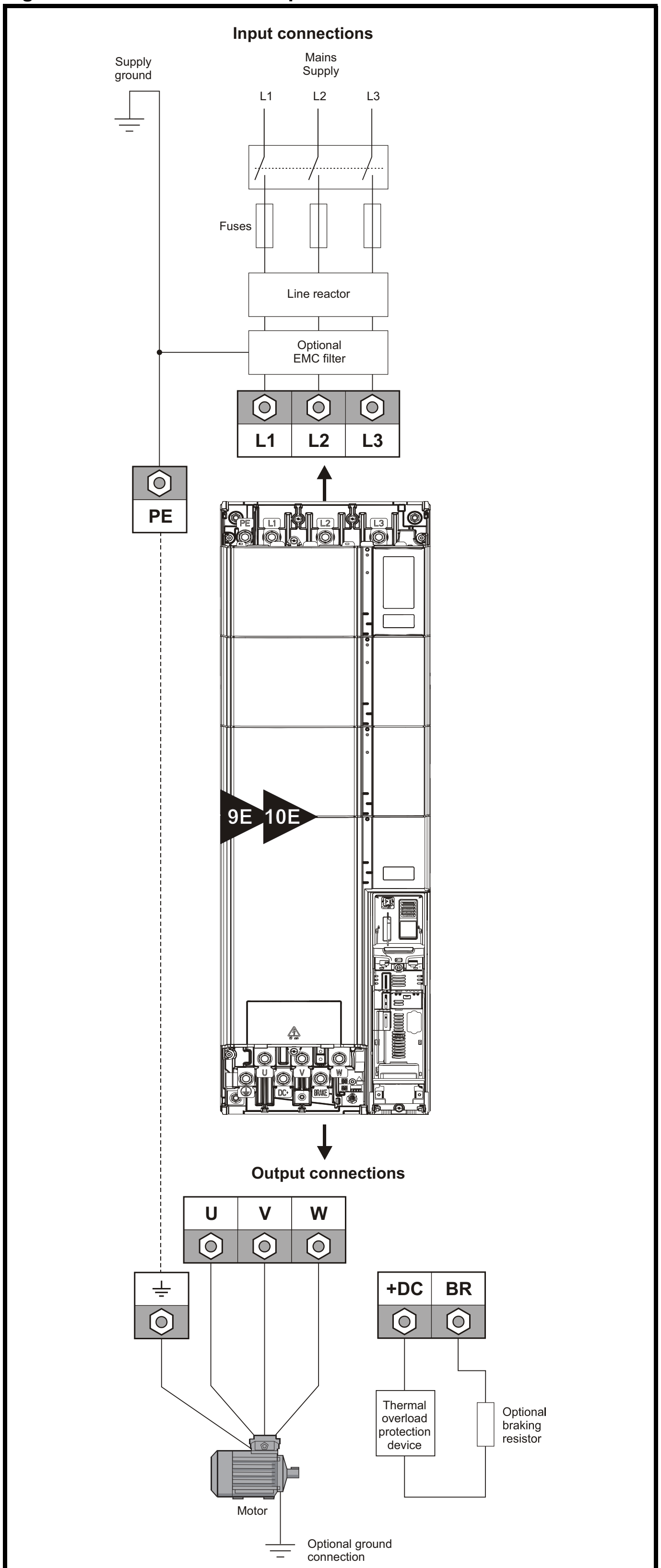


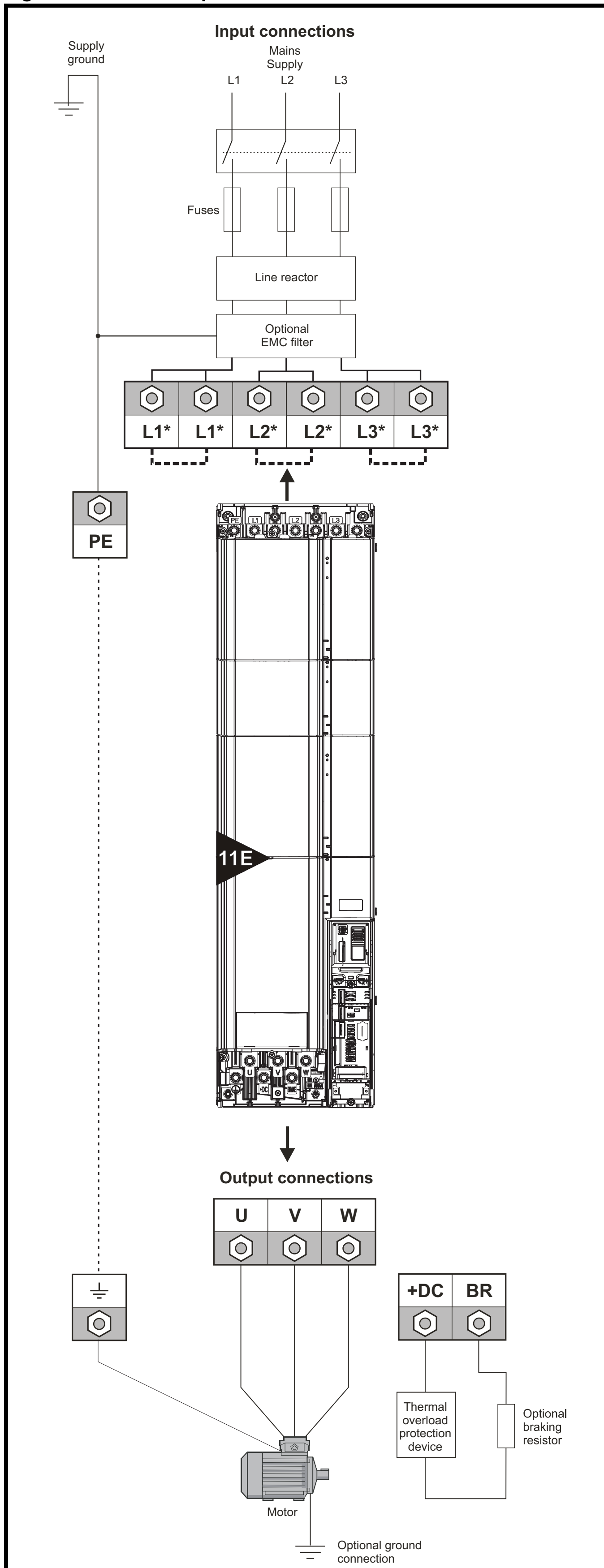
Figure 4-7 Size 9E and 10E power connections



A separate line reactor (INLXXX) of at least the value shown in Table 4-3 and Table 4-2 on page 101 must be used with size 9E, 10E and 11E. Failure to provide sufficient reactance could damage or reduce the service life of the drive.

CAUTION

Figure 4-8 Size 11E power connections



* Common AC supply connections are internally linked.

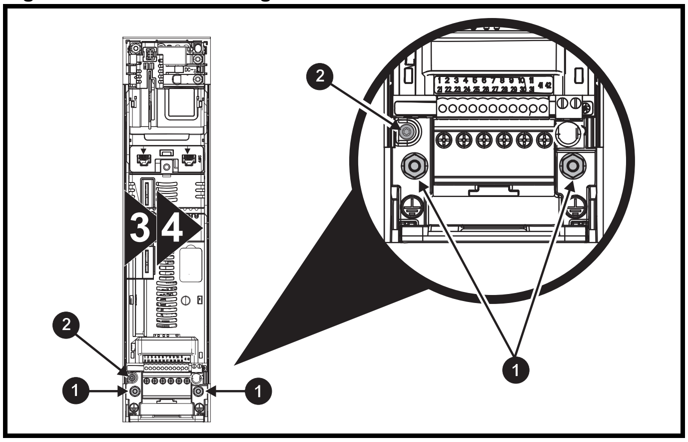
4.1.2 Ground connections

WARNING

Electrochemical corrosion of grounding terminals
Ensure that grounding terminals are protected against corrosion i.e. as could be caused by condensation.

Size 3 and 4
On sizes 3 and 4, the supply and motor ground connections are made using the M4 studs located either side of the drive near the plug-in power connector. Refer to Figure 4-9 for additional ground connection.

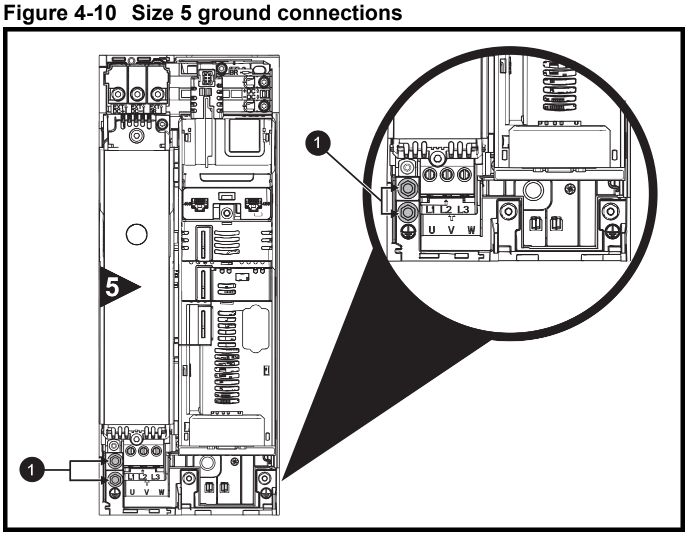
Figure 4-9 Size 3 and 4 ground connections



1. Ground connection studs.
2. Additional ground connection.

Size 5
On size 5, the supply and motor ground connections are made using the M5 studs located near the plug-in power connector. Refer to Figure 4-10 for additional ground connection.

Figure 4-10 Size 5 ground connections

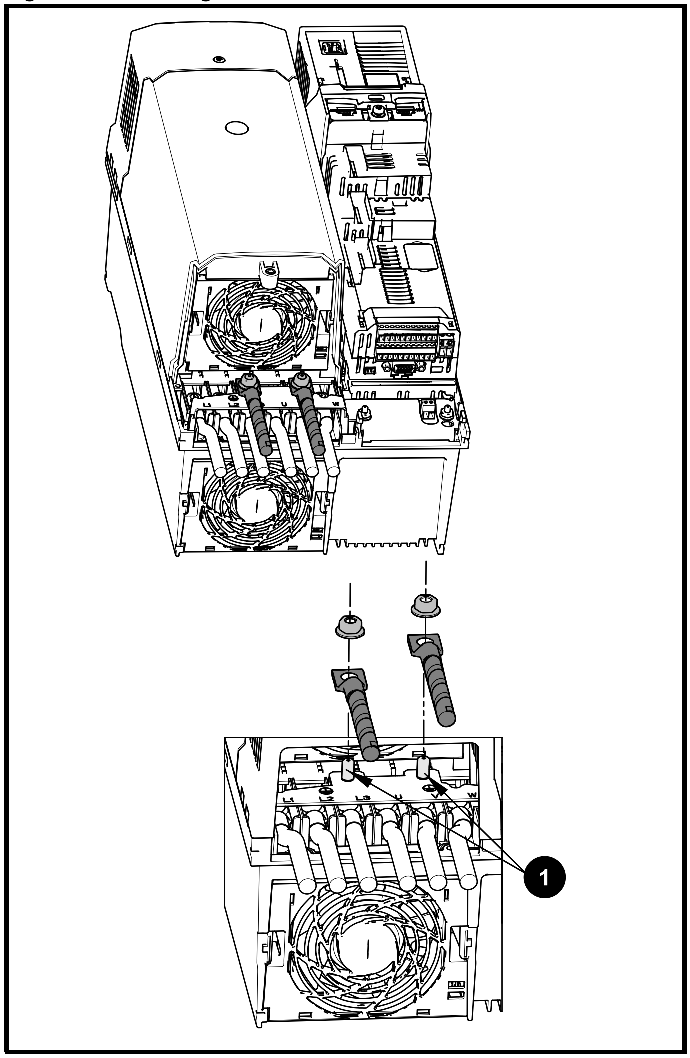


1. Ground connection studs.

Size 6

On a size 6, the supply and motor ground connections are made using the M6 studs located above the supply and motor terminals. Refer to Figure 4-11 below.

Figure 4-11 Size 6 ground connections



1. Ground connection studs

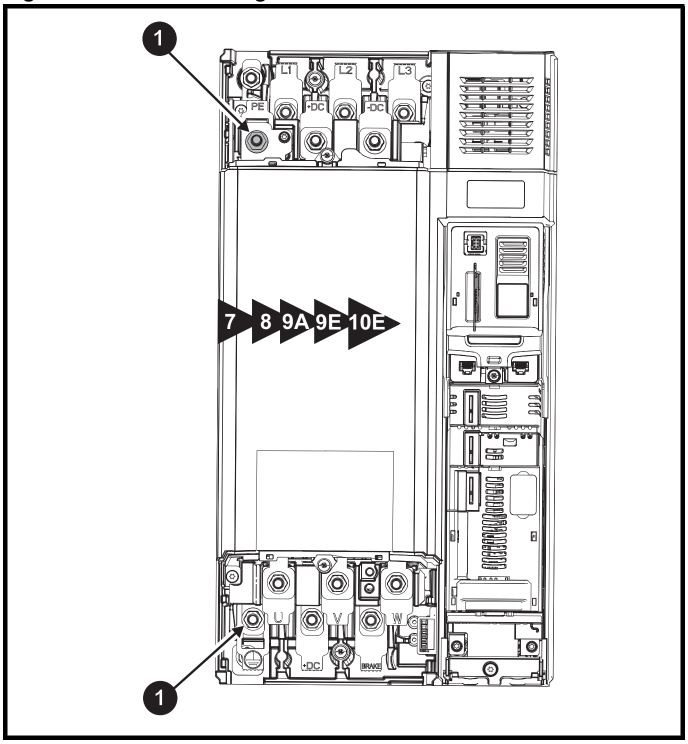
Size 7

On size 7, the supply and motor ground connections are made using the M8 studs located by the supply and motor connection terminals.

Size 8 to 11

On size 8 to 11, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals.

Figure 4-12 Size 7 to 10 ground connections



1. Ground connection studs.

> **WARNING**
>
> The ground loop impedance must conform to the requirements of local safety regulations.
>
> The drive must be grounded by a connection capable of carrying the prospective fault current until the protective device (fuse, etc.) disconnects the AC supply.
>
> The ground connections must be inspected and tested at appropriate intervals.

Figure 4-13 Size 11E ground connections

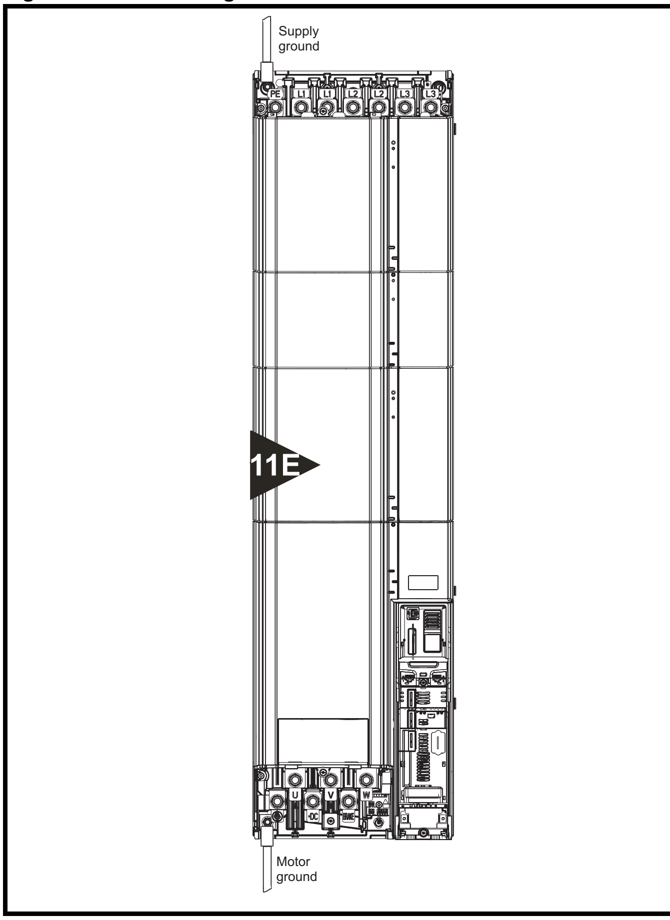


Table 4-1 Protective ground cable ratings

Input phase conductor size	Minimum ground conductor size
≤ 10 mm²	Either 10 mm² or two conductors of the same cross-sectional area as the input phase conductor.
> 10 mm² and ≤ 16 mm²	The same cross-sectional area as the input phase conductor
> 16 mm² and ≤ 35 mm²	16 mm²
> 35 mm²	Half of the cross-sectional area of the input phase conductor

4.2 AC supply requirements

Voltage:

200 V drive: 200 V to 240 V ±10 %
400 V drive: 380 V to 480 V ±10 %
575 V drive: 500 V to 575 V ±10 %
690 V drive: 500 V to 690 V ±10 %

Number of phases: 3

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

Frequency range: 45 to 66 Hz

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

4.2.1 Supply types

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

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

Drives are suitable for use on supplies of installation category III and lower, according to IEC60664-1. This means they may be connected permanently to the supply at its origin in a building, but for outdoor installation additional over-voltage suppression (transient voltage surge suppression) must be provided to reduce category IV to category III.

WARNING

Operation with IT (ungrounded) supplies:
Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used (removed) or additional independent motor ground fault protection must be provided.
For instructions on removal, refer to section 4.12.2 *Internal EMC filter* on page 123. For details of ground fault protection contact the supplier of the drive.

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

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

4.2.2 Supplies requiring line reactors

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

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

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

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

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

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

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

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

03200066, 03200080, 03200110, 03200127, 03400034, 03400045, 03400062, 03400077

Model sizes 03400104 to 07600730 have an internal DC choke and model sizes 08201490 to 0801080 and frame 9A have internal AC line chokes so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions. Drive sizes 9E,10E and 11E do not have internal input line reactors hence an external input line reactor must be used. For more information refer to section 4.2.3 *Drive model and input line reactor* on page 101.

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

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

CAUTION

A separate line reactor (INLXXX) of at least the value shown in Table 4-3 and Table 4-2 must be used with size 9E, 10E and 11E. Failure to provide sufficient reactance could damage or reduce the service life of the drive.

4.2.3 Drive model and input line reactor

Table 4-2 Drive model and line reactor part number

Size	Drive model	Inductor model	Line reactor part number
3	03200066, 03200080	INL 2001	4401-0143
	03200110, 03200127	INL 2002	4401-0144
	03400034, 03400045	INL 4001	4401-0148
	03400062	INL 4002	4401-0149
	03400077, 03400104	INL 4011	4401-0234
	03400123	INL 4003	4401-0151
4	04200180	INL 2002	4401-0144
	04200250	INL 2003	4401-0145
	04400185	INL 4004	4401-0152
	04400240	INL 4005	4401-0153
5	05200300	INL 2008	4401-0226
	05400300	INL 4013	4401-0236
	05500039	INL 5007	4401-0242
	05500061	INL 5008	4401-0243
	05500100	INL 5009	4401-0244
6	06200500	INL 2004	4401-0146
	06200580	INL 2005	4401-0147
	06400380	INL 4006	4401-0154
	06400480	INL 4007	4401-0155
	06400630	INL 4008	4401-0156
	06500120	INL 5001	4401-0157
	06500170	INL 5002	4401-0158
	06500220	INL 5003	4401-0159
	06500270	INL 5004	4401-0160
	06500340	INL 5005	4401-0161
	06500430	INL 5006	4401-0223
7	07200750	INL 2009	4401-0227
	07200940	INL 2010	4401-0228
	07201170	INL 2011	4401-0229
	07400790	INL 4014	4401-0237
	07400940	INL 4015	4401-0238
	07401120	INL 4016	4401-0239
	07500530	INL 5006	4401-0223
	07500730	INL 5010	4401-0245
	07600230	INL 6001	4401-0248
	07600300	INL 6002	4401-0249
	07600360	INL 6003	4401-0250
	07600460	INL 6004	4401-0251
	07600520	INL 6005	4401-0252
	07600730	INL 6006	4401-0253
8	08201490	INL 2012	4401-0230
	08201800	INL 2013	4401-0231
	08401550	INL 4017	4401-0240
	08401840	INL 4018	4401-0241
	08500860	INL 5011	4401-0246
	08501080	INL 5012	4401-0247
	08600860	INL 6007	4401-0254
	08601080	INL 6008	4401-0255
9E	09202160, 09202660, 09402210, 09402660	INL 401	4401-0181
	09501250, 09501500, 09601720, 09601970	INL 601	4401-0183
10E	10203250, 10203600, 10403200, 10403610	INL 402	4401-0182
	10502000, 10601720, 10601970	INL 602	4401-0184
11E	11404370	INL 403L**	4401-0274
	11404370, 11404870, 11405070	INL 403*	4401-0259
	11502480, 11502880, 11503150, 11602250, 11602750, 11603050	INL 603*	4401-0261

* Natural cooling.

** May represent a more economic solution when operating below 420 A.

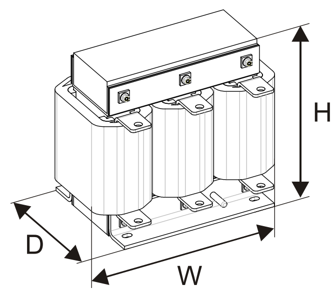
Table 4-3 Input line reactor ratings (2 %)

Part number	Model	Current A	Inductance µH	Overall width (W) mm	Overall depth (D) mm	Overall height (H) mm	Weight kg	Max ambient temp °C	Min airflow m/s	Maximum losses W
4401-0143	INL 2001	13.5	790	156	70	125	1.8	50	0	42
4401-0144	INL 2002	20.6	480	156	80	125	2.4	50	0	43
4401-0145	INL 2003	26.8	320	156	80	125	2.5	50	0	48
4401-0148	INL 4001	6.6	2940	80	75	130	1.3	50	0	31
4401-0149	INL 4002	9.1	1620	156	70	125	1.8	50	0	42
4401-0234	INL 4011	13	1120	156	80	125	2.5	50	0	46
4401-0151	INL 4003	15.8	1050	156	80	125	2.6	50	0	47
4401-0152	INL 4004	18.7	790	156	60	145	3.5	50	0	62
4401-0153	INL 4005	24.3	610	156	75	145	4.9	50	0	59
4401-0226	INL 2008	32	260	156	60	145	3.30	50	0	64
4401-0146	INL 2004	48.8	170	156	75	145	4.8	50	0	59
4401-0147	INL 2005	56.6	150	156	120	130	4.9	50	0	58
4401-0236	INL 4013	32	480	156	75	145	4.9	50	0	63
4401-0154	INL 4006	36.5	400	206	140	200	8	50	0	78
4401-0155	INL 4007	46.2	320	206	140	200	9	50	0	84
4401-0156	INL 4008	60.6	240	255	125	195	11	50	0	104
4401-0242	INL 5007	4.3	492	80	75	130	1.4	50	0	35
4401-0243	INL 5008	6.8	311	156	70	125	1.8	50	0	39
4401-0244	INL 5009	11.4	1890	156	60	145	3.2	50	0	60
4401-0157	INL 5001	13.2	1600	156	60	145	3.5	50	0	60
4401-0158	INL 5002	18.7	1130	156	75	145	4.9	50	0	59
4401-0159	INL 5003	24.3	870	206	95	200	6	50	0	73
4401-0160	INL 5004	29.4	720	206	130	200	7.4	50	0	77
4401-0161	INL 5005	37.1	570	230	130	210	11	50	0	108
4401-0223	INL 5006	47	480	255	130	210	12.5	50	0	122
4401-0227	INL 2009	67	130	206	130	160	6.9	50	0	90
4401-0228	INL 2010	88	100	206	140	160	9	50	0	97
4401-0229	INL 2011	105	80	206	140	160	9.5	50	0	90
4401-0230	INL 2012	137	62	254	130	195	12.5	50	0	143
4401-0231	INL 2013	166	51	254	150	195	14	50	0	137
4401-0237	INL 4014	74	200	254	130	195	12	50	0	129
4401-0238	INL 4015	88	170	254	150	195	14	50	0	127
4401-0239	INL 4016	105	140	254	150	195	14	50	0	139
4401-0240	INL 4017	155	95	290	160	205	20	50	0	182
4401-0241	INL 4018	177	83	290	170	205	22	50	0	200
4401-0245	INL 5010	67	340	290	150	205	18	50	0	139
4401-0246	INL 5011	88	250	290	170	205	22	50	0	147
4401-0247	INL 5012	105	200	290	180	225	25	50	0	167
4401-0248	INL 6001	20	1270	206	95	200	5.8	50	0	71
4401-0249	INL 6002	26	980	206	130	200	7.4	50	0	80
4401-0250	INL 6003	32	880	206	140	200	10	50	0	84
4401-0251	INL 6004	39	650	254	130	210	12	50	0	123
4401-0252	INL 6005	45	580	254	130	210	12.5	50	0	124
4401-0253	INL 6006	67	410	290	150	205	18	50	0	123
4401-0254	INL 6007	88	300	290	170	205	22	50	0	169
4401-0255	INL 6008	105	240	290	180	225	25	50	0	204
4401-0181	INL 401	245	63	240	190	225	32	50	1	148

Part number	Model	Current A	Inductance µH	Overall width (W) mm	Overall depth (D) mm	Overall height (H) mm	Weight kg	Max ambient temp °C	Min airflow m/s	Maximum losses W
4401-0182	INL 402	370	44	276	200	225	36	50	1	205
4401-0183	INL 601	145	178	240	190	225	33	50	1	88
4401-0184	INL 602	202	133	276	200	225	36	50	1	116
4401-0181	INL 401	245	63	240	190	225	32	50	1	148
4401-0182	INL 402	339	44	276	200	225	36	50	1	205
4401-0274	INL 403L*	420	30	300	216	264	57	40	0	289
4401-0259	INL403*	557	30	300	216	264	57	40	0	330
4401-0183	INL 601	145	178	240	190	225	33	50	1	88
4401-0184	INL 602	192	133	276	200	225	36	50	1	116
4401-0261	INL 603*	331	93	300	216	264	58	40	0	320

* Natural cooling.

Figure 4-14 Input line reactor dimensions



4.2.4 Input inductor calculation

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

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

Where:

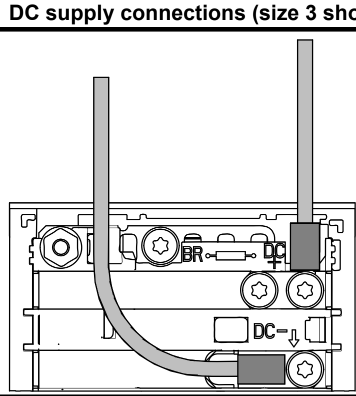
I = drive rated input current (A)
L = inductance (H)
f = supply frequency (Hz)
V = voltage between lines

4.3 Supplying the drive with DC

All drive sizes have the option to be powered from an external DC power supply. Refer to section 3.13 *Electrical terminals* on page 79 to identify the location of DC supply connections.

The DC supply connections for size 3 and 4 are located under the DC / Terminal cover. Figure 4-15 below shows DC supply connections and cable routing.

Figure 4-15 DC supply connections (size 3 shown)



NOTE

The Internal EMC filter and plastics have been removed from the above Figure 4-15 to demonstrate the routing of the DC cables.

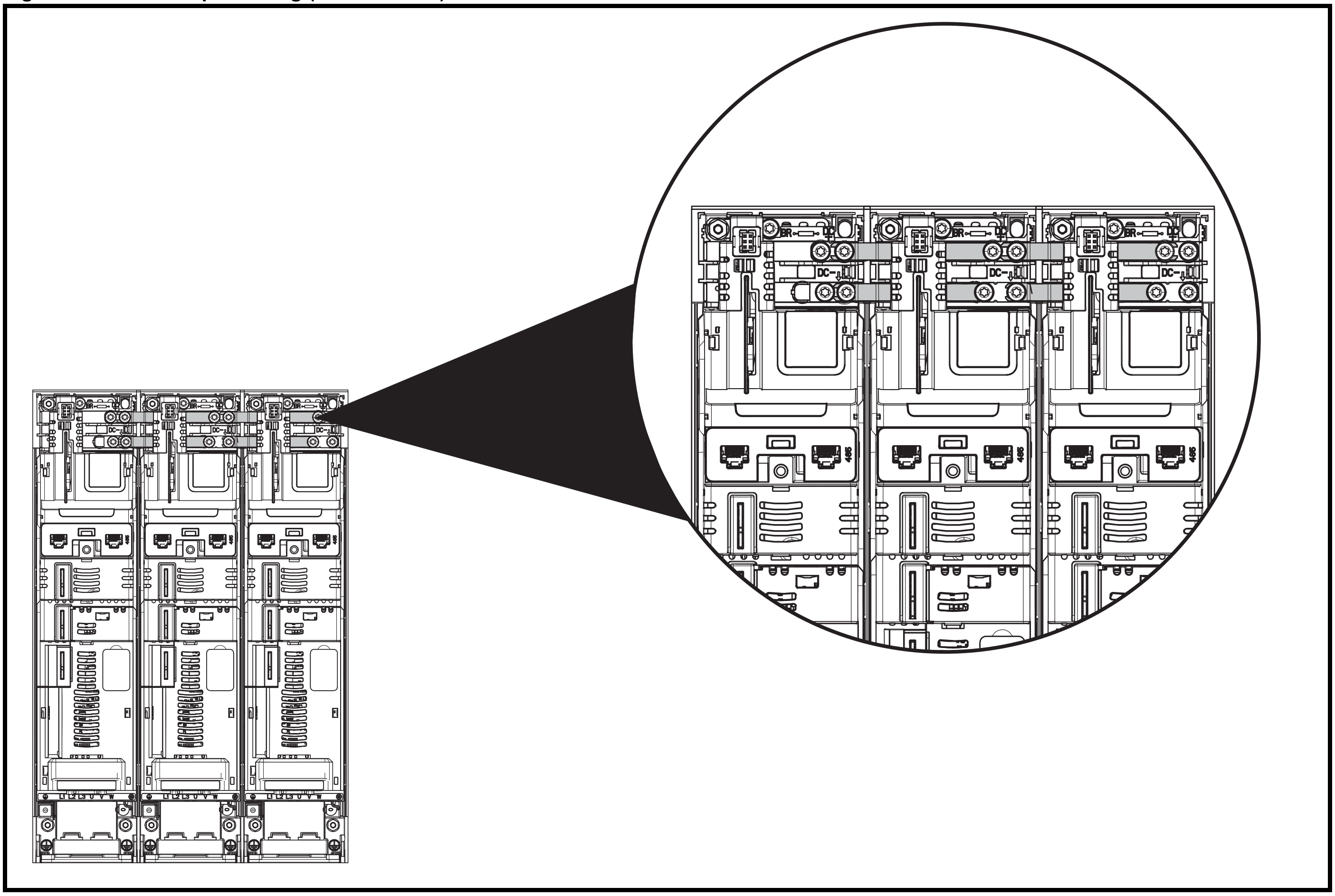
4.4 DC bus paralleling

DC bus paralleling using standard cable / busbars is supported by all frame sizes.

On frame sizes 3, 4, 5 and 6, terminal and enclosure design enables the DC bus of a number of drives to be connected together using pre-made busbars. The diagram below shows how the busbar links connect the DC bus of several drives together.

The connecting of the DC bus between several drives is typically used to return energy from a drive which is being overhauled by the load to a second motoring drive.

Figure 4-16 DC bus paralleling (size 3 shown)



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

For application data, contact the supplier of the drive.

NOTE

The DC bus paralleling kit is not supplied with the drive but is available to order.

Table 4-4 DC bus paralleling kit part numbers

Size	CT part number
3	3470-0048
4	3470-0061
5	3470-0068
6	3470-0063

4.5 24 Vdc supply

The 24 Vdc supply connected to control terminals 1 & 2 provides the following functions:

- It can be used to supplement the drive's own internal 24 V supply when multiple option modules are being used and the current drawn by these module is greater than the drive can supply.
- It can be used as a back-up power supply to keep the control circuits of the drive powered up when the line power supply is removed. This allows any fieldbus modules, application modules, or serial communications to continue to operate.
- It can be used to commission the drive when the line power supply is not available, as the display operates correctly. However, the drive will be in the Under voltage trip state unless either line power supply or low voltage DC operation is enabled, therefore diagnostics may not be possible. (Power down save parameters are not saved when using the 24 V back-up power supply input).
- If the DC bus voltage is too low to run the main SMPS in the drive, then the 24 V supply can be used to supply all the low voltage power requirements of the drive. *Low Under Voltage Threshold Select* (06.067) must also be enabled for this to happen.

NOTE

On size 6 and larger, the power 24 Vdc supply (terminals 51, 52) must be connected to enable the 24 Vdc supply to be used as a backup supply, when the line power supply is removed. If the power 24 Vdc supply is not connected none of the above mentioned functions can be used, "Waiting For Power System" will be displayed on the keypad and no drive operations are possible. The location of the power 24 Vdc can be identified from Figure 4-17 *Location of the 24 Vdc power supply connection on size 6* on page 105.

Table 4-5 24 Vdc Supply connections

Function	Sizes 3-5	Sizes 6-11
Supplement the drive's internal supply	Terminal 1, 2	Terminal 1, 2
Back-up supply for the control circuit	Terminal 1, 2	Terminal 1, 2 51, 52

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

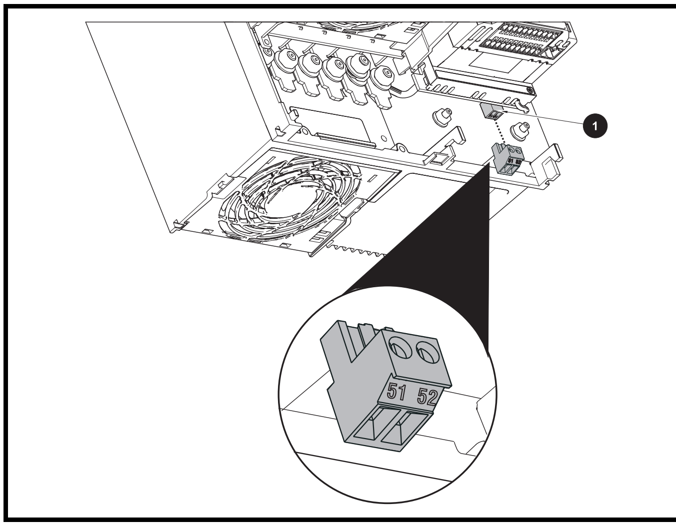
1	**0V common**
2	**+24 Vdc**
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 V
Maximum continuous operating voltage	28.0 V
Minimum start up voltage	21.6 V
Maximum power supply requirement at 24 V	40 W
Recommended fuse	3 A, 50 Vdc

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

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

51	**0V common**
52	**+24 Vdc**
Size 6	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	18.6 Vdc
Maximum continuous operating voltage	28.0 Vdc
Minimum startup voltage	18.4 Vdc
Maximum power supply requirement	40 W
Recommended fuse	4 A @ 50 Vdc
Size 7 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

Figure 4-17 Location of the 24 Vdc power supply connection on size 6



1. 24 Vdc power supply connection

Figure 4-18 Location of the 24 Vdc power supply connection on size 7

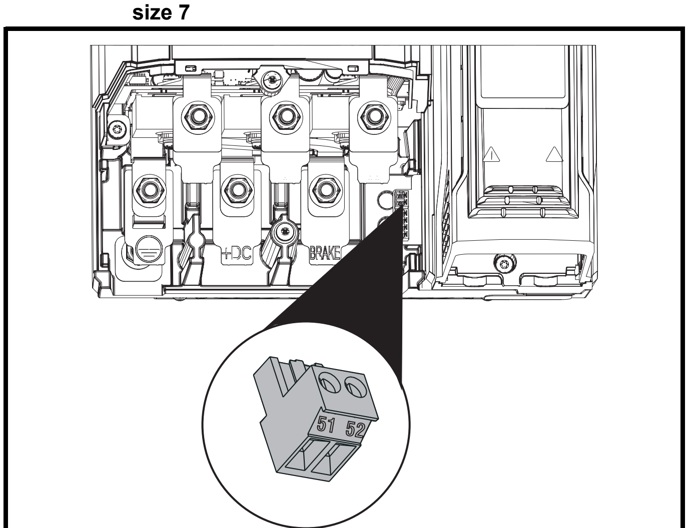
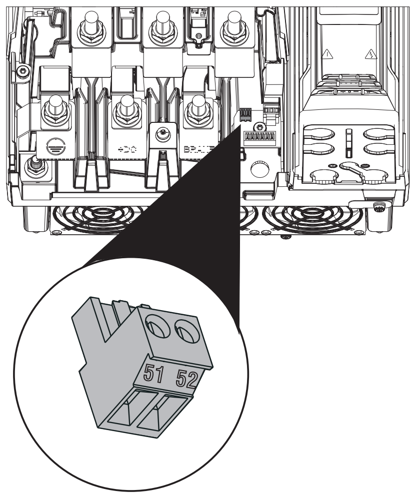


Figure 4-19 Location of the 24 Vdc power supply connection on size 8 to 11



4.6 Low voltage operation

With the addition of a 24 Vdc power supply to supply the control circuits, the drive is able to operate from a low voltage DC supply with a range from 24 Vdc to the maximum DC volts. It is possible for the drive to go from operating on a normal line power supply voltage to operating on a much lower supply voltage without interruption.

Going from low voltage operation to normal mains operation requires the inrush current to be controlled. This may be provided externally. If not, the drive supply can be interrupted to utilise the normal soft starting method in the drive.

To fully exploit the new low voltage mode of operation, the under voltage level is now user programmable. For application data, contact the supplier of the drive.

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

Size 3 to 11

Minimum continuous operating voltage: 26 V

Minimum start up voltage: 32 V

Maximum over voltage trip threshold: 230 V drives: 415 V
400 V drives: 830 V
575 V drives: 990 V
690 V drives: 1190 V

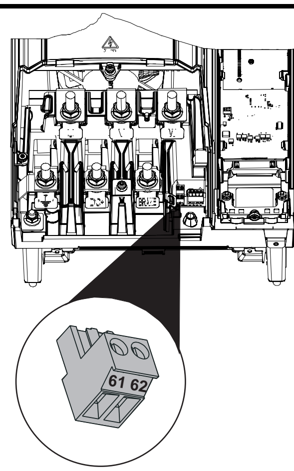
NOTE

Pump Drive F600 size 9E, 10E and 11E drives do not have an accessible negative DC terminal. It is recommended that 9D, 10D and 11D drives are used as an alternative when this is needed, please refer to the *Unidrive M Modular Installation Guide* for further details.

In low voltage mode only, with frame size 9 to 11, a 24 V supply needs to be provided for the heatsink fan. The fan supply should be connected to terminal 61 and 62.

61	**0V common**
62	**+24 Vdc heatsink fan supply**
Size 9 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	23.5 Vdc
Maximum continuous operating voltage	27 Vdc
Current consumption	Size 9 to 10 (all): 6A
Recommended power supply	24 V, 7 A
Recommended fuse	8A fast blow

Figure 4-20 Location of the heatsink fan supply connector on size 9 to 11



4.7 Heatsink fan supply

When operating on normal mains supply the heatsink fan on all drive sizes is supplied internally by the drive. When operating size 9 to 11 in low voltage mode it is necessary to connect an external 24 V supply to terminal 61 and 62 if heatsink fan operation is required. Please see section 4.6 *Low voltage operation* on page 106 for more details.

4.8 Ratings

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

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

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

Maximum continuous input current
The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance. The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the supply fault current given in Table 4-6.

Table 4-6 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

WARNING

Fuses
The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 4-7 shows recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 4-7 AC Input current and fuse ratings (200 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
	A	A	A	Nominal A	Maximum A	Class	Nominal A	Maximum A	Class
03200066	8.2	10.4	15.8	16	25	gG	20	25	CC, J or T*
03200080	9.9	12.6	20.9	20					
03200110	14	17	25				25		
03200127	16	20	34	25					
04200180	17	20	30	25	25	gG	25	25	CC, J or T*
04200250	23	28	41	32	32		30	30	
05200300	24	31	52	40	40	gG	40	40	CC, J or T*
06200500	42	48	64	63	63	gG	60	60	CC, J or T*
06200580	49	56	85				60		
07200750	58	67	109	80	80	gG	80	80	CC, J or T*
07200940	73	84	135	100	100		100	100	
07201170	91	105	149	125	125		125	125	
08201490	123	137	213	200	200	gR	200	200	HSJ
08201800	149	166	243				225	225	
09202160	172	205	270	250	250	gR	250	250	HSJ
09202660	228	260	319	315	315		300	300	
10203250	277	305	421	400	400	gR	400	400	HSJ
10203600	333	361	494	450	450		450	450	

* These fuses are fast acting.

Table 4-8 AC Input current and fuse ratings (400 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
	A	A	A	Nominal A	Maximum A	Class	Nominal A	Maximum A	Class
03400034	5	5	7	10	10	gG	10	10	CC, J or T*
03400045	6	7	9						
03400062	8	9	13						
03400077	11	13	21	20	20		20	20	
03400104	12		20						
03400123	14	16	25						
04400185	17	19	30	25	25	gG	25	25	CC, J or T*
04400240	22	24	35	32	32		30	30	
05400300	26	29	52	40	40	gG	35	35	CC, J or T*
06400380	32	36	67	63	63	gG	40	60	CC, J or T*
06400480	41	46	80				50		
06400630	54	60	90				60		
07400790	67	74	124	100	100	gG	80	80	CC, J or T*
07400940	80	88	145				100	100	
07401120	96	105	188	125	125		125	125	
08401550	137	155	267	250	250	gR	225	225	HSJ
08401840	164	177	303						
09402210	211	232	306	315	315	gR	300	300	HSJ
09402660	245	267	359				350	350	
10403200	306	332	445	400	400	gR	400	400	HSJ
10403610	370	397	523	450	450		450	450	
11404370	424	449	579	500	500	gR	600	600	HSJ
11404870	455	492	613						
11405070	502	539	752	630	630				

* These fuses are fast acting.

Table 4-9 AC Input current and fuse ratings (575 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
05500039	4	4	7	10	20	gG	10	10	CC, J or T*
05500061	6	7	9						
05500100	9	11	15	20			20	20	
06500120	12	13	22	20	40	gG	20	30	CC, J or T*
06500170	17	19	33	32			25		
06500220	22	24	41	40			30		
06500270	26	29	50	50	63		35	50	
06500340	33	37	63				40		
06500430	41	47	76	63			50		
07500530	41	45	75	50	50	gG	50	50	CC, J or T*
07500730	57	62	94	80	80		80	80	
08500860	74	83	121	125	125	gR	100	100	HSJ
08501080	92	104	165	160	160		150	150	
09501250	145	166	190	150	150	gR	150	150	HSJ
09501500	145	166	221	200	200		175	175	
10502000	177	197	266	250	250	gR	250	250	HSJ
11502480	240	265	327	400	400	gR	400	400	HSJ
11502880	285	310	395						
11503150	313	338	473						

* These fuses are fast acting.

Table 4-10 AC Input current and fuse ratings (690 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
07600230	18	20	32	25	50	gG	25	50	CC, J or T*
07600300	23	26	41	32			30		
07600360	28	31	49	40			35		
07600460	36	39	65	50			50		
07600520	40	44	75		80			80	
07600730	57	62	92	80			80		
08600860	74	83	121	125	125	gR	100	100	HSJ
08601080	92	104	165	160	160		150	150	
09601250	124	149	194	150	150	gR	150	150	HSJ
09601550	145	171	226	200	200		200	200	
10601720	180	202	268	225	225	gR	250	250	HSJ
10601970	202	225	313	250	250	gR	250	250	
11602250	225	256	379	400	400	gR	400	400	HSJ
11602750	217	302	425						
11603050	298	329	465						

* These fuses are fast acting.

NOTE

Ensure cables used suit local wiring regulations.

CAUTION

The nominal cable sizes below are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.

Table 4-11 Cable ratings (200 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
03200066	1.5	4	B2	1.5	4	B2	14	10	14	10
03200080										
03200110	4			4			12		12	
03200127										
04200180	6	8	B2	6	8	B2	10	8	10	8
04200250	8			8			8		8	
05200300	10	10	B2	10	10	B2	8	8	8	8
06200500	16	25	B2	16	25	B2	4	3	4	3
06200580	25			25			3		3	
07200750	35	70	B2	35	70	B2	2	1/0	2	1/0
07200940							1		1	
07201170	70			70			1/0		1/0	
08201490	95	2 x 70	B2	95	2 x 70	B2	3/0	2 x 1	3/0	2 x 1
08201800	2 x 70			2 x 70			2 x 1		2 x 1	
09202160	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
09202660	2 x 95			2 x 120			2 x 4/0		2 x 4/0	
10203250	2 x 120	2 x 185	B1	2 x 120	2 x 150	C	2 x 250	2 x 500	2 x 250	2 x 350
10203600	2 x 150		C	2 x 120			2 x 300		2 x 300	

Table 4-12 Cable ratings (400 V)

Model	Cable size (IEC)						Cable size (UL)			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation	Nominal	Maximum	Installation	Nominal	Maximum	Nominal	Maximum
03400034	1.5	4	B2	1.5	4	B2	18	10	18	10
03400045							16		16	
03400062							14		14	
03400077	2.5			2.5						
03400104										
03400123							12		12	
04400185	4	6	B2	4	6	B2	10	8	10	8
04400240	6			6			8		8	
05400300	6	6	B2	6	6	B2	8	8	8	8
06400380	10	25	B2	10	25	B2	6	3	6	3
06400480	16			16			4		4	
06400630	25			25			3		3	
07400790	35	70	B2	35	70	B2	1	1/0	1	1/0
07400940	50			50			2		2	
07401120	70			70			1/0		1/0	
08401550	2 x 50	2 x 70	B2	2 x 50	2 x 70	B2	2 x 1	2 x 1/0	2 x 1	2 x 1/0
08401840	2 x 70			2 x 70			2 x 1/0		2 x 1/0	
09402210	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
09402660	2 x 95			2 x 120			2 x 4/0		2 x 4/0	
10403200	2 x 120	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 250	2 x 350
10403610	2 x 150			2 x 150			2 x 350		2 x 300	
11404370	4 x 95		C	2 x 185	2 x 185	C	4 x 3/0		2 x 400	
11404870				2 x 240	2 x 240		4 x 4/0			
11405070										

Table 4-13 Cable ratings (575 V)

Model	Cable size (IEC)						Cable size (UL)			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation	Nominal	Maximum	Installation	Nominal	Maximum	Nominal	Maximum
05500039	0.75	1.5	B2	0.75	1.5	B2	16	16	16	16
05500061	1			1			14		14	
05500100	1.5			1.5			14		14	
06500120	2.5	25	B2	2.5	25	B2	14	3	14	3
06500170	4			4			10		10	
06500220	6			6			10		10	
06500270	10			10			8		8	
06500340							6		6	
06500430	16						6		6	
07500530	16	25	B2	16	25	B2	4	3	4	3
07500730	25			25			3		3	
08500860	35	50	B2	35	50	B2	1	1	1	1
08501080	50			50						
09501250	2 x 70	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09501500				2 x 50					2 x 1	
10502000	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
11502480	2 x 70		C	2 x 70		C	2 x 3/0			
11502880	2 x 95			2 x 95			2 x 4/0			
11503150	2 x 120			2 x 120			2 x 250			

Table 4-14 Cable ratings (690 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
07600230	10	25	B2	10	25	B2	8	3	8	3
07600300							6		6	
07600360							6		6	
07600460	16			16			4		4	
07600520	16			16			4		4	
07600730	25			25			3		3	
08600860	50	70	B2	50	70	B2	2	1/0	2	1/0
08601080	70			70			1/0		1/0	
09601250	2 x 50	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09601550	2 x 70			2 x 50			2 x 1/0		2 x 1	
10601720	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 1/0	2 x 350
10601970	2 x 95						2 x 3/0		2 x 2/0	
11602250	2 x 70		C	2 x 70		C	2 x 3/0			
11602750	2 x 95			2 x 95			2 x 4/0			
11603050				2 x 95			2 x 250			

NOTE

PVC insulated cable should be used.

NOTE

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

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

B1 - Separate cables in conduit.
B2 - Multicore cable in conduit.
C - Multicore cable in free air.

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

NOTE

The nominal output cable sizes assume that the motor maximum current matches that of the drive. Where a motor of reduced rating is used the cable rating may be chosen to match that of the motor. To ensure that the motor and cable are protected against overload, the drive must be programmed with the correct motor rated current.
A fuse or other protection must be included in all live connections to the AC supply.

Fuse types

The fuse voltage rating must be suitable for the drive supply voltage.

Ground connections

The drive must be connected to the system ground of the AC supply. The ground wiring must conform to local regulations and codes of practice.

NOTE

For information on ground cable sizes, refer to Table 4-1 *Protective ground cable ratings* on page 99.

4.8.1 Main AC supply contactor

The recommended AC supply contactor type is AC1.

4.9 Output circuit and motor protection

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

The drive provides overload protection for the motor and its cable.
For this to be effective, *Rated Current* (**00.006**) must be set to suit the motor.

WARNING

Rated Current (**00.006**) must be set correctly to avoid a risk of fire in the event of motor overload.

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

4.9.1 Cable types and lengths

Since capacitance in the motor cable causes loading on the output of the drive, ensure the cable length does not exceed the values given in Table 4-15 to Table 4-18.

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

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

Table 4-15 Maximum motor cable lengths (200 V drives)

<table>
<tr><th colspan="8">200 V Nominal AC supply voltage</th></tr>
<tr><th rowspan="2">Model</th><th colspan="7">Maximum permissible motor cable length for each of the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>03200066</td><td colspan="5">65 m (210 ft)</td><td rowspan="4">50 m (165 ft)</td><td rowspan="4">37 m (120 ft)</td></tr>
<tr><td>03200080</td><td colspan="4">100 m (330 ft)</td><td rowspan="3">75 m (245 ft)</td></tr>
<tr><td>03200110</td><td colspan="3">130 m (425 ft)</td><td rowspan="2">100 m (330 ft)</td></tr>
<tr><td>03200127</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td></tr>
<tr><td>04200180</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>04200250</td></tr>
<tr><td>05200300</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td><td>100 m (330 ft)</td><td>75 m (245 ft)</td><td>50 m (165 ft)</td><td>37 m (120 ft)</td></tr>
<tr><td>06200500</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>06200580</td></tr>
<tr><td>07200750</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td rowspan="3">62 m (203 ft)</td><td rowspan="3">46 m (151 ft)</td></tr>
<tr><td>07200940</td></tr>
<tr><td>07201170</td></tr>
<tr><td>08201490</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>08201800</td></tr>
<tr><td>09202160</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>09202660</td></tr>
<tr><td>10203250</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>10203600</td></tr>
</table>

Table 4-16 Maximum motor cable lengths (400 V drives)

<table>
<tr><th colspan="8">400 V Nominal AC supply voltage</th></tr>
<tr><th rowspan="2">Model</th><th colspan="7">Maximum permissible motor cable length for each of the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>03400034</td><td colspan="5">65 m (210 ft)</td><td rowspan="6">50 m (165 ft)</td><td rowspan="6">37 m (120 ft)</td></tr>
<tr><td>03400045</td><td colspan="4">100 m (330 ft)</td><td rowspan="5">75 m (245 ft)</td></tr>
<tr><td>03400062</td><td colspan="3">130 m (425 ft)</td><td rowspan="4">100 m (330 ft)</td></tr>
<tr><td>03400077</td><td colspan="2" rowspan="3">200 m (660 ft)</td><td rowspan="3">150 m (490 ft)</td></tr>
<tr><td>03400104</td></tr>
<tr><td>03400123</td></tr>
<tr><td>04400185</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>04400240</td></tr>
<tr><td>05400300</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td><td>100 m (330 ft)</td><td>75 m (245 ft)</td><td>50 m (165 ft)</td><td>37 m (120 ft)</td></tr>
<tr><td>06400380</td><td colspan="2" rowspan="3">200 m (660 ft)</td><td rowspan="3">150 m (490 ft)</td><td rowspan="3">100 m (330 ft)</td><td rowspan="3">75 m (245 ft)</td><td rowspan="3">50 m (165 ft)</td><td rowspan="3">37 m (120 ft)</td></tr>
<tr><td>06400480</td></tr>
<tr><td>06400630</td></tr>
<tr><td>07400790</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td rowspan="3">62 m (203 ft)</td><td rowspan="3">46 m (151 ft)</td></tr>
<tr><td>07400940</td></tr>
<tr><td>07401120</td></tr>
<tr><td>08401550</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>08401840</td></tr>
<tr><td>09402210</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>09402660</td></tr>
<tr><td>10403200</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>10403610</td></tr>
<tr><td>11404370</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td></td><td></td></tr>
<tr><td>11404870</td><td></td><td></td></tr>
<tr><td>11405070</td><td></td><td></td></tr>
</table>

Table 4-17 Maximum motor cable lengths (575 V drives)

575 V Nominal AC supply voltage							
Model	**Maximum permissible motor cable length for each of the following switching frequencies**						
	2 kHz	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
05500039	200 m (660 ft)		150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	37 m (120 ft)
05500061							
05500100							
06500120	200 m (660 ft)		150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	37 m (120 ft)
06500170							
06500220							
06500270							
06500340							
06500430							
07500530	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07500730							
08500860	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
08501080							
09501250	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
09501500							
10502000	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
11502480	250 m (820 ft)		187 m (614 ft)				
11502880							
11503150							

Table 4-18 Maximum motor cable lengths (690 V drives)

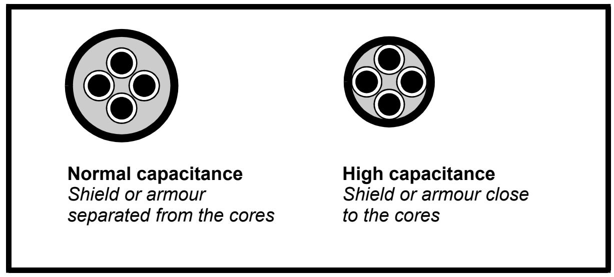
690 V Nominal AC supply voltage							
Model	**Maximum permissible motor cable length for each of the following switching frequencies**						
	2 kHz	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
07600230	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07600300							
07600360							
07600460							
07600520							
07600730							
08600860	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
08601080							
09601250	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
09601550							
10601720	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
10601970							
11602250	250 m (820 ft)		187 m (614 ft)				
11602750							
11603050							

4.9.2 High-capacitance / reduced diameter cables

The maximum cable length is reduced from that shown in section 4.9.1 *Cable types and lengths* if high capacitance or reduced diameter motor cables are used.For further information, refer to section 4.9.2 *High-capacitance / reduced diameter cables* on page 113.

Most cables have an insulating jacket between the cores and the armor or shield; these cables have a low capacitance and are recommended. Cables that do not have an insulating jacket tend to have high capacitance; if a cable of this type is used, the maximum cable length is half that quoted in the tables, (Figure 4-21 shows how to identify the two types).

Figure 4-21 Cable construction influencing the capacitance



The maximum motor cable lengths specified in section 4.9.1 *Cable types and lengths* is shielded and contains four cores. Typical capacitance for this type of cable is 130 pF/m (i.e. from one core to all others and the shield connected together).

4.9.3 Motor winding voltage

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

For normal operation with AC supplies up to 500 Vac and a standard motor with a good quality insulation system, there is no need for any special precautions. In case of doubt the motor supplier should be consulted. Special precautions are recommended under the following conditions, but only if the motor cable length exceeds 10 m:

- AC supply voltage exceeds 500 V
- DC supply voltage exceeds 670 V (i.e. regenerative / AFE supply)
- Operation of 400 V drive with continuous or very frequent sustained braking
- Multiple motors connected to a single drive

For multiple motors, the precautions given in section 4.9.4 *Multiple motors* on page 114 should be followed.

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

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

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

4.9.4 Multiple motors

Open-loop only

If the drive is to control more than one motor, one of the fixed V/F modes should be selected (Pr **05.014** = Fixed or Squared). Make the motor connections as shown in Figure 4-22 and Figure 4-23. The maximum motor cable lengths specified in section 4.9.1 *Cable types and lengths* on page 112 apply to the sum of the total cable lengths from the drive to each motor.

It is recommended that each motor is connected through a protection relay since the drive cannot protect each motor individually. For ⅄ connection, a sinusoidal filter or an output inductor must be connected as shown in Figure 4-23, even when the cable lengths are less than the maximum permissible. For high DC voltages or when supplied by a regen system, a sinusoidal filter is recommended. For details of filter or inductor sizes refer to the supplier of the drive.

Figure 4-22 Preferred chain connection for multiple motors

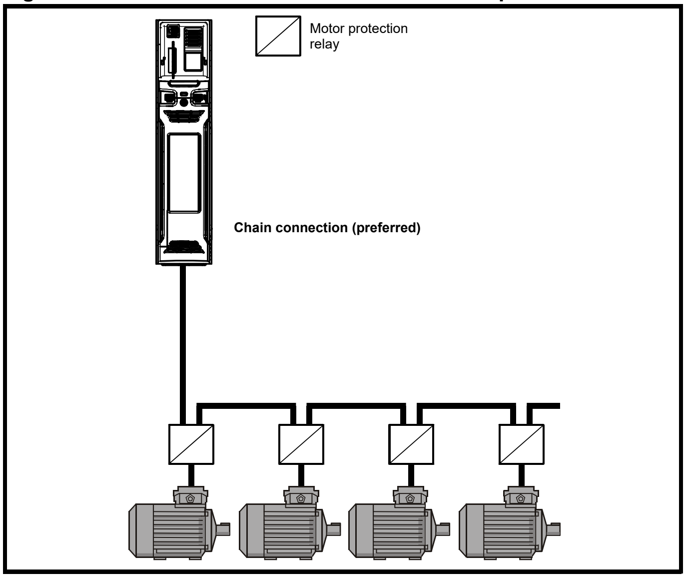
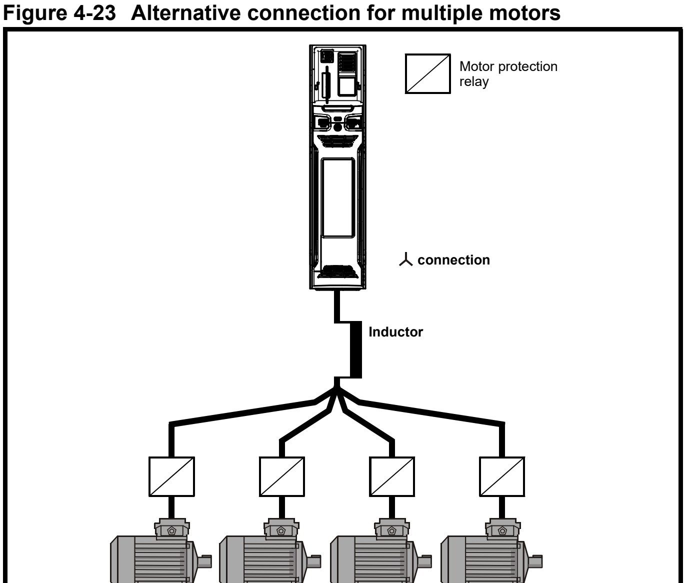


Figure 4-23 Alternative connection for multiple motors



4.9.5 ⅄ / Δ motor operation

The voltage rating for ⅄ and Δ connections of the motor should always be checked before attempting to run the motor.

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

400 V drive 400 V rated voltage
230 V drive 230 V rated voltage

A typical 3 phase motor would be connected in ⅄ for 400 V operation or Δ for 230 V operation, however, variations on this are common e.g. ⅄ 690 V Δ 400 V.

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

4.9.6 Output contactor

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

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

The recommended motor contactor is the AC3 type.

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

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

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

The Drive Enable terminal (T29) when opened provides a Safe Torque Off function. This can in many cases replace output contactors.

For further information see section 4.15 *Safe Torque Off (STO)* on page 136.

4.10 Ground leakage

The ground leakage current depends upon whether the internal EMC filter is installed or not. The drive is supplied with the filter installed. Instructions for removing the internal filter are given in section 4.12.2 *Internal EMC filter* on page 123.

With internal filter installed:

Size 3 to 5: 28 mA* AC at 400 V 50 Hz

30 μA DC with a 600 V DC bus (10 MΩ)

Size 7 to 11: 56 mA* AC at 400 V 50 Hz

18 μA DC with a 600 V DC bus (33 MΩ)

* Proportional to the supply voltage and frequency.

With internal filter removed:**

< 1 mA

**Please note that the internal filter is not removable on size 9E, 10E and 11E

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

4.10.1 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

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

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

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

4.11 Braking

Braking occurs when the drive is decelerating the motor, or is preventing the motor from gaining speed due to mechanical influences. During braking, energy is returned to the drive from the motor. When motor braking is applied by the drive, the maximum regenerated power that the drive can absorb is equal to the power dissipation (losses) of the drive.

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

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

Table 4-19 shows the default DC voltage level at which the drive turns on the braking transistor. However the braking resistor turn on and the turn off voltages are programmable with *Braking IGBT Lower Threshold* (**06.073**) and *Braking IGBT Upper Threshold* (**06.074**).

Table 4-19 Default braking transistor turn on voltage

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

NOTE

When a braking resistor is used, Pr **02.004** should be set to Fast ramp mode.

WARNING

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

4.11.1 Heatsink mounted braking resistor

A resistor has been especially designed to be mounted within the heatsink of the drive (size 3, 4 and 5). See section 4.11.1 *Heatsink mounted braking resistor* on page 116 for mounting details. The design of the resistor is such that no thermal protection circuit is required, as the device will fail safely under fault conditions. On size 3, 4 and 5 the in built software overload protection is set-up at default for the designated heatsink mounted resistor. The heatsink mounted resistor is not supplied with the drive and can be purchased separately.

Table 4-20 provides the resistor data for each drive rating.

NOTE

The internal / heatsink mounted resistor is suitable for applications with a low level of regen energy only. See Table 4-20.

CAUTION

Braking resistor overload protection parameter settings
Failure to observe the following information may damage the resistor.
The drive software contains an overload protection function for a braking resistor. On size 3, 4 and 5 this function is enabled at default to protect the heatsink mounted resistor. Below are the parameter settings.

Parameter		Size 3		Size 4		Size 5		
		200 V drive	400 V drive	200 V drive	400 V drive	200 V drive	400 V drive	575 V drive
Braking resistor rated power	Pr **10.030**	50 W		100 W		100 W		
Braking resistor thermal time constant	Pr **10.031**	3.3 s		2.0 s		2.0 s		
Braking resistor resistance	Pr **10.061**	75 Ω		38 Ω		38 Ω		

For more information on the braking resistor software overload protection, see Pr **10.030,** Pr **10.031** and Pr **10.061** full descriptions in the *Parameter Reference Guide*.

If the resistor is to be used at more than half of its average power rating, the drive cooling fan must be set to full speed by setting Pr **06.045** to 11.

Table 4-20 Heatsink mounted braking resistor data

Parameter	Size 3	Size 4	Size 5
Part number	1220-2752-00	1299-0003-00	
DC resistance at 25 °C	75 Ω	37.5 Ω	
Peak instantaneous power over 1 ms at nominal resistance	8 kW	16 kW	
Average power over 60 s *	50 W	100 W	
Ingress Protection (IP) rating	IP54		
Maximum altitude	2000 m		

* To keep the temperature of the resistor below 70 °C (158 °F) in a 30 °C (86 °F) ambient, the average power rating is 50 W for size 3, 100 W for size 4 and 5. The above parameter settings ensure this is the case.

4.11.2 External braking resistor

WARNING

Overload protection
When an external braking resistor is used, it is essential that an overload protection device is incorporated in the braking resistor circuit; this is described in *Figure 4-24 on page 120.*

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

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

When compliance with EMC emission standards is required, external connection requires the cable to be armored or shielded, since it is not fully contained in a metal enclosure. See section 4.12.6 *Compliance with generic emission standards* on page 127 for further details.

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

Minimum resistances and power ratings for the braking resistor at 40 °C (104 °F)

Table 4-21 Braking resistor resistance and power rating (200 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
03200066	22	7.7	0.75
03200080			1.1
03200110			1.5
03200127			2.2
04200180	18	9.4	3
04200250			4
05200300	19	8.9	5.5
06200500	10	16.9	7.5
06200580			11
07200750	4.5	37.6	15
07200940			18.5
07201170	4.5	37.6	22
08201490	2.3	73.5	30
08201800			37
09202160 (9A)	2	84.5	45
09202660 (9A)			55
09202160 (9E)	1.4	120.8	45
09202660(9E)			55
10203250	1.7	99.5	75
10203600			90

Table 4-22 Braking resistor resistance and power rating (400 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
03400034	74	9.2	0.75
03400045			1.1
03400062			1.5
03400077			2.2
03400104	50	13.6	3
03400123			4
04400185	37	18.3	5.5
04400240			7.5
05400300	40	16.9	11
06400380	20	33.8	15
06400480			18.5
06400630			22
07400790	7.5	90.2	30
07400940			37
07401120			45
08401550	6.3	107.4	55
08401840			75
09402210 (9A)	3.6	187.8	90
09402660 (9A)			110
09402210 (9E)	2.6	260	90
09402660 (9E)			110
10403200	3.1	218.1	132
10403610			160
11404370	1.83	369.4	185
11404870	1.2	563.4	200
11405070			250

Table 4-23 Braking resistor resistance and power rating (575 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
05500039	80	12.1	1.5
05500061			2.2
05500100			4
06500120	15	64.1	5.5
06500170			7.5
06500220			11
06500270			15
06500340			18.5
06500430			22
07500530	11	87.4	30
07500730			37
08500860	5.5	174.8	45
08501080			55
09501250 (9A)	5.1	188.5	75
09501500(9A)			90
09501250 (9E)	3.3	291.3	75
09501500 (9E)			90
10502000	3.3	291.3	110
11502480	1.83	525.2	150
11502880			185
11503150			225

Table 4-24 Braking resistor resistance and power rating (690 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
07600230	13	107.3	15
07600300			18.5
07600360			22
07600460			30
07600520			37
07600730			45
08600860	5.5	253.5	55
08601080			75
09601250(9A)	6.5	214.5	90
09601500(9A)			110
09601250(9E)	4.2	331.9	90
09601500 (9E)			110
10601720	4.2	331.9	132
10601970	3.8	366.8	160
11602250	2.2	633.6	185
11602750			200
11603050			250

* Resistor tolerance: ±10 %

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

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

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

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

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

The following external brake resistors are available from Control Techniques for drive sizes 3 to 6.

Table 4-25 External brake resistors for drive sizes 3 to 6

Part number	Part description	Resistance value	Continuous power (40 °C)	Max. instantaneous (40 °C) ton = 1 ms	Pulse power (40 °C) 1/120 s (ED 0.8 %)	Pulse power (40 °C) 5/120 s (ED 4.2 %)	Pulse power (40 °C) 10/120 s (ED 8.3 %)	Pulse power (40 °C) 40/120 s (ED 33.3 %)
1220-2201	DBR, 100 W, 20R, 130 x 68, TS	20 Ω	100 W	2.0 MW	2300 W	1000 W	650 W	250 W
1220-2401	DBR, 100 W, 40R, 130 x 68, TS	40 Ω	100 W	1.6 MW	1900 W	900 W	610 W	240 W
1220-2801	DBR, 100 W, 80R, 130 x 68, TS	80 Ω	100 W	1.25 MW	1500 W	775 W	570 W	230 W

The brake resistors can be used in a series or parallel to get the required resistance and power depending on the size of the drive as per Table 4-21 to Table 4-24. The brake resistor is equipped with a thermal switch. The thermal switch should be integrated in the control circuit by the user.

The resistor combinations shown in Table 4-26 below can be made using one or more brake resistor/s from Table 4-25 above. Pr **10.030**, Pr **10.031** and Pr **10.061** should be set as per information provided in Table 4-26 below. Refer to description of Pr **10.030**, Pr **10.031** and Pr **10.061** in the *Parameter Reference Guide* for more information.

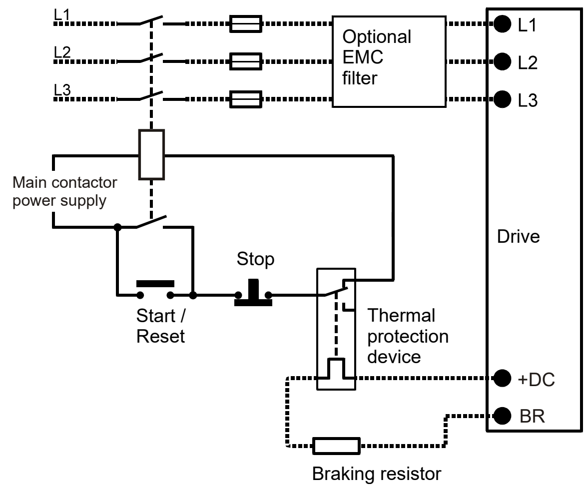
Table 4-26 Resistor combinations

Pump Drive F600 type	Normal duty (kW)	150 % Peak power (Ω)	Braking voltage (Vdc)	Resistor Min. value (Ω)	Resistor combinations (Ω)
03200066	1.1	135	390	22	1 x 40 = 40 2 x 80 = 40 (when connected in parallel)
03200080	1.5	92			
03200110	2.2	68			
03200127	3	46			
03400034	1.1	540	780	74	1 x 80 = 80 2 x 40 = 80 (when connected in series)
03400045	1.5	370			
03400062	2.2	271			
03400077	3	184			
03400104	4	135		50	
03400123	5.5	101			
04200180	4	34	390	18	1 x 20 = 20 2 x 40 = 20 (when connected in parallel)
04200250	5.5	26			
04400185	7.5	74	780	37	1 x 40 = 40 2 x 80 = 40 (when connected in parallel)
04400240	11	54			
05200300	7.5	19	390	19	1 x 20 = 20 2 x 40 = 20 (when connected in parallel)
05400300	15	37	780	40	1 x 40 = 40 2 x 80 = 40 (when connected in parallel)
05500039	2.2	384	930	80	1 x 80 = 80 2 x 40 = 80 (when connected in parallel)
05500061	4	263			
05500100	5.5	144			
06200500	11	13.3	390	10	2 x 20 = 10 (when connected in parallel) 4 x 40 = 10 (when connected in parallel)
06200580	15	9.3			
06400380	18.5	27	780	20	1 x 20 = 20 2 x 40 = 20 (when connected in parallel) 4 x 80 = 20 (when connected in parallel)
06400480	22	22			
06400630	30	18.4			
06500120	7.5	104	930	15	1 x 20 = 20 2 x 40 = 20 (when connected in parallel) 4 x 80 = 20 (when connected in parallel)
06500170	11	77			
06500220	15	52			
06500270	18.5	39			
06500340	22	33			
06500430	30	27			

Thermal protection circuit for the braking resistor

The thermal protection circuit must disconnect the AC supply from the drive if the resistor becomes overloaded due to a fault. Figure 4-24 shows a typical circuit arrangement.

Figure 4-24 Typical protection circuit for a braking resistor



See Figure 4-1 on page 92 and Figure 4-4 on page 95 for the location of the +DC and braking resistor connections.

4.11.3 Braking resistor software overload protection

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

- *Braking Resistor Rated Power* (**10.030**)
- *Braking Resistor Thermal Time Constant* (**10.031**)
- *Braking Resistor Resistance* (**10.061**)

This data should be obtained from the manufacturer of the braking resistors. The braking resistor thermal time constant can be calculated from resistor data sheet values using the following equation:

$$\textbf{Pr 10.031} = \frac{\textbf{Resistor pulse power rating x Braking time}}{\textbf{Resistor continuous power rating}}$$

Pr **10.039** gives an indication of braking resistor temperature based on a simple thermal model. Zero indicates the resistor is close to ambient and 100 % is the maximum temperature the resistor can withstand. A ‘Brake Resistor’ alarm is given if this parameter is above 75 % and the braking IGBT is active. A Brake R Too Hot trip will occur if Pr **10.039** reaches 100 %, when Pr **10.037** is set to 0 (default value) or 1.

If Pr **10.037** is equal to 2 or 3, a Brake R Too Hot trip will not occur when Pr **10.039** reaches 100 %, but instead the braking IGBT will be disabled until Pr **10.039** falls below 95 %. This option is intended for applications with parallel connected DC buses where there are several braking resistors, each of which cannot withstand full DC bus voltage continuously. With this type of application it is unlikely the braking energy will be shared equally between the resistors because of voltage measurement tolerances within the individual drives. Therefore with Pr **10.037** set to 2 or 3, then as soon as a resistor has reached its maximum temperature the drive will disable the braking IGBT, and another resistor on another drive will take up the braking energy. Once Pr **10.039** has fallen below 95 % the drive will allow the braking IGBT to operate again.

See the *Parameter Reference Guide* for more information on Pr **10.030**, Pr **10.031**, Pr **10.037** and Pr **10.039**.

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

4.12 EMC (Electromagnetic compatibility)

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

Section 4.12.4, General requirements for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in Chapter 11 *Technical data* on page 393 will be met, but no specific emission standards are applied. Note also the special requirements given in *Surge immunity of control circuits - long cables and connections outside a building* on page 130 for increased surge immunity of control circuits where control wiring is extended.

Section 4.12.5, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN 61800-3:2004).

Section 4.12.6, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN 61000-6-4:2007.

The recommendations of section 4.12.4 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 4.12.5 or section 4.12.6 should be followed to give reduced radio-frequency emission.

In order to ensure the installation meets the various emission standards described in:

- The EMC data sheet available from the supplier of the drive
- The Declaration of Conformity at the front of this manual
- Chapter 11 *Technical data* on page 393

The correct external EMC filter must be used and all of the guidelines in section 4.12.4 *General requirements for EMC* on page 126 and section 4.12.6 *Compliance with generic emission standards* on page 127 must be followed.

Table 4-27 Drive and EMC filter cross reference

Model	CT part number
200 V	
03200066 to 03200127	4200-3230
04200180 to 04200250	4200-0272
05200300	4200-0312
06200500 to 06200580	4200-2300
07200750 to 07201170	4200-1132
08201490 to 08201800	4200-1972
09202160 to 09202660 (9A)	4200-3021
09202160 to 09202660 (9E)	4200-4460
10203250 to 10203600	4200-4460
400 V	
03400034 to 03400123	4200-3480
04400185 to 04400240	4200-0252
05400300	4200-0402
06400380 to 06400630	4200-4800
07400790 to 07401120	4200-1132
08401550 to 08401840	4200-1972
09402210 to 09402660 (9A)	4200-3021
09402210 to 09402660 (9E)	4200-4460
10403200 to 10403610	4200-4460
11404370 to 11405070	4200-0400
575 V	
05500039 to 05500100	4200-0122
06500120 to 06500430	4200-3690
07500530 to 07500730	4200-0672
08500860 to 08501080	4200-1662
09501250 to 09501500 (9A)	4200-1660
09501250 to 09501500 (9E)	4200-2210
10502000	4200-2210
11502480 to 11503150	4200-0690
690 V	
07600230 to 07600730	4200-0672
08600860 to 08601080	4200-1662
09601250 to 09601550 (9A)	4200-1660
09601250 to 09601550 (9E)	4200-2210
10601720 to 10601970	4200-2210
11602250 to 11603050	4200-0690

WARNING

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

NOTE

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

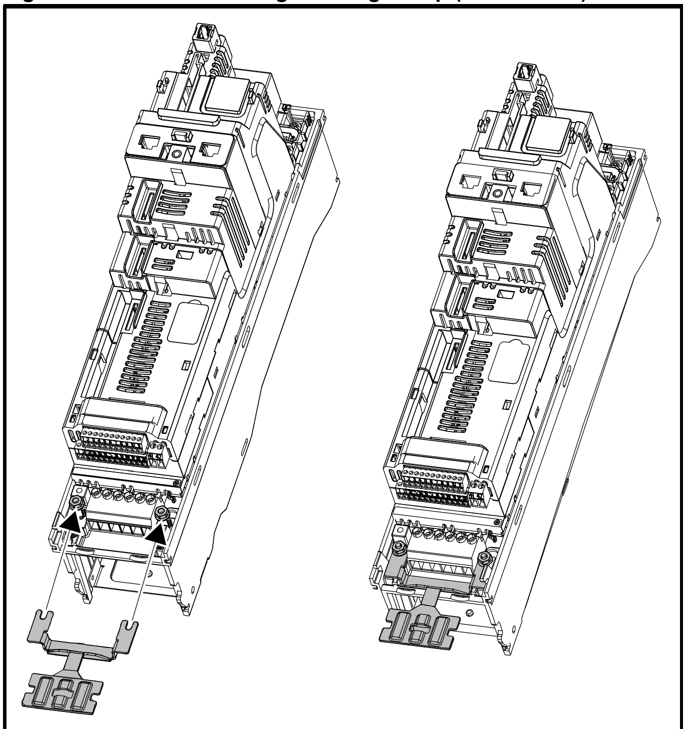
4.12.1 Grounding hardware

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

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

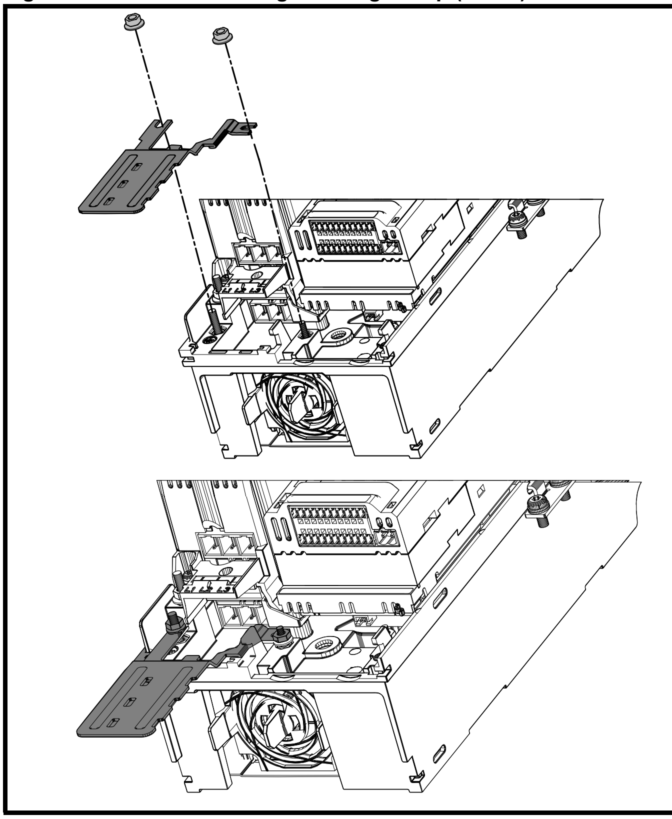
- See Figure 4-25, Figure 4-26 and Figure 4-27 for details on installing the grounding clamp.
- See Figure 4-28 for details on installing the grounding bracket.

Figure 4-25 Installation of grounding clamp (size 3 and 4)



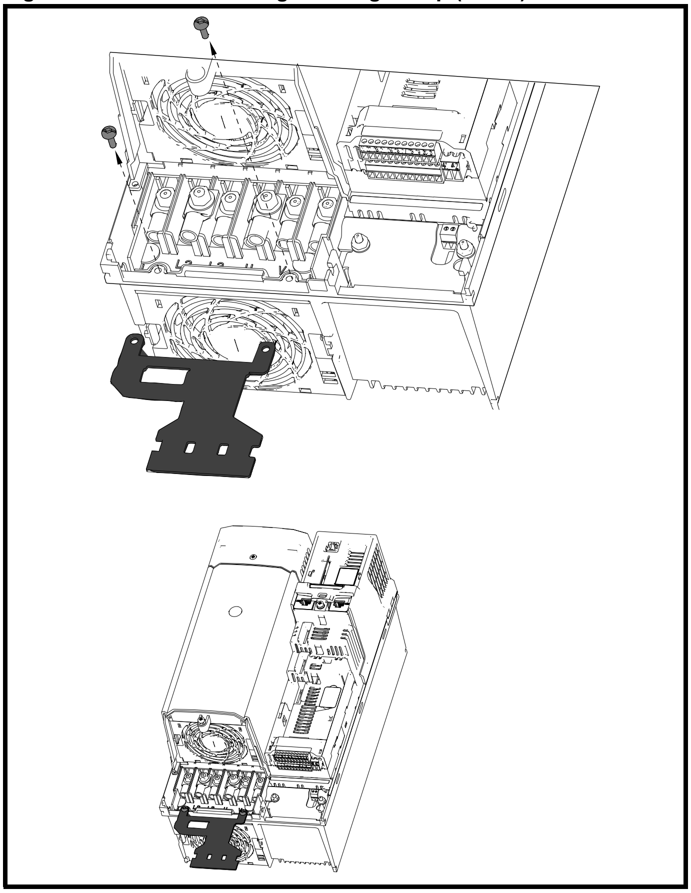
Loosen the ground connection nuts and slide the grounding clamp in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

Figure 4-26 Installation of grounding clamp (size 5)



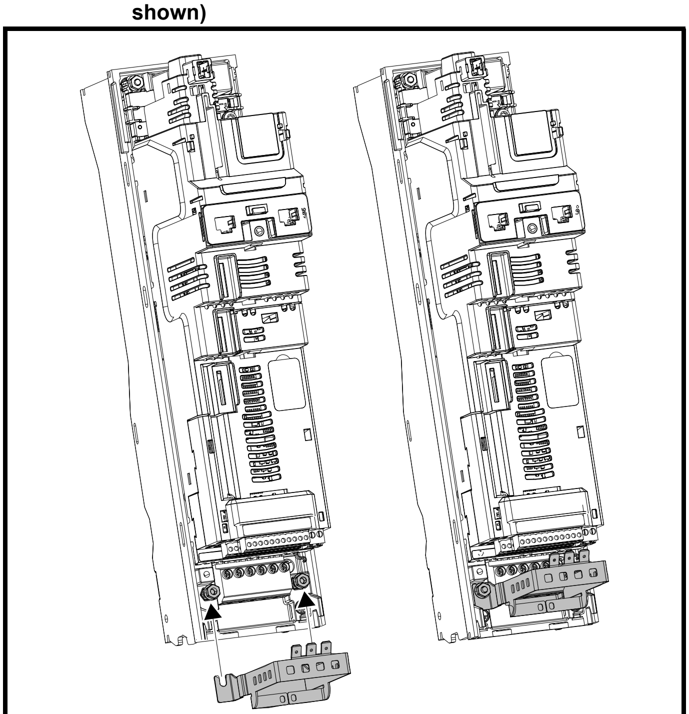
Loosen the ground connection nuts and slide the grounding clamp down onto the pillars in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

Figure 4-27 Installation of grounding clamp (size 6)



The grounding clamp is secured using the provided 2 x M4 x 10 mm fasteners. The fasteners should be tightened with the maximum torque of 2 N m (1.47 lb ft).

Figure 4-28 Installation of grounding bracket (all sizes - size 3 shown)



Loosen the ground connection nuts and slide the grounding bracket in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

WARNING

On size 3 the grounding bracket is secured using the power ground terminal of the drive. Ensure that the supply ground connection is secure after installing / removing the grounding bracket. Failure to do so will result in the drive not being grounded.

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

4.12.2 Internal EMC filter

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

WARNING

If the drive is used with ungrounded (IT) supplies, the internal EMC filter must be removed unless additional motor ground fault protection is installed.
For instructions on removal refer to section 4.12.2.
For details of ground fault protection contact the supplier of the drive.

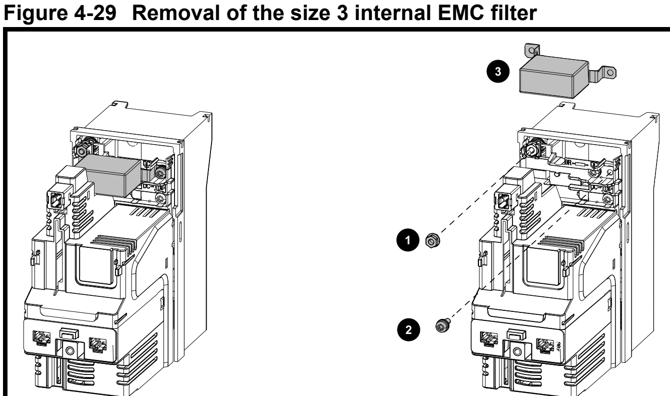
If the drive is used as part of a regen system, then the internal EMC filter must be removed.

The internal EMC filter reduces radio-frequency emission into the line power supply. Where the motor cable is short, it permits the requirements of EN 61800-3:2004 to be met for the second environment - see section 4.12.5 *Compliance with EN 61800-3:2004 (standard for Power Drive Systems)* on page 127 and section 11.1.24 *Electromagnetic compatibility (EMC)* on page 419. For longer motor cables the filter continues to provide a useful reduction in emission levels, and when used with any length of shielded motor cable up to the limit for the drive, it is unlikely that nearby industrial equipment will be disturbed. It is recommended that the filter be used in all applications unless the instructions given above require it to be removed, or where the ground leakage current of 28 mA for size 3 is unacceptable. See section 4.12.2 for details of removing and installing the internal EMC filter.

WARNING

The supply must be disconnected before removing the internal EMC filter.

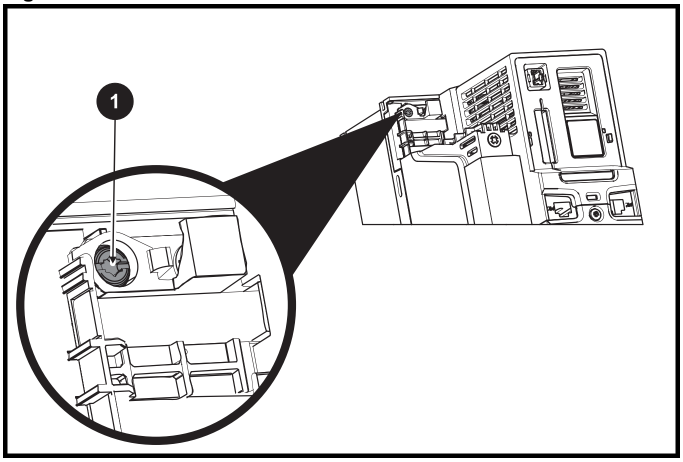
Figure 4-29 Removal of the size 3 internal EMC filter



Remove the screw and nut (1) and (2) as shown above.

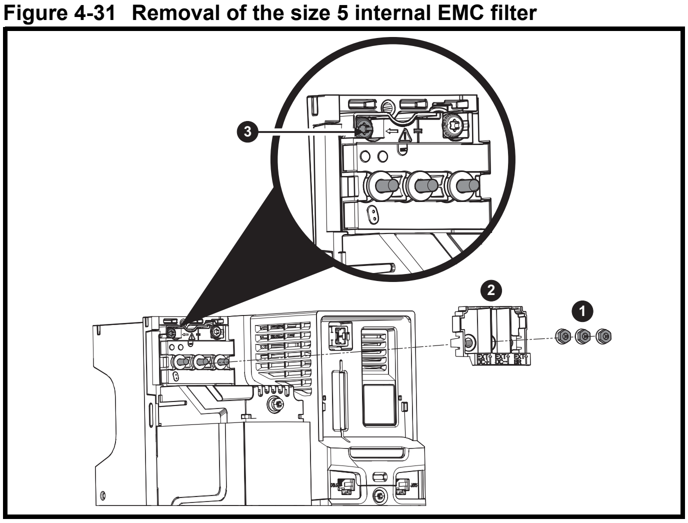
Lift away from the securing points and rotate away from the drive. Ensure the screw and nut are replaced and re-tightened with a maximum torque of 2 N m (1.47 lb ft).

Figure 4-30 Removal of the size 4 internal EMC filter



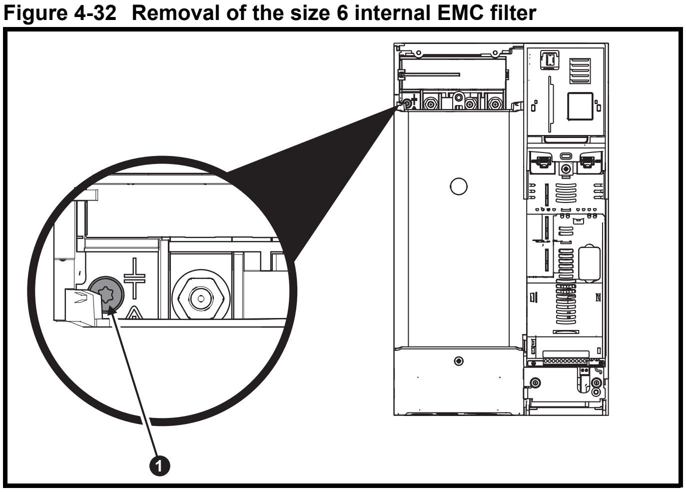
To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

Figure 4-31 Removal of the size 5 internal EMC filter



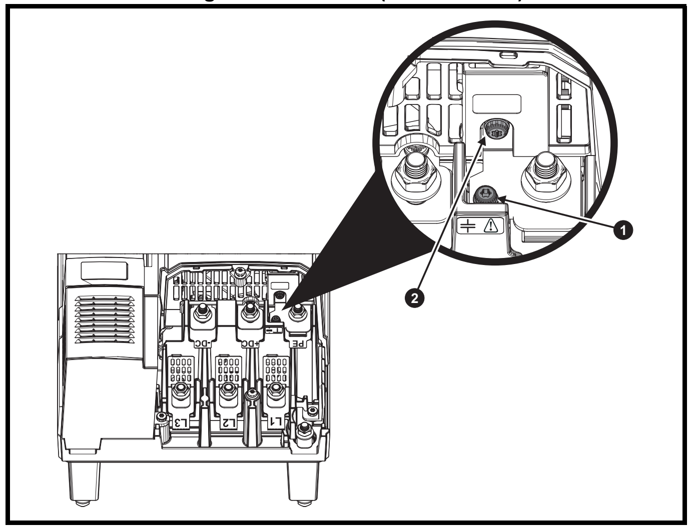
Remove the three M4 terminal nuts (1). Lift away the cover (2) to expose the M4 Torx internal EMC filter removal screw. Finally remove the M4 Torx internal EMC filter removal screw (3) to electrically disconnect the internal EMC filter.

Figure 4-32 Removal of the size 6 internal EMC filter



To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

Figure 4-33 Removal of the size 7, 8 and 9A internal EMC filter and line to ground varistors (size 7 shown)



To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

To electrically disconnect the line to ground varistors, remove the screw as highlighted above (2).

NOTE

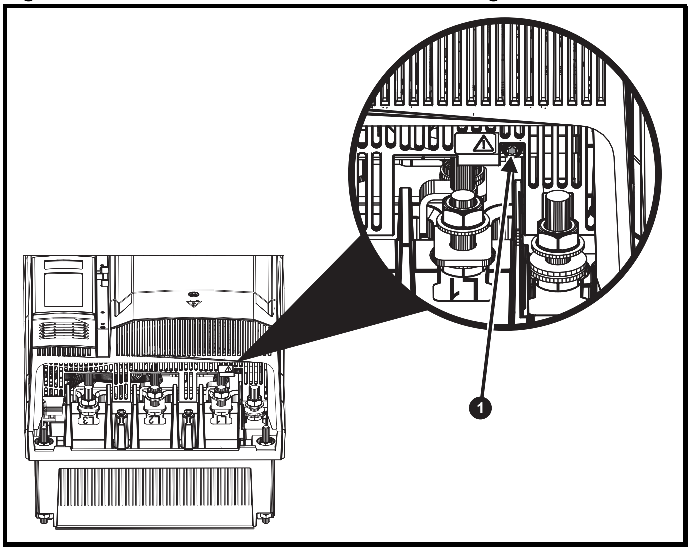
The Internal EMC filter on size 9E, 10E and 11E cannot be removed.

4.12.3 Line to ground varistors

WARNING

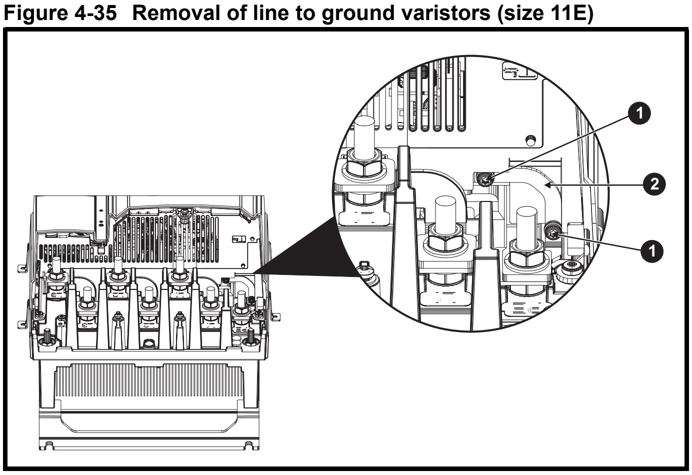
The line to ground varistors should only be removed in special circumstances such as ungrounded supplies with more than one source, for example on ships. Where the line to ground varistors are removed, ensure that line to ground transients are limited to values of category II. This is to ensure that line to ground transients do not exceed 4 kV as the drive insulation system from power to ground is designed to category II.Contact the supplier of the drive for more information.

Figure 4-34 Removal of size 9E and 10E line to ground varistors



To electrically disconnect the line to ground varistors, remove the screw as highlighted above (1).

Figure 4-35 Removal of line to ground varistors (size 11E)



To electrically disconnect the line to ground varistors, remove the two screws highlighted (1) above and remove the bracket (2).

NOTE

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

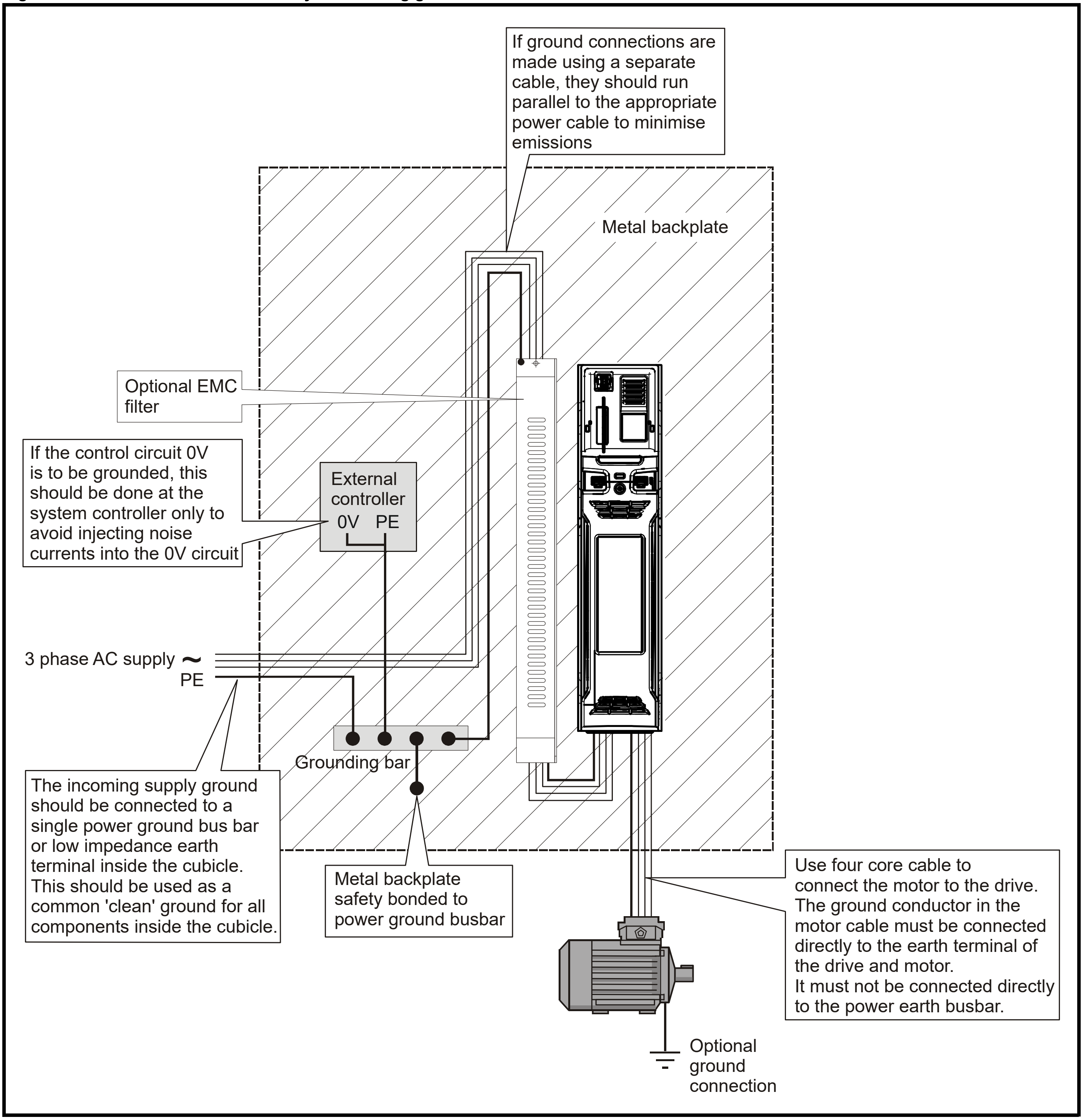
4.12.4 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 4-36, which shows a single drive on a back-plate with or without an additional enclosure.

Figure 4-36 shows how to configure and minimise EMC when using unshielded motor cable. However shielded cable is a better option, in which case it should be installed as shown in section 4.12.6 *Compliance with generic emission standards* on page 127.

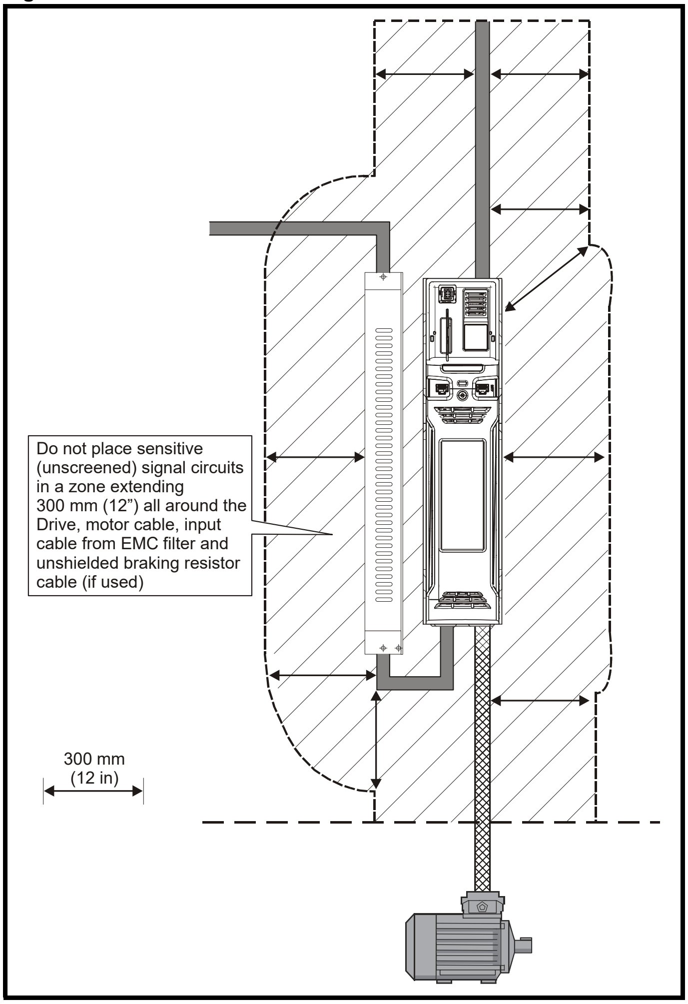
Figure 4-36 General EMC enclosure layout showing ground connections



Cable layout

Figure 4-37 indicates the clearances which should be observed around the drive and related 'noisy' power cables by all sensitive control signals / equipment.

Figure 4-37 Drive cable clearances



NOTE

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

4.12.5 Compliance with EN 61800-3:2004 (standard for Power Drive Systems)

Meeting the requirements of this standard depends on the environment that the drive is intended to operate in, as follows:

Operation in the first environment

Observe the guidelines given in section 4.12.6 *Compliance with generic emission standards* on page 127. An external EMC filter will always be required.

> **CAUTION**
>
> This is a product of the restricted distribution class according to IEC 61800-3
>
> In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

Operation in the second environment

In all cases a shielded motor cable must be used, and an EMC filter is required for all drives with a rated input current of less than 100 A.

The drive contains an in-built filter for basic emission control. In some cases feeding the motor cables (U, V and W) once through a ferrite ring can maintain compliance for longer cable lengths.

For longer motor cables, an external filter is required. Where a filter is required, follow the guidelines in section 4.12.6 *Compliance with generic emission standards*.

Where a filter is not required, follow the guidelines given in section 4.12.4 *General requirements for EMC* on page 126.

> **CAUTION**
>
> The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in section 4.12.6 *Compliance with generic emission standards* be adhered to.

Refer to section 11.1.24 *Electromagnetic compatibility (EMC)* on page 419 for further information on compliance with EMC standards and definitions of environments.

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

4.12.6 Compliance with generic emission standards

The following information applies to frame sizes 3 to 10.

Use the recommended filter and shielded motor cable. Observe the layout rules given in Figure 4-38 and Figure 4-41. Ensure the AC supply and ground cables are at least 100 mm from the power module and motor cable.

Figure 4-38 Supply and ground cable clearance (sizes 3 to 6)

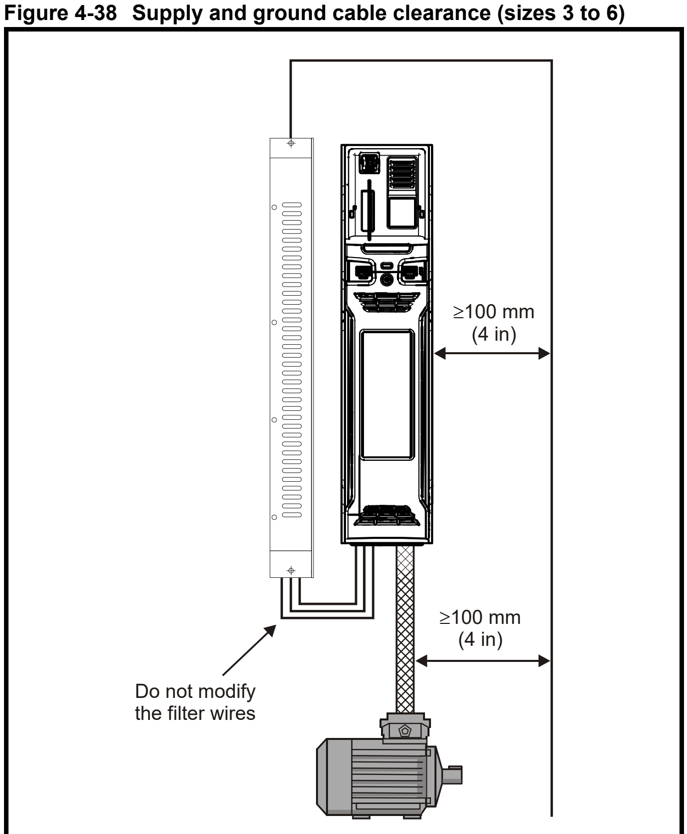
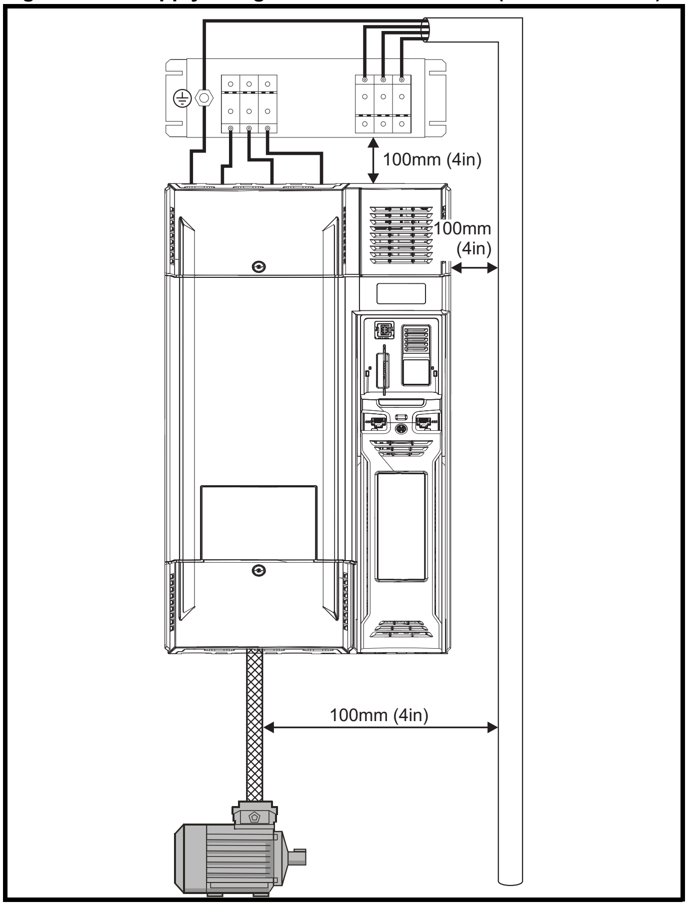
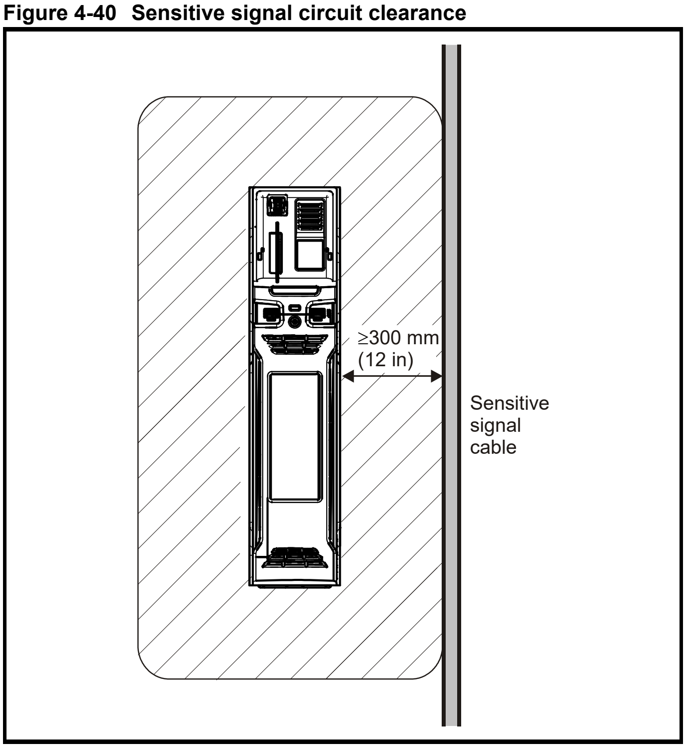


Figure 4-39 Supply and ground cable clearance (size 7 onwards)



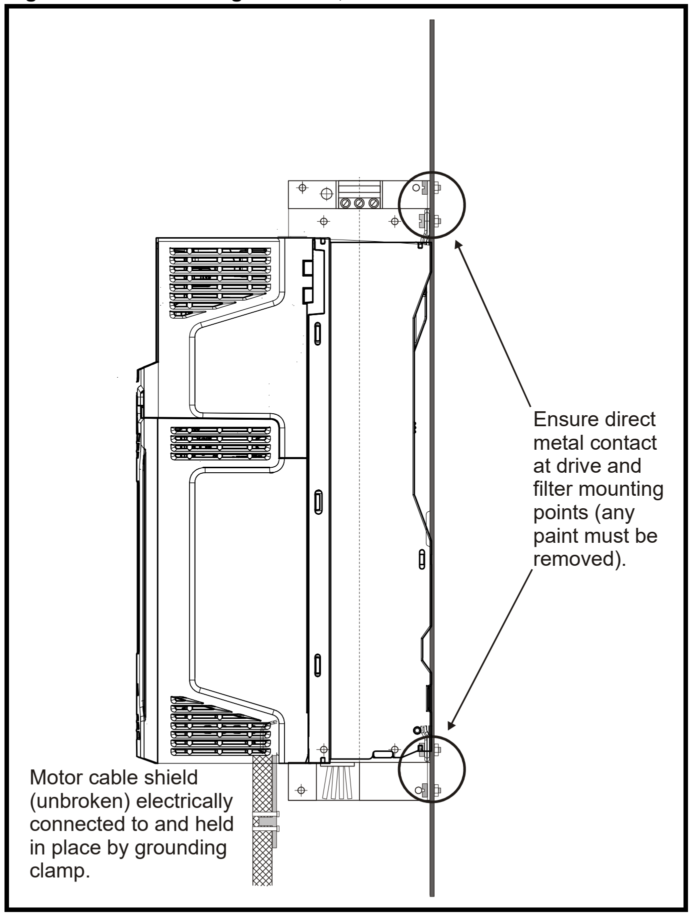
Ensure the AC supply and ground cables are at least 100 mm from the power module and motor cable.

Figure 4-40 Sensitive signal circuit clearance



Avoid placing sensitive signal circuits in a zone 300 mm (12 in) in the area immediately surrounding the power module. Ensure good EMC grounding.

Figure 4-41 Grounding the drive, motor cable shield and filter

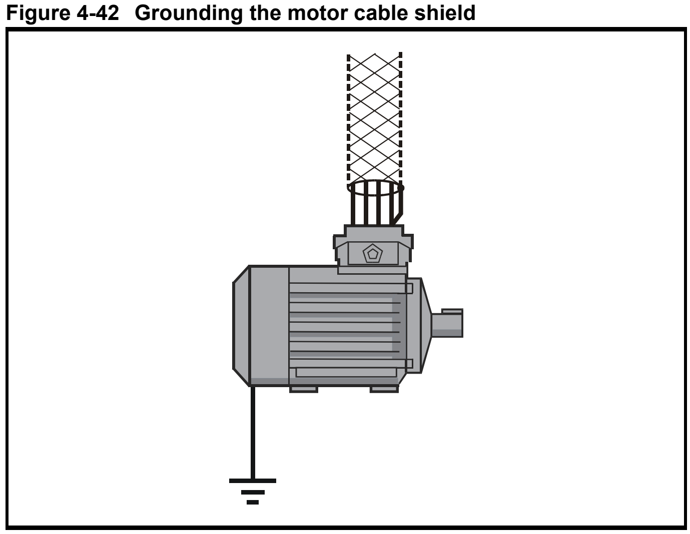


Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 in) long.

A complete 360° termination of the shield to the terminal housing of the motor is beneficial.

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

Figure 4-42 Grounding the motor cable shield

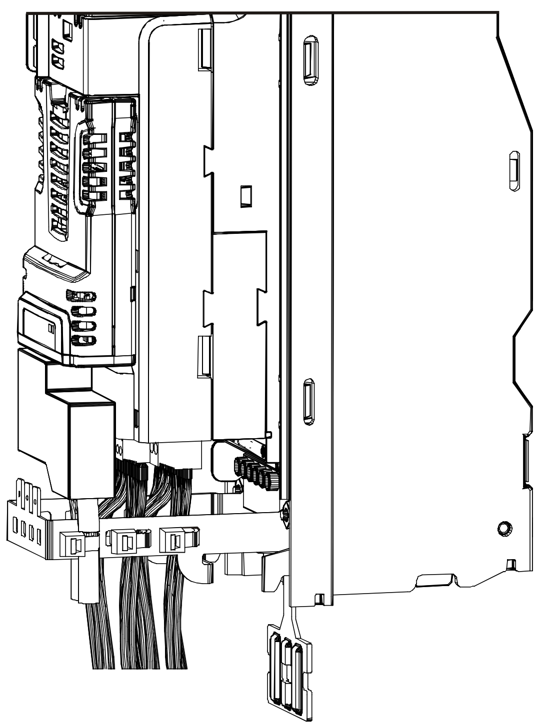


Unshielded wiring to the optional braking resistor(s) may be used provided the wiring runs internally to the enclosure.

If the control wiring is to leave the enclosure, it must be shielded and the shield(s) clamped to the drive using the grounding bracket as shown in Figure 4-43. Remove the outer insulating cover of the cable to ensure the shield(s) make direct contact with the bracket, but keep the shield(s) intact until as close as possible to the terminals

Alternatively, wiring may be passed through a ferrite ring, part number 3225-1004.

Figure 4-43 Grounding of signal cable shields using the grounding bracket



4.12.7 Variations in the EMC wiring

Interruptions to the motor cable

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

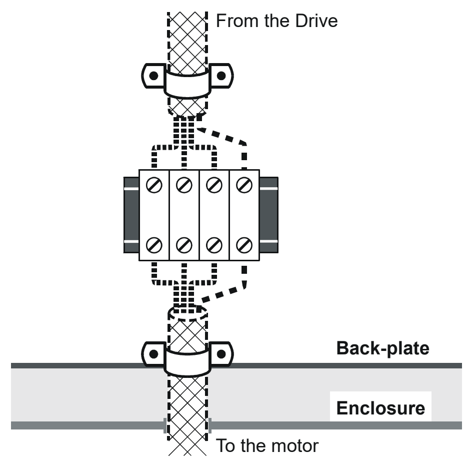
- Connecting the motor cable to a terminal block in the drive enclosure
- Installing a motor isolator / disconnect switch for safety when work is done on the motor

In these cases the following guidelines should be followed.

Terminal block in the enclosure

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

Figure 4-44 Connecting the motor cable to a terminal block in the enclosure



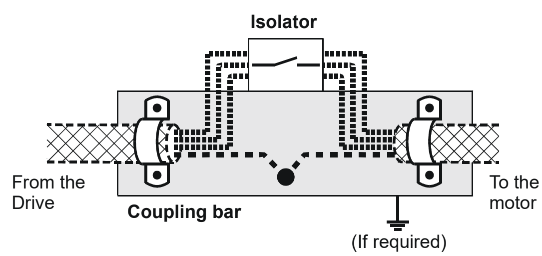
Using a motor isolator / disconnect-switch

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

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

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

Figure 4-45 Connecting the motor cable to an isolator / disconnect switch



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

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

These circuits meet the requirements of EN 61000-6-2:2005 (1 kV surge) provided the 0V connection is not grounded.

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

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

1. Galvanic isolation, i.e. do not connect the control 0V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is accompanied by its return (0V) wire.
2. Shielded cable with additional power ground bonding. The cable shield may be connected to ground at both ends, but in addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equipotential bonding cable) with cross-sectional area of at least 10 mm², or 10 times the area of the signal cable shield, or to suit the electrical safety requirements of the plant. This ensures that fault or surge current passes mainly through the ground cable and not in the signal cable shield. If the building or plant has a well-designed common bonded network this precaution is not necessary.
3. Additional over-voltage suppression - for the analog and digital inputs and outputs, a zener diode network or a commercially available surge suppressor may be connected in parallel with the input circuit as shown in Figure 4-46 and Figure 4-47.

If a digital port experiences a severe surge its protective trip may operate (I/O Overload trip). For continued operation after such an event, the trip can be reset automatically by setting Pr **10.034** to 5.

Figure 4-46 Surge suppression for digital and unipolar inputs and outputs

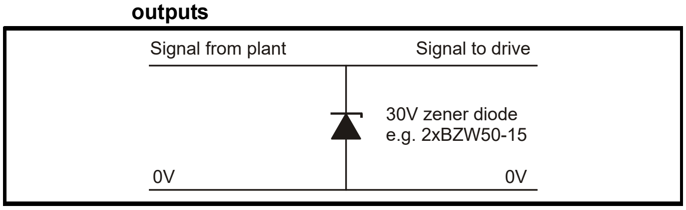
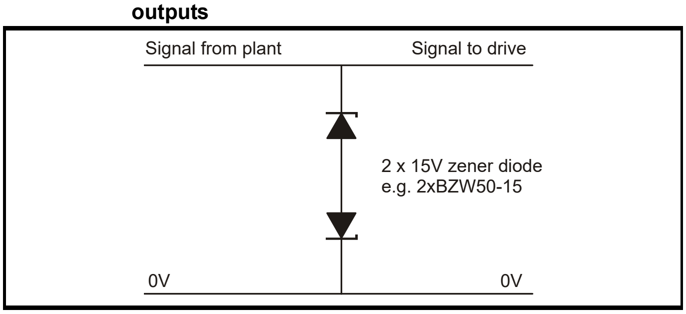


Figure 4-47 Surge suppression for analog and bipolar inputs and outputs



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

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

These devices are not suitable for fast digital data networks, because the capacitance of the diodes adversely affects the signal. For data networks, follow the specific recommendations for the particular network.

4.13 Communications

The drive offers a 2 wire EIA-485 serial interface located beneath the control terminals, see Figure 4-48 *Location of the comms connector* below. The drive supports the Modbus RTU protocol as standard. See Table 4-28 for the connection details.

Figure 4-48 Location of the comms connector

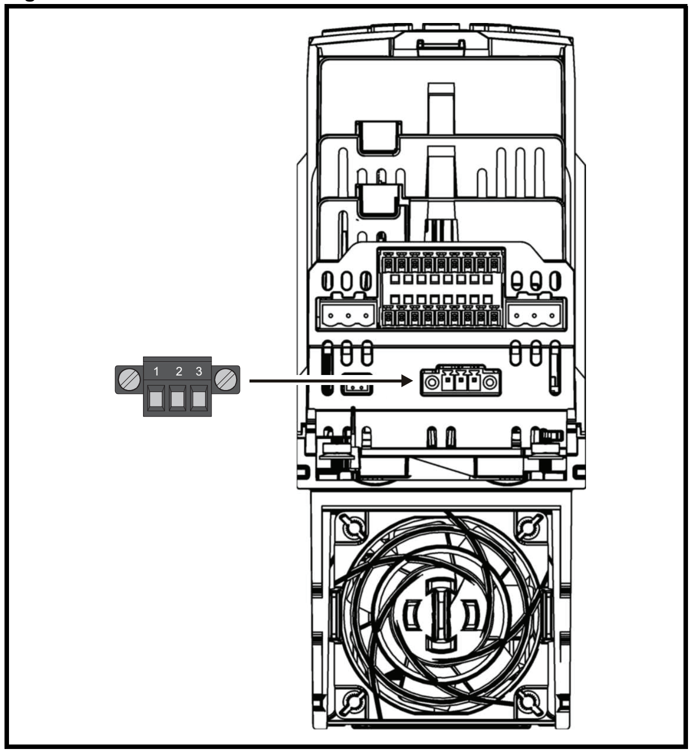


Table 4-28 Serial communication port pin-outs

Pin	Function
1	RX TX
2	Isolated 0V
3	RX\ TX\

EIA-485 Serial communications

The serial communications port is a 3 way screw type connector, which is isolated from the power stage and the other control terminals.The communications port applies a 2 unit load to the communications network.

USB/EIA-232 to EIA-485 Communications

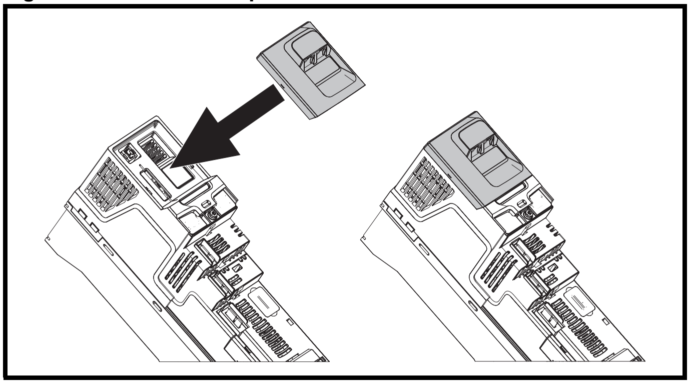
An external USB/EIA-232 hardware interface such as a PC cannot be used directly with the 2-wire EIA-485 interface of the drive.

To gain access to the drive parameters (including connection to Connect), a KI-485 Adaptor should be installed as shown in Figure 4-15 and used in conjunction with a suitable USB to EIA-485 isolated converter. A suitable isolated converter is available from Control Techniques:

- CT USB Comms Cable (CT part number: 4500-0096).

A KI-485 Adaptor is also required for remote LCD keypad operation. The communications cable between the KI-485 Adaptor and keypad is wired one to one. The maximum cable length is 100 m when conductors of 0.129 mm² (AWG 26) or larger are used and the cable shield should be connected to the grounded panel / cubicle at the keypad end of the cable.

Figure 4-49 KI-485 Adaptor Installation



To install, align the KI-485 Adaptor and press gently in the direction shown until it clicks into position.

To remove, reverse the installation instructions.

NOTE

IEC cable sizes assume Copper conductor, PVC insulation, Installation method B2 and ambient temperature of 40 °C (104 °F). UL cable sizes assume Copper conductor with insulation rated at 75 °C (167 °F).

When using the Control Techniques converters or any other suitable converter with the drive, it is recommended that no terminating resistors be connected on the network. It may be necessary to disconnect the terminating resistor within the converter depending on which type is used.

Serial communications set-up parameters

The following parameters need to be set according to the system requirements.

Serial communications set-up parameters		
Serial Mode (**11.024**)	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)	The drive only supports the Modbus RTU protocol and is always a slave. This parameter defines the supported data formats used by the EIA 485 comms port on the drive. This parameter can be changed via the drive keypad, via an option module or via the comms interface itself.
Serial Baud Rate (**11.025**)	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600(8), 76800(9), 115200 (10)	This parameter can be changed via the drive keypad, via an option module or via the comms interface itself. If it is changed via the comms interface, the response to the command uses the original baud rate. The master should wait at least 20 ms before sending a new message using the new baud rate.
Serial Address (**11.023**)	1 to 247	This parameter defines the serial address and an addresses between 1 and 247 are permitted.

4.14 Control connections

4.14.1 General

Table 4-29 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Single ended analog input	2	Mode, offset, invert, scaling, destination	5, 6
Analog output	2	Source, scaling, mode	7, 8
Digital input	3	Destination, invert, logic select	25, 26, 27
Digital input / output	3	Input / output mode select, destination / source, invert, logic select	22, 23, 24
Relay	2	Source, invert	41, 42, 71, 72
Drive enable (Safe Torque Off)	1		29
+24 V User output	1	Source, invert	3
0V common	5		1, 4, 9, 21, 28
+24 V External input	1	Destination, invert	2

Key:

Destination parameter:	Indicates the parameter which is being controlled by the terminal / function
Source parameter:	Indicates the parameter being output by the terminal
Mode parameter:	Analog - indicates the mode of operation of the terminal, i.e. voltage 0-10 V, current 4-20 mA etc. Digital - indicates the mode of operation of the terminal, i.e. positive / negative logic (the Drive Enable terminal is fixed in positive logic), open collector.

All analog terminal functions can be programmed in menu 7.
All digital terminal functions (including the relay) can be programmed in menu 8.

WARNING

The control circuits are isolated from the power circuits in the drive by basic insulation (single insulation) only. The installer must ensure that the external control circuits are insulated from human contact by at least one layer of insulation (supplementary insulation) rated for use at the AC supply voltage.

WARNING

If the control circuits are to be connected to other circuits classified as Safety Extra Low Voltage (SELV) (e.g. to a personal computer), an additional isolating barrier must be included in order to maintain the SELV classification.

CAUTION

If any of the digital inputs (including the drive enable input) are connected in parallel with an inductive load (i.e. contactor coil), then suitable suppression (i.e. diode or varistor) should be used on the coil of the load. If no suppression is used then over voltage spikes can cause damage to the digital inputs and outputs on the drive.

CAUTION

Ensure the logic sense is correct for the control circuit to be used. Incorrect logic sense could cause the motor to be started unexpectedly.
Positive logic is the default state for the drive.

NOTE

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

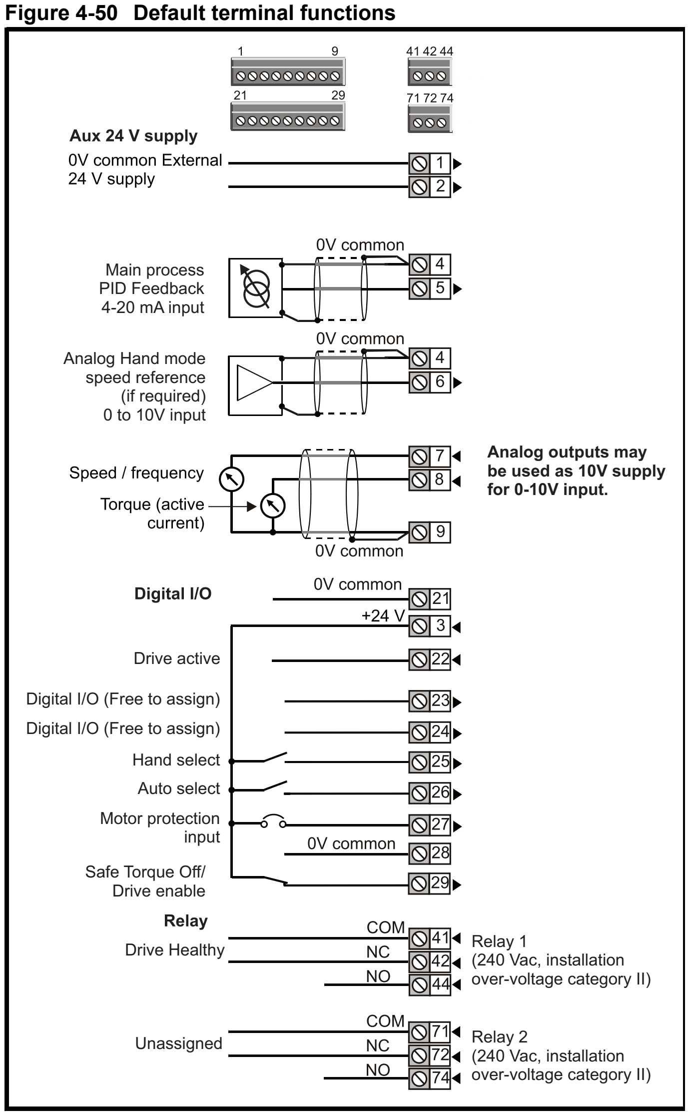
NOTE

The Safe Torque Off drive enable terminal is a positive logic input only. It is not affected by the setting of *Input Logic Polarity* Pr **08.029**.

NOTE

The common 0V from analog signals should, wherever possible, not be connected to the same 0 V terminal as the common 0 V from digital signals. Terminals 1, 4 and 9 should be used for connecting the 0 V common of analog signals, and terminals 21 and 28 for digital signals. This is to prevent small voltage drops in the terminal connections causing inaccuracies in the analog signals.

Figure 4-50 Default terminal functions



*The Safe Torque Off / Drive enable terminal is a positive logic input only.

4.14.2 Control terminal specification

1	0V common
Function	**Common connection for all external devices**

2	+24V external input
Function	**To supply the control circuit without providing a supply to the power stage**
Programmability	Can be switched on or off to act as a digital input by setting the source Pr **08.063** and input invert Pr **08.053**
Nominal voltage	+24.0 Vdc
Minimum continuous operating voltage	+19.2 Vdc
Maximum continuous operating voltage	+28.0 Vdc
Minimum start-up voltage	21.6 Vdc
Recommended power supply	40 W 24 Vdc nominal
Recommended fuse	3 A, 50 Vdc

3	+24 V user output (selectable)
Terminal 3 default function	**+24 V user output**
Programmability	Can be switched on or off to act as a fourth digital output (positive logic only) by setting the source Pr **08.028** and source invert Pr **08.018**
Nominal output current	100 mA combined with DIO3
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Protection	Current limit and trip
Sample / update period	2 ms when configured as an output (output will only change at the update rate of the source parameter if slower)

4	0V common
Function	**Common connection for all external devices**

5	Analog input 1
6	**Analog input 2**
Terminal 5 Default function	**Main process PID Feedback 4-20 mA input (Pr 29.034)**
Terminal 6 Default function	**Analog Hand mode speed reference (Pr 1.036)**
Type of input AI 1 [AI 2]	Unipolar current and Bipolar single-ended analog voltage
Mode controlled by:	Pr **07.007** [**07.011**]
Operating in current mode (Default for terminal 5)	
Current ranges	0 to 20 mA ±5 %, 20 to 0 mA ±5 %, 4 to 20 mA ±5 %, 20 to 4 mA ±5 %
Maximum offset	250 µA
Absolute maximum voltage (reverse bias)	±36 V relative to 0V
Absolute maximum current	±30 mA
Equivalent input resistance	≤ 300 Ω
Operating in voltage mode (Default for terminal 6)	
Full scale voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0V
Input resistance	≥100 k Ω
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update	250 µs with destinations Pr **01.036**, Pr **01.037** or Pr **03.022,** Pr **04.008** in RFC-A or RFC-S. 4 ms for open loop mode and all other destinations in RFC-A or RFC-S mode.
Operating in thermistor input mode	
Voltage range ±10 V ±2 %	
Supported thermistor types	Din 4408, KTY 84, PT100, PT 1000, PT 2000, NI 1000
Internal pull-up voltage 5 V	
Trip threshold resistance	User defined in Pr **07.055 [07.060]**
Reset resistance	User defined in Pr **07.056 [07.061]**
Short-circuit detection resistance	50 Ω ± 40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	4 ms

7	Analog output 1
8	**Analog output 2**

Terminal 7 default function	**OL> Motor FREQUENCY output signal RFC> SPEED output signal**
Terminal 8 default function	**Motor active current**
Type of output	Bipolar single-ended analog voltage or unipolar current
AOI [AO2] Mode controlled by...	Pr **07.021** [**07.024**]
Operating in Voltage mode (default)	
Voltage range	±10 V ±5 %
Maximum offset	±120 mV
Maximum output current	±20 mA
Load resistance	≥1 k Ω
Protection	20 mA max. Short circuit protection
Operating in current mode	
Current ranges	0 to 20 mA ±5%, 20 to 0 mA ±5% 4 to 20 mA ±5%, 20 to 4 mA ±5%
Common to all modes	
Resolution	10-bit
Sample / update period	250 μs (output will only change at update the rate of the source parameter if slower)

9	0V common
Function	**Common connection for all external devices**

21	0V common
Function	**Common connection for all external devices**

22	Digital I/O 1
23	**Digital I/O 2**
24	**Digital I/O 3**

Terminal 22 default function	**DRIVE ACTIVE output**
Terminal 23 default function	**Unassigned**
Terminal 24 default function	**Unassigned**
Type	Positive or negative logic digital inputs, positive logic voltage source outputs
Input / output mode controlled by...	Pr **08.031**, Pr **08.032** and Pr **08.033**
Operating as an input	
Logic mode controlled by...	Pr **08.029**
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Operating as an output	
Nominal maximum output current	100 mA (DIO1 & 2 combined) 100 mA (DIO3 & 24 V User Output Combined)
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Common to all modes	
Voltage range	0 V to +24 V
Sample / Update period	2 ms (output will only change at the update rate of the source parameter)

25	Digital Input 4
26	**Digital Input 5**

Terminal 25 default function	**Default is Hand select**
Terminal 26 default function	**Default is Auto select**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0 V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Sample / Update period	2 ms

27	Digital Input 6

Terminal 27 default function	**Default is motor protection input**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0 V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Sample / Update period	2 ms

28	**0V common**
Function	**Common connection for all external devices**

29	**Safe Torque Off function (drive enable)**
Type	Positive logic only digital input
Voltage range	0 V to +24 V
Absolute maximum applied voltage	30 V
Logic Threshold	10 V ± 5 V
Low state maximum voltage for disable to SIL3 and PL e	5 V
Impedance	>4 mA @15 V from IEC 61131-2, type 1, 3.3 k Ω
Low state maximum current for disable to SIL3 and PL e	0.5 mA
Response time	Nominal: 8 ms Maximum: 20 ms
The Safe Torque Off function may be used in a safety-related application in preventing the drive from generating torque in the motor to a high level of integrity. The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards. If the Safe Torque Off function is not required, this terminal is used for enabling the drive.	

Refer to section 4.15 *Safe Torque Off (STO)* on page 136 for further information.

41	**Relay 1 Common**
42	**Relay 1 Normally closed**
44	**Relay 1 Normaly open**
Default function	**Drive Healthy indicator**
Contact voltage rating	240 Vac, Installation over-voltage category II
Contact maximum current rating	2 A AC 240 V 4 A DC 30 V resistive load 0.5 A DC 30 V inductive load (L/R = 40 ms)
Contact minimum recommended rating	12 V 100 mA
Contact type	Common - 41 Normally closed - 42 Normally open - 44
Default contact condition	Closed when power applied and drive healthy
Update period	4 ms

51	**0V common***
52	**+24 Vdc***
Size 6	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	18.6 Vdc
Maximum continuous operating voltage	28.0 Vdc
Minimum startup voltage	18.4 Vdc
Maximum power supply requirement	40 W
Recommended fuse	4 A @ 50 Vdc
Size 7 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

*See Figure 4-17 to Figure 4-19 on page 106 for location.

71	**Relay 2 Common**
72	**Relay 2 Normally closed**
74	**Relay 2 Normally open**
Default function	**UNASSIGNED**
Contact voltage rating	240 Vac, Installation over-voltage category II
Contact maximum current rating	2 A AC 240 V 4 A DC 30 V resistive load 0.5 A DC 30 V inductive load (L/R = 40 ms)
Contact minimum recommended rating	12 V 100 mA
Contact type	Common - 71 Normally closed - 72 Normally open - 74
Default contact condition	Closed when power applied and drive healthy
Update period	4 ms

WARNING

To prevent the risk of a fire hazard in the event of a fault, a fuse or other over-current protection must be installed in the relay circuit.

4.15 Safe Torque Off (STO)

The Safe Torque Off function provides a means for preventing the drive from generating torque in the motor, with a very high level of integrity. It is suitable for incorporation into a safety system for a machine. It is also suitable for use as a conventional drive enable input.

The safety function is active when the STO input is in the logic-low state as specified in the control terminal specification. The function is defined according to EN 61800-5-2 and IEC 61800-5-2 as follows. (In these standards a drive offering safety-related functions is referred to as a PDS(SR)):

'Power, that can cause rotation (or motion in the case of a linear motor), is not applied to the motor. The PDS(SR) will not provide energy to the motor which can generate torque (or force in the case of a linear motor)'.

This safety function corresponds to an uncontrolled stop in accordance with stop category 0 of IEC 60204-1.

The Safe Torque Off function makes use of the special property of an inverter drive with an induction motor, which is that torque cannot be generated without the continuous correct active behavior of the inverter circuit. All credible faults in the inverter power circuit cause a loss of torque generation.

The Safe Torque Off function is fail-safe, so when the Safe Torque Off input is disconnected the drive will not operate the motor, even if a combination of components within the drive has failed. Most component failures are revealed by the drive failing to operate. Safe Torque Off is also independent of the drive firmware. This meets the requirements of the following standards, for the prevention of operation of the motor.

Machinery Applications

The Safe Torque Off Function has been independently assessed by Notified Body, TüV Rheinland for use as a safety component of a machine:

Prevention of unintended motor operation: The safety function "Safe Torque Off" can be used in applications up to Cat 4. PL e according to EN ISO 13849-1, SIL 3 according to EN 61800-5-2/ EN 62061/IEC 61508 and in lift applications according to EN 81-1 and EN81-2.

Type examination certificate No.	Date of issue	Models
01.205/5270.01/17	2017-08-28	F600

This certificate is available for download from the TüV Rheinland website at: http://www.tuv.com

Safety Parameters as verified by TüV Rheinland:

According to IEC 61508-1 to 07 / EN 61800-5-2 / EN 62061

Type	Value	Percentage of SIL 3 allowance
Proof test interval	20 years	
High demand or a continuous mode of operation		
PFH (1/h)	4.21×10^{-11} 1/h	<1 %
Low demand mode of operation (not EN 61800-5-2)		
PFDavg	3.68×10^{-6}	< 1 %

According to EN ISO 13849-1

Type	Value	Classification
Category	4	
Performance Level (PL)	e	
$MTTF_D$	> 2500 years	High
DC_{avg}	≥ 99 %	High
Mission time	20 years	

NOTE

Logic levels comply with IEC 61131-2:2007 for type 1 digital inputs rated at 24 V. Maximum level for logic low to achieve SIL3 and PL e 5 V and 0.5 mA.

UL Approval

The Safe Torque Off function has been independently assessed by Underwriters Laboratories (UL). The on-line certification (yellow card) reference is: FSPC.E171230.

Safety Parameters as verified by UL:

According to IEC 61508-1 to 7

Type	Value
Safety Rating	SIL 3
SFF	> 99 %
PFH (1/h)	4.43 x 10^{-10} 1/h (<1 % of SIL 3 allowance)
HFT	1
Beta Factor	2 %
CFF	Not applicable

According to EN ISO 13849-1

Type	Value
Category	4
Performance Level (PL)	e
$MTTF_D$	2574 years
Diagnostic coverage	High
CCF	65

Note on response time of Safe Torque Off, and use with safety controllers with self-testing outputs:

Safe Torque Off has been designed to have a response time of greater than 1 ms so that it is compatible with safety controllers whose outputs are subject to a dynamic test with a pulse width not exceeding 1 ms.

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

When the drive is disabled through Safe Torque Off, a possible (although highly unlikely) failure mode is for two power devices in the inverter circuit to conduct incorrectly.

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

WARNING

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

WARNING

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

WARNING

Safe Torque Off does not provide electrical isolation.
The supply to the drive must be disconnected by an approved isolation device before gaining access to power connections.

With Safe Torque Off there are no single faults in the drive which can permit the motor to be driven. Therefore it is not necessary to have a second channel to interrupt the power connection, nor a fault detection circuit.

It is important to note that a single short-circuit from the Safe Torque Off input to a DC supply of >5 V could cause the drive to be enabled.
This can be excluded under EN ISO 13849-2 by the use of protected wiring. The wiring can be protected by either of the following methods:

- By placing the wiring in a segregated cable duct or other enclosure.

or

- By providing the wiring with a grounded shield in a positive-logic grounded control circuit. The shield is provided to avoid a hazard from an electrical fault. It may be grounded by any convenient method; no special EMC precautions are required.

WARNING

It is essential to observe the maximum permitted voltage of 5 V for a safe low (disabled) state of Safe Torque Off.
The connections to the drive must be arranged so that voltage drops in the 0V wiring cannot exceed this value under any loading condition. It is strongly recommended that the Safe Torque Off circuit be provided with a dedicated 0V conductor which should be connected to terminal 28 at the drive.

Safe Torque Off over-ride

The drive does not provide any facility to over-ride the Safe Torque Off function, for example for maintenance purposes.

5 Getting started / Running the Motor

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

5.1 Understanding the display

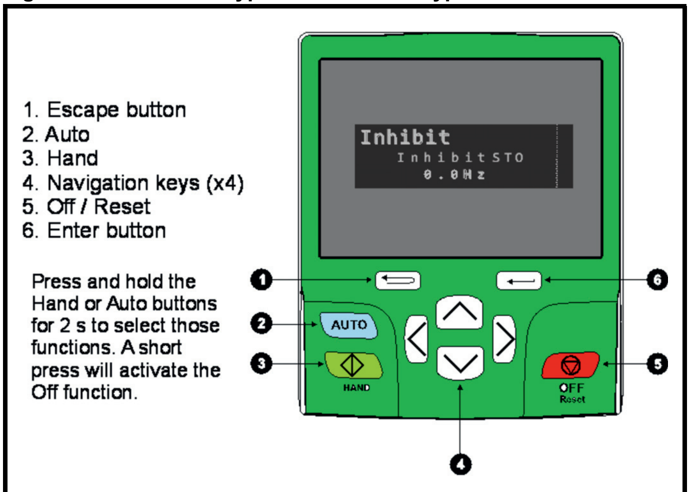
The KI-HOA keypad RTC can only be mounted on the drive. The HOA keypad RTC can be mounted on the drive or remotely mounted.

5.1.1 Keypad details

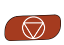
The display of both keypads consists of two rows of text. The upper row shows the drive status or the menu and parameter number currently being viewed. The lower row of the display line shows the parameter value or the specific trip type. The last two characters on the first row may display special indications. If more than one of these indications is active then the indications are prioritized as shown in Table 5-2.

When the drive is powered up the lower row will show the power up parameter defined by *Parameter Displayed At Power-Up* (11.022).

Figure 5-1 KI-HOA Keypad RTC / HOA Keypad RTC



NOTE

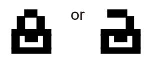
The red stop  button is also used to reset the drive.

The parameter value is correctly displayed in the lower row of the keypad display, see table below.

Table 5-1 Keypad display formats

Display formats	Value
IP Address	127.000.000.000
MAC Address	01ABCDEF2345
Time	12:34:56
Date	31-12-11 or 12-31-11
Version number	01.02.02.00
Character	ABCD
32 bit number with decimal point	21474836.47
16 bit binary number	0100001011100101

Table 5-2 Active action icon

Active action icon	Description	Row (1=top)	Priority in row
	Accessing non-volatile media card	1	1
	Alarm active	1	2
	Keypad real-time clock battery low	1	3
	Drive security active and locked or unlocked	1	4
	User program running	3	1
	Keypad reference active	4	1

5.2 Keypad operation

5.2.1 Control buttons

The keypad consists of:

- Navigation Keys - Used to navigate the parameter structure and change parameter values.
- Enter / Mode button - Used to toggle between parameter edit and view mode.
- Escape / Exit button - Used to exit from parameter edit or view mode. In parameter edit mode, if parameter values are edited and the exit button is pressed, the parameter value will be restored to the value it had on entry to edit mode.

Three control buttons are used to select Hand / Off / Auto modes (see below).

NOTE

Low battery voltage is indicated by  low battery symbol on the keypad display. Refer to section 3.14.1 *Real time clock battery replacement* on page 82 for information on battery replacement.

Figure 5-2 *Display modes* on page 139, shows an example of moving between menus and editing parameters.

Auto

In Auto mode, the reference for the motor speed/frequency will be selected by the value set in Pr **01.021**.

Hand

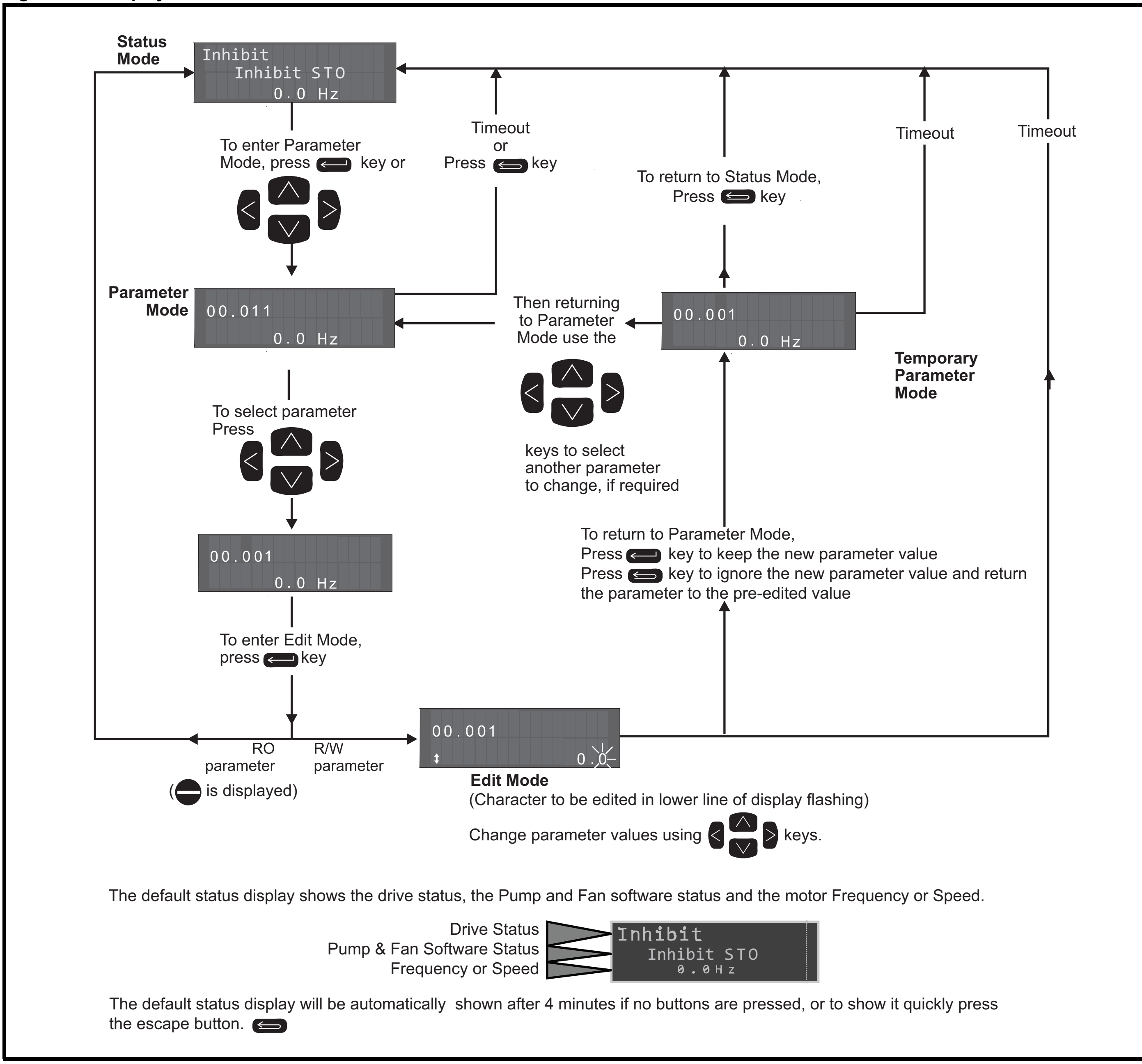
The speed/frequency reference Pr **01.022** is automatically set to keypad reference. The motor speed is determined by the value in the keypad control mode reference which can be adjusted by pressing the Up/Down arrows on the keypad.

If Hand mode is selected from Off mode, the motor will ramp up to the speed determined by the keypad control mode reference.

Off

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

Figure 5-2 Display modes



NOTE

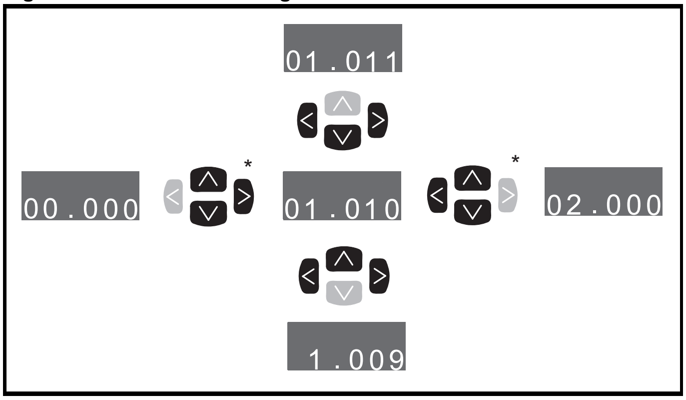
The navigation keys can only be used to move between menus if Pr **00.001** has been set to show 'All Menus'. Refer to section 5.10 *Parameter access level and security* on page 157.

5.3 Menu structure

The drive parameter structure consists of menus and parameters.

The drive initially powers up so that only Menu 0 can be viewed. The up and down arrow buttons are used to navigate between parameters and once Pr **00.001** has been set to 'All Menus' the left and right buttons are used to navigate between menus. For further information, refer to section 5.10 *Parameter access level and security* on page 157

Figure 5-3 Parameter navigation



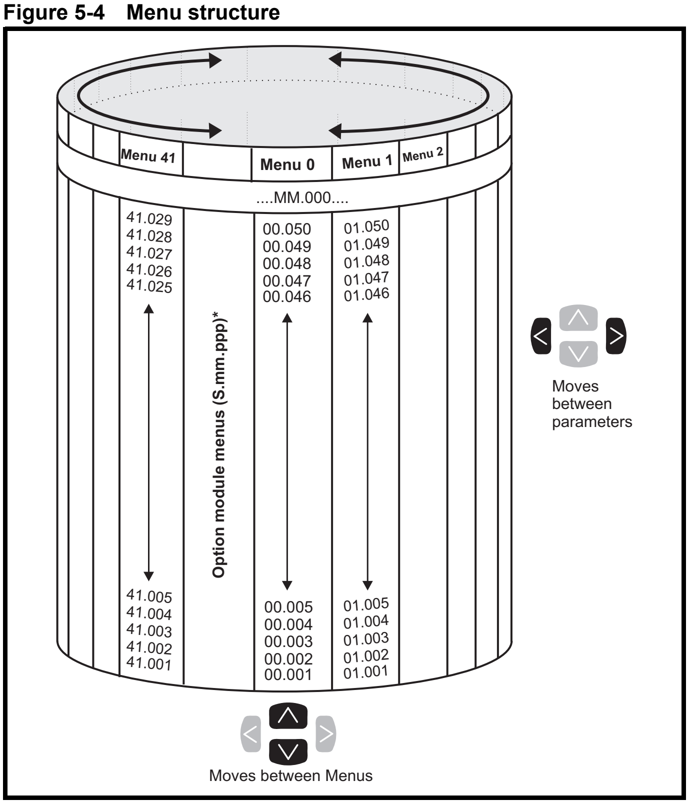
* Can only be used to move between menus if all menus have been enabled (Pr **00.001**). Refer to section 5.10 *Parameter access level and security* on page 157.

The menus and parameters roll over in both directions.

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

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

Figure 5-4 Menu structure



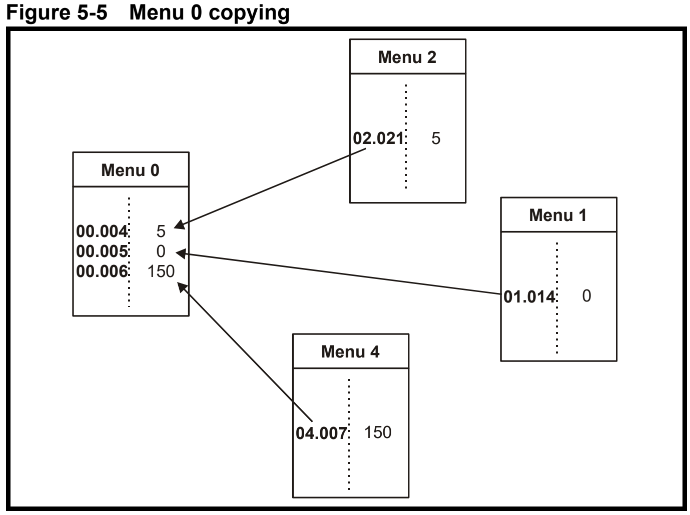
* The option module menus (S.mm.ppp) are only displayed if option modules are installed. Where S signifies the option module slot number and the mm.ppp signifies the menu and the parameter number of the option module's internal menus and parameter.

5.4 Menu 0

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. The parameters displayed in Menu 0 can be configured in Menu 22.
Appropriate parameters are copied from the advanced menus into Menu 0 and thus exist in both locations.

For further information, refer to Chapter 6 *Basic parameters* on page 158.

Figure 5-5 Menu 0 copying

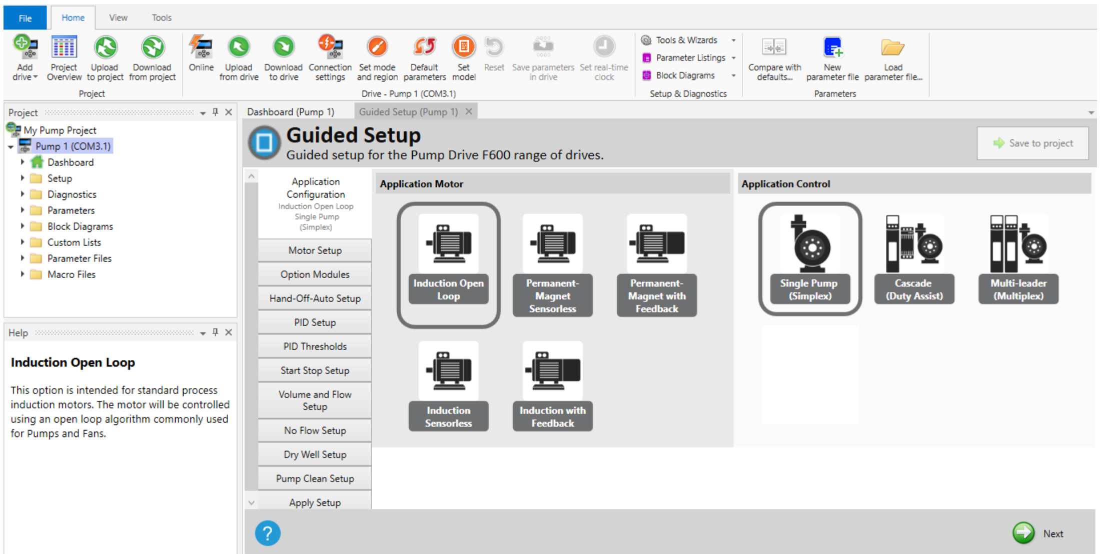


5.5 Step by Step Setup

Connect and guided setup tool for PC

To help the user to configure and monitor their pump system, Control Techniques has a drive commissioning tool called Connect. This software allows the user to setup, monitor, default, save and recover drive parameters and update drive and option module software over digital communications. This tool is available from http://controltechniques.com/support.

Connect features a comprehensive guided setup tool that covers all 3 operating modes for the drive, in a logical configuration order, with a context-based help system to simplify setup of the Pump Drive F600 If it is possible to use a PC laptop during commissioning, and the required comms lead is available, this is a highly recommended way to setup the drive.



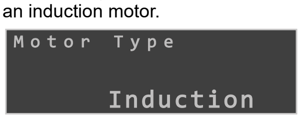
STEP 1: Run the drive for the first time in Hand mode

Step 1 and 2 cover basic fixed pressure pump setup. There is a comprehensive guided set-up wizard included in the Connect PC software package which covers pump system set-up.

Hand mode is where the drive runs from a fixed frequency or speed reference where the process PID loop is disabled. The user can modify the hand mode frequency or speed as detailed in the following steps.

Before starting, it is important to identify the type of motor used in the application. If the type of motor isn't known, please contact the motor manufacturer to find out if it is an induction or permanent-magnet motor.

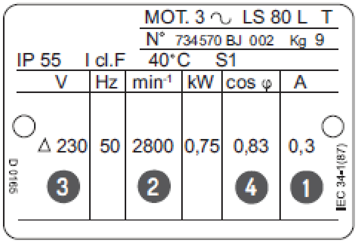
Run an Induction motor in open-loop (OL) control

Action	Detail
Before power up.	Open the Enable or Safe Torque Off, Hand and Auto mode switches so the drive powers up in the *Inhibit* state. Make sure that no items are preventing the application motor from turning e.g. a seized pump.
Power up the drive.	After power up the display indicates as shown below. 
Select "Induction" motor.	Set Motor Type Pr **0.004** to *Induction* and press the red OFF / Reset button to change the mode. This selects open-loop (OL) control for an induction motor.  OFF Reset  If "Induction" is already shown, then skip this step.

Run an Induction motor in open-loop (OL) control

<table>
<tr><td>Configure the motor name plate details.</td><td>

- Set *Rated Current* Pr **0.006** to the motor rated current in Amps.
- Set *Rated Speed* Pr **0.007**, the motor rated speed in rpm.
- Set *Rated Voltage* Pr **0.008**, the motor rated voltage in Volts.
- Set *Rated Power Factor* Pr **0.009**, the motor rated power factor, (cos phi or cos φ).



</td></tr>
<tr><td>Configure motor thermal protection.</td><td>

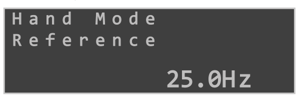
If a normally closed motor thermal protection switch has been connected, (contacts closed = temperature OK, contacts open = temperature fault), set *Motor Thermal Protection Enable* Pr **0.017** to On. Otherwise leave Pr **0.017** set to Off.

</td></tr>
<tr><td>Set the Maximum Reference Clamp.</td><td>

By default, *Maximum Reference Clamp* Pr **0.022** normally matches *Rated Frequency* Pr **0.005**

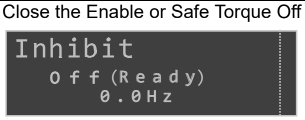
It may be required when running to reduce this value if pump cavitation is suspected during operation.
</td></tr>
<tr><td>Set the Hand Mode Reference frequency..</td><td>

Set *Hand Mode Reference* Pr **0.026** to configure the frequency reference used in Hand mode. By default, this is half of the motor rated frequency



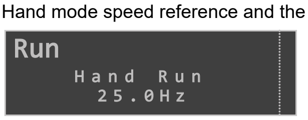
</td></tr>
<tr><td>Enable the drive.</td><td>

Close the Enable or Safe Torque Off input switch to the drive. The pump software status changes to *Off (Ready)*.

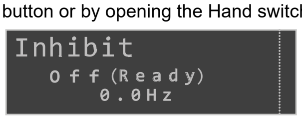


</td></tr>
<tr><td>Start the motor in Hand mode.</td><td>

Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. The motor will turn at the Hand mode speed reference and the pump software status changes to *Hand Run*.



If the application requires more starting torque to get the motor turning, e.g. a waste water pump, increase *Low Frequency Voltage Boost* Pr **0.008**, in 1 % steps. If 5 % is reached and the motor still does not turn, stop the Motor by pressing and holding the red OFF / Reset button or by opening the Hand switch. The pump software status changes to *Off (Ready)*.

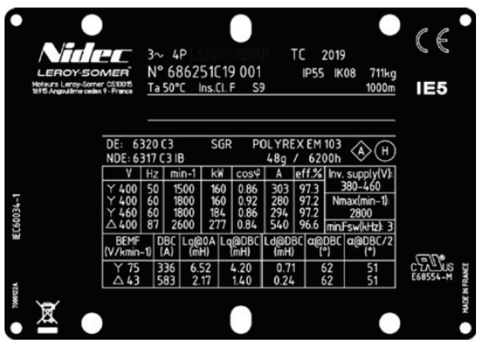


When safe to do so, check the application for physical items that may be preventing the motor from rotating.
</td></tr>
</table>

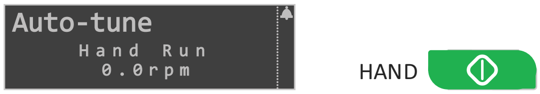
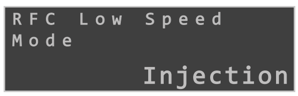
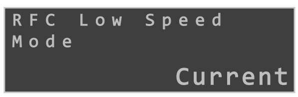
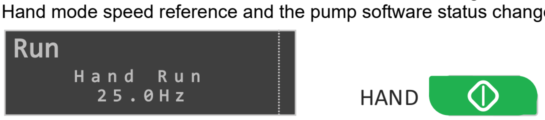
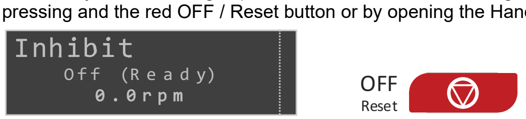
Run an Induction motor in open-loop (OL) control

Check the motor is turning in the correct direction.	All pumps have a direction to turn in for their main operation. Use the manufacturer's data or labels on the apparatus and compare to the direction of rotation of the cooling fan or motor output shaft. *Hand Mode Reference* Pr **0.026** may need to be lowered to see the direction.  If the motor appears to be running in the wrong direction, reverse two motor phases electrically when safe to do so. Alternatively, set *Reverse Output Phase Sequence* Pr **0.018** to *On* to do this in software, and Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button.  
Stop the motor.	Stop the Motor by pressing and holding the red OFF / Reset button or by opening the Hand switch. The pump software status in changes to *Off (Ready)*. 

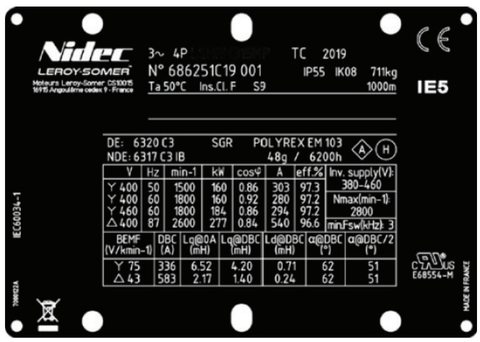
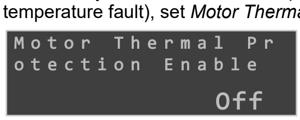
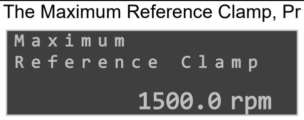
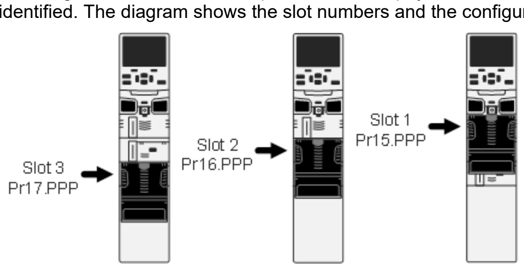
Run a Permanent-magnet motor in closed-loop sensorless (RFC-S)

Action	Detail
Before power up.	Open the Enable or Safe Torque Off, Hand and Auto mode switches so the drive powers up in the Inhibit state. Make sure that no items are preventing the application motor from turning e.g. a ceased or blocked pump.
Power up.	After power, up the display indicates as shown below. Inhibit Inhibit STO 0.0rpm
Select Permanent-magnet motor.	Set parameter Pr **0.004** to *Permanent-magnet* and press the red OFF / Reset button to change the mode. This selects closed-loop sensorless (RFC-S) control for a permanent-magnet motor. Motor Type Permanent-magnet OFF Reset If *Permanent-magnet* is already shown, then skip this step.
Configure the motor name plate details.	• Set *Volts Per 1000 rpm* Pr **0.005**, the Back EMF / Ke in V/kmin-1. • Set *Rated Current* Pr **0.006**, the motor rated current in Amps. • Set *Rated Speed* Pr **0.007,** the motor rated speed in rpm. • Set *Rated Voltage* Pr **0.008,** the motor rated voltage in Volts. • Set *Number Of Motor Poles* Pr **0.009**. 
Configure Motor Thermal Protection.	If a normally closed motor thermal protection switch has been connected, (contacts closed = temperature OK, contacts open = temperature fault), set *Motor Thermal Protection* Enable Pr **0.017** to *On*. Otherwise leave Pr **0.017** set to *Off*. Motor Thermal Pr otection Enable Off
Set the Maximum Reference Clamp.	The Maximum Reference Clamp, Pr **0.022** normally matches the motor name plate speed as entered in Pr **0.007**. Maximum Reference Clamp 1500.0 rpm It may be required when running to reduce this value if pump cavitation is suspected during operation.
Set the Hand Reference Speed.	Set the Hand mode digital frequency reference Pr **0.026**. By default, this is half of the motor rated speed. Hand Mode Reference 750.0rpm
Select the auto-tune mode.	Set *Auto-tune* Pr **0.013** to *Stationary* to select a stationary auto-tune. The motor shaft will not rotate as a part of this test, however, as a precaution it should be treated as if will rotate. Auto-tune Stationary
Enable the drive.	Close the Enable or Safe Torque Off input switch to the drive. The pump software status changes to Off (*Ready)*. Inhibit Off (Ready) 0.0rpm

Run a Permanent-magnet motor in closed-loop sensorless (RFC-S)

Run the auto-tune.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch.  The drive will run the auto-tune to measure the electrical properties of the motor. The autotune process takes approximately 30 s. When the Autotune is completed the pump software status changes to *Inhibit STO*. The drive sequencer prevents the drive running in an unexpected way after the auto-tune. To allow the motor to run after the auto-tune, do one of the following: • Open the Enable or Safe Torque Off switch. • Or press the red stop button. • Or open the Hand switch. The pump software status changes to *Off (Ready)*. 
Does the motor have a load?	If the motor has a pump attached or *RFC Low Speed Mode* Pr **0.014** = Injection, move to the next step to *Save the drive parameters*.  If the motor has no load attached e.g. for a basic bench test, and *RFC Low Speed Mode* Pr **0.014** = Current, reduce the Low Speed Sensorless Mode Current Pr **0.015** to 50.0 %.  When the load is attached, increase Pr **0.015** back to 100.0%.
Save the drive parameters.	Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button. 
Start the motor in Hand mode.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. The motor will turn at the Hand mode speed reference and the pump software status changes to *Hand Run*.  If instability is noted at high speed and load, additional filtering of the estimated speed feedback may be required. Stop the Motor by pressing and the red OFF / Reset button or by opening the Hand switch. The pump software status changes to *Off (Ready)*.  Increase the Sensorless Mode Filter value Pr **0.019** in single steps until the required performance is reached. Stop and start the motor making sure it starts and runs at high speed properly. If the motor doesn't start properly and there is significant starting torque required to turn the load, check if the RFC Low Speed Mode Pr **0.014** = Injection. If it is set to "Injection" please try setting Pr **0.014** to "Current" instead and Increase the Low Speed Sensorless Current Pr **0.015** to 100 %.
Check the motor is turning in the correct direction.	All pumps have a direction to turn in for their main operation. Use the manufacturers data or labels on the apparatus and compare to the direction of rotation of the cooling fan or motor output shaft. The *Hand Mode Reference* Pr **0.026** may need to be lowered to see the direction.  If the motor appears to be running in the wrong direction, reverse two motor phases electrically, when safe to do so. Alternatively, set *Reverse Output Phase Sequence* Pr **0.018** to On to do this in software, then set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button. 
Stop the motor.	Stop the Motor by pressing the red OFF / Reset button or by opening the Hand switch. The pump software status changes to Off (*Ready)*. 

Run a permanent-magnet motor with feedback.

Before power up.	Open the Enable or Safe Torque Off, Hand and Auto mode switches so the drive powers up in the *Inhibit STO* state. Make sure that no items are preventing the application motor from turning e.g. a ceased or blocked pump. Ensure an SI-Universal Encoder module has been fitted and connected to the motor encoder.
Power up.	After power, up the display indicates as shown below. 
Select Permanent-magnet motor.	Set Motor Type Pr **0.004** to Permanent-magnet and press the red OFF / Reset button to change the mode. This selects closed loop sensorless control for a permanent-magnet motor.  If "Permanent-magnet" is already shown, then skip this step.
Configure the motor name plate details.	• Set *Volts Per 1000 rpm* Pr **0.005**, the Back EMF / Ke in V/kmin-1. • Set *Rated Current* Pr **0.006**, the motor rated current in Amps. • Set *Rated Speed* Pr **0.007,** the motor rated speed in rpm. • Set *Rated Voltage* Pr **0.008,** the motor rated voltage in Volts. • Set *Number Of Motor Poles* Pr **0.009**.. 
Configure Motor Thermal Protection.	If a normally closed motor thermal protection switch has been connected, (contacts closed = temperature OK, contacts open = temperature fault), set *Motor Thermal Protection* Enable Pr **0.017** to *On*. Otherwise leave Pr **0.017** set to *Off*. 
Set the Maximum Reference Clamp.	The Maximum Reference Clamp, Pr **0.022** normally matches the motor name plate speed as entered in Pr **0.007**.  It may be required when running to reduce this value if pump cavitation is suspected during operation.
Set the Hand Reference Speed.	Set the Hand mode digital frequency reference Pr **0.026**. By default, this is half of the motor rated speed. 
Identify the encoder interface slot number.	To configure the motor encoder parameters, the physical slot that the SI-Universal Encoder option module has been fitted in must be identified. The diagram shows the slot numbers and the configuration parameter menus  PPP = 3 digit encoder parameter number

Run a permanent-magnet motor with feedback.

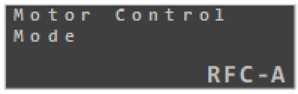
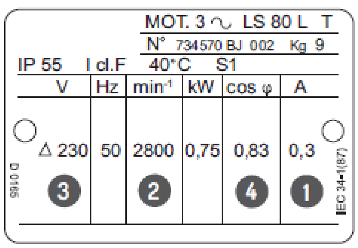
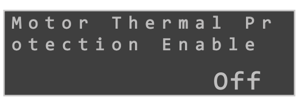
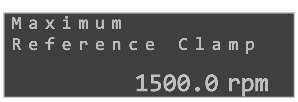
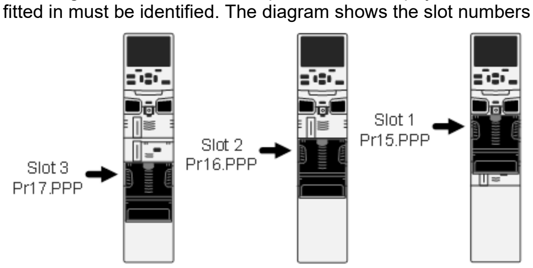
Configure the encoder interface	Set up the encoder interface parameters. MM = 15, 16 or 17 as identified in the previous step. • Ensure *Menu Access Level* Pr **0.001** is set to *All Menus* to allow access to the encoder option parameters. Menu Access Level All Menus • Set *P1Rotary Lines Per Revolution* PrMM.034 to the number of lines or encoder counts per revolution. P1 Rotary Lines Per Revolution 1024 • Set *P1 Supply Voltage* PrMM.036 to the supply voltage stated on the encoder *5 V, 8 V or 15 V*. P1 Supply Voltage 5V • Set *P1 Comms Baud Rate* PrMM0.37 to 2M Baud if the encoder is and *EnDat* or *BiSS* type. Leave at the default of 300 k for all other types P1 Comms Baud Rate 2M Baud • Set *P1 Device Type* PrMM.038 to the correct value for the encoder fitted. P1 Device Type AB Servo • Set *P1 Auto-config* select to *Enabled*. P1 Auto-config Select Enabled • Reset any encoder trips caused when changing the encoder type by pressing the red OFF / reset button. OFF Reset
Change to encoder feedback mode.	• First, set *Motor Control Feedback Select* Pr **3.026** to *P1 Slot1, P1 Slot2* or *P1 Slot3*, depending on the option slot that the SI-Universal encoder option is fitted in, to select the location of the encoder feedback. • Set *RFC Feedback Mode* Pr **3.024** to Feedback to select encoder feedback. RFC Feedback Mode Feedback Motor Control Feedback Select P1 Slot3
Increase the speed loop I gain.	*Increase Speed Controller I Gain Ki* Pr **3.011** to 1.00 s^2/rad. Speed Controller I Gain Ki 1.00 s^2/rad
Select the Auto-tune test mode.	Set *Auto-tune* Pr **0.013** to *Full Stationary*. The motor shaft will not rotate as a part of this test, however, as a precaution it should be treated as if it will rotate. Auto-tune Full Stationary
Enable the drive.	Close the Enable or Safe Torque Off input switch to the drive. The pump software status changes to *Off (Ready)*. Inhibit Off (Ready) 0.0rpm

Run a permanent-magnet motor with feedback.

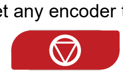
Run the Auto-tune.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. Auto-tune Hand Run 0.0rpm HAND The drive will run the Auto-tune to measure the electrical properties of the motor. The Auto-tune process takes approximately 30 s. When the Auto-tune is completed the pump software status changes to *Inhibit STO*. The drive sequencer prevents the drive running in an unexpected way after the Auto-tune. To allow the motor to run after the Auto-tune, do one of the following: • Open the Enable or Safe Torque Off switch. • Or press the red OFF / Reset button • Or open the Hand switch. The pump software status changes to *Off (Ready)*. Auto-tune Hand Run 0.0rpm OFF Reset
Save the drive parameters.	Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button. Parameter mm.000 Save parameters OFF Reset
Start the motor in Hand mode.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. The motor will turn at the Hand mode speed reference and the pump software status changes to *Hand Run* Run Hand Run 750.0rpm HAND
Check the motor is turning in the correct direction.	All pumps have a direction to turn in for their main operation. Use the manufacturers data or labels on the apparatus and compare to the direction of rotation of the motor cooling fan or motor output shaft. *Hand Mode Reference* Pr **0.026** may need to be lowered to see the direction Hand Mode Reference 750.0rpm If the motor appears to be running in the wrong direction: • Stop the Motor by pressing the red OFF / Reset button or by opening the Hand switch. OFF Reset • Set *Reverse Output Phase Sequence* Pr **0.018** to *On* to change the motor direction of rotation. Reverse Output Phase Sequence On • Set *P1 Feedback Reverse* PrMM.056* to *On* to change the motor feedback direction of rotation. MM = the menu for the encoder interface. P1 Feedback Reverse On • Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button Parameter mm.000 Save parameters OFF Reset * *Menu Access Level* Pr **0.001** must be set to *All Menus* to allow access to PrMM.056. Menu Access Level All Menus
Stop the motor.	Stop the Motor by pressing the red OFF / Reset button or by opening the Hand switch. The pump software status changes to *Off (Ready)*. Inhibit Off (Ready) 0.0rpm OFF Reset

STEP 2

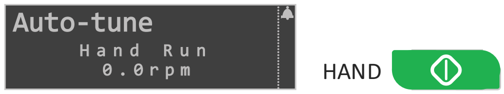
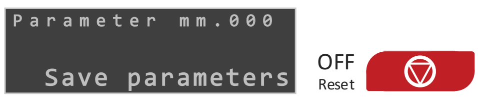
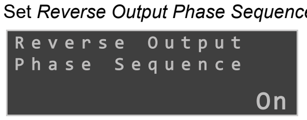
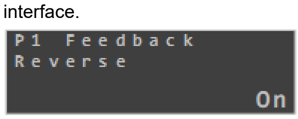
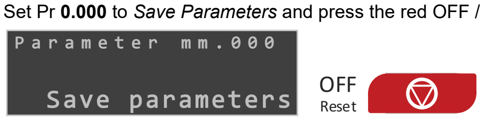
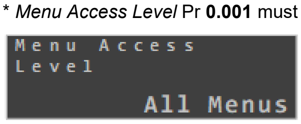
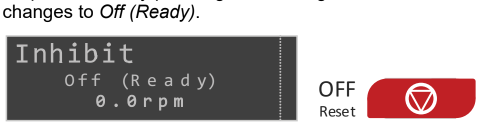
Run an induction motor with feedback

Before power up.	Open the Enable or Safe Torque Off, Hand and Auto mode switches so the drive powers up in the *Inhibit STO* state. Make sure that no items are preventing the application motor from turning e.g. a ceased or blocked pump. Ensure an SI-Universal Encoder or SI-Encoder module has been fitted and connected to the motor encoder.
Power up.	After power, up the display indicates as shown below. 
Select RFC-A motor control mode for induction motors in closed loop.	• Set *Motor Control Mode* Pr **11.031** to *RFC-A*  • Set Pr **0.000** to 1253 for 50Hz regions, or 1254 for 60Hz regions.  • Press the red OFF / Reset button to change the mode. This selects closed loop sensorless control for an induction motor in closed loop motor. 
Configure the motor name plate details.	• Set *Rated Current* Pr **0.006** to the motor rated current in Amps. • Set *Rated Speed* Pr **0.007**, the motor rated speed in rpm. • Set *Rated Voltage* Pr **0.008**, the motor rated voltage in Volts. • Set *Rated Power Factor* Pr **0.009**, the motor rated power factor, (cos phi or cos φ). 
Configure the motor thermal protection	If a normally closed motor thermal protection switch has been connected, (contacts closed = temperature OK, contacts open = temperature fault), set *Motor Thermal Protection Enable* Pr **0.017** to *On*. Otherwise leave Pr **0.017** set to *Off*. 
Set the maximum reference clamp.	*Maximum Reference Clamp* Pr **0.022** normally matches the motor name plate speed as entered in *Rated Speed* Pr **0.007**.  It may be required when running to reduce this value if pump cavitation is suspected during operation.
Set the Hand mode reference speed.	Set *Hand Mode Reference* Pr **0.026**. By default, this is half of the motor rated speed. 
Identify the encoder interface slot number.	To configure the motor encoder parameters, the physical slot that the SI-Universal Encoder or SI-Encoder option module has been fitted in must be identified. The diagram shows the slot numbers and the configuration parameter menus.  PPP = 3 digit encoder parameter number

Run an induction motor with feedback

Configure the encoder interface	Set up the encoder interface parameters. MM = 15, 16 or 17 as identified in the previous step. • Ensure *Menu Access Level* Pr **0.001** is set to *All Menus* to allow access to the encoder option parameters. Menu Access Level All Menus • Set *P1Rotary Lines Per Revolution* PrMM.034 to the number of lines or encoder counts per revolution. P1 Rotary Lines Per Revolution 1024 • Set *P1 Supply Voltage* PrMM.036 to the supply voltage stated on the encoder *5 V, 8 V or 15 V.* P1 Supply Voltage 5V • Set *P1 Comms Baud Rate* PrMM0.37 to 2M Baud if the encoder is and *EnDat* or *BiSS* type. Leave at the default of 300 k for all other types P1 Comms Baud Rate 2M Baud • Set *P1 Device Type* PrMM.038 to the correct value for the encoder fitted. P1 Device Type AB Servo • Set *P1 Auto-config* select to *Enabled.* P1 Auto-config Select Enabled • Reset any encoder trips caused when changing the encoder type by pressing the red reset button. OFF Reset 
Change to encoder feedback mode.	• First, set *Motor Control Feedback Select* Pr **3.026** to *P1 Slot1, P1 Slot2* or *P1 Slot3*, depending on the option slot that the SI-Universal encoder option is fitted in, to select the location of the encoder feedback. • Set *RFC Feedback Mode* Pr **3.024** to Feedback to select encoder feedback. RFC Feedback Mode Feedback Motor Control Feedback Select P1 Slot3
Increase the speed loop I gain.	*Increase Speed Controller I Gain Ki* Pr **3.011** to 1.00 s^2/rad. Speed Controller I Gain Ki 1.00 s^2/rad
Select the Auto-tune test mode.	Set *Auto-tune* Pr **0.013** to *Basic* The motor shaft will not rotate as a part of this test, however, as a precaution it should be treated as if will rotate. Auto-tune Basic
Enable the drive.	Close the Enable or Safe Torque Off input switch to the drive. The pump software status changes to *Off (Ready)*. Inhibit Off (Ready) 0.0rpm

Run an induction motor with feedback

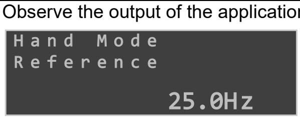
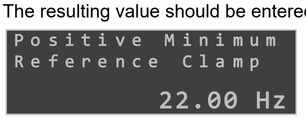
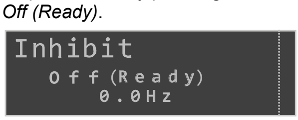
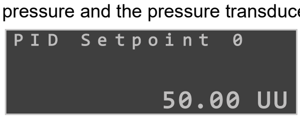
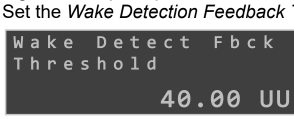
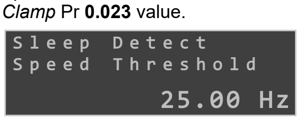
Run the Auto-tune.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch.  The drive will run the Auto-tune to measure the electrical properties of the motor. The Auto-tune process takes approximately 30 s. When the Auto-tune is completed the pump software status changes to *Inhibit STO*. The drive sequencer prevents the drive running in an unexpected way after the Auto-tune. To allow the motor to run after the Auto-tune, do one of the following: • Open the Enable or Safe Torque Off switch. • Or press red OFF / Reset button • Or open the Hand switch. The pump software status changes to *Off (Ready)*. 
Save the drive parameters.	Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button. 
Start the motor in Hand mode.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. The motor will turn at the Hand mode speed reference and the pump software status changes to *Hand Run* 
Check the motor is turning in the correct direction.	All pumps have a direction to turn in for their main operation. Use the manufacturers data or labels on the apparatus and compare to the direction of rotation of the motor cooling fan or motor output shaft. *Hand Mode Reference* Pr **0.026** may need to be lowered to see the direction  If the motor appears to be running in the wrong direction: • Stop the Motor by pressing the red OFF / Reset button or by opening the Hand switch.  • Set *Reverse Output Phase Sequence* Pr **0.018** to *On* to change the motor direction of rotation.  • Set *P1 Feedback Reverse* PrMM.056* to *On* to change the motor feedback direction of rotation. MM = the menu for the encoder interface.  • Set Pr **0.000** to *Save Parameters* and press the red OFF / Reset button  * *Menu Access Level* Pr **0.001** must be set to *All Menus* to allow access to PrMM.056. 
Stop the motor.	Stop the Motor by pressing and holding the red OFF / Reset button or by opening the Hand switch. The pump software status changes to *Off (Ready)*. 

STEP 2: Running the drive in Auto mode

This section gives guidance on how to get running in Auto mode assuming the most common application, a single pump application running with closed process PID loop to control pressure.

It is assumed that the process feedback device is a 4-20 mA transducer which has been connected to terminal 4 and 5.

Running the drive in Auto mode

Action	Detail
Setup the process PID control feedback scaling.	Setup the *PID Minimum Scaling* Pr **0.030** and *PID Maximum Scaling* in Pr **0.031**. By default, the feedback is configured in percent where the range is 0.00 % to 100.00 %, where 100 % = the feedback device maximum value e.g. for a 1 bar pressure sensor 100 % = 1 bar.   Note that all setpoints and feedback related parameters will use this scaling. The units of the feedback and setpoint may be scaled into any unit type e.g. percent but on the display the unit type will be shown as *UU* or User Unit.
Test the feedback device.	Make sure it is safe to run the motor. Press and hold the green Hand button for 2 s or close the Hand switch. The motor will turn at the Hand mode speed reference and the pump software status changes to *Hand Run*.   Observe the *PID Final Feedback* Pr **0.067** and vary the *Hand Mode Reference* Pr **0.026**. The PID Final Feedback Pr **0.067** should increase with an increase in *Hand Mode Reference* Pr **0.026**.  If the feedback does not respond in proportion to the speed e.g. remains at 0. Please check the configuration of the feedback device and wiring.
Find the frequency or speed where flow starts.	Observe the output of the application. Increase the *Hand Mode Reference* Pr **0.026** and note the value when output flow is detected.  The resulting value should be entered as the *Positive Minimum Reference Clamp* Pr **0.023**. 
Stop the motor.	Stop the Motor by pressing and holding the red OFF / Reset button or by opening the Hand switch. The pump software status changes to *Off (Ready)*.  
Set the process PID setpoint.	Set process *PID Setpoint 0* Pr **0.029** to the value required by the system design, e.g. A system is designed to run at a constant 0.5 bar pressure and the pressure transducer maximum is 1 bar so the process PID setpoint in percent units would be 50.00 %. 
Set the wake threshold.	The wake threshold determines the feedback value, below which, the drive will start operating and the minimum working feedback level, e.g. if the setpoint pressure is 50.00 % and the wake threshold is 40.00 % the drive try to maintain its output between these values. Set the *Wake Detection Feedback Threshold* Pr **0.040**. 
Set the sleep threshold.	The sleep threshold determines the frequency or speed below which the drive will stop during normal operation. Set the Sleep Detect Speed Threshold Pr **0.042** to a value in the order of 1 % to 5 % of motor rated frequency or speed above the *Positive Minimum Reference Clamp* Pr **0.023** value.  Setting the sleep threshold less than the *Positive Minimum Reference Clamp* Pr **0.023** value disables the sleep threshold.

Running the drive in Auto mode

Run in Auto mode.	When it is safe to do so, run the system in Auto mode. To do this, press and hold the blue Auto button for 2 s or close the Auto switch. The display will change to *Auto Run*. Run Auto Run 25.9 Hz AUTO The application motor should run at a speed that controls the system output at the process *PID Setpoint 0* Pr **0.029**. If the system remains in the sleeping state, the *process PID Final Feedback* Pr **0.075** has not fallen below the *Wake Detection Feedback Threshold* Pr **0.040**. Ready Sleeping 0.0 Hz Pid Final Feedback 43.21 UU Wake Detect Fbck Threshold 40.00 UU Move to the next step when the drive is running in Auto mode.
Verify the sleep threshold.	If the application has a discharge valve, slowly close it and make sure that the drive enters the *Sleeping* state. If the sleeping state is not entered with a fully closed discharge valve, note the frequency or speed while in this condition, and increase the Sleep Detect Speed Threshold to 1 % to 5 % above the noted value. Sleep Detect Speed Threshold 27.00 Hz
Stop the motor when finished.	Stop the Motor by pressing and holding the red OFF / Reset button for or by opening the Hand switch. The pump software status changes to *Off (Ready)*. Inhibit Off(Ready) 0.0Hz OFF Reset
Save the drive parameters.	Set Pr **0.000** to “Save Parameters” and press the red OFF / Reset button. Parameter mm.000 Save parameters OFF Reset
Choose the operating mode and additional features.	Set *Pump Control* Mode Pr **0.021** to match the system. The options available are Single Pump, Cascade and Multi-leader. Pump & Fan Control Mode Single Pump Configure the Pump system features required. See 7 section Functional descriptions details on the control modes and features available.

5.6 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. Menus 0 to 41 can be viewed on the KI-HOA Keypad RTC or HOA Keypad RTC.

The option module menus (S.mm.ppp) are only displayed if option modules are installed. Where S signifies the option module slot number and the mm.ppp signifies the menu and parameter number of the option module's internal menus and parameter.

Table 5-1 Advanced menu descriptions

Menu	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, Temperature monitoring
8	Digital I/O
9	Programmable logic, motorized pot, binary sum, timers and scope
10	Status and trips
11	Drive set-up and identification, serial communications
12	Threshold detectors and variable selectors
14	User PID controller
15	Option module slot 1 set-up menu
16	Option module slot 2 set-up menu
17	Option module slot 3 set-up menu
18	General option module application menu 1
19	General option module application menu 2
20	General option module application menu 3
22	Menu 0 set-up
23	Not allocated
28	Reserved menu
29	Reserved for pump functionality
30	Reserved
Slot 1	Slot 1 option menus*
Slot 2	Slot 2 option menus*
Slot 3	Slot 3 option menus*

*Only displayed when the option modules are installed.

5.6.1 KI-HOA Keypad RTC and HOA Keypad RTC

To enter the keypad set-up menu press and hold the escape button on the keypad from status mode. All the keypad parameters are saved to the keypad non-volatile memory when exiting from the keypad set-up menu.

To exit from the keypad set-up menu press the escape or < or > button. Below are the keypad set-up parameters.

Table 5-2 Keypad set-up parameters

Parameters		Range	Type
Keypad.00	Language*	Classic English (0) English (1) German (2) French (3) Italian (4) Spanish (5) Chinese (6)	RW
Keypad.01	Show Units	Off (0), On (1)	RW
Keypad.02	Backlight Level	0 to 100 %	RW
Keypad.03	Keypad Date	01.01.10 to 31.12.99	RO
Keypad.04	Keypad Time	00:00:00 to 23:59:59	RO
Keypad.05	Show Raw Text Parameter Values	Off (0), On (1)	RW
Keypad.06	Software Version	00.00.00.00 to 99.99.99.99	RO
Keypad.07	Language version	00.00.00.00 to 99.99.99.99	RO
Keypad.08	Font version	0 to 1000	RO
Keypad.09	Show menu names	Off (0), On (1)	RW

NOTE

It is not possible to access the keypad parameters via any communications channel.

* The languages available will depend on the keypad software version.

5.6.2 Display messages

The following tables indicate the various possible mnemonics which can be displayed by the drive and their meaning.

Table 5-3 Drive status indications

Upper row string	Description	Drive output stage
Inhibit	The drive is inhibited and cannot be run. The Safe Torque Off signal is not applied to Safe Torque Off terminals or Pr **06.015** is set to 0. The other conditions that can prevent the drive from enabling are shown as bits in *Enable Conditions* (06.010)	Disabled
Ready	The drive is ready to run. The drive enable is active, but the drive inverter is not active because the final drive run is not active	Disabled
Stop	The drive is stopped / holding zero speed	Enabled
Run	The drive is active and running	Enabled
Supply Loss	Supply loss condition has been detected	Enabled
Deceleration	The motor is being decelerated to zero speed / frequency because the final drive run has been deactivated	Enabled
dc injection	The drive is applying dc injection braking	Enabled
Trip	The drive has tripped and no longer controlling the motor. The trip code appears in the lower display	Disabled
Under Voltage	The drive is in the under voltage state either in low voltage or high voltage mode	Disabled
Heat	The motor pre-heat function is active	Enabled
Phasing	The drive is performing a ‘phasing test on enable’	Enabled

5.6.3 Alarm indications

An alarm is an indication given on the display by alternating the alarm string with the drive status string on the upper row and showing the alarm symbol in the last character in the upper row. Alarms strings are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

Table 5-4 Alarm indications

Alarm string	Description
Brake Resistor	Brake resistor overload. *Braking Resistor Thermal Accumulator* Pr **10.039** in the drive has reached 75.0 % of the value at which the drive will trip.
Motor Overload	*Motor Protection Accumulator* Pr **04.019** in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is > 100 %.
Drive Overload	Drive over temperature. *Percentage Of Drive Thermal Trip Level* Pr **07.036** in the drive is greater than 90 %.
Auto Tune	The autotune procedure has been initialized and an autotune in progress.

Table 5-5 Option module and NV media card and other status indications at power-up

First row string	Second row string	Status
Booting	**Parameters**	Parameters are being loaded
Drive parameters are being loaded from a NV Media Card		
Writing To	**NV Card**	Data being written to NV Media Card
Data is being written to a NV Media Card to ensure that its copy of the drive parameters is correct because the drive is in Auto or Boot mode		
Waiting For	**Power System**	Waiting for power stage
The drive is waiting for the processor in the power stage to respond after power-up		
Waiting For	**Options**	Waiting for an option module
The drive is waiting for the options modules to respond after power-up		
Uploading From	**Options**	Loading parameter database
At power-up it may be necessary to update the parameter database held by the drive because an option module has changed or because an applications module has requested changes to the parameter structure. This may involve data transfer between the drive an option modules. During this period ‘Uploading From Options’ is displayed		

5.7 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. *User security status* Pr **00.001** and *User security code* Pr **11.030** are not affected by this procedure).

Procedure

Use the following procedure only if a different operating mode is required:

1. Ensure the drive is not enabled, i.e. terminal 29 is open or Pr **06.015** is OFF (0)
2. Enter either of the following values in Pr **mm.000**, as appropriate:
   1253 (50 Hz AC supply frequency)
   1254 (60 Hz AC supply frequency)
3. Change the setting of Pr **29.157** as follows:

Parameter	00.004 (29.157) *Motor Type*		
Short description	Use this to select the system motor type. Reset drive to accept a new selection.		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	8 Bit Volatile	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This parameter simplifies setup and selection of the application motor. To action the motor selection a drive reset must be actioned e.g. by pressing the red reset button on the keypad.

The following options are available:

Motor type	Value	Description
Induction	0	When *Motor Type* Pr **29.157** changes to Induction and a reset is performed, the drive will change to open-loop mode for induction motors and the previous regional defaults will be applied.
Permanent-magnet	1	When *Motor Type* Pr **29.157** changes to Permanent-magnet and a reset is performed, the drive will change to RFC-S mode for servo motors and the previous regional defaults will be applied. By default the motor will be operating in sensorless mode i.e. no speed feedback device is required to run the motor.

NOTE

Entering 1253 or 1254 in Pr **mm.000** will only load defaults if the setting of Pr **29.157** has been changed.

5.8 Saving parameters

When changing a parameter in Menu 0, the new value is saved when pressing the Enter button to return to parameter view mode from parameter edit mode.

If parameters have been changed in the advanced menus, then the change will not be saved automatically. A save function must be carried out.

Procedure

1. Select ‘Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**)
2. Either:

- Press the red reset button
- Toggle the reset digital input, or
- Carry out a drive reset through serial communications by setting Pr **10.038** to 100

5.9 Restoring parameter defaults

Restoring parameter defaults by this method saves the default values in the drives memory. *User security status* (00.001) and *User security code* (11.030) are not affected by this procedure).

Procedure

1. Ensure the drive is not enabled, i.e. terminal 29 is open or Pr **06.015** is OFF (0)
2. Select 'Reset 50 Hz Defs' or 'Reset 60 Hz Defs' in Pr **mm.000**. (alternatively, enter 1233 (50 Hz settings) or 1244 (60 Hz settings) in Pr **mm.000**).
3. Either:

- Press the red reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.038** to 100

5.10 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 41) 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 Table 5-6.

Table 5-6 Parameter access level and security

Menu Access Level (11.044)	Access level	User security	Menu 0 status	Advanced menu status
0	Menu 0	Open	RW	Not visible
		Closed	RO	Not visible
1	All Menus	Open	RW	RW
		Closed	RO	RO
2	Read-only Menu 0	Open	RO	Not visible
		Closed	RO	Not visible
3	Read-only	Open	RO	RO
		Closed	RO	RO
4	Status only	Open	Not visible	Not visible
		Closed	Not visible	Not visible
5	No access	Open	Not visible	Not visible
		Closed	Not visible	Not visible

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

5.10.1 Access Level

The drive provides a number of different levels of access that can be set by the user via *Menu Access Level* (11.044); these are shown in the table below.

Menu Access Level (Pr 11.044)	Description
Menu 0 (0)	All writable parameters are available to be edited but only parameters in Menu 0 are visible
All menus (1)	All parameters are visible and all writable parameters are available to be edited
Read- only Menu 0 (2)	Access is limited to Menu 0 parameters only. All parameters are read-only
Read-only (3)	All parameters are read-only however all menus and parameters are visible
Status only (4)	The keypad remains in status mode and no parameters can be viewed or edited
No access (5)	The keypad remains in status mode and no parameters can be viewed or edited. Drive parameters cannot be accessed via a comms/ fieldbus interface in the drive or any option module

5.10.2 Changing the User Security Level /Access Level

The security level is determined by the setting of Pr **00.001** or Pr **11.044**. The Security Level can be changed through the keypad even if the User Security Code has been set.

5.10.3 User Security Code

The User Security Code, when set, prevents write access to any of the parameters in any menu.

Setting User Security Code

Enter a value between 1 and 2147483647 in Pr **11.030** and press the button; the security code has now been set to this value. In order to activate the security, the Security level must be set to desired level in Pr **00.001**. When the drive is reset, the security code will have been activated and the drive returns to Menu 0 and the symbol is displayed in the right hand corner of the keypad display. The value of Pr **11.030** will return to 0 in order to hide the security code.

Unlocking User Security Code

Select a parameter that need to be edited and press the button, the upper display will now show ‘Security Code’. Use the arrow buttons to set the security code and press the 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 following message ‘Incorrect security code’ is displayed, then the display will revert to parameter view mode.

Disabling User Security

Unlock the previously set security code as detailed above. Set Pr **11.030** to 0 and press the button. The User Security has now been disabled, and will not have to be unlocked each time the drive is powered up to allow read / write access to the parameters.

5.11 Displaying parameters with non-default values only

By selecting 'Show non-default' in Pr **mm.000** (Alternatively, enter 12000 in Pr **mm.000**), the only parameters that will be visible to the user will be those containing a non-default value. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **mm.000** and select 'No action' (alternatively enter a value of 0). Please note that this function can be affected by the access level enabled, refer to section 5.10 *Parameter access level and security* on page 157 for further information regarding access level.

5.12 Displaying destination parameters only

By selecting 'Destinations' in Pr **mm.000** (Alternatively enter 12001 in Pr **mm.000**), the only parameters that will be visible to the user will be destination parameters. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **mm.000** and select 'No action' (alternatively enter a value of 0).

Please note that this function can be affected by the access level enabled, refer to section 5.10 *Parameter access level and security* on page 157 for further information regarding access level.

6 Basic parameters

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. All the parameters in Menu 0 appear in other menus in the drive (denoted by {…}). Menu 22 can be used to configure the parameters in Menu 0.

6.1 Menu 0: Basic parameters

Parameter			Range			Default		
	Description		OL	RFC-A	RFC-S	OL	RFC-A	RFC-S
00.001	Menu access level	11.044	Menu 0 (0), All Menus (1), Read only Menu 0 (2), Read only (3), Status Only (4), No Access (5)					
00.002	Parameter cloning	11.042	None (0), Load File 1 (1), Save File 1 (2), Auto (3), Boot (4)			None (0)		
00.003		0.000						
00.004	Motor type	29.157	Induction (0), Permanent magnet (1)			Induction (0)		Permanent-magnet (1)
00.005	Volts per 1000 rpm	5.033	Rated Frequency		0 V to 1000 V	98 V		
00.006	Rated current	5.007	VM_RATED_CURRENT[MIN] to VM_RATED_CURRENT[MAX] A			VM_RATED_CURRENT[MAX]		
00.007	Rated speed	5.008	0 to 35940 rpm	0.00 to 33000.00 rpm		Std: 50 Hz: US:60 Hz:	Std:1450 rpm US: 1750 rpm	Std:1500 rpm US:1800 rpm
00.008	Rated voltage	5.009	VM_AC_VOLTAGE_SET[MIN] to VM_AC_VOLTAGE_SET[MAX] V			200V drive: 230 V 400V drive 50Hz: 400 V 400V drive 60Hz: 460 V 575V drive: 575 V 690V drive: 690 V		
00.009 (Not RFC-S)	Rated power factor	5.010	0.000 to 1.000			0.85		
00.010	Number or motor poles	5.011	Automatic (0) to 480 (240) Poles			Automatic (0) Poles		
00.011 (Not RFC-S)	Low frequency voltage boost	5.015	0.0 to 25.0 %			1.0 %		
00.012 (OL only)	Low load power saving	5.013	OFF (0) or ON (1)			ON (1)	OFF (0)	
00.013 (RFC modes only)	Autotune	5.012		None (0), Basic (1), Improved (2)	None (0) Stationary(1) Full Stationary(5)	None (0)		
00.014 (RFC-S mode only)	RFC low speed mode	5.064	Injection (0), Current (1), Current (2), Current No Test (3), Current Step (4), Current Only (5)			Current (2)		
00.015 (RFC-S mode only)	Low speed sensor-less mode current	5.071	0.0 to 1000.0 %					100.0 %
00.016	Symmetrical current limit	4.007	VM_MOTOR1_CURRENT_LIMIT[MIN] to VM_MOTOR1_CURRENT_LIMIT[MAX] %			110.0 %		
00.017	Motor thermal protection enable	29.087	OFF (0) or ON (1)			OFF (0)		
00.018	Reverse output phase sequence	5.042	OFF (0) or ON (1)			OFF (0)		
00.019 (RFC-S mode only)	Sensor-less mode filter	3.079			4 (0), 8 (1), 16 (2), 32 (3), 64 (4) ms			4 (0) ms
00.020		0.000						
00.021	Pump control mode	29.011	Single Pump (0), Cascade (1), Multi leader (2)			Single Pump (0)		
00.022	Maximum reference clamp	1.006	VM_NEGATIVE_REF_CLAMP1[MIN] to VM_NEGATIVE_REF_CLAMP1[MAX]			Std: 50 Hz US: 60 Hz	Std: 1500.0 rpm US: 1800.0 rpm	
00.023	Positive minimum reference clamp	1.004	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			0.0 Hz	0.0 rpm	
00.024	Control input mode	29.012	Input (0), Input & Keypad (1), Ctrl Wrd (2), Ctrl Wrd & Input (3)			Input & Keypad (1)		
00.025	Hand mode reference select	29.016	Digital Speed (0), Analog Speed (1)			Digital Speed (0)		
00.026	Hand mode frequency/speed reference	1.022	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			Std:25 Hz US:30 Hz	Std: 750 rpm US: 900 rpm	
00.027	General acceleration rate 1	2.011	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			1.0 s	1.000 s	
00.028	General deceleration rate 1	2.021	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			1.0 s	1.000 s	
00.029	PID setpoint 0	29.022	0.00 to 327.67 UU			0.00 UU		

Parameter			Range			Default		
	Description		OL	RFC-A	RFC-S	OL	RFC-A	RFC-S
00.030	PID feedback min scaling	29.031	0.00 to 327.67 UU			0.00 UU		
00.031	PID feedback max scaling	29.032	0.00 to 327.67 UU			100.00 UU		
00.032	PID feedback filter time constant	29.033	0.00 to 327.67 s			1.00 s		
00.033	PID feedback loss action	29.048	Ignore (0), Trip (1), Fixed Speed (2)			Trip (1)		
00.034	PID feedback high trip threshold	29.041	0.00 to 327.67 UU			0.00 UU		
00.035	PID feedback low delay	29.042	0.0 to 6553.5 s			5.0 s		
00.036	PID feedback low mode	29.043	Disabled (0), Threshold (1), Bandwidth (2)			Disabled (0)		
00.037	PID feedback low threshold	29.044	0.00 to 327.67 UU			2.00 UU		
00.038		0.000						
00.039		0.000						
00.040	Wake detect feedback threshold	29.049	0.00 to 327.37			1.00 UU		
00.041	Wake detect delay	29.050	0.0 to 6553.5 s			5.0 s		
00.042	Sleep detect speed threshold	29.051	0.0 to 60.0			25.0		
00.043	Sleep detect delay	29.052	0.0 to 6553.5 s			5.0 s		
00.044	Number of auto-reset attempts	10.034	None (0), 1 (1), 2 (2), 3 (3), 4 (4), 5 (5), Infinite (6)			5 (5)		
00.045	Auto-reset delay	10.035	1.0 to 600.0 s			10.0 s		
00.046	Pipe fill mode	29.075	Disabled (0), Feedback Level (1), Flow Switch (2)			Disabled (0)		
00.047	Pipe fill reference	1.024	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			Std: 25 Hz US: 30 Hz	Std: 750 rpm US: 900 rpm	
00.048	Pipe fill maximum time	29.077	0.0 to 6553.5 s			0.0 s		
00.049	Pipe fill threshold	29.076	0.00 to 327.67 UU			0.00 UU		
00.050	Dry well low load detection threshold percent	29.057	0.00% to 100%			1.00 %		
00.051	Dry well low load detection delay	29.058	0.0 to 6553.5 s			0.0 s		
00.052	Dry well low load mode	29.059	Disabled (0), Alarm Only (1), Trip (2), Lower PID Output (3)			Disabled (0)		
00.053	Dry well low load PID output reduction	29.060	0.00% to 100%			50.00%		
00.054	Dry well low load restart delay	29.061	0.0 to 6553.5 s			5.0 s		
00.055	No flow detection threshold	29.069	0.0 to 3000.0			0.0 Hz	0.0 rpm	
00.056	No flow detection band	29.070	0.0 to 3000.0			150.0		
00.057	No flow detection delay	29.071	0.0 to 6553.5 s			5.0 s		
00.058	No flow setpoint settling delay	29.072	0.0 to 6553.5 s			1.0 s		
00.059	No flow setpoint reduction	29.073	0.00 to 2.55 UU			0.06 UU		
00.060	Over-cycle mode	29.127	Disabled (0), Alarm Only (1), Trip (2), Inc Setpoint (3)			Alarm Only (1)		
00.061	Over-cycle starts per hour	29.128	0 to 255			5		
00.062		0.000						
00.063		0.000						
00.064	PID 1 proportional gain	14.010	0.000 to 4.000			2.000		
00.065	PID 1 integral gain	14.011	0.000 to 4.000			1.000		
00.066	PID1 reference	14.020	±100.00 %					
00.067	PID feedback	14.021	±100.00 %					
00.068	PID 1 output	14.001	+/-100%					

Parameter			Range			Default		
	Description		OL	RFC-A	RFC-S	OL	RFC-A	RFC-S
00.069	Output frequency	5001	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX] Hz					
00.069	Speed feedback	3.002		VM_SPEED[MIN] to VM_SPEED[MAX]				
00.070	Percentage load	4.020	VM_USER_CURRENT[MIN] to VM_USER_CURRENT[MAX] %					
00.071	Output power	5.003	VM_POWER[MIN] to VM_POWER[MAX] kW					
00.072	Analog input 1 current loop loss	7.028	OFF (0) or ON (1)					
00.073	Operating status	29.003	Inhibit STO (0), Off (Ready) (1), Hand Run (2), Waking (3), Pipe Fill (4), Auto Run (5), Auto Run Leader (6), Auto Run Assist (7), Pre sleep (8), Sleeping (9),Cleaning (10), Level Stop (11),Timer Stop (12), Hand Timeout (13), Over cycle (14), Fbck Loss Run (15)Dry Well Run(16) Dry Well Stop(17) Auto Stop Assist(18)			Inhibit STO (0)		
00.074	NV Media Card Action Status	11.078	None (0), Active (1), Card Slot 1 (2), Card Slot 2 (3), Card Slot 3 (4), Card Slot 4 (5), Card Product (6), Card User Prog (7), Card Busy (8), Card Data Exists (9), Card Option (10), Card Read Only (11), Card Error (12), Card No Data (13), Card Full (14), Card File Error (15), Card Rating (16), Card File Data (17), Card Derivative (18)					
00.075	PID final feedback	29.036	-327.68 to 327.67 UU			0.00 UU		
00.076		0.000						
00.077	Derivative software version	29.001	0 to 99999999					
00.078	Trip 0	10.020	0 to 255					
00.079	Trip 1	10.021	0 to 255					
00.080	Trip 2	10.022	0 to 255					

*Following a rotating autotune Pr **00.009** {05.010} is continuously written by the drive, calculated from the value of Stator Inductance (Pr **05.025**). To manually enter a value into Pr **00.009** {05.010}, Pr **05.025** will need to be set to 0. Please refer to the description of Pr **05.010** in the Parameter Reference Guide for further details.

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination
IP	IP address	Mac	Mac address	Date	Date parameter	Time	Time parameter						

Note

Parameter numbers shown in brackets (...) are the equivalent Menu 0 parameters. Some Menu 0 parameters appear twice since their function depends on the operating mode.

The Range - RFC-A / S column applies to both RFC-A and RFC-S. For some parameters, this column applies to only one of these modes, this is indicated accordingly in the Default columns.

In some cases, the function or range of a parameter is affected by the setting of another parameter. The information in the lists relates to the default condition of any parameters affected in this way.

Parameter	00.001 (11.044) *Menu Access Level*		
Short description	Defines the menu access level within the drive		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	0	**Maximum**	5
Default		**Units**	
Type	8 Bit Volatile	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, ND, PT		

Value	Text
0	Menu 0
1	All Menus
2	Read-only Menu 0
3	Read-only
4	Status Only
5	No Access

Security

The drive provides a number of different levels of security that can be set by the user via *Menu Access Level* (**11.044**); these are shown in the table below.

Security Level	Description	Menu Access Level (11.044)
Menu 0	All writable parameters are available to be edited but only parameters in Menu 0 are visible	0
All menus	All writable parameters are visible and available to be edited.	1
Read-only Menu 0	All parameters are read-only. Access is limited to Menu 0 parameters only.	2
Read-only	All parameters are read-only however all menus and parameters are visible.	3
Status only	The keypad remains in status mode and no parameters can be viewed or edited	4
No access	The keypad remains in status mode and no parameters can be viewed or edited. Drive parameters cannot be accessed via serial comms.	5

When security has been set up the drive can either be in the locked or unlocked state. In the locked state the security level that has been set up applies. In the unlocked state the security is not active, but when the drive is powered down and powered up again the drive will be in the locked state. The drive may be relocked without powering down by selecting the required security level with the *Menu Access Level* (**11.044**) and initiating a drive reset.

Security can be set up as follows:

1. The *User Security Code* (**11.030**) should be set to the desired security unlock code (not zero). For security to remain set after power down then a parameter save should be performed to retain the set value.
2. If no further action is taken when the drive is powered down and then powered up read-only security will be set up and locked.
3. If at any time the *Menu Access Level* (**11.044**) is set to a value corresponding the one of the security levels shown in the table above and a drive reset is performed the security level is changed to that level. The desired security level is automatically saved and retained after power down, the keypad state changes to status mode and security is locked. (The security level that is active, provided *User Security Code* (**11.030**) has been saved as a non-zero value, is shown in *Security Status* (**11.085**).)

When security is set up and locked:

1. Parameter access is restricted as shown in the table above.
2. *User Security Code* (**11.030**) reads as zero except in parameter edit mode. Therefore it is not possible to read the value of the security code when any level of security is active and locked.

Security can be unlocked as follows:

1. If read-only security is set and locked then any attempt to edit any read/write parameter causes "Security code" to be displayed on the first row of the display. When the Up or Down keys are pressed the second row shows the code being adjusted. On setting the code the user presses the Enter key. If the correct code has been entered then the drive switches to Parameter edit mode on the parameter the user selected to edit, but if the correct code has not been entered the notification "Incorrect security code" is displayed for 2 s and the drive returns to Parameter view mode.
2. If Status only or No access security is set and locked then any attempt to leave status mode causes the security code to be requested as per the process described above. The security code entered must be correct for the keypad state machine to switch to the Parameter view mode. It is then possible to access all parameters normally.

Security can be cleared as follows:

1. Security must be unlocked.
2. The *User Security Code* (**11.030**) should be set to zero. For security to remain cleared after power down then a parameter save should be performed.

At any time *Menu Access Level* (**11.044**) can be changed between 0 and 1 to restrict access to Menu 0 alone or to all menus. If the change is made by a keypad the new value becomes active on leaving parameter edit mode. It should be noted that Menu *Access Level* (**11.044**) is a volatile parameter and that the actual state of the security system is stored in *Security Status* (**11.085**) and *Menu Access Status* (**11.086**), which are both power-down save parameters. Therefore the security status will be stored when the drive goes into the under-voltage state. If the drive is already in the under-voltage state the security state should be saved by writing 1001 to *Parameter mm.000* (mm.000) and initiating a reset

Parameter	00.002 (11.042) *Parameter Cloning*		
Short description	Can be used to initiate a data transfer to or from an NV media card		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	0	**Maximum**	4
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background write
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, NC		

Value	Text
0	None
1	Read
2	Program
3	Auto
4	Boot

* Only a value of 0 or 3 in this parameter is saved.

Parameter Cloning (**11.042**) can be used to initiate data transfer to or from an NV media card as described below. The required action is only initiated if the parameter value has been changed before a drive reset is initiated. This ensures that if Auto or Boot mode are selected that a write is not performed to the card on every drive reset. If Read (1) or Program (2) are successful this parameter is reset to zero, but if Auto (3) or Boot (4) are successful in creating File 001 then this parameter is not reset to zero so that the drive remains in Auto or Boot mode. If any of these actions are not successful then this parameter is not modified, and must be modified by the user before another attempt is made to initiate the required action.

1: Read

If a parameter difference file with file identification number 1 exists on the NV media card then setting this parameter to 1 and initiating a drive reset transfers the parameter data to the drive (i.e. the same action as writing 6001 to *Parameter mm.000 (mm.000)*). When the action is complete this parameter is automatically reset to zero.

2: Program

Setting this parameter to 2 and initiating a drive reset transfers the parameter data from the drive to a parameter difference file with file identification number 1. This is the same action as writing 3001 to *Parameter mm.000 (mm.000)*. When the action is complete this parameter is automatically reset to zero.

3: Auto

Setting this parameter to 3 and initiating a drive reset performs the same action as Program (2) and selects automatic back-up mode. See File System, SD and SMART Card document for more details.

4: Boot

The action is the same as Auto (3) except the file saved to the card is "bootable". See File System, SD and SMART Card document for more details.

Parameter	00.004 (29.157) *Motor Type*		
Short description	Use this to select the system motor type. Reset drive to accept a new selection.		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	8 Bit Volatile	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This parameter simplifies setup and selection of the application motor. To action the motor selection a drive reset must be actioned e.g. by pressing the red reset button on the keypad.

The following options are available:

Motor type	Value	Description
Induction	0	*When Motor Type* (**29.157**) changes to Induction and a reset is performed, the drive will change to open-loop mode for induction motors and the previous regional defaults will be applied.
Permanent-magnet	1	*When Motor Type* (**29.157**) changes to Permanent-magnet and a reset is performed, the drive will change to RFC-S mode for servo motors and the previous regional defaults will be applied. By default the motor will be operating in sensorless mode i.e. no speed feedback device is required to run the motor.

Parameter	00.005 (05.033) *Volts per 100 rpm*		
Short description	Volts per 1000rpm		
Mode	RFC-S		
Minimum	0	**Maximum**	10000
Default	98	**Units**	V
Type	16 Bit User Save	**Update Rate**	Background Read
Display Format	Standard	**Decimal Places**	0
Coding	RW		

Volts Per 1000 rpm (**05.033**) defines the r.m.s. line voltage produced by the motor flux at 1000 rpm, i.e. running at this speed with no current in the motor.

Volts Per 1000 rpm (**05.033**) is used as described in the table below.

Function	Details
Voltage feed-forwards	Provides voltage feed-forwards for the current control system.
Over-speed protection	Ke is used to determine the trip speed if Enable High Speed Mode (**05.022**) is set to Limit mode
Rated torque angle	If the drive defines Rated Torque Angle (**05.089**) no-load Lq is used in the calculation.
Spin start	Ke is used to define a threshold to detect when the motor is at standstill and spin start is not possible with sensorless operation.

Parameter	00.006 (05.007) *Rated Current*		
Short description	Set to the rated current rated of the motor		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	VM_RATED_CURRENT[MIN]	**Maximum**	VM_RATED_CURRENT[MAX]
Default	0.000	**Units**	A
Type	32 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW		

Rated Current (**05.007**) is used as follows:

Function	Details
Motor thermal protection	Defines the motor rated current.
Motor pre-heat	Motor pre-heat is set up as a percentage of rated current.
Motor control	Used in the motor control algorithm.
Current limits	Current limits are set up as a percentage of rated torque producing current.

Parameter	00.007 (05.008) *Rated Speed*		
Short description	Set to the rated speed of the motor		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	Open-Loop: 0 RFC-S & RFC-A: 0.00	**Maximum**	Open-Loop: 35940 RFC-S & RFC-A: 33000.00
Default	See exceptions below	**Units**	rpm
Type	32 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	Open-Loop: 0 RFC-A: 2
Coding	RW		

Default Value		
Open-Loop	**RFC-A**	**RFC-S**
Std: 1500 US: 1750	Std: 1450.00 US: 1750.00	Std: 1500.00 US: 1800.00

Set this to the motor name plate rated speed in rpm.

Rated Speed (**05.008**) is used in conjunction with *Number Of Motor Poles* (**05.011**) to define the rated frequency and this is used as described in the table below.

Function	Details
Sensorless control thresholds	The thresholds for changes from low speed starting mode to high speed normal operation and vice versa.
Flux controller gain	Rated frequency is to define the gain of the flux controller.

The units for *Rated Speed* (**05.008**) are rpm.

Parameter	00.008 (05.009) *Rated Voltage*		
Short description	Set to the rated voltage of the motor		
Mode	Open-Loop, RFC-S, RFC-A		
Minimum	VM_AC_VOLTAGE_SET[MIN]	**Maximum**	VM_AC_VOLTAGE_SET[MAX]
Default	See exceptions below	**Units**	rpm
Type	16 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	0
Coding	RW, VM		

Voltage	Region	Default Value
200 V	All	230
400 V	50 Hz	400
400 V	60 Hz	460
575 V	All	575
690 V	All	690

Open-Loop

Rated Frequency (**05.006**) and *Rated Voltage* (**05.009**) define the frequency to voltage characteristic applied to the motor. See *Open-loop Control Mode* (**05.014**) for more details.

RFC-S

Set this to the motor name plate rated voltage in Volts.

The *Rated Voltage* (**05.009**) is the maximum continuous voltage that is applied to the motor. Some headroom must be allowed if high performance is required at higher speeds. It should be noted that this limit is not applied unless *Enable High Speed Mode* (**05.022**) is set to 1.

Rated Voltage (**05.009**) is used as described in the table below.

RFC-A

The *Rated Voltage* (**05.009**) is the maximum continuous voltage that is applied to the motor. Normally this should be set to the motor nameplate value. If the drive is supplied through its own diode rectifier the maximum possible output voltage is just below the supply voltage level, and so the output voltage will not reach *Rated Voltage* (**05.009**) if this is equal to or above the supply voltage. If high transient performance is required at higher speeds then *Rated Voltage* (**05.009**) should be set to 95% of the minimum d.c. link voltage divided by √2 to allow some headroom for the drive to control the motor current. If the drive is fed through its own diode rectifier the minimum d.c. link voltage is approximately supply voltage x √2.

In some cases it may be necessary to set the *Rated Voltage* (**05.009**) to a value other than the motor nameplate value. If this is the case the *Rated Frequency* (**05.006**) and Rated Speed (**05.008**) should be set up as follows:

K = *Rated Voltage* (**05.009**) / motor rated voltage

Rated Frequency (**05.006**) = motor rated frequency x K

Rated Speed (**05.008**) = motor rated speed + [(K - 1) x motor rated frequency x 60 / (number of motor poles / 2)]

The *Rated Voltage* (**05.009**), *Rated Frequency* (**05.006**) and *Number Of Motor Poles* (**05.011**) are used during the auto-tuning process to determine the flux level required in the motor for normal operation. Therefore if the *Rated Voltage* (**05.009**) is set to a value other than the nameplate value and the above adjustment is not applied the motor may be under or over-fluxed

Parameter	00.009 (05.010) *Rated Power Factor*		
Short description	Set to the rated power factor of the motor. This value can be measured by the drive during a rotating autotune.		
Mode	Open-Loop, RFC-A		
Minimum	0.000	**Maximum**	1.000
Default	0.850	**Units**	
Type	16 Bit User Save	**Update Rate**	Background read/write
Display Format	Standard	**Decimal Places**	3
Coding	RW		

Set this to the motor name plate rated power factor. Normally this is a value in the region of 0.6 to 0.95 and is commonly represented by Cos φ or Cos Phi or PF.

Rated Power Factor (**05.010**) is the true power factor of the motor under rated conditions, i.e. the cosine of the angle between the motor voltage and current. If *Stator Inductance* (**05.025**) is set to a non-zero value then the stator inductance is used to calculate the rated magnetising current for the motor and the rated power factor can be calculated by the drive. Therefore if *Stator Inductance* (**05.025**) is non-zero *Rated Power Factor* (**05.010)** is continuously set to the calculated value of rated power factor by the drive. If *Stator Inductance* (**05.025**) is set to zero then *Rated Power Factor* (**05.010**) is used to estimate the rated magnetising current which is an approximation and not as accurate. *Stator Inductance* (**05.025**) can be measured by the drive during auto-tuning and this is the preferred option, however, if it is not possible to obtain the value for *Stator Inductance* (**05.025**) then *Rated Power Factor* (**05.010**) should be set to the motor nameplate value.

Parameter	00.010 (05.011) *Number Of Motor Poles*		
Short description	Set to the number of poles of the motor		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	240
Default	4	**Units**	PolePairs
Type	8 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, BU		

Open-Loop

The default setting of this parameter is "Automatic" which uses the following fomula to work out the correct setting:

Pole pairs = 60 x *Rated Frequency* (**05.006**) / *Rated Speed* (**05.008**) rounded down to the nearest integer.

When setting *Number Of Motor Poles* (**05.011**) via the keypad or Connect, it must be set to the number of motor poles e.g. for a 1500 rpm motor the number of poles is 4.

When setting *Number Of Motor Poles* (**05.011**) via communications, it must be set to the number of motor pole pairs, i.e. number of motor poles / 2, e.g. for a 1500 rpm motor the number of motor pole pairs is 2.

* The units relate to the numeric value of the parameter and not the text string.

RFC-A

* The units relate to the numeric value of the parameter and not the text string.

The numeric value in *Number Of Motor Poles* (**05.011**) should be set to the number of motor pole pairs (i.e. number of motor poles / 2). The text strings associated with *Number Of Motor Pole*s (**05.011**) show the number of motor poles (i.e. the parameter value x 2). If a linear position feedback device is used Number Of Motor Poles (**05.011)** should be set to 1 (2 Poles).

If Number Of Motor Poles (**05.011**) = 0 (Automatic) the number of motor poles are calculated automatically as given below.

Pole pairs = 60 x *Rated Frequency* (**05.006**) / *Rated Speed* (**05.008**) rounded down to the nearest integer.

During an autotune when position feedback is being used, the drive will check to ensure that the combination of motor poles and position feedback resolution have been set up correctly, and will produce an Autotune 7 trip if this is not the case. The Autotune 7 trip will not occur if *Number Of Motor Poles* (**05.011**) ≥ 6 (i.e. 12 poles).

RFC-S

* The units relate to the numeric value of the parameter and not the text string.

The numeric value in *Number Of Motor Poles* (**05.011**) should be set to the number of motor pole pairs (i.e. number of motor poles / 2). The text strings associated with *Number Of Motor Poles* (**05.011**) show the number of motor poles (i.e. the parameter value x 2). If a linear position feedback device is used *Number Of Motor Poles* (**05.011)** should be set to 1 (2 Poles).

If *Number Of Motor Poles* (**05.011**) = 0 (Automatic) the number of motor poles = 3 (6 Poles).

During an autotune when position feedback is being used, the drive will check to ensure that the combination of motor poles and position feedback resolution have been set up correctly, and will produce an Autotune 7 trip if this is not the case. The Autotune 7 trip will not occur if *Number Of Motor Poles* (**05.011**) ≥ 6 (i.e. 12 poles).

Parameter	00.011 (05.015) *Low Frequency Voltage Boost*		
Short description	Defines the level of voltage boost at 0Hz when using a fixed V to F relationship		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	25.0
Default	1.0	**Units**	%
Type	8 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

Open-Loop

The default value for this parameter depends on the frame size of the drive as follows:

3.0 % up to frame size 06 drives,

2.0 % for frame size 07and frame size 08 drives

1.0 % for larger sizes

See *Open-loop Control Mode* (**05.014**).

RFC-A

The default value of 1 % is suitable for most Fan and Pump systems where the torque required to start is relatively small. For a waste water system where ragging or a build up of material inside the pump is likely, an increased percentage can be used to get the pump started e.g. 2 % or 3 %.

During auto-tune test 2 the drive uses the Open-loop mode control strategy with fixed voltage boost. *Low Frequency Voltage Boost* (**05.015)** is used to define the level of low voltage boost used during the test. See *Open-loop Control Mode* (**05.014**) in Open-loop mode for more details.

RFC-S

Value	*Text*	*Value*	*Text*
0	1 %	5	25 %
1	2 %	6	50 %
2	3 %	7	100 %
3	6 %		
4	12 %		

See *Minimal Movement Phasing Test Mode* (**05.013**).

Parameter	00.012 (05.013) *Low Load Power Saving*		
Short description	Set to On to enable power saving at low load		
Mode	Open-Loop		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	1 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW		

Low load power saving is intended for applications where power loss should be kept to a minimum under low load conditions, but dynamic performance is not important. The reduction in power loss under low load conditions is achieved by increasing the rated frequency used to derive the frequency to voltage characteristic of the drive with reduced load. If *Low Load Power Saving* (**05.013**) = 0 then *Rated Frequency* (05.006) is used directly to define the output voltage characteristic. If Low Load Power Saving (05.013) = 1 then a modified value of rated frequency is used when |*Percentage Load* (**04.020**)|

rated frequency = *Rated Frequency* (**05.006**) x [2 - |*Percentage Load* (**04.020**)| / 70.0%]

For higher load levels *Rated Frequency* (**05.006)** is used directly.

Parameter	00.013 (05.012) *Auto-tune*		
Short description	Defines the auto-tune test to be performed		
Mode	RFC-S, RFC-A		
Minimum	0	**Maximum**	RFC-A: 2 RFC-S: 5
Default	0	**Units**	
Type	8 Bit Volatile	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, NC		

RFC-A

Value	*Text*	*Description*
0	None	
1	Stationary	Autotune for sensorless operation
5	Full Stationary	Autotune for operation with a feedback device

The following describes how an auto-tune test can be initiated and normal operation can be resumed after the test for RFC-S mode:

An auto-tune test cannot be initiated if the drive is tripped or the drive inverter is active, i.e. *Drive Healthy* (**10.001**) = 0 or *Drive Active* (**10.002**) = 1. The inverter can be made inactive by ensuring that the Final drive enable is inactive, or the Final drive run is inactive and *Hold Zero Speed* (**06.008**) = 0.

1. An auto-tune test is initiated by setting *Auto-tune* (**05.012**) to a non-zero value and making the Final drive enable and the Final drive run active.
2. All tests that move the motor will move the motor in the forward direction if *Reverse Select* **(01.012**) = 0 or the reverse direction if *Reverse Select* (**01.012**) = 1.
3. If the auto-tune sequence is completed successfully the Final drive enable is set to the inactive state and *Auto-tune* (**05.012**) is set to zero. The Final drive enable can only be set to the active state again by removing the enable and re-applying it. The enable can be removed by setting *Drive Enable* (**06.015**) = 0, or by setting bit 0 of the Legacy Control Word (**06.042**) to 0 provided *Legacy Control Word Enable* (**06.043**) = 1, or by making *Hardware Enable* (**06.029**) = 0.
4. If a trip occurs during the auto-tune sequence the drive will go into the trip state and *Auto-tune* (**05.012**) is set to zero. As in 4 above the enable must be removed and re-applied before the drive can be restarted after the trip has been reset. However, care should be taken because if the auto-tune was not completed the drive parameters that should have been measured and set up will still have their original values.
5. If the Final drive enable is made active, the Final drive run is inactive and *Hold Zero Speed* (**06.008**) = 1 the drive would normally be in the Stop state (i.e. the inverter is active, but the frequency or speed reference is 0).

The following describes the effects of the auto-tune test on the drive parameters for RFC-S mode:

1. All auto-tune tests rely on the motor being stationary when the test is initiated to give accurate results.
2. When each stage of the test is completed, the results are written to the appropriate parameters and these parameters saved in the drive non-volatile memory. If *Parameter Cloning* (**11.042**) is set to 3 or 4 the parameters are also written to a non-volatile media card fitted in the drive.

The table below shows the parameters required for motor control indicating which should be set by the user and which can be measured with an auto-tune test.

Parameter	Required for	Measured in test
*Rated Frequency (***05.006***)*	Basic control	User set-up
*Rated Current (***05.007***)*	Basic control	User set-up
*Rated Speed (***05.008***)*	Basic control	User set-up
*Rated Voltage (***05.009***)*	Basic control	User set-up
*Rated Power Factor (***05.010***)*	Basic control	2
*Number Of Motor Poles (***05.011***)*	Basic control	User set-up
*Stator Resistance (***05.017***)*	Basic control	1, 2
*Transient Inductance (***05.024)**	Basic control	1, 2
*Stator Inductance (***05.025***)*	Improved performance	2
*Saturation Breakpoint 1 (***05.029***)*	Improved performance with flux weakening	2
*Saturation Breakpoint 3 (***05.030***)*	Improved performance with flux weakening	2
*Maximum Deadtime Compensation (***05.059***)*	Basic control	1, 2
*Current At Maximum Deadtime Compensation (***05.060***)*	Basic control	1, 2
*Saturation Breakpoint 2 (***05.062***)*	Improved performance with flux weakening	2
*Saturation Breakpoint 4 (***05.063***)*	Improved performance with flux weakening	2
*Motor And Load Inertia (***03.018***)*	Speed controller set-up and torque feed-forwards	3, 4
*Inertia Times 1000 (***04.033***)*	Speed controller set-up and torque feed-forwards	3, 4
*Current Controller Kp Gain (***04.013***)*	Basic control	1, 2
*Current Controller Ki Gain (***04.014***)*	Basic control	1, 2
*No-load Core Loss (***04.045***)*	*Torque feedback	2
*Rated Core Loss (***04.046***)*	*Torque feedback	User set-up

*Torque feedback is provided in *Percentage Torque* (**04.026**). The estimated value can be improved by setting up the *No-load Core Loss* (**04.045)** and *Rated Core Los*s (**04.046**) for the motor. It should be noted that the core loss characteristic for a motor is complex and depends to some extent on the switching frequency, but the drive can include an approximation to the core losses based on these two parameters. The value for the no-load core losses measured by the auto-tuning is likely to be higher than the actual value, but can be used to significantly reduce the difference that will be seen in the estimate torque between motoring and regenerating operation. If more accurate core loss compensation is required *No-load Core Loss* (**04.045**) and *Rated Core Loss* (**04.046**) must be set up based on testing the motor using a torque transducer.

1: Basic

This test measures the basic control parameters without moving the motor.

1. A stationary test is performed to measure Stator Resistance (**05.017**), Transient Inductance (**05.024**), Maximum Deadtime Compensation (**05.059**) and Current At Maximum Deadtime Compensation (**05.060**). If Enable Stator Compensation (**05.049**) = 1 then Stator Base Temperature (**05.048**) is made equal to Stator Temperature (**05.046**).
2. Stator Resistance (**05.017**) and Transient Inductance (**05.024**) are used to set up *Current Controller Kp Gain* (**04.013**) and *Current Controller Ki Gain* (**04.014**). This is only performed once during the test, and so the user can make further adjustments to the current controller gains if required.

2: Improved

This test measures the parameters for improved performance by rotating the motor.

1. Auto-tune 1 test is performed.
2. A rotating test is performed in which the motor is accelerated with the currently selected ramps up to a frequency of *Rated Frequency* (05.006) x 2/3, and the frequency is maintained at that level for up to 40 seconds. *Stator Inductance* (**05.025**) is measured and this value is used in conjunction with other motor parameters to calculate *Rated Power Factor* (**05.010**). *Saturation Breakpoint 1* (**05.029**), *Saturation Breakpoint 3* (**05.030**), *Saturation Breakpoint 2* (**05.062**) and *Saturation Breakpoint 4* (**05.063**) are measured. The no-load motor core losses are measured and written to No-load Core Loss (**04.045**). It is not possible to measure the rated load motor core losses, and so *Rated Core Loss* (**04.046**) is set to zero. The motor should be unloaded for this test.

3: Inertia 1

This test measures the mechanical characteristic of the motor and load by rotating the motor at the speed defined by the present speed reference and injecting a series of speed test signals. This test should only be used provided all the basic control parameters have been set-up correctly and the speed controller parameters should be set to conservative levels, such as the default values, so that the motor is stable when it runs. The test may give inaccurate results if standard ramp is active, particularly with high inertia low loss loads. The test measures the motor and load inertia, which can be used in automatic set-up of the speed controller gains and in producing a torque feed-forward term. If *Mechanical Load Test Level* (**05.021**) is left at its default value of zero then the peak level of the injection signal will be 1% of the maximum speed reference subject to a maximum of 500 rpm. If a different test level is required then *Mechanical Load Test Level* (**05.021**) should be set to a non-zero value to define the level as a percentage of the maximum speed reference, again subject to a maximum of 500 rpm. The user defined speed reference which defines the speed of the motor should be set to a level higher than the test level, but not high enough for flux weakening to become active. In some cases however, it is possible to perform the test at zero speed provided the motor is free to move, but it may be necessary to increase the test signal from the default value. The test will give the correct results when there is a static load applied to the motor and in the presence of mechanical damping. This test should be used if possible, however for sensorless mode, or if the speed controller cannot be set up for stable operation an alternative test is provided (*Auto-tune* (**05.012**) = 4) where a series of torque levels are applied to accelerate and decelerate the motor to measure the inertia.

1. A rotating test is performed in which the motor is accelerated with the currently selected ramps up to the currently selected speed reference, and this speed is maintained for the duration of the test. The *Motor And Load Inertia* (**03.018**) and *Inertia Times 1000* (**04.033**) are set up.

4: Inertia 2

Auto-tune test 3 should normally be used for mechanical load measurement, but under some circumstances this test may be used as an alternative. This test will not give such accurate results as test 3 if the motor rated speed is not set to the correct value for the motor. Also this test is likely to give incorrect results if standard ramp mode is active. A series of progressively larger torque levels are applied to the motor (20 %, 40 % ... 100 % of rated torque) to accelerate the motor up to 3/4 x VM_SPEED_FREQ_REF (i.e. speed reference variable maximum) to determine the inertia from the acceleration/deceleration time. The test attempts to reach the required speed within 5 s, but if this fails the next torque level is used. When 100 % torque is used the test allows 60 s for the required speed to be reached, but if this is unsuccessful a trip is initiated. To reduce the time taken for the test it is possible to define the level of torque to be used for the test by setting *Mechanical Load Test Level* (**05.021**) to a non-zero value. When the test level is defined the test is only carried out at the defined test level and 60s is allowed for the motor to reached the required speed. It should be noted that if the maximum speed allows for flux weakening then it may not be possible to achieve the required torque level to accelerate the motor fast enough. If this is the case, the maximum speed reference should be reduced.

1. The motor is accelerated in the required direction up to 3/4 of the maximum speed reference and then decelerated to zero speed.
2. The test is repeated with progressively higher torques until the required speed is reached.
3. *Motor And Load Inertia* (**03.018**) and *Inertia Times 1000* (**04.033)** are set up.

The table below shows the trips that can occur during an auto-tune test:

Trip	Reason
Autotune Stopped	The final drive enable or the final drive run were removed before the test was completed.
Resistance.001	The measured value of *Stator Resistance* (**05.017**) exceeded a value of (VFS / √2) / *Full Scale Current Kc* (**11.061)**, where VFS is the full scale d.c. link voltage.
Resistance.002	It has not been possible to measure the drive inverter characteristic to define *Maximum Deadtime Compensation* (**05.059**) and *Current At Maximum Deadtime Compensation* (**05.060**).
Autotune 1.001	The position feedback did not change when position feedback is being used.
Autotune 1.002	The motor did not reach the required speed.
Autotune 2.001	Position feedback direction is incorrect when position feedback is being used.
Autotune 2.002	A SINCOS encoder with comms is being used for position feedback and the comms position is rotating in the opposite direction to the sine wave based position.
Autotune 3.001	The measured inertia exceeds the parameter range.
Autotune 3.003	The mechanical load test has failed to identify the inertia.
Autotune 7	The motor poles or the position feedback resolution have been set up incorrectly where position feedback is being used. The trip will not occur if *Number Of Motor Poles* (**05.011**) ≥ 6 (i.e. 12 poles).

If *Sensorless Mode Active* (**03.078**) = 1 then trips Autotune 1, Autotune 2 and Autotune 7 are disabled.

RFC-S

The following describes how an auto-tune test can be initiated and normal operation can be resumed after the test for RFC-S mode:

An auto-tune test cannot be initiated if the drive is tripped or the drive inverter is active, i.e. *Drive Healthy* (**10.001**) = 0 or *Drive Active* (**10.002**) = 1. The inverter can be made inactive by ensuring that the Final drive enable is inactive, or the Final drive run is inactive and *Hold Zero Speed* (**06.008**) = 0.

An auto-tune test is initiated by setting *Auto-tune* (**05.012**) to a non-zero value and making the Final drive enable and the Final drive run active.

All tests that move the motor will move the motor in the forward direction if *Reverse Select* (**01.012**) = 0 or the reverse direction if *Reverse Select* (**01.012**) = 1.

If the auto-tune sequence is completed successfully the Final drive enable is set to the inactive state and *Auto-tune* (**05.012**) is set to zero. The Final drive enable can only be set to the active state again by removing the enable and re-applying it. The enable can be removed by setting *Drive Enable* (**06.015**) = 0, or by setting bit 0 of the *Legacy Control Word* (**06.042**) to 0 provided *Legacy Control Word Enable* (**06.043**) = 1, or by making *Hardware Enable* (**06.029**) = 0.

If a trip occurs during the auto-tune sequence the drive will go into the trip state and *Auto-tune* (**05.012**) is set to zero. As in 4 above the enable must be removed and re-applied before the drive can be restarted after the trip has been reset. However, care should be taken because if the auto-tune was not completed the drive parameters that should have been measured and set up will still have their original values.

If the Final drive enable is made active, the Final drive run is inactive and *Hold Zero Speed* (**06.008**) = 1 the drive would normally be in the Stop state (i.e. the inverter is active, but the frequency or speed reference is 0).

The following describes the effects of the auto-tune test on the drive parameters for RFC-S mode:

All auto-tune tests rely on the motor being stationary when the test is initiated to give accurate results.

When each stage of the test is completed, the results are written to the appropriate parameters and these parameters saved in the drive non-volatile memory. If *Parameter Cloning* (**11.042**) is set to 3 or 4 the parameters are also written to a non-volatile media card fitted in the drive.

The table below shows the parameters required for motor control indicating which should be set by the user and which can be measured with an auto-tune test.

Parameter	Required for	Measured in test
Rated Current (**05.007**)	Basic control	User set-up
Rated Speed (**05.008**)	Basic control	User set-up
Rated Voltage (**05.009**)	Basic control	User set-up
Number Of Motor Poles (**05.011**)	Basic control	User set-up
Stator Resistance (**05.017**)	Basic control	1, 5
Ld (**05.024**)	Basic control	1, 5
Maximum Deadtime Compensation (**05.059**)	Basic control	1, 5
Current At Maximum Deadtime Compensation (**05.060**)	Basic control	1, 5
Current Controller Kp Gain (***04.013***)	Basic control	1, 5
Current Controller Ki Gain (***04.014***)	Basic control	1, 5
Volts Per 1000rpm (***05.033***)	Basic control	Not currently measured
Inverted Saturation Characteristic (***05.070***)	Sensorless control using current injection mod	Not currently measured
Phase Offset At Defined Iq Current (***05.077***)	Sensorless control using current injection mod	Not currently measured
Low Speed Sensorless Mode Current (***05.071***)	Sensorless control using current injection mod	Not currently measured
No-load Lq (***05.072***)	Sensorless control and high performance current control	1, 5
Lq At The Defined Iq Current (***05.078***)	Sensorless control	Not currently measured
Lq At The Defined Id Current (***05.084***)	Sensorless control	Not currently measured
Position Feedback Phase Angle (***03.025***)	Basic control with position feedback	1, 5

1: Stationary (for sensorless permanent-magnet motors)

This test can be used to measure all the necessary parameters for basic control.

1. A test is performed to locate the flux axis of the motor. If *Minimal Movement Phasing Test Angle* (**05.016**) = 0 then motor inductance measurement is used and the motor should not move, otherwise a minimal movement method is used. See *Minimal Movement Phasing Test Mode* (**05.013**) for details. If sensorless control is being used (i.e. *Sensorless Mode Active* (**03.078**) = 1) then inductance measurement is always used.
2. A stationary test is performed to measure *Stator Resistance* (**05.017**), *Maximum Deadtime Compensation* (**05.059**) and *Current At Maximum Deadtime Compensation* (**05.060**).
3. If *Enable Stator Compensation* **(05.049**) = 1 then *Stator Base Temperature* (**05.048**) is made equal to *Stator Temperature* (**05.046**).
4. A stationary test is performed to locate the flux axis of the motor again in case the motor has moved during the previous test.
5. If sensorless mode is not selected (i.e. *Sensorless Mode Active* (**03.078**) = 0) then the position feedback phasing angle measured during stage 1 of this test is compared with the value measured during this stage of the test. If there is a difference of 30^o or more then a Autotune 1.6 trip is initiated. Otherwise *Position Feedback Phase Angle* (**03.025**) is set up for the position from the position feedback interface selected with *Motor Control Feedback Select* (**03.026**). Whether inductance measurement or minimal movement was used to locate the flux *Minimal Movement Phasing Test Angle* (**05.016**), *Minimal Movement Phasing Test Current* (**05.015**) and *Minimal Movement Phasing Test Mechanical Load Phase* (**05.019)** are saved. If inductance measurement is used then the values are set to their default levels. If minimal movement is used then the values are set as a result of the test.
6. A stationary test is performed to measure *Ld* (**05.024**) and *No-load Lq* (**05.072**).
7. *Stator Resistance* (**05.017**) and *Ld* (**05.024)** are used to set up *Current Controller Kp Gain* (**04.013)** and *Current Controller Ki Gain* (**04.014**). This is only performed once during the test, and so the user can make further adjustments to the current controller gains if required.

It should be noted that because this is a stationary or minimal movement test, it is not possible to check the direction of the position feedback. If the motor power connection phase sequence is incorrect so that the position feedback counts in reverse when the drive applies a phase sequence U-V-W to operate in the forward direction then when the drive is enabled after the auto-tune the motor will jump thought 90^o electrical and stop with a current in the motor defined by the current limits. This can be corrected by changing the drive output phase sequence with *Reverse Output Phase Sequence* (**05.042)** and then repeating the auto-tuning. This will make the motor rotate correctly in the direction defined by the position feedback rotation. If the position feedback direction is correct the motor will then rotate under control in the required direction, but if the position feedback direction is incorrect the motor will then rotate under control in the wrong direction.

When using any type of encoder with digital commutation signals (i.e. AB Servo) the absolute position is not fully defined until the motor has moved by between 1 and 2 electrical revolutions (i.e. between 120^o and 240^o mechanical for a 6 pole motor). This means that *Position Feedback Phase Angle* (**03.025**) can only be measured correctly using motor inductance measurement (i.e. *Minimal Movement Phasing Test Angle* (**05.016**) = 0). Also if *Position Feedback Phase Angle* (**03.025**) is measured for a motor using this type of position feedback using a stationary test when the motor has not moved since power-up, or after the position feedback is re-initialised, there can be an error of +/-30^o in the result. When the motor subsequently moves, the drive synchronises more accurately to the commutation signal edges and adjusts *Position Feedback Phase Angle* (**03.025**) to be correct and then saves the value in the drive. If a stationary auto-tune is performed and the motor is not moved by at least 2 electrical revolutions before powering down again this process is not carried out and the auto-tune should be repeated. When an encoder with digital commutation signals is used there is always an error of up to 30^o in the phasing angle during starting until the motor has rotated by 1/3 of an electrical revolution. It should be noted that the +/-30^o error in the phasing angle can increase this error to 60^o and reduce the possible torque by up to 50 %. Once the motor has rotated by 2 electrical revolutions full torque will be available.

The stationary test cannot be used with commutation only type devices, and test 2 below should be used instead.

If inductance measurement is being used to locate the flux axis of the motor (see *Minimal Movement Phasing Test Mode* (**05.013**)) and the motor inductance is very high (i.e. low speed motor with high pole number), or the inductance is moderately high and the drive has a much higher power rating than the motor, then the drive may find it difficult to locate the flux axis. If this is a problem and position feedback is being used then the minimal movement method can be performed instead.

5: Full Stationary (for permanent-magnet motors with a feedback device)

This test is intended to measure as many parameters as possible without rotating the motor. *Minimal Movement Phasing Test Mode* (**05.013**) should to be set to indicate whether the motor is free or constrained. The test is carried out as follows:

1. The stationary test described above is performed using inductance measurement.
2. If Stage 1 is successful the test is now complete. If position feedback is being used and the test has failed because the saturation characteristic of the motor cannot be measured (Inductance.004), the position feedback phasing angle is different by more than 30^o between the first and second time the motor flux is located (Autotune 1.006), or the motor is not salient enough to use inductance measurement to locate the motor flux (Inductance.003) then the stationary test is repeated using minimal movement instead of inductance measurement to locate the motor flux. If *Minimal Movement Phasing Test Angle* (**05.016**) has a value of zero when the test is started *Minimal Movement Phasing Test Angle* (**05.016**) is set to an angle equivalent to at least 75 counts from the position feedback device if it is a rotary device and is connected to the P1 position feedback interface on the drive, subject to a minimum of 0.05^o if the motor is constrained or 1.0^o if the motor is free to rotate. The table below shows how the angle is calculated, subject to a maximum of 0.5^o if the motor is constrained or 5.0^o if it is free to rotate. If the device is not included in the table, is a linear device or is not connected to the P1 interface then the minimum values are used. If *Minimal Movement Phasing Test Angle* (**05.016**) is non-zero when the test is started then this value is used. If position feedback is not being used or any other trips occurred during the first stationary test the test is aborted and the drive is tripped.
3. If Stage 2 is successful the test is now complete.

NOTE

Further stages will be added to this test in the future, and so it should not be assumed that the test will be complete after the stages given above in future software versions.

Position feedback type	Calculation of minimal movement phasing test angle
AB, FD, FR, AB Servo, FD Servo, FR Servo	6750 / P1 Rotary Lines Per Revolution (03.034)
SC, SC Hiperface, SC EnDat, SC SSI, SC Servo, SC SC	6750 / (P1 Rotary Lines Per Revolution (03.034) x 256)
Resolver	5^{o}
EnDat, SSI, BiSS	$27000 / 2^{(\text{P1 Comms Bits (03.035) - P1 Rotary Turns Bits (03.033)})}$

Trip	**Reason**
Autotune Stopped	The final drive enable or the final drive run were removed before the test was completed.
Resistance.001	The measured value of Stator Resistance (**05.017**) exceeded a value of (V_{FS} / √2) / Full Scale Current Kc (**11.061**), where V_{FS} is the full scale d.c. link voltage.
Resistance.002	It has not been possible to measure the drive inverter characteristic to define Maximum Deadtime Compensation (**05.059)** and Current At Maximum Deadtime Compensation (**05.060**).
Autotune 1.001	The position feedback did not change when position feedback is being used.
Autotune 1.002	The motor did not reach the required speed.
Autotune 1.003	The required commutation signal edge could not be found with commutation signal only position feedback.
Autotune 1.004	The required angular movement did not occur during a minimal movement test.
Autotune 1.005	The fine location of the motor flux during a minimal movement test failed.
Autotune 1.006	The phasing offset angle is measured twice during a stationary auto-tune and the two values were not within 30 degrees.
Autotune 1.007	The motor was rotating when a minimal movement test was performed to find the phasing offset angle on enable.
Autotune 1.009	During the final stage of the minimal movement phasing test with a constrained motor it was not possible to achieve the required movement.
Autotune 2.001	Position feedback direction is incorrect when position feedback is being used.
Autotune 2.002	A SINCOS encoder with comms is being used for position feedback and the comms position is rotating in the opposite direction to the sine wave based position.
Autotune 3.001	The measured inertia exceeds the parameter range.
Autotune 3.003	The mechanical load test has failed to identify the inertia.
Autotune 3.002	A position feedback device with commutation signals is being used (i.e. AB Servo, FD Servo, FR Servo, SC Servo) and the commutation signals changed in the wrong direction.
Autotune 4	A position feedback device with commutation signals is being used (i.e. AB Servo, FD Servo, FR Servo, SC Servo) and U signal did not change.
Autotune 5	A position feedback device with commutation signals is being used (i.e. AB Servo, FD Servo, FR Servo, SC Servo) and V signal did not change.
Autotune 6	A position feedback device with commutation signals is being used (i.e. AB Servo, FD Servo, FR Servo, SC Servo) and W signal did not change.
Autotune 7	The motor poles or the position feedback resolution have been set up incorrectly where position feedback is being used. The trip will not occur if *Number Of Motor Poles* (**05.011**) ≥ 6 (i.e. 12 poles).
Inductance.003	The difference between the d and q axis inductance is not large enough to correctly determine the location of the motor flux. If position feedback is being used the measured value for *Position Feedback Phase Angle* (**03.025**) may not be reliable. Also the measured values of *Ld* (**05.024**) and *No-load Lq* (**05.072**) may not correspond to the d and q axis respectively. The test is completed and all the parameters saved to non-volatile memory in the drive, but the user should note that the measured results may not be correct. It should be noted that this trip is not produced if sensorless mode is selected and active (i.e. *Sensorless Mode Active* (**03.078**) = 1).
Inductance.004	During auto-tune test 1 when position feedback is being used (i.e. *Sensorless Mode Active* (**03.078)** = 0), the direction of the flux in the motor must be detected by the change of inductance with different currents. This trip is initiated if the

If Sensorless Mode Active (03.078) = 1 then trips Autotune 1, Autotune 2 and Autotune 7 are disabled.

Parameter	00.014 (05.064) *RFC Low Speed Mode*		
Short description	Defines the low speed mode of the drive when position feedback is not being used		
Mode	RFC-S		
Minimum	0	**Maximum**	5
Default	2	**Units**	
Type	8 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE		

If sensorless mode is being used and is active (i.e. *Sensorless Mode Active* (**03.078**) = 1) and the motor is operating at low speed then a low speed algorithm must be used to control the motor. The change between the low speed and normal operation algorithms is related to the drive output frequency. An upper threshold is provided for the change from low speed to normal operation, and a lower threshold is provided for the change back from normal to low speed operation as given in the table below. These values are a percentage of *Rated Speed* (**05.008**). If high saliency control is being used (*Active Saliency Torque Mode* (**05.066**) = 2) then the lower threshold is always 15 % and the upper threshold is 20 %.

Switching Frequency (05.037)	Lower Threshold	Upper Threshold
2 kHz	5 %	10 %
3 kHz	5 %	10 %
4 kHz	5 %	10 %
6 kHz	10 %	15 %
8 kHz	10 %	15 %
12 kHz	15 %	20 %
16 kHz	15 %	20 %

RFC Low Speed Mode (**05.064**) is used to select the algorithm to be used as described below. The following should be noted:

1. Current modes should not be used for motors with high saliency.
2. Torque control can be used with the "Injection" starting method in the same way as with position feedback. However if torque control is to be used in an application where the other starting methods are used then the following should be considered: Torque control should not be enabled until the low speed algorithm is no longer active and the motor speed must not drop to a level where the low speed mode will become active again while torque control is active. This means that the motor must be started in speed control and torque control should only be selected when the speed is high enough. To stop the motor the drive can simply be disabled or the run command should be removed for the drive to stop the motor. Removing the run causes the drive to switch from torque control to speed control, and so the motor speed can be reduced back down though the range where the low speed algorithm is active.

0: Injection

A high frequency signal is injected into the motor to detect the motor flux axis. For this to operate correctly the motor must remain salient while the low speed mode is active. The no-load inductance parameters are checked by the drive on enable and if the motor is not sufficiently salient then a Inductance trip is initiated. See the details of this trip for the inductances required. Generally the q axis inductance falls as the q axis current is increased, i.e. the motor is loaded. While low speed operation is active the drive will apply a current limit defined by *Low Speed Sensorless Mode Current* (**05.071**) to prevent the q axis inductance from falling to a level that would cause the motor to become non-salient. It will be necessary to limit the bandwidth of the speed controller to a level of 10Hz or less for stable operation particularly at low speeds. Provided these conditions are met this method can be used in the same way as control with position feedback, but the control performance is limited.

1 or 2: Current

This method, which applies a rotating current vector at the frequency defined by the speed reference, can be used with any motor with no saliency or moderate saliency. It should only be used with motors where more of the torque is produced in conjunction with the magnet flux rather than from saliency torque. This mode does not provide the same level of control at low speed as injection mode, but it can be used with a motor that is not salient. The following should be considered:

1. Only speed control can be used when low speed mode operation is active.
2. A current specified by *Low Speed Sensorless Mode Current* (**05.071**) is applied when low speed mode is active. This current should be sufficient to start the motor with the highest expected load. If the motor has some saliency with no-load applied, and a suitable saturation characteristic, the drive can detect the rotor position and apply the current at the correct angle to avoid starting transient. If the motor is non-salient as defined by the conditions for Inductance trip then the drive will not attempt to detect the rotor position and the current will be applied at an arbitrary angle. This could cause a starting transient if the level of current applied is high, and so *Low Speed Sensorless Mode Current* (**05.071**) should not be set to a higher level than necessary. To minimise the movement as a result of applying the current, it is increased over the period defined by S*ensorless Mode Current Ramp* (**05.063**) in the form of a squared characteristic (i.e. it is increased with a low rate of change at the beginning and the rate of change is gradually increased).
3. It is not possible to measure the motor inertia using auto-tuning with *Auto-tune* (**05.012**) = 4.

4. As the level of current when low speed mode is active is not dependent on the applied load, but is as defined by *Low Speed Sensorless Mode Current* (**05.071**), and so the motor may become too hot if low speed mode is active for a prolonged period of time.
5. Generally *Low Speed Sensorless Mode Current* (**05.071**) should be set to a level higher than the expected maximum load, and can be set to a much higher level than the load if the saliency and saturation characteristic allow the position of the rotor to be detected on starting. However, *Low Speed Sensorless Mode Current* (**05.071**) should be matched more closely to the expected load under the following conditions: the load inertia is high compared to the motor inertia, or there is very little damping/loss in the load system, or where the q axis inductance of the motor changes significantly with load.

3: Current no test

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. This can be selected for example, if the motor does not have a suitable saturation characteristic to allow the rotor position to be determined during starting, or if faster starting is required. The initial current vector angle will be at an arbitrary position with respect to the actual rotor position. As the vector sweeps round it must make the rotor start to rotate. If the ramp rate is too high the rotor may not keep up with the current vector and the motor may not start. If this is the case then the ramp rate should be reduced and/or the current used to start the motor should be increased.

4: Current step

The current starting modes normally provide a smooth transition between the low speed current mode and normal running at higher speeds. If the drive accelerates very rapidly and only spends short periods of time in each mode the transition smoothing can malfunction. "Current step" mode is similar to "Current no test" mode except that the transition smoothing is disabled. It is not advisable to use this mode unless it is necessary as torque transients will occur when changing between low speed and normal running operation.

5: Current only

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. The system remains in this starting mode at all speeds and does not change to the normal operating algorithms. This provides a very basic open-loop control method, that is not recommended for most applications. Flux weakening is not possible, and so this method will not operate correctly when the motor voltage approaches the maximum voltage available from the drive.

The current applied to the motor is always the level defined by *Low Speed Sensorless Mode Current* (**05.071**) and the frequency is defined by the frequency reference. The following should be noted:

It is possible that the motor may become unstable especially on light load.

The current in the motor will always be at the level defined by *Low Speed Sensorless Mode Current* (**05.071**) whatever the load. Care should be taken not to overheat the motor.

The speed feedback provided is derived from the reference, and so it does not necessarily represent the actual speed of the motor.

Parameter	00.015 (05.071) *Low Speed Sensorless Mode Current*		
Short description	Current reference applied in low speed current mode or maximum current limit for low speed injection mode		
Mode	RFC-S		
Minimum	0.0	**Maximum**	1000.0
Default	100.0	**Units**	%
Type	16 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW		

See *RFC Low Speed Mode* (**05.064**).

Parameter	00.016 (04.007) *Symmetrical Current Limit*		
Short description	Defines the symmetrical current limit		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_MOTOR1_CURRENT_LIMIT[MIN]	**Maximum**	VM_MOTOR1_CURRENT_LIMIT[MAX]
Default	0.0	**Units**	%
Type	16 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	1
Coding	RW, VM		

See *Motoring Current Limit* (**04.005**).

Parameter	00.017 (29.087) *Motor Thermal Protection Enable*		
Short description	Off = Disabled, On = Enabled. Selectes whether the motor temperature monitoring input is enabled or not		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	1 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW		

When set to On(1), to the *Motor Thermal Protection Input* (**29.086**) is enabled.

When set to Off(0), to the *Motor Thermal Protection Input* (**29.086**) is disabled.

See *Motor Thermal Protection Input* (**29.086**).

Parameter	00.018 (05.042) *Reverse Output Phase Sequence*		
Short description	Set to 1 to reverse the sequence on the output phases		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	1 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW		

If *Reverse Output Phase Sequence* (**05.042**) = 0 the output phase sequence is U-V-W when *Output Frequency* (**05.001)** is positive and W-V-U when *Output Frequency* (**05.001**) is negative. If *Reverse Output Phase Sequence* (**05.042**) = 1 the output phase sequence is reversed so that the phase sequence in W-V-U for positive frequencies and U-V-W for negative frequencies.

Parameter	00.018 (03.079) *Sensorless Mode Filter*		
Short description	Defines the filter for the estimated motor speed when sensorless mode is active		
Mode	RFC-S		
Minimum	0	**Maximum**	4
Default	0	**Units**	ms
Type	8 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE		

Value	**Text**
0	4
1	8
2	16
3	32
4	64

When sensorless mode is active the estimated motor speed can include some unwanted noise. Some motors have concentrated windings which results is flux distortion when the motor is loaded, which in turn causes ripple in the motor currents and additional unwanted components in the calculated speed feedback. This usually has a more significant effect if the motor is running at high speed when the voltage controller may be active to limit the motor voltage. A filter is applied to the speed feedback with a time constant defined by *Sensorless Mode Filter* (**03.079**). The default value for this parameter gives the maximum amount of filtering, so that motors which introduce unwanted feedback noise will operate correctly. If the motor does not introduce this type of noise it is possible to reduce the filter time constant to give better dynamic performance when speed control is required.

Parameter	00.021 (29.011) *Pump Control Mode*		
Short description	This sets the control mode for the drive e.g. Single pump, Cascade etc		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	2
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This defines the type of system that the drive is being applied to. The following table shows the options available:

Value	Text	Description
0	Single Pump	A single drive pump application
1	Cascade	A single leader drive with up to 2 assist soft starters
2	Multi-leader	Upto 3 drive system where the leader role is rotated

Mode	Value	Description
Single Pump (Simplex)	0	This is for a single pump installation running from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference. Single Pump is the default control mode.
Cascade (Duty Assist)	1	This is for a single leader pump drive with up to 2 cascaded assist pumps powered by soft starters. The soft starters are commanded with simple digital I/O from the leader pump drive; the leader drive may require an SI-I/O option to Handle the assist control signals, e.g. *when Assist Control Mode* (**29.106**) = *Full I/O*. The application may run from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference.
Multi-leader (Multiplex)	2	This is for a multi-leader pump installation where up to 3 pumps, controlled by F600 pump drives, are in the system. The role of leader drive is cycled between the pump drives, after a user set time, to even out pump wear. The leader drive requests assist pumps over an Ethernet network; each drive requires an SI-Ethernet option with >=V01.07.03.03 firmware to facilitate the control. The application may run from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference. This has improved redundancy compared to the other modes where any drive can assume the role of leader in the event of a fault. In the event of a faulty PID feedback transducer, the leader can use the feedback from another drive via the Ethernet connection between drives.

Parameter	00.022 (01.006) *Maximum Reference Clamp*		
Short description	Defines the maximum value for the reference		
Mode	Open-Loop		
Minimum	VM_POSITIVE_REF_CLAMP 1[MIN]	**Maximum**	VM_POSITIVE_REF_CLAMP1[MAX]
Default	See exceptions below	**Units**	
Type	32 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	1
Coding	RW, VM		

Default Value		
OL	**RFC-A**	**RFC-S**
50.0	1500.0	
60.0	1800.0	

Maximum Reference Clamp (**01.006**) provides a limit on the maximum frequency or speed. This is normally set to the rated frequency or speed for the Pump motor.

Parameter	00.023 (01.004) *Positive Minimum Reference Clamp*		
Short description	Sets the positive minimum reference clamp.		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_SPEED_FREQ_REF[MIN]	**Maximum**	VM_SPEED_FREQ_REF[MAX]
Default	0.0	**Units**	
Type	32 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	1
Coding	RW, VM		

For Pump systems, this may be used to set the minimum positive frequency or speed that the Pump or fan can run at that will affect the main process PID feedback, (*PID Final Feedback* (**29.036**) or PID *Final Feedback Percent* (**29.035**)). Most fans and pumps don't give an appreciable output until up to 50% of their rated frequency or speed is reached.

When a Pump Cleaning / deragging cycle is running this is not used to permit the motor to turn backwards.

Parameter	00.024 (29.012) *Control Input Mode*		
Short description	Selects how the system will be started and stopped		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	3
Default	1	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

Value	**Text**	**Description**
0	Input	Hand and Auto switched inputs
1	Input & Keypad	Hand Off and Auto from switched inputs and keypad button press
2	Ctrl Wrd	All of the main system inputs are handled Control and status words Word
3	Ctrl Wrd & Input	The control word and local inputs can be used in parallel for HMIs

This selects how the system will respond to control inputs. The following table shows the options available:

Mode	Value	Description
Input	0	In this mode the control logic is supplied to local bit type inputs such as *Hand Select Input* (**29.013**) or *Auto Select Input* (**29.015**). The user is intended to direct digital inputs to all bit type input parameters to be controlled.
Input & Keypad (Default)	1	In this mode the control logic to apply either a Hand or Auto or to stop the system can come from either the Keypad HAND, OFF and AUTO buttons or from the digital inputs directed to *Hand Select Input* (**29.013**) or *Auto Select Input* (**29.015**). In this mode of control the keypad can be used to start and stop the drive, but will be overridden by *Hand Select Input* (**29.013**) or *Auto Select Input* (**29.015**) if they are used. When the keypad is overridden, any selections made by it are reset. To activate Hand or Auto controls on the keypad press and hold the required function key for 2 s. The Off key operates with a short press. All other local bit type control inputs are handled the same as Input.
Ctrl Wrd	2	In this mode, control inputs are exclusively handled by *Pump Control Word 1* (**29.151**) and *Pump Control Word 2* (**29.152**) i.e. the local bit type inputs are ignored. This intended for PLC control, where most PLCs have hardware I/O to Handle devices such as flow switches.
Ctrl Wrd & Input	3	In this mode, control inputs may be asserted via *Pump Control Word 1* (**29.151**) and *Pump Control Word 2* (**29.152**) or by the equivalent local boolean inputs such as the *Flow Switch Input* (**29.066**). This intended for HMI control, where most HMIs don’t have hardware I/O, and the Pump Drive F600 I/O is used for devices like flow switches, but the HMI is used to select Hand or Auto mode.

Parameter	00.025 (29.016) *Hand Mode Reference Select*		
Short description	Selects the reference type used to define the Hand mode speed.		
Mode	Open-Loop		
Minimum	0	**Maximum**	1
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE		

This selects where the frequency or speed reference comes from when Hand mode is selected. When set to Digital Speed, Pr1.022 sets the reference. When set to Analog Speed, by default, a 0 to 10V signal is applied to analog input 2 T6. See the following table.

Mode	Value	Description
0	Digital Speed	In this mode when Hand is selected, the motor speed or frequency reference is provided by *Hand Mode Reference* (**01.022**).
1	Analog Speed	In this mode when Hand is selected, the motor speed or frequency reference is provided by a drive analog input *Hand Mode Analog Reference* (**01.036**). The default is via T6 Analog input 2.

Parameter	00.026 (01.022) *Hand Mode Reference*		
Short description	Defines the value for Hand mode reference 2		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_SPEED_FREQ_REF[MIN]	**Maximum**	VM_SPEED_FREQ_REF[MAX]
Default	See exceptions below	**Units**	
Type	32 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	1
Coding	RW, VM		

Default Value		
OL	**RFC-A**	**RFC-S**
25.0	750.0	
30.0	900.0	

This defines the speed or frequency reference used when running in Hand mode and when *Hand Mode Reference Select* (**29.016**) = Digital Speed. See *Hand Select Input* (**29.013**).

Parameter	00.027 (02.011) *General Acceleration Rate*		
Short description	Defines the general acceleration rate		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_ACCEL_RATE[MIN]	**Maximum**	VM_ACCEL_RATE[MAX]
Default	OL: 5.0 RFC-A \ RFC-S: 1.000	**Units**	s
Type	32 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	OL: 1 RFC-A \ RFC-S: 3
Coding	RW, VM		

This defines the acceleration rate in Hand and Auto, exept when a pump cleaning or de-ragging cycle is running.

The units of *General Acceleration Rate* (**02.011**), *Cleaning Phase 1 Acceleration Rate* (**02.012**), *Cleaning Phase 2 Acceleration Rate* (**02.013**) and *Cleaning Phase 3 Acceleration Rate* (**02.014**) are s / Ramp rate frequency or s / Ramp rate speed. See *Ramp Rate Units* (**02.039**) for the definition of Ramp rate frequency and Ramp rate speed.

Selecting a ramp rate that has been set to zero in Open-loop mode disables the ramp system so that the *Post Ramp Reference* (**02.001**) follows the *Pre-ramp Reference* (**01.003**) without any delay for acceleration or deceleration. It should be noted that this also disables the standard ramp d.c. link voltage controller and the frequency based current limits.

Parameter	00.028 (02.021) *General Deceleration Rate*		
Short description	Defines the general deceleration rate		
Mode	Open-Loop		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	OL: 1.0 RFC-A \ RFC-S: 1.000	Units	s
Type	32 Bit User Save	Update Rate	4 ms read
Display Format	Standard	Decimal Places	OL: 1 RFC-A \ RFC-S: 3
Coding	RW, VM		

This defines the acceleration rate in Hand and Auto, exept when a pump cleaning or de-ragging cycle is running.

The units of *General Acceleration Rate* (**02.011**), *Cleaning Phase 1 Acceleration Rate* (**02.012**), *Cleaning Phase 2 Acceleration Rate* (**02.013**) and *Cleaning Phase 3 Acceleration Rate* (**02.014**) are s / Ramp rate frequency or s / Ramp rate speed. See *Ramp Rate Units* (**02.039**) for the definition of Ramp rate frequency and Ramp rate speed.

Selecting a ramp rate that has been set to zero in Open-loop mode disables the ramp system so that the *Post Ramp Reference* (**02.001**) follows the *Pre-ramp Reference* (**01.003**) without any delay for acceleration or deceleration. It should be noted that this also disables the standard ramp d.c. link voltage controller and the frequency based current limits.

Parameter	00.029 (29.022) *PID Setpoint 0*		
Short description	PID setpoint 0 which is used as the main setpoint, set in user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU
Type	16 Bit User Save	Update Rate	Background
Display Format	Standard	Decimal Places	2
Coding	RW		

PID Setpoint 0 (**29.022**) is the main process PID setpoint. *PID Setpoint 0* (**29.022**) is selected by default because the PID setpoint select inputs, *PID Setpoint Select Input 0* (**29.026**) and *PID Setpoint Select Input 1* (**29.027**) are set to Off(0) by default.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	00.030 (29.031) *PID Feedback Minimum Scaling*		
Short description	Defines the minimum scaling value for the analogue PID feedback i.e. the user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU
Type	16 Bit User Save	Update Rate	Background
Display Format	Standard	Decimal Places	2
Coding	RW		

PID Feedback Minimum Scaling (**29.031**) defines the minimum value for the main process PID feedback provided by a transducer connected to Analog input 1 T5. *PID Feedback Minimum Scaling* (**29.031**) is used in combination with *PID Feedback Maximum Scaling* (**29.032**) to define to feedback scaling.

The units of this parameter UU, (User Units), are defined by the feedback type e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure scaling parameter. All of the PID related parameters are scaled within this range e.g. any setpoint or feedback value.

Parameter	00.031 (29.032) *PID Feedback Maximum Scaling*		
Short description	Defines the maximum scaling value for the analogue PID feedback i.e. the user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.01	**Maximum**	327.67
Default	100.00	**Units**	UU
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

PID Feedback Maximum Scaling (**29.032**) defines the maximum value for the main process PID feedback provided by a transducer connected to Analog input 1 T5. *PID Feedback Minimum Scaling* (**29.031**) is used in combination with *PID Feedback Maximum Scaling* (**29.032**) to define to feedback scaling.

The units of this parameter UU, (User Units), are defined by the feedback type e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure scaling parameter.

Parameter	00.032 (29.033) *PID Feedback Filter Time Constant*		
Short description	Sets the PID feedback filter time constant in seconds		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	327.67
Default	1.00	**Units**	s
Type	16 Bit User Save	**Update Rate**	4 ms
Display Format	Standard	**Decimal Places**	2
Coding	RW		

This is the time constant in seconds for the low pass filter used to condition the value from the feedback transducer connected to Analog input 1 T5.

For a step change in feedback value, after 5x the filter time constant the input and output of the filter will be approximately equal e.g. if the time constant is 1 s, after a step change in feedback, after 5 s the output will approximately match the input.

The input to the filter is *PID Feedback Percent* (**29.034**) and the output from the filter is *PID Final Feedback Percent* (**29.035**).

Parameter	00.033 (29.048) *PID Feedback Loss Action*		
Short description	Sets the PID feedback filter time constant in seconds		
Mode	Open-Loop		
Minimum	0	**Maximum**	2
Default	1	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This chooses the action of the software when there is a total loss of PID feedback as indicated by *Analog Input 1 Current Loop Loss* (**07.028**) = On(1). The table below shows the options available:

Mode	Value	Description
Ignore	0	Ignore the feedback loss - do nothing.
Trip	1	Trip the drive, (*PID Feedbk Loss*).
Fixed Speed	2	Run at a fixed speed defined by *PID Disabled / Feedback Loss Reference* (**01.023**).

Parameter	00.034 (29.041) *PID Feedback High Trip Threshold*		
Short description	Defines the upper limit for the PID feedback in user feedback units before a trip		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	327.67
Default	0.00	**Units**	UU
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

When set to 0, the main process PID high trip mechanism is disabled.

When set >0, this defines the threshold above which a *PID Feedbk High* trip is actioned.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

Parameter	00.035 (29.042) *PID Feedback Low Delay*		
Short description	The filter delay applied when detecting if the feedback is low		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the continuous time in seconds that the feedback may be low for without actioning a feedback low drive trip. This acts as a filter for transient feedback conditions that prevents false detection of a main process PID feedback low condition.

This parameter is only used when *PID Feedback Low Mode* (**29.043**) = Threshold or Bandwidth.

The function of this parameter is defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is an under-pressure detection delay.

Parameter	00.036 (29.043) *PID Feedback Low Mode*		
Short description	Selects the method used to detect feedback low		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	2
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

PID Feedback Low Mode (**29.043**) selects which mode to use when generating a feedback low indication and trip. The table below shows the options available:

Mode	Value	Description
Disabled	0	No feedback low trip.
Threshold	1	If the main process PID feedback, *PID Final Feedback* (**29.036**), falls below the *PID Feedback Low Threshold* (**29.044**) for *PID Feedback Low Delay* (**29.042**) seconds, and the motor output frequency or speed is in the *Maximum Drive Reference Band* (**29.083**), then a PID Low drive trip is actioned. Status indication via *PID Feedback Low Output* (**29.047**) is also available.
Bandwidth	2	If the main process PID feedback, *PID Final Feedback* (**29.036**), falls below the *PID At Setpoint Band* (**29.045**) for *PID Feedback Low Delay* (**29.042**) seconds, and the motor output frequency or speed is in the *Maximum Drive Reference Band* (**29.083**), then a PID Feedbk Low trip is actioned. The detection band follows the current PID setpoint dynamically. Status indication via *PID Feedback Low Output* (**29.047**) is also available.

Parameter	00.037 (29.044) *PID Feedback Low Threshold*		
Short description	Sets the PID feedback low threshold in user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	327.67
Default	2.00	**Units**	UU
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

This defines the PID feedback low threshold, used when *PID Feedback Low Mode* (**29.043**) = Bandwidth.

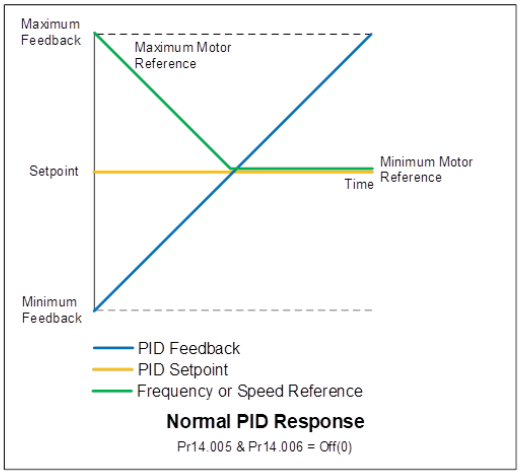
If the main process PID feedback, PID Final Feedback (**29.036**), falls below the *PID Feedback Low Threshold* (**29.044**) for *PID Feedback Low Delay* (**29.042**) seconds then a PID Low drive trip is actioned and a PID low indication is given via *PID Feedback Low Output* (**29.047**).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

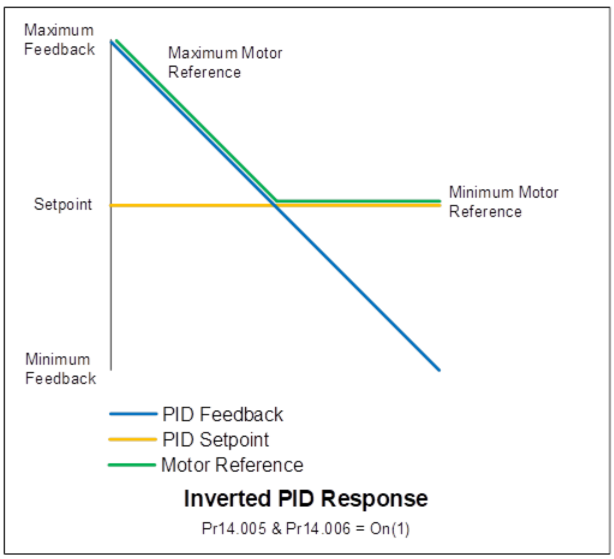
Parameter	00.040 (29.049) *Wake Detect Feedback Threshold*		
Short description	Sets the system wake threshold in user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	327.67
Default	1.00	**Units**	UU
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

If the PID is running with a normal error response, (*PID1 Reference Invert* (**14.005**) and *PID1 Feedback Invert* (**14.006**) = Off(0)), *Wake Detect Feedback Threshold* (**29.049**) defines the main process PID feedback level, *PID Final Feedback* (**29.036**), below which the system will wake when the system is running in Auto mode, and defines the minimum working feedback level for the system. For example, a pumping system with a pressure feedback device gives a high PID output with a low pressure, and a low PID output with high pressure. In this scenario when the feedback is above the setpoint the setpoint the motor reference will reduce down to the minimum. In order to wake the system the PID Feedback must be below the wake threshold.

In a Cascade or Multi-leader system the *Wake Detect Feedback Threshold* (**29.049**) is used in combination with the *Add Assist Band* (**29.123**) to decide when to start an assist i.e. both the add assist and wake thresholds must be satisfied to start an assist.



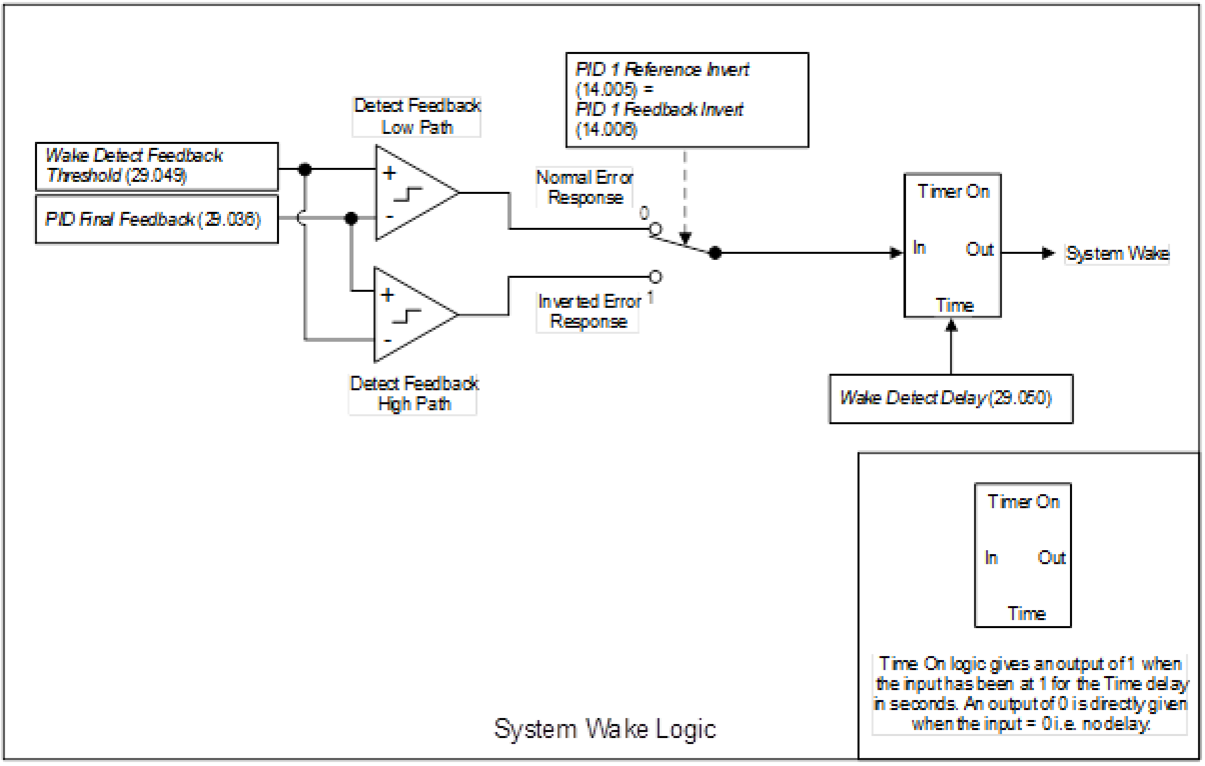
If the PID is running with an inverse error response, (*PID1 Reference Invert* (**14.005**) and *PID1 Feedback Invert* (**14.006**) = On(1)), *Wake Detect Feedback Threshold* (**29.049**) defines the main process PID feedback level, *PID Final Feedback* (**29.036**), above which the system will wake when the system is running in Auto mode. For example, cooling system with a temperature feedback device gives a high PID output with a high temperature, and a low PID output with low temperature. In this scenario when the feedback is below the setpoint the motor reference will reduce down to the minimum. In order to wake the system the PID Feedback must be above the wake threshold.



The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

NOTE

If the main process PID has been disabled via PID1 Enable (**14.008**), then the wake threshold is ignored and the system will wake when started in Auto mode



Parameter	00.041 (29.050) *Wake Detect Delay*		
Short description	Sets the system wake detection delay time		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the continuous time in seconds that the main process PID feedback, *PID Final Feedback* (**29.036)**, must be above the *Wake Detect Feedback Threshold* (**29.049**) before the system is automatically started. *Wake Detect Delay* (**29.050**) filters out any intermittent wake conditions.

Note that if the main process PID has been disabled via *PID1 Enable* (**14.008**), then the wake threshold is ignored and the system will wake when started in Auto mode.

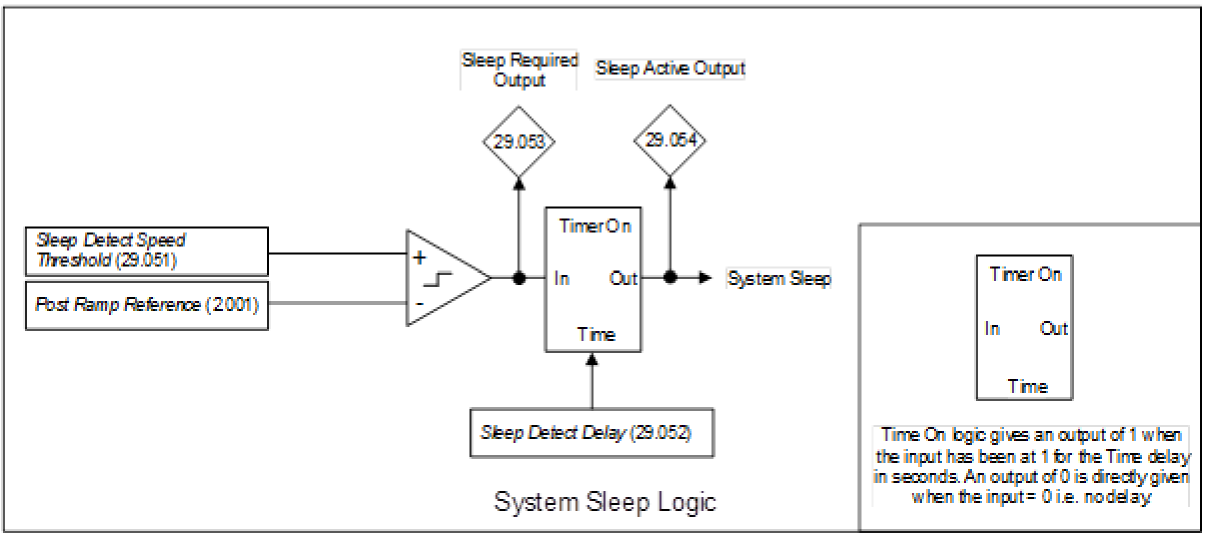
See *Wake Detect Feedback Threshold* (**29.049**).

Parameter	00.042 (29.051) *Sleep Detect Speed Threshold*		
Short description	Sets the speed threshold where the system should go to sleep		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	Maximum	60.0
Default	25.0	Units	
Type	32 Bit User Save	Update Rate	Background
Display Format	Standard	Decimal Places	1
Coding	RW		

This defines the drive output frequency or speed below which the system will sleep. This must be set to a value greater than or equal to the *Minimum Reference Clamp* (**01.007**) to ensure the system will sleep in Auto mode.

If the system must never automatically sleep but still control using the PID then set *Sleep Detect Speed Threshold* (**29.051**) to a lower value than *Minimum Reference Clamp* (**01.007**). Note that other conditions like Dry Well Low Load or No Flow can still stop the system automatically.

The system will tend to reach this threshold if there is no output demand from the pump e.g. in a pump system if a pump output valve is closed the motor speed will drop because the main process PID can reach the setpoint with a reduced speed where the system will enter this threshold.



Parameter	00.043 (29.052) *Sleep Detect Delay*		
Short description	Sets the system sleep detection delay time		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s
Type	16 Bit User Save	Update Rate	Background
Display Format	Standard	Decimal Places	1
Coding	RW, BU		

This defines the continuous time in seconds that the motor frequency or speed must be below the *Sleep Detect Speed Threshold* (**29.051**) before the system is automatically stopped. *Sleep Detect Delay* (**29.052**) filters out any intermittent sleep conditions.

See *Sleep Detect Speed Threshold* (**29.051**).

Parameter	00.044 (10.034) *Number Of Auto-reset Attempts*		
Short description	Set to the number of required auto-reset attempts		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	6
Default	5	**Units**	
Type	8 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE		

Value	Text
0	None
1	1
2	2
3	3
4	4
5	5
6	Infinite

If *Number Of Auto-reset Attempts* (**10.034**) = 0 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 after a delay defined by *Auto-reset Delay* (**10.035**) subject to the minimum reset time allowed for the type of trip. Note that for some trips the minimum is 10 s. The auto-reset count is only incremented when the trip is the same as the previous trip otherwise it is reset to 0. When the auto-reset count reaches the programmed value, any further trip of the same value will not cause an auto-reset. If the number of auto-reset attempts defined by *Number Of Auto-reset Attempts* (**10.034**) has not been reached and there has been no trip for 5 minutes then the auto-reset count is cleared. Auto reset will not occur after any trips with priority levels 1, 2 or 3 as defined in *Trip 0* (**10.020**). When a manual reset occurs the auto-reset counter is reset to zero.

If *Number Of Auto-reset Attempts* (**10.034**) = 6 the auto-reset counter is held at zero, and so there is no limit on the number of auto-reset attempts.

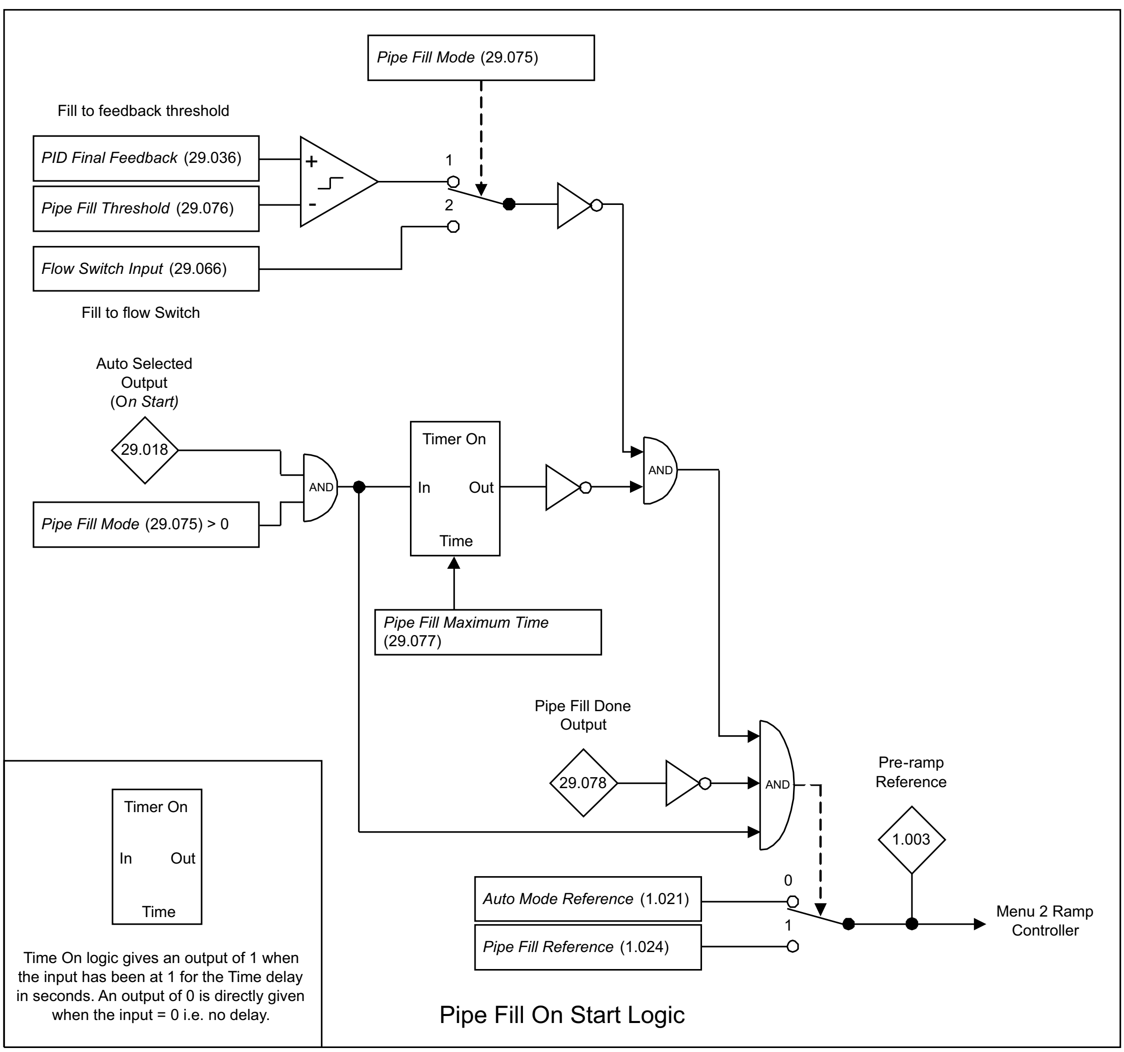
Parameter	00.045 (10.035) *Auto-reset Delay*		
Short description	Set to the required auto-reset delay		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	1.0	**Maximum**	600.0
Default	10.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	1
Coding	RW		

See *Number Of Auto-reset Attempts* (**10.034**).

Parameter	00.046 (29.075) *Pipe Fill Mode*		
Short description	Used to disable pipe fill or choose the feedback type that indicates when the pipe is full		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	2
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This defines the operating mode of the automated pipe fill routine. The following options are available:

Mode	Value	Description
Disabled	0	The pipe fill routine is disabled.
Feedback Level	1	*Pipe Fill Reference* (**01.024**) will be applied until *Pipe Fill Threshold* (**29.076**) is reached by the main process PID feedback. In the event that the *Pipe Fill Threshold* (**29.076**) isn't reached the *Pipe Fill Maximum Time* (**29.077**) will elapse stopping the automatic pipe filling routine.
Flow Switch	2	*Pipe Fill Reference* (**01.024**) will be applied until the *Flow Switch Input* (**29.066**) = On(1). In the event that the *Flow Switch Input* (**29.066**) isn't set to On(1) the *Pipe Fill Maximum Time* (**29.077**) will elapse stopping the automatic pipe filling routine.



Parameter	00.047 (01.024) *Pipe Fill Reference*		
Short description	Defines the value for pipe fill reference 4		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_SPEED_FREQ_REF[MIN]	**Maximum**	VM_SPEED_FREQ_REF[MAX]
Default	See exceptions below	**Units**	
Type	32 Bit User Save	**Update Rate**	4 ms read
Display Format	Standard	**Decimal Places**	1
Coding	RW		

Default Value		
Open-Loop	**RFC-A**	**RFC-S**
25.0	750.0	
30.0	900.0	

This defines the speed or frequency reference used when the automated pipe filling routine is running. See *Pipe Fill Mode* (**29.075**).

Parameter	00.048 (29.077) *Pipe Fill Maximum Time*		
Short description	This defines the maximum time that the pipe fill function will run for		
Mode	Open-Loop, RFC-A, RFC-A		
Minimum	0.0	**Maximum**	6553.5
Default	0.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the maximum time in seconds that the pipe filling routine will run for in the event that pipe filled isn't detected by either feedback detection or flow switch detection.

See *Pipe Fill Mode* (**29.075**).

Parameter	00.049 (29.076) *Pipe Fill Threshold Pipe Fill Reference*		
Short description	Sets the feedback threshold in user feedback units when the pipe is considered filled		
Mode	Open-Loop, RFC-A, RFC-A		
Minimum	0.0	**Maximum**	327.67
Default	0.0	**Units**	UU
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

This defines main PID feedback threshold above which the pipe is considered to be filled when *Pipe Fill Mode* (**29.075**) = Feedback Level. *Pipe Fill Threshold* (**29.076**) is compared against *PID Final Feedback* (**29.036**).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

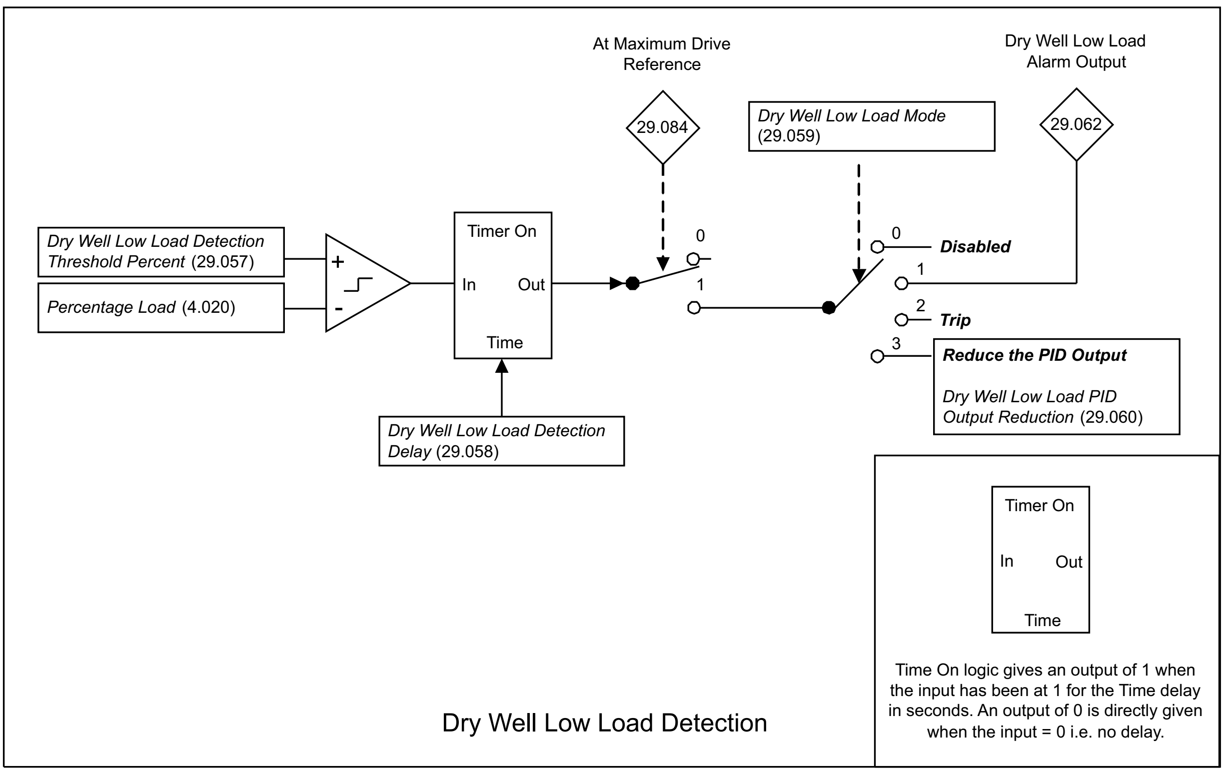
See *Pipe Fill Mode* (**29.075**).

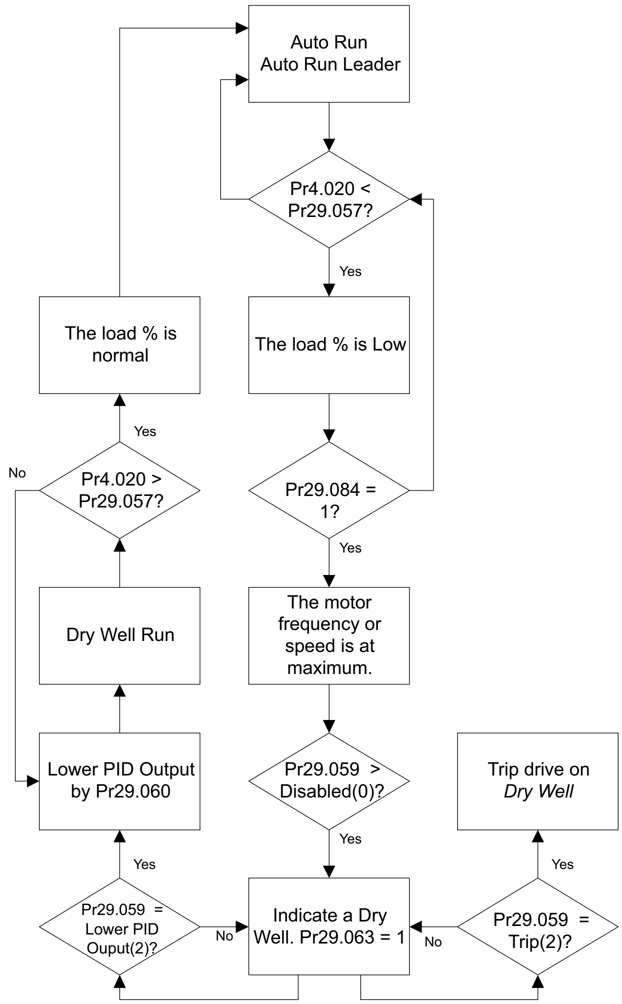
Parameter	00.050 (29.057) *Dry Well Low Load Detection Threshold Percent*		
Short description	Sets the percentage PID output level below which Dry Well is detected		
Mode	Open-Loop		
Minimum	0.0	**Maximum**	100.0
Default	1.0	**Units**	%
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the load percentage below which a dry well low load condition is detected. *Dry Well Low Load Detection Threshold Percent* (**29.057**) is compared against *Percentage Load* (**04.020**). To complete the dry well low load detection logic the motor frequency or speed must be within the *Maximum Drive Reference Band* (**29.083**).

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then Dry Well Low Load detection is internally disabled.





Parameter	00.051 (29.058) *Dry Well Low Load Detection Delay*		
Short description	Sets the dry well / low load detection delay		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the continuous time in seconds that the load level must be below the *Dry Well Low Load Detection Threshold Percent* (**29.057**) and the motor frequency or speed must be within the *Maximum Drive Reference Band* (**29.083**) to detect a dry well low load condition. *Dry Well Low Load Detection Delay* (**29.058**) filters out any intermittent Dry Well Low Load conditions.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then Dry Well Low Load detection is internally disabled.

Parameter	00.052 (29.059) *Dry Well Low Load Mode*		
Short description	Selects the action taken when dry well / low load is detected		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	3
Default	0	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

Mode	Value	Description
Disabled	0	The Dry Well Low Load detection system is disabled.
Alarm Only	1	If a Dry Well Low Load condition is detected, an alarm is raised where *Dry Well Low Load Alarm Output* (**29.062**) = On(1).
Trip	2	If a Dry Well Low Load condition is detected, a Dry Well trip is actioned.
Lower PID Output	3	If a Dry Well Low Load condition is detected, the PID output is lowered by the *Dry Well Low Load PID Output Reduction* (**29.060**) value thereby limiting potential damage to the pump. When the load value is above the *Dry Well Low Load Detection Threshold Percent* (**29.057**), the PID output is restored. *Operating Status* (**29.003**) = Dry Well Run when the PID output has been reduced due to a dry well condition.

If a Dry Well condition is detected in a Cascade system, *Pump Control Mode* (**29.011**) = Cascade the Soft Starters will be stopped to prevent pump wear. The Soft Starters will automatically restart when the Dry Well condition has finished.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then Dry Well Low Load detection is internally disabled.

Parameter	00.053 (29.060) *Dry Well Low Load PID Output Reduction*		
Short description	A percentage to lower the PID output by during Dry Well / Low Load		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	100.00
Default	50.00	**Units**	%
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW		

When *Dry Well Low Load Mode* (**29.059**) = Lower PID Output, if a Dry Well Low Load condition is detected, the PID output is lowered by the *Dry Well Low Load PID Output Reduction* (**29.060**) value thereby limiting potential damage to the pump. When the load value is above the *Dry Well Low Load Detection Threshold Percent* (**29.057**), the PID output is restored.

Operating Status (**29.003**) = Dry Well Run when *Dry Well Low Load PID Output Reduction* (**29.060**) has been used to reduce the PID output due to a dry well condition.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then Dry Well Low Load detection is internally disabled.

Parameter	00.054 (29.061) *Dry Well Low Load Restart Delay*		
Short description	When the drive trips due to low load this is the minimum restart time		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

The defines the minimum time in seconds after the drive has been tripped due to a Dry Well Low Load condition before it can be restarted. This prevents the system from automatically resetting and attempting to run again without there being sufficient time to allow the well or tank to fill again. This is only used when *Dry Well Low Load Mode* (**29.059**) = Trip.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then Dry Well Low Load detection is internally disabled.

Parameter	00.055 (29.069) *No Flow Detection Threshold*		
Short description	Sets the speed / frequency below which no flow will be detected		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	Open-Loop: 60.0 RFC-A \ RFC-S: 3000.0
Default	0.0	**Units**	
Type	32 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW		

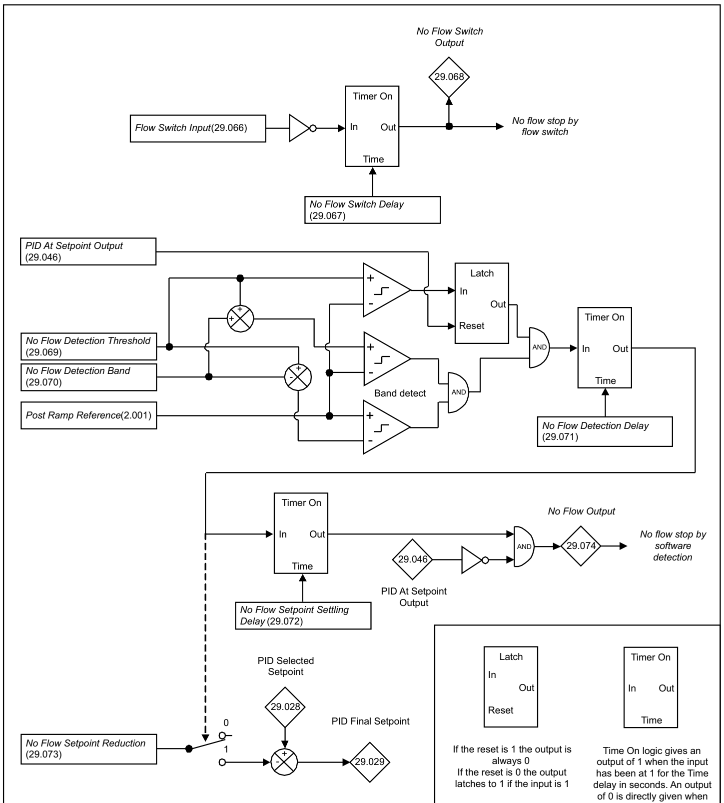
When *No Flow Detection Threshold* (**29.06**9) is > 0, software detection of no flow is enabled. This defines the frequency or speed threshold below which software based no flow is detected. This must be set to the greater of the *Positive Minimum Reference Clamp* (**01.004**) OR the *Sleep Detect Speed Threshold* (**29.051**) + *No Flow Detection Band* (**29.070**). In the event of a closed pump discharge, the main process PID feedback will rise causing the motor frequency or speed to dip below this level.

When *No Flow Detection Threshold* (**29.069**) = 0, software detection of no flow is disabled.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then then no flow detection when running in Auto mode is disabled.

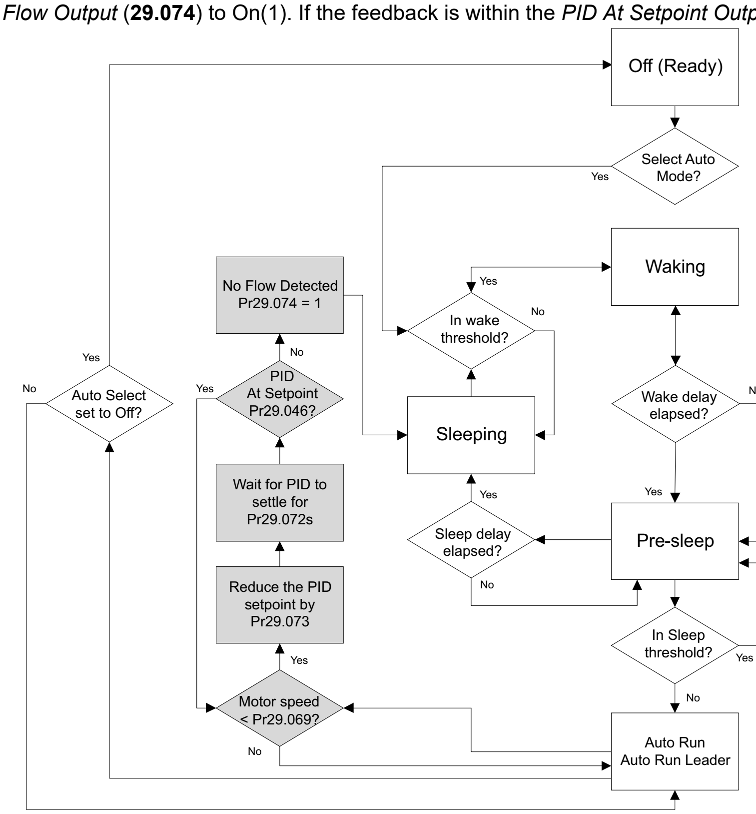
In the event that a no flow is detected, *Operating Status* (**29.003**) will transition to Sleeping and the motor will stop.



No Flow Detection

The No Flow by software detection scheme is made up of four stages:

1. Is the motor frequency or speed is < *No Flow Detection Threshold* (**29.069**)? If yes, move to the next step.
2. Is the motor frequency or speed within the *No Flow Detection Band* (**29.070**) for *No Flow Detection Delay* (**29.071**) seconds? If yes, move to the next step.
3. Reduce the main process PID setpoint by *No Flow Setpoint Reduction* (**29.073**) and wait for the *No Flow Setpoint Settling Delay* (**29.072**) to elapse. Is the PID is unable to follow the new setpoint? If yes, move to the next step.
4. Stop the system and set *No Flow Output* (**29.074**) to On(1). If the feedback is within the *PID At Setpoint Output* (**29.046**) window, move to step 1.



Parameter	00.056 (29.070) *No Flow Detection Band*		
Short description	A time that the now flow condition must be detected for before taking action.		
Mode	Open-Loop		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the frequency or speed band used by the software no flow detection scheme. It is recommended to set this to 10 % of the *Maximum Reference Clamp* (**01.006**). In the event of a closed pump discharge, the PID feedback will rise causing the motor frequency or speed to dip into this band.

This is only used when *No Flow Detection Threshold* (**29.069**) is > 0. See *No Flow Detection Threshold* (**29.069**) for details on the no flow by software detection process.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* (**29.003**) will transition to Sleeping and the motor will stop.

See *No Flow Detection Threshold* (**29.069**).

Parameter	00.057 (29.071) *No Flow Detection Delay Pipe Fill Reference*		
Short description	A time that the now flow condition must be detected for before taking action.		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.0	**Maximum**	6553.5
Default	5.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the continuous time in seconds that the motor frequency or speed must be below the *No Flow Detection Threshold* (**29.069**) to complete stage 1 of the no flow by software detection scheme. *No Flow Detection Delay* (**29.071**) filters out any intermittent No Flow conditions.

This is only used when *No Flow Detection Threshold* (**29.069**) is > 0. See *No Flow Detection Threshold* (**29.069**) for details on the no flow by software detection process.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* (**29.003**) will transition to Sleeping and the motor will stop.

See *No Flow Detection Threshold* (**29.069**).

Parameter	00.058 (29.072) *No Flow Setpoint Settling Delay*		
Short description	A settling delay applied after the setpoint had been reduced by the no flow software detection		
Mode	Open-Loop		
Minimum	0.0	**Maximum**	6553.5
Default	1.0	**Units**	s
Type	16 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	1
Coding	RW, BU		

This defines the continuous time in seconds that the no flow by software detection scheme will wait after applying the *No Flow Setpoint Reduction* (**29.073**) before checking if the main process PID is able to track the change in setpoint. If the main process PID isn't able to track the change in setpoint a no flow by software detection stop is actioned and *No Flow Output* (**29.074**) is set to On(1).

This is only used when *No Flow Detection Threshold* (**29.069**) is > 0. See *No Flow Detection Threshold* (**29.069**) for details on the no flow by software detection process.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* (**29.003**) will transition to Sleeping and the motor will stop.

See *No Flow Detection Threshold* (**29.069**).

Parameter	00.059 (29.073) *No Flow Setpoint Reduction*		
Short description	Used to reduce the setpoint in user feedback units when no flow is detected		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.00	**Maximum**	2.55
Default	0.06	**Units**	UU
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW, BU		

This defines the main process PID setpoint reduction value used in stage 2 of detecting no flow by software. After applying the *No Flow Setpoint Reduction* (**29.073**) and waiting for the *No Flow Setpoint Settling Delay* (**29.072**) to elapse, the software will check to see if the main process PID hasn't been able to track the change in setpoint; if it hasn't then software no flow is detected and the system will stop.

This is only used when *No Flow Detection Threshold* (**29.069**) is > 0. See *No Flow Detection Threshold* (**29.069**) for details on the no flow by software detection process.

NOTE

If the main process PID has been disabled via *PID1 Enable* (**14.008**), then then no flow detection when running in Auto mode is disabled.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

In the event that a no flow is detected, *Operating Status* (**29.003**) will transition to Sleeping and the motor will stop.

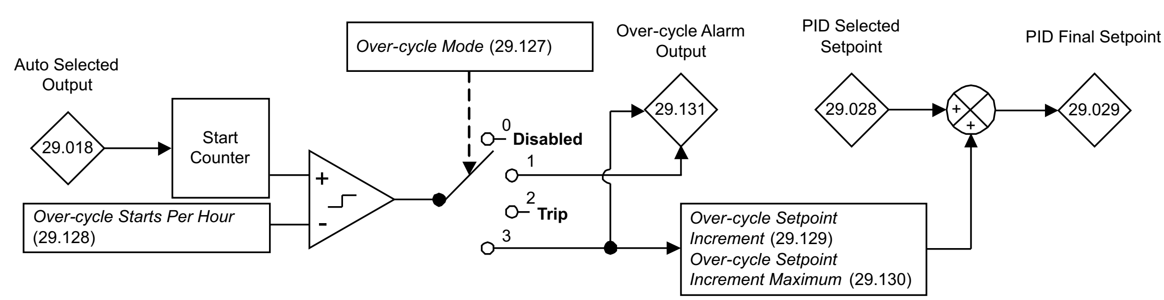
See *No Flow Detection Threshold* (**29.069**).

Parameter	00.060 (29.127) *Over-cycle Mode*		
Short description	Sets what the system will do when the over-cycle starts per hour limit is reached		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	3
Default	1	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, TE, BU		

This defines the over-cycle protection mode used by Single Pump, and when the drive is a Leader in a Cascade or Multi-Leader system. Soft Starter Assist over-cycle is always enabled and is handled separately; See *Assist Starts Per Hour* (**29.120**) and *Assist Over-cycle Mode* (**29.121**).

The following over-cycle modes are available:

Mode	Value	Description
Disabled	0	Over-cycle protection is disabled.
Alarm Only	1	When the *Over-cycle Starts Per Hour* (**29.128**) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* (**29.131**)
Trip	2	When the *Over-cycle Starts Per Hour* (**29.128)** has been reached the system will trip Over-cycle.
Inc Setpoint	3	When the *Over-cycle Starts Per Hour* (**29.128**) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* (**29.131**) and the PID setpoint will be increased by the *Over-cycle Setpoint Increment* (**29.129**) in order to keep the system running. The maximum amount that the PID setpoint can be increased by is set by *Over-cycle Setpoint Increment Maximum* (**29.130**). An alarm is given via the *Over-cycle Alarm Output* (**29.131**) when *Over-cycle Setpoint Increment Maximum* (**29.130**) is reached. This helps prevent the system from going to sleep as often thereby reducing the number of starts per hour. An alternative to this is to use *PID1 Pre-sleep Boost Level* (**14.028**) and *PID1 Pre-Sleep Maximum Boost Time* (**14.029**).



Over-cycle Protection

Parameter	00.061 (29.128) *Over-cycle Starts Per Hour*		
Short description	Sets the maximum number of starts per hour thrshold for the over-cycle protection		
Mode	Open-Loop		
Minimum	0	**Maximum**	255
Default	5	**Units**	
Type	8 Bit User Save	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, BU		

Sets the maximum number of starts per hour threshold for the over-cycle detection system. The internal count of starts is reset every hour. See *Over-cycle Mode* (**29.127**) for more details.

Parameter	00.064 (14.010) *PID1 Proportional Gain*		
Short description	Defines the Kp gain used for PID1		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.000	**Maximum**	4.000
Default	2.000	**Units**	
Type	16 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	3
Coding	RW		

PID1 is used as the main process PID controller by the Pump software.

PID1 Proportional Gain (**14.010**) is the main process PID1 loop proportional gain. The default value of 2.000 is a good starting point for most applications. CT Scope may be used to tune the main process PID loop once the drive is operational to refine the performance according to the applications needs.

See *PID1 Output* (**14.001**).

Parameter	00.065 (14.011) *PID1 Integral Gain*		
Short description	Defines the Ki gain used for PID1		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0.000	**Maximum**	4.000
Default	2.000	**Units**	
Type	16 Bit User Save	**Update Rate**	Background read
Display Format	Standard	**Decimal Places**	3
Coding	RW		

PID1 is used as the main process PID controller by the Pump software.

PID1 Integral Gain (**14.011**) is the main process PID1 loop integral gain. The default value of 1.000 is a good starting point for most applications. CT Scope may be used to tune the main process PID loop once the drive is operational to refine the performance according to the applications needs.

See *PID1 Output* (**14.001**).

Parameter	00.066 (14.020) *PID1 Reference*		
Short description	Displays the value of the reference for PID1		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	-100.00	**Maximum**	100.00
Default		**Units**	%
Type	16 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	2
Coding	RO, ND, NC, PT		

PID1 is used as the main process PID controller by the Pump software.

PID1 Reference (**14.020**) indicates the level of the PID1 reference, which is the sum of the parameter pointed to by *PID1 Reference Source* (**14.003**) and *PID1 Digital Reference* (**14.025**), multiplied by *PID1 Reference Scaling* (**14.023**), in percent units.

Reference

The reference section for the PID controllers is shown in the introduction. The pre-sleep boost control is only included in PID controller 1. The reference sections are always active even if the PID controller itself is disabled or the reference sources are not routed to valid parameters. If a reference source is not a valid parameter or is 0.000 then the value is taken as zero.

The reference is the sum of the reference source, the *PID1 Digital Reference* (**14.025**) and the *PID1 Pre-sleep Boost Level* (**14.028**) when it is active. The result is multiplied by *PID1 Reference Scaling* (**14.023**) and then limited to +/-100.00 %. The reference can then be inverted if required (*PID1 Reference Invert* (**14.005**) = 1) and then a slew rate limit is applied with *PID1 Reference Slew Rate* (**14.007**). This limits the maximum rate of change so that a change from 0.00 to 100.00 % takes the time given in *PID1 Reference Slew Rate* (**14.007**).

Parameter	00.067 (14.021) *PID1 Feedback*		
Short description	Displays the value of the feedback for PID1		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	-100.00	**Maximum**	100.00
Default		**Units**	%
Type	16 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	2
Coding	RO, ND, NC, PT		

PID1 is used as the main process PID controller by the Pump software.

PID1 Feedback (**14.021**) indicates the level of the PID1 feedback, which is the sum of the parameter pointed to by *PID1 Feedback Source* (**14.004**) and *PID1 Digital Feedback* (**14.026**), multiplied by *PID1 Feedback Scaling* (**14.024**), in percent units.

Feedback

The feedback section for the PID controllers is shown in the introduction. The feedback sections are always active even if the PID controller itself is disabled or the feedback sources are not routed to valid parameters. If a feedback source is not a valid parameter or is 0.000 then the value is taken as zero.

The feedback is the sum of the feedback source and the *PID1 Digital Feedback* (**14.026**). The result is multiplied by *PID1 Feedback Scaling* (**14.024**) and then limited to +/-100.00 %. A square root function can be applied (*PID1 Feedback Square Root Enable 1* (**14.060**) = 1) and the feedback can then be inverted if required (*PID1 Feedback Invert* (**14.006**) = 1). The square root function is defined as follows.

Square root function output = Sign(Input) x 100.00 % x √(|Input| / 100.00 %)

where Sign(Input) = 1 if Input ≥ 0 or -1 otherwise

The square root function is useful in applications where the PID controller is operating with air flow as its reference and feedback and the motor is controlling a fan. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √Pressure the square root function can be used in the conversion.

Parameter	00.068 (14.001) *PID1 Output*		
Short description	Displays the output for Main Process PID1		
Mode	Open-Loop		
Minimum	-100.00	**Maximum**	100.00
Default		**Units**	%
Type	16 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	2
Coding	RO, ND, NC, PT		

PID1 is used as the main process PID controller by the Pump software.

Controller

The controller section for the PID controllers is shown in the introduction. The structure of PID controller 1 shown in the introduction is when *PID1 Mode Selector* (**14.059**) = 0, *PID1 Feedback Output Scaling* (**14.058**) = 1.000, and *PID1 Feedback Square Root Enable 2* (**14.062**) = 0. The additional features provided by these parameters are not available for PID controller 2, and so this controller always has the structure shown. If the combined enable is inactive then all internal states are held at zero and the destination parameter will be defined by *PID1 Feed-forwards Reference* (**14.019**) alone. If the enable is active the PID controller is active even if the destination is not routed to a valid parameter or to 0.000. It should be noted that if either of the enable sources is routed to 0.000 or to a non-valid parameter the source value is taken as 1, therefore with default settings, *PID1 Enable Source 1* (**14.009**) = 0.000 and *PID1 Enable Source 2* (**14.027**) = 0.000, the PID controller can be enabled by simply setting *PID1 Enable* (**14.008**).

PID1 Error (**14.022**) is the difference between the reference and feedback produced by the reference and feedback systems described in the previous sections. The PID controller output is defined as follows:

PID1 Output (**14.001**) = *PID1 Error* (**14.022**) x [Kp + Ki/s + sKd/(0.064 s + 1)]

Kp = *PID1 Proportional Gain* (**14.010**)

Ki = *PID1 Integral Gain* (**14.011**)

Kd = *PID1 Differential Gain* (**14.012**)

Therefore:

1. If *PID1 Error* (**14.022**) = 100.00% the proportional term gives a value of 100.00 % if *PID1 Proportional Gain* (**14.010**) = 1.000.
2. If *PID1 Error* (**14.022**) = 100.00% the integral term gives a value that increases linearly by 100.00 % per second if *PID1 Integral Gain* (**14.011**) = 1.000.
3. If *PID1 Error* (**14.022**) increases linearly by 100.00 % per second the differential term gives a value of 100.00% if *PID1 Differential Gain* (**14.012**) = 1.000. (A filter with a time constant of 64 ms is provided on the differential gain to reduce the noise produced by this term.)

The output may be limited to a range that is less than the maximum range of *PID1 Output* (**14.001**) using *PID1 Output Upper Limit* (**14.013**) and *PID1 Output Lower Limit* (**14.014**). If *PID1 Output Lower Limit* (**14.014**) > *PID1 Output Upper Limit* (**14.013**) then the output is held at the value defined by *PID1 Output Upper Limit* (**14.013**). If *PID1 Symmetrical Limit Enable* (**14.018**) = 1 then the lower limit = -(*PID1 Output Upper Limit* (**14.013**)). If the output reaches either of these limits the integral term accumulator is frozen until the output moves away from the limit to prevent integral wind-up. The integral hold function can also be enabled by the user by setting *PID1 Integral Hold* (**14.017**) = 1.

PID1 Output Scaling (**14.015**) can be used to scale the output, which is limited to a range from -100.00 % to 100.00 % after this function. The output is then added to *PID1 Feed-forwards Reference* (**14.019**) and is again limited to the range from -100.00 % to 100.00 % before being routed to the destination defined by *PID1 Destination* (**14.016**).

Parameter	00.069 (05.001) *Output Frequency*		
Short description	Displays the frequency applied to the motor		
Mode	Open-Loop		
Minimum	VM_SPEED_FREQ_REF[MIN]	**Maximum**	VM_SPEED_FREQ_REF[MAX]
Default		**Units**	Hz
Type	32 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	1
Coding	RO, FI, VM, ND, NC, PT		

If *Enable Frequency Slaving* (**03.013**) = 0 the *Output Frequency* (**05.001**) is the sum of the *Post Ramp Reference* (**02.001**) and the motor slip compensation frequency. If *Enable Frequency Slaving* (**03.013**) = 1 the *Output Frequency* (**05.001**) is given directly by the *Frequency Slaving Demand* (**03.001**).

Parameter	00.069 (03.002) *Speed Feedback*		
Short description	Displays the speed feedback from the selected feedback source		
Mode	RFC-A, RFC-S		
Minimum	VM_SPEED[MIN]	**Maximum**	VM_SPEED[MAX]
Default		**Units**	
Type	32 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	1
Coding	RO, FI, VM, ND, NC, PT		

The speed feedback can be selected with *Motor Control Feedback Select* (**03.026**) to be taken from either of the drive position feedback interfaces or from a position feedback interface in a position feedback category option module. It is also possible to selected sensorless speed feedback with *RFC Feedback Mode* (**03.024**). *Speed Feedback* (**03.002**) shows the level of the speed feedback selected for the speed controller.

The FI attribute is set for this parameter, so display filtering is active when this parameter is viewed with one of the drive keypads. The value held in the drive parameter (accessible via comms or an option module) does not include this filter, but is a value that is obtained over a sliding 16 ms period to limit the ripple. The speed feedback includes quantisation ripple given by the following equation in rpm:

Ripple in *Speed Feedback* (**03.002**) = 60 / 16 ms / Position resolution

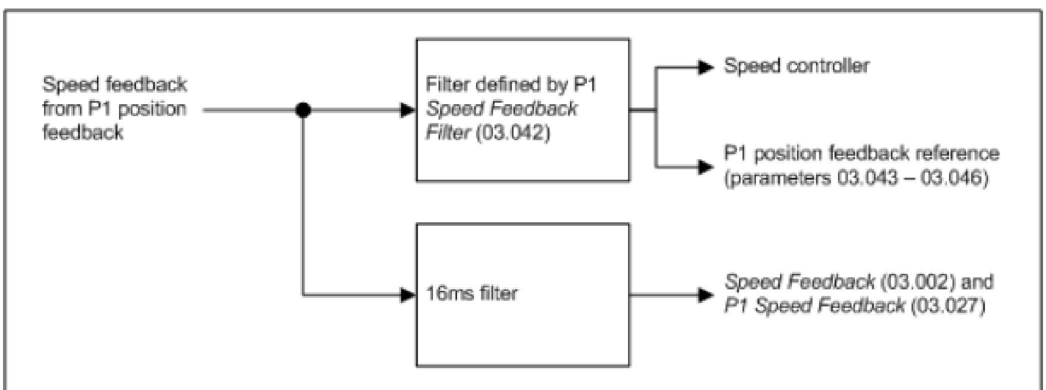
The ripple for a linear system is given by the following equation in mm/s:

Ripple in *Speed Feedback* (**03.002**) = Pole pitch in mm / 16 ms / Position resolution

The position resolution for each type of feedback device is defined in the table below.

Position feedback device	Position resolution
AB, AB Servo	4 x lines per revolution or pole pitch
FD, FR, FD Servo, FR Servo	2 x lines per revolution or pole pitch
SC, SC Hiperface, SC EnDat, SC SSI, SC Servo	1024 x sine waves per revolution or pole pitch
EnDat, SSI, BiSS	Comms bits per revolution or pole pitch
Resolver	See *P1 Resolver Excitation* (**03.066**)

For example the ripple in Speed Feedback (**03.002**) when a 4096 line AB type encoder is used is 0.23 rpm. It should be noted that no filtering is applied to the speed feedback used by the speed controller or for the position feedback reference system unless the feedback filter for that particular interface is activated by putting a non-zero value in the appropriate set up parameter (i.e. P1 Feedback Filter (**03.042**) for the P1 drive position feedback interface). The diagram below shows the filtering applied to the speed feedback when this is taken from the P1 drive position feedback interface.



Speed feedback filtering for P1 position feedback interface

The speed feedback ripple seen by the speed controller and the position feedback reference is given by the following equations when the filter set up value *P1 Feedback Filter* (**03.042**) = 0.

Ripple for a rotary system in rpm = 60 / Speed controller sample time / Position resolution

Ripple for a linear system in mm/s = Pole pitch in mm / Speed controller sample time / Position resolution

The speed controller sample time is 250 μs. If the filter set up value is non-zero the ripple is given by:

Ripple for a rotary system in rpm = 60 / Filter time / Position resolution

Ripple for a linear system in mm/s = Pole pitch in mm / Filter time / Position resolution

The description so far covers the P1 drive position feedback interface. Similar filtering is provided with the P2 drive position feedback interface and with position feedback interfaces in position feedback category option modules.

It is not advisable to use the speed feedback filter unless it is specifically required for high inertia applications with high controller gains, or if commutation signals alone are used for feedback, because the filter has a non-linear transfer function. It is preferable to use the current demand filters (*Current Reference Filter 1 Time Constant* (**04.012**) or *Current Reference Filter 2 Time Constant* (**04.023**)) as these are linear first order filters that provide filtering on noise generated from both the speed reference and the speed feedback. It should be noted that any filtering included within the speed controller feedback loop, either on the speed feedback or the current demand, introduces a delay and limits the maximum bandwidth of the controller for stable operation.

The speed ripple seen by the speed controller can be quite high in some cases, for example with a 4096 line encoder the speed ripple is 14.6 rpm with a sample time of 250 μs. This causes high frequency torque ripple and acoustic motor noise. These effects increase with the level of speed feedback ripple and with the gains used in the speed controller. Therefore high speed feedback ripple usually limits the maximum possible gain settings for the speed controller, and so a position feedback device with high position resolution is usually required for a system with high dynamic performance or stiffness. **It should be noted that the ripple caused by feedback quantisation and does not define speed feedback resolution. The speed controller accumulates all pulses from the position feedback, and so the speed controller resolution is not limited by the feedback, but by the resolution of the speed reference.**

Parameter	00.070 (04.020) *Percentage Load*		
Short description	Shows the level of torque producing current as a percentage of rated torque producing current for the motor		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_USER_CURRENT[MIN]	**Maximum**	VM_USER_CURRENT[MAX]
Default		**Units**	%
Type	16 Bit Volatile	**Update Rate**	Background write
Display Format	Standard	**Decimal Places**	1
Coding	RO, FI, VM, ND, NC, PT		

Percentage Load (**04.020**) gives the Iq, *Torque Producing Current* (**04.002**) as a percentage of the rated torque producing current for the motor. Positive values indicate motoring and negative values represent regenerating.

Parameter	00.071 (05.003) *Output Power*		
Short description	Displays the power flowing via the a.c. terminals of the drive		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	VM_POWER[MIN]	**Maximum**	VM_POWER[MAX]
Default		**Units**	kW
Type	32 Bit Volatile	**Update Rate**	4 ms write
Display Format	Standard	**Decimal Places**	3
Coding	RO, FI, VM, ND, NC, PT		

The Output Power (**05.003**) is the power flowing via the a.c. terminals of the drive. The power is derived as the dot product of the output voltage and current vectors, and so this is correct even if the motor parameters are incorrect and the motor model does not align the reference frame with the flux axis of a motor in RFC-A mode. For Open-loop, RFC-A and RFC-S modes a positive value of power indicates power flowing from the drive to motor. For Regen mode a positive value of power indicates power flowing from the supply to the regen drive.

Parameter	00.072 (07.028) *Analog Input 1 Current Loop Loss*		
Short description	Displays when analog input 1 falls below 3mA		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	1
Default		**Units**	
Type	1 Bit Volatile	**Update Rate**	Background write
Display Format	Standard	**Decimal Places**	0
Coding	RO, ND, NC, PT		

By default, analog input 1 T5 is routed to the Pump and Fan software analog feedback input parameter *PID Feedback Percen*t (**29.034**). This parameter provides feedback to the Pump and Fan software on the integrity of the main process PID feedback device current loop.

If Analog Input 1 Mode (**07.007**) is set to any of the 4-20 mA or 20-4 mA modes and the current falls below 3 mA then *Analog Input 1 Current Loop Loss* (**07.028**) is set to one. If the current is more than 3 mA or any other mode is selected then *Analog Input 1 Current Loop Loss* (**07.028**) is set to zero.

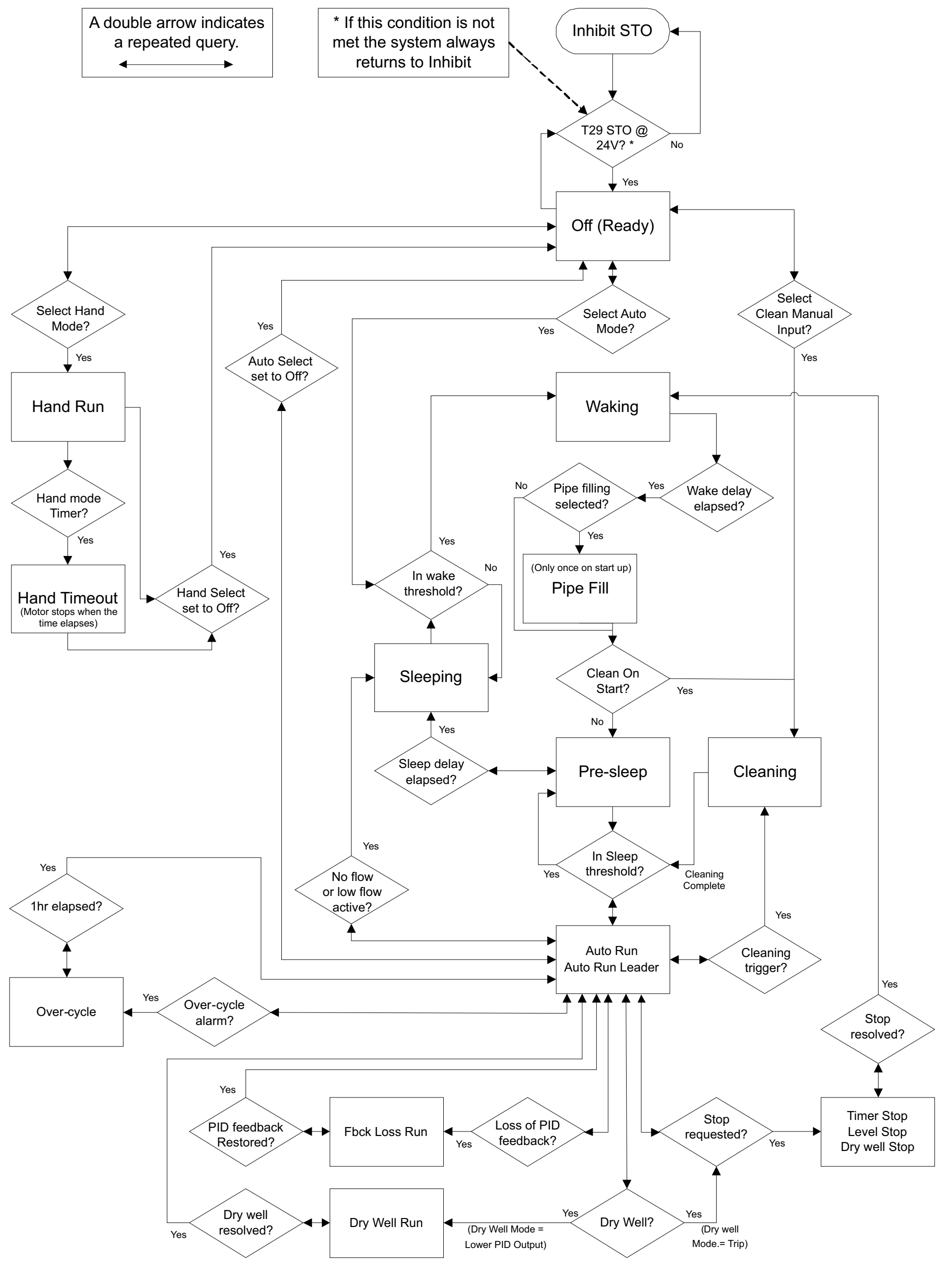
Parameter	00.073 (29.003) *Operating Status*		
Short description	Indicates which operating state the drive is in		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	18
Default	0	**Units**	
Type	8 Bit Volatile	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	0
Coding	RW, PR, TE, NC, PT, BU		

Value	Text
0	Inhibit STO
1	Off (Ready)
2	Hand Run
3	Waking
4	Pipe Fill
5	Auto Run
6	Auto Run Leader
7	Auto Run Assist
8	Pre-sleep
9	Sleeping
10	Cleaning
11	Level Stop
12	Timer Stop
13	Hand Timeout
14	Over-cycle
15	Fbck Loss Run
16	Dry Well Run
17	Dry Well Stop
18	Auto Stop Assist

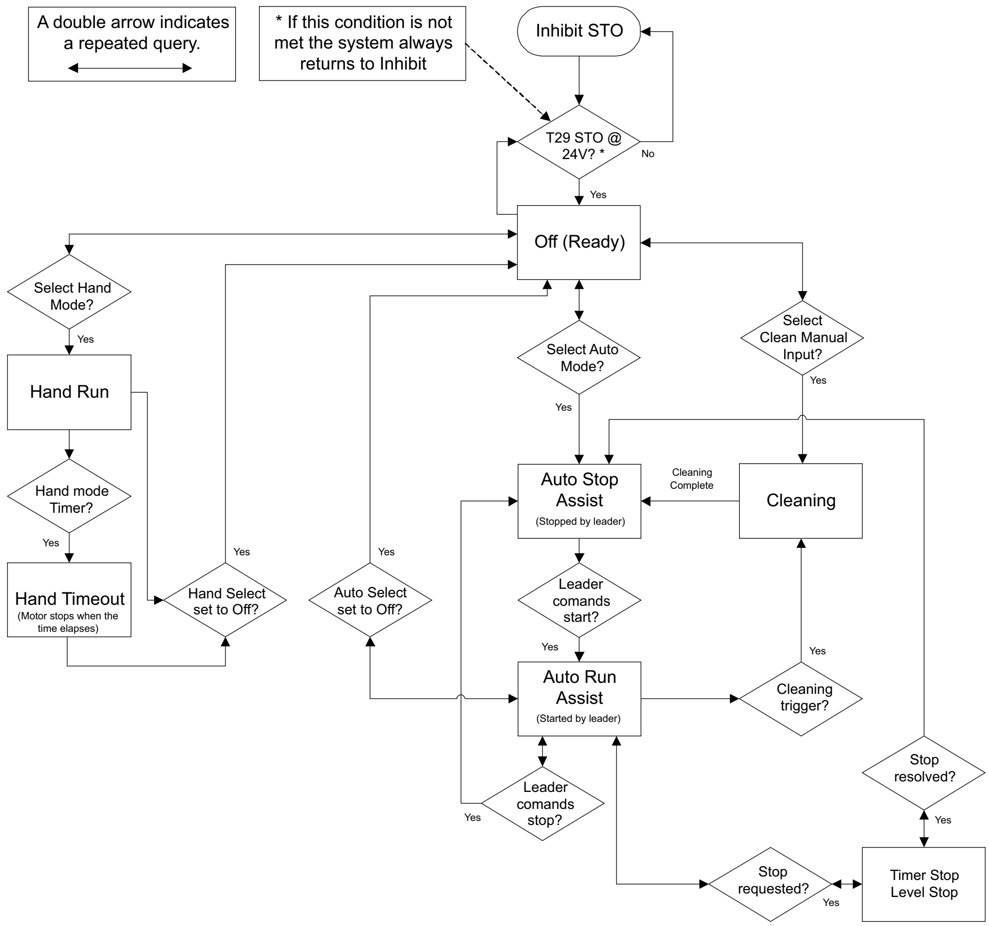
This parameter indicates the operating status of the pump software. This forms an important diagnostic aid which tells the user what the system is doing at any moment and why e.g. if the pump has gone to sleep or stopped the operating status will indicate why. The following table shows all of the status values:

Mode	Value	Description
Inhibit STO	0	The drive is inhibited i.e. the STO input on drive terminal T29 is at 0 V. To enable the drive to move to the Off (Ready) state, apply 24 V to drive terminal T29.
Off (Ready)	1	The drive is hardware enabled and is waiting for a command to run i.e. Off.
Hand Run	2	The drive is running in Hand mode from a fixed speed reference.
Waking	3	The drive is in the process of waking i.e. the Wake Detect Delay (**29.050**) is timing.
Pipe Fill	4	The automated pipe filling routine is running.
Auto Run	5	The drive is running in Single Pump control in Auto mode
Auto Run Leader	6	The drive is running in Cascade or Multi-leader control in Auto mode as a Leader.
Auto Run Assist	7	The drive is running in Multi-leader control in Auto mode as an Assist
Pre-sleep	8	The drive is in pre-sleep i.e. the output frequency or speed is less than Sleep Detect Speed Threshold (**29.051**) and the Sleep Detect Delay (**29.052**) is counting down. This is shown for a short period when starting in Auto mode while the PID output builds up.
Sleeping	9	The drive is in Auto mode but has gone to sleep. The system enters Sleeping when the motor speed or frequency value satisfies the Sleep Detect Speed Threshold (**29.051**), if no flow from a flow switch, no flow by software detection or low flow is detected.
Cleaning	10	The drive is running the cleaning or de-ragging routine.
Level Stop	11	The system has stopped due to the high level switch being reached. See Level Switch High Input (**29.079)**. This many be overridden by Hand or Manual Clean operation.
Timer Stop	12	The system has stopped because the timer switch input is not set to On indicating a timer shut-down period. See Time Schedule Run Input Enable (**29.055)** and Time Schedule Run Input (**29.056**). This many be overridden by Hand or Manual Clean operation.
Hand Timeout	13	The system was stopped while running in Hand mode after the Hand Mode Timeout (**29.017**) elapsed. To reset this deselect and reselect Hand mode.
Over-cycle	14	The system has detected an over-cycle condition. The drive has started too many times in this hour. See Over-cycle Mode (**29.127**) and Over-cycle Starts Per Hour (**29.128**).
Fbck Loss Run	15	Analog Input 1 Current Loop Loss (**07.028**) = On(1) indicating that there is a current loop loss for the main process PID feedback, and PID Feedback Loss Action (**29.048**) = Fixed Speed where the drive is running with
Dry Well Run	16	A dry well low load condition has been detected and the drive is running with a reduced reference as defined by Dry Well Low Load PID Output Reduction (**29.060**). This state can only be reached when Dry Well Low Load
Dry Well Stop	17	A dry well low load condition has been detected and the drive has tripped on Dry Well, where Dry Well Low Load Mode (**29.059**) = Trip. When this happens the drive will remain stopped in the Dry Well Stop state until the
Auto Stop Assist	18	This indicates that the drive is an assist in a multi-leader system, Auto has been selected but the system leader has not commanded this assist to run.

The following state diagrams show the interactions between the states.



State diagram for Single Pump, Cascade and Multileader (Lead drive)



State diagram for Multi-leader (Assist drive)

Parameter	00.074 (11.078) *NV Media Card Action Status*		
Short description	Shows the status of an action on an NV media card initiated with parameter mm.000.		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	18
Default		**Units**	
Type	8 Bit Volatile	**Update Rate**	Background Write
Display Format	Standard	**Decimal Places**	0
Coding	RO, TE, ND, NC, PT		

Value	Text	Value	Text	Value	Text
0	None	7	Card User Prog	14	Card Full
1	Active	8	Card Busy	15	Card File Error
2	Card Slot 1	9	Card Data Exists	16	Card Rating
3	Card Slot 2	10	Card Option	17	Card File Data
4	Card Slot 3	11	Card Read Only	18	Card Derivative
5	Card Slot 4	12	Card Error	14	Card Full
6	Card Product	13	Card No Data		

This parameter shows the status of any action on an NV media card that is initiated by setting a value in parameter mm.000. When the action starts this parameter changes to Active (1) and if the action completes successfully it changes back to None (0). If however, the action fails this parameter changes to another value to show the cause. Non-critical failures, i.e. an error that is detected when writing to a card, do not cause drive trips as these may disable the drive and disturb the wider system, and so this parameter is a way to find the cause of a non-critical error.

Parameter	00.075 (29.036) *PID Final Feedback*		
Short description	The final PID feedback in user feedback units		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	-327.68	**Maximum**	327.67
Default	0.00	**Units**	UU
Type	16 Bit Volatile	**Update Rate**	Background
Display Format	Standard	**Decimal Places**	2
Coding	RW, PR, NC		

This parameter is the output of the main process PID feedback filter, (see *PID Feedback Filter Time Constant* (**29.033**)), and scaled in to feedback units via *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**).

PID Final Feedback (**29.036)** = *PID Feedback Minimum Scaling* (**29.031**) + (*PID Final Feedback Percent* (**29.035**) * (*PID Feedback Maximum Scaling* (**29.032**) - *PID Feedback Minimum Scaling* (**29.031)**) / 100).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* (**29.031**) and *PID Feedback Maximum Scaling* (**29.032**), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure feedback value with the same scaling.

Parameter	00.077 (29.001) *Pump Software Version*		
Short description	This is the version of the Pump Drive F600 software		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	99999999
Default	0	**Units**	
Type	32 Bit Volatile	**Update Rate**	Background
Display Format	Version	**Decimal Places**	0
Coding	RW, PR, ND, NC, PT		

This parameter indicates the pump software version number in the format ww.xx.yy.zz e.g. 01.00.00.00.

Parameter	00.078 (10.020) *Trip 0*		
Short description	Shows the current or last trip to have occurred		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	Maximum	255
Default		Units	
Type	8 Bit Power Down Save	Update Rate	Write on trip
Display Format	Standard	Decimal Places	0
Coding	RO, TE, ND, NC, PT, BU		

Refer to Table 12-4*Serial communications look up table on page 455* for full list of trips and descriptions.

Trip 0 (**10.020**) to *Trip 9* (**10.029**) store the most recent 10 trips that have occurred where *Trip 0* (**10.020**) is the most recent and *Trip 9* (**10.029**) is the oldest. When a new trip occurs it is written to *Trip 0* (**10.020**) and all the other trips move down the log, with oldest being lost. The date and time when each trip occurs are also stored in the date and time log, i.e. *Trip 0 Date* (**10.041**) to *Trip 9 Time* (**10.060**). The date and time are taken from Date (**06.016**) and *Time* (**06.017**). Some trips have sub-trip numbers which give more detail about the reason for the trip. If a trip has a sub-trip number its value is stored in the sub-trip log, i.e. *Trip 0 Sub-trip Number* (**10.070**) to *Trip 9 Sub-trip Number* (**10.079**). If the trip does not have a sub-trip number then zero is stored in the sub-trip log.

Trip categories and priorities

Trips are grouped into the categories given in the table below. A trip can only occur when the drive is not tripped, or if it is already tripped and the new trip has a higher priority than the active trip (i.e. lower priority number). Unless otherwise stated a trip cannot be reset until 1.0 s after it has been initiated.

Priority	Category	Trips	Comments
1	Internal faults	HF01 - HF26	These are fatal problems that cannot be reset. All drive features are inactive after any of these trips occur. If a basic keypad is fitted it will show the trip, but the keypad will not function. These trips are not stored in the trip log.
1	Stored HF trip	*Stored HF*	This trip cannot be cleared unless 1299 is entered into Parameter mm.000 (mm.000) and a reset is initiated.
2	Non-resettable trips	Trip numbers 218 to 247, *Slot1 HF, Slot2 HF, Slot3 HF* or *Slot4 HF*	These trips cannot be reset.
3	Volatile memory failure	*EEPROM Fail*	This can only be reset if Parameter mm.000 (mm.000) is set to 1233 or 1244, or if *Load Defaults* (**11.043**) is set to a non-zero value.
4	Internal 24V power supply	*PSU 24V*	
5	Non-volatile media trips	Trip numbers 174, 175 and 177 to 188	These trips are priority 6 during power-up.
5	Position feedback interface power supply	Encoder 1	This trip can override *Encoder 2* to *Encoder 6* trips.
6	Trips with extended reset times	*OI ac, OI Brake*, and *OI dc*	These trips cannot be reset until 10 s after the trip was initiated.
6	Phase loss and d.c. link power circuit protection	*Phase Loss* and *OHt dc bus*	The drive will attempt to stop the motor before tripping if a Phase Loss.000 trip occurs unless this feature has been disabled (see *Action On Trip Detection* (**10.037**). The drive will always attempt to stop the motor before tripping if an *OHt dc bus* occurs.
6	Standard trips	All other trips	

Internal faults

Trips {*HF01*} to {*HF26*} are internal faults that do not have trip numbers. If one of these trips occurs, the main drive processor has detected an irrecoverable error. All drive functions are stopped and the trip message will be displayed on the drive keypad. The error can only be reset by powering the drive down and up again. The table below gives the reasons for internal faults and their corresponding trip.

Trip	Reason
{HF01}	CPU has detected an address error
{HF02}	CPU DMAC has detected an address error
{HF03}	CPU has detected an Illegal opcode
{HF04}	CPU has detected an Illegal slot instruction
{HF05}	An interrupt has occurred that does not have a defined function (Undefined exception)
{HF06}	An interrupt has occurred which is reserved (Reserved exception)
{HF07}	Watchdog failure
{HF08}	CPU Interrupt crash
{HF09}	Free store overflow
{HF10}	Parameter routing system error
{HF11}	Non-volatile memory comms error
{HF12}	Stack overflow. Sub-trip is shown to indicate which stack: 1 - background tasks 2 - timed tasks 3 - main system interrupts
{HF13}	The control hardware is not compatible with the firmware. The sub-trip number gives the actual ID code of the control board hardware.
{HF14}	CPU register bank error
{HF15}	CPU divide error
{HF16}	RTOS error (the background task has returned)
{HF17}	The clock supplied to the control board logic is out of specification
{HF18}	The internal flash memory has failed when writing option module parameter data. Sub-trip is shown to indicate which failure: 1 - Programming error while writing menu in flash 2 - Erase flash block containing setup menus failed 3 - Erase flash block containing application menus failed
{HF19}	Invalid main application firmware CRC. Reprogramming required.
{HF20}	The ASIC is not compatible with the firmware. The sub-trip number displayed is the ASIC version.
{HF23}	If this trip occurs please consult the drive supplier.
{HF24}	If this trip occurs please consult the drive supplier.
{HF25}	If this trip occurs please consult the drive supplier.
{HF26}	The control pod is either a UF90A or a UF99A and is fitted to a power stage that is not compatible because it only provided two phase current feedback. If this trip occurs pleas consult the drive supplier.

When the drive is subsequently powered up a *Stored HF* trip is initiated where the sub-trip number is the number of the HF trip that last occurred. This trip will occur at every power-up until it is reset. The trip can only be reset by first entering 1299 into Parameter mm.000 (mm.000). If the drive is powered up and a *Stored HF* trip occurs, *Onboard User Program: Enable* (**11.047**) is reset to zero to prevent the on-board user program from running. This ensures that the user program can be changed or erased in case it causes an HF trip at every power-up. Once the *Stored HF* is cleared, it is necessary to power cycle the drive or to re-download the user program to allow the program to restart.

Similar trips that can be initiated by the control system or the power system

Trips shown in the table below can be generated either from the drive control system or from the power system. The sub-trip number which is in the form xxyzz is used to identify the source of the trip. The digits xx are 00 for a trip generated by the control system or the number of a power module if generated by the power system. If the drive is not a multi-power module drive then xx will always have a value of 1 indicating the trip is related to the power system. The y digit is used to identify the location of a trip which is generated by a rectifier module connected to a power module. Where the y digit is relevant it will have a value of 1 or more, otherwise it will be 0. The zz digits give the reason for the trip and are defined in each trip description.

Over Volts	*OHt dc bus*
OI ac	*Phase Loss*
OI Brake	*Power Comms*
PSU	*OI Snubber*
OHt Inverter	*Cloning*
OHt Power	*Temp Feedback*
OHt Control	*Power Data*

Braking IGBT

The list below gives conditions that will disable the braking IGBT:

1. *Braking IGBT Upper Threshold* (**06.074**) = 0, or *Low Voltage Braking IGBT Threshold Select* (**06.076**) = 1 and *Low Voltage Braking IGBT Threshold* (**06.075**) = 0.
2. The drive is in the under-voltage state.
3. A priority 1, 2 or 3 trip is active (see *Trip 0* (**10.020**)).
4. One of the following trips is active or would be active if another trip is not already active: OI Brake, PSU, Th Brake Res or OHt Inverter.
5. Percentage Of Drive Thermal Trip Level (**07.036**) = 100 %. This is an indication that some part of the drive is too hot and is used to indicate if an internally fitted braking resistor is too hot.
6. Brake R Too Hot is active or the system has been set up to disable the braking IGBT based on the braking resistor temperature and the resistor is too hot (i.e. bit 2 of *Action On Trip Detection* (**10.037**) is set).

NOTE

The braking IGBT over-current trip cannot be reset until 10s after it is initiated. This period consists of a 9 s period after the trip where the braking IGBT cannot be switched on again and the OI Brake trip is held active and cannot be reset. This 9 s period is followed by the normal 1 s delay, that is present for other trips, before the trip can be reset. During this 1s period it is possible for the braking IGBT to switch on again. If the conditions are still present that caused the trip then the trip will be initiated again with a further 9 s hold-off period etc.

Parameter	00.079 (10.021) *Trip 1*		
Short description	Shows the 2nd from last trip to have occurred		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	255
Default		**Units**	
Type	8 Bit Power Down Save	**Update Rate**	Write on trip
Display Format	Standard	**Decimal Places**	0
Coding	RO, TE, ND, NC, PT, BU		

See *Trip 0* (**10.020**).

Parameter	00.080 (10.022) *Trip 2*		
Short description	Shows the 3rd from last trip to have occurred		
Mode	Open-Loop, RFC-A, RFC-S		
Minimum	0	**Maximum**	255
Default		**Units**	
Type	8 Bit Power Down Save	**Update Rate**	Write on trip
Display Format	Standard	**Decimal Places**	0
Coding	RO, TE, ND, NC, PT, BU		

See *Trip 0* (**10.020**).

6.2 Parameter descriptions

6.2.1 Pr mm.000

Pr **mm.000** is available in all menus, commonly used functions are provided as text strings in Pr **mm.000** shown in Table . The functions in Table can also be selected by entering the appropriate numeric values (as shown in Table 6-1) in Pr **mm.000**. For example, enter 7001 in Pr **mm.000** to erase the file in NV media card location 001.

Table 6-1 Functions in Pr mm.000

Value	Action
1000	Save parameters when *Under Voltage Active* (Pr **10.016**) is not active and *Low Under Voltage Threshold Select* mode (Pr **06.067** = Off) is not active.
1001	Save parameter under all conditions
1070	Reset all option modules
1233	Load standard (50 Hz) defaults
1234	Load standard (50 Hz) defaults to all menus except option module menus (i.e 15 to 20 and 24 to 28)
1244	Load US (60 Hz) defaults
1245	Load US (60 Hz) defaults to all menus except option module menus (i.e 15 to 20 and 24 to 28)
1253	Change drive mode and load standard (50 Hz) defaults
1254	Change drive mode and load US (60 Hz) defaults
1255	Change drive mode and load standard (50 Hz) defaults except for menus 15 to 20 and 24 to 28
1256	Change drive mode and load US (60 Hz) defaults except for menus 15 to 20 and 24 to 28
1299	Reset {Stored HF} trip.
2001*	Create a boot file on a non-volatile media card based on the present drive parameters including all Menu 20 parameters
4yyy*	NV media card: Transfer the drive parameters to parameter file xxx
5yyy*	NV media card: Transfer the onboard user program to onboard user program file xxx
6yyy*	NV media card: Load the drive parameters from parameter file xxx or the onboard user program from onboard user program file xxx
7yyy*	NV media card: Erase file xxx
8yyy*	NV Media card: Compare the data in the drive with file xxx
9555*	NV media card: Clear the warning suppression flag
9666*	NV media card: Set the warning suppression flag
9777*	NV media card: Clear the read-only flag
9888*	NV media card: Set the read-only flag
9999*	NV media card: Erase and format the NV media card
59999	Delete onboard user program
12000**	Only display parameters that are different from their default value. This action does not require a drive reset.
12001**	Only display parameters that are used to set-up destinations (i.e. DE format bit is 1). This action does not require a drive reset.
40yyy	Back-up all drive data.
60yyy	Load all drive data.

* See Chapter 9 *NV Media Card Operation* on page 317 for more information on these functions.

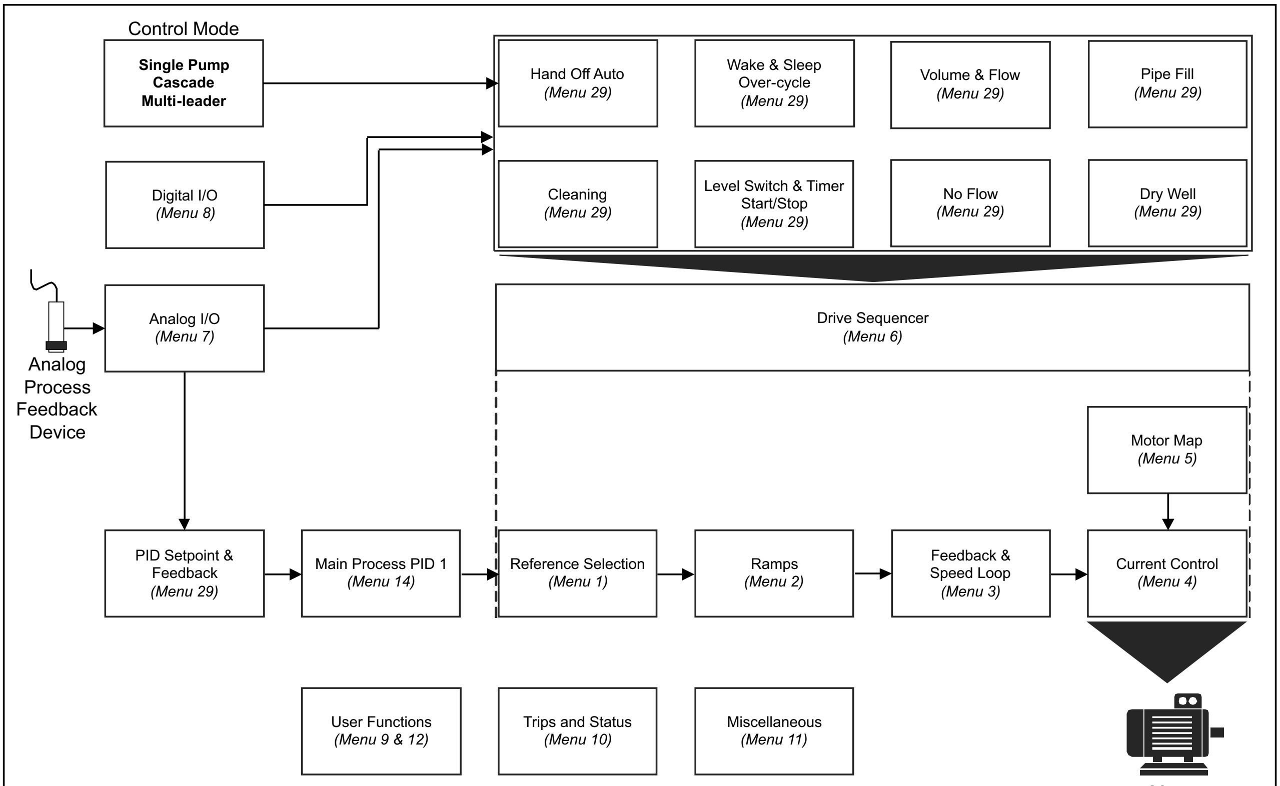
** These functions do not require a drive reset to become active. All other functions require a drive reset to initiate the function.

To allow easy access to some commonly used functions, refer to the table overleaf. Equivalent values and strings are also provided in the table above.

7 Functional descriptions

7.1 Parameter menu and functionality overview

The diagram below shows the functionality of the F600 and which parameter menus Handle it.



Functional Overview

7.2 Control mode and feature matrix

The following table shows the features available in each control mode, as selected by Pr **29.011**(0.021).

Feature	Single Pump	Cascade	Multi-leader
Main process PID control.	✓	✓	✓
Auxiliary PID control.	✓	✓	✓
Multiple PID setpoints.	✓	✓	✓
Wake and sleep setpoints.	✓	✓	✓
Over-cycle protection.	✓	✓	✓
Main process PID feedback high / low detection.	✓	✓	✓
Flow and volume indication (100Hz max. pulsed input).	✓	✓	✓
No flow detection (flow switch, flow meter, software detection).	✓	✓	✓
Keypad Hand, off and Auto controls.	✓	✓	✓
HMI / PLC control, status and alarm words	✓	✓	✓
Run time indication.	✓	✓	✓
Analog or digital Hand reference.	✓	✓	✓
Timer start and stop using keypad real time clock.	✓	✓	✓
Level switch control (start and stop).	✓	✓	✓

Feature	Single Pump	Cascade	Multi-leader
External equipment fault input.	✓	✓	✓
Fault log.	✓	✓	✓
Auto reset.	✓	✓	✓
Dynamic V/F energy saving (open loop induction motors).	✓	✓	✓
Loss of PID feedback transducer Handling.	✓	✓	✓
Dry well low load detection.	✓	✓	✓
Pipe filling routine.	✓	✓	✓
Pump cleaning (de-ragging).	✓	✓	✓
Pump starting order alternation.	✓	✓	✓
Cascade control - may require SI-I/O options, (24 V signal control of up to 2 soft starters).	✓	✓	✓
Multi-leader control - requires SI-Ethernet options, (Ethernet based coordination of up to 3 F600 drives).	✓	✓	✓

*A limited feature set is available

7.3 Control modes

The F600 supports 3 different control modes for single or parallel pumps. *Pump Control Mode* Pr **29.011** (0.021) sets the control mode as described in the following table.

Control Mode	Description
Single Pump (Simplex) (Default)	This is for a single pump installation running from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference. *Single Pump* is the default control mode.
Cascade (Duty Assist)	This is for a single leader pump drive with up to 2 cascaded assist pumps powered by soft starters. The soft starters are commanded with simple digital I/O from the leader pump drive; the leader drive may require an SI-I/O option to Handle the assist control signals, e.g. when Assist Control Mode Pr **29.106** = Full I/O. The application may run from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference.
Multi-leader (Multiplex)	This is for a multi-leader pump installation where up to 3 pumps, controlled by F600 pump drives, are in the system. The role of leader drive is cycled between the pump drives, after a user set time, to even out pump wear. The leader drive requests assist pumps over an Ethernet network; each drive requires an SI-Ethernet option with >=V01.07.03.03 firmware to facilitate the control. The application may run from a local Hand mode reference or in Auto mode using the main process PID controller to maintain a setpoint e.g. pressure or flow or level. Alternatively, if PID control isn't required in Auto mode, the drive can run from a fixed speed reference. This has improved redundancy compared to the other modes where any drive can assume the role of leader in the event of a fault. In the event of a faulty PID feedback transducer, the leader can use the feedback from another drive via the Ethernet connection between drives.

Note that changes to the control mode will only take effect while the system is not running:

- Hand mode must not be selected e.g. *Hand Selec*t Pr **29.013** = *Off(0)*.
- Auto mode must not be selected e.g. *Auto Select* Pr **29.015** = *Off(0).*
- Manual cleaning must not be selected e.g. Clean Manual Input Pr **29.088** = *Off(0)*.

7.4 Drive controls

The main operating modes for the F600 are Hand and Auto modes.

Hand mode is where the drive runs from a fixed frequency or speed reference for where the process PID loop is disabled. This is intended for localised manual control over the drive system.

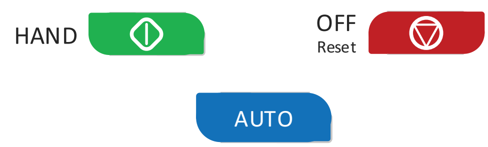
Auto mode is where the drive typically runs using the main process PID controller with a suitable feedback transducer, e.g. pressure transducer, to maintain a constant setpoint. This is intended for Autonomous control over the drive system. While running in Auto mode the following features are available to respond to common system requirements:

- PID high / low detection
- Wake and sleep based on PID demand
- No flow stop by software detection or flow switch
- Low flow stop based on pulsed flow meter
- Dry well detection

- Pipe filling
- PID feedback loss Handling
- Automatic cleaning
- Level switch control

7.4.1 Control input mode

The way that Hand and Auto modes may be selected depends on the *Control Input Mode* Pr **29.012**(0.024). The following selections are available.

Mode	Description
Input	In this mode the control logic is supplied to local bit type inputs such as *Hand Select Input* Pr **29.013** or *Auto Select Input* Pr **29.015**. The user is intended to direct digital inputs to all bit type input parameters to be controlled.
Input & Keypad (Default)	In this mode the control logic to apply either a Hand or Auto or to stop commands comes from either the Keypad HAND, OFF and AUTO buttons or from the digital inputs directed to *Hand Select Input* Pr **29.013** or *Auto Select Input* Pr **29.015**. In this mode of control the keypad can be used to start and stop the drive, however, the keypad controls will be overridden by *Hand Select Input* Pr **29.013** or *Auto Select Input* Pr **29.015** if they are used. When the keypad is overridden, any selections made by it are reset. To activate Hand or Auto controls on the keypad press and hold the required function key for 2 s. The Off key activates with a short press.  All other local bit type control inputs are Handled the same as *Input*. *Input & Keypad* is the default control input mode.
Ctrl Wrd	In this mode, control inputs are exclusively Handled by *Pump Control Word 1* Pr **29.151** and *Pump Control Word 2* Pr **29.152** i.e. the local bit type inputs are ignored. This intended for PLC control, where most PLCs have hardware I/O to Handle devices such as flow switches.
Ctrl Wrd & Input	In this mode, control inputs may be asserted via *Pump Control Word 1* Pr **29.151** and *Pump Control Word 2* Pr **29.152** or by the equivalent local bit type inputs such as the *Flow Switch Input* Pr **29.066**. This intended for HMI control, where most HMIs don't have hardware I/O, and the F600 Pump drive I/O is used for devices like flow switches, but the HMI is used to select Hand or Auto mode

7.4.2 Control, status and alarm

The following tables shows the Control, Status and Alarm words with their respective equivalent bit type parameters. The control, status and alarm words are used when *Control Input Mode* Pr **29.012**(0.024) = *Ctrl Wrd or Ctrl Wrd & Input.*

The equivalent parameters are used when *Control Input Mode* Pr **29.012**(0.024) = *Input or Input & Keypad or Ctrl Wrd & Input*. 24 V Digital I/O is configured as the source or destination for the equivalent parameters, see I/O section 7.4.4.

Table 7-1 *Pump Control Word* 1 Pr 29.151 and equivalent control parameters.

Bit	Equivalent parameter	Function
0	*Drive Enable* Pr **06.015**.	Remote software disable input via *Drive Enable* Pr **06.015**. This is in addition to the drive's STO input. Note that bit 0 is not a safety input.
1	*Drive Reset* Pr **10.033**.	Resets the drive from a trip when set to 1
2	*Hand Select Input* Pr **29.013**.	Selects Hand mode when set to 1.
3	N/A	Reserved
4	*Auto Select Input* Pr **29.015**.	Selects Auto mode when set to 1.
5	*Reset Volume Input* Pr **29.010**.	Resets *Volume* Pr **29.004** to 0 when set to 1.
6	*PID Setpoint Select Input 0* Pr **29.026**.	Used to select between the 4 different main process PID setpoints, *PID Setpoint 0* Pr **29.022** to *PID Setpoint 3* Pr **29.025**
7	*PID Setpoint Select Input 1* Pr **29.027**.	
8	*Time Schedule Run Input* Pr **29.056**.	In Auto mode, if *Time Schedule Run Input Enable* Pr **29.055** = *On(1)*, the time schedule run input must be set to 1 when the system must run and 0 when the system must stop.
9	*Flow Switch Input* Pr **29.066**.	A system flow switch may be routed to this input where 1 = flow, 0 = No flow.
10	*Level Switch High Input* Pr **29.079**.	In Auto mode, when set to 1, the system will stop. This is routed to a sensor that detects when the liquid level is at the maximum.

Bit	Equivalent parameter	Function
11	*Level Switch Low Input* Pr **29.080**.	In Auto mode, when set to 1, the system will restart. This is routed to a sensor that detects when the liquid level is at the minimum level.
12	*External Pump Fault Input* Pr **29.085**.	This is used to indicate to the pump that there is a system fault and the drive must stop. 1 = fault, 0 = OK.
13	*Motor Thermal Protection Input* Pr **29.086**.	This is used to input a signal from a normally closed thermal switch where 1 = OK, 0 = too hot.
14	*Clean Manual Input* Pr **29.088**	If Hand or Auto mode are not selected, setting the manual clean input to 1 runs a cleaning cycle. Cleaning continues run for as long as this input remains at 1.
15	N/A	A system HMI or PLC must toggle this bit 0 to 1 to 0 continuously. At least once per second is recommended with the default setting of *Pump Control Word Watchdog Time* Pr **29.150**.

Table 7-2 *Pump Control Word 2* Pr 29.152 and equivalent control parameters.

Bit	Equivalent parameter	Function
0	*Assist 1 Ready Input* Pr **29.108**.	Used in Cascade mode by assist 1 to indicate when it is ready to run e.g. healthy. 1 = Ready, 0 = Not ready.
1	*Assist 1 Running Input* Pr **29.109**	Used in Cascade mode by assist 1 to indicate when it is running. 1 = Running, 0 = Not running.
2	*Assist 2 Ready Input* Pr **29.114**.	Used in Cascade mode by assist 2 to indicate when it is ready to run e.g. healthy. 1 = Ready, 0 = Not ready.
3	*Assist 2 Running Input* Pr **29.115.**	Cascade mode assist 2 running input. 1 = Running, 0 = Not running.

Table 7-3 *Pump Status Word 1* Pr 29.153 and equivalent status parameters.

Bit	Equivalent parameter	Function
0	*Auto Selected Output* Pr **29.018.**	When set to 1, indicates that Auto mode has been selected.
1	*Hand Selected Output* Pr **29.019**.	When set to 1, indicates that Hand mode has been selected.
2	*Auto Operational Output* Pr **29.021**.	When set to 1, indicates that Auto mode has been selected, and the system may be running or sleeping due to the system demand.
3	*Auto Running Output* Pr **29.020**.	When set to 1, indicates that Auto mode has been selected, and the system is running.
4	*PID Software Enable* Pr **29.038**.	When set to 1, indicates that the Pump software is commanding the main process PID to enable. *PID1 Enable* Pr **14.008** may be used to override this bit and disable the PID in Auto mode.
5	*PID At Setpoint Output* Pr **29.046**.	When set to 1, indicates that the main process PID is at setpoint.
6	*PID Feedback Low Output* Pr **29.047**.	When set to 1, indicates that the main process PID is either lower than *PID At Setpoint Band* Pr **29.045** or less than *PID Feedback Low Threshold* Pr **29.044**.
7	*Sleep Required Output* Pr **29.053**.	When set to 1, indicates that the motor frequency or speed has dropped into *Sleep Detect Speed Threshold* Pr **29.051** and *Sleep Detect Delay* Pr **29.052** is timing out.
8	*Sleep Active Output* Pr **29.054**.	When set to 1, indicates that the drive has entered the Sleeping state due to low system demand.
9	*Pipe Fill Done Output* Pr **29.078**.	When set to 1, indicates that the pipe filling routine has completed.
10	*Clean Active Output* Pr **29.104**.	When set to 1, indicates that the Pump Drive F600 is running a cleaning cycle.
11	N/A	Cleaning was triggered due to load current threshold as configured by *Clean On Load Current Low Threshold* Pr **29.099** or Clean On Load Current High Threshold pr **29.098**.
12	N/A	Cleaning was triggered due to motor load accumulator build up as indicated by *Motor Overload Alarm* Pr **10.017**.
13	N/A	Cleaning was triggered due to the *Clean On Interval Time* Pr **29.096** elapsing.
14	N/A	Cleaning was triggered on start up. See *Clean On Start* Pr **29.089**.
15	N/A	Cleaning was triggered due to *Clean Manual Input* Pr **29.088** being set to 1.

Table 7-4 *Pump Status Word* 2 Pr 29.154 and equivalent status parameters.

Bit	Equivalent parameter	Function
0	*Assist 1 Run Output* Pr **29.107**.	Used in Cascade mode by assist 1 to command when the soft starter must run. 1 = Run, 0 = Do not run.
1	*Assist 2 Run Output* Pr **29.113**.	Used in Cascade mode by assist 2 to command when the soft starter must run. 1 = Run, 0 = Do not run.

Table 7-5 *Pump Alarm Word* Pr 29.155 and equivalent alarm parameters.

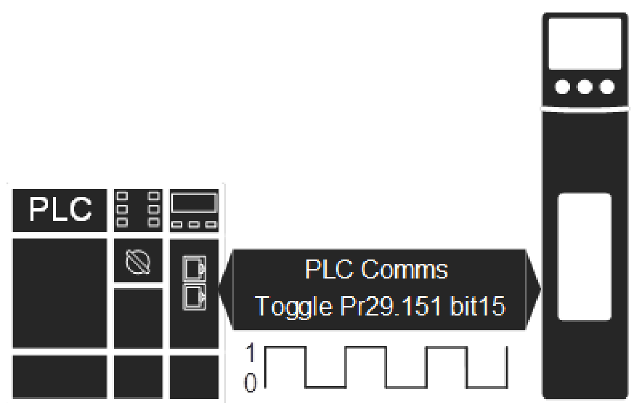
Bit	Equivalent parameter	Function
0	*No Flow Switch Output* Pr **29.068**	When set to 1, indicates that no flow from a flow switch has been triggered.
1	*No Flow Output* Pr **29.074**	When set to 1, indicates that no flow detected by the no flow software has been triggered.
2	*Low Flow Meter Stop Output* Pr **29.065**	When set to 1, indicates that low flow detected by a flow meter has been triggered. See *Low Flow Meter Stop Threshold* Pr **29.063**
3	*At Maximum Drive Reference* Pr **29.084**	When set to 1, indicates that the F600 Pump drive output frequency or speed is in the *Maximum Drive Reference Band* Pr **29.083**.
4	*PID Feedback High Alarm Output* Pr **29.040**	When set to 1, indicates that the main process PID feedback level is greater than *PID Feedback High Alarm Threshold* Pr **29.039**.
5	*Clean Per Hour Alarm Output* Pr **29.105**	When set to 1, indicates that *Clean Per Hour Limit* Pr **29.100** has been reached.
6	*Over-cycle Alarm Output* Pr **29.131**	When set to 1, indicates that Pr **29.128** *Over-cycle Starts Per Hour limit* has been reached.
7	*Dry Well Low Load Alarm Output* Pr **29.062**	When set to 1, indicates that a Dry well has been detected.
8	N/A	Reserved
9	*Assist 1 Lockout Output* Pr **29.112**	When set to 1, indicates that Cascade mode assist 1 has started too many times in an hour and is now locked out. *Assist 1 Lockout Countdown* Pr **29.111** indicates the remaining time until it is allowed to start.
10	*Assist 2 Lockout Output* Pr **29.118**	When set to 1, indicates that Cascade mode assist 2 has started too many times in an hour and is now locked out. *Assist 1 Lockout Countdown* Pr **29.111** indicates the remaining time until it is allowed to start.

7.4.2.1 Control Word watchdog

Pump Control Word Watchdog Time Pr **29.150** is used to give an indication if there is a communications failure between a connected PLC or HMI and the F600.

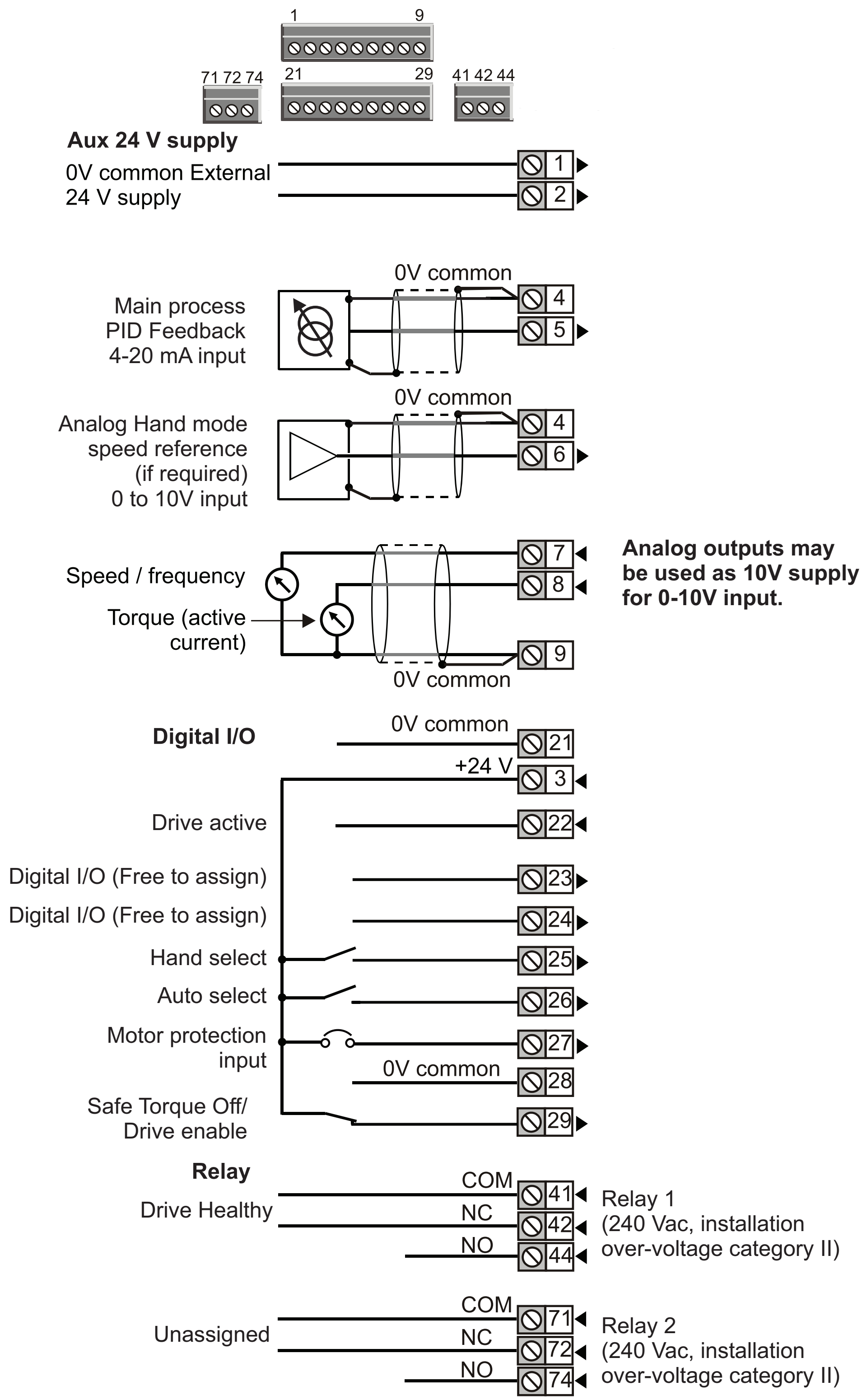
If *Pump Control Word Watchdog Time* Pr **29.150** is set to 0 the watchdog feature is disabled.

If *Pump Control Word Watchdog Time* Pr **29.150** is set to >0 the watchdog feature is enabled. The maximum time allowed without a state of *Pump Control Word 1* Pr **29.150** bit 15 is defined by *Pump Control Word Watchdog Time* Pr **29.150**, change and where the watchdog bit must be toggled 1 to 0 or 0 to 1 inside this time period by the PLC or HMI, otherwise a *Ctrl Wrd Watchdg* trip will occur, stopping the system. The watchdog is only started after the first time a change in the state of *Pump Control Word* Pr **29.151** bit 15 is seen.



7.4.3 I/O Terminals

The diagram below shows the F600 I/O terminals and their default assignment. The assignment can be customised if required.



7.4.4 I/O Assignment

I/O must be assigned for systems that use hard wired I/O for the control, i.e. *Control Input Mode* Pr **29.012**(0.024) = Input or Input & Keypad or Ctrl Wrd & Input. The F600 has 6 different types of I/O available:

- 3x 24 V digital inputs
- 3x 24 V user configured digital inputs or outputs
- 2x 4 - 20 mA or 0 to 10 v analog inputs
- 2x 4 - 20 mA or 0 to 10 v analog outputs
- 2x 240 V relay outputs
- 2x 24 V Supply

All of these I/O types are assigned in the same manner, where the I/O needs a source or destination parameter pointer, i.e. a place for the signal data to go to or to come from. For example, to assign Digital I/O 2 as a flow switch input set *Digital I/O 02 Source/Destination* Pr **8.022** to **29.066** (Flow Switch Input).

Care must be taken that the source / destination parameter used is of the correct type for the I/O e.g. a bit type (On/Off) parameter for a digital input or a numerical value for an analog input.

Table 7-2 Digital I/O terminals and configuration parameters

Terminal	Function	I/O Status	Invert	Source / Destination	Output Select	Default Source / Destination
22	24 V Input / Output 1	Pr 8.001	Pr 8.011	Pr 8.021	Pr 8.031	Drive Running 1.011
23	24 V Input / Output 2	Pr 8.002	Pr 8.012	Pr 8.022	Pr 8.032	Free to assign 0.000
24	24 V Input / Output 3	Pr 8.003	Pr 8.013	Pr 8.023	Pr 8.033	Free to assign 0.000
25	24 V Input 4	Pr 8.004	Pr 8.014	Pr 8.024	N/A	Hand Select Input 29.013
26	24 V Input 5	Pr 8.005	Pr 8.015	Pr 8.025	N/A	Auto Select Input 29.015
27	24 V Input 6	Pr 8.006	Pr 8.016	Pr 8.026	N/A	Motor Thermal Protection 29.086
29	STO Input	Pr 8.009	N/A	N/A	N/A	N/A
3	24 V Supply Output (May be used as a control output)	Pr 8.008	Pr 8.018	Pr 8.028	N/A	Free to assign 0.000
2	24 V Supply Input (May be used as a control input)	Pr 8.043	Pr 8.053	Pr 8.063	N/A	Free to assign 0.000
1, 4, 9, 21, 28	0 V common	N/A	N/A	N/A	N/A	N/A

Table 7-3 Relay output terminals and configuration parameters.

Terminal	Function	I/O Status	Invert	Source / Destination	Default Source / Destination
41 Com 42 NC 44 NO	240 V Relay Output 1	Pr 8.007	Pr 8.017	Pr 8.027	Drive Healthy 10.001
71 Com 72 NC 74 NO	240 V Relay Output 2	Pr 8.045	Pr 8.055	Pr 8.065	Free to assign 0.000

Table 7-4 Analog I/O terminals and parameters

Terminal	Function	I/O Status	Mode	Scaling	Invert	Source / Destination	Default Source / Destination
5	Analog Input 1	Pr 7.001	Pr 7.007	Pr 7.008	Pr 7.009	Pr 7.010	PID Feedback 29.034
6	Analog Input 2	Pr 7.002	Pr 7.011	Pr 7.012	Pr 7.009	Pr 7.014	Hand Mode Analog Ref1.036
7	Analog Output 1	N/A	Pr 7.007	Pr 7.020	N/A	Pr 7.019	Frequency / Speed 5.001 / 3.002
8	Analog Output 2	N/A	Pr 8.032	Pr 7.023	N/A	Pr 7.022	Torque Current 4.002
1, 4, 9, 21, 28	0 V common	N/A	N/A	N/A	N/A	N/A	N/A

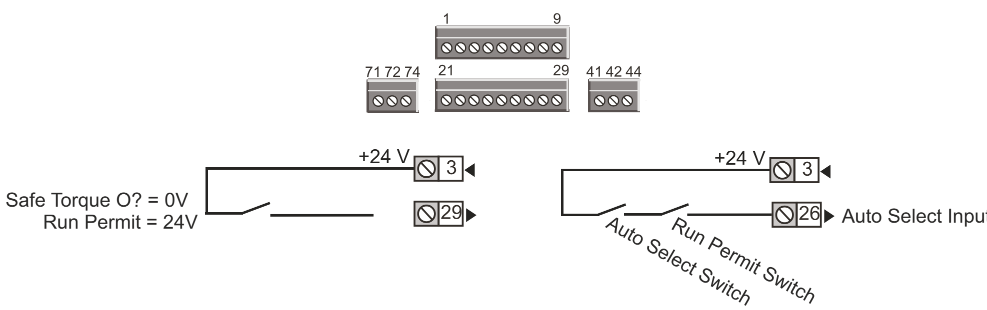
Note that the analog outputs may be used as a 10 V supply for a Hand mode speed potentiometer; set the source parameter for the analog output to an unused application parameter e.g. 18.011, and then set Pr **18.011** to 32767 (the parameter maximum) to give a 10 V output. If the source parameter for an analog output is set to its maximum, the analog output is also set to the maximum of 10 V. Save the parameters by setting Pr **0.000** to *Save Parameters* and press the red reset button .


Please see the advanced parameters section, menus 7 and 8 for more information.

7.4.5 Run permit

For systems that require a run permit, i.e. a run command signal in addition to the Auto Mode Select input, the following solutions area available:

- The STO input may be used as a run permit input for systems where the pump may coast to a stop when the run permit signal is removed.
- The Auto input may be interrupted by an additional switch contact for systems where the pump must decelerate to a stop when the run permit signal is removed.

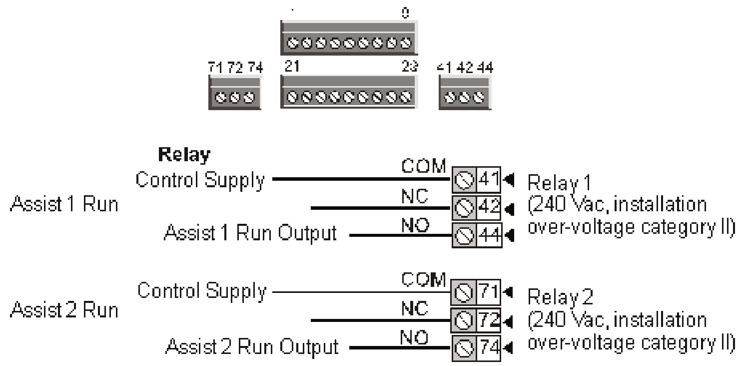


7.4.6 Cascade (run only)

When Cascade mode is selected, *Pump Control Mode* Pr **29.011** = *Cascade*, and *Assist Control Mode* Pr **29.106** = *Run Only*, a single run signal is used to start an assist soft starter. This signal may be sent to the soft starter by a relay output or by 24 V digital output, whichever is the most suitable for the system.

7.4.6.1 Run by relay output

The following terminal diagram shows the additional connections for the run output control relays, that command the soft starters to run.

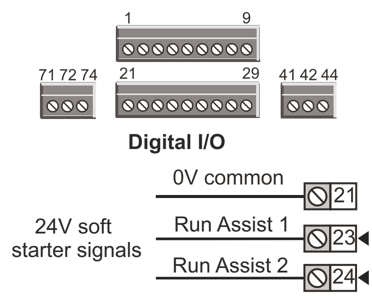


The control parameter source for the relay must be configured to control the relays. The following parameter settings must be made to use this configuration:

- *Relay Output Source* Pr **8.027** = 29.107
- *Relay 2 Source* Pr **8.065** = 29.113
- Set Pr0.000 to *Save Parameters* and press the red reset button

7.4.6.2 Run by 24 V digital output

The following terminal diagram shows the additional connections for the 24 V digital outputs that command the soft starter to run.



The control parameter source must be configured to control the digital I/O and they must be assigned as outputs. The following parameter settings must be made to use this configuration:

- *Digital I/O 02 Source/Destination* Pr **8.022** = 29.107
- *Digital I/O 03 Source/Destination* Pr **8.023** = 29.113
- *Digital I/O 02 Output Select* Pr **8.032** = *On(1)*
- *Digital I/O 03 Output Select* Pr **8.033** = *On(1)*
- Set Pr **0.000** to *Save Parameters* and press the red reset button

7.4.7 Cascade (Full I/O)

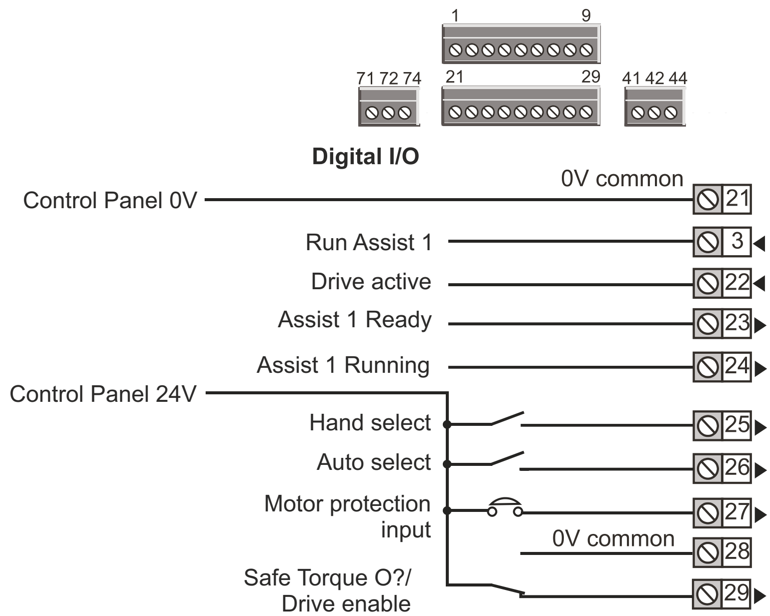
When Cascade mode is selected, *Pump Control Mode* Pr **29.011** = *Cascade*, and *Assist Control Mode* Pr **29.106** = *Full I/O*, assist soft starters will be controlled using Run output, Ready Input and Running Input. Using the drives existing hardware, the drive can control:

- A single soft starter with feedback, where the drives 24V supply output is used to supply the run signal. A control panel 24 V supply is required for the motor protection input, Hand and Auto select inputs.
- Other combinations are possible by rearranging the flexible I/O.

With the addition of an SI-I/O module, 2 assist soft starters with feedback is possible using 24 V digital I/O.

7.4.7.1 Single soft starter with full I/O

The following terminal diagram shows the connections for the 24 V digital I/O to command the soft starter to run and receive feedback using the Pump Drive F600 I/O.



The control parameter source and destinations must be configured to control the digital I/O and they must be assigned as outputs. The following parameter settings must be made to use this configuration:

Digital I/O 02 Source/Desination Pr **8.022** = 29.108

Digital I/O 03 Source/Destination Pr **8.023** = 29.109

24 V Supply Input Destination Pr **8.063** = 29.107

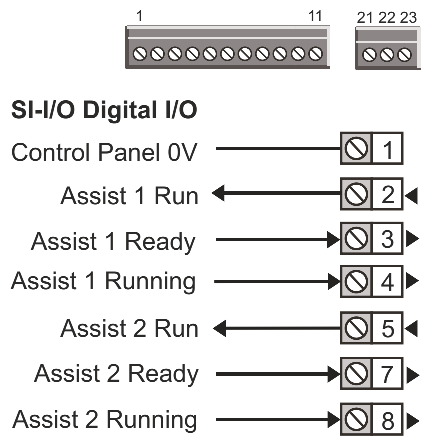
Digital I/O 02 Output Select Pr **8.032** = *Off(0)*

Digital I/O 03 Output Select Pr **8.033** = *Off(0)*

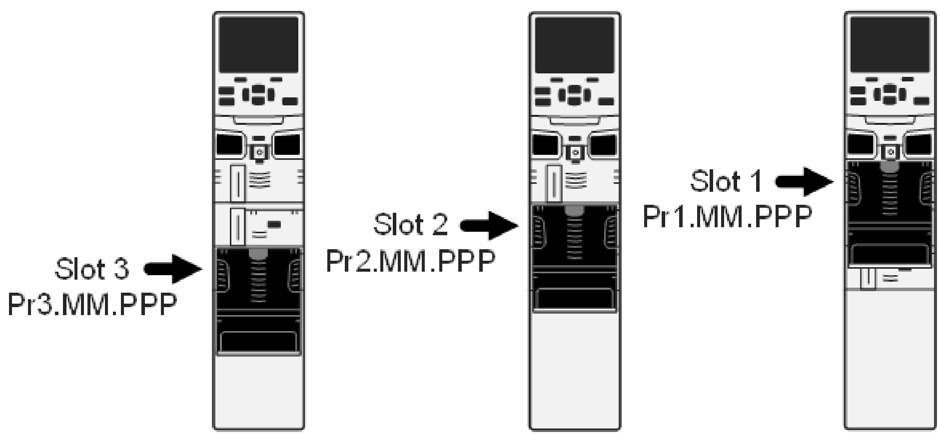
Set Pr **0.000** to *Save Parameters* and press the red reset button

7.4.7.2 Dual soft starters with full I/O

The following terminal diagram shows the additional connections for the 24 V digital I/O to command the soft starter to run and receive feedback using an SI-I/O option module.



The control parameter source and destinations must be configured to control the digital I/O and they must be assigned as inputs or outputs as required. To do this the parameter Menu for the slot that the SI-I/O option is fitted in must be known.



MM= menu number, PPP = parameter number.

The following parameter settings must be made to use this configuration, where the slot number S = 1, 2 or 3 as identified in the previously:

Digital I/O 01 Source/Destination PrS. **02.021**= 29.107 (Assist 1 Run)

Digital I/O 02 Source/Destination PrS. **02.022** = 29.108 (Assist 1 Ready)

Digital I/O 03 Source/Destination PrS. **02.023** = 29.109 (Assist 1 Running)

Digital I/O 01 Source/Destination PrS. **02.024**= 29.113 (Assist 2 Run)

Digital I/O 02 Source/Destination PrS. **02.025** = 29.114 (Assist 3 Ready)

Digital I/O 03 Source/Destination PrS. **02.026** = 29.115 (Assist 4 Running)

T2 Digital I/O 1 Mode PrS. **01.011** = *On(1)*

T3 Digital I/O 2 Mode PrS.**01.012** = *Off(0)*

T4 Digital I/O 3 Mode PrS.**01.013** = *Off(0)*

T5 Digital I/O 4 Mode PrS.**01.014** = *On(1)*

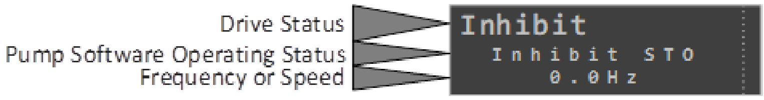
T7 Input 5 Mode PrS.**01.015** = *Digital Input(0)*

T8 Input 5 Mode PrS.**01.016** = *Digital Input(0)*

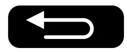
Set Pr **0.000** to Save Parameters and press the red reset button

7.5 Pump software operating status

The default status display shows the *Drive Status* Pr **29.101**, the *Pump software Operating Status* Pr **29.003**(0.073) and the *Output Frequency* Pr **5.001**(0.069) or *Speed Feedback* Pr **3.002**(0.069).

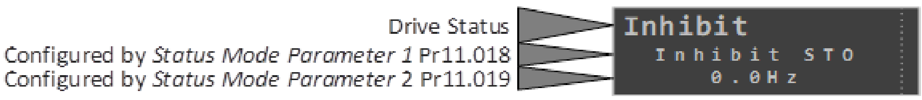


The default status display will be Automatically shown after 4 minutes if no buttons are pressed, or to show it quickly press the Escape button on the keypad.



The bottom 2 rows of the display may be easily customised to suit to the application requirements, although it is highly recommended to keep the *Operating Status* Pr **29.003**(0.073) displayed.

The following diagram illustrates the parameters responsible for configuring the bottom 2 rows of the status display:



Status Mode Parameter 1 Pr **11.018** and *Status Mode Parameter 2* Pr **11.019** are parameter pointers, where the value entered is the parameter number that should be displayed. Any MM.PPP format parameter may be used, however some common parameter selections are given in the table below:

Parameter	Name
1.021	Auto Mode Reference (Single Pump, Cascade or Multi-leader (lead drive)
1.028	Multi-leader assist reference
2.001	Post Ramp Reference
3.002	Speed Feedback (in closed loop mode only)
4.020	Percentage load
5.001	Output Frequency
5.003	Output Power
14.020	PID Reference (in % units)
14.021	PID Feedback (in % units)
14.022	PID Error (in % units)
29.002	Total Run Time
29.003	Operating Status
29.004	Volume
29.005	Flow
29.029	PID Final Setpoint (in user units)
29.036	PID Final Feedback (in user units)
29.037	PID Error (in user units)

To adjust *Status Mode Parameter* 1 Pr **11.018** and *Status Mode Parameter 2* Pr 1**1.019**, *Menu Access Level* Pr **0.001** must be set to All Menus.

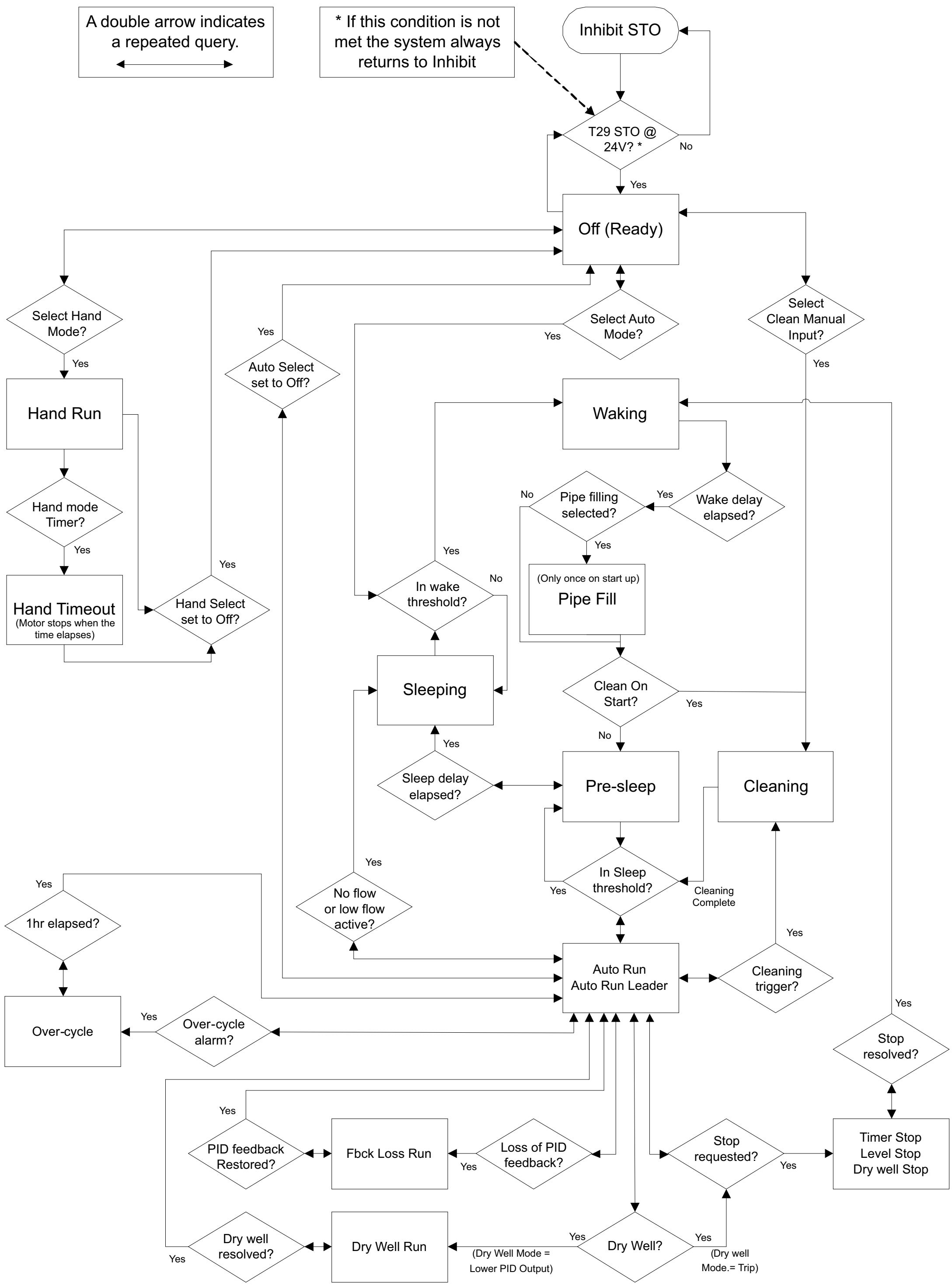
The following table lists the possible Pump software operating statuses and their meaning.

Status	Description
Inhibit STO	The drive is inhibited i.e. the STO input on drive terminal T29 is at 0 V. To enable the drive to move to the Off (*Ready*) state, apply 24 V to drive terminal T29.
Off (Ready)	The drive is hardware enabled and is waiting for a command to run.
Hand Run	The drive is running in Hand mode from a fixed speed reference.
Waking	The drive is in the process of waking i.e. the *Wake Detect Delay* Pr **29.050**(0.041) is timing
Pipe Fill	The Automated pipe filling routine is running.
Auto Run	The drive is running in Single Pump control in Auto mode.
Auto Run Leader	The drive is running in Cascade or Multi-leader control in Auto mode as a leader.
Auto Run Assist	The drive is running in Multi-leader control in Auto mode as an assist
Pre-sleep	The drive is in Pre-sleep i.e. the output frequency or speed is less than *Sleep Detect Speed Threshold* Pr **29.051** and the *Sleep Detect Delay* Pr **29.052** is counting down. This is shown for a short period when starting in Auto mode while the PID output builds up.

Status	Description
Sleeping	The drive is in Auto mode but has gone to sleep. The system enters Sleeping when the motor speed or frequency value satisfies the *Sleep Detect Speed Threshold* Pr **29.051**, if no flow from a flow switch, no flow by software detection or low flow is detected.
Cleaning	The drive is running the cleaning or de-ragging routine.
Level Stop	The system has stopped due to the high-level switch being reached. See *Level Switch High Input* Pr **29.079**. This may be overridden by Hand mode or Manual Clean operation.
Timer Stop	The system has stopped because the timer switch input is set to Off(0), indicating a timer shut-down period. See *Time Schedule Run Input Enable* Pr **29.055** and *Time Schedule Run Input* Pr **29.056**. This may be overridden by Hand or Manual Clean operation.
Hand Timeout	The system was stopped while running in Hand mode after the *Hand Mode Timeout* Pr **29.017** elapsed. To reset a Hand mode timeout, deselect and reselect Hand mode.
Over-cycle	The system has detected an over-cycle condition. The drive has started too many times in this hour. See *Over-cycle Mode* Pr **29.127**(0.060) and *Over-cycle Starts Per Hour* Pr **29.128**(0.061).
Fbck Loss Run	*Analog Input 1 Current Loop Loss* Pr **07.028** = *On(1)* indicating that there is a current loop loss for the main process PID feedback, and *PID Feedback Loss Action* Pr **29.048** = Fixed Speed where the drive is running with at a fixed speed defined by *PID Disabled / Feedback Loss Reference* Pr **01.023**.
Dry Well Run	A dry well low load condition has been detected and the drive is running with a reduced reference as defined by *Dry Well Low Load PID Output Reduction* Pr **29.060(**0.053). This state can only be reached when *Dry Well Low Load Mode* Pr **29.059**(0.052) = *Lower PID Output.*
Dry Well Stop	A dry well low load condition has been detected and the drive has tripped on Dry Well, where *Dry Well Low Load Mode* Pr **29.059**(0.052) = *Trip*. When this happens, the drive will remain stopped in the *Dry Well Stop state* until the *Dry Well Low Load Restart Delay* Pr **29.061**(0.054) has elapsed.
Auto Stop Assist	This indicates that the drive is an assist in a Multi-leader system, Auto mode has been selected, but the system leader has not commanded this assist to run yet.

7.5.1 Single Pump, Cascade and Multi-leader (leader) state diagram

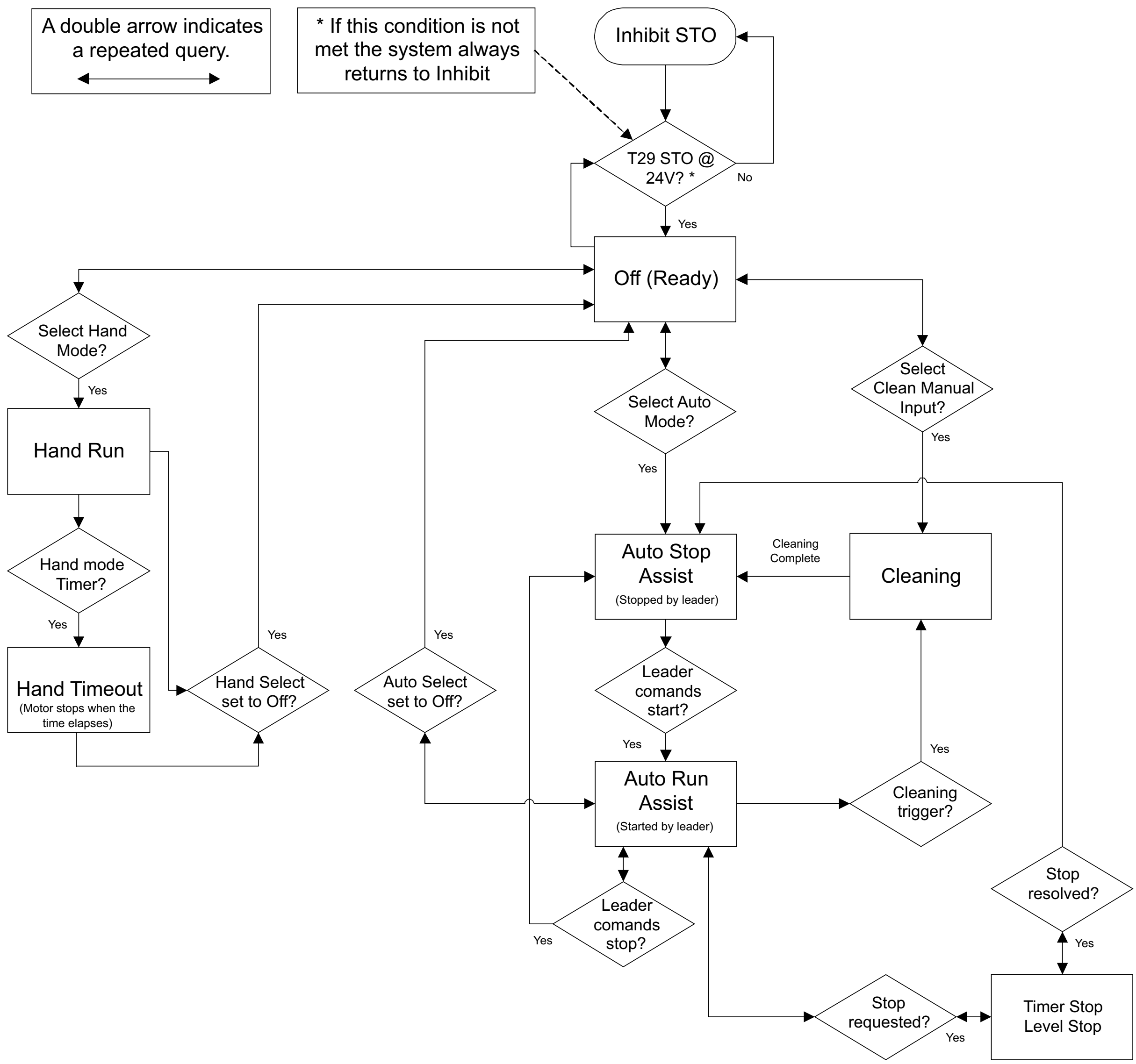
The following diagram shows the pump software status transitions for Single Pump, Cascade and Multi-leader (leader) as indicated by *Operating Status* Pr **29.003**(0.073).



State diagram for Single Pump, Cascade and Multi-leader (Lead drive)

7.5.2 Multi-leader (assist) state diagram

The following diagram shows the pump software status transitions for Multi-leader (assist) as indicated by *Operating Status* Pr **29.003**(0.073).



State diagram for Multi-leader (Assist drive)

7.6 Hand mode

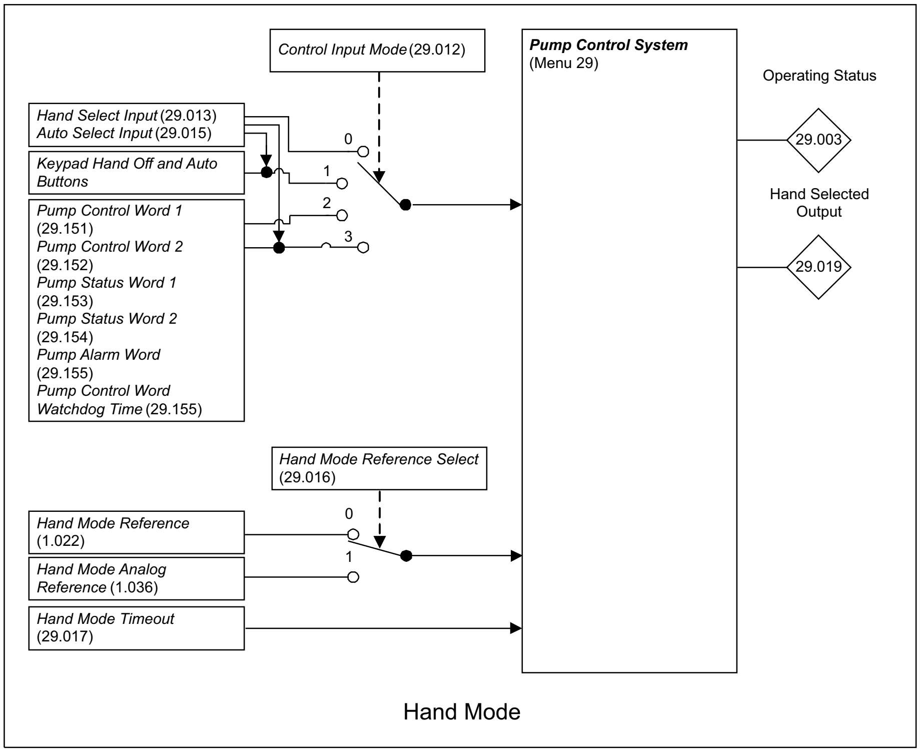
Hand mode runs the pump at a user defined fixed speed, from either a digital pre-set or an analog reference. The mode has a timeout facility to prevent continuous running in Hand mode if required.

By default, the following setup is made for Hand mode:

- Hand mode is selected by either:
  - o Press and hold the Hand key for 2 s. HAND 
  - o Apply 24 V to Digital input 4 T25
- The frequency or speed setpoint is set using Pr **1.022**(0.026).
- The Hand mode reference will run continuously while selected.

7.6.1 Hand mode logic diagram

The following diagram shows the parameters used by Hand mode.



7.6.2 Hand mode parameters

The following section details the parameters used by Hand mode.

Parameter	Parameter 29.016 (0.025) *Hand Mode Reference Select*		
Short Description	Selects the reference type used to define the Hand mode speed		
Minimum	0.0	Maximum	25.0
Default	0.0	Units	minutes

This selects where the frequency or speed reference comes from when Hand mode is selected. When set to *Digital Speed*, Pr **1.022** sets the reference. When set to *Analog Speed,* by default, a 0 to 10 V signal is applied to analog input 2 T6.

NOTE

If a 10 V supply is required an analog output can be setup to provide this, see I/O section 7.4.4.

Parameter	29.017 *Hand Mode Timeout*		
Minimum	0.0	Maximum	25.0
Default	0.0	Units	minutes

When set to 0.0 minutes, Hand mode timeout is disabled, i.e. the system will run in Hand mode for as long as Hand mode is selected.

When set > 0.0, this sets the time in minutes that Hand mode will be selected for before timing out and stopping the motor, where *Operating State* Pr **29.003** changes to *Hand Timeout*. To reset the Hand mode timeout, Hand mode must be deselected.

Parameter	29.013 *Hand Select Input*		
Minimum	0.0	Maximum	1
Default	0.0	Units	

This is the destination for a 24V digital input that is used to select Hand mode. This is used when *Control Input Mode* Pr **29.012** = *Input or Input & Keypad or Ctrl Wrd & Input.* By default, digital input 4 T25 is configured for this purpose.

When *Control Input Mode* Pr **29.012** = *Ctrl Wrd* This input is not used.

Parameter	1.036 *Hand Mode Analog Reference*		
Minimum	Minimum VM_SPEED_FREQ_USER_REFS[MIN]	Maximum	VM_SPEED_FREQ_USER_REFS[MAX]
Default	0.0	Units	Hz or rpm

Used to receive the final analogue speed / frequency reference in Hand mode. By default, analog input 2 T6 is directed to this parameter, and us used when analog Hand mode reference is selected by setting *Hand Mode Reference* Select Pr **29.016**(0.025) = Analog Speed.

Parameter	1.022 (0.026) *Hand Mode Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	DefaultSTD = 750, US = 900.	Units	Hz or rpm

This defines the speed or frequency reference used when running in Hand mode and when *Hand Mode Reference Select* Pr **29.016**(0.025) = *Digital Speed*.

Parameter	29.019 *Hand Selected Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates that Hand mode has been selected. The following conditions must be met for *Hand Selected Output* Pr ***29.019*** to become set to *On(1)*:

- *Hand Select Input* Pr **29.013** = On(1), or Hand button pressed for 2 s, or *Pump Control Word 1* Pr **29.151** bit2 = 1.
- The drive is enabled where *Hardware Enable* Pr **6.029** = *On(1)*. 24 V must be applied to the STO input T29.
- Auto mode hasn't been selected where *Auto Select Input* Pr **29.015** = *Off(0)* or *Pump Control Word 1* Pr **29.151** bit4 = 0.
- Hand mode time-out is disabled or hasn't timed out via *Hand Mode Timeout* Pr **29.017**.

When set to Off, Hand mode is not selected.

Parameter	29.003 (0.073) *Operating Status*		
Minimum	0	Maximum	18
Default	0	Units	

When Hand mode is running *Operating Status = Hand Run*. See section 7.5 Pump software operating status for more information on the operating states.

7.7 Auto mode

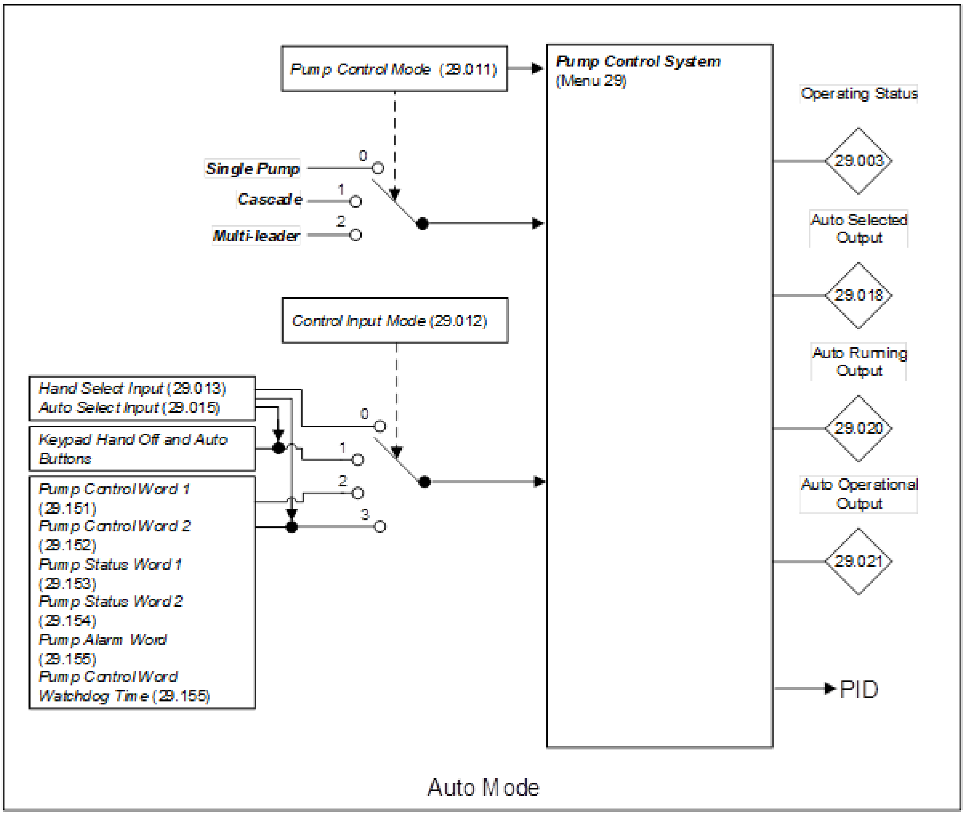
In Auto Mode, the pump starts Automatically with a start delay when the wake condition is detected, e.g. pressure transducer signal goes below wake threshold. Initially, a pipe fill operation may be performed to remove air from the pipes. An optional PID control then regulates the system to the setpoint e.g. for a constant pressure system, the demand pressure will be regulated by adjusting the motor speed. If the pump detects a stop condition for a defined time period it will Automatically stop and enter the *Sleeping state*. There are four main stop conditions - sleep on low motor speed, software no flow detection, no flow from a flow switch and low flow from a pulsed flow meter. All four conditions can be individually enabled to suit the system requirements.

In Cascade or Multi-leader parallel pumping systems, when the leader drive PID output is at maximum, additional assist F600s or soft starters are commanded to run. If the sleeping threshold is reached additional assist F600s or soft starters are commanded to stop.

Optionally, Auto mode can run with no PID control and a fixed frequency or speed reference. This is helpful in tank filling systems that have a fixed head, where the pump starts and stops with level switch control instead of PID demand. See section 7.8 PID and 7.14 Level switches.

7.7.1 Auto mode logic diagram

The following diagram shows the parameters used by Auto mode.



Note that the PID control is covered separately in section 7.8 PID.

7.7.2 Auto mode parameters

The following section details the parameters used by Auto mode.

Parameter	29.011 (0.021) *Pump Control Mode*		
Minimum	0	Maximum	3
Default	0	Units	

This decides which type of system the F600 drive is being applied to and the behaviour in Auto mode. In *Single Pump*, Auto mode only runs a single independent pump. In Cascade or Multi-leader, when running in Auto mode, up to 2 additional parallel assist pumps are automatically commanded to run as required. See section 7.20 Cascade and 7.21 Multi-leader for more details.

Parameter	29.015 *Auto Select Input*		
Minimum	0	Maximum	1
Default	0	Units	

This is the destination for a 24 V digital input that is used to select Auto mode. This is used when *Control Input Mode* Pr **29.012**(0.024) = *Input or Input & Keypad or Ctrl Wrd & Input*. By default, digital input 5 T26 is configured for this purpose.

When *Control Input Mode* Pr **29.012**(0.024) = *Ctrl Wrd* This input is not use

Parameter	29.018 *Auto Selected Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates that Auto mode has been selected. The following conditions must be met for *Auto Selected Output* Pr **29.018** to become set to *On(1)*:

- *Auto Select Input* Pr **29.015** = *On(1)*, or Auto button pressed for 2s, or *Pump Control Word 1* Pr **29.151** bit4 = 1.
- The drive is enabled where *Hardware Enable* Pr **6.029** = *On(1)*. 24V must be applied to the STO input T29.
- Hand mode hasn't been selected where *Hand Select Input* Pr **29.013** = *Off(0)* or *Pump Control Word 1* Pr **29.151** bit2 = 0.
- The time schedule function is disabled via *Time Schedule Run Input Enable* Pr **29.055**, or *Time Schedule Run Input Enable* Pr **29.055** = *On(1)* and *Time Schedule Run Input* Pr **29.056** = *On(1)*.

Parameter	29.020 *Auto Running Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates that Auto mode is selected, and the motor is energised.

Parameter	29.021 *Auto Operational Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates that Auto mode is selected, and the system is sleeping (motor stopped) or running (motor energised).

Parameter	29.003 *(0.073) Operating Status*		
Minimum	0	Maximum	18
Default	0	Units	

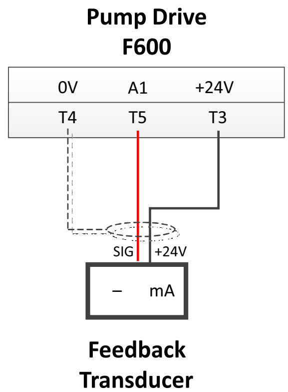
When Auto mode is running:

- *Operating Status* = *Auto Run* in Single Pump mode.
- *Operating Status* = *Auto Leader Run* in Cascade and Multi-leader mode, where a Multi-leader drive is the system leader.
- *Operating Status* = *Auto Assist Run* in Multi-leader mode, where the Multi-leader drive is an assist to the leader.

See section 7.5 Pump software operating status for more information on the operating states.

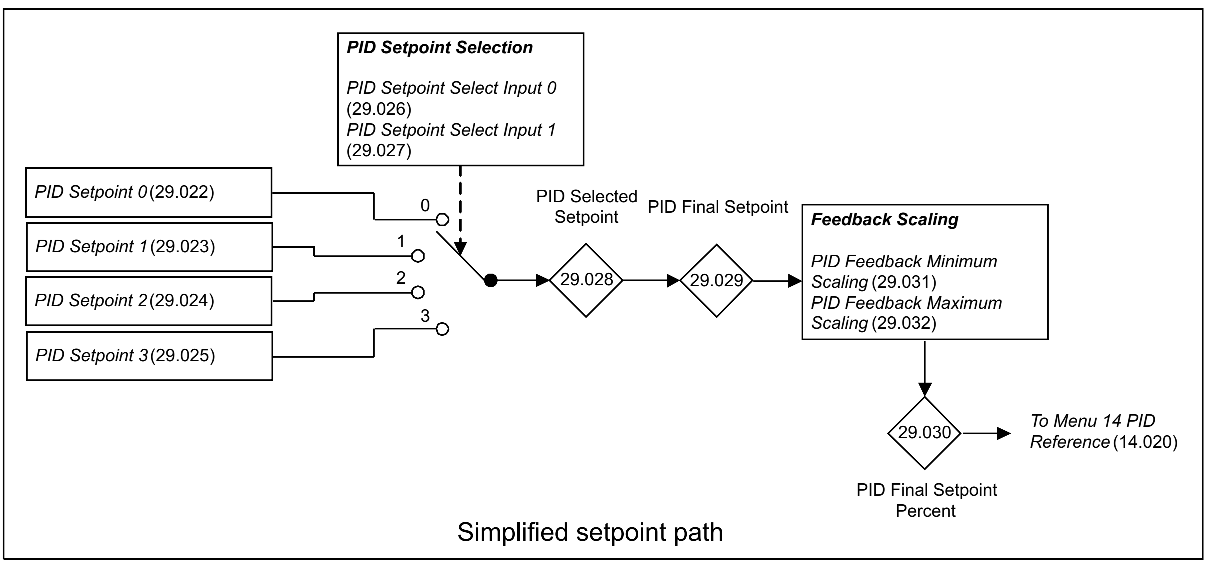
7.8 PID

The main process PID controller is used to modify the motor frequency or speed between the minimum and maximum in order to match the feedback to the setpoint while the system is in Auto mode. By default, the main process PID feedback is connected to Analog input 1 T5 and requires a 4-20 mA signal, (the signal type may be changed if required). In a Multi-leader system, each F600 may have a pressure feedback device to offer to best redundancy, or a 4-20 mA signal duplicator may be used and a single feedback transducer signal can then be split between the drives.



The feedback transducer defines the units that the main process PID controls in, e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor, then the PID is a pressure controller. The scaling defined by *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), where the PID feedback and setpoint will be in the units defined by the scaling. By default, the scaling is setup for percent units i.e. 0.00 % to 100.00 %.

The system has up to 4 selectable PID setpoints depending on the system requirements; selecting the different setpoints is done using *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027**. By default, the system is setup to accept a single *PID setpoint, PID Setpoint 0* Pr **29.022**(0.029).



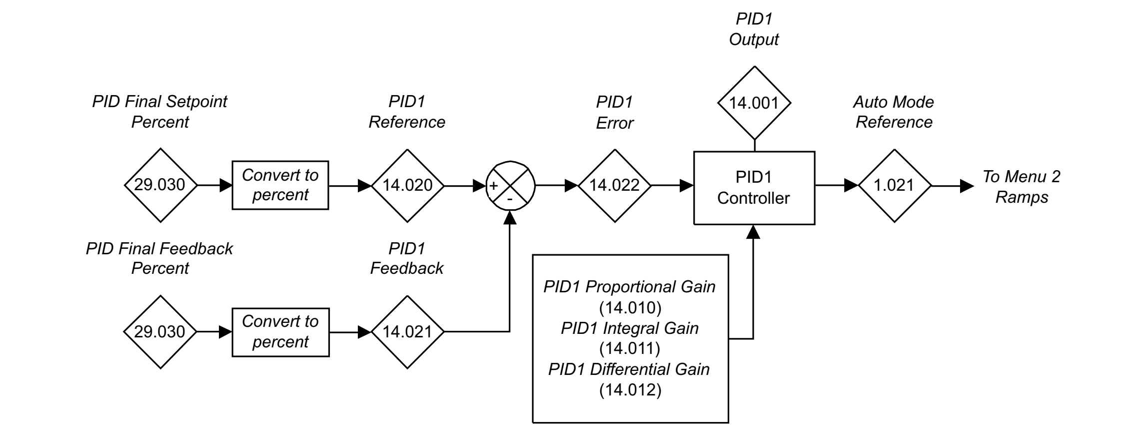
The resulting feedback and setpoint, *PID Final Feedback Percent* Pr **29.035** and *PID Final Setpoint Percent* Pr **29.030**, are passed to PID1 the main process PID in Menu 14 to control the motor frequency or speed, where the output of PID1 is routed to *Auto Mode Reference* Pr **1.021**.

7.8.1 PID tuning

The default PID loop gains are a good starting point when commissioning the system, however, each system has different characteristics and tuning may be required. If the PID loop needs to be tuned to it is recommended that CT Scope is used to monitor the following parameters:

- *PID1 Reference* Pr **14.020**(0.066)
- *PID1 Feedback* Pr **14.021**(0.067)

While monitoring the PID reference, feedback and error using CT Scope, adjust *PID1 Proportional Gain* Pr **14.010**(0.064) and *PID1 Integral Gain* Pr **14.011**(0.065). It may be helpful to vary the PID setpoint between two values in order to see the performance of the PID As a starting point while changing the gains, the best practice when stiffening the PID loop performance is to double both *PID1 Proportional Gain* Pr **14.010**(0.064) and *PID1 Integral Gain* Pr **14.011**(0.065) to maintain the balance between the two gains. It is not recommended to introduce differential gain as this tends to introduce noise to the main process PID control loop, and for this reason by default *PID1 Differential Gain* Pr **14.012** is set to 0.000.



Simplified main process PID controller

The PID controller output is defined as follows:

PID1 Output Pr **14.001** = *PID1 Error* Pr **14.022** x [Kp + Ki/s + sKd / (0.064s + 1)]

Kp = *PID1 Proportional Gain* Pr **14.010**(0.064)

Ki = *PID1 Integral Gain* Pr **14.011**(0.065)

Kd = *PID1 Differential Gain* Pr **14.012**

Therefore:

- If *PID1 Error* Pr **14.022** = 100.00 % the proportional term gives a value of 100.00% if *PID1 Proportional Gain* Pr **14.010**(0.064) = 1.000.
- If *PID1 Error* Pr **14.022** = 100.00 % the integral term gives a value that increases linearly by 100.00 % per second if *PID1 Integral Gain* Pr **14.011**(0.065) = 1.000.
- If *PID1 Error* Pr **14.022** increases linearly by 100.00 % per second, the differential term gives a value of 100.00 % if *PID1 Differential Gain* Pr **14.012** = 1.000. (A filter with a time constant of 64 ms is provided on the differential gain to reduce the noise produced by this term.)

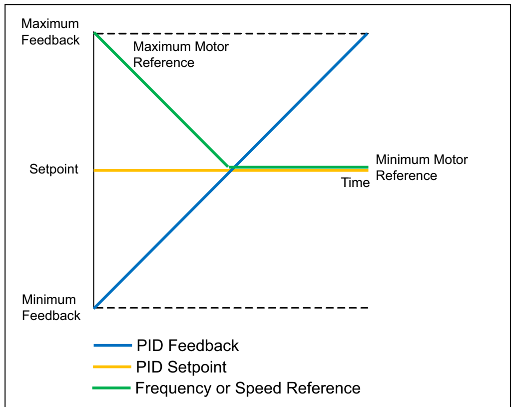
Note that for a very rapid response, <1 s to full output, the default acceleration and deceleration rates configured by *General Acceleration Rate* Pr **2.011**(0.027) and *General Deceleration Rate* Pr **2.021**(0.028) may require adjustment.

7.8.2 Inverting the main process PID error response

PID1 Reference Invert Pr **14.005** may be used in combination with *PID1 Feedback Invert* Pr **14.006** to invert the response characteristics of the main process PID. This is helpful in applications where if the feedback value is greater than the setpoint the system motor should speed up rather than slow down as it does with a normal error response.

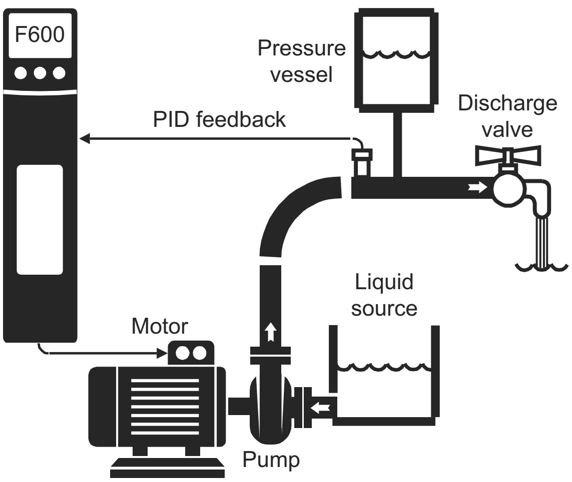
7.8.2.1 Normal PID Error response

If *PID1 Feedback Source* Pr **14.004** and PID1 *Reference Invert* Pr **14.005** = *Off(0)* then the main process PID will give a normal error response characteristic. See the following diagram:



Normal PID Response

Pr14.005 & Pr14.006 = Off(0)

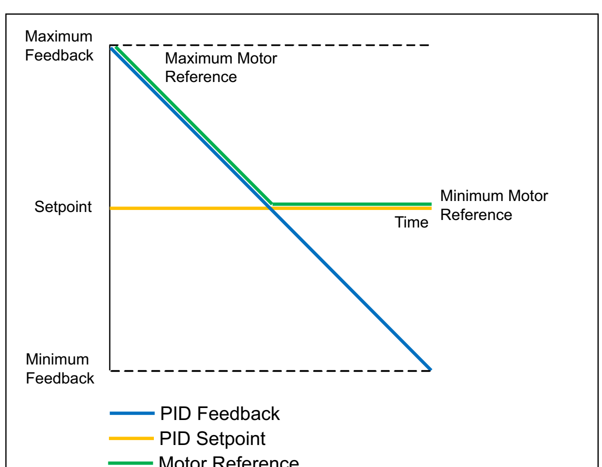


Normal error response example:

A pumping system with a pressure feedback device gives a high PID output with a low pressure, and a low PID output with high pressure. In this scenario when the feedback is above the setpoint, the setpoint the motor reference will reduce down to the minimum since the pressure is greater than the setpoint value.

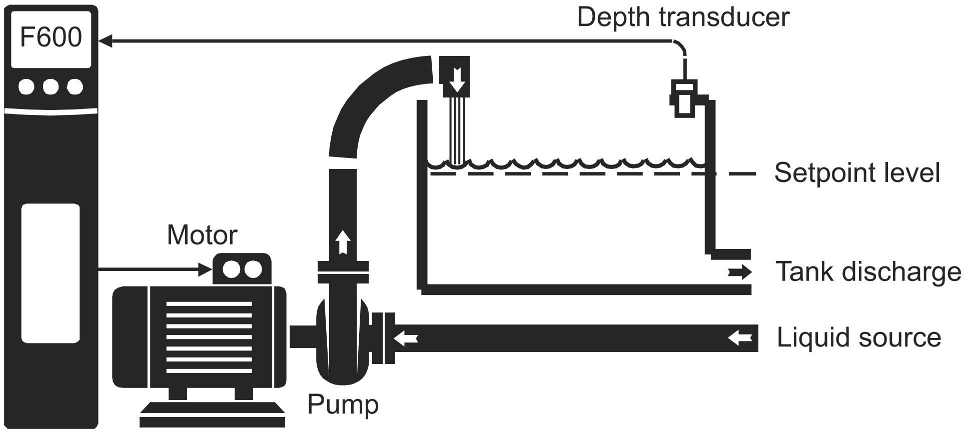
7.8.2.2 Inverted PID Error response

If *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005** = *On(1)* then the main process PID will give an inverted error response characteristic. See the following diagram:



Inverted PID Response

Pr14.005 & Pr14.006 = On(1)



Inverted error response example:

A tank emptying system with a depth feedback device gives a high PID output with a high depth, and a low PID output with low depth. In this scenario when the feedback is above the setpoint, the motor reference will increase up to the maximum to empty the water rapidly since the liquid level is too high. If the liquid level is low the PID output will reduce, allowing the tank to fill.

Note that the *Wake Detect Feedback Threshold* Pr **29.049**(0.040) changes function depending on the state of *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005**.

- If *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr**1 4.005** = *Off(0)* then the feedback must be less than *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for the system to wake.
- If *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005** = *On(1)* then the feedback must be greater than *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for the system to wake.

7.8.3 Disabling the PID for fixed speed systems

For some applications the PID is not necessary when running in Auto mode e.g. if filling a tank using level switches with a fixed head. In a fixed speed application:

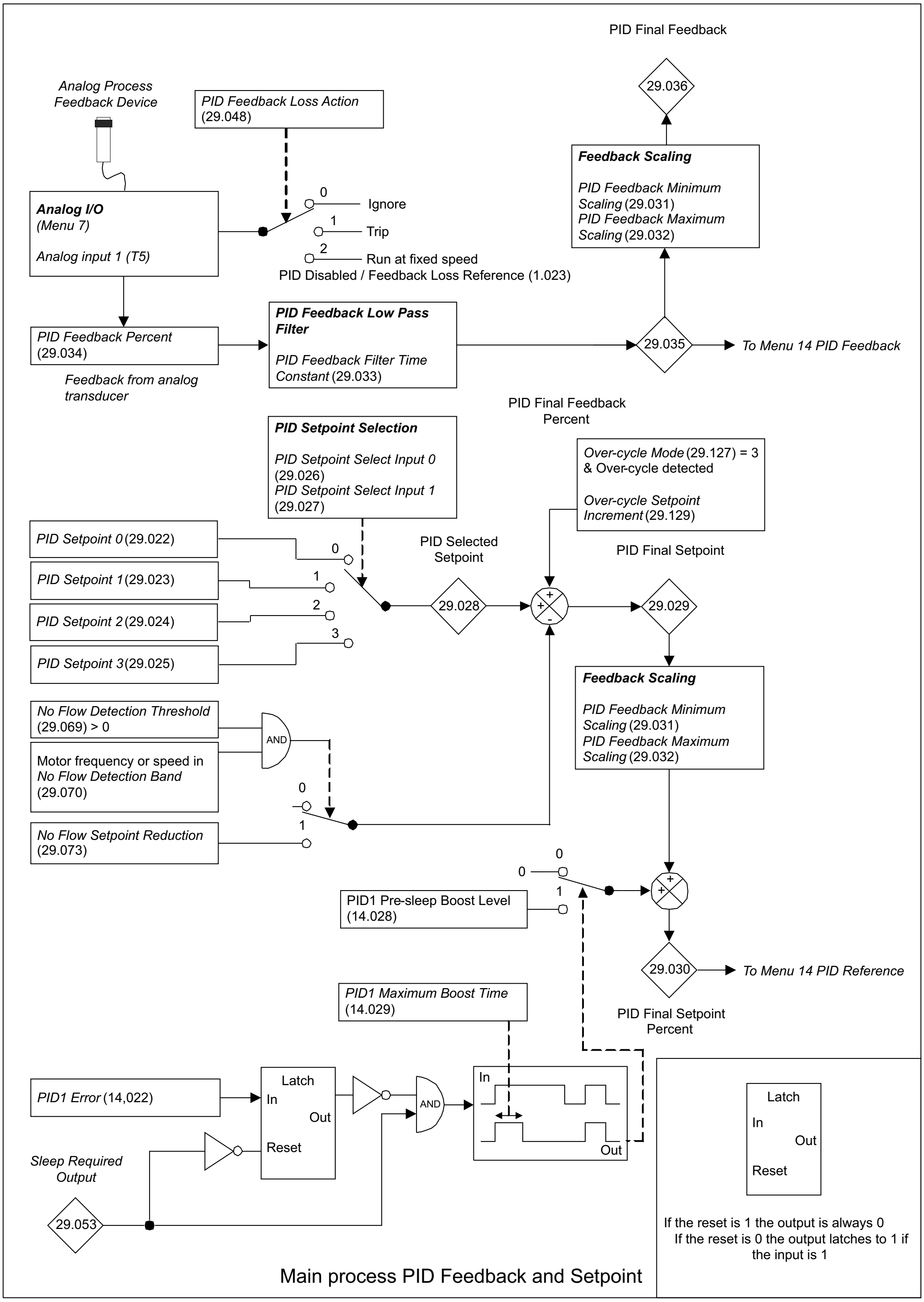
- The main process PID is disabled while running in Auto mode by setting *PID Enable* Pr **14.008** to *Off(0)*.
- The fixed speed reference used while running in Auto is set by *PID Disabled / Feedback Loss Reference* Pr **1.023.**

When the main process PID is disabled, the following features are affected:

- PID pressure control - this is disabled.
- Waking / Starting - the system will start immediately after the start time elapses.
- Sleeping / Stopping - the system will only stop if low flow or no flow from a flow switch is detected.
- Pipe filling - only available if a flow sensor or a flow switch is fitted.
- Feedback High / Low detection - Only available if a feedback device is connected.
- Software no flow detection - this is disabled.
- Dry well low load detection - this is disabled.

7.8.4 PID feedback and setpoint logic diagram

The following diagram shows the parameters used by the PID feedback and setpoint



7.8.5 PID feedback and setpoint parameters

The following section details the parameters used by the PID feedback and setpoint.

Parameter	29.022 (0.029) *PID Setpoint 0*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This is the main process PID setpoint and is selected by default, since the PID setpoint select inputs, *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027** are set to *Off(0)* by default.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	29.023 *PID Setpoint 1*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This is an additional setpoint and requires the PID setpoint select inputs, *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027**, to command it. If *PID Setpoint Select Input 0* Pr **29.026** = *On(1)* and *PID Setpoint Select Input 1* Pr **29.027** = *Off(0)*, *PID Setpoint 1* Pr **29.023** is selected.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	29.024 *PID Setpoint 2*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This is an additional setpoint and requires the PID setpoint select inputs, *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027**, to command it. If *PID Setpoint Select Input 0* Pr **29.026** = *Off(0)* and *PID Setpoint Select Input 1* Pr **29.027** = *On(1)*, *PID Setpoint 2* Pr **29.023** is selected.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling

Parameter	29.025 *PID Setpoint 3*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This is an additional setpoint and requires the PID setpoint select inputs, *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027**, to command it. If *PID Setpoint Select Input 0* Pr **29.026** = *On(1)* and *PID Setpoint Select Input 1* Pr **29.027** = *On(1)*, *PID Setpoint 3* Pr **29.023** is selected.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	29.026 *PID Setpoint Select Input 0*		
Minimum	0	Maximum	1
Default	0	Units	

PID Setpoint Select Input 0 Pr **29.026** is used in combination with *PID Setpoint Select Input 1* Pr **29.027** to select the 4 different main process PID setpoints. By default, both inputs are set to Off where *PID Setpoint 0* Pr **29.022**(0.029) is selected.

PID Setpoint Select Input 0 Pr29.026 Value	PID Setpoint Select Input 1 Pr29.027 Value	Result
Off(0)	Off(0)	*PID Setpoint 0* Pr **29.022**(0.029) is selected.
On(1)	Off(0)	*PID Setpoint 1* Pr **29.023** is selected.
Off(0)	On(1)	*PID Setpoint 2* Pr **29.024** is selected.
On(1)	On(1)	*PID Setpoint 3* Pr **29.025** is selected.

Parameter	29.027 *PID Setpoint Select Input 1*		
Minimum	0	Maximum	1
Default	0	Units	

PID Setpoint Select Input 1 Pr **29.027** is used in combination with *PID Setpoint Select Input 0* Pr **29.026** to select the 4 different main process PID setpoints. By default, both inputs are set to Off where *PID Setpoint 0* Pr **29.022**(0.029) is selected.

See *PID Setpoint Select Input 0* Pr **29.026** for the selection table.

Parameter	29.028 *PID Selected Setpoint*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This indicates the value of the setpoint selected by *PID Setpoint Select Input 0* Pr **29.026** and *PID Setpoint Select Input 1* Pr **29.027**.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	29.029 *PID Final Setpoint*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This indicates the final value of the setpoint passed to the main process *PID reference setpoint PID1 Reference* Pr **14.020** shown in feedback units. *PID Final Setpoint* Pr **29.029** = *PID Selected Setpoint* Pr **29.028** - *No Flow Setpoint Reduction* Pr **29.073.**

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

Parameter	29.30 *PID Final Setpoint Percent*		
Minimum	0.00	Maximum	100.00
Default	0.00	Units	%

This indicates the final value of the setpoint passed to the main process *PID reference setpoint PID1 Reference* Pr **14.020** in percent units. *PID Final Setpoint Percent* Pr **29.030** = 100 * (*PID Selected Setpoint* Pr **29.028** - *No Flow Setpoint Reduction* Pr **29.073**) / (*PID Feedback Maximum Scaling* Pr **29.032** - *PID Feedback Minimum Scaling* Pr **29.031**).

Parameter	29.31 (0.030) *PID Feedback Minimum Scaling*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

PID Feedback Minimum Scaling Pr **29.031**(0.030) defines the minimum value for the main process PID feedback, provided by a transducer connected to Analog input 1 T5. *PID Feedback Minimum Scaling* Pr **29.031**(0.030) is used in combination with *PID Feedback Maximum Scaling* Pr **29.032** to define to feedback scaling.

Parameter	29.32 (0.031) *PID Feedback Maximum Scaling*		
Minimum	0.00	Maximum	327.67
Default	100.00	Units	UU

PID Feedback Maximum Scaling Pr **29.032**(0.031) defines the maximum value for the main process PID feedback, provided by a transducer connected to Analog input 1 T5. *PID Feedback Minimum Scaling* Pr **29.031**(0.030) is used in combination with *PID Feedback Maximum Scaling* Pr **29.032**(0.031) to define to feedback scaling.

Parameter	29.33 *PID Feedback Filter Time Constant*		
Minimum	0.00	Maximum	327.67
Default	1.00	Units	s

This is the time constant in seconds for the low pass filter used to condition the value from the feedback transducer connected to Analog input 1 T5.

For a step change in feedback value, after 5 x the filter time constant the input and output of the filter will be approximately equal e.g. if the time constant is 1 s, after a step change in feedback, after 5 s the output will approximately match the input.

The input to the filter is *PID Feedback Percent* Pr **29.034** and the output from the filter is *PID Final Feedback Percen*t Pr **29.035**.

Parameter	29.34 *PID Feedback Percent*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

This parameter is the destination for the main process PID feedback analog input. by default, Analog input 1 T5 is routed to this parameter. This value is filtered, (see *PID Feedback Filter Time Constant* Pr **29.033**(0.032)), where the result of the filter is passed to *PID Final Feedback Percent* Pr **29.035** which is used as the main process PID feedback value.

Parameter	29.35 *PID Final Feedback Percent*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

This parameter is the output of the main process PID feedback filter and is routed to the main process PID Feedback reference source in Menu 14.

See *PID Feedback Filter Time Constant* Pr **29.033**(0.032).

Parameter	29.36 *PID Final Feedback*		
Minimum	-327.68	Maximum	327.67
Default	0.00	Units	UU

This parameter is the output of the main process PID feedback filter, scaled into feedback units via *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.032).

PID Final Feedback Pr **29.036** = *PID Feedback Minimum Scaling* Pr **29.031** + (*PID Final Feedback Percent* Pr **29.035** * (*PID Feedback Maximum Scaling* Pr **29.032** - *PID Feedback Minimum Scaling* Pr **29.031**) / 100).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

See *PID Feedback Filter Time Constant* Pr **29.033**(0.032).

Parameter	29.37 *PID Error*		
Minimum	-327.68	Maximum	327.67
Default	0.00	Units	UU

This indicates the main process PID Error in feedback units.

PID Error Pr **29.037** = *PID Feedback Minimum Scaling* Pr **29.031** + (*PID1 Error* Pr **14.022** * (*PID Feedback Maximum Scaling* Pr **29.032** - *PID Feedback Minimum Scaling* Pr **29.031**) / 100).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure setpoint with the same scaling.

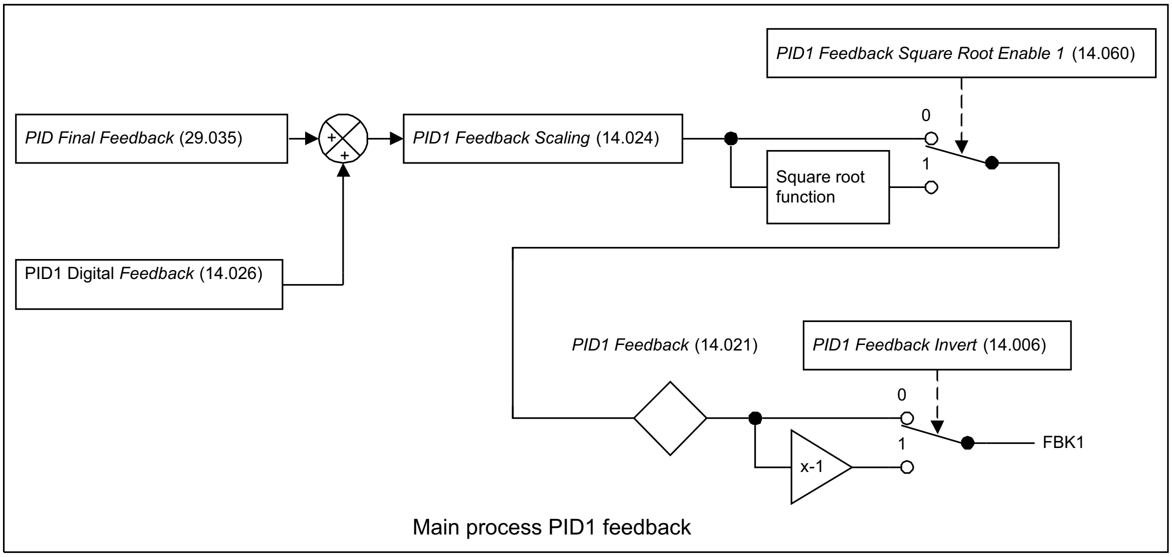
Parameter	29.048 *PID Feedback Loss Action*		
Minimum	0	Maximum	2
Default	1	Units	

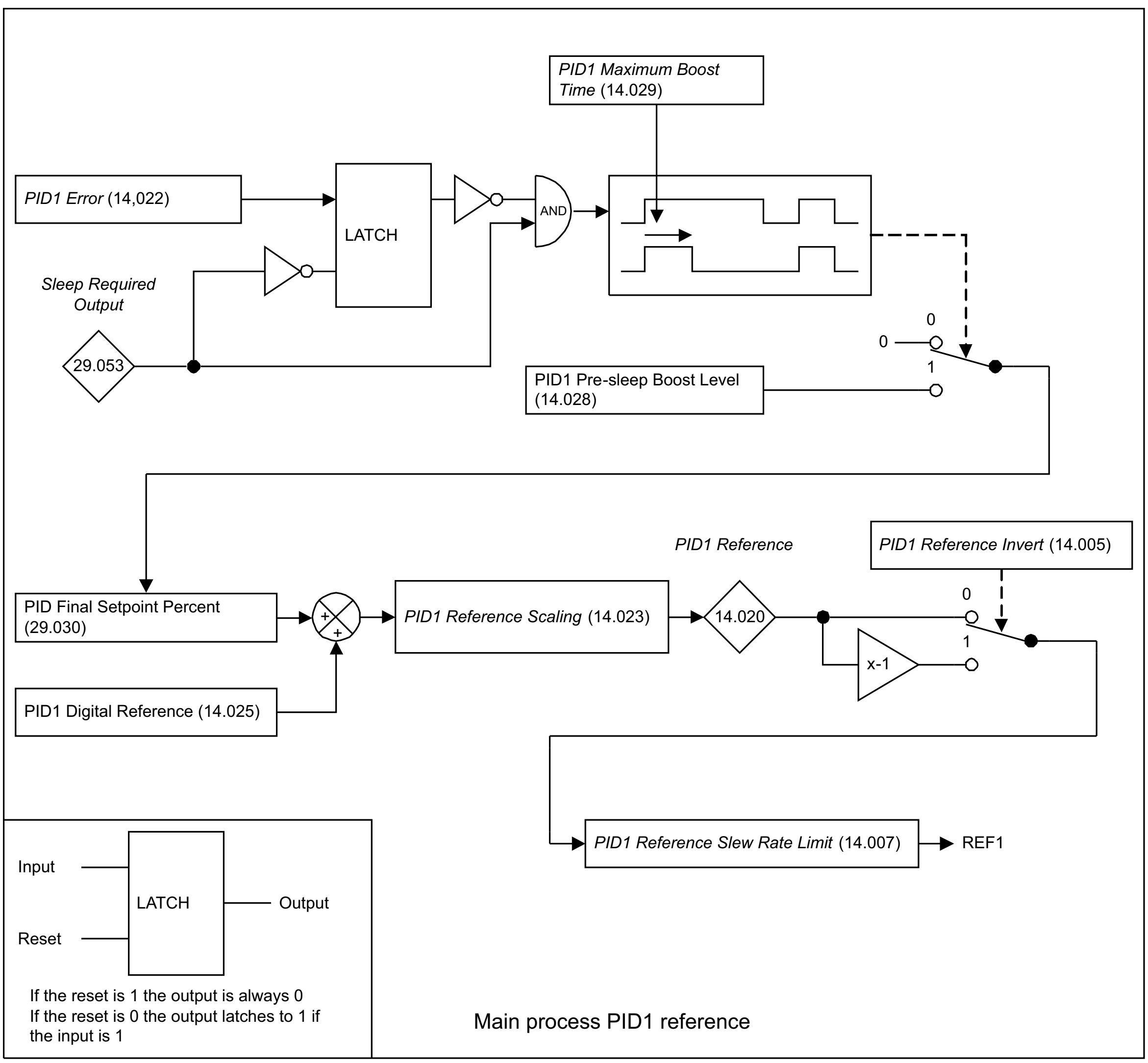
This chooses the action of the software when there is a total loss of PID feedback, as indicated by *Analog Input 1 Current Loop Loss* Pr **07.028** = *On(1),* which shows when there is a connection fault to a 4-20mA transducer. If *Analog Input 1 Mode* Pr **7.007** is set to *Volt(6)* for 0 to 10V operation, this parameter has no effect. The table below shows the options available:

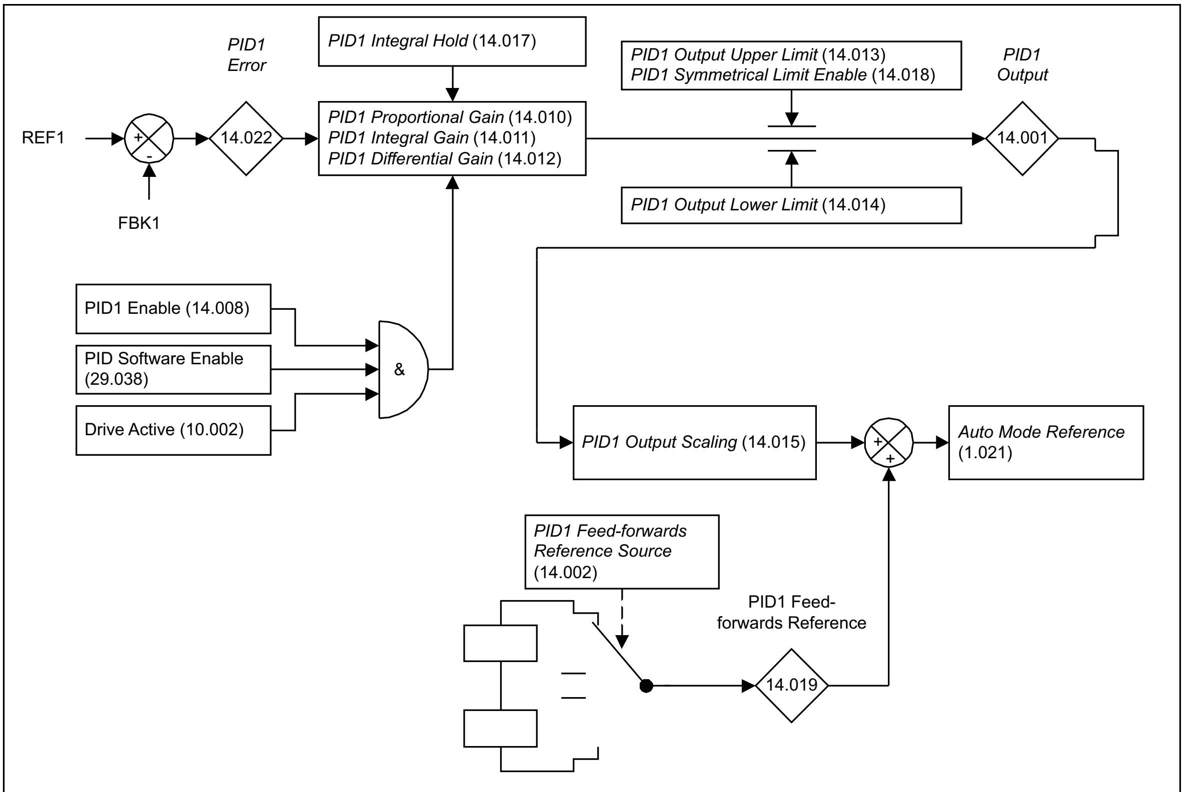
Mode	Value	Description
Ignore	0	Ignore the feedback loss - do nothing.
Trip	1	Trip the drive, (*PID Feedbk Loss*).
Fixed Speed2	2	Run at a fixed speed defined by *PID Disabled / Feedback Loss Reference* Pr **01.023**.

7.8.6 Main process PID logic diagrams

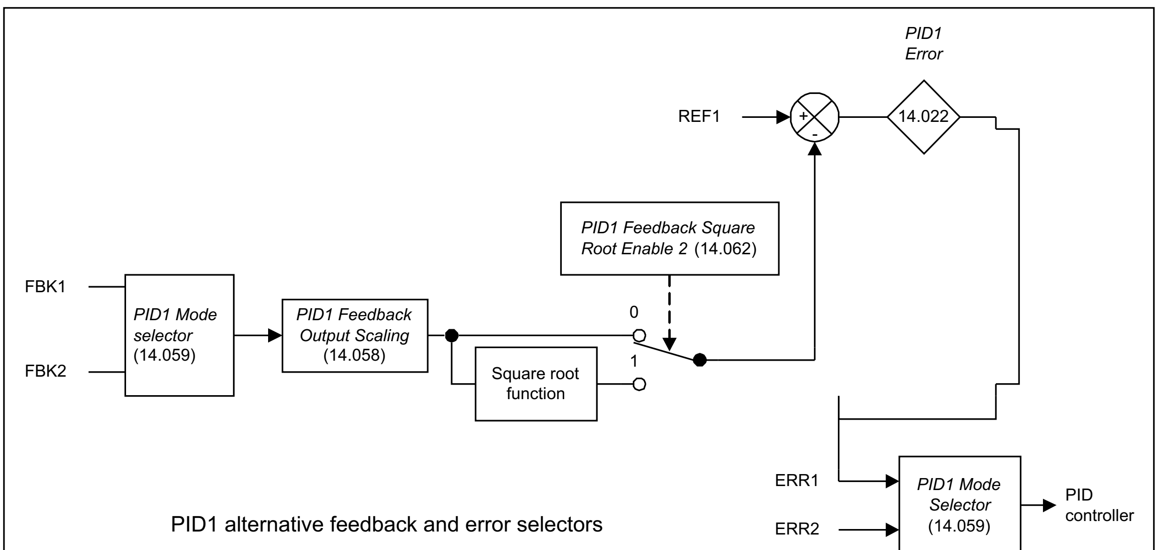
The following diagrams show the parameters used by the main process PID.







Main process PID1 controller (standard mode)



PID1 alternative feedback and error selectors

7.8.7 Main process PID parameters

The following section details the parameters used by the main process PID.

Parameter	14.001 *PID1 Output*		
Minimum	-100	Maximum	100
Default		Units	%

PID1 is used as the main process PID controller by the Pump software. The output from the PID controller is routed to Auto Mode Reference Pr **1.021**.

The structure of PID controller 1 shown in section 7.8.6 is when *PID1 Mode Selector* Pr **14.059** = 0, PID1 *Feedback Output Scaling* Pr **14.058** = 1.000, and *PID1 Feedback Square Root Enable 2* Pr **14.062** = 0. If the PID enable inputs are inactive (Pr **14.008**, Pr **29.038** and Pr **10.002** = *Off(0)*), all internal states are held at zero and the destination parameter will be defined by *PID1 Feed-forwards Reference* Pr **14.019** alone.

PID1 Error Pr **14.022** is the difference between the reference and feedback produced by the reference and feedback systems described in the previous sections. The PID controller output is defined as follows:

PID1 Output Pr **14.001** = *PID1 Error* Pr **14.022** x [Kp + Ki/s + sKd / (0.064 s + 1)]

Kp = *PID1 Proportional Gain* Pr **14.010**

Ki = *PID1 Integral Gain* Pr **14.011**

Kd = *PID1 Differential Gain* Pr **14.012**

Therefore:

1. If *PID1 Erro*r Pr **14.022**Pr = 100.00 % the proportional term gives a value of 100.00% if *PID1 Proportional Gain* Pr **14.010** = 1.000.

2. If *PID1 Erro*r Pr **14.022** = 100.00 % the integral term gives a value that increases linearly by 100.00 % per second if *PID1 Integral Gain* Pr **14.011** = 1.000.

3. If *PID1 Error* Pr **14.022** increases linearly by 100.00 % per second the differential term gives a value of 100.00 % if *PID1 Differential Gain* Pr **14.012** = 1.000. (A filter with a time constant of 64 ms is provided on the differential gain to reduce the noise produced by this term.)

The output may be limited to a range that is less than the maximum range of *PID1 Output* Pr **14.001** using *PID1 Output Upper Limit* Pr **14.013** and *PID1 Output Lower Limit* Pr **14.014**. If PID1 *Output Lower Limit* Pr **14.014** > PID1 *Output Upper Limit* Pr **14.013** then the output is held at the value defined by *PID1 Output Upper Limit* Pr **14.013**. If *PID1 Symmetrical Limit Enable* Pr **14.018** = 1 then the lower limit = - (*PID1 Output Upper Limit* Pr **14.013**). If the output reaches either of these limits the integral term accumulator is frozen until the output moves away from the limit to prevent integral wind-up. The integral hold function can also be enabled by the user by setting *PID1 Integral Hold* Pr **14.017** = 1.

PID1 Output Scaling Pr **14.015** can be used to scale the output, which is limited to a range from -100.00 % to 100.00 % after this function. The output is then added to *PID1 Feed-forwards Reference* Pr **14.019** and is again limited to the range from -100.00 % to 100.00 % before being routed to the destination defined by *PID1 Destination* Pr **14.016**.

Parameter	14.002 *PID1 Feed-forwards Reference Source*		
Minimum	0.000	Maximum	59.999
Default	0.000	Units	

PID1 Feed-forwards Reference Source Pr **14.002** is used to set the source parameter for PID1 feedforward reference source. It is not used by default by the Pump software but may be added if required.

See 14.001 *PID1 Output* .

Parameter	14.003 *PID1 Reference Source*		
Minimum	0.000	Maximum	59.999
Default	29.030	Units	

PID1 Reference Source Pr **14.003** is used to set the source parameter for PID1 reference source. By default, it is pointed at *PID Final Setpoint Percent* Pr **29.030** so it is serviced by the Pump software. It is not recommended to change this.

Parameter	14.004 *PID1 Feedback Source*		
Minimum	0.000	Maximum	59.999
Default	29.030	Units	

PID1 Feedback Source Pr **14.004** is used to set the source parameter for PID1 feedback source. By default, it is pointed at *PID Final Feedback Percent* Pr **29.035** so it is serviced by the Pump software. It is not recommended to change this.

Parameter	14.005 *PID1 Reference Invert*		
Minimum	0	Maximum	1
Default	0	Units	

PID1 Reference Invert Pr **14.005** may be used in combination with *PID1 Feedback Invert* Pr **14.006** to invert the response characteristics of the main process PID.

If *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005** = *Off(0)* then the main process PID will give a normal error response characteristic.

If *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr1**4.005** = *On(1)* then the main process PID will give an inverted error response characteristic.

See section 7.8.2 Inverting the main process PID error response

NOTE

The *Wake Detect Feedback Threshold* Pr **29.049** changes function depending on the state of *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005**.

See *Wake Detect Feedback Threshold* Pr **29.049**(0.040) and *PID1 Reference* Pr **14.020**.

Parameter	14.006 *PID1 Feedback Invert*		
Minimum	0	Maximum	1
Default	0	Units	

PID1 Feedback Invert Pr **14.006** may be used in combination with *PID1 Reference Invert* Pr **14.005** to invert the response characteristics of the main process PID.

See *PID1 Reference Invert* Pr **14.005** and *PID1 Reference* Pr **14.020**.

Parameter	14.007 *PID1 Reference Slew Rate*		
Minimum	0.0	Maximum	3200.0
Default	0.0	Units	s

This introduces a fixed rate slew function that may be used to filter an incoming reference to the PID e.g. if the Pump software setpoint is derived from a noisy analog source such as a potentiometer.

See *PID1 Reference Source* Pr **14.003**.

Parameter	14.008 *PID1 Enable*		
Minimum	0	Maximum	1
Default	1	Units	

PID1 Enable Pr **14.008** provides a means for the user to disable the main process PID for systems that don't require the motor speed to be controlled in order to reach a particular setpoint. Typically, it used by pumping systems that fill a tank with a fixed head, where high level and low level switches are used to command the pump to start or stop, (see *Level Switch Mode* Pr **29.082**).

When *PID1 Enable* Pr **14.008** = *On(1)* and Auto is selected, *Auto Select Input* Pr **29.015** = On(1), the main process PID output reference is selected, *Auto Mode Reference* Pr **1.021**.

When PID1 Enable Pr **14.008** = *Off(0)* and Auto is selected, the main process PID is disabled and the drive will run from the fixed speed reference set by *PID Disabled / Feedback Loss Reference* Pr **01.023**. See section 7.8.3 Disabling the PID for fixed speed systems.

See 14.001 *PID1 Output* .

Parameter	14.009 *PID1 Enable Source 1*		
Minimum	0.000	Maximum	59.999
Default	29.038	Units	

By default, *PID1 Enable Source 1* Pr **14.009** is directed to *PID Software Enable* Pr **29.038** as required by Pump software to operate correctly. This allows the Pump software to control when the PID is enabled or disabled. It is recommended to leave *PID1 Enable Source 1* Pr **14.009** set at the default value for normal Pump operation.

The user can still manually disable the PID if required by setting *PID1 Enable* Pr **14.008** to *Off(0)*.

Parameter	14.010 *PID1 Proportional Gain*		
Minimum	0.000	Maximum	4.000
Default	2.000	Units	

PID1 Proportional Gain Pr **14.010**(0.064) is the main process PID1 loop proportional gain. The default value of 2.000 is a good starting point for most applications. CT Scope may be used to tune the main process PID loop once the drive is operational to refine the performance according to the applications needs.

See 14.001 *PID1 Output* .

Parameter	14.011 *PID1 Integral Gain*		
Minimum	0.000	Maximum	4.000
Default	1.000	Units	

PID1 Integral Gain Pr **14.011**(0.065) is the main process PID1 loop integral gain. The default value of 1.000 is a good starting point for most applications. CT Scope may be used to tune the main process PID loop once the drive is operational to refine the performance according to the applications needs.

See 14.001 *PID1 Output* .

Parameter	14.012 *PID1 Differential Gain*		
Minimum	0.000	Maximum	4.000
Default	0.000	Units	

PID1 Differential Gain Pr14.012 is the main process PID1 loop differential gain. The default value of 0.000 is a good starting point for most applications. Note that the differential gain gives an output proportional to the rate of change of error which for most systems only serves to amplify feedback noise; it is recommended to leave this at 0.000.

See 14.001 PID1 Output .

Parameter	14.013 *PID1 Output Upper Limit*		
Minimum	0.00	Maximum	100.00
Default	100.00	Units	%

PID1 Output Upper Limit Pr **14.013** defines the PID output upper limit in percent units. It is written to by the Pump software and can't be modified by the user.

If *Dry Well Low Load Mode* Pr **29.059** = Lower PID Output and a dry well condition has been detected, *PID1 Output Upper Limit* Pr **14.013** is set to Dry Well *Low Load PID Output Reduction* Pr **29.060**.

For all other conditions *PID1 Output Upper Limit* Pr **14.013** is set to 100.00 %, as required by normal PID operation.

See 14.001 *PID1 Output* .

Parameter	14.014 *PID1 Output Lower Limit*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

PID1 Output Lower Limit Pr **14.014** sets the minimum output for the main process PID, where the default of 0 % is recommended such that reverse rotation of the pump is prevented, while running in Auto mode.

See 14.001 *PID1 Output* .

Parameter	14.015 *PID1 Output Scaling*		
Minimum	0.000	Maximum	4.000
Default	1.000	Units	

PID1 Output Scaling Pr **14.015** implements a PID output scaling function. It is recommended to leave this at the default of 1.000 for normal operation.

See 14.001 *PID1 Output* .

Parameter	14.016 *PID1 Integral Hold*		
Minimum	0	Maximum	1
Default	0	Units	

By default, this is directed to *Auto Mode Reference* Pr **01.021**, as required by Pump software to operate correctly in Auto mode.

See 14.001 *PID1 Output* .

Parameter	14.017 *PID1 Destination*		
Minimum	0.000	Maximum	59.999
Default	1.021	Units	

PID1 Integral Hold Pr **14.017** is used to prevent PID integral term from winding up in some applications. The default of *Off(0)* is suitable for most Pump applications.

See 14.001 *PID1 Output* .

Parameter	14.018 *PID1 Symmetrical Limit Enable*		
Minimum	0	Maximum	1
Default	0	Units	

When *PID1 Symmetrical Limit Enable* Pr **14.018** = *Off(0)*, *PID1 Output Upper Limit* Pr **14.013** and *PID1 Output Lower Limit* Pr **14.014** define the main process PID output limits.

When *PID1 Symmetrical Limit Enable* Pr **14.018** = *On(1)*, *PID1 Output Upper Limit* Pr **14.013** defines the main process PID output limits where the lower limit = -(*PID1 Output Upper Limit* Pr **14.013**).

The default of *Off(0)* is recommended such that reverse rotation of the pump is prevented, while running in Auto mode.

See 14.001 *PID1 Output* .

Parameter	14.019 *PID1 Feed-forwards Reference*		
Minimum	-100.00	Maximum	100.00
Default		Units	%

PID1 Feed-forwards Reference Pr **14.019** indicates the level of the PID1 feed-forward reference, pointed to by *PID1 Feed-forwards Reference Source* Pr **14.002**, in percent units.

Parameter	14.020 *PID1 Reference*		
Minimum	-100.00	Maximum	100.00
Default		Units	%

PID1 Reference Pr **14.020** indicates the level of the PID1 reference, which is the sum of the parameter pointed to by *PID1 Reference Source* Pr **14.003** and *PID1 Digital Reference* Pr **14.025**, multiplied by *PID1 Reference Scaling* Pr **14.023**, in percent units.

The reference sections are always active even if the PID controller itself is disabled or the reference sources are not routed to valid parameters. If a reference source is not a valid parameter or is 0.000 then the value is taken as zero.

The reference is the sum of the reference source, *PID1 Digital Reference* Pr **14.025** and the *PID1 Pre-sleep Boost Level* Pr **14.028**) when it is active. The result is multiplied by *PID1 Reference Scaling* Pr **14.023** and then limited to +/-100.00 %. The reference can then be inverted if required (PID1 Reference Invert Pr **14.005** = 1) and then a slew rate limit is applied with *PID1 Reference Slew Rate* Pr **14.007**. This limits the maximum rate of change so that a change from 0.00 to 100.00 % takes the time given in *PID1 Reference Slew Rate* Pr **14.007**.

Parameter	14.021 *PID1 Feedback*		
Minimum	-100.00	Maximum	100.00
Default		Units	%

PID1 Feedback Pr **14.021** indicates the level of the PID1 feedback, which is the sum of the parameter pointed to by *PID1 Feedback Source* Pr **14.004** and *PID1 Digital Feedback* Pr **14.026**, multiplied by *PID1 Feedback Scaling* Pr **14.024**, in percent units.

The feedback sections are always active even if the PID controller itself is disabled or the feedback sources are not routed to valid parameters. If a feedback source is not a valid parameter or is 0.000 then the value is taken as zero.

The feedback is the sum of the feedback source and the *PID1 Digital Feedback* Pr **14.026**. The result is multiplied by *PID1 Feedback Scaling* Pr **14.024** and then limited to +/-100.00 %. A square root function can be applied (*PID1 Feedback Square Root Enable 1* Pr **14.060** = 1) and the feedback can then be inverted if required (*PID1 Feedback Invert* Pr **14.006** = 1). The square root function is defined as follows.

Square root function output = Sign(Input) x 100.00 % x √(|Input| / 100.00 %)

where Sign(Input) = 1 if Input ≥ 0 or -1 otherwise

The square root function is useful in applications where the PID controller is operating with flow as its reference and feedback and the motor is controlling a pump. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √Pressure the square root function can be used in the conversion.

Parameter	14.022 *PID1 Error*		
Minimum	-100.00	Maximum	100.00
Default		Units	%

PID1 Error Pr **14.022** indicates the main process PID error in percent units.

Parameter	14.023 *PID1 Reference Scaling*		
Minimum	0.000	Maximum	4.000
Default	1.000	Units	

PID1 Reference Scaling Pr **14.023** implements a PID reference scaling function that is applied to the sum of the parameter pointed to by *PID1 Reference Source* Pr **14.003** and *PID1 Digital Reference* Pr **14.025**. It is recommended to leave this at the default of 1.000 for normal operation.

Parameter	14.024 *PID1 Reference Scaling*		
Minimum	0.000	Maximum	4.000
Default	1.000	Units	

PID1 Feedback Scaling Pr **14.024** implements a PID reference scaling function that is applied to the sum of the parameter pointed to by *PID1 Feedback Source* Pr **14.004** and *PID1 Digital Feedback* Pr **14.026**. It is recommended to leave this at the default of 1.000 for normal operation.

Parameter	14.025 *PID1 Digital Reference*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

PID1 Digital Reference Pr **14.025** is summed with *PID1 Reference Source* Pr **14.003,** after conversion to a percentage of the parameter maximum, and passed to *PID1 Reference Scaling* Pr **14.023**. It may be used to provide an offset to *PID1 Reference Source* Pr **14.003**.

For normal operation of the Pump software, it is recommended to leave *PID1 Digital Reference* Pr **14.025** at the default of 0.00 %.

Parameter	14.026 *PID1 Digital Feedback*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

PID1 Digital Feedback Pr **14.026** is summed with *PID1 Feedback Source* Pr **14.004**, after conversion to a percentage of the parameter maximum, and passed to *PID1 Feedback Scaling* Pr **14.024**. It may be used to provide an offset to *PID1 Feedback Source* Pr **14.004.**

For normal operation of the Pump software, it is recommended to leave *PID1 Digital Feedback* Pr **14.026** at the default of 0.00 %.

Parameter	14.027 *PID1 Enable Source 2*		
Minimum	0.000	Maximum	59.999
Default	10.002	Units	

By default, *PID1 Enable Source 2* Pr **14.027** is pointed to *Drive Active* Pr **10.002** as required by Pump software to operate correctly. This ensures that the PID is only enabled when the motor is energised. It is recommended to leave *PID1 Enable Source 2* Pr **14.027** set at the default value for normal Pump operation.

The user can still manually disable the PID if required by setting *PID1 Enable* Pr**14.008** to *Off(0)*.

Parameter	14.028 *PID1 Pre-sleep Boost Level*		
Minimum	0.00	Maximum	100.00
Default	0.00	Units	%

PID1 Pre-sleep Boost Level Pr **14.028** is used to provide a small amount of PID reference boost as the drive enters *Sleep Detect Speed Threshold* Pr **29.051**(0.042), as indicated by *Sleep Required Output* Pr **29.053.** The boost level is only applied for a maximum of *PID1 Pre-Sleep Maximum Boost Time* Pr **14.029** seconds.

This feature is a benefit in pumping systems where the output of the pump is controlled by a valve. In this scenario boosting the setpoint by a small amount can help prevent the system from going to sleep as often, and in the event that the system does go to sleep the boost in pump output will hold the system in sleep for longer reducing pump wear and running costs.

Parameter	14.029 *PID1 Pre-Sleep Maximum Boost Time*		
Minimum	0.00	Maximum	250.00
Default	0.00	Units	s

The *PID1 Pre-sleep Boost Level* Pr **14.028** is only applied for a maximum of *PID1 Pre-Sleep Maximum Boost Time* Pr **14.029** seconds.

See *PID1 Pre-sleep Boost Level* Pr **14.028**.

Parameter	14.058 *PID1 Feedback Output Scaling*		
Minimum	0.000	Maximum	4.000
Default	1.000	Units	

PID1 Feedback Output Scaling Pr**14.058** is used scale the result PID feedback after the effect of *PID1 Mode Selector* Pr**14.059** has been applied. *PID1 Feedback Square Root Enable 2* Pr**14.062** can be used in converting the output of the combined feedback from pressure to flow. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √Pressure the square root function can be used in the conversion.

See *PID1 Mode Selector* Pr**14.059.**

Parameter	14.059 *PID1 Mode Selector*		
Minimum	0	Maximum	7
Default	0	Units	

The description given in *PID1 Output* Pr **14.001** assumed that *PID1 Mode Selector* Pr **14.059** = 0 so that PID controller 1 uses its own feedback (FBK1). It is possible to select alternative configurations that allow various combinations of feedback or error from either PID controller to be used as shown below.

PID1 Mode Selector Pr **14.059** can be used to select the feedback and error as shown in the table below. It should be noted that PID controller 2 will operate normally even when its feedback or error has been selected for PID controller 1. However, if *PID1 Mode Selector* Pr **14.059** is non-zero PID controller 2 enable is controlled directly by the enable state of PID controller 1.

PID1 Mode Selector Pr14.059	Feedback	Error
0: Fbk1	FBK1	ERR1
1: Fbk2	FBK2	ERR1
2: Fbk1 + Fbk2	FBK1 + FBK2	ERR1
3: Min Fbk	Lowest of FBK1 or FBK2	ERR1
4: Max Fbk	Highest of FBK1 or FBK2	ERR1
5: Av Fbk	(FBK1 + FBK2) / 2	ERR1
6: Min Error	FBK1	If |ERR1| ≤ |ERR2| then ERR1 Else ERR2
7: Max Error	FBK1	If |ERR1| ≥ |ERR2| then ERR1 Else ERR2

Parameter	14.060 *Feedback Square Root Enable 1*		
Minimum	0	Maximum	1
Default	0	Units	

PID1 Feedback Square Root Enable 1 Pr **14.060** applies a square root function to *PID1 Feedback* Pr **14.021**, and the feedback can then be inverted if required, (*PID1 Feedback Invert* Pr **14.006** = 1). The square root function is defined as follows.

Square root function output = Sign(Input) x 100.00% x √(|Input| / 100.00%)

Where Sign(Input) = 1 if Input ≥ 0 or -1 otherwise

The square root function is useful in applications where the PID controller is operating with flow as its reference and feedback and the motor is controlling a pump. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √Pressure the square root function can be used in the conversion.

Parameter	14.062 *Feedback Square Root Enable 1*		
Minimum	0	Maximum	1
Default	0	Units	

PID1 Feedback Square Root Enable 2 Pr **14.062** can be used in converting the output of the combined feedback from pressure to flow. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √Pressure the square root function can be used in the conversion.
See *PID1 Feedback Output Scaling* Pr **14.058**.

7.9 PID thresholds

The PID thresholds offer system protection against situations where the main process PID is High or Low and provide an indication when the main process PID is at the setpoint.

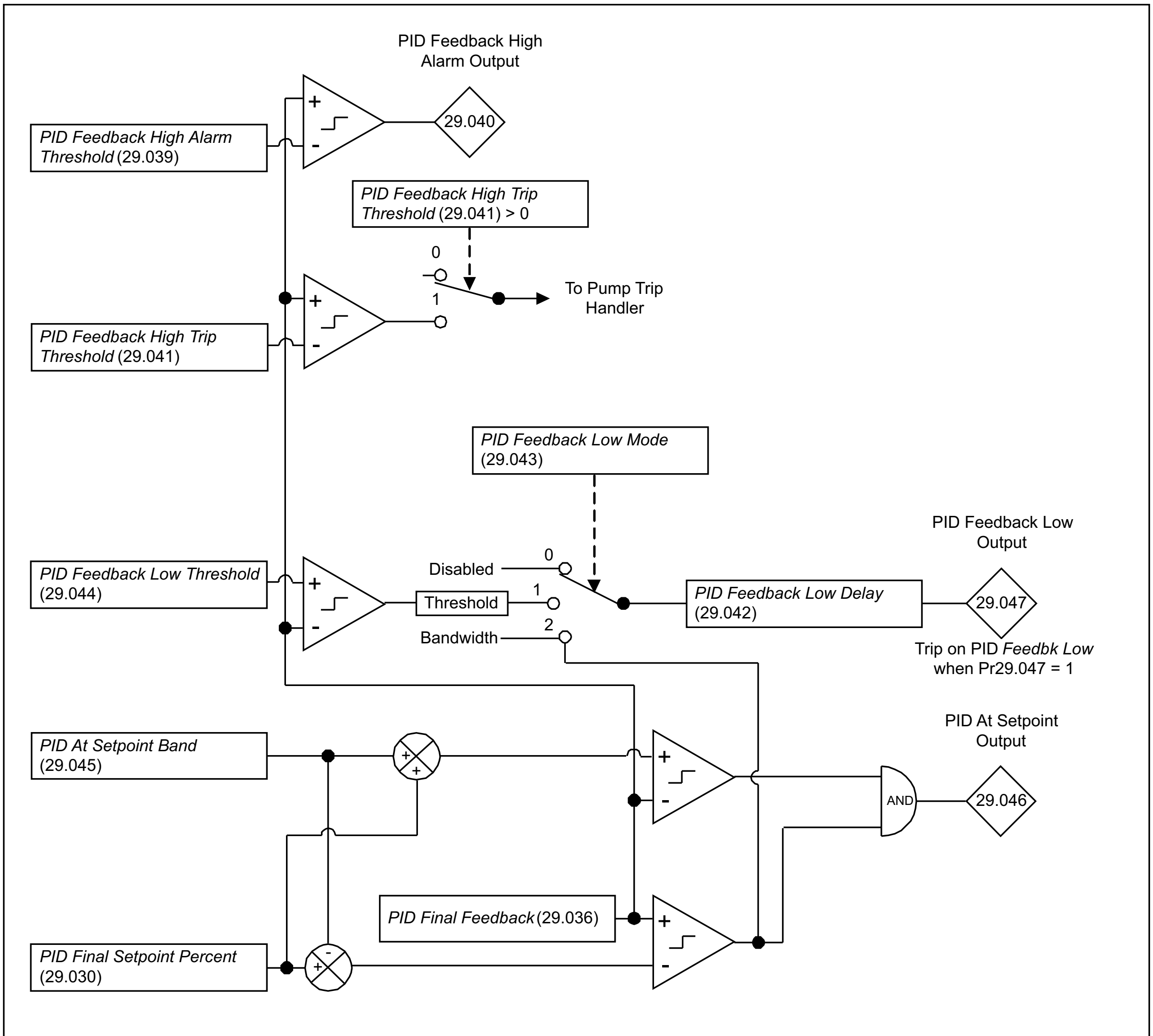
The PID feedback high detection thresholds provide alarm and trip detection when the main process PID feedback is high e.g. if the feedback device is a pressure transducer then this function provides over-pressure detection.

The PID feedback low detection threshold provides alarm and trip detection when the main process PID feedback is low e.g. if the feedback device is a pressure transducer then this function provides under-pressure detection which can protect the system in the event of a burst output pipe.

PID at setpoint detection is provided with a configurable band.

7.9.1 PID thresholds logic diagram

The following diagram shows the parameters used by the PID thresholds.



Main process PID Feedback High and Low detection

7.9.2 PID threshold parameters

The following section shows the parameters used by the PID feedback and setpoint.

Parameter	29.039 *PID Feedback High Alarm Threshold*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This defines the threshold above which a main process PID feedback High alarm is given by the *PID Feedback High Alarm Output* Pr **29.040**.

If *PID Feedback High Alarm Threshold* Pr **29.039** = 0.00, then the feedback high alarm feature is disabled.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031** (0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

Parameter	29.040 *PID Feedback High Alarm Output*		
Minimum	0	Maximum	1
Default	0	Units	

This indicates when the *PID Feedback High Alarm Threshold* Pr **29.039** has been reached or exceed by the *PID Final Feedback* Pr **29.036**.

Parameter	29.041(0.034) *PID Feedback High Trip Threshold*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

When set to 0, the main process PID high trip mechanism is disabled.

When set >0, this defines the threshold above which a *PID Feedbk High* trip is actioned.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031** (0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

Parameter	29.042(0.036) *PID Feedback Low Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the continuous time in seconds that the feedback may be low for without actioning a feedback low drive trip. This acts as a filter for transient feedback conditions that prevents false detection of a main process PID feedback low condition.

This parameter is only used when *PID Feedback Low Mode* Pr **29.043**(0.036) = *Threshold* or *Bandwidth*.

Parameter	29.043(0.036) *PID Feedback Low Mode*		
Minimum	0	Maximum	2
Default	0	Units	

PID Feedback Low Mode Pr **29.043**(0.036) selects which mode to use when generating a feedback low indication and trip. The table below shows the options available:

Mode	Value	Description
Disabled	0	No feedback low trip.
Threshold	1	If the main process PID feedback, *PID Final Feedback* Pr **29.036**, falls below the *PID Feedback Low Threshold* Pr**29.044** for *PID Feedback Low Delay* Pr **29.042** seconds, and the motor output frequency or speed is in the *Maximum Drive Reference Band* Pr **29.083**, then a PID Low drive trip is actioned. Status indication via *PID Feedback Low Output* Pr **29.047** is also available.
Bandwidth	2	If the main process PID feedback, *PID Final Feedback* Pr **29.036,** falls below the *PID At Setpoint Band* Pr **29.045** for *PID Feedback Low Delay* Pr **29.042** seconds, and the motor output frequency or speed is in the *Maximum Drive Reference Band* Pr **29.083**, then a *PID Feedbk Low* trip is actioned. The detection band follows the current PID setpoint dynamically. Status indication via *PID Feedback Low Output* Pr **29.047** is also available.

Parameter	29.044(0.037) *PID Feedback Low Mode*		
Minimum	0.00	Maximum	327.67
Default	2.00	Units	UU

This defines the PID feedback low threshold, used when *PID Feedback Low Mode* Pr **29.043** = *Bandwidth*.

If the main process PID feedback, *PID Final Feedback* Pr **29.036**, falls below the *PID Feedback Low Threshold* Pr **29.044**(0.037) for *PID Feedback Low Delay* Pr **29.042**(0.035) seconds then a PID Low drive trip is actioned and a PID low indication is given via *PID Feedback Low Output* Pr **29.047**.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr**29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

Parameter	29.045 *PID At Setpoint Band*		
Minimum	0.00	Maximum	327.67
Default	0.35	Units	UU

This defines a symmetrical band around the PID setpoint, *PID Final Setpoint* Pr **29.029**, where the system is considered to be at the setpoint i.e. the top of the band is *PID Final Setpoint* Pr **29.029** + *PID At Setpoint Band* Pr **29.045**, and the bottom of the band is *PID Final Setpoint* Pr **29.029** - *PID At Setpoint Band* Pr **29.045**.

If the main process PID feedback, *PID Final Feedback* Pr **29.036**), is within the *PID At Setpoint Band* Pr **29.045**, *PID At Setpoint Output* Pr **29.046** is set to *On(1)* indicating that the system is at the setpoint.

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031** (0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure band with the same scaling.

Parameter	29.046 *PID At Setpoint Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates when the main process PID feedback, *PID Final Feedback* Pr **29.036** is within the *PID At Setpoint Band* Pr **29.045** indicating that the system is at the setpoint, *PID At Setpoint Output* Pr **29.046**.

When set to *Off(0)*, the system isn't at the setpoint.

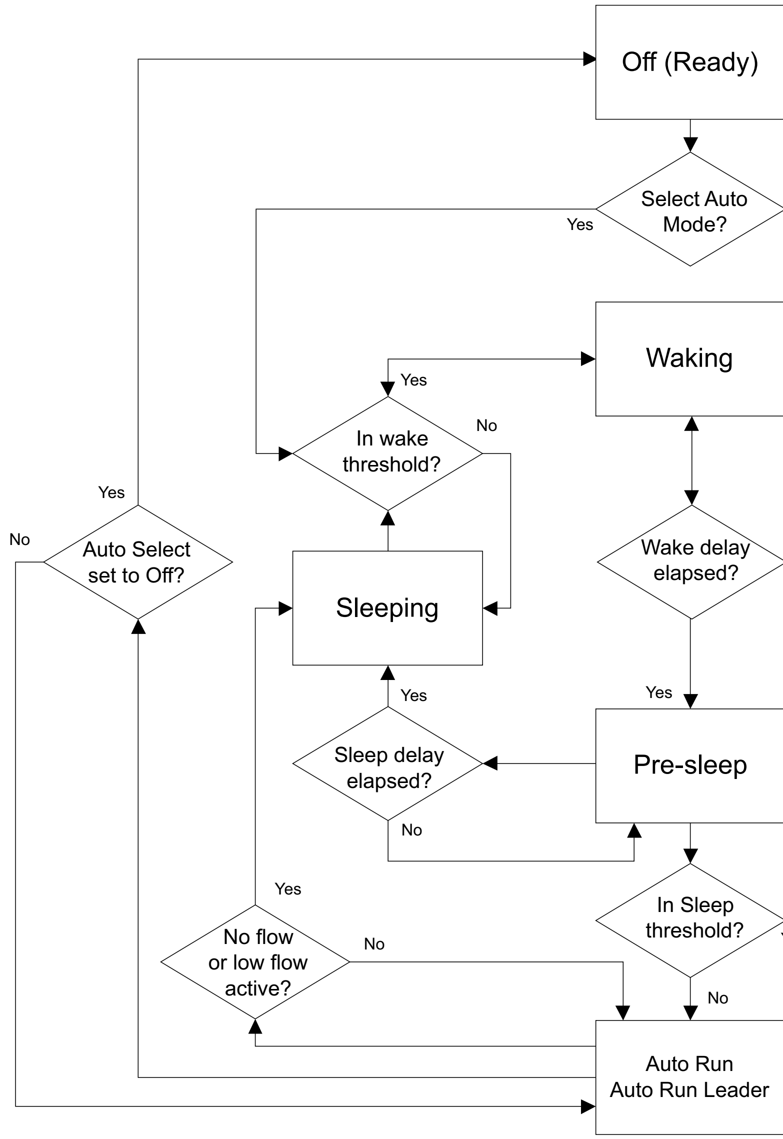
Parameter	29.046 *PID At Setpoint Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates when the main process PID feedback, *PID Final Feedback* Pr **29.036** is either less than the *PID At Setpoint Band* Pr **29.045** or the *PID Feedback Low Threshold* Pr **29.044**(0.037) indicating that the system is output is lower than the setpoint, *PID Final Setpoint* Pr **29.029**.

When set to *Off(0)*, the system output isn't low

7.10 Wake and sleep

When the Auto mode has been selected, the wake and sleep system is activated, which instructs the system when to start and when to stop. The following diagram shows the wake and sleep system for single drive systems and parallel system leaders:



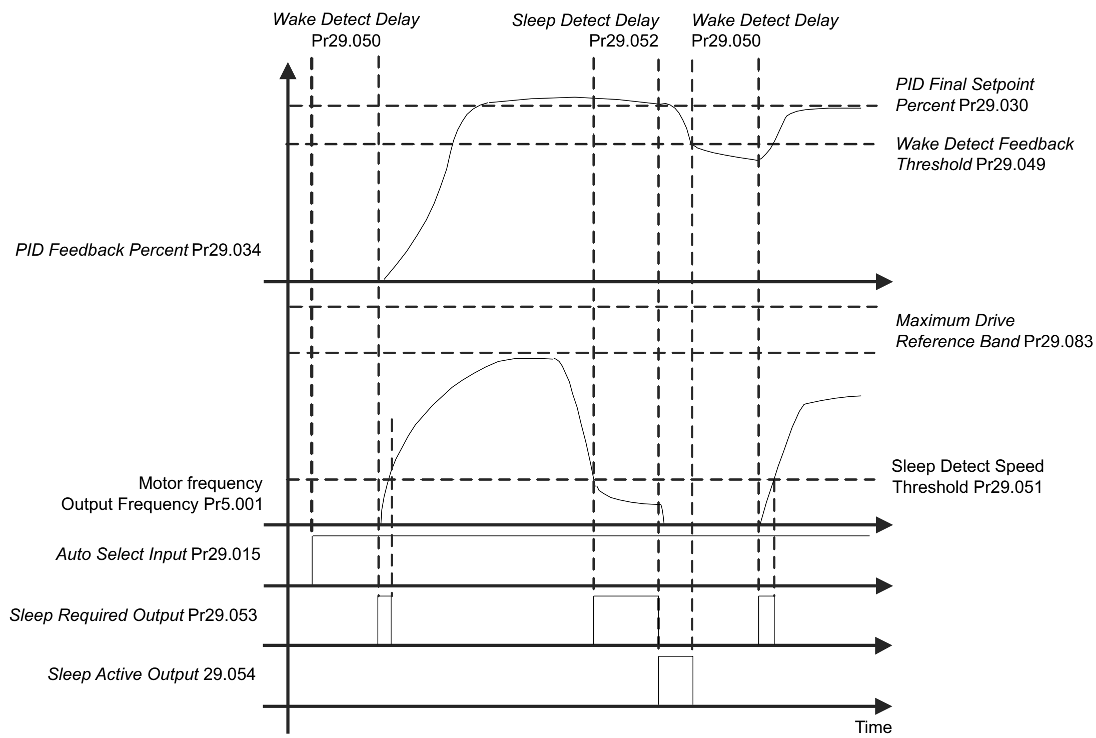
Note that an assist in a Multi-leader system is started and stopped in Auto mode by the system leader.

When the drive is placed in Auto mode, *Operating Status* Pr **29.003**(0.073) changes to *Sleeping* and the system checks if the PID feedback meets the wake threshold requirements. By default, *PID Final Feedback* Pr **29.036** must be less than *Wake Detect Feedback Threshold* Pr **29.049**(0.040). If the PID has been inverted, (*PID1 Reference Invert* Pr **14.005** and *PID1 Feedback Invert* Pr **14.005** = 1), the feedback must be greater than the *Wake Detect Feedback Threshold* Pr **29.049**(0.040). See 7.8.2 Inverting the main process PID error response for more information.

When the wake threshold has been satisfied, and the *Wake Detect Delay* Pr **29.049(**0.041) has elapsed, *Operating Status* Pr **29.003**(0.073) changes to *Pre-sleep*. Normally this happens for a few moments while the PID controller output accelerates the motor until the frequency or speed is above the *Sleep Detect Speed Threshold* Pr **29.051**(0.042), where *Operating Status* Pr **29.003**(0.073) changes to *Auto Run* or *Auto Run Leader*.

If the system output demand drops, the PID controller will reduce the speed of the motor until the *Sleep Detect Speed Threshold* Pr **29.051**(0.042) is reached and *Operating Status* Pr **29.003**(0.073) changes to *Pre-sleep*. If the speed remains below the *Sleep Detect Speed Threshold* Pr **29.051**(0.042) for the duration of the *Sleep Detect Delay* Pr **29.052**(0.043), the motor is stopped and *Operating Status* Pr **29.003**(0.073) changes to *Sleeping*.

The following timing diagram illustrates the wake and sleep process in Auto mode:

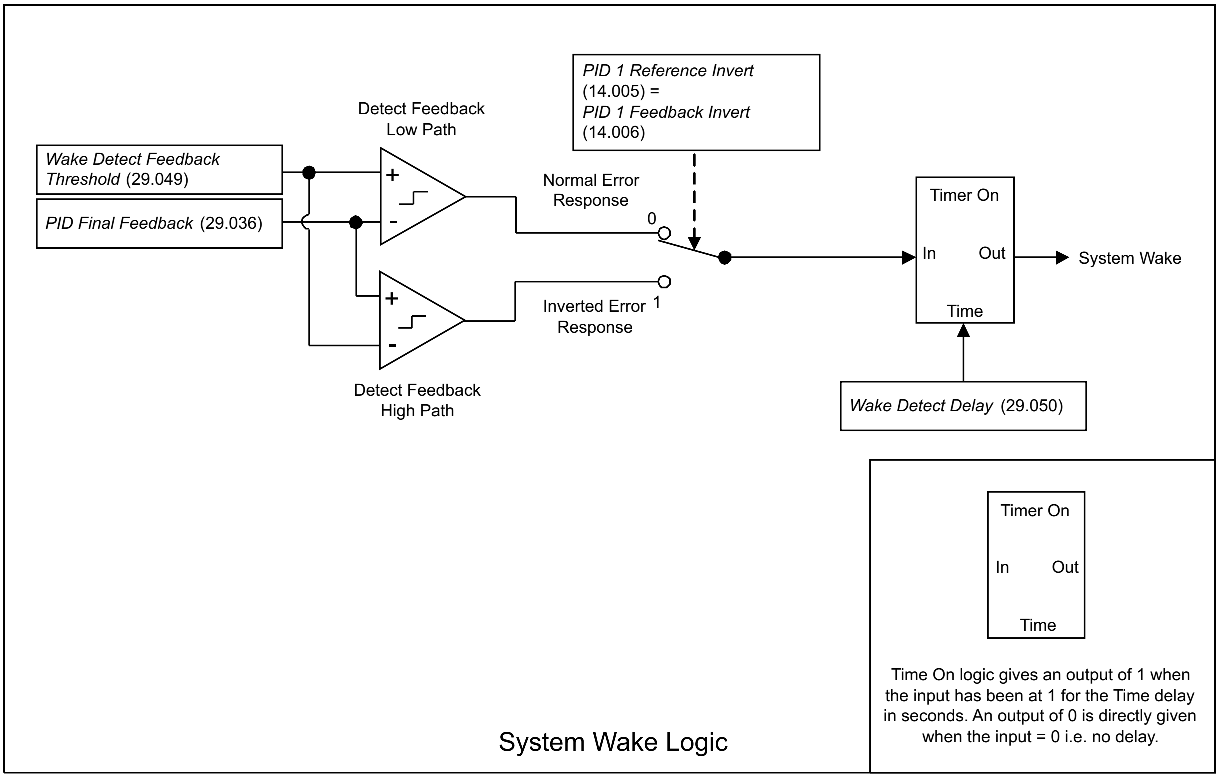


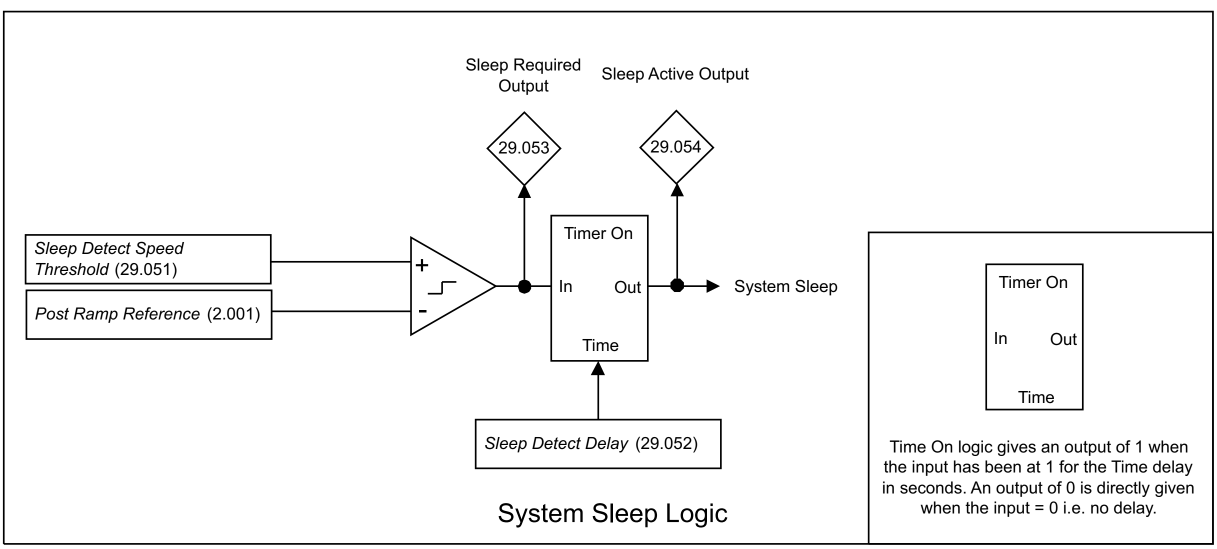
Waking and sleeping

Note that if the main process PID has been disabled by setting *PID1 Enable* Pr **14.008** = *Off(0)*, then the wake threshold is ignored and the system will wake when started in Auto mode.

7.10.1 Wake and sleep logic diagrams

The following diagram shows the parameters used by the wake and sleep system.





7.10.2 Wake and sleep parameters

The following section shows the parameters used by the wake and sleep system.

Parameter	29.049(040) *Wake Detect Feedback Threshold*		
Minimum	0.00	Maximum	327.67
Default	1.00	Units	UU

If the PID is running with a normal error response, (*PID1 Reference Invert* Pr **14.005** and *PID1 Feedback Invert* Pr **14.006** = Off(0)), *Wake Detect Feedback Threshold* Pr **29.049**(0.040) defines the main process PID feedback level, *PID Final Feedback* Pr **29.036**, below which the system will wake when the system is running in Auto mode, and defines the minimum working feedback level for the system. For example, a pumping system with a pressure feedback device gives a high PID output with a low pressure, and a low PID output with high pressure. In this scenario when the feedback is above the setpoint the setpoint the motor reference will reduce to the minimum. In order to wake the system, the PID Feedback must be below the wake threshold.

If the PID is running with an inverse error response, (*PID1 Reference Invert* Pr **14.005** and *PID1 Feedback Invert* Pr **14.006** = On(1)), *Wake Detect Feedback Threshold* Pr **29.049**(0.040) defines the main process PID feedback level, *PID Final Feedback* Pr **29.036**, above which the system will wake when the system is running in Auto mode. For example, a cooling system with a temperature feedback device gives a high PID output with a high temperature, and a low PID output with low temperature. In this scenario when the feedback is below the setpoint the motor reference will reduce to the minimum. In order to wake the system, the PID Feedback must be above the wake threshold.

See section 7.8.2 Inverting the main process PID error response .

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

Note that if the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then the wake threshold is ignored, and the system will wake when started in Auto mode.

Parameter	29.050(041) *Wake Detect Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the continuous time in seconds that the main process PID feedback, *PID Final Feedback* Pr **29.036**, must be above the *Wake Detect Feedback Threshold* Pr**29.049**(0.040) before the system is Automatically started. *Wake Detect Delay* Pr **29.050**(0.041) filters out any intermittent wake conditions.

Note that if the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then the wake threshold is ignored, and the system will wake when started in Auto mode.

See *Wake Detect Feedback Threshold* Pr **29.049**(0.040).

Parameter	29.051(042) *Sleep Detect Speed Threshold*		
Minimum	0.0	Maximum	3000.0
Default	750.0	Units	

This defines the drive output frequency or speed below which the system will sleep. This must be set to a value greater than or equal to the *Minimum Reference Clamp* Pr **1.007** to ensure the system will sleep in Auto mode.

If the system must never Automatically sleep but still control using the PID then set *Sleep Detect Speed Threshold* Pr **29.051**(0.042) to a lower value than *Minimum Reference Clamp* Pr **1.007**. Note that other conditions like Dry Well Low Load or No Flow can still stop the system Automatically.

The system will tend to reach this threshold if there is no output demand from the pump e.g. in a pump system if a pump output valve is closed the motor speed will drop because the main process PID can reach the setpoint with a reduced speed where the system will enter this threshold.

Parameter	29.052(043) *Sleep Detect Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the continuous time in seconds that the motor frequency or speed must be below *Sleep Detect Speed Threshold* Pr **29.051**(0.042) before the system is Automatically stopped. *Sleep Detect Delay* Pr **29.052**(0.043) filters out any intermittent sleep conditions.

See *Sleep Detect Speed Threshold* Pr **29.051**(0.042).

Parameter	29.053 *Sleep Required Output*		
Minimum	0	Maximum	1
Default	0	Units	

This indicates when the motor frequency or speed is below the *Sleep Detect Speed Threshold* Pr **29.051** and the *Sleep Detect Delay* Pr **29.052**(0.043) is timing down indicating that a sleep is required i.e. pre-sleep.

See *Sleep Detect Speed Threshold* Pr **29.051**(0.042).

Parameter	29.054 *Sleep Active Output*		
Minimum	0	Maximum	1
Default	0	Units	

This indicates when the motor frequency or speed was below the *Sleep Detect Speed Threshold* Pr **29.051** and the *Sleep Detect Delay* Pr **29.052** has elapsed and the system is sleeping.

See *Sleep Detect Speed Threshold* Pr **29.051**(0.042).

7.11 Over-cycle

The Pump software over-cycle protection that is used to check if the system has Automatically started and stopped too many times in an hour, due to the action of the wake and sleep system. For some systems it is not desirable for the system to stop and start too many times in an hour as this may disrupt system output.

- *Over-cycle Mode* Pr **29.127**(0.060) configures how the over-cycle detection system operates:
- *Disabled* = Over-cycle protection is disabled.
- *Alarm Only* = When the *Over-cycle Starts Per Hour* Pr **29.128**(0.061) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* Pr **29.131**.
- *Trip* = When the *Over-cycle Starts Per Hour* Pr **29.128**(0.061) has been reached the system will trip *Over-cycle*.
- *Inc Setpoint* = When the *Over-cycle Starts Per Hour* Pr **29.128**(0.061) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* Pr **29.131** and the PID setpoint will be increased by the *Over-cycle Setpoint Increment* Pr **29.129** in order to keep the system running. The maximum amount that the PID setpoint can be increased by is set by *Over-cycle Setpoint Increment Maximum* Pr29.130. An alarm is given via the *Over-cycle Alarm Output* Pr **29.131** when *Over-cycle Setpoint Increment Maximum* Pr **29.130** is reached. This helps to prevent the system from going to sleep as often thereby reducing the number of starts per hour.

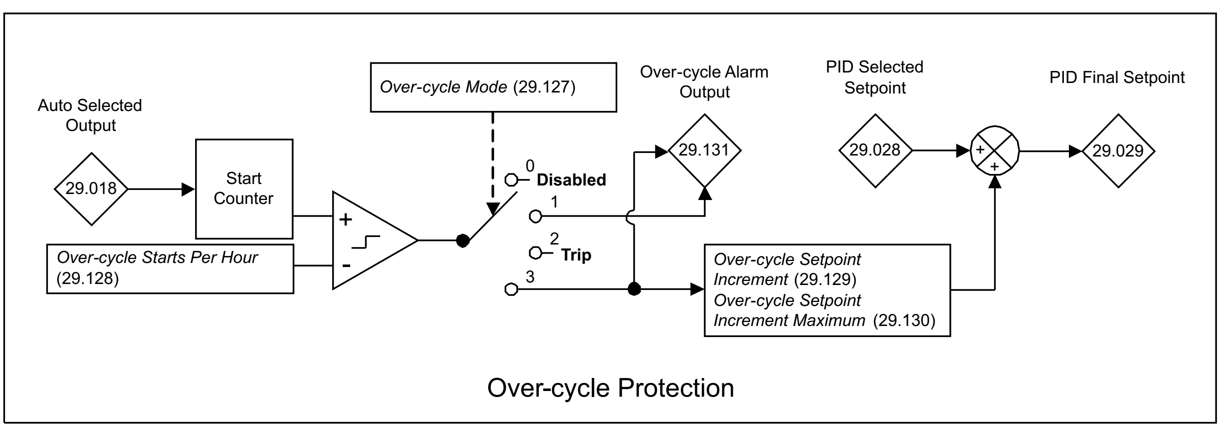
An alternative to these methods is to use the pre-sleep boost feature, configured using *PID1 Pre-sleep Boost Level* Pr **14.028** and *PID1 Pre-Sleep Maximum Boost Time* Pr **14.029**.

PID1 Pre-sleep Boost Level Pr **14.028** is used to provide a small amount of PID reference boost as the drive enters *Sleep Detect Speed Threshold* Pr **29.051**(0.042), as indicated by *Sleep Required Output* Pr **29.053**). The boost level is only applied for a maximum of *PID1 Pre-Sleep Maximum Boost Time* Pr **14.029** seconds.

This feature is a benefit in pumping systems where the output of the pump is controlled by a valve. In this scenario boosting the setpoint by a small amount can help prevent the system from going to sleep as often. In the event that the system does go to sleep, the boost in pump output will hold the system in sleep for longer, reducing pump wear and running costs.

7.11.1 Over-cycle logic diagram

The following diagram shows the parameters used by the over-cycle detection scheme.



7.11.2 Over-cycle parameters

The following section shows the parameters used by the over-cycle detection scheme.

Parameter	29.127(0.060) *Over-cycle Mode*		
Minimum	0	Maximum	3
Default	1	Units	

This defines the over-cycle protection mode used by a single drive application like Single Pump, and when the drive is a Leader in a Cascade or Multi-Leader system. Soft Starter Assist over-cycle is always enabled and is Handled separately; See *Assist Starts Per Hour* Pr **29.120** and *Assist Over-cycle Mode* Pr **29.121**.

The following over-cycle modes are available:

Mode	Value	Description
Disabled	0	Over-cycle protection is disabled.
Alarm Only	1	When the *Over-cycle Starts Per Hour* Pr**29.128**(0.061) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* Pr**29.131**.
Trip	2	When the *Over-cycle Starts Per Hour* Pr**29.128**(0.061) has been reached the system will trip *Over-cycle*.
Inc Setpoint	3	When the *Over-cycle Starts Per Hour* Pr **29.128**(0.061) has been reached the system will indicate an alarm via the *Over-cycle Alarm Output* Pr **29.131** and the PID setpoint will be increased by the *Over-cycle Setpoint Increment* Pr **29.129** in order to keep the system running. The maximum amount that the PID setpoint can be increased by is set by *Over-cycle Setpoint Increment Maximum* Pr **29.130**). An alarm is given via the *Over-cycle Alarm Output* Pr**29.131**) when *Over-cycle Setpoint Increment Maximum* Pr **29.130** is reached. This helps prevent the system from going to sleep as often thereby reducing the number of starts per hour. An alternative to this is to use *PID1 Pre-sleep Boost Level* Pr **14.028** and *PID1 Pre-Sleep Maximum Boost Time* Pr **14.029**.

Parameter	29.128(0.061) *Over-cycle Starts Per Hour*		
Minimum	0	Maximum	255
Default	5	Units	

Sets the maximum number of starts per hour threshold for the over-cycle detection system. The internal count of starts is reset every hour.

See *Over-cycle Mode* Pr **29.127**(0.060) for more details.

Parameter	29.129 *Over-cycle Setpoint Increment*		
Minimum	0.1	Maximum	2.00
Default	0.01	Units	%

Over-cycle Setpoint Increment Pr **29.129** is only used when *Over-cycle Mode* Pr**29.127**(0.060) = *Inc Setpoint*.

This defines the amount that will be added to the main process PID setpoint in the event that an over-cycle condition is detected. The maximum amount that the main process PID setpoint can be increased by is defined by *Over-cycle Setpoint Increment Maximum* Pr **29.130**. This helps prevent the system from going to sleep as often thereby reducing the number of starts per hour.

See *Over-cycle Mode* Pr **29.127**(0.060) for more details.

Parameter	29.130 *Over-cycle Setpoint Increment Maximum*		
Minimum	0.01	Maximum	15.00
Default	0.60	Units	%

Over-cycle Setpoint Increment Maximum Pr **29.130** is only used when *Over-cycle Mode* Pr **29.127**(0.060) = *Inc Setpoint*.

This defines the maximum amount that will be added to the main process PID setpoint in the event that an over-cycle condition is detected. The amount that the main process PID setpoint is increased by is defined by *Over-cycle Setpoint Increment* Pr **29.129**. This helps prevent the system from going to sleep as often thereby reducing the number of starts per hour.

See *Over-cycle Mode* Pr **29.127**(0.060) for more details.

Parameter	29.131 *Over-cycle Alarm Output*		
Minimum	0	Maximum	1
Default	0	Units	

In the event that *Over-cycle Starts Per Hour* Pr29.128(0.061) has been reached *Over-cycle Alarm Output* Pr **29.131** is set to *On(1)*.

7.12 Pipe fill on start up

An important feature for pumping systems is priming the output of the pump system with a pipe filling operation. This prevents saturation of the pressure control PID on start-up, which could result in erratic operation. Once the pipe fill operation is complete on the system, the operation will not run again until the system is stopped and re-enters Auto mode, or all drives are switched off.

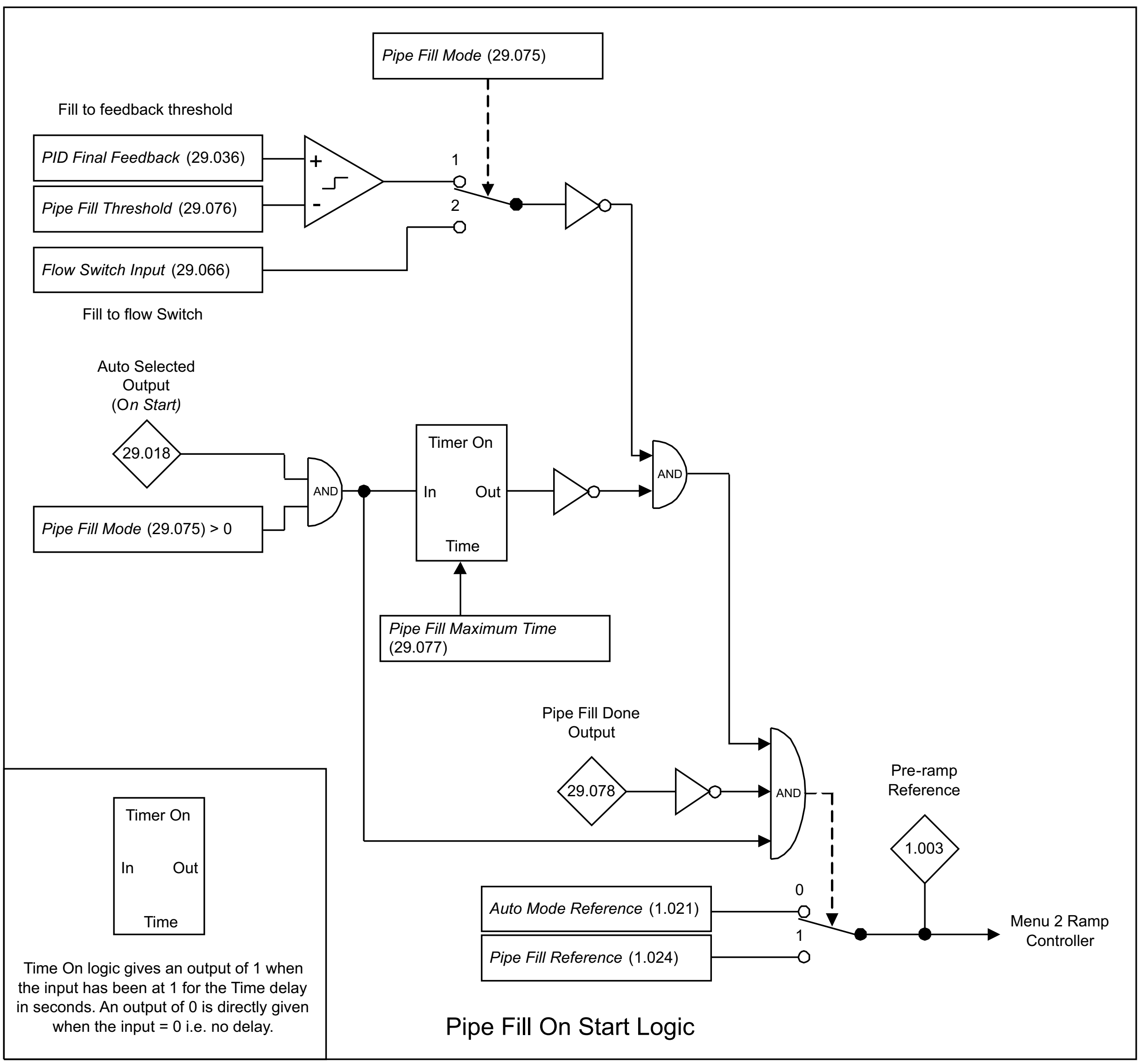
When starting the drive in Auto mode but prior to Automatic running, the drive may optionally run a fixed reference pipe filling routine. The routine has a time limit, (maximum time), to run which can be superseded by either reaching a PID feedback threshold or if flow is indicated from a hardware flow switch. When the routine is running *Operating Status* Pr **29.003**(0.073) changes to *Pipe Fill*. When the routine completes, the system moves to Auto Run where the PID controls the motor speed.

The pipe filing routine is configured using *Pipe Fill Mode* Pr **29.075**(0.046) with the following options:

- *Disabled* = The pipe fill routine is disabled.
- *Feedback Level* = *Pipe Fill Reference* Pr **1.024**(0.047) will be applied until *Pipe Fill Threshold* Pr **29.076**(0.049) is reached by the main process PID feedback. In the event that the *Pipe Fill Threshold* Pr **29.076**(0.049) isn't reached, the *Pipe Fill Maximum Time* Pr **29.077**(0.048) will elapse stopping the Automatic pipe filling routine
- *Flow Switch* = *Pipe Fill Reference* Pr **1.024**(0.047) will be applied until the *Flow Switch Input* Pr **29.066** = *On(1)*. In the event that the *Flow Switch Input* Pr **29.066** isn't set to *On(1)* the *Pipe Fill Maximum Time* Pr **29.077**(0.048) will elapse stopping the Automatic pipe filling routine.

7.12.1 Pipe fill logic diagram

The following diagram shows the parameters used by the pipe fill on start logic.



7.12.2 Pipe fill parameters

The following section shows the parameters used by the pipe fill logic.

Parameter	29.075(0.046) *Pipe Fill Mode*		
Minimum	0	Maximum	2
Default	0	Units	

This defines the operating mode of the Automated pipe fill routine. The following options are available:

Mode	Value	Description
Disabled	0	The pipe fill routine is disabled.
Feedback Level	1	*Pipe Fill Reference* Pr **1.024**(0.047) will be applied until *Pipe Fill Threshold* Pr **29.076**(0.049) is reached by the main process PID feedback. In the event that the *Pipe Fill Threshold* Pr **29.076**(0.049) isn't reached the *Pipe Fill Maximum Time* Pr **29.077**(0.048) will elapse stopping the Automatic pipe filling routine.
Flow Switch	2	*Pipe Fill Reference* Pr**1.024**(0.047) will be applied until the *Flow Switch Input* Pr **29.066** = *On(1)*. In the event that the *Flow Switch Input* Pr **29.066** isn't set to *On(1)* the *Pipe Fill Maximum Time* Pr **29.077**(0.048) will elapse stopping the Automatic pipe filling routine.

Parameter	29.076(0.047) *Pipe Fill Threshold*		
Minimum	0.00	Maximum	327.67
Default	0.00	Units	UU

This defines main PID feedback threshold above which the pipe is considered to be filled when *Pipe Fill Mode* Pr **29.075**(0.046) = *Feedback Level*. *Pipe Fill Threshold* Pr **29.076**(0.048) is compared against *PID Final Feedback* Pr **29.036**).

The units of this parameter UU, (User Units), are defined by the feedback type and scaling, *PID Feedback Minimum Scaling* Pr **29.031**(0.030) and *PID Feedback Maximum Scaling* Pr **29.032**(0.031), e.g. if the feedback transducer connected to Analog input 1 is a pressure sensor then this is a pressure threshold with the same scaling.

See *Pipe Fill Mode* Pr **29.075**(0.046).

Parameter	29.077(0.048) *Pipe Fill Maximum Time*		
Minimum	0.0	Maximum	6553.5
Default	0.0	Units	s

This defines the maximum time in seconds that the pipe filling routine will run for in the event that pipe filled isn't detected by either feedback detection or flow switch detection.

See *Pipe Fill Mode* Pr **29.075**(0.046).

Parameter	29.078 *Pipe Fill Done Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates that the pipe filling routine has completed.

When set to *Off(0)*, this indicates that the pipe filling routine is not enabled via *Pipe Fill Mode* Pr **29.075**(0.046) or pipe filling has not been completed.

7.13 Timer scheduling

The Pump software has a dedicated input for a timer to select when the system will run in Auto and when it will be stopped, *Operating Status* Pr **29.003**(0.073) changes to *Timer Stop*. Timer scheduling doesn't affect Hand mode operation. The timer control input is enabled by setting *Time Schedule Run Input Enable* Pr **29.055**.

The timer can be run in one of two ways:

- An external timer with a 24 V output signal can be connected into a spare digital input that is directed to *Time Schedule Run Input* Pr **29.056**. Note that to use this method *Timer 1 Destination* Pr **9.043** must be set to 0.000 and press reset.

- The real time clock in the keypad supplied with the F600 may be used with the timer functionality in menu 9 to start and stop the drive in Auto mode. The output of Timer 1, configured by *Timer 1 Destination* Pr **9.043,** is directed to *Time Schedule Run Input* Pr **29.056** by default.

To use the real time clock in the keypad the time must be set correctly. To do this set:

Select the date format using *Date Format* Pr **6.020**, STD = DD-MM-YY, US = MM-DD-YY.

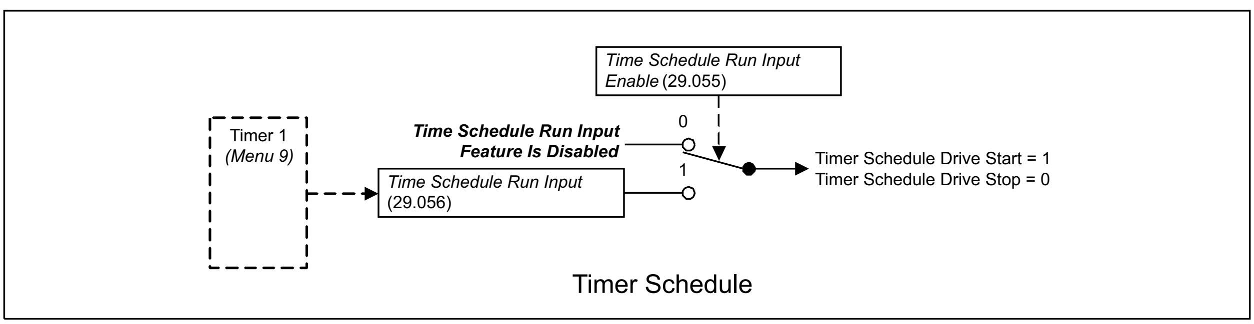
- Set *Date/Time Selector* Pr **6.019** to *Set* to allow the date and time to be updated
- Set *Date* Pr6.016 and *Time* Pr **6.017**. Note that *Day Of Week* Pr**6.018** will Automatically be resolved.
- Set *Date/Time Selector* Pr **6.019** to *Local Keypad*

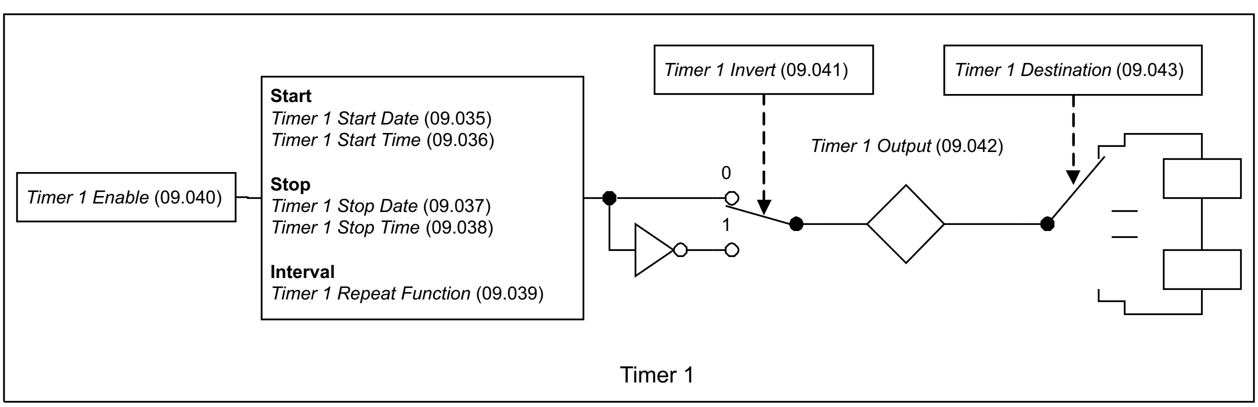
To use timer 1 in menu 9 to schedule the on and off period in each day set the following parameters:

- Set *Timer 1 Start Time* Pr **9.036** in 24hour format.
- Set *Timer 1 Stop Time* Pr **9.038** in 24hour format.
- Set *Timer 1 Repeat Function* Pr **9.039** to *Day.*
- Set *Timer 1 Enable* Pr **9.040** to *On(1)*
- Perform a save by setting Pr0.000 to Save Parameters and then press the red reset button.

7.13.1 Timer scheduling logic diagrams

The following diagram shows the parameters used by the timer scheduling logic.





7.13.2 Timer scheduling parameters

The following section shows the parameters used by the timer scheduling logic.

Parameter	29.055 *Time Schedule Run Input Enable*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, *Time Schedule Run Input* Pr **29.056** is enabled. To run the system in Auto *Time Schedule Run Input* Pr **29.056** must be set to *On(1)*, and to stop the system *Time Schedule Run Input* Pr **29.056** must be set to *Off(0)*.

This feature is intended to be operated by a clock such as the one provided by a KI-HOA Keypad RTC keypad, where timer 1 in the *User Functions 1* Menu 9 may be used to define on and off periods for the system e.g. for an irrigation pump it may be desirable to run the pump during the day only. By default, the output of timer 1, *Timer 1 Output* Pr **9.042**, is routed to the *Time Schedule Run Input* Pr **29.056** using *Timer 1 Destination* Pr **9.043**.

When set to *Off(0)*, *Time Schedule Run Input* Pr **29.056** is disabled and has no effect on the system.

Parameter	29.056 *Time Schedule Run Input*		
Minimum	0	Maximum	1
Default	0	Units	

To use this input *Time Schedule Run Input Enable* Pr **29.055** must be set to *On(1)*.

When set to *On(1)*, the system will be permitted to run in Auto mode.

When set to *Off(1)*, the system will be stopped in Auto mode.

This feature is intended to be operated by a clock such as the one provided by a KI-HOA Keypad RTC keypad, where timer 1 in the *User Functions 1* Menu 9 may be used to define on and off periods for the system e.g. for an irrigation pump it may be desirable to run the pump during the day only. By default, the output of timer 1, *Timer 1 Output* Pr **9.042**, is routed to the *Time Schedule Run Input* Pr **29.056** using *Timer 1 Destination* Pr **9.043**.

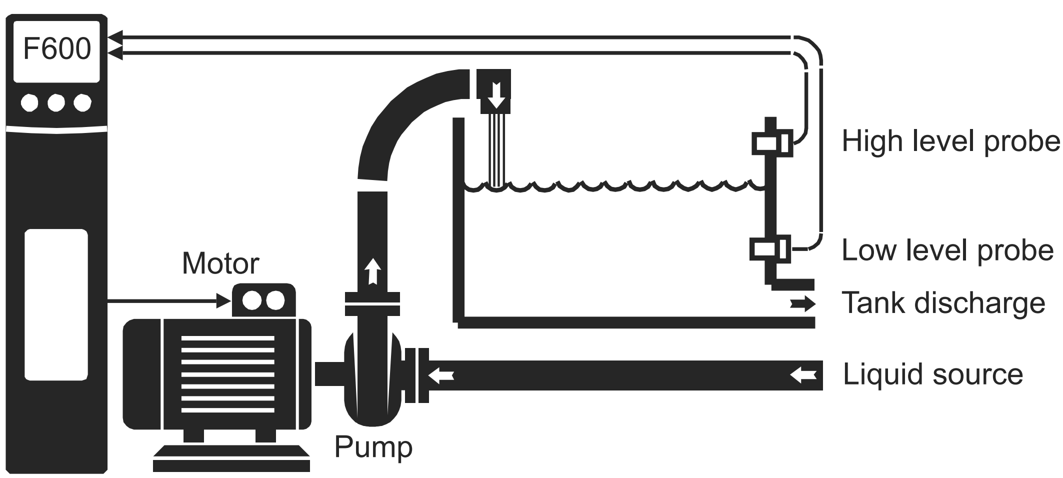
See *Time Schedule Run Input Enable* Pr **29.055**.

7.14 Level switches

The level switch functionality allows the user to run the drive in two different ways, configured by *Level Switch Mode* Pr **29.082**:

High Only = Stop the system in Auto mode when *Level Switch High Input* Pr **29.079** = *On(1)*; *Operating Status* Pr **29.003** changes to *Level Stop*. The system restarts when the high level switch input is set to *Off(0)*. This is intended for pumping systems that fill a tank or reservoir, that have a high level probe to detect if the tank is going to over-fill.

High Low Toggle = Start the system in Auto mode when *Level Switch Low Input* Pr **29.079** = *On(1)*, and stop the system when *Level Switch High Input* Pr **29.079** = *On(1)*; *Operating Status* Pr **29.003** changes to *Level Stop*. If the *Level Switch Low Input* Pr **29.079** and *Level Switch High Input* Pr **29.079** both = *On(1)* the high level switch has priority and the system will stop. This is intended for pumping systems that fill a tank or reservoir, that have a high and low level probe, where the liquid level must rise and fall between the two level probes.



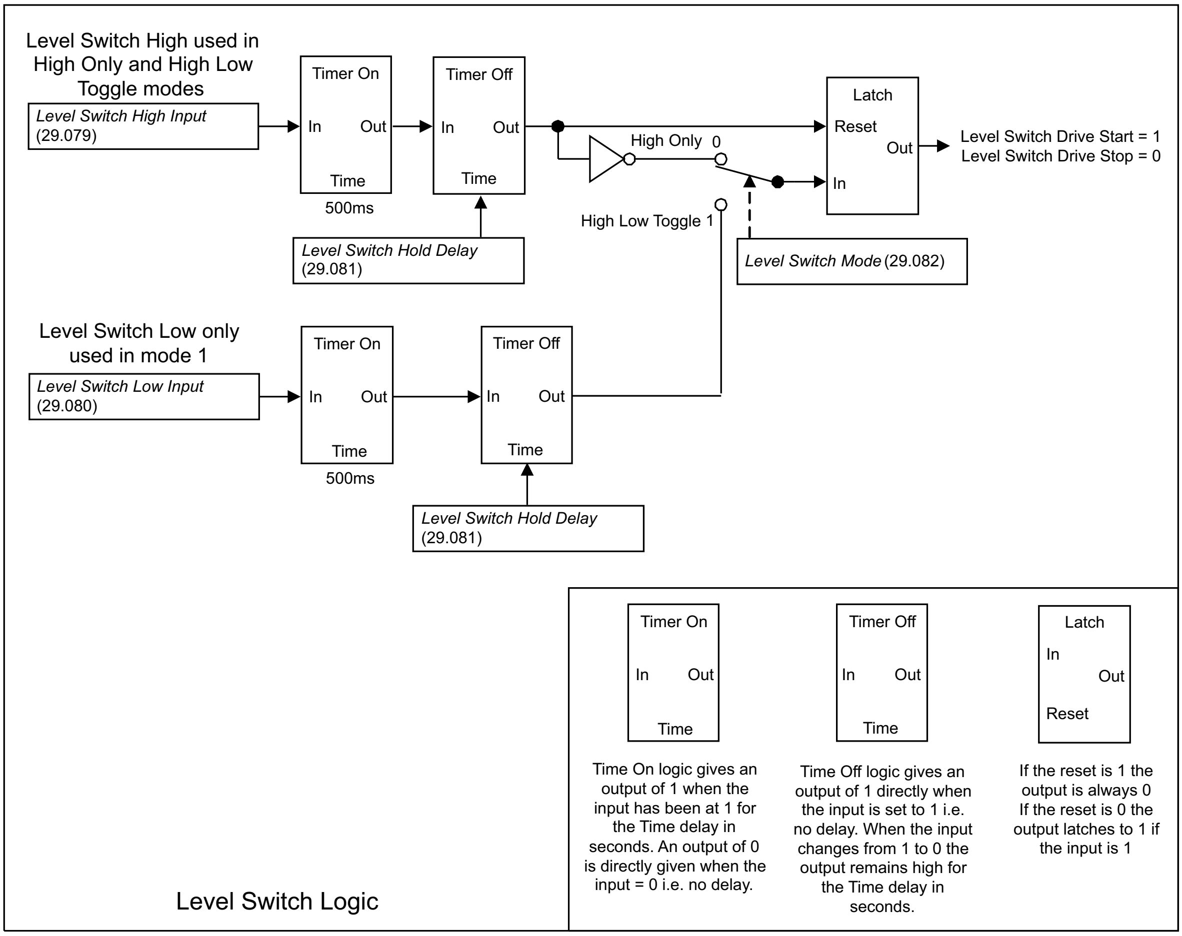
The high level probe must be configured to detect when it comes into contact with liquid i.e. it outputs 24 V when liquid is present. The low level probe must be configured to detect when it isn't in contact with liquid, so that the level drops just below the sensor to start the pump. If the level probes can't be configured in this way directly, the F600 digital inputs may be inverted to get the correct logic.

To filter out transient conditions, e.g. ripple on the liquid surface triggering the level probes, a fixed 500 ms settling time is used when triggering the high and low inputs, and once triggered the condition is held for a minimum time defined by *Level Switch Hold Delay* Pr **29.081**.

Note that if the main process PID has been disabled by setting *PID1 Enable* Pr **14.008** = *Off(0)*, then the wake threshold is ignored and the system will wake when started in Auto mode, even if *Level Switch Low Input* Pr **29.079** hasn't been set to *On(1)*. If the PID is enabled, *Wake Detect Feedback Threshold* Pr **29.049**(0.040) must be met by the feedback for the system to start.

7.14.1 Level switch logic diagram

The following diagram shows the parameters used by the level switch logic.



7.14.2 Level switch parameters

The following section shows the parameters used by the level switch logic.

Parameter	29.079 *Level Switch High Input*		
Minimum	0	Maximum	1
Default	0	Units	

This is the input for a tank level high probe or switch where *Off(0)* = not at high level, *On(1)* = at the high level and the system must shut down. A digital input with a tank high level probe or switch connected should be routed to *Level Switch High Input* Pr **29.079.**

If *Level Switch High Input* Pr **29.079** and *Level Switch Low Input* Prb = *On(1)* the high switch action has priority and the system will stop.

Parameter	29.080 *Level Switch Low Input*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This is the input for a tank low level probe or switch where *Off(0)* = not at low level, *On(1)* = at the low level, where if *Level Switch Mode* Pr**29.082** = *High Low Toggle* the system will start. A digital input with a tank level low probe or switch connected should be routed to *Level Switch Low Input* Pr**29.080**.

If *Level Switch High Input* Pr **29.079** and *Level Switch Low Input* (**29.080**) = *On(1)* the high switch action has priority and the system will stop. The low level switch is only active when running in Auto mode.

This is intended to be used in a pumping system where the PID is not in use, *PID1 Enable* (**14.008**) = *Off(0)*, and the system must fill a tank until the high level switch is reached, and then let the level fall until the low level switch is reached where the system will start again. If *PID1 Enable* Pr**14.008** = *On(1)*, then the system must hit the low level switch and meet the wake criteria e.g. *Wake Detect Feedback Threshold* Pr **29.049(**0.040).

Parameter	29.081 *Level Switch Hold Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the minimum time in seconds for either a high or low level switch activation to be maintained for regardless of the state of the *Level Switch High Input* (**29.079**) or *Level Switch Low Input* (**29.080**). A fixed 500 ms switch debounce delay is added when confirming a level high or low switch activation.

Parameter	29.082 *Level Switch Mode*		
Minimum	0	Maximum	1
Default	0	Units	

This defines the operating mode of the level switches. The following options are available:

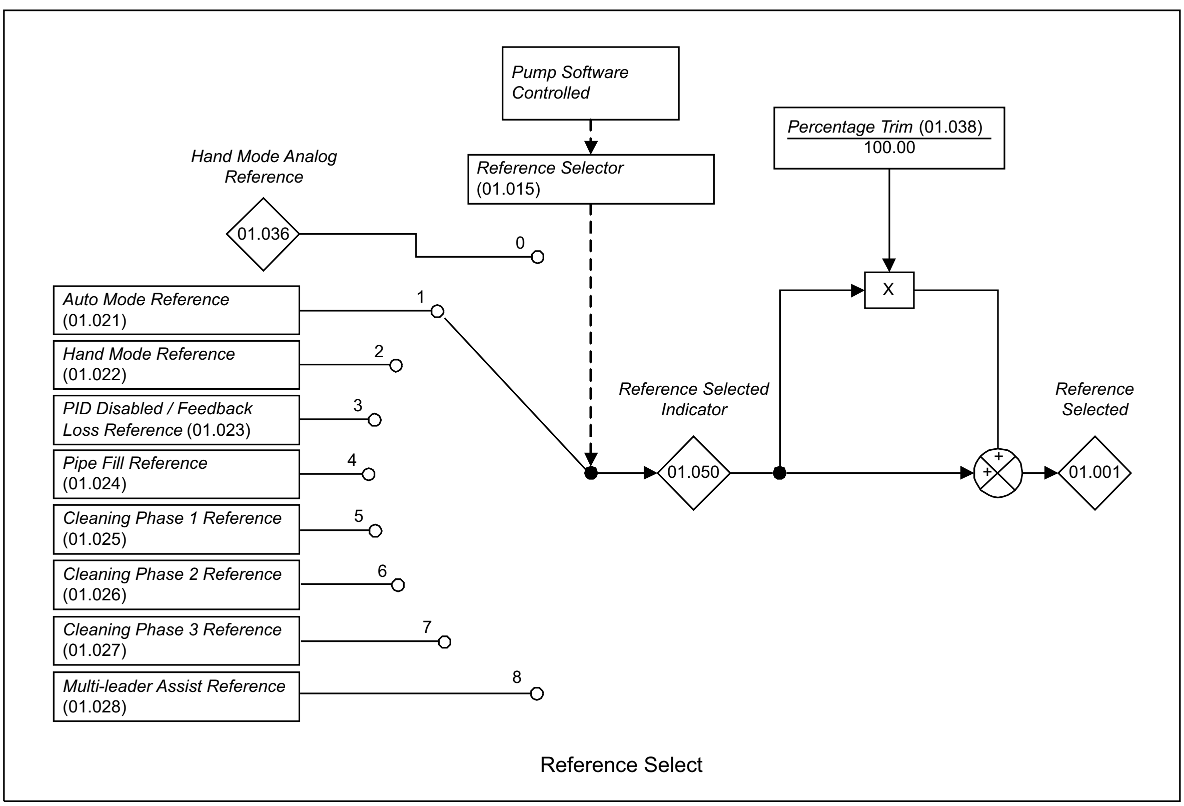
Mode	Value	Description
High Only	0	When the *Level Switch High Input* Pr **29.079** is set to *On(1)* the system will stop. This only happens when running in Auto mode, Hand mode and Cleaning are not affected. The *Level Switch Low Input* Pr **29.080** is not used.
High Low Toggle	1	The *Level Switch Low Input* Pr **29.080** is enabled where if this input = *On(1)* the system will run until the *Level Switch High Input* Pr **29.079** = *On(1)* when the system stops. The level will rise and fall automatically between these two limits. The low input and high input logic level does not need to be maintained

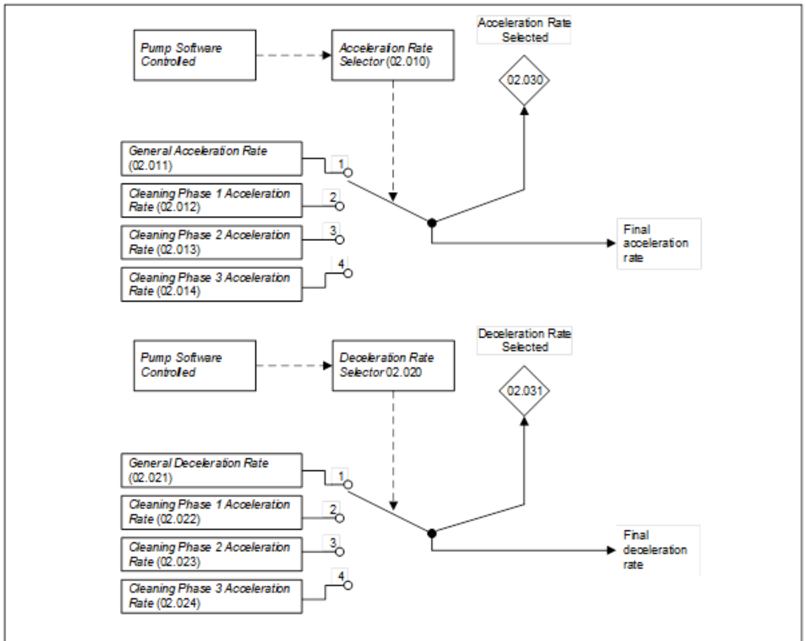
7.15 References, acceleration and deceleration

The frequency or speed setpoints and profile acceleration and deceleration are situated in Menu 1 and 2. Menu 1 is where the reference clamps, references and selection are found. Menu 2 is where the acceleration, deceleration and selection are found.

7.15.1 Reference, acceleration and deceleration logic diagrams

The following diagram shows the parameters used by the reference, acceleration and deceleration logic.





Acceleration and deceleration rate selection

7.15.2 Reference, acceleration and deceleration parameters

The following section shows the parameters used by the reference, acceleration and deceleration logic.

Parameter	01.001 *Reference Selected*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default		Units	Hz or rpm

Reference Selected Pr **01.001** is the basic reference selected from the available sources including the effect of the percentage trim.

Parameter	01.015 *Reference Selector*		
Minimum	0	Maximum	8
Default	1	Units	

Used by the Pump software to select the frequency or speed reference. See the table below for the list of reference selections:

Value	Reference
0	*Hand Mode Analog Reference* Pr **01.036**
1	*Auto Mode Reference* Pr **01.021**
2	*Hand Mode Reference* Pr **01.022**(0.026)
3	*PID Disabled / Feedback Loss Reference* Pr **01.023**
4	*Pipe Fill Reference* Pr **01.024**(0.047)
5	*Cleaning Phase 1 Reference* Pr **01.025**
6	*Cleaning Phase 2 Reference* Pr **01.026**
7	*Cleaning Phase 3 Reference* Pr **01.027**
8	*Multi-leader Assist Reference* Pr **01.028**

Parameter	01.021 *Auto Mode Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	0.0	Units	Hz or rpm

This defines the speed or frequency reference used when running in Auto mode. The output of the main process PID, (PID1), is routed to this parameter. See *Auto Select Input* Pr **29.015** and *User PID Controller* Menu 14.

Parameter	01.022(0.026) *Hand Mode Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	25 Hz or 750 rpm (Std) 30 Hz or 900 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when running in Hand mode. See *Hand Select Input* Pr **29.013**.

Parameter	01.023 *PID Disabled / Feedback Loss Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	25 Hz or 750 rpm (Std) 30 Hz or 900 rpm (US)	Units	Hz or rpm

Parameter	01.024(0.047) *Pipe Fill Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	25 Hz or 750 rpm (Std) 30 Hz or 900 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when the Automated pipe filling routine is running. See *Pipe Fill Mode* Pr **29.075**(0.046).

Parameter	01.025 *Cleaning Phase 1 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	-15 Hz or -450 rpm (Std) -18 Hz or -540 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 1 is in progress.
See *Cleaning Phase 1 Time At Reference* Pr **29.093**, *Cleaning Phase 1 Acceleration Rate* Pr **2.012** and *Cleaning Phase 1 Deceleration Rate* Pr **2.022**.

Parameter	01.026 *Cleaning Phase 2 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	15 Hz or 450 rpm (Std) 18 Hz or 540 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 2 is in progress.
See *Cleaning Phase 2 Time At Reference* Pr **29.094**, *Cleaning Phase 2 Acceleration Rate* Pr **2.013** and *Cleaning Phase 2 Deceleration Rate* Pr **2.023**.

Parameter	01.027 *Cleaning Phase 3 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	40 Hz or 1200rpm (Std) 54 Hz or 1440rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 3 is in progress. See *Cleaning Phase 3 Time At Reference* Pr **29.095,** *Cleaning Phase 3 Acceleration Rate* Pr **2.014** and *Cleaning Phase 3 Deceleration Rate* Pr **2.024**.

Parameter	01.028 *Multi-leader Assist Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	0.0	Units	Hz or rpm

This defines the speed or frequency reference used by this drive when it is an assist to the leader drive in a Multi-leader system, *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Parameter	01.036 *Hand Mode Analog Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	0.0	Units	Hz or rpm

Used to receive the final analogue speed / frequency reference in Hand mode. By default, analog input 2 T6 is directed to this parameter, and us used when analog Hand mode reference is selected by setting *Hand Mode Reference Select* Pr **29.016**(0.025) = *Analog Speed*.

Parameter	01.038 *Percentage Trim*		
Minimum	-100.00	Maximum	100.00
Default	0.00	Units	%

Percentage Trim Pr **1.038** is used to apply an offset to the *Reference Selected* Pr**1.001**. The default of 0.00 is suitable for most applications. The final reference is calculated from *Reference Selected* Pr **1.001** multiplied by [1 + (*Percentage Trim* Pr **1.038** / 100.00)].

Parameter	01.050 *Reference Selected Indicator*		
Minimum	1	Maximum	8
Default		Units	

Indicates which speed or frequency reference has been selected by *Reference Selector* Pr**1.015.** See the table below for the list of reference selections:

Value	Reference
0	*Hand Mode Analog Reference* Pr **01.036**
1	*Auto Mode Reference* Pr **01.021**
2	*Hand Mode Reference* Pr **01.022**(0.026)
3	*PID Disabled / Feedback Loss Reference* Pr **01.023**
4	*Pipe Fill Reference* Pr **01.024**(0.047)
5	*Cleaning Phase 1 Reference* Pr **01.025**
6	*Cleaning Phase 2 Reference* Pr **01.026**
7	*Cleaning Phase 3 Reference* Pr **01.027**
8	*Multi-leader Assist Reference* Pr **01.028**

Parameter	2.001 *Post Ramp Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default		Units	

The *Post Ramp Reference* Pr **2.001** is combined with the slip compensation frequency to define the output frequency of the drive.

Parameter	2.010 *Acceleration Rate Selector*		
Minimum	1	Maximum	4
Default	1	Units	

The *Acceleration Rate Selector* Pr **2.010** is used to select an acceleration rate by the Pump software. The following table shows the rates that may be selected:

Value	Reference
1	*General Acceleration Rate* Pr **2.011**
2	*Cleaning Phase 1 Acceleration Rate* Pr **2.012**
3	*Cleaning Phase 2 Acceleration Rate* Pr **2.013**
4	*Cleaning Phase 3 Acceleration Rate* Pr **2.014**

Parameter	2.011 *General Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	1.0	Units	s

This defines the acceleration rate in Hand and Auto, except when a pump cleaning or de-ragging cycle is running.

The units of *General Acceleration Rate* Pr **2.011**), *Cleaning Phase 1 Acceleration Rate* Pr **2.012**, *Cleaning Phase 2 Acceleration Rate* Pr **2.013** and *Cleaning Phase 3 Acceleration Rate* Pr **2.014** are s / Ramp rate frequency or s / Ramp rate speed. See *Ramp Rate Units* Pr **2.039** for the definition of Ramp rate frequency and Ramp rate speed.

Parameter	2.012 *Cleaning Phase 1 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 1 of the cleaning or de-ragging routine; See *Cleaning Phase 1 Time At Reference* Pr **29.093**.

Parameter	2.013 *Cleaning Phase 2 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 2 of the cleaning or de-ragging routine.

Parameter	2.014 *Cleaning Phase 3 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 3 of the cleaning or de-ragging routine.

Parameter	2.020 *Deceleration Rate Selector*		
Minimum	1	Maximum	4
Default	1	Units	

The *Deceleration Rate Selector* Pr**2.020** is used to select an acceleration rate by the Pump software. The following table show the selections possible:

Value	Deceleration Rate Selected
1	*General Acceleration Rate* Pr **2.021**
2	*Cleaning Phase 1 Acceleration Rate* Pr **2.022**
3	*Cleaning Phase 2 Acceleration Rate* Pr **2.023**
4	*Cleaning Phase 3 Acceleration Rate* Pr **2.024**

Parameter	2.021 *General Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	1.0	Units	s

This defines the acceleration rate in Hand and Auto, except when a pump cleaning or de-ragging cycle is running.

The units of *General Deceleration Rate* Pr **2.021**, *Cleaning Phase 1 Deceleration Rate* Pr **2.022**, *Cleaning Phase 2 Deceleration Rate* Pr **2.023** and *Cleaning Phase 3 Deceleration Rate* Pr **2.024** are s / Ramp rate frequency or s / Ramp rate speed. See *Ramp Rate Units* Pr **2.039**) for the definition of Ramp rate frequency and Ramp rate speed.

Parameter	2.022 *Cleaning Phase 1 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 1 of the cleaning or de-ragging routine.

Parameter	2.023 *Cleaning Phase 2 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 2 of the cleaning or de-ragging routine.

Parameter	2.024 *Cleaning Phase 3 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 3 of the cleaning or de-ragging routine.

Parameter	2.030 *Acceleration Rate Selected*		
Minimum	0	Maximum	8
Default		Units	

Acceleration Rate Selected **2.030** shows the acceleration rate that has been selected by the Pump software. The following table shows the rates that may be selected:

Value	Acceleration Rate Selected
1	*General Acceleration Rate* Pr **2.011**
2	*Cleaning Phase 1 Acceleration Rate* Pr **2.012**
3	*Cleaning Phase 2 Acceleration Rate* Pr **2.013**
4	*Cleaning Phase 3 Acceleration Rate* Pr **2.014**

Parameter	2.031 *Deceleration Rate Selected*		
Minimum	0	Maximum	8
Default		Units	

Deceleration Rate Selected Pr **2.031** the deceleration rate that has been selected by the Pump software. The following table show the selections possible:

Value	Deceleration Rate Selected
1	*General Acceleration Rate* Pr **2.021**
2	*Cleaning Phase 1 Acceleration Rate* Pr **2.022**
3	*Cleaning Phase 2 Acceleration Rate* Pr **2.023**
4	*Cleaning Phase 3 Acceleration Rate* Pr **2.024**

Parameter	2.039 *Deceleration Rate Selected*		
Minimum	0	Maximum	1
Default	1	Units	

The ramp rate parameters, *General Acceleration Rate* Pr **2.011**, *Cleaning Phase 1 Acceleration Rate* Pr **2.012**, *Cleaning Phase 2 Acceleration Rate* Pr **2.013**, *Cleaning Phase 3 Acceleration Rate* Pr **2.014**, *General Deceleration Rate* Pr **2.021,** *Cleaning Phase 1 Deceleration Rate* Pr **2.022**, *Cleaning Phase 2 Deceleration Rate* Pr **2.023** and *Cleaning Phase 3 Deceleration Rate* Pr **2.024**, are specified in s / Ramp rate frequency for Open-loop mode and s / Ramp rate speed for RFC-A and RFC-S modes. Ramp rate frequency and Ramp rate speed are selected with *Ramp Rate Units* Pr **2.039** as defined in the table below:

Ramp Rate Units (2.039)	Open-loop Ramp rate frequency	RFC-A and RFC-S mode Ramp rate speed
0	100 Hz	1000 rpm
1	Maximum frequency (*Maximum Reference Clamp* Pr **1.006**)	Maximum speed (*Maximum Reference Clamp* Pr **1.006**)

7.16 Volume and flow using a pulsed flow meter

The F600 has volume and flow indication when a suitable pulsed flow sensor has been connected to a digital input routed to *Flow Meter Pulse Input* Pr **29.008**. The maximum input frequency is 100 Hz.

Flow Scaling Pr **29.007** converts the pulses from the flow meter into the equivalent flow rate e.g. Litres per minute or Gallons per minute. Many flow meters give a flow rate at a given frequency e.g. 100 Hz = 120 litres per minute, where this can be converted to a flow scale factor by dividing the flow rate by the frequency and then multiplying by the 5 s pump software sample rate e.g. flow Scale Factor = 120/(100*5) = 0.24.

Volume Scaling Pr **29.006** converts the pulses from the flow meter into the equivalent volume e.g. Litres per minute of Gallons per minute. Many flow meters give a flow rate at a given frequency e.g. 100 Hz = 120 litres per minute, where this can be converted to a volume per pulse by dividing the flow rate by the frequency e.g. Volume Scaling = 120/100 = 1.2.

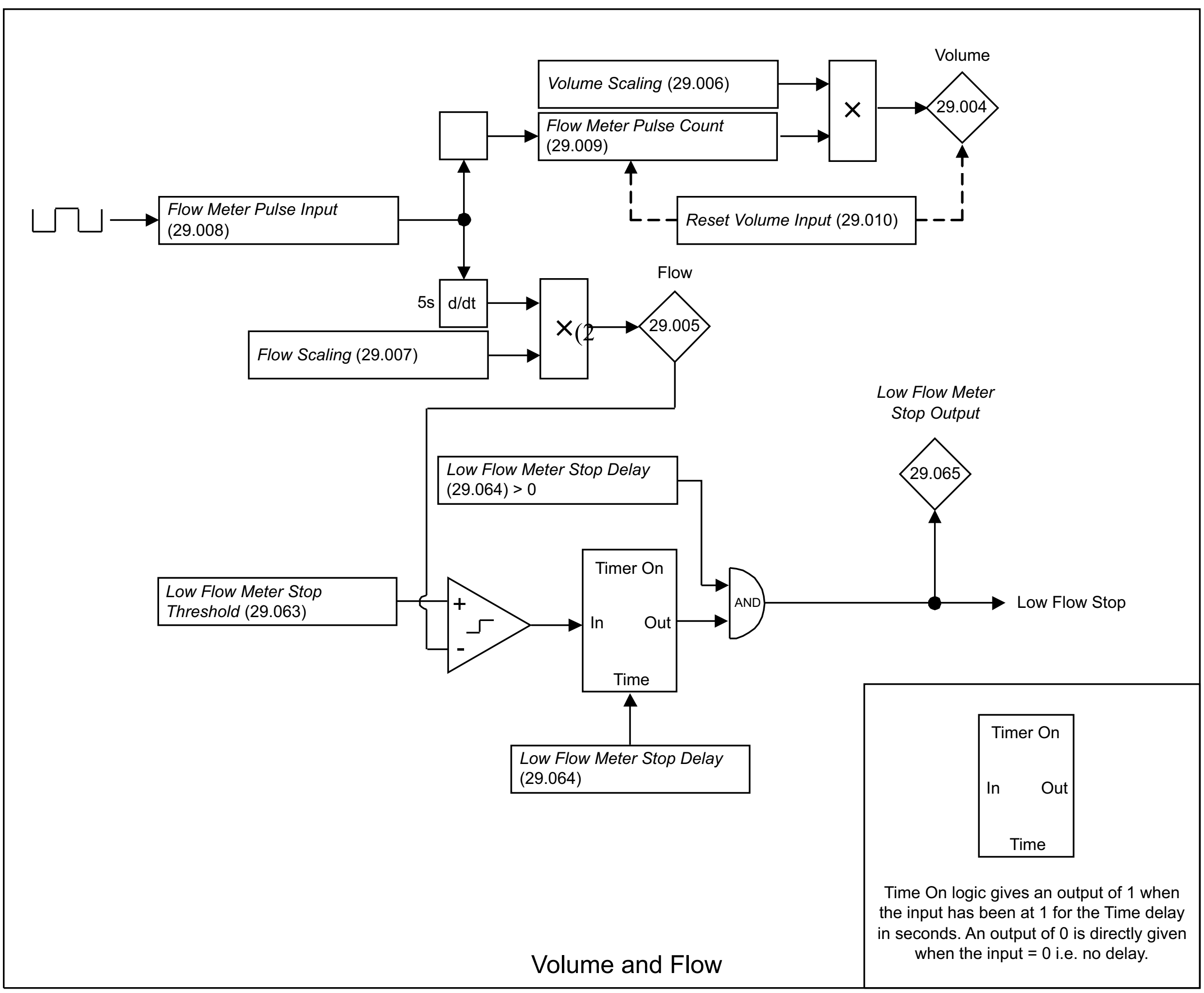
Volume Pr **29.004** indicates the total volume so far in the units defined by *Volume Scaling* Pr **29.006**. The value may be reset during operation by setting *Reset Volume Input* Pr **29.010** to *On(1)*.

Flow Pr **29.005** indicates the flow in the units defined by *Flow Scaling* Pr **29.007**.

Once a suitable pulsed flow meter is connected, the system may be stopped in the event of the liquid flow going below *Low Flow Meter Stop Threshold* Pr **29.063**. The feature is enabled when Low Flow Meter Stop Delay Pr **29.064** is set >0.0 s.

7.16.1 Volume and flow logic diagram

The following diagram shows the parameters used by the volume and flow logic.



7.16.2 Volume and flow logic parameters

The following section shows the parameters used by the volume and flow logic.

Parameter	29.004 *Volume*		
Minimum	0	Maximum	2147483647
Default	0	Units	Defined by *Volume Scaling* Pr **29.006**

This indicates the system total volume so far in units defined by *Volume Scaling* Pr **29.006** e.g. Litres or Gallons. The volume value can be reset by setting *Reset Volume Input* Pr **29.010** to On(1). To calculate Volume a suitable pulsed output flow meter must be connected to a digital input routed to *Flow Meter Pulse Input* Pr **29.008**.

Parameter	29.005 *Flow*		
Minimum	0.0	Maximum	100000000.0
Default	0.0	Units	*Flow Scaling* Pr **29.007**

This indicates the system flow in units defined by *Flow Scaling* Pr **29.007** e.g. Litres per minute or Gallons per minute. To calculate Flow a suitable pulsed output flow meter must be connected to a digital input routed to *Flow Meter Pulse Input* Pr **29.008.**

Parameter	29.006 *Volume Scaling*		
Minimum	0.000000	Maximum	1000.000000
Default	1.000000	Units	

This is the scaling factor to convert the pulsed flow meter count into a volume in a user selected unit e.g. Gallons or Litres. The scaling factor is a volume per flow meter pulse. Many flow meters give a flow rate at a given frequency e.g. 100 Hz = 120 litres per minute, where this can be converted to a volume per pulse by dividing the flow rate by the frequency e.g. Volume Scaling = 120/100 = 1.2.

Parameter	29.007 *Flow Scaling*		
Minimum	0.000000	Maximum	1000.000000
Default	1.000000	Units	

This is the scaling factor to convert the pulsed flow meter count into a flow rate in a user selected unit e.g. Gallons per minute or Litres per minute. The scaling factor converts the flow rate at maximum frequency to the equivalent flow with a 5s sample rate. Many flow meters give a flow rate at a given frequency e.g. 100 Hz = 120 litres per minute, where this can be converted to a flow scale factor by dividing the flow rate by the frequency * 5 s e.g. flow Scale Factor = 120/(100*5) = 0.24.

Parameter	29.008 *Flow Meter Pulse Input*		
Minimum	0	Maximum	1
Default	0	Units	

This is the system input for a pulsed flow meter used to derive Flow and Volume. The maximum input frequency is 100 Hz. A digital input with a pulsed flow meter connected should be routed to this parameter.

Parameter	29.009 *Flow Meter Pulse Count*		
Minimum	0	Maximum	2147483647
Default	0	Units	

This indicates the total number of flow meter pulses detected so far from the *Flow Meter Pulse Input* Pr **29.008**. This count can be reset by setting *Reset Volume Input* Pr **29.010** to *On(1)*. This count is the basis for the Volume calculation so resetting this value will also reset *Volume* Pr **29.004**.

Parameter	29.010 *Reset Volume Input*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this resets the total number of flow meter pulses detected so far in *Flow Meter Pulse Count* Pr **29.009** and *Volume* Pr **29.004.**

Parameter	29.063 *Low Flow Meter Stop Threshold*		
Minimum	0.0	Maximum	214748364.7
Default	0.0	Units	

This defines the threshold below which the system will stop due to a low flow condition, detected using the pulsed flow meter feedback. This is set in the units defined by the *Flow Scaling* Pr **29.007**.

A suitable pulsed output flow meter must be connected to a digital input routed to the *Flow Meter Pulse Input* Pr **29.008** to allow the Low Flow functionality to operate.

In the event that a low flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping*.

Parameter	29.064 *Low Flow Meter Stop Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

When set to 0, the low flow stop feature is disabled.

When set to >0, the low flow stop feature is enabled.

This defines the continuous time in seconds that the *Flow* Pr **29.005** must be below *Low Flow Meter Stop Threshold* Pr **29.063** to detect a low flow condition. *Low Flow Meter Stop Delay* Pr **29.064** filters out any intermittent Low Flow conditions.

A suitable pulsed output flow meter must be connected to a digital input routed to *Flow Meter Pulse Input* Pr **29.008** to allow the Low Flow functionality to operate.

Parameter	29.065 *Low Flow Meter Stop Output*		
Minimum	0	Maximum	1
Default	0	Units	

This indicates when a Low Flow meter stop has been actioned. This happens when the *Flow* Pr **29.005** is below the *Low Flow Meter Stop Threshold* Pr **29.063** and the *Low Flow Meter Stop Delay* Pr **29.064** has elapsed.

A suitable pulsed output flow meter must be connected to a digital input routed to *Flow Meter Pulse Input* Pr **29.008** to allow the Low Flow functionality to operate.

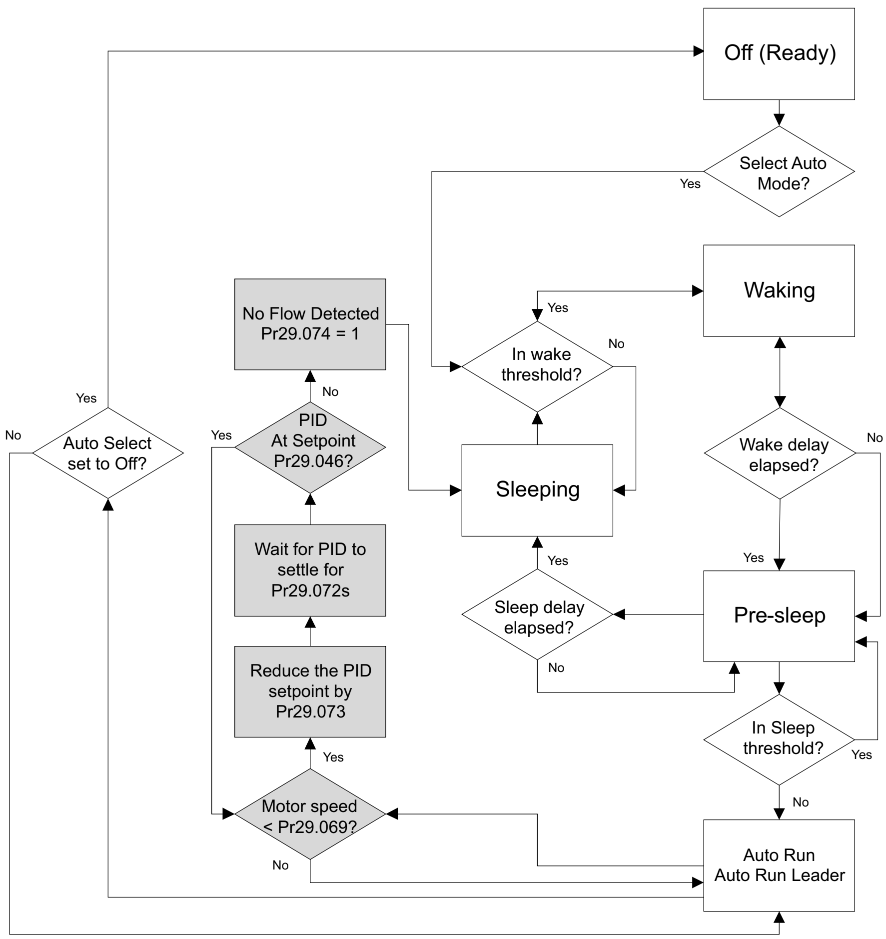
7.17 No flow detection

The F600 supports 2 no flow mechanisms, either from a flow switch or by software detection to stop the system in the event of no flow condition. The no flow detection schemes are intended to detect when there is no liquid flow due to a closed pump discharge valve, e.g. a closed tap. This is intended to be used in a pump system where the main process PID feedback is a pressure transducer and not a flow transducer.

No flow detection from a flow switch requires a digital input to be routed to *Flow Switch Input* Pr **29.066**, where 24 V to the digital input represents when there is flow, and *Flow Switch Input* Pr **29.066** is set to *On(1)*. When there is no flow, *Flow Switch Input* Pr **29.066** is set to *Off(0)*, and after *No Flow Switch Delay* Pr **29.067** has elapsed, *Operating Status Pr* **29.003**(0.073) is set to *Sleeping* and the motor will stop. *No Flow Switch Output* Pr **29.068** indicates when the system has stopped due to no flow caused by *Flow Switch Input* Pr **29.066** = *Off(0)* for *No Flow Switch Delay* Pr **29.067** seconds.

If a flow switch is not available, no flow detection by software detection is available, provided that the main process PID is enabled, *PID1 Enable* Pr **14.008** = *On(1).*

The following diagram illustrates the no flow software detection process:



The No Flow by software detection scheme is made up of four stages:

Is the motor frequency or speed < *No Flow Detection Threshold* Pr **29.069**(0.055)? If yes, move to the next step.

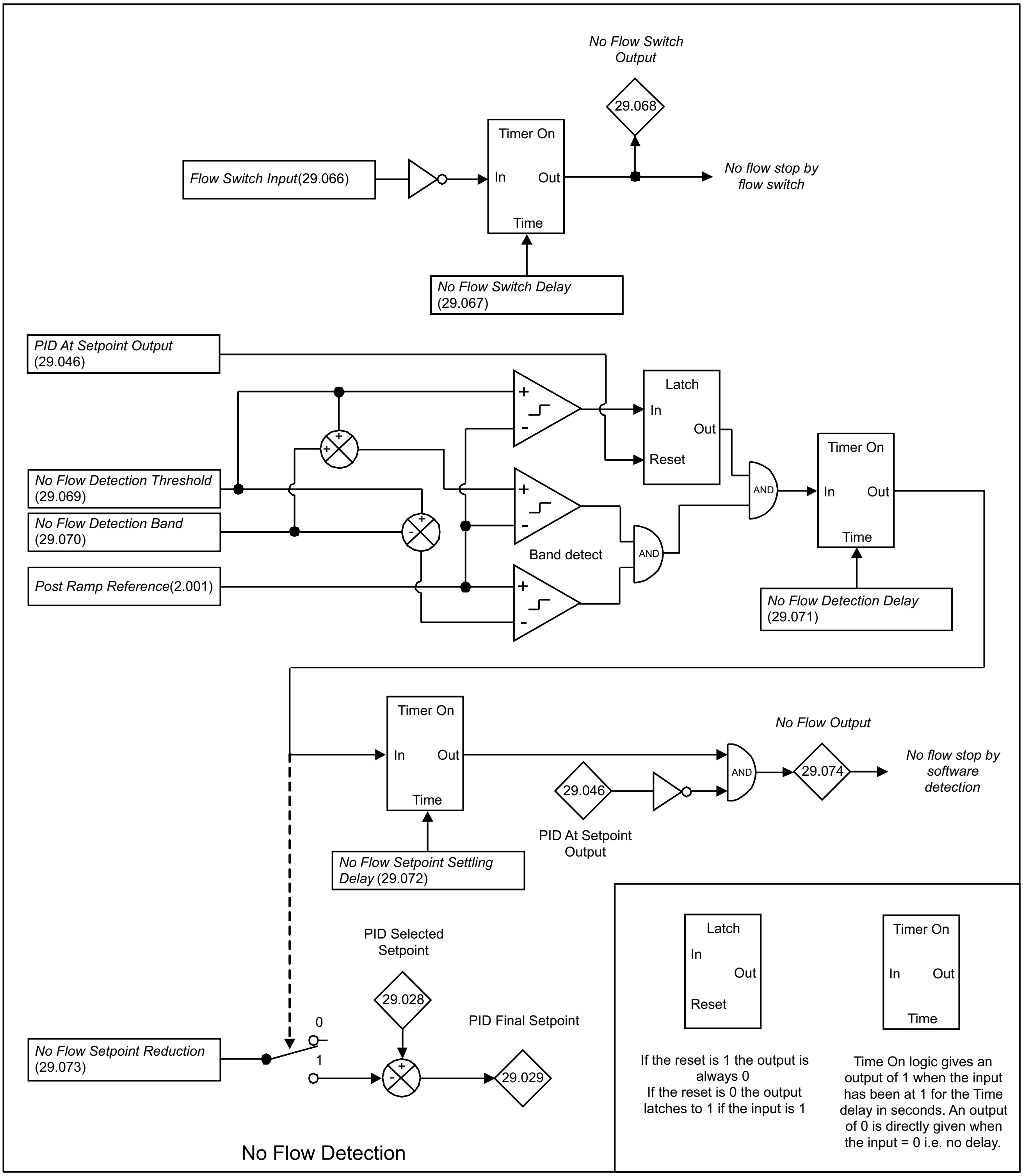
Is the motor frequency or speed within the

1. *No Flow Detection Band* Pr **29.070**(0.056) for *No Flow Detection Delay* Pr **29.071**(0.057) seconds? If yes, move to the next step.
2. Reduce the main process PID setpoint by
3. *No Flow Setpoint Reduction* Pr **29.073**(0.059) and wait for the *No Flow Setpoint Settling Delay* Pr **29.072**(0.058) to elapse. Is the PID is unable to follow the new setpoint? If yes, move to the next step.
4. Stop the system and set *No Flow Output* Pr **29.074** to *On(1)*. If the feedback is within the *PID At Setpoint Output* Pr **29.046** window, move to step 1.

It is recommended to set *No Flow Detection Band* Pr **29.070**(0.056) to 10 % of the value found in the *Maximum Reference Clamp* Pr **1.006**(0.022), and *No Flow Detection Threshold* Pr **29.069** to the greater of the *Positive Minimum Reference Clamp* Pr **1.004**(0.023) OR the *Sleep Detect Speed Threshold* Pr **29.051**(0.042) + *No Flow Detection Band* Pr **29.070**(0.056). In the event of a closed pump discharge valve the PID feedback will rise causing the PID output frequency or speed to dip into the *No Flow Detection Band* Pr **29.070**(0.056).

7.17.1 No flow logic diagram

The following diagram shows the parameters used by the no flow logic.



7.17.2 No flow logic parameters

The following section shows the parameters used by the no flow logic.

Parameter	29.066 *Flow Switch Input*		
Minimum	0	Maximum	1
Default	0	Units	

This is the input for a flow switch where *Off(0)* = No flow, *On(1)* = Flow. A digital input with a flow switch connected should be routed to this parameter. This input is used to detect when the system should stop due to no flow and to terminate the Automatic pipe filling routine when flow is detected; see *No Flow Switch Delay* Pr **29.067** and *Pipe Fill Mode* Pr **29.075**.

Where a flow switch is not fitted, set *Flow Switch Input* Pr **29.066** to *On(1)* and perform a drive parameter save to prevent a false no flow stop.

Parameter	29.067 *No Flow Switch Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the continuous time in seconds that the *Flow Switch Input* Pr **29.066** must be set to *Off(0)* to detect a no flow condition. *No Flow Switch Delay* Pr **29.067** filters out any intermittent No Flow conditions.

A suitable flow switch must be connected to a digital input routed to the *Flow Switch Input* Pr **29.066** to allow the No Flow by switch functionality to operate.

If a flow switch is fitted, then no flow by software detection is not required. A pump will be protected from running into a closed discharge using the flow switch.

In the event that a no flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping* and the motor will stop.

Parameter	29.068 *No Flow Switch Output*		
Minimum	0	Maximum	1
Default	0	Units	

This indicates when a No Flow detection from a flow switch has been detected. This happens when the *Flow Switch Input* Pr **29.066** = *Off(0)* for *No Flow Switch Delay* Pr **29.067** seconds.

A suitable flow switch must be connected to a digital input routed to the *Flow Switch Input* Pr **29.066** to allow the No Flow by switch functionality to operate.

In the event that a no flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping* and the motor will stop.

Parameter	29.069(0.55) *No Flow Detection Threshold*		
Minimum	0.0	Maximum	3000.0
Default	0.0	Units	Hz or rpm

When *No Flow Detection Threshold* Pr **29.069**(0.055) is > 0, software detection of no flow is enabled. This defines the frequency or speed threshold below which software based no flow is detected. This must be set to the greater of the *Positive Minimum Reference Clamp* Pr **1.004** OR the *Sleep Detect Speed Threshold* Pr **29.051** + *No Flow Detection Band* Pr **29.070**(0.056). In the event of a closed pump output the main process PID feedback will rise causing the motor frequency or speed to dip below this level.

When *No Flow Detection Threshold* Pr **29.069**(0.055) = 0, software detection of no flow is disabled.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping* and the motor will stop.

Parameter	29.070(0.56) *No Flow Detection Band*		
Minimum	0.0	Maximum	3000.0
Default	150.0	Units	

This defines the frequency or speed band used by the software no flow detection scheme. It is recommended to set this to 10% of the *Maximum Reference Clamp* Pr **1.006**. In the event of a closed pump or fan output the PID feedback will rise causing the motor frequency or speed to dip into this band.

This is only used when *No Flow Detection Threshold* Pr **29.069** is > 0. See *No Flow Detection Threshold* Pr **29.069** for details on the no flow by software detection process.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* Pr **29.003** will transition to *Sleeping*.

Parameter	29.071(0.57) *No Flow Detection Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

This defines the continuous time in seconds that the motor frequency or speed must be below the *No Flow Detection Threshold* Pr **29.069**(0.055) to complete stage 1 of the no flow by software detection scheme. *No Flow Detection Delay* Pr **29.071**(0.057) filters out any intermittent No Flow conditions.

This is only used when *No Flow Detection Threshold* Pr **29.069**(0.055) is > 0.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* Pr **29.003(**0.073) will transition to *Sleeping* and the motor will stop.

Parameter	29.072 *No Flow Setpoint Settling Delay*		
Minimum	0.0	Maximum	6553.5
Default	1.0	Units	s

This defines the continuous time in seconds that the no flow by software detection scheme will wait after applying the *No Flow Setpoint Reduction* Pr **29.073**(0.059) before checking if the main process PID is able to track the change in setpoint. If the main process PID isn't able to track the change in setpoint a no flow by software detection stop is actioned and *No Flow Output* Pr **29.074** is set to *On(1)*.

This is only used when *No Flow Detection Threshold* Pr **29.069**(0.055) is > 0.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping* and the motor will stop.

Parameter	29.073(0.059) *No Flow Setpoint Reduction*		
Minimum	0.00	Maximum	2.55
Default	0.06	Units	UU

This defines the main process PID setpoint reduction value used in stage 2 of detecting no flow by software. After applying the *No Flow Setpoint Reduction* Pr **29.073**(0.059) and waiting for the *No Flow Setpoint Settling Delay* Pr **29.072** to elapse, the software will check to see if the main process PID hasn't been able to track the change in setpoint; if it hasn't then software no flow is detected. and the system will stop.

This is only used when *No Flow Detection Threshold* Pr **29.069** is > 0.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then then no flow detection when running in Auto mode is disabled.

In the event that a no flow is detected, *Operating Status* Pr **29.003**(0.073) will transition to *Sleeping* and the motor will stop.

7.18 Dry well

In a pump application, e.g. pumping from a well or tank, the level of liquid being pumped may drop below the level of the pump suction pipe. In this situation the pump should be slowed down or stopped to prevent pump wear. Dry Well Low Load detection Automatically checks for this condition and is configured by *Dry Well Low Load Mode* Pr **29.059**(0.052) to respond in one of the following ways:

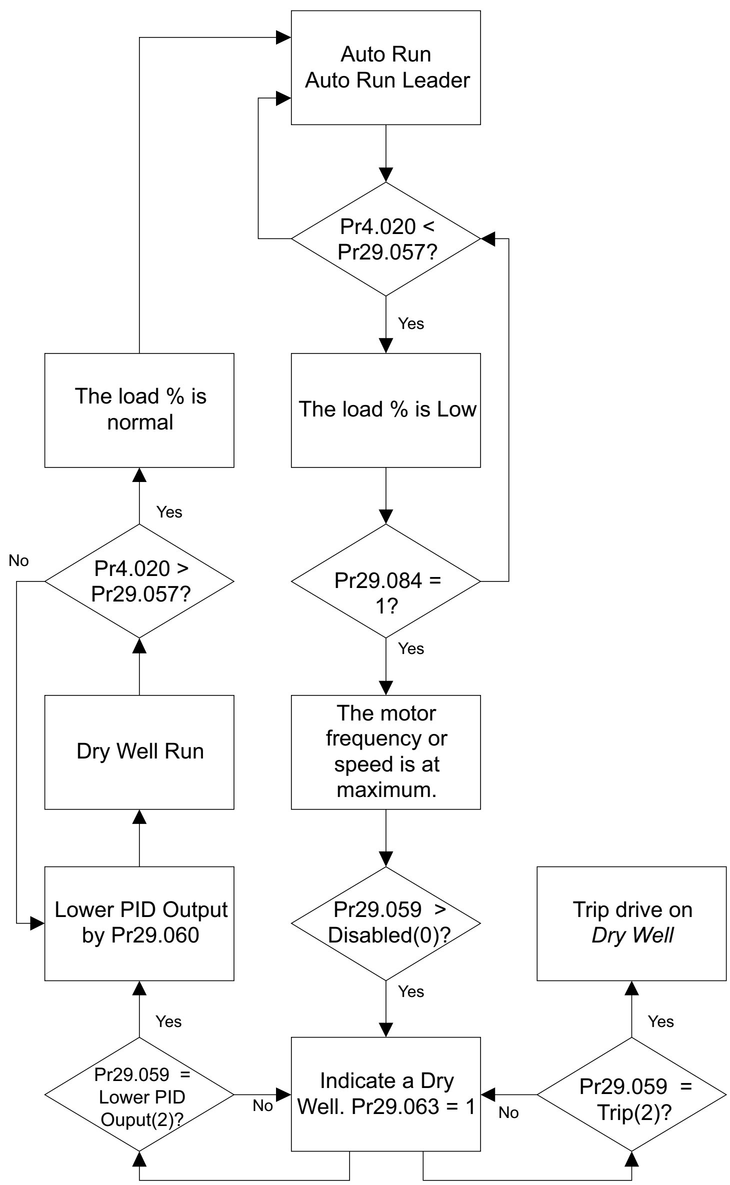
- *Disabled* – The Dry Well Low Load detection system is disabled.
- *Alarm only* – If a Dry Well Low Load condition is detected, an alarm is raised by setting *Dry Well Low Load Alarm Output* Pr **29.062** = *On(1)*.
- *Trip* – If a Dry Well Low Load condition is detected, a Dry Well trip is actioned.
- *Lower PID Output* – If a Dry Well Low Load condition is detected, the PID output is lowered by the *Dry Well Low Load PID Output Reduction* Pr **29.060**(0.053) value thereby limiting potential damage to the pump. When the load value is above the *Dry Well Low Load Detection Threshold Percent* Pr **29.057**(0.050), the PID output is restored. *Operating Status* Pr **29.003**(0.073) = *Dry Well Run* when the PID output has been reduced due to a dry well condition.

A dry well is detected when the load level is below the *Dry Well Low Load Detection Threshold Percent* Pr **29.057**(0.050) and the motor frequency or speed must be within the *Maximum Drive Reference Band* Pr **29.083** to detect a dry well low load condition. *Dry Well Low Load Detection Delay* Pr **29.058**(0.051) filters out any intermittent Dry Well Low Load conditions.

If a Dry Well condition is detected in a Cascade system, *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* the Soft Starters will be stopped to prevent pump wear. The soft starters will Automatically restart when the Dry Well condition has finished.

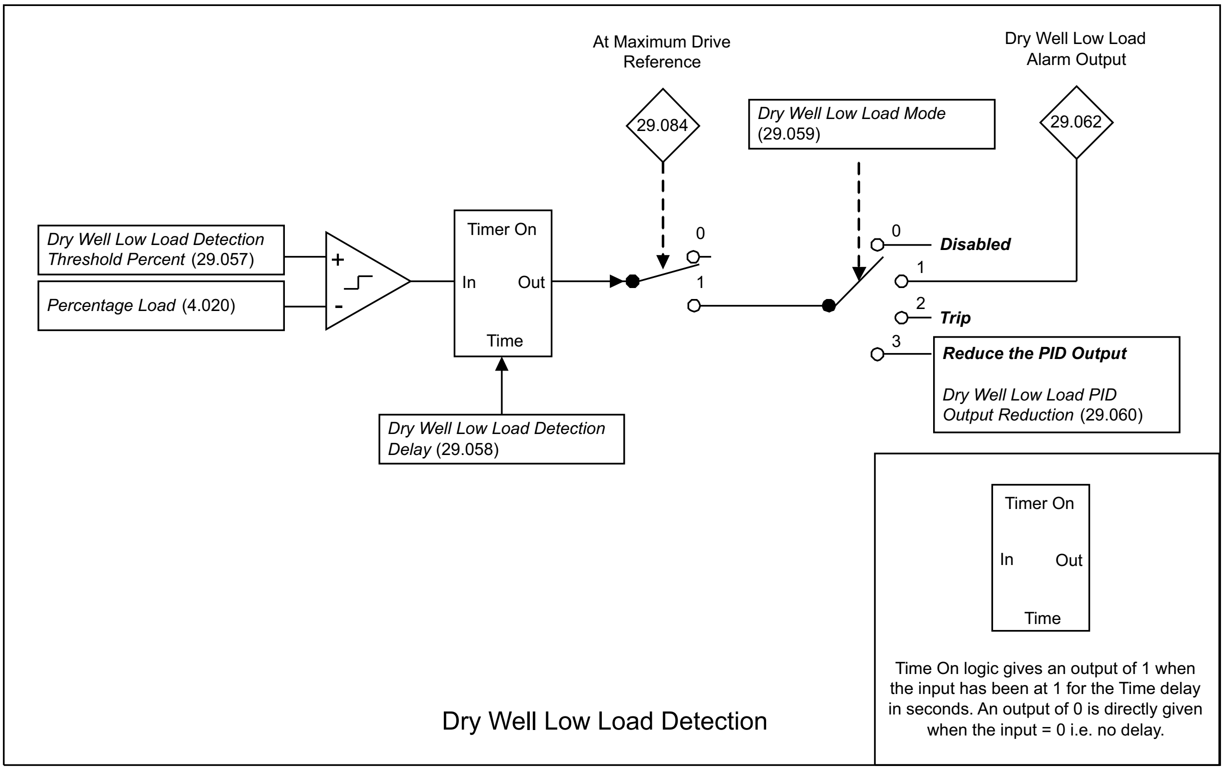
If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then Dry Well Low Load detection is internally disabled.

The following flow chart illustrates dry well process:



7.18.1 Dry well logic diagrams

The following diagram shows the parameters used by the dry well logic.



7.18.2 Dry well logic parameters

The following section shows the parameters used by the no flow logic.

Parameter	29.057(0.050) *Dry Well Low Load Detection Threshold Percent*		
Minimum	0.0	Maximum	100.0
Default	1.0	Units	%

This defines the load percentage below which a dry well low load condition is detected. *Dry Well Low Load Detection Threshold Percent* Pr **29.057**(0.050) is compared against *Percentage Load* Pr **4.020**. To complete the dry well low load detection logic the motor frequency or speed must be within the *Maximum Drive Reference Band* Pr **29.083**.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr**14.008**, then Dry Well Low Load detection is internally disabled.

Parameter	29.059(0.052) *Dry Well Low Load Mode*		
Minimum	0	Maximum	3
Default	0	Units	

This defines the Dry Well Low Load system will operate. The following options are available:

Mode	Value	Description
Disabled	0	The Dry Well Low Load detection system is disabled
Alarm Only	1	If a Dry Well Low Load condition is detected, an alarm is raised, *Dry Well Low Load Alarm Output* Pr **29.062** = *On(1)*.
Trip	2	If a Dry Well Low Load condition is detected, a *Dry Well* trip is actioned when a dry well low load condition is detected.
Lower PID Output	3	If a Dry Well Low Load condition is detected, the PID output is lowered by the *Dry Well Low Load PID Output Reduction* Pr **29.060**(053) value thereby limiting potential damage to the pump. When the load value is above the *Dry Well Low Load Detection Threshold Percent* Pr **29.057**(0.050), the PID output is restored. *Operating Status* Pr **29.003**(0.073) = *Dry Well Run* when the PID output has been reduced due to a dry well condition.

Parameter	29.060(0.053) *Dry Well Low Load PID Output Reduction*		
Minimum	0.00	Maximum	100.00
Default	50.00	Units	%

When *Dry Well Low Load Mode* Pr **29.059**(0.052) = *Lower PID Output*, if a Dry Well Low Load condition is detected, the PID output is lowered by the *Dry Well Low Load PID Output Reduction* Pr **29.060** value thereby limiting potential damage to the pump. When the load value is above the *Dry Well Low Load Detection Threshold Percent* Pr **29.057**(0.050), the PID output is restored.

Operating Status Pr **29.003**(0.073) = *Dry Well Run* when *Dry Well Low Load PID Output Reduction* Pr **29.060**(0.053) has been used to reduce the PID output due to a dry well condition.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then Dry Well Low Load detection is internally disabled.

Parameter	29.061 *Dry Well Low Load Restart Delay*		
Minimum	0.0	Maximum	6553.5
Default	5.0	Units	s

The defines the minimum time in seconds after the drive has been tripped due to a Dry Well Low Load condition before it can be restarted. This prevents the system from Automatically resetting and attempting to run again without there being sufficient time to allow the well or tank to fill again. This is only used when Dry Well Low Load Mode Pr **29.059** = *Trip*.

NOTE

If the main process PID has been disabled via *PID1 Enable* Pr **14.008**, then Dry Well Low Load detection is internally disabled.

Parameter	29.062 *Dry Well Low Load Alarm Output*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this indicates when a Dry Well Low Load condition has been detected.

7.19 Pump cleaning

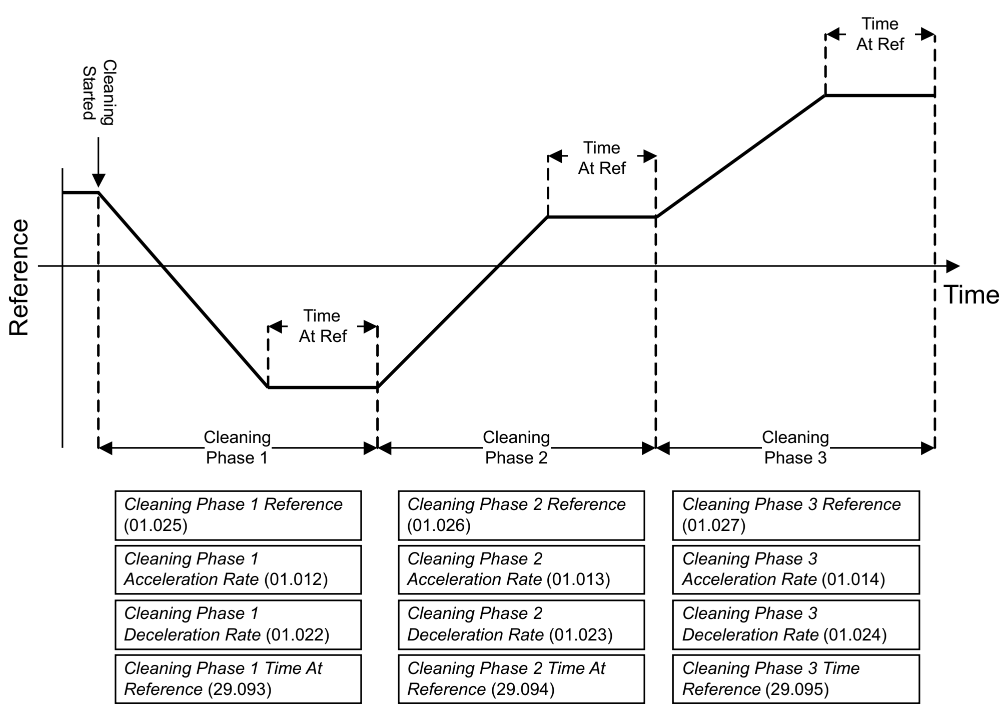
The pump cleaning or de-ragging functionality of the software works by cycling pump backwards and forwards with a user defined cleaning profile to release rags or other debris back into the suction tank where they can settle away from the pump suction inlet. This helps to keep remote pumps operating with moderate blockages without user intervention. For a persistent blockage, manual intervention may be still be required.

Before using this feature the pump manufacturer must be consulted to find out if the pump can be run backwards without damaging it; not all pumps can be run backwards e.g. centrifugal pumps are designed to run forwards only.

The pump cleaning or de-ragging functionality is started using the following triggers:

- A digital input routed to *Clean Manual Input* Pr **29.088**. The cleaning routine runs while this input is set to *On(1)*. Hand and Auto mode are a higher priority than manual clean and will cancel any manual cleaning that is in progress even if *Clean Manual Input* Pr **29.088** = *On(1)*.
- A cleaning cycle may be activated when the system is started in Auto mode, by setting *Clean On Start* Pr **29.089** = *On(1)*.
- A cleaning cycle may be activated after *Clean On Interval Time* Pr **29.096**, by setting Pr **29.090** *Clean On Interval* = *On(1)*. This is not available in Cascade mode, *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.
- A cleaning cycle may be activated when either the Clean On Load Current High Threshold Pr **29.098** or *Clean On Load Current Low Threshold* Pr **29.09**9 is reached, by setting *Clean On Load Current Threshold* Pr **29.091** = *On(1)*. This is not available in Cascade mode, *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.
- A cleaning cycle may be activated when *Motor Overload Alarm* Pr **10.017** = *On(1)*, by setting *Clean On Motor Over-load* Pr **29.092** = *On(1).* This is not available in Cascade mode, *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.

When the cleaning cycle is triggered, the cleaning profile runs the motor at 3 user defined frequencies or speeds. By default, the initial rotation is backwards to release debris from the impellor back into the suction tank thereby clearing the blockage. The following diagram shows the profile configuration:



Pump Cleaning Profile

The load current supplied to the pump motor is sampled before and after the cleaning routine in *Pre-clean Load Current* Pr **29.102** and *Post-clean Load Current* Pr **29.103** to give an indication of how well the blockage has been removed.

To protect the system for attempting to clean too many times in an hour, *Clean Per Hour Limit* Pr**29.100** set the maximum allowed number of cleaning cycles before taking the action configured by *Clean Per Hour Limit Mode* Pr **29.101**:

Alarm Only – An alarm will be raised where *Clean Per Hour Alarm Output* Pr **29.105** is set to *On(1)* when the limit is reached.

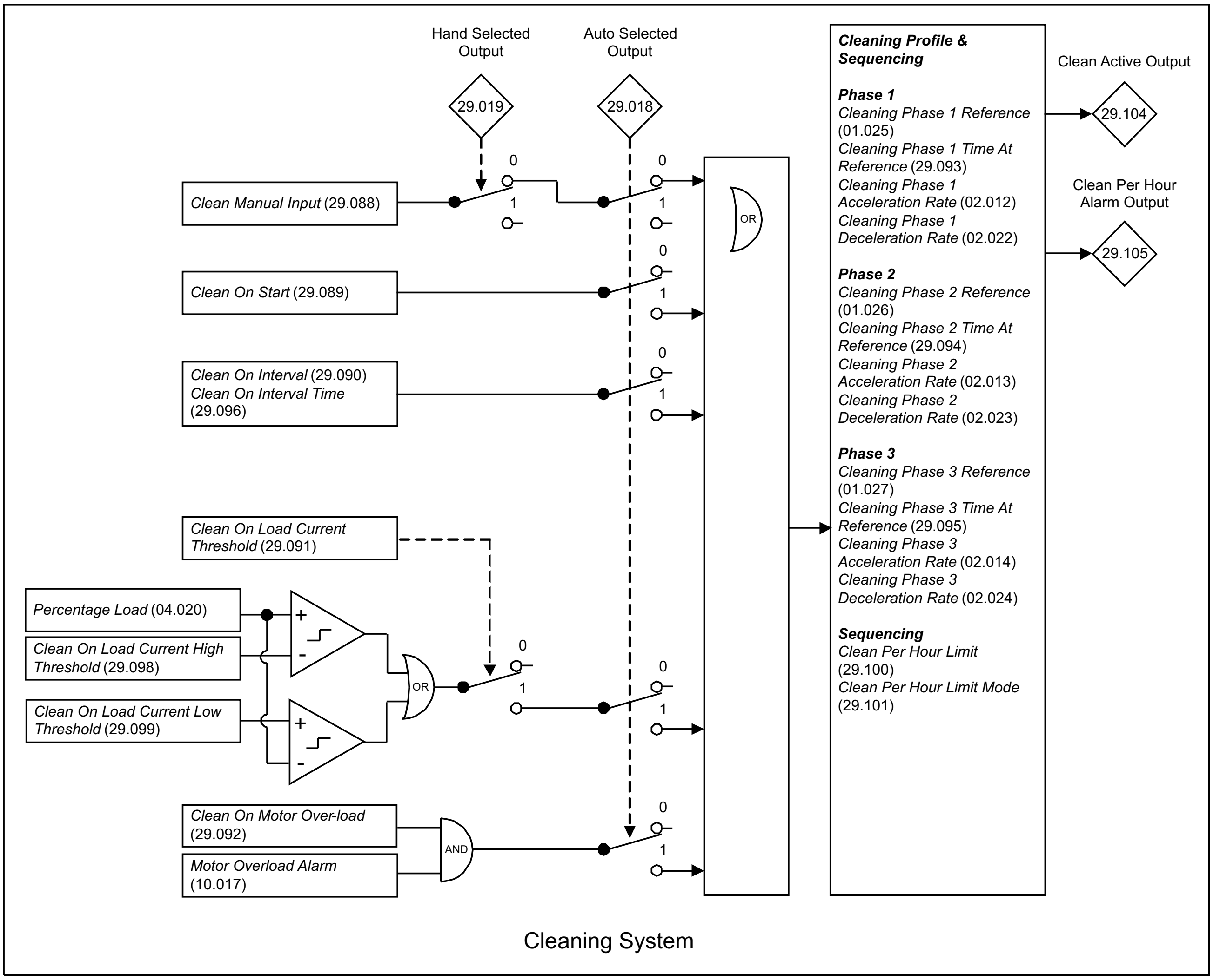
Stop Cleaning – An alarm will be raised where *Clean Per Hour Alarm Output* Pr **29.105** is set to On*(1)* and cleaning will be deactivated for the remainder of the current hour when the limit is reached.

Trip – The drive will trip *Clean Over-cycle* when the clean per hour limit is reached. Resetting the trip will reset the internal clean per hour counters so that cleaning can continue after the reset if triggered. The *Clean Over-cycle* will be logged in the trip log, *Trip 0* Pr **10.020** to *Trip 9* Pr **10.029**.

When cleaning is activated *Clean Active output* Pr **29.104** is set to *On(1)*.

7.19.1 Pump cleaning logic diagrams

The following diagram shows the parameters used by the pump cleaning logic.



7.19.2 Pump cleaning logic parameters

The following section shows the parameters used by the pump cleaning logic.

Parameter	1.025 *Cleaning Phase 1 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	-15 Hz or -450 rpm (Std) -18 Hz or -540 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 1 is in progress.
See *Cleaning Phase 1 Time At Reference* Pr **29.093**, *Cleaning Phase 1 Acceleration Rate* Pr **2.012** and *Cleaning Phase 1 Deceleration Rate* Pr **2.022**.

Parameter	1.026 *Cleaning Phase 2 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	15 Hz or 450 rpm (Std) 18 Hz or 540 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 2 is in progress.
See *Cleaning Phase 2 Time At Reference* Pr **29.094**, *Cleaning Phase 2 Acceleration Rate* Pr **2.013** and *Cleaning Phase 2 Deceleration Rate* Pr **2.023**.

Parameter	1.027 *Cleaning Phase 3 Reference*		
Minimum	VM_SPEED_FREQ_REF[MIN]	Maximum	VM_SPEED_FREQ_REF[MAX]
Default	40 Hz or 1200 rpm (Std) 54 Hz or 1440 rpm (US)	Units	Hz or rpm

This defines the speed or frequency reference used when pump cleaning, (de-ragging), phase 3 is in progress. See *Cleaning Phase 3 Time At Reference* Pr **29.095**, *Cleaning Phase 3 Acceleration Rate* Pr **2.014** and *Cleaning Phase 3 Deceleration Rate* Pr **2.024**.

Parameter	2.012 *Cleaning Phase 1 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 1 of the cleaning or de-ragging routine.

Parameter	2.013 *Cleaning Phase 2 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 2 of the cleaning or de-ragging routine.

Parameter	2.014 *Cleaning Phase 3 Acceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the acceleration rate when executing phase 3 of the cleaning or de-ragging routine.

Parameter	2.022 *Cleaning Phase 1 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 1 of the cleaning or de-ragging routine.

Parameter	2.023 *Cleaning Phase 2 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 2 of the cleaning or de-ragging routine.

Parameter	2.024 *Cleaning Phase 3 Deceleration Rate*		
Minimum	VM_ACCEL_RATE[MIN]	Maximum	VM_ACCEL_RATE[MAX]
Default	5.0	Units	s

This defines the deceleration rate when executing phase 3 of the cleaning or de-ragging routine.

Parameter	29.089 *Clean On Start*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this activates the pump cleaning cycle when the system is first run in Auto mode i.e. if the system goes to sleep and then wakes in Auto mode cleaning on start will not be triggered. If the pipe fill function is enabled via *Pipe Fill Mode* Pr **29.075**(0.046), then the pipe fill will happen first.

When set to *Off(0)*, pump cleaning on start is disabled.

Parameter	29.090 *Clean On Interval*		
Minimum	0	Maximum	1
Default	0	Units	

When set to On, this activates cleaning on interval. The interval is started when Auto mode is selected where the pump cleaning cycle will happen at the end of the interval, each time the interval elapses. The interval is defined by *Clean On Interval Time* Pr **29.096**.

This method of cleaning is not available when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.

Parameter	29.091 *Clean On Load Current Threshold*		
Minimum	0	Maximum	1
Default	0	Units	

When set to On(1), this activates cleaning on current load thresholds defined by *Clean On Load Current High Threshold* Pr **29.098** and *Clean On Load Current Low Threshold* Pr**29.099**. Intermittent cleaning load current conditions are filtered using the *Clean On Load Current Delay* Pr **29.097**. A high current can by caused by a blocked pump rotor, and low current can be caused by a blocked pump input. The low and high current threshold should be set outside of the normal pumping current range.

This method of cleaning is not available when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.

Parameter	29.092 *Clean On Motor Over-load*		
Minimum	0	Maximum	1
Default	0	Units	

When set to *On(1)*, this activates cleaning on motor over-load as indicated when *Motor Overload Alarm* Pr **10.017** = *On(1)*.
The *Motor Thermal Time Constant 1* Pr **4.015** must be set up correctly when using this feature; consult the pump motor manufacturer or documentation to find this value.

This method of cleaning is not available when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.

Parameter	29.093 *Cleaning Phase 1 Time At Reference*		
Minimum	0.1	Maximum	6553.5
Default	15.0	Units	s

This defines the time in seconds that the pump will spend at *Cleaning Phase 1 Reference* Pr **1.025** before moving to phase 2 of the pump cleaning cycle.

Parameter	29.094 *Cleaning Phase 2 Time At Reference*		
Minimum	0.1	Maximum	6553.5
Default	10.0	Units	s

This defines the time in seconds that the pump will spend at *Cleaning Phase 2 Reference* Pr **1.026** before moving to phase 3 of the pump cleaning cycle.

Parameter	29.095 *Cleaning Phase 3 Time At Reference*		
Minimum	0.1	Maximum	6553.5
Default	10.0	Units	s

This defines the time in seconds that the pump will spend at *Cleaning Phase 3 Reference* Pr **1.027** before completing the pump cleaning cycle.

Parameter	29.096 *Clean On Interval Time*		
Minimum	1	Maximum	65535
Default	1440	Units	minutes

This defines the pump cleaning time interval in minutes used when *Clean On Interval* Pr **29.090** = *On(1)*. If the drive is running in Auto mode, when *Clean On Interval Time* Pr **29.096** elapses a cleaning cycle is actioned. If the drive is sleeping in Auto mode when the *Clean On Interval Time* Pr **29.096** elapses, a clean will be actioned next time the drive runs.

Parameter	29.097 *Clean On Load Current Delay*		
Minimum	0.1	Maximum	6553.5
Default	10.0	Units	s

Clean On Load Current Delay Pr **29.097** is only used when *Clean On Load Current Threshold* Pr **29.091** = *On(1)*.

This defines the continuous time in seconds that the motor load current must be below the *Clean On Load Current Low Threshold* Pr **29.099** or above the *Clean On Load Current High Threshold* Pr **29.098** to initiate a clean on load current. *Clean On Load Current Delay* Pr **29.097** filters out any intermittent load current conditions that would otherwise trigger a clean on load current.

A high current can by caused by a blocked pump rotor, and low current can be caused by a blocked pump input. The low and high current threshold should be set outside of the normal pumping current range.

Parameter	29.098 *Clean On Load Current High Threshold*		
Minimum	0.0	Maximum	200.0
Default	80.0	Units	%

Clean On Load Current High Threshold Pr **29.098** is only used when *Clean On Load Current Threshold* Pr **29.091** = *On(1)*.

This defines the high load current threshold above which a clean on load current is initiated. *Clean On Load Current High Threshold* Pr **29.098** is compared against *Percentage Load* Pr **4.020**. *Clean On Load Current Delay* Pr **29.097** filters out any intermittent load current conditions that would otherwise trigger a clean on load current.

A high current can by caused by a blocked pump rotor, and low current can be caused by a blocked pump input. The low and high current threshold should be set outside of the normal pumping current range.

Parameter	29.099 *Clean On Load Current Low Threshold*		
Minimum	0.0	Maximum	50.0
Default	10.0	Units	%

Clean On Load Current Low Threshold Pr **29.099** is only used when *Clean On Load Current Threshold* Pr **29.091** = *On(1)*.

This defines the low load current threshold below which a clean on load current is initiated. *Clean On Load Current Low Threshold* Pr **29.099** is compared against *Percentage Load* Pr **4.020**. *Clean On Load Current Delay* Pr **29.097** filters out any intermittent load current conditions that would otherwise trigger a clean on load current.

A high current can by caused by a blocked pump rotor, and low current can be caused by a blocked pump input. The low and high current threshold should be set outside of the normal pumping current range.

Parameter	29.100 *Clean Per Hour Limit*		
Minimum	1	Maximum	30
Default	5	Units	Cleaning cycles

This defines the maximum number of pump cleaning cycles per hour. The action taken when the limit is reached is configured by the *Clean Per Hour Limit Mode* Pr **29.101**. When this limit is reached the *Clean Per Hour Alarm Output* Pr **29.105** = *On(1)*.

Parameter	29.101 *Clean Per Hour Limit Mode*		
Minimum	0	Maximum	2
Default	1	Units	

This sets the action taken when the *Clean Per Hour Limit* Pr**29.100** is reached. The following modes are available:

Mode	Value	Description
Alarm Only	0	An alarm will be raised where *Clean Per Hour Alarm Output* Pr **29.105** is set to On(1) when the limit is reached.
Stop Cleaning	1	An alarm will be raised where *Clean Per Hour Alarm Output* Pr **29.105** is set to On(1) and cleaning will be deactivated for the remainder of the current hour when the limit is reached
Trip	2	The drive will trip *Clean Over-cycle* when the clean per hour limit is reached. Resetting the trip will reset the internal clean per hour counters so that cleaning can continue after the reset if triggered.

Parameter	29.102 *Pre-clean Load Current*		
Minimum	-1000.0	Maximum	1000.0
Default	0.0	Units	%

This indicates the load current percentage sampled from *Percentage Load* Pr **4.020** prior to running the cleaning cycle. By using *Pre-clean Load Current* (**29.102**) and comparing it to *Post-clean Load Current* Pr **29.103** it is possible to see if the cleaning cycle was effective.

Pre-clean Load Current Pr **29.102** and *Post-clean Load Current* Pr **29.103** are not updated if the cleaning cycle was started either manually via *Clean Manual Input* Pr **29.088** or on start-up via *Clean On Start* Pr **29.089**.

Parameter	29.103 *Post-clean Load Current*		
Minimum	-1000.0	Maximum	1000.0
Default	0.0	Units	%

This indicates the load current percentage sampled from *Percentage Load* Pr **4.020** after running the cleaning cycle. By using *Pre-clean Load Current* Pr **29.102** and comparing it to Post-clean Load Current Pr **29.103** it is possible to see if the cleaning cycle was effective.

Parameter	29.104 *Clean Active Output*		
Minimum	0	Maximum	1
Default	0	Units	

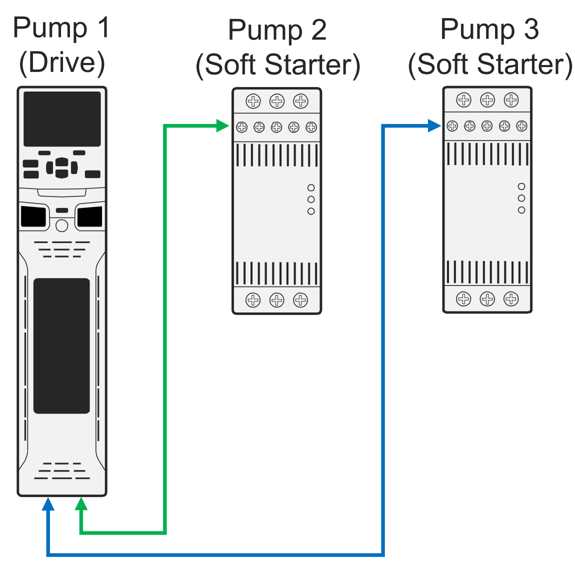
This indicates when a pump cleaning cycle is running.

Parameter	29.105 *Clean Per Hour Alarm Output*		
Minimum	0	Maximum	1
Default	0	Units	

When *Clean Per Hour Limit Mode* Pr **29.101** = *Alarm Only* or *Stop Cleaning*, this indicates when the *Clean Per Hour Limit* Pr **29.100** has been reached.

7.20 Cascade mode

A Cascade system is where a single leader drive is assisted by parallel pumps controlled by Soft Starters. The Soft Starters assists are commanded by 24 V I/O signals or relay outputs provided by the Leader drive. Cascade mode is selected when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade.*

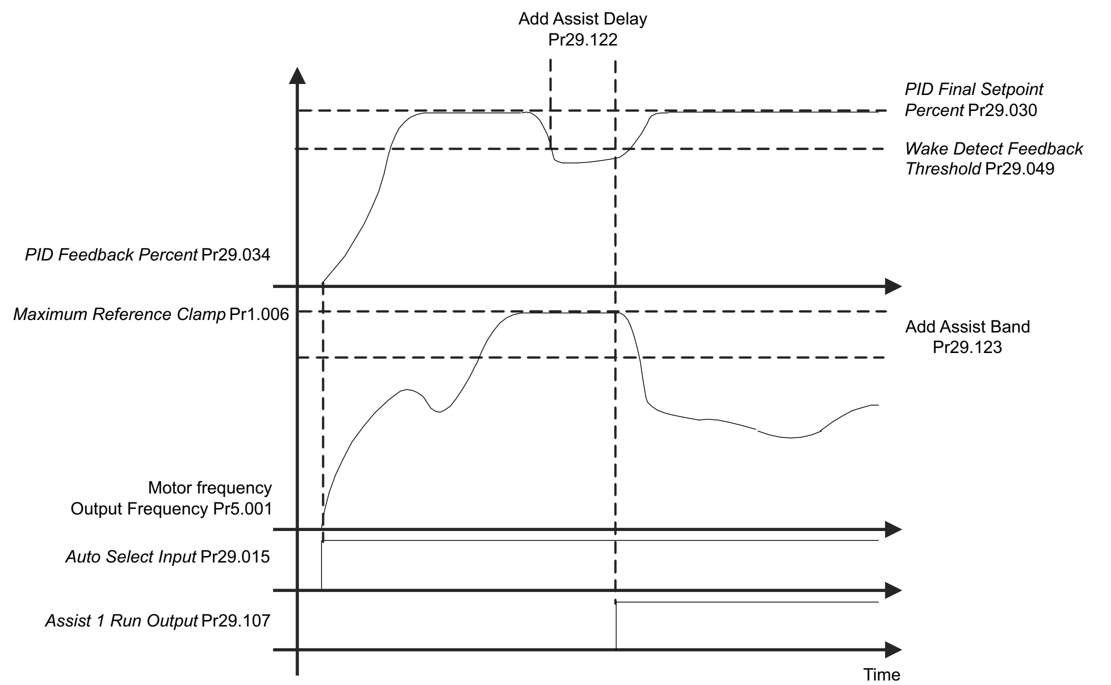


The F600 Pump drive is started and stopped using the logic described in section 7.10 Wake and sleep .

In a Cascade system, the leader drive commands assist soft starters to run or stop in order meet the setpoint demand. An assist soft starter is commanded to run when:

- The motor frequency or speed is within the *Add Assist Band* Pr **29.123** where the PID is at maximum output and unable to meet the demand.
- *PID Final Feedback* Pr **29.036** is < *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for *Wake Detect Delay* Pr **29.050(**0.041) seconds, when *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005** = *Off(0)*.
- *PID Final Feedback* Pr **29.036** is > *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for *Wake Detect Delay* Pr **29.050**(0.041) seconds, when *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* Pr **14.005** = *On(1)*.

It is important to note that *Wake Detect Feedback Threshold* Pr **29.049(**0.040) not only defines the feedback level when the soft starters will be commanded to assist the leader drive, but also the minimum operating pump system output level, e.g. if the setpoint is 80.00 UU and the wake threshold is 70.00 UU then the pump discharge will operate between these two levels.

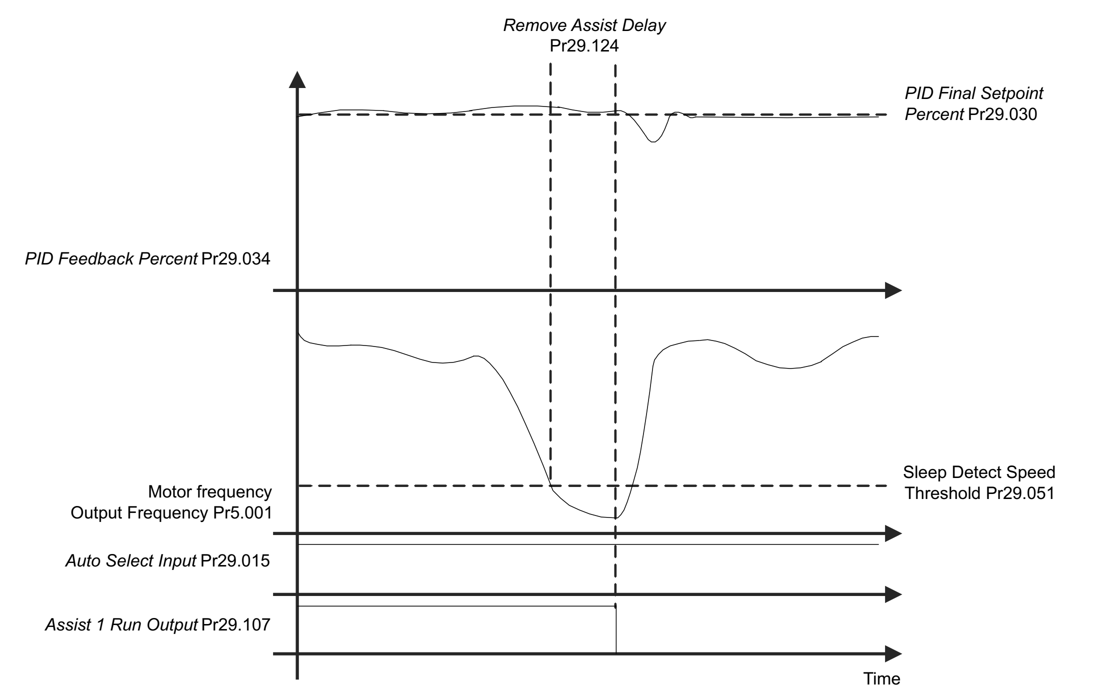


Starting an assist

The process shown in the previous diagram illustrates the starting behaviour for a single assist, however, the process is repeated for a second assist.

In a Cascade system the assist soft starters run at full speed, where the leader drives main process PID loop trims the pump motor frequency or speed to match the setpoint. The system may run in this mode with a single assist or two assists as required by the pump system design.

An assist soft starter is commanded to stop when the motor frequency or speed drops within the *Sleep Detect Speed Threshold* Pr **29.051**(0.042) for *Remove Assist Delay* Pr **29.124** seconds.



Stopping an assist

The process shown in the previous diagram illustrates the stopping behaviour for a single assist, however, the process is repeated for a second assist.

When controlling an assist, the user has 2 different control I/O options, as configured by *Assist Control Mode* Pr **29.106**:

- *Run Only* – In this mode assist Soft Starters are only provided a run command signal via *Assist 1 Run Output* Pr **29.107** and *Assist 2 Run Output* Pr **29.113**. The assist run outputs must be routed to digital or relay outputs that are connected to Soft Starter run inputs.

  It is assumed that a Soft Starter is running after the *Add Assist Delay* Pr **29.122** has elapsed. If the Soft Starter pump has contributed enough, the main process PID output will reduce and no further Soft Starters will be commanded to run. If the Soft Starter pump hasn't contributed enough, the main process PID output will remain high and another Soft Starter will be commanded to run, if another is installed.
- *Full I/O* – In this mode assist soft starter controlled and monitored using the following control and status signals:
  • *Assist 1 Run Output* Pr **29.107** and *Assist 2 Run Output* Pr **29.113**.
  • *Assist 1 Ready Input* Pr **29.108** and *Assist 2 Ready Input* Pr **29.114**.
  • *Assist 1 Running Input* Pr **29.109** and *Assist 2 Running Input* Pr **29.115**.
  If the Soft Starter pump has contributed enough, the main process PID output will reduce and no further Soft Starters will be commanded to run. If the Soft Starter pump hasn't contributed enough, the main process PID output will remain high and another Soft Starter will be commanded to run, if another is installed.

  The Ready input is used to determine whether to attempt to start a given Soft Starter. If the Soft Starter indicates that it is Ready then it will be started if required. If it does not indicate that it is Ready then an alternative Soft Starter will be started instead if available. If a Soft Starter does not give a Ready signal during pumping its run output will be set to off and it will not be retried until it gives a Ready signal again. If a Soft Started does not give a running signal within *Add Assist Delay* Pr **29.122** seconds, the Run output for that Soft Starter will be set to Off, and an alternative Soft Starter will be started instead if available.

  The Running input is used to give a more accurate running time for a given starter, and to provide indication on whether the start was successful or not via *Assist Last Failed Start* Pr **29.119**.

Note that the system may run with only 1 assist starter if required, where the assist 2 parameters can be left at their default value.

See section   for more information on how to configure the drive digital I/O and relay outputs. Additional I/O may be added to the drive with an SI I/O module.

The assist soft starters have their own individual over-cycle protection, where the user can configure *Assist Starts Per Hour* Pr **29.120** to protect the soft starters in the event that they are started more times in an hour than their rating, due to pump system demand. *Assist Over-cycle Mode* Pr **29.121** configures how the protection operates:

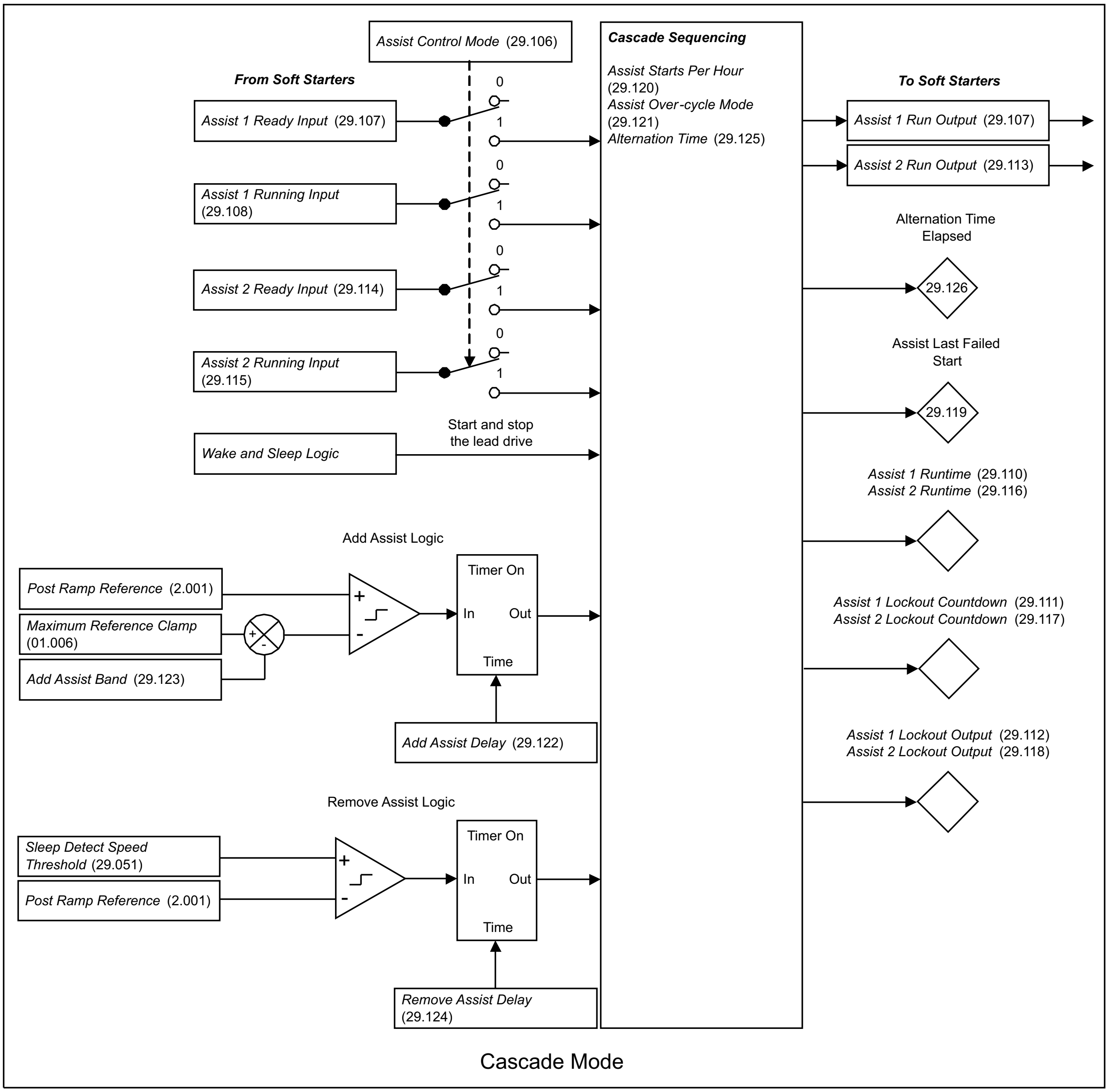
- *Wait 1hr Cool* – In this mode the system will wait 1 hour from the last permitted start for the Soft Starter to cool down. After the cooling time has elapsed the Soft Starter will be allowed to run again, Automatically.
- *Trip* – In this mode the drive will trip *Assist 1 Cycle* or *Assist 2 Cycle* indicating an over-cycle, and the system will wait 1 hour from the last permitted start for the Soft Starter to cool down. After the cooling time has elapsed and the trip is cleared the Soft Starter will be allowed to run again Automatically. By default, the system will Auto-reset the trip, but the Soft Starter over-cycle trip will be logged in the drives trip log, *Trip 0* Pr **10.020** to *Trip 9* Pr **10.029**, for diagnostic purposes.

In the event of an assist over-cycle lockout, *Assist 1 Lockout Output* Pr **29.112** and *Assist 2 Lockout Output* Pr **29.118** will be set to *On(1)* and the remaining time cooling time for the soft starters is indicated by *Assist 1 Lockout Countdown* Pr29.111 and *Assist 1 Lockout Countdown* Pr **29.117** in seconds.

To even wear on the assist pumps the starting order is alternated after the *Alternation Time* Pr **29.125** has elapsed.

7.20.1 Cascade mode diagrams

The following diagram shows the parameters used by cascade mode.



7.20.2 Cascade mode parameters

The following section shows the parameters used by cascade mode.

Parameter	29.106 *Assist Control Mode*		
Minimum	0	Maximum	1
Default	0	Units	

Assist Control Mode Pr **29.106** is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*.

This selects how much I/O is required to control assist soft starters. Two options are available:

Mode	Value	Description
Run Only	0	In this mode assist Soft Starters are only provided a run command signal via *Assist 1 Run Output* Pr **29.107** and *Assist 2 Run Output* Pr **29.113**. The assist run outputs must be routed to digital outputs that are connected to Soft Starter run inputs. It is assumed that a Soft Starter is running after the *Add Assist Delay* Pr **29.122** has elapsed. If the Soft Starter pump has contributed enough, the main process PID output will reduce and no further Soft Starters will be commanded to run. If the Soft Starter pump hasn't contributed enough, the main process PID output will remain high and another Soft Starter will be commanded to run. Note that the system may run with only 1 assist starter if required, where the assist 2 parameters can be left at their default value.
Fill I/O	1	In this mode assist soft starter controlled and monitored using the following control and status signals: • *Assist 1 Run Output* Pr **29.107** and *Assist 2 Run Output* Pr **29.113**. • *Assist 1 Ready Input* Pr **29.108** and *Assist 2 Ready Input* Pr **29.114**. • *Assist 1 Running Input* Pr **29.109** and *Assist 2 Running Input* Pr **29.115**. If the Soft Starter pump has contributed enough, the main process PID output will reduce and no further Soft Starters will be commanded to run. If the Soft Starter pump hasn't contributed enough, the main process PID output will remain high and another Soft Starter will be commanded to run. The Ready input is used to determine whether to attempt to start a given Soft Starter. If the Soft Starter indicates that it is *Ready* then it will be started if required. If it does not indicate that it is *Ready* then an alternative Soft Starter will be started instead if available. If a Soft Starter does not give a Ready signal during pumping its run output will be set to off and it will not be retried until it gives a Ready signal again. If a Soft Started does not give a running signal within *Add Assist Delay* Pr **29.122** seconds, the Run output for that Soft Starter will be set to Off, and an alternative Soft Starter will be started instead, if available. The Running input is used to give a more accurate running time for a given starter, and to provide indication on whether the start was successful or not via *Assist Last Failed Start* Pr **29.119**. Note that the system may run with only 1 assist starter if required, where the assist 2 parameters can be left at their default value.

The Soft Starter assists are called to run or stop using *Add Assist Delay* Pr **29.122**, *Add Assist Band* Pr **29.123** and *Remove Assist Delay* Pr **29.124**. The starting order of the Soft Starter assists is rotated using the *Alternation Time* Pr **29.125**.

Parameter	29.107 *Assist 1 Run Output*		
Minimum	0	Maximum	1
Default	0	Units	

This is the Run command output for Assist 1. A digital output must be routed to this parameter where the subsequent 24 V signal is connected to the run Input of Soft Starter Assist 1.

Parameter	29.108 *Assist 1 Ready Input*		
Minimum	0	Maximum	1
Default	0	Units	

Assist 1 Ready Input Pr **29.108** is only used when *Assist Control Mode* Pr **29.106** = *Full I/O.*

This is the Ready feedback input for Assist 1. A digital input must be routed to this parameter where a 24 V signal is connected to a ready or healthy output from Soft Starter Assist 1.

Parameter	29.109 *Assist 1 Running Input*		
Minimum	0	Maximum	1
Default	0	Units	

Assist 1 Running Input Pr **29.109** is only used when *Assist Control Mode* Pr **29.106** = *Full I/O*.

This is the Running feedback input for Assist 1. A digital input must be routed to this parameter where a 24 V signal is connected to a running output from Soft Starter Assist 1.

Parameter	29.110 *Assist 1 Runtime*		
Minimum	0	Maximum	2147483647
Default	0	Units	minutes

This indicates the running time for Assist Soft Starter 1 in minutes since the Leader drive was powered up.

Parameter	29.111 *Assist 1 Lockout Countdown*		
Minimum	0.0	Maximum	3600.0
Default	0.0	Units	s

In the event that *Assist Starts Per Hour* Pr **29.120** has been reached by Assist Soft Starter 1, *Assist 1 Lockout Countdown* Pr **29.111** indicates the remaining time in seconds that this Soft Starter is locked out for to allow time for it to cool down.

Parameter	29.112 *Assist 1 Lockout Output*		
Minimum	0	Maximum	1
Default	0	Units	

In the event that *Assist Starts Per Hour* Pr **29.120** has been reached by Assist Soft Starter 1, *Assist 1 Lockout Output* Pr **29.112** indicates when this Soft Starter is locked out to allow time for it to cool down.

Parameter	29.113 *Assist 2 Run Output*		
Minimum	0	Maximum	1
Default	0	Units	

This is the Run command output for Assist 2. A digital output must be routed to this parameter where the subsequent 24 V signal is connected to the run Input of Soft Starter Assist 2.

Parameter	29.114 *Assist 2 Ready Input*		
Minimum	0	Maximum	1
Default	0	Units	

Assist 2 Ready Input Pr **29.114** is only used when *Assist Control Mode* Pr **29.106** = *Full I/O*.

This is the Ready feedback input for Assist 2. A digital input must be routed to this parameter where a 24 V signal is connected to a ready or healthy output from Soft Starter Assist 2.

Parameter	29.115 *Assist 2 Running Input*		
Minimum	0	Maximum	1
Default	0	Units	

Assist 2 Running Input Pr **29.115** is only used when *Assist Control Mode* Pr **29.106** = *Full I/O*.

This is the Running feedback input for Assist 2. A digital input must be routed to this parameter where a 24 V signal is connected to a running output from Soft Starter Assist 2.

Parameter	29.116 *Assist 2 Runtime*		
Minimum	0	Maximum	2147483647
Default	0	Units	minutes

This indicates the running time for Assist Soft Starter 2 in minutes since the Leader drive was powered up.

Parameter	29.117 *Assist 2 Lockout Countdown*		
Minimum	0.0	Maximum	3600.0
Default	0.0	Units	s

In the event that *Assist Starts Per Hour* Pr **29.120** has been reached by Assist Soft Starter 2, *Assist 2 Lockout Countdown* Pr **29.117** indicates the remaining time in seconds that this Soft Starter is locked out for to allow time for it to cool down.

Parameter	29.118 *Assist 2 Lockout Output*		
Minimum	0	Maximum	1
Default	0	Units	

In the event that Assist Starts Per Hour Pr **29.120** has been reached by Assist Soft Starter 2, Assist 2 Lockout Output Pr **29.118** indicates when this Soft Starter is locked out to allow time for it to cool down.

Parameter	29.119 *Assist Last Failed Start*		
Minimum	0	Maximum	2
Default	0	Units	

When *Assist Control Mode* Pr **29.106** = *Full I/O*, *Assist Last Failed Start* Pr **29.119** indicates which starter failed to run as indicated by *Assist 1 Running Input* Pr **29.109** and *Assist 2 Running Input* (**29.115**) failing to change to On(1) within the *Add Assist Delay* Pr **29.122** + 1 second.

When *Assist Control Mode* Pr **29.106** = *Run Only*, *Assist Last Failed Start* P r**29.119** is set to *No Failed Starts*.

Parameter	29.120 *Assist Starts Per Hour*		
Minimum	1	Maximum	60
Default	5	Units	

This defines the maximum number of starts per hour for Soft Starter Assist 1 and 2. Please consult the Soft Starter documentation to find out how many starts per hour the particular Soft Starter used in the system is rated for.

Parameter	29.121 *Assist Over-cycle Mode*		
Minimum	0	Maximum	1
Default	0	Units	

This defines how the assist over-cycle detection will be Handled by the Leader drive. Assist over-cycle is always enabled to protect the Soft Starter. The following options are available:

Mode	Value	Description
Wait 1hr Cool	0	In this mode the system will wait 1 hour from the last permitted start for the Soft Starter to cool down. After the cooling time has elapsed the Soft Starter will be allowed to run again Automatically
Trip	1	In this mode the drive will trip *Assist 1 Cycle* or *Assist 2 Cycle* indicating an over-cycle, and the system will wait 1 hour from the last permitted start for the Soft Starter to cool down. After the cooling time has elapsed and the trip is cleared the Soft Starter will be allowed to run again Automatically. By default, the system will Auto-reset the trip, but the Soft Starter over-cycle trip will be logged in the drives trip log (*Trip 0* Pr **10.020** to *Trip 9* Pr **10.029**) for diagnostic purposes.

Over-cycle Starts Per Hour Pr **29.128** used to detect an assist over-cycle condition.

Parameter	29.122 *Add Assist Delay*		
Minimum	0.0	Maximum	6553.5
Default	3.0	Units	s

Add Assist Delay Pr **29.122** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the continuous time period in seconds that the leader drive main process PID must set the drive output frequency or speed within the *Add Assist Band* Pr **29.123** until an assist drive or soft starter is requested. *Add Assist Delay* Pr **29.122** is used to filter intermittent entry to the *Add Assist Band* Pr**29.123**.

In a Cascade or Multi-leader system the *Wake Detect Feedback Threshold* Pr **29.049**(0.040) is used in combination with the *Add Assist Band* Pr **29.123** to decide when to start an assist i.e. both the add assist and wake thresholds must be satisfied to start an assist.

Parameter	29.123 *Add Assist Band*		
Minimum	0.0	Maximum	3000.0
Default	30.0	Units	Hz or rpm

Add Assist Band Pr **29.123** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the frequency or speed band in which an assist Drive or Soft Starter will be requested by the Leader Drive, after the *Add Assist Delay* Pr **29.122** has elapsed. The top end of this band is aligned with the *Maximum Reference Clamp* Pr **1.006** i.e. the add assist band moves with the maximum reference clamp.

In a Cascade or Multi-leader system the *Wake Detect Feedback Threshold* Pr **29.049**(0.040) is used in combination with the *Add Assist Band* Pr **29.123** to decide when to start an assist i.e. both the add assist and wake thresholds must be satisfied to start an assist.

This is used in both Cascade and Multi-leader systems to add an assist soft starter or drive.

Parameter	29.124 *Remove Assist Delay*		
Minimum	0.0	Maximum	6553.5
Default	3.0	Units	s

Remove Assist Delay Pr **29.124** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the continuous time period in seconds that the leader drive main process PID must set the drive output frequency or speed below the *Sleep Detect Speed Threshold* Pr **29.051**(0.052) until an assist drive or soft starter is stopped, (Sleeping). *Remove Assist Delay* Pr **29.124** is used to filter intermittent entry to the *Sleep Detect Speed Threshold* Pr **29.051**(0.052).

This is used in both Cascade and Multi-leader systems to add an assist soft starter or drive.

Parameter	29.125 *Alternation Time*		
Minimum	0.0	Maximum	3276.7
Default	24.0	Units	hours

In a Cascade system, where *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*, this defines the time period in hours that the a given assist starting order will be used for. When the time elapses the starting sequence of the Assists will be swapped. The starting sequences are Leader - Assist 1 - Assist 2, or Leader - Assist 2 - Assist 1.

In a Multi-leader system, where *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*, this defines the time period in hours that in that an individual drive will be the system Leader. When the time elapses, the Leader will be passed to the next drive in the sequence. The drive starting sequences are 1- 2-3, 2-3-1, 3-1-2.

Parameter	29.126 *Alternation Time Elapsed*		
Minimum	0.0	Maximum	3276.7
Default	0.0	Units	hours

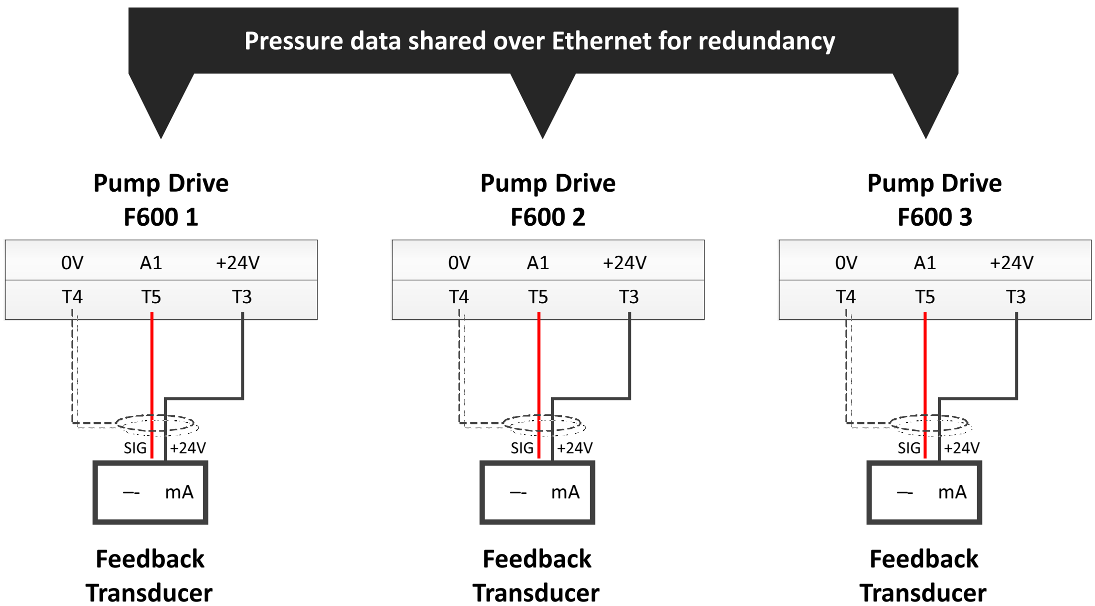
Alternation Time Elapsed Pr **29.126** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This indicates the alternation time elapsed so far in hours. When *Alternation Time Elapsed* Pr **29.126** = *Alternation Time* Pr **29.125** the system will alternate the running order of the connected Drives or Soft Starters. See *Alternation Time* Pr **29.125**.

7.21 Multi-leader mode

The system consists of up to 3 variable speed pump drives of similar size. The pumps are controlled to regulate the pressure of the system to an optimum pressure set point. Each pump drive will be run based on the system demand where the higher the demand, the more drive pumps that will be commanded to run. The first pump drive to run is known as the leader pump and the pumps that are run after are called assist pumps, with system response controlled by the lead pump.

This software can run 2 or 3 pump systems, in addition to running individual pumps in Single Pump mode when necessary. Each drive has the option of a local PID feedback transducer that is shared across the network of drives, giving redundancy should a transducer failure occur.

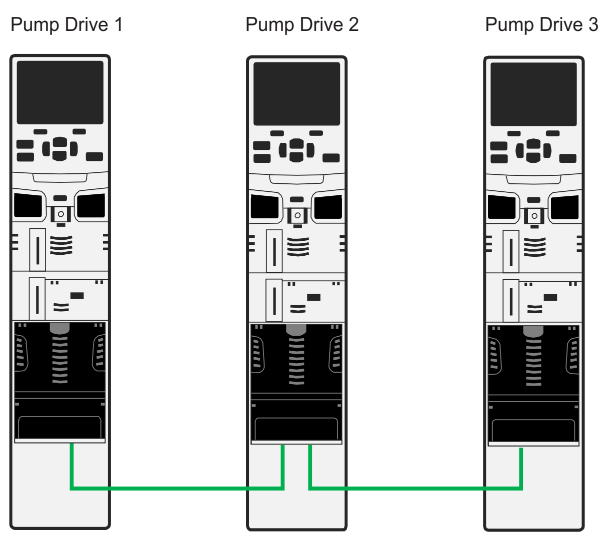


For more economic systems:

- A minimum of 1 sensor may be fitted to any drive on the network and shared over comms.
- A 4-20 mA signal duplicator may be used where a single feedback transducer signal can then be split between the drives.

In the event of a fault with the system leader, the lead will Automatically pass to the next available drive in the system.

To use multi-leader, all drives in the system must have SI-Ethernet modules fitted, (software version >=V01.07.03.03 loaded), with suitable Ethernet connection cables so that the drives can pass control data between each other.

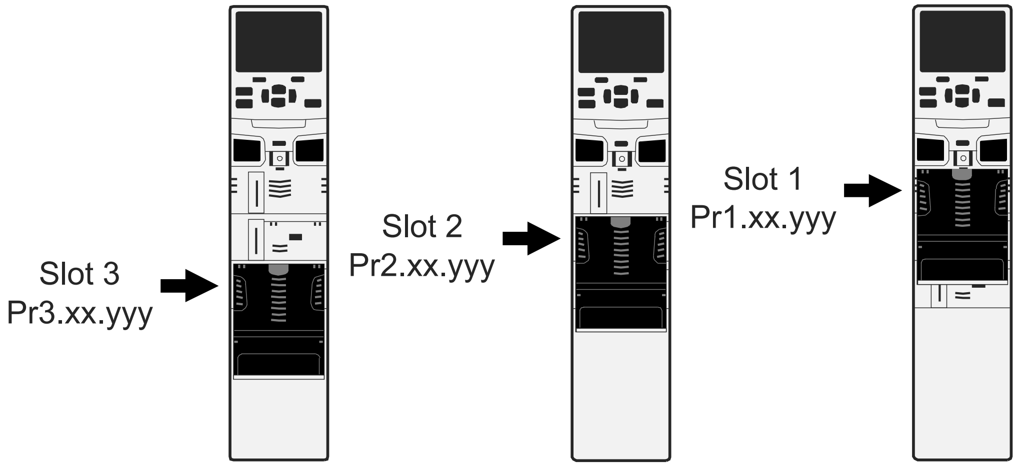


Multi-leader mode is selected by setting *Pump Control Mode* Pr **29.011**(0.021) to *Multi-leader*.

Each of the drives must have a unique static IP address configured, where it is recommended that the least significant IP Address number is 1, 2 or 3 to match pump 1, 2 or 3, for example:

- 192.168.1.1 for pump 1.
- 192.168.1.2 for pump 2.
- 192.168.1.3 for pump 3.

To set up the SI-Ethernet module, the slot number that the SI-Ethernet module is fitted in must be known. The following diagram illustrates the option slot numbers and their configuration menu:



To offer the best mechanical fit, option modules are fitted starting with slot 3 and ending with slot 1.

The steps required to configure the Ethernet IP Address are given below:

- Set DHCP Enable *PrS.**02.005*** to *Off(0).* This configures a static IP Address.
- Set IP Address
- *PrS.**02.006*** to a unique IP Address e.g. *192.168.1.1.*
- Set Subnet Mask
- *PrS.**02.007*** to *255.255.255.0.*
- Set Reset *PrS.**00.007** to On(1).* After 1s this will Automatically change back to *Off(0)*.
- Communications are now configured. Repeat this process for all drives in the system giving each a unique IP address.

S = the slot number.

After the IP Address configuration is completed, each pump must be assigned a node number which is configured by *Multi-leader Node ID* Pr **29.132**. The number must be either 1,2 or 3. If only 2 drives exist in the system then 1 or 2 should be selected. This tells the system software how to configure the Ethernet communications used to pass control and status data between the drives and is used by the Multi-leader control and scheduling. It is recommended to assign the pump node IDs as follows:

- Pump **1** = Node ID **1** = IP Address 192.168.1.**1**
- Pump **2** = Node ID **2** = IP Address 192.168.1.**2**
- Pump **3** = Node ID **3** = IP Address 192.168.1.**3**

Note that the node ID configuration takes effect 2 seconds after *Multi-leader Node ID* Pr **29.132** stops changing, where the user must select Multi-leader mode by setting *Pump Control Mode* Pr **29.011**(0.021) to *Multi-leader* before setting the node ID. After the configuration takes place it can take up to 30s for the network to establish a connection between drives.

Once all the pump drives have a unique node ID, the communications should be checked to make sure they are operating correctly. To verify this check *Cyclic Messages Per Second* PrS.**10.004** where a 2 drive system should have 200 messages per second and a 3 drive system should have 300 messages per second.

If an incorrect number of messages per second is seen, verify that each drive has a unique IP address and a unique node number.

In the event that communications are lost by an assist drive to the system leader, the user can choose between running the drive as a single pump or tripping, as configured by *Multi-leader Network Loss Mode* Pr **29.133**.

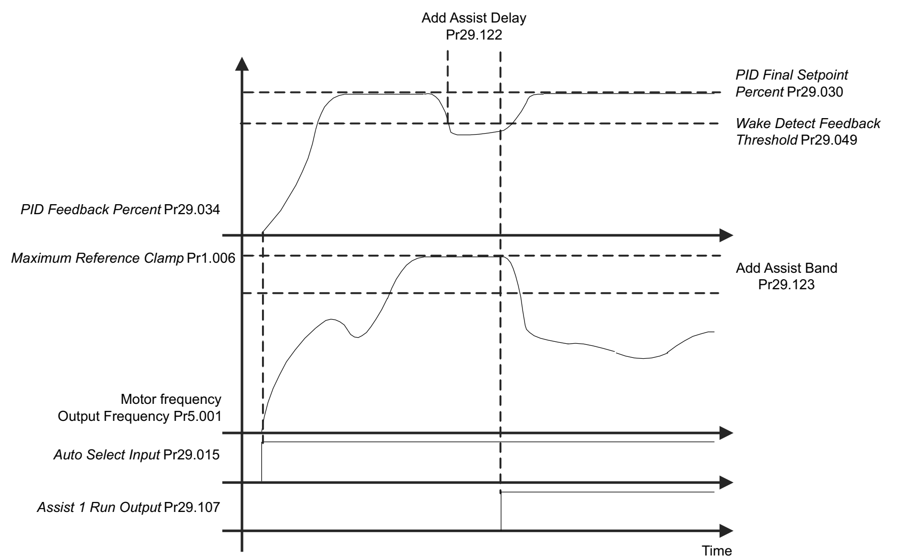
The lead drive in a Multi-leader system is started and stopped using the logic described in section 7.10 Wake and sleep .

When running the system in Auto, the first drive that receives the command to run in Auto will become the system leader, and when running, will indicate this by displaying *Operating Status* Pr **29.003**(0.073) = *Auto Run Leader.* The assist drives in the system will display *Operating Status* Pr **29.003**(0.073) = *Auto Stop Assist* while system demand is too low to command the assists to run, and *Operating Status* Pr **29.003**(0.073) = *Auto Run Assist* when they are running in parallel with the system leader.

In a Multi-leader system, the leader drive commands assist drives to run or stop in order meet the setpoint demand. An assist drive is commanded to run by the leader when:

- The motor frequency or speed is within the *Add Assist Band* Pr **29.123** where the PID is at maximum output and unable to meet the demand.
- *PID Final Feedback* Pr **29.036** is < *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for *Wake Detect Delay* Pr **29.050**(0.041) seconds, when *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* **14.005** = Off(0).
- *PID Final Feedback* Pr **29.036** is > *Wake Detect Feedback Threshold* Pr **29.049**(0.040) for *Wake Detect Delay* Pr **29.050**(0.041) seconds, when *PID1 Feedback Source* Pr **14.004** and *PID1 Reference Invert* **14.005** = On(1).

It is important to note that *Wake Detect Feedback Threshold* Pr **29.049**(0.040) not only defines the feedback level when the assist drives will be commanded to assist the leader, but also the minimum operating pump system output level, e.g. if the setpoint is 80.00 UU and the wake threshold is 70.00 UU then the pump discharge will operate between these two levels.



Starting an assist

The process shown in the previous diagram illustrates the starting behaviour for a single assist drive, however, the process is repeated for a second assist drive.

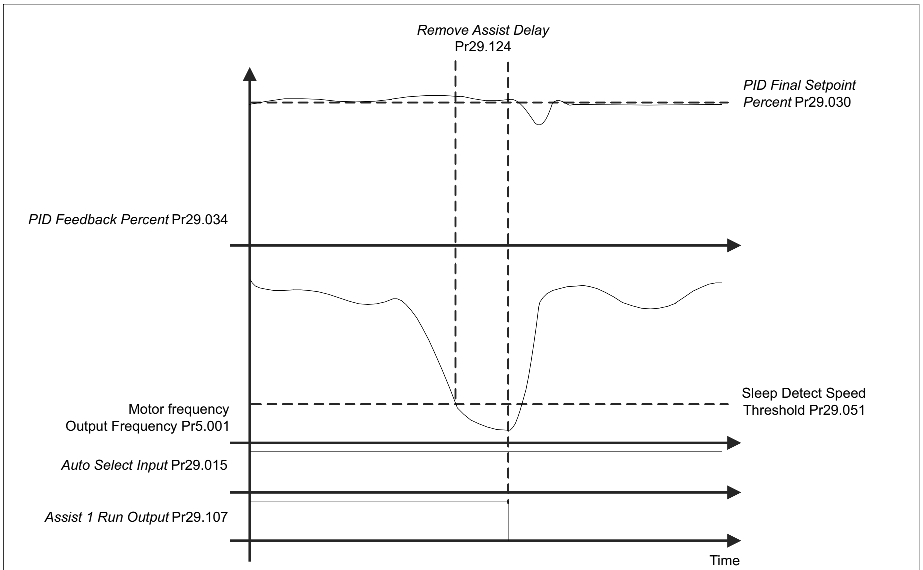
NOTE

The *Multi-leader Node n Control Word* uses bits 0 to 2 to indicate which drives in the system must run where:

- If bit 0 = 1, Pump 1 is commanded to run.
- If bit 1 = 1, Pump 2 is commanded to run.
- If bit 2 = 1, Pump 3 is commanded to run.

In a Multi-leader system, the assist drives receive a frequency or speed reference from the leader drives, where the leader drives main process PID loop trims the pump motor frequency or speed on all drives running in the system to match the setpoint.

An assist drive is commanded to stop when the leader drive motor frequency or speed drops within the *Sleep Detect Speed Threshold* Pr **29.051**(0.042) for *Remove Assist Delay* Pr **29.124** seconds.



Stopping an assist

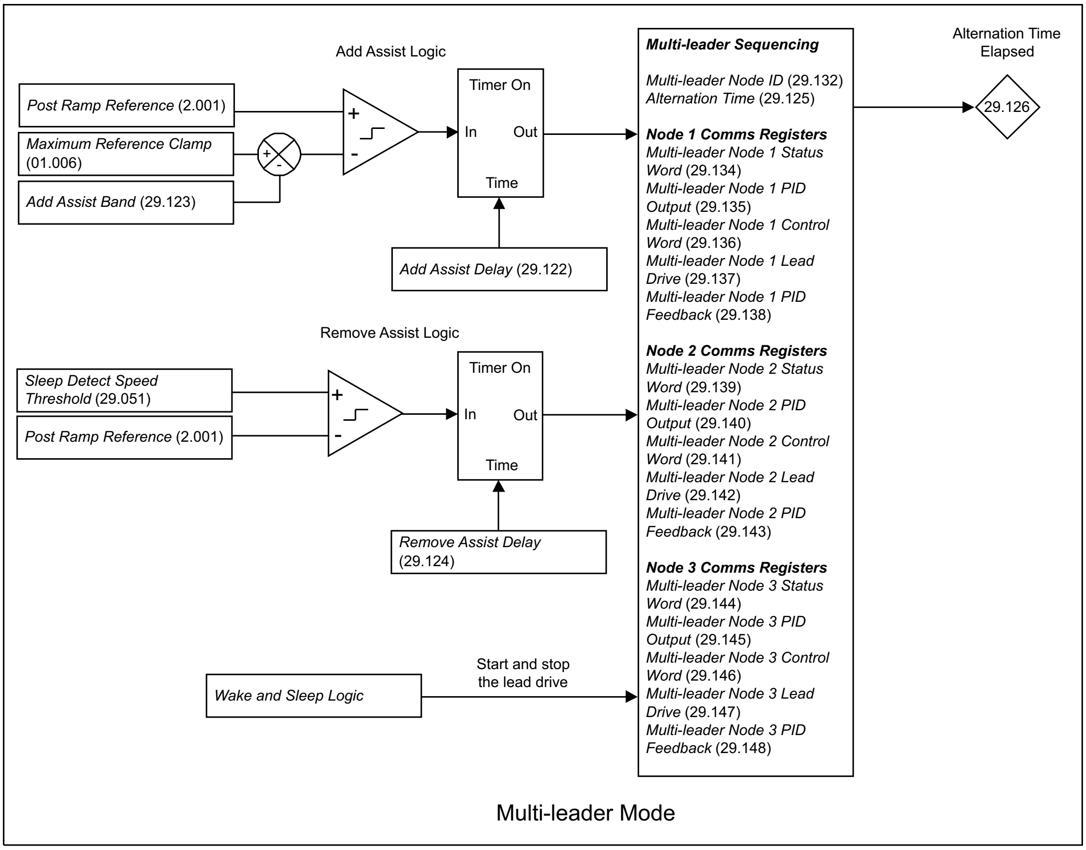
The process shown in the previous diagram illustrates the stopping behaviour for a single assist drive, however, the process is repeated for a second assist drive.

If only a single drive in the system has Auto mode selected, it will behave in the same way as a drive when *Pump Control Mode* Pr **29.011**(0.021) = *Single pump.*

Each drive retains the ability to run totally independently in Hand mode if required.

7.21.1 Multi-leader mode diagrams

The following diagram shows the parameters used by Multi-leader mode.



7.21.2 Multi-leader mode parameters

The following section shows the parameters used by multi-leader mode.

Parameter	29.122 *Add Assist Delay*		
Minimum	0.0	Maximum	6553.5
Default	3.0	Units	s

Add Assist Delay Pr **29.122** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the continuous time period in seconds that the leader drive main process PID must set the drive output frequency or speed within the *Add Assist Band* Pr **29.123** until an assist drive or soft starter is requested. *Add Assist Delay* Pr **29.122** is used to filter intermittent entry to the *Add Assist Band* Pr **29.123**.

In a Cascade or Multi-leader system the *Wake Detect Feedback Threshold* Pr **29.049**(0.040) is used in combination with the *Add Assist Band* Pr **29.123** to decide when to start an assist i.e. both the add assist and wake thresholds must be satisfied to start an assist.

Parameter	29.123 *Add Assist Band*		
Minimum	0.0	Maximum	3000.0
Default	30.0	Units	Hz or rpm

Add Assist Band Pr **29.123** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the frequency or speed band in which an assist Drive or Soft Starter will be requested by the Leader Drive, after the *Add Assist Delay* Pr **29.122** has elapsed. The top end of this band is aligned with the *Maximum Reference Clamp* Pr **1.006** i.e. the add assist band moves with the maximum reference clamp.

In a Cascade or Multi-leader system the *Wake Detect Feedback Threshold* Pr **29.049**(0.040) is used in combination with the *Add Assist Band* Pr **29.123** to decide when to start an assist i.e. both the add assist and wake thresholds must be satisfied to start an assist.

This is used in both Cascade and Multi-leader systems to add an assist soft starter or drive.

Parameter	29.124 *Remove Assist Delay*		
Minimum	0.0	Maximum	6553.5
Default	3.0	Units	s

Remove Assist Delay Pr **29.124** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This defines the continuous time period in seconds that the leader drive main process PID must set the drive output frequency or speed below the *Sleep Detect Speed Threshold* Pr **29.051**(0.052) until an assist drive or soft starter is stopped, (Sleeping). *Remove Assist Delay* Pr **29.124** is used to filter intermittent entry to the *Sleep Detect Speed Threshold* Pr **29.051**(0.052).

This is used in both Cascade and Multi-leader systems to add an assist soft starter or drive.

Parameter	29.125 *Alternation Time*		
Minimum	0.0	Maximum	3276.7
Default	0.0	Units	hours

In a Cascade system, where *Pump Control Mode* Pr **29.011**(0.021) = *Cascade*, this defines the time period in hours that the a given assist starting order will be used for. When the time elapses the starting sequence of the Assists will be swapped. The starting sequences are Leader - Assist 1 - Assist 2, or Leader - Assist 2 - Assist 1.

In a Multi-leader system, where *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*, this defines the time period in hours that in that an individual drive will be the system Leader. When the time elapses, the Leader will be passed to the next drive in the sequence. The drive starting sequences are 1- 2-3, 2-3-1, 3-1-2.

Parameter	29.126 *Alternation Time Elapsed*		
Minimum	0.0	Maximum	3276.7
Default	0.0	Units	hours

Alternation Time Elapsed Pr **29.126** is used when *Pump Control Mode* Pr **29.011**(0.021) = *Cascade* or *Multi-leader*.

This indicates the alternation time elapsed so far in hours. When *Alternation Time Elapsed* Pr **29.126** = *Alternation Time* Pr **29.125** the system will alternate the running order of the connected Drives or Soft Starters. See *Alternation Time* Pr **29.125**.

Parameter	29.132 *Multi-leader Node ID*		
Minimum	1	Maximum	3
Default	1	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

This defines the node ID of this drive within a Multi-leader pump system. The number must be either 1,2 or 3. Note that if only 2 drives exist in the system then 1 or 2 should be selected. This tells the system software how to configure the Ethernet communications used to pass control and status data between the drives and is used by the Multi-leader control and scheduling.

The drive assists are called to run or stop using *Add Assist Delay* Pr **29.122**, *Add Assist Band* (**29.123**) and *Remove Assist Delay* (**29.124**). The starting order of the Leader and drive assists is rotated using the *Alternation Time* (**29.125**).

Parameter	29.133 *Multi-leader Network Loss Mode*		
Minimum	0	Maximum	1
Default	Run Single Pump (0)	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

This defines how the pump drive will respond in the event that Ethernet communications are lost to the Leader while running in Auto mode.

When Set to *Run Single Pump*, the system will switch internally to run as a Single Pump using its own feedback and main process PID.

When set to Trip, the system will trip *Network Loss* if the connection is lost to the leader drive.

Parameter	29.134 *Multi-leader Node 1 Status Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	

This parameter is only used when *Pump Control Mode* Pr**29.011**(0.021) = *Multi-leader*.

Multi-leader Node 1 Status Word Pr**29.13**4 is used by the Pump software as part of a Multi-leader system for drive node 1. The user is not intended to modify this value.

The following status bits are available:

Status Bit	Description
0	Drive On Network
1	Ready
2	Auto running
3	Drive Active
4	Loss Of Feedback
5	Hand Selected
6	Auto Selected
7	Pipe Fill Complete
8	Clean Request
9	Clean Permit

Parameter	29.135 *Multi-leader Node 1 PID Output*		
Minimum	-3276.8	Maximum	3276.7
Default	0.0	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 1 PID Output Pr **29.135** is used by the Pump software as part of a Multi-leader system for drive node 1. The user is not intended to modify this value.

This indicates the main process PID output represented as a frequency or speed.

Parameter	29.136 *Multi-leader Node 1 Control Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 1 Control Word Pr **29.136** is used by the pump software as part of a Multi-leader system for drive node 1. The user is not intended to modify this value.

Control Bit	Description
0	Run drive node 1
1	Run drive node 2
2	Run drive node 3

Parameter	29.137 *Multi-leader Node 1 Lead Drive*		
Minimum	0	Maximum	3
Default	0	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 1 Lead Drive Pr **29.137** is used by the pump software as part of a Multi-leader system for drive node 1. The user is not intended to modify this value.

This indicates the current system leader and is used to change the Leader drive over after the *Alternation Time* **29.125** has elapsed.

Parameter	29.139 *Multi-leader Node 2 Status Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 2 Status Word Pr **29.139** is used by the pump software as part of a Multi-leader system for drive node 2. The user is not intended to modify this value.

The following status bits are available:

Status Bit	Description
0	Drive On Network
1	Ready
2	Auto running
3	Drive Active
4	Loss Of Feedback
5	Hand Selected
6	Auto Selected
7	Pipe Fill Complete
8	Clean Request
9	Clean Permit

Parameter	29.140 *Multi-leader Node 2 PID Output*		
Minimum	-3276.8	Maximum	3276.7
Default	0.0	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 2 PID Output Pr **29.140** is used by the pump software as part of a Multi-leader system for drive node 2. The user is not intended to modify this value.

This indicates the main process PID output represented as a frequency or speed.

Parameter	29.141 *Multi-leader Node 2 Control Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 2 Control Word Pr **29.141** is used by the pump software as part of a Multi-leader system for drive node 2. The user is not intended to modify this value.

The following control bits are available:

Control bit	Description
0	Run drive node 1
1	Run drive node 2
2	Run drive node 3

Parameter	29.142 *Multi-leader Node 2 Lead Drive*		
Minimum	0	Maximum	3
Default	0	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 2 Lead Drive Pr **29.142** is used by the pump software as part of a Multi-leader system for drive node 2. The user is not intended to modify this value.

This indicates the current system leader and is used to change the Leader drive over after the *Alternation Time* **29.125** has elapsed.

Parameter	29.143 *Multi-leader Node 2 PID Feedback*		
Minimum	-327.68	Maximum	327.67
Default	0.00	Units	%

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 2 PID Feedback Pr **29.143** is used by the pump software as part of a Multi-leader system for drive node 2. The user is not intended to modify this value.

This indicates the main process PID feedback after the filter has been applied, *PID Final Feedback Percent* Pr**29.035**. This is used by other drive nodes if the local PID feedback is not working.

Parameter	29.144 *Multi-leader Node 3 Status Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	%

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 3 Status Word Pr **29.144** is used by the pump software as part of a Multi-leader system for drive node 3. The user is not intended to modify this value.

The following status bits are available:

Status Bit	Description
0	Drive On Network
1	Ready
2	Auto running
3	Drive Active
4	Loss Of Feedback
5	Hand Selected
6	Auto Selected
7	Pipe Fill Complete
8	Clean Request

Parameter	29.145 *Multi-leader Node 3 PID Output*		
Minimum	-3276.8	Maximum	3276.7
Default	0.00	Units	

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 3 PID Output Pr **29.145** is used by the pump software as part of a Multi-leader system for drive node 3. The user is not intended to modify this value.

This indicates the main process PID output represented as a frequency or speed.

Parameter	29.146 *Multi-leader Node 3 Control Word*		
Minimum	0 (Display: 0000000000000000)	Maximum	65535 (Display: 1111111111111111)
Default	0 (Display: 0000000000000000)	Units	%

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 3 Control Word Pr **29.146** is used by the pump software as part of a Multi-leader system for drive node 3. The user is not intended to modify this value.

The following control bits are available:

Control bit	Description
0	Run drive node 1
1	Run drive node 2
2	Run drive node 3

Parameter	29.147 *Multi-leader Node 3 Lead Drive*		
Minimum	0	Maximum	3
Default	0	Units	

This parameter is only used when Pump Control Mode Pr **29.011**(0.021) = Multi-leader.

Multi-leader Node 3 Lead Drive Pr **29.147** is used by the pump software as part of a Multi-leader system for drive node 3. The user is not intended to modify this value.

This indicates the current system leader and is used to change the Leader drive over after the *Alternation Time* Pr **29.125** has elapsed.

Parameter	29.148 *Multi-leader Node 3 PID Feedback*		
Minimum	-327.68	Maximum	327.67
Default	0.00	Units	%

This parameter is only used when *Pump Control Mode* Pr **29.011**(0.021) = *Multi-leader*.

Multi-leader Node 3 PID Feedback Pr **29.148** is used by the pump software as part of a Multi-leader system for drive node 3. The user is not intended to modify this value.

This indicates the main process PID feedback after the filter has been applied, *PID Final Feedback Percent* Pr **29.035**. This is used by other drive nodes if the local PID feedback is not working.

7.22 Additional features

To extend the pump specific functionality, additional logic is provided in menus 9, 12 and 14. The following table indicates the functionality available.

Menu	Function	Use
9	Logic functions	Perform simple binary logic like ANDing
9	Motorised Pot	Bit type control to numerical output
9	Binary Sum	Bit type to numerical conversion
9	Timers	Perform actions after specified times using the keypad real time clock.
12	Threshold detectors	Numerical level to binary output.
12	Variable selectors	Numerical signal processing and selection
14	Second PID controller	Trim the main PID e.g. to implement anti-cavitation or control external valves.

Please see the advanced parameters diagrams for more information on these functions.

8 Optimization

This chapter takes the user through methods of optimizing the drive set-up and maximize the performance. The auto-tuning features of the drive simplify the optimization tasks.

8.1 Motor map parameters

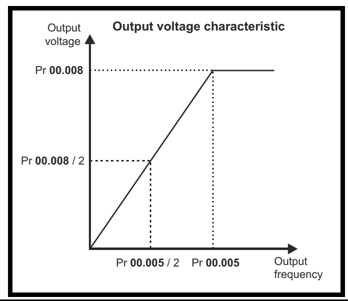
8.1.1 Open loop motor control

Pr 00.006 {05.007} ***Rated Current***	**Defines the maximum continuous motor current**

- The rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following:
- Current limits (see section 8.3 *Switching frequency* on page 309, for more information).
- Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 308, for more information)
- Slip compensation (see *Enable Slip Compensation* (**05.027**), later in this table)
- Dynamic V/F control

Pr 00.008 {05.009} ***Rated Voltage***	**Defines the voltage applied to the motor at rated frequency**
Pr 00.005 {05.033} Volts per 1000 rpm	**Defines the frequency at which rated voltage is applied**

The *Rated Voltage* (**00.008**) and the *Rated Frequency* (**00.005**) are used to define the voltage to frequency characteristic applied to the motor (see *Open Loop Control Mode* (**05.014)**, later in this table). The *Rated Frequency* (**00.005**) is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see *Rated Speed* (**00.007**), later in this table).



Pr 00.007 {05.008} ***Rated Speed***	**Defines the full load rated speed of the motor**
Pr 00.010 {05.011} ***Number Of Motor Poles***	**Defines the number of motor poles**

The motor rated speed and the number of poles are used with the motor rated frequency to calculate the rated slip of induction machines in Hz.

Rated slip (Hz) = Motor rated frequency - (Number of pole pairs x [Motor rated speed / 60]) = $\mathbf{00.047} = \left(\frac{\mathbf{00.010}}{\mathbf{2}} \times \frac{\mathbf{00.007}}{\mathbf{60}}\right)$

If Pr **00.007** is set to 0 or to synchronous speed, slip compensation is disabled. If slip compensation is required this parameter should be set to the nameplate value, which should give the correct rpm for a hot machine. Sometimes it will be necessary to adjust this when the drive is commissioned because the nameplate value may be inaccurate. Slip compensation will operate correctly both below base speed and within the field-weakening region. Slip compensation is normally used to correct for the motor speed to prevent speed variation with load. The rated load rpm can be set higher than synchronous speed to deliberately introduce speed droop. This can be useful to aid load sharing with mechanically coupled motors.

Pr **00.010** is also used in the calculation of the motor speed display by the drive for a given output frequency. When Pr **00.010** is set to ‘Automatic’, the number of motor poles is automatically calculated from the rated frequency Pr **00.005**, and the motor rated speed Pr **00.007**.

Number of poles = 120 x (*Rated Frequency* (**00.005**) / *Rated Speed* (**00.007**)) rounded to the nearest even number.

Pr 00.009 {05.010} ***Rated Power Factor***	**Defines the angle between the motor voltage and current**

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. The power factor is used in conjunction with the *Rated Current* (**00.006**), to calculate the rated active current and magnetising current of the motor. The rated active current is used extensively to control the drive, and the magnetising current is used in vector mode stator resistance compensation. It is important that this parameter is set up correctly. The drive can measure the motor rated power factor by performing a rotating autotune (see Autotune (Pr **05.012**), below).

Pr 00.013 {05.012} Autotune
There are two autotune tests available in open loop mode, a stationary and a rotating test. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive. • A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary test measures the *Stator Resistance* (**05.014**) and *Transient Inductance* (**05.024**) which are required for good performance in vector control modes (see *Open Loop Control Mode* (**00.007)**, later in this table). The stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.009**. To perform a Stationary autotune, set Pr **05.012** to 1, and provide the drive with both an enable signal (on terminal 29) and a Hand select signal (on terminal 25). • A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune, as above, then a rotating test is performed in which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (**05.006**) x $^{2}/_{3}$, and the frequency is maintained at that level for 4 seconds. *Stator Inductance* (**05.025**) is measured and this value is used in conjunction with other motor parameters to calculate *Rated Power Factor* (**05.010**). To perform a Rotating autotune, set Pr **05.012** to 2, and provide the drive with both an enable signal (on terminal 29) and a Hand select signal (on terminal 25). Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the *Drive Enable* (**06.015**) to OFF (0) or disabling the drive via the *Control Word* (**06.042**) and *Control Word Enable* (**06.043**).

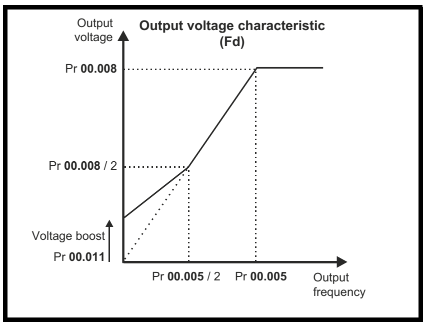
Pr 05.014 *Open Loop Control Mode*
There are several voltage modes available which fall into two categories, vector control and fixed boost. Vector control Vector control mode provides the motor with a linear voltage characteristic from 0 Hz to motor *Rated Frequency* (**00.005**), and then a constant voltage above motor rated frequency. When the drive operates between motor rated frequency/50 and motor rated frequency/4, full vector based stator resistance compensation is applied. When the drive operates between motor rated frequency/4 and motor rated frequency/2 the stator resistance compensation is gradually reduced to zero as the frequency increases. For the vector modes to operate correctly the *Rated Power Factor* (**00.009**) and *Stator Resistance* (**05.017**) are required to be set up accurately. The drive can be made to measure these by performing an autotune (see Pr **05.012** *Autotune*). The drive can also be made to measure the stator resistance automatically every time the drive is enabled or the first time the drive is enabled after it is powered up, by selecting one of the vector control voltage modes. (0) **Ur S** = The stator resistance is measured and the parameter for the selected motor map are over-written each time the drive is made to run. This test can only be done with a stationary motor where the flux has decayed to zero. Therefore this mode should only be used if the motor is guaranteed to be stationary each time the drive is made to run. To prevent the test from being done before the flux has decayed there is a period of 1 second after the drive has been in the ready state during which the test is not done if the drive is made to run again. In this case, previously measured values are used. Ur S mode ensures that the drive compensates for any change in motor parameters due to changes in temperature. The new value of stator resistance is not automatically saved to the drive's EEPROM. (4) **Ur I** = The stator resistance is measured when the drive is first made to run after each power-up. This test can only be done with a stationary motor. Therefore this mode should only be used if the motor is guaranteed to be stationary the first time the drive is made to run after each power-up. The new value of stator resistance is not automatically saved to the drive's EEPROM. (1) **Ur** = The stator resistance is not measured. The user can enter the motor and cabling resistance into the *Stator Resistance* (**05.017**). However this will not include resistance effects within the drive inverter. Therefore if this mode is to be used, it is best to use an autotune test initially to measure the stator resistance. (3) **Ur_Auto** = The stator resistance is measured once, the first time the drive is made to run. After the test has been completed successfully the *Open Loop Control Mode* (**05.014**) is changed to Ur mode. The *Stator Resistance* (**05.017**) parameter is written to, and along with the *Open Loop Control Mode* (**05.014**), are saved in the drive's EEPROM. If the test fails, the voltage mode will stay set to Ur Auto and the test will be repeated next time the drive is made to run.

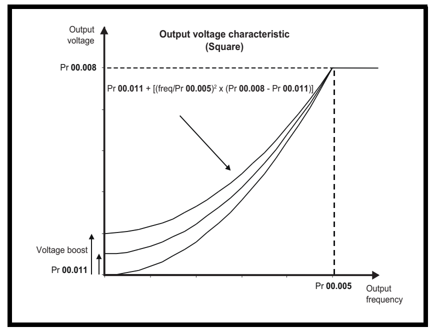
Pr 05.014 *Open Loop Control Mode (cont)*

Fixed boost

The stator resistance is not used in the control of the motor, instead a fixed characteristic with low frequency voltage boost as defined by parameter Pr **00.008**, is used. Fixed boost mode should be used when the drive is controlling multiple motors. There are two settings of fixed boost available:
(2) **Fixed** = This mode provides the motor with a linear voltage characteristic from 0 Hz to *Rated Frequency* (**00.005**), and then a constant voltage above rated frequency.
(5) **Square** = This mode provides the motor with a square law voltage characteristic from 0 Hz to *Rated Frequency* (**00.005)**, and then a constant voltage above rated frequency. This mode is suitable for variable torque applications like fans and pumps where the load is proportional to the square of the speed of the motor shaft. This mode should not be used if a high starting torque is required.

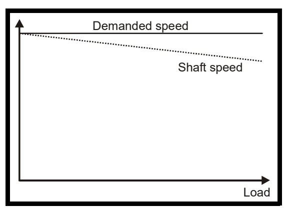
For both these modes, at low frequencies (from 0 Hz to ½ x Pr **00.005**) a voltage boost is applied defined by Pr **00.011** as shown below:





Pr 05.027 *Enable Slip Compensation*

When a motor, being controlled in open loop mode, has load applied a characteristic of the motor is that the output speed droops in proportion to the load applied as shown:



In order to prevent the speed droop shown above slip compensation should be enabled. To enable slip compensation Pr **05.027** must be set to a 1 (this is the default setting), and the motor rated speed must be entered in Pr **00.007** (Pr **05.008**).

The motor rated speed parameter should be set to the synchronous speed of the motor minus the slip speed. This is normally displayed on the motor nameplate, i.e. for a typical 18.5 kW, 50 Hz, 4 pole motor, the motor rated speed would be approximately 1465 rpm. The synchronous speed for a 50 Hz, 4 pole motor is 1500 rpm, so therefore the slip speed would be 35 rpm. If the synchronous speed is entered in Pr **00.007**, slip compensation will be disabled. If too small a value is entered in Pr **00.007**, the motor will run faster than the demanded frequency. The synchronous speeds for 50 Hz motors with different numbers of poles are as follows:

2 pole = 3000 rpm, 4 pole = 1500 rpm, 6 pole =1000 rpm, 8 pole = 750 rpm

8.1.2 RFC-A Sensorless mode

Induction motor without position feedback

Pr 00.006 {05.007} ***Motor Rated Current***	**Defines the maximum motor continuous current**

The motor rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following:

- Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 308, for more information)
- Vector control algorithm

Pr 00.008 {05.009} ***Rated Voltage***	**Defines the voltage applied to the motor at rated frequency**
Pr 00.005 {05.006} ***Rated Frequency***	**Defines the frequency at which rated voltage is applied**

The motor rated voltage Pr **00.008** and the motor rated frequency Pr **00.005** are used to define the relationship between the voltage and frequency applied to the motor.
The motor rated voltage is used by the field controller to limit the voltage applied to the motor. Normally this is set to the nameplate value. To allow current control to be maintained, it is necessary for the drive to leave some 'headroom' between the motor terminal voltage and the maximum available drive output voltage. For good transient performance at high speed, the motor rated voltage should be set below 95 % of the minimum supply voltage to the drive.
The motor rated voltage and motor rated frequency are also used during the rotating autotune test (see Autotune Pr **05.012** later in this table) therefore, it is important that the correct value for motor rated voltage is used.

Pr 00.007 {05.008} ***Rated Speed***	**Defines the full load rated speed of the motor**
Pr 00.010 {05.011} ***Number Of Motor Poles***	**Defines the number of motor poles**

The motor rated speed and motor rated frequency are used to determine the full load slip of the motor which is used by the vector control algorithm.

Incorrect setting of this parameter has the following effects:

- Reduced efficiency of motor operation
- Reduction of maximum torque available from the motor
- Reduced transient performance
- Inaccurate control of absolute torque in torque control modes

The nameplate value is normally the value for a hot motor; however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate.

When Pr **00.010** is set to 'Automatic', the number of motor poles is automatically calculated from the motor *Rated Frequency* (**00.005**), and the motor *Rated Speed* (**00.007**).

Number of poles = 120 x (Motor *Rated Frequency* (**00.005** / Motor *Rated Speed* (**00.007**) rounded to the nearest even number.

Pr 00.009 {5.010} ***Rated Power Factor***	**Defines the angle between the motor voltage and current**

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. If the *Stator Inductance* (**05.025**) is set to zero then the power factor is used in conjunction with the motor *Rated Current* (**00.006**) and other motor parameters to calculate the rated active and magnetising currents of the motor, which are used in the vector control algorithm. If the stator inductance has a non-zero value this parameter is not used by the drive, but is continuously written with a calculated value of power factor. The stator inductance can be measured by the drive by performing a rotating autotune (see *Autotune* (Pr **05.012**), later in this table).

Pr 05.012 ***Autotune***	

There are two autotune tests available in RFC-A mode, a stationary test, and a rotating test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive.

It is highly recommended that a rotating autotune is performed (Pr **05.012** set to 2).

Autotune test 1:

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the *Stator Resistance* (**05.017**) and *Transient Inductance* **(00.016**) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **04.013** and Pr **04.014** are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.009**. To perform a stationary autotune, set Pr **05.012** to 1, and provide the drive with both an enable signal (on terminal 29) and a Hand select signal (on terminal 25).

Autotune test 2:

- A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune, a rotating test is then performed in which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (**05.006**) x 2/3, and the frequency is maintained at the level for up to 40 s. During the rotating autotune the *Stator Inductance* (**05.025**) is modified by the drive. The power factor is also modified for user information only, but is not used after this point as the stator inductance is used in the vector control algorithm instead. To perform a Rotating autotune, set Pr **05.012** to 2, and provide the drive with both an enable signal (on terminal 29) and a Hand select signal (on terminal 25).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the *Drive Enable* (**06.015**) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**).

Pr 04.013 / Pr 04.014 *Current Loop Gains*

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. However, for optimal performance in dynamic applications it may be necessary to change the gains to improve the performance. The *Current Controller Kp Gain* (**04.013**) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by performing a stationary or rotating autotune (see *Autotune* Pr **05.012**, earlier in this table) the drive measures the *Stator Resistance* (**05.017**) and *Transient Inductance* (**00.016**) of the motor and calculates the current loop gains.

This will give a step response with minimum overshoot after a step change of current reference. The proportional gain can be increased by a factor of 1.5 giving a similar increase in bandwidth; however, this gives a step response with approximately 12.5 % overshoot. The equation for the integral gain gives a conservative value. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed Sensorless RFC-A induction motor applications) the integral gain may need to have a significantly higher value.

***Speed Loop Gains* 03.010, 03.011, 03.012**

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term.

Speed Controller Proportional Gain (Kp), Pr **03.010**

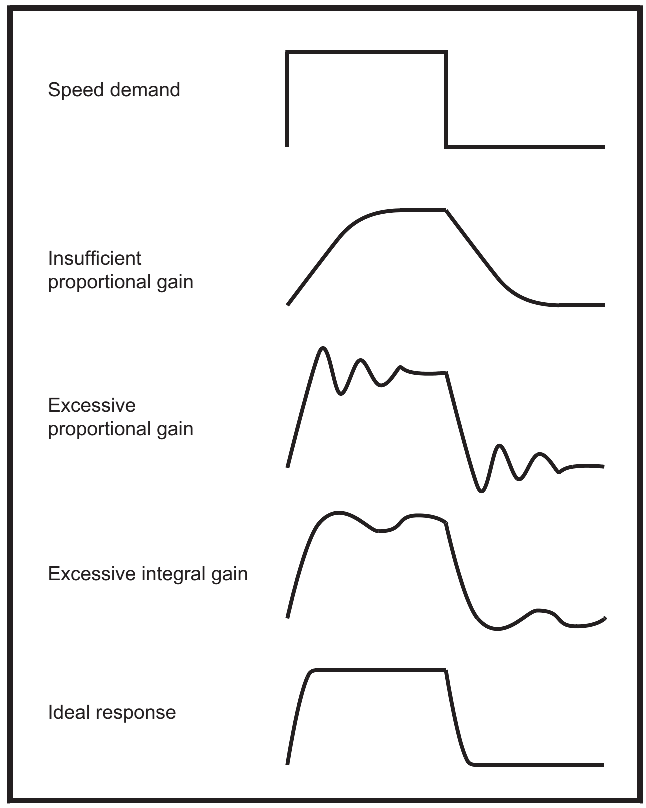
If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the stability limit is reached.

Speed Controller Integral Gain (Ki), Pr **03.011**

The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain.
A compromise must be reached where the system response, stiffness and damping are all adequate for the application. For RFC-A Sensorless mode, it is unlikely that the integral gain can be increased much above 0.50.

Differential Gain (Kd), Pr **03.012**

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.



8.1.3 RFC-S Sensorless mode

Permanent magnet motor without Position feedback

Pr 00.006 {05.007} ***Rated Current***	**Defines the maximum motor continuous current**
The motor rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following: • Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 308, for more information)	

Pr 00.010 {05.011} ***Number Of Motor Poles***	**Defines the number of motor poles**
The number of motor poles parameter defines the number of electrical revolutions in one whole mechanical revolution of the motor. This parameter must be set correctly for the control algorithms to operate correctly. When Pr **00.010** is set to "Automatic" the number of poles is 6.	

Pr 05.012 ***Autotune***	
There are three autotune tests available in RFC-S sensorless mode, a stationary autotune and a locked rotor test. • Auto tune test 1: Stationary Autotune The stationary autotune can be used to measure all the necessary parameters for basic control. The tests measures *Stator Resistance* (**05.017**), *Ld* (**00.016**) and *No Load Lq* (**05.07**2). *The Stator Resistance* (**05.017**) and *Ld* (**00.016)** are then used to set up *Current controller Kp Gain* (**04.013)** and *Current Controller Ki Gain* (**04.014**). To perform a Stationary autotune, set Pr **05.012** to 1, and provide the drive with both an enable signal (on terminal 29) and a Hand signal (on terminal 25). • Autotune test 2: Rotating Autotune In sensorless mode, if Rotating autotune is selected (Pr **05.012** = 2), then a stationary autotune is performed. Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the drive Enable Parameter (**06.015**) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**). • Autotune test 6: Locked rotor test for load dependant parameters This test is not implemented at the time of writing.	

Pr 03.079 ***Sensorless Mode Filter***	
When RFC-S sensorless mode is active the measured speed can include some ripple, which increases as the drive passes into field weakening. A filter is applied to the estimated speed and *Sensorless Mode Filter* (**03.079**) defines the time constant. The default time constant is 64 ms. This is particularly useful when using standard ramp or spinning start with a low friction high inertia load, and can prevent over voltage trips when the drive has no braking resistor.	

Pr 00.014 {05.064} *RFC Low Speed Mode* /
Pr 05.071 *Low Speed Sensorless Mode Current*

(0) Injection mode

For low speed sensorless operation with signal injection (*RFC Low Speed Mode* (**05.064**) = 0) it is necessary to have a ratio of Lq/Ld = 1.1. Even if a motor has a larger ratio on no load, this ratio normally reduces as the q axis current is increased from zero. *Low Speed Sensorless Mode Current* (**05.071**) should be set at a level that is lower than the point where the inductance ratio falls to 1.1. The value of this parameter is used to define the drive current limits when signal injection is active and prevent loss of control of the motor.

(1) Non-salient mode

For low speed sensorless operation for non-salient motors (*RFC Low Speed Mode* (**05.064**) = 1) this defines a current applied in the d axis to aid starting. For most motors and application requiring up to 60 % torque on starting the default value is suitable. However the level of current may need to be increased to make the motor start.

(2) Current

This method, which applies a rotating current vector at the frequency defined by the speed reference, can be used with any motor with no saliency or moderate saliency. It should only be used with motors where more of the torque is produced in conjunction with the magnet flux rather than from saliency torque. This mode does not provide the same level of control at low speed as injection mode, but is easier to set up and more flexible than "Non-salient" mode. The following should be considered:

1. A current specified by *Low Speed Sensorless Mode Current* (**05.071**) is applied when low speed mode is active. This current should be sufficient to start the motor with the highest expected load. If the motor has some saliency with no-load applied, and a suitable saturation characteristic, the drive can detect the rotor position and apply the current at the correct angle to avoid starting transient. If the motor is non-salient as defined by the conditions for Inductance trip then the drive will not attempt to detect the rotor position and the current will be applied at an arbitrary angle. This could cause a starting transient if the level of current applied is high, and so *Low Speed Sensorless Mode Current* (**05.071**) should not be set to a higher level than necessary. To minimise the movement as a result of applying the current, it is increased over the period defined by *Sensorless Mode Current Ramp* (**05.063**) in the form of a squared characteristic (i.e. it is increased with a low rate of change at the beginning and the rate of change is gradually increased).
2. As the level of current when low speed mode is active is not dependent on the applied load, but is as defined by *Low Speed Sensorless Mode Current* (**05.071**), and so the motor may become too hot if low speed mode is active for a prolonged period of time.
3. Generally *Low Speed Sensorless Mode Current* (**05.071)** should be set to a level higher than the expected maximum load, and can be set to a much higher level than the load if the saliency and saturation characteristic allow the position of the rotor to be detected on starting. However, *Low Speed Sensorless Mode Current* (**05.071**) should be matched more closely to the expected load under the following conditions: the load inertia is high compared to the motor interia, or there is very little damping/loss in the load system, or where the q axis inductance of the motor changes significantly with load.

(3) Current no test

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. This can be selected for example, if the motor does not have a suitable saturation characteristic to allow the rotor position to be determined during starting, or if faster starting is required. The initial current vector angle will be at an arbitary position with respect to the actual rotor position. As the vector sweeps round it must make the rotor start to rotate. If the ramp rate is too high the rotor may not keep up with the current vector and the motor may not start. If this is the case then the ramp rate should be reduced and/or the current used to start the motor should be increased.

(4) Current step

The current starting modes normally provide a smooth transition between the low speed current mode and normal running at higher speeds. If the drive accelerates very rapidly and only spends short periods of time in each mode the transition smoothing can malfunction. "Current step" mode is similar to "Current no test" mode except that the transition smoothing is disabled. It is not advisable to use this mode unless it is necessary as torque current and torque transients will occur when changing between low speed and normal running operation.

(5) Current only

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. The system remains in this starting mode at all speeds and does not change to the normal operating algorithms. This provides a very basic open-loop control method, that is not recommended for most applications. Flux weakening is not possible, and so this method will not operate correctly when the motor voltage approaches the maximum voltage avaialble from the drive.

Pr 04.012 *Current Reference Filter 1 Time Constant*

Current Reference Filter 1 Time Constant (**04.012**) defines the time constant of a first order filter that can be applied to the *Final Current Reference* (**04.004)**. The filter is provided to reduce acoustic noise and vibration produced as a result of position feedback quantisation. The filter introduces a lag in the speed controller loop, and so the speed controller gains may need to be reduced to maintain stability as the filter time constant is increased.

Pr 04.013 / Pr 04.014 *Current Loop Gains*

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. The proportional gain (Pr **04.013**) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by performing a stationary or rotating autotune (see *Autotune* Pr **05.012**, earlier in this table) the drive measures the *Stator Resistance* (**05.01**7) and *Transient Inductance* (**05.07**1) of the motor and calculates the current loop gains.

Speed Loop Gains Pr 03.010, Pr 03.011, Pr 03.012

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term.

NOTE: In sensorless mode, the speed controller bandwidth may need to be limited to 10 Hz or less for stable operation.

Speed Controller Proportional Gain (Kp), Pr **03.010**

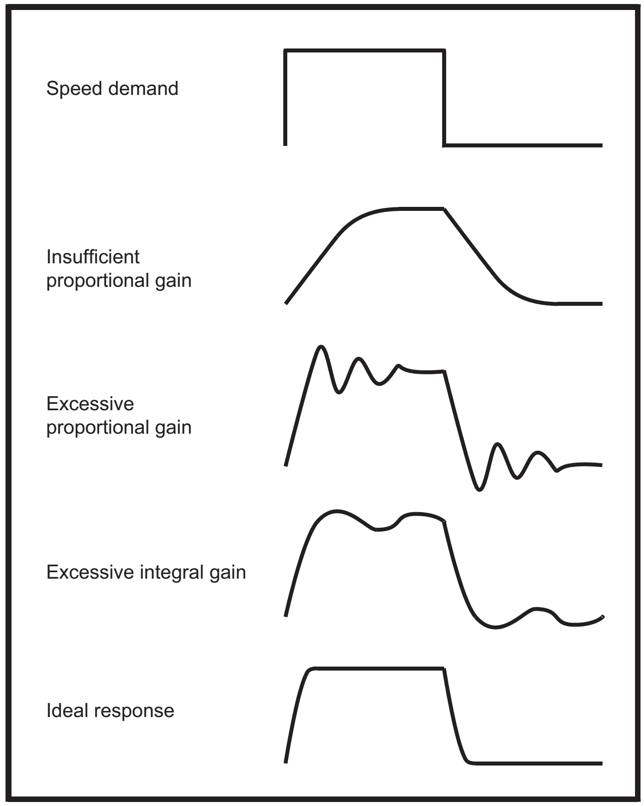
If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the stability limit is reached.

Speed Controller Integral Gain (Ki), Pr **03.011**

The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain.
A compromise must be reached where the system response, stiffness and damping are all adequate for the application.

Differential Gain (Kd), Pr **03.012**

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.



8.2 Motor thermal protection

A dual time constant thermal model is provided to estimate the motor temperature as a percentage of its maximum allowed temperature.

The motor thermal protection is modelled using losses in the motor. The losses in the motor are calculated as a percentage value, so that under these conditions the *Motor Protection Accumulator* (**04.019**) would eventually reach 100 %.

Percentage losses = 100 % x [Load related losses + Iron losses]

Where:

Load related losses = $(1 - K_{fe}) \times (I / (K_1 \times I_{Rated}))^2$

Iron losses = $K_{fe} \times (w / w_{Rated})^{1.6}$

Where:

I = *Current Magnitude* (**04.001**)

I_{Rated} = *Rated Current* (**05.007**)

K_{fe} = *Rated Iron Losses As Percentage Of Losses* (**04.039)** / 100 %

The *Motor Protection Accumulator* (**04.019**) is given by:

Pr **04.019** = Percentage Losses x $[(1 - K_2) (1 - e^{-t/t1}) + K_2 (1 - e^{-t/t2})]$

Where:

T = *Motor Protection Accumulator* (**04.019**)

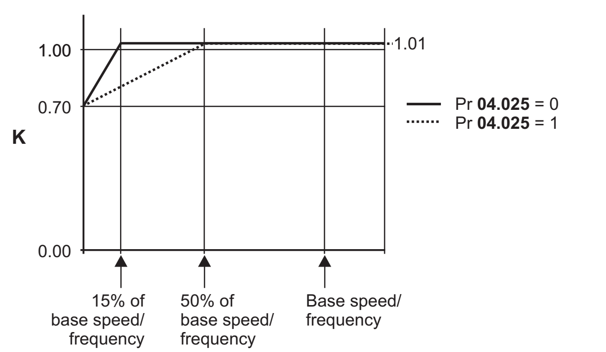
K_2 = *Motor Thermal Time Constant 2 Scaling* (**04.038**) / 100 %

t^1 = *Motor Thermal Time Constant 1* (**04.015**)

t^2 = *Motor Thermal Time Constant 2* (**04.037**)

K_1 = Varies, see below

Figure 8-1 Motor thermal protection (Normal Duty)



Both settings of Pr **04.025** are intended for motors where the cooling effect of the motor fan reduces with reduced motor speed, but with different speeds below which the cooling effect is reduced. If Pr **04.025** is 0 the characteristic is intended for motors where the cooling effect reduces with motor speed below 15 % of base speed/frequency. If Pr **04.025** is 1 the characteristic is intended for motors where the cooling effect reduces with motor speed below 50 % of base speed/frequency. The maximum value for K1 is 1.01, so that above the knee of the characteristics the motor can operate continuously up to 101 % current.

When the estimated temperature in Pr **04.019** reaches 100 % the drive takes some action depending on the setting of Pr **04.016**. If Pr **04.016** is 0, the drive trips when Pr **04.019** reaches 100 %. If Pr **04.016** is 1, the current limit is reduced to (K - 0.05) x 100 % when Pr **04.019** reaches 100 %.

The current limit is set back to the user defined level when Pr **04.019** falls below 95 %. The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the motor while them drive remains powered-up. If the rated current defined by Pr **05.007** is altered, the accumulator is reset to zero.

The default setting of the thermal time constant (Pr **04.015**) is 89 s which is equivalent to an overload of 110 % for 165 s from cold.

WARNING

Fire Mode - Important Warning.
When Fire Mode is active the motor overload and thermal protection are disabled, as well as a number of drive protection functions. Fire Mode is provided for use only in emergency situations where the safety risk from disabling protection is less than the risk from the drive tripping - typically in smoke extraction operation to permit evacuation of a building. The use of Fire Mode itself causes a risk of fire from overloading of the motor or drive, so it must only be used after careful consideration of the balance of risks.

Care must be taken to prevent inadvertent activation or de-activation of Fire Mode. Fire Mode is indicated by a flashing display text warning "Fire mode active".

Care must be taken to ensure that parameters Pr **01.053** or Pr **01.054** are not inadvertently re-allocated to different inputs or variables. It should be noted that, by default, Pr **01.054** is controlled from digital input 4 and changing Pr **08.024** can re-allocate this digital input to another parameter. These parameters are at access level 2 in order to minimize the risk of inadvertent or unauthorized changes. It is recommended that User Security be applied to further reduce the risk (see section 5.10 *Parameter access level and security* on page 157). These parameters may also be changed via serial communications so adequate precautions should be taken if this functionality is utilized.

8.3 Switching frequency

The default switching frequency is 3 kHz, however this can be increased up to a maximum of 16 kHz by Pr **05.018** (dependent on drive size). The available switching frequencies are shown below.

Table 8-1 Available switching frequencies

<table>
<tr><th>Drive size</th><th>Model</th><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>3</td><td rowspan="8">All</td><td rowspan="8">✓</td><td rowspan="8">✓</td><td rowspan="8">✓</td><td rowspan="8">✓</td><td rowspan="8">✓</td><td rowspan="8">✓</td><td rowspan="8">✓</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td><td>400 V</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>11</td><td>575 and 690 V</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td></tr>
</table>

If the switching frequency is increased from 3 kHz the following apply:

1. Increased heat loss in the drive, which means that derating to the output current must be applied.
   See the derating tables for switching frequency and ambient temperature in *section 11.1.1 Power and current ratings (Derating for switching frequency and temperature)* on page 393.
2. Reduced heating of the motor - due to improved output waveform quality.
3. Reduced acoustic noise generated by the motor.
4. Increased sample rate on the speed and current controllers.

A trade off must be made between motor heating, drive heating and the demands of the application with respect to the sample time required.

Table 8-2 Sample rates for various control tasks at each switching frequency

	3, 6, 12 kHz	2, 4, 8, 16 kHz	Open loop	RFC-A / RFC-S
Level 1	3 kHz = 167µs 6 kHz = 83 µs 12 kHz = 83 µs	2 kHz = 250 µs 4 kHz = 125 µs 8 kHz = 62.5 µs 16 kHz = 62.5 µs	Peak limit	Current controllers
Level 2	250 µs	2 kHz -500 µs 4 kHz - 250 µs 8 kHz - 125 µs 16 kHz - 125 µs	Current limit and ramps	Speed controller and ramps
Level 3	1 ms		Voltage controller	
Level 4	4 ms		Time critical user interface	
Background			Non-time critical user interface	

8.4 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 32 bit extension to the standard 16 bit register data format.

8.4.1 MODBUS RTU

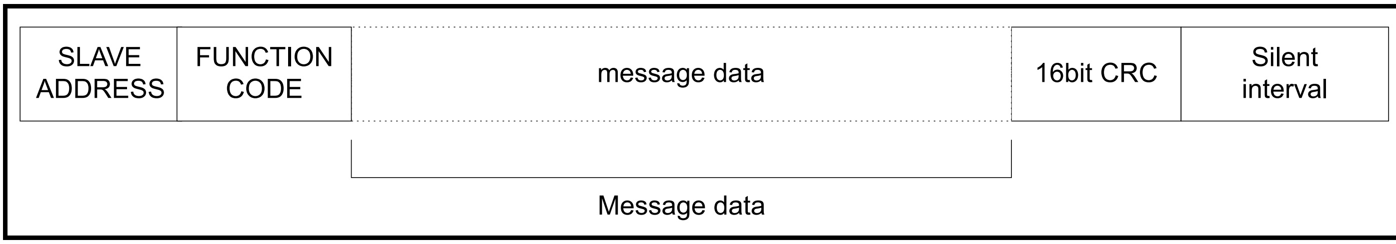
Physical layer

Attribute	Description
Normal physical layer for multi-drop operation	EIA 485 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, 76800, 115200

* The drive will accept a packet with 1 or 2 stop bits but will always transmit 2 stop bits

RTU framing

The frame has the following basic format

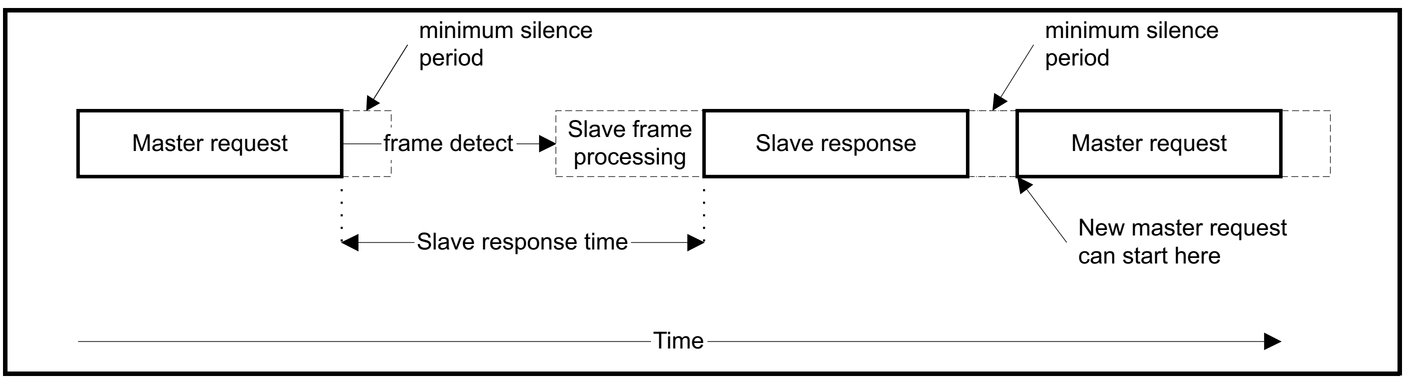


The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2 ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without any gaps greater or equal to the silence period. If an erroneous gap is inserted then receiving nodes may start frame processing early in which case the CRC will fail and the frame will be discarded.

MODBUS RTU is a master slave system. All master requests, except broadcast requests, will lead to a response from an individual slave. The slave will respond (i.e. start transmitting the response) within the quoted maximum slave response time (this time is quoted in the data sheet for all Control Techniques products). The minimum slave response time is also quoted but will never be less that the minimum silent period defined by 3.5 character times.

If the master request was a broadcast request then the master may transmit a new request once the maximum slave response time has expired.

The master must implement a message time out to handle transmission errors. This time out period must be set to the maximum slave response time + transmission time for the response.



8.4.2 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.

8.4.3 MODBUS registers

The MODBUS register address range is 16 bit (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

The Modbus register address is 16 bits in size, of which the upper two bits are used for data type selection leaving 14 bits to represent the parameter address, taking into account the slave increments the address value by 1, this results in a theoretical maximum parameter address of 163.84 (limited to 162.99 in software) when the default standard addressing mode (see *Serial Mode* Pr **00.035** {**11.024**}) is used.

To access a parameter number above 99 in any drive menu then the modified addressing mode must be used (see *Serial Mode* Pr **00.035** {**11.024**}), this will allow access to parameter numbers up to 255 but also limit the maximum menu number to 63.

The Modbus slave device increments the register address by 1 before processing the command, this effectively prevents access to parameter Pr 00.000 in the drive or option module.

The table below shows how the start register address is calculated for both addressing modes.

Parameter	Addressing mode	Protocol register			
0.mm.ppp	Standard	mm x 100 + ppp - 1			
	Modified	mm x 256 + ppp - 1			
Examples					
		16-bit		32-bit	
		Decimal	Hex (0x)	Decimal	Hex (0x)
0.01.021	Standard	120	00 78	16504	40 78
	Modified	276	01 14	16660	41 14
0.01.000	Standard	99	00 63	16483	40 63
	Modified	255	00 FF	16639	40 FF
0.03.161	Standard	N/A	N/A	N/A	N/A
	Modified	928	03 A0	17312	43 A0

Data types

The MODBUS protocol specification defines registers as 16 bit signed integers. All CT devices support this data size. Refer to the section 8.4.7 *Extended data types* on page 314 for detail on accessing 32 bit register data.

8.4.4 Data consistency

All CT devices support a minimum data consistency of one parameter (16 bit or 32 bit data). Some devices support consistency for a complete multiple register transaction.

8.4.5 Data encoding

MODBUS RTU uses a 'big-endian' representation for addresses and data items (except the CRC, which is 'little-endian'). This means that when a numerical quantity larger than a single byte is transmitted, the MOST significant byte is sent first. So for example

16 - bits	0x1234	would be	0x12	0x34		
32 - bits	0x12345678	would be	0x12	0x34	0x56	0x78

8.4.6 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 16 bit registers
6	Write single register
16	Write multiple 16 bit registers
23	Read and write multiple 16 bit 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 8-3 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 16 bit registers MSB
5	Number of 16 bit registers LSB
6	CRC LSB
7	CRC MSB

Table 8-4 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 16 bit 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 32 bit parameter but only 16 bits of data can be sent.

Table 8-5 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 8-6 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

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 8-7 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 16 bit registers MSB
5	Number of 16 bit 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 8-8 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 16 bit registers written MSB
5	Number of 16 bit 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 8-9 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 16 bit registers to read MSB
5	Number of 16 bit registers to read LSB
6	Start register address to write MSB
7	Start register address to write LSB
8	Number of 16 bit registers to write MSB
9	Number of 16 bit 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 8-10 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

8.4.7 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 32 bit data types (integer and float) the MODBUS multiple read and write services are used to transfer a contiguous array of 16bit registers.

Slave devices typically contain a mixed set of 16 bit and 32 bit registers. To permit the master to select the desired 16 bit or 32 bit access the top two bits of the register address are used to indicate the selected data type.

Note

The selection is applied for the whole block access.

bit 15 TYP1	bit 14 TYP0	bits 0 - 13
Type select		Parameter address X x 100+Y-1

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 32 bit data type is selected then the slave uses two consecutive 16 bit MODBUS registers (in 'big endian'). The master must also set the correct 'number of 16 bit registers'.

Example, read Pr **20.021** through Pr **20.024** as 32 bit parameters using FC03 from node 8:

Table 8-11 Master request

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x47	Start register address Pr **20.021** (16384 + 2021 - 1) = 18404 = 0x47E4
3	0xE4	
4	0x00	Number of 16bit registers to read Pr **20.021** through Pr **20.024** is 4x32 bit registers = 8x16 bit registers
5	0x08	
6	CRC LSB	
7	CRC MSB	

Table 8-12 Slave response

Byte	Value	Description
0	0x08	Slave destination node address
1	0x03	FC03 multiple read
2	0x10	Length of data (bytes) = 4x32 bit registers = 16 bytes
3-6		Pr **20.021** data
7-10		Pr **20.022** data
11-14		Pr **20.023** data
15-18		Pr **20.024** 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 Pr **01.028** is a 32 bit parameter with a value of 0x12345678, Pr **01.029** is a signed 16 bit parameter with a value of 0xABCD, and Pr **01.030** is a signed 16 bit parameter with a value of 0x0123.

Read	Start register address	Number of 16 bit registers	Response	Comments
Pr **01.028**	127	1	0x5678	Standard 16 bit access to a 32 bit register will return low 16 bit word of truncated data
Pr **01.028**	16511*	2	0x12345678	Full 32 bit access
Pr **01.028**	16511*	1	Exception 2	Number of words must be even for 32 bit access
Pr **01.029**	128	1	0xABCD	Standard 16 bit access to a 32 bit register will return low 16 bit word of data
Pr **01.029**	16512*	2	0xFFFFABCD	32 bit access to a 16 bit register will return 32 bit sign extended data
Pr **01.030**	16513*	2	0x00000123	32 bit access to a 16 bit register will return 32 bit sign extended data
Pr **01.028 to** Pr **01.029**	127	2	0x5678, 0xABCD	Standard 16 bit access to a 32 bit register will return low 16 bit word of truncated data
Pr **01.028 to** Pr **01.029**	16511*	4	0x12345678, 0xFFFFABCD	Full 32 bit access

* Bit 14 is set to allow 32 bit access.

Writes when actual parameter type is different from selected

The slave will allow writing a 32 bit value to a 16 bit parameter as long as the 32 bit value is within the normal range of the 16 bit parameter.

The slave will allow a 16 bit write to a 32 bit parameter. The slave will sign extend the written value, therefore the effective range of this type of write will be -32768 to +32767.

Examples, if Pr **01.028** has a range of ±100000, and Pr **01.029** has a range of ±10000.

Write	Start register address	Number of 16bit registers	Data	Comments
Pr **01.028**	127	1	0x1234	Standard 16 bit write to a 32bit register. Value written = 0x00001234
Pr **01.028**	127	1	0xABCD	Standard 16 bit write to a 32bit register. Value written = 0xFFFFABCD
Pr **01.028**	16511	2	0x00001234	Value written = 0x00001234
Pr **01.029**	128	1	0x0123	Value written = 0x0123
Pr **01.029**	16512	2	0x00000123	Value written = 0x00000123

* Bit 14 is set to allow 32 bit access

8.4.8 Exceptions

The slave will respond with an exception response if an error is detected in the master request. If a message is corrupted and the frame is not received or the CRC fails then the slave will not issue an exception. In this case the master device will time out. If a write multiple (FC16 or FC23) request exceeds the slave maximum buffer size then the slave will discard the message. No exception will be transmitted in this case and the master will time out.

Exception message format

The slave exception message has the following format.

Byte	Description
0	Slave source node address
1	Original function code with bit 7 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.

8.4.9 CRC

The CRC is a 16 bit cyclic redundancy check using the standard CRC-16 polynomial x16 + x15 + x2 + 1. The 16 bit CRC is appended to the message and transmitted LSB first.

The CRC is calculated on ALL the bytes in the frame.

8.4.10 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
Baud rate	Baud rate used by Modbus RTU
32 bit 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.

9 NV Media Card Operation

9.1 Introduction

The Non-Volatile Media Card feature enables simple configuration of parameters, parameter back-up, storing / reading PLC programs and drive copying using a SMARTCARD or SD card storing / reading PLC programs. The drive offers backward compatibility for a Unidrive SP SMARTCARD.

The NV Media Card can be used for:

- Parameter copying between drives
- Saving drive parameter sets
- Saving an onboard user program

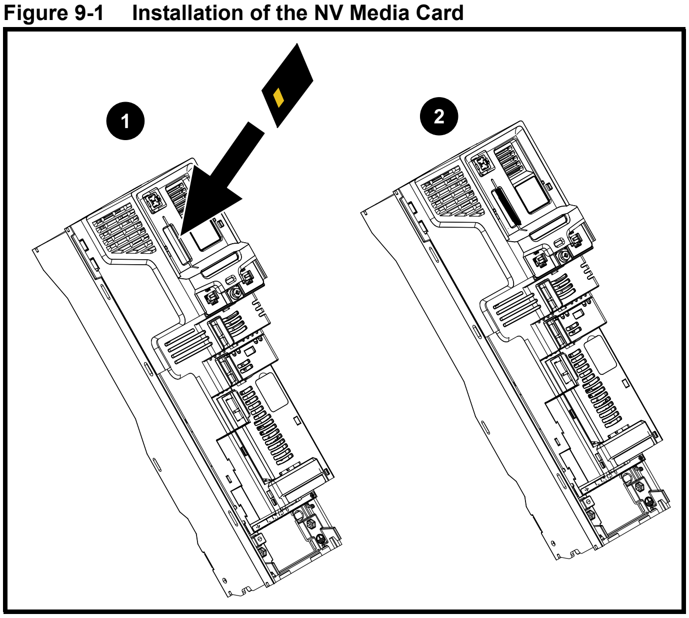
The NV Media Card is located at the top of the module under the drive display (if installed) on the left-hand side.

Ensure the NV Media Card is inserted with the contacts facing the left-hand side of the drive.

The drive only communicates with the NV Media Card when commanded to read or write, meaning the card may be "hot swapped".

> **WARNING**
> Beware of possible live terminals when installing the NV Media Card.

Figure 9-1 Installation of the NV Media Card



1. Installing the NV Media Card
2. NV Media Card installed

NV Media Card	Part number
SD Card Adaptor (memory card not included)	3130-1212
8 kB SMARTCARD	2214-4246
64 kB SMARTCARD	2214-1006

9.2 NV Media Card support

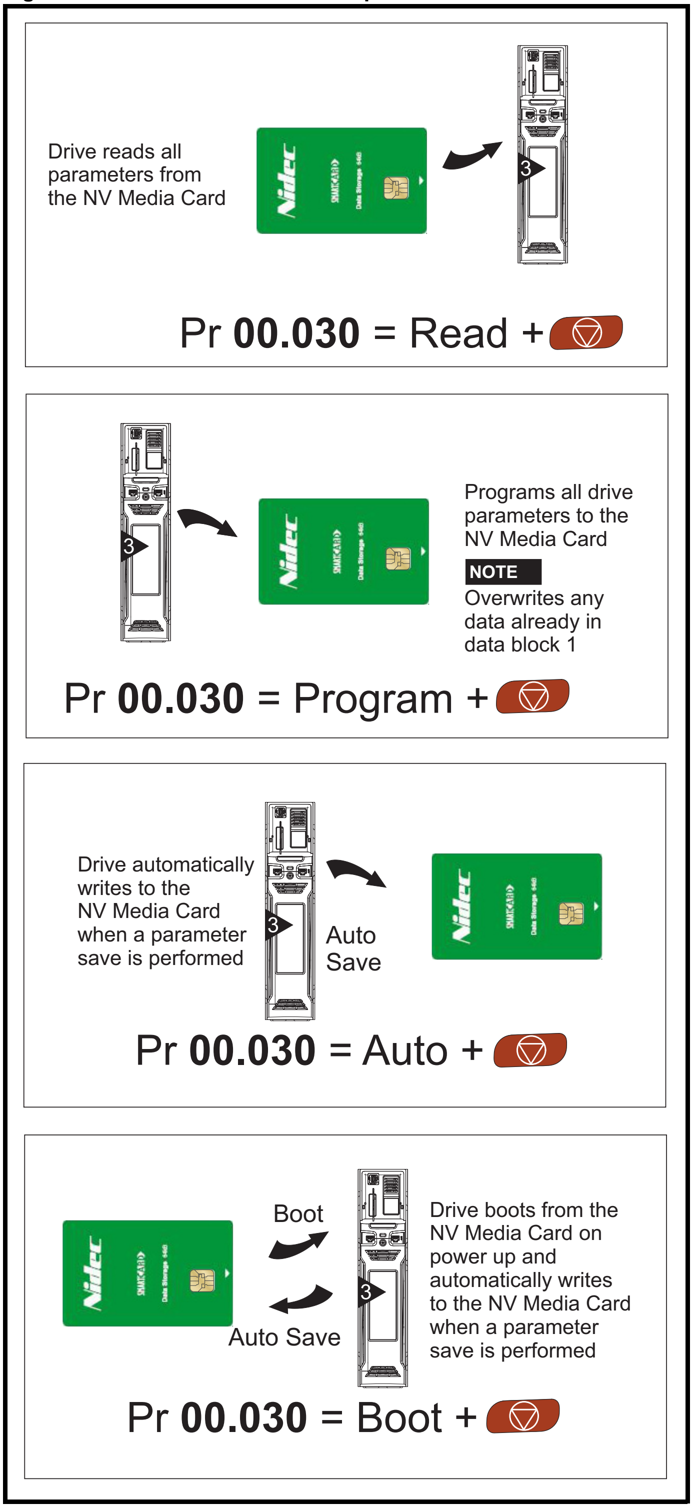
The NV Media Card can be used to store drive parameter sets and / or PLC programs set from the Pump Drive F600 in data blocks 001 to 499 on the card.

The Pump Drive F600 is compatible with a Unidrive SP SMARTCARD and is able to read and translate the Unidrive SP parameter set into a compatible parameter set for Pump Drive F600. This is only possible if the Unidrive SP parameter set was transferred to the SMARTCARD using the difference from defaults transfer method (i.e. 4yyy transfer).

The Pump Drive F600 is not able to read any other type of Unidrive SP data block on the card. Although it is possible to transfer difference from default data blocks from a Unidrive SP into the Pump Drive F600, the following should be noted:

1. If a parameter from the source drive does not exist in the target drive then no data is transferred for that parameter.
2. If the data for the parameter in the target drive is out of range then the data is limited to the range of the target parameter.
3. If the target drive has a different rating to the source drive then the normal rules for this type of transfer apply.

Figure 9-2 Basic NV Media Card operation



The whole card may be protected from writing or erasing by setting the read-only flag as detailed in section 9.3.9 *9888 / 9777 - Setting and clearing the NV Media Card read only flag* on page 320.

The card should not be removed during data transfer, as the drive will produce a trip. If this occurs then either the transfer should be reattempted or in the case of a card to drive transfer, default parameters should be loaded.

9.3 Transferring data

Data transfer, erasing and protecting the information is performed by entering a code in Pr **mm.000** and then resetting the drive as shown in Table 9-1.

Table 9-1 SMARTCARD and SD card codes

Code	Operation	SMARTCARD	SD card
2001	Transfer the drive parameters to parameter file 001 and sets the block as bootable. This will include the parameters from attached option modules.	✓	✓
4yyy	Transfer the drive parameters to parameter file yyy. This will include the parameters from attached option modules.	✓	✓
7yyy	Erase file yyy.	✓	✓
8yyy	Compare the data in the drive with file yyy. If the files are the same then *Pr **mm.000*** (**mm.000**) is simply reset to 0 when the compare is complete. If the files are different a ‘Card Compare’ trip is initiated. All other NV media card trips also apply.	✓	✓
9555	Clear the warning suppression flag	✓	✓
9666	Set the warning suppression flag	✓	✓
9777	Clear the read-only flag	✓	✓
9888	Set the read-only flag	✓	✓
9999	Erase and format the NV media card	✓	

Where yyy indicates the block number 001 to 999.

Note

If the read only flag is set then only codes 6yyy or 9777 are effective.

9.3.1 Writing to the NV Media Card

4yyy - Writes defaults differences to the NV Media Card

The data block only contains the parameter differences from the last time default settings were loaded.

All parameters except those with the NC (Not copied) coding bit set are transferred to the NV Media Card. In addition to these parameters all menu 20 parameters (except Pr **20.000**), can be transferred to the NV Media Card.

Writing a parameter set to the NV Media Card (Pr 11.042 = Program (2))

Setting Pr **11.042** to Program (2) and resetting the drive will save the parameters to the NV Media Card, i.e. this is equivalent to writing 4001 to Pr **mm.000**. All NV Media Card trips apply except 'Card Change'.
If the data block already exists it is automatically overwritten. When the action is complete this parameter is automatically reset to None (0).

9.3.2 Reading from the NV Media Card

6yyy - Reading from NV Media Card

When the data is transferred back to the drive, using 6yyy in Pr **mm.000**, it is transferred to the drive RAM and the EEPROM. A parameter save is not required to retain the data after-power down. Set up data for any option modules installed stored on the card are transferred to the drive. If the option modules installed are different between source and destination drives, the menus for the option module slots where the option module categories are different are not updated from the card and will contain their default values after the copying action. The drive will produce a 'Card Option' trip if the option module installed to the source and the destination drives are different or are in different slots. If the data is being transferred to the drive with different voltage or current rating a 'Card Rating' trip will occur.

The following drive rating dependant parameters (RA coding bit set) will not be transferred to the destination drive by a NV Media Card when the voltage rating of the destination drive is different from the source drive and the file is a parameter file.

However, drive rating dependent parameters will be transferred if only the current rating is different. If drive rating dependant parameters are not transferred to the destination drive they will contain their default values.

Pr **02.008** *Standard Ramp Voltage*

Pr **04.005** to Pr **04.007** *Motoring Current Limits*

Pr **04.024** *User Current Maximum Scaling*

Pr **05.007** *Rated Current*

Pr **05.009** *Rated Voltage*

Pr **05.010** *Rated Power Factor*

Pr **05.017** *Stator Resistance*

Pr **05.018** *Maximum Switching Frequency*

Pr **05.024** *Transient Inductance*

Pr **05.025** *Stator Inductance*

Pr **06.006** *Injection Braking Level*

Pr **06.048** *Supply Loss Detection Level*

Pr **06.065** *Standard Under Voltage Threshold*

Pr **06.066** *Low Under Voltage Threshold*

Reading a parameter set from the NV Media Card (Pr 11.042 = Read (1))

Setting Pr **11.042** to Read (1) and resetting the drive will transfer the parameters from the card into the drive parameter set and the drive EEPROM, i.e. this is equivalent to writing 6001 to Pr **mm.000**.

All NV Media Card trips apply. Once the parameters are successfully copied this parameter is automatically reset to None (0). Parameters are saved to the drive EEPROM after this action is complete.

9.3.3 Auto saving parameter changes (Pr 11.042 = Auto (3))

This setting causes the drive to automatically save any changes made to menu 0 parameters on the drive to the NV Media Card. The latest menu 0 parameter set in the drive is therefore always backed up on the NV Media Card. Changing Pr **11.042** to Auto (3) and resetting the drive will immediately save the complete parameter set from the drive to the card, i.e. all parameters except parameters with the NC coding bit set.
Once the whole parameter set is stored only the individual modified menu 0 parameter setting is updated.

Advanced parameter changes are only saved to the NV Media Card when Pr **mm.000** is set to 'Save Parameters' or a 1001 and the drive reset.

All NV Media Card trips apply, except 'Card Change'. If the data block already contains information it is automatically overwritten.

If the card is removed when Pr **11.042** is set to 3 Pr **11.042** is then automatically set to None (0).

When a new NV Media Card is installed Pr **11.042** must be set back to Auto (3) by the user and the drive reset so the complete parameter set is rewritten to the new NV Media Card if auto mode is still required.

When Pr **11.042** is set to Auto (3) and the parameters in the drive are saved, the NV Media Card is also updated, and therefore the NV Media Card becomes a copy of the drives stored configuration.

At power up, if Pr **11.042** is set to Auto (3), the drive will save the complete parameter set to the NV Media Card. The drive will display 'Card Write' during this operation. This is done to ensure that if a user puts a new NV Media Card in during power down the new NV Media Card will have the correct data.

Note

When Pr **11.042** is set to Auto (3) the setting of Pr **11.042** itself is saved to the drive EEPROM but not the NV Media Card.

9.3.4 Booting up from the NV Media Card on every power up (Pr 11.042 = Boot (4))

When Pr **11.042** is set to Boot (4) the drive operates the same as Auto mode except when the drive is powered-up. The parameters on the NV Media Card will be automatically transferred to the drive at power up if the following are true:

- A card is inserted in the drive
- Parameter data block 1 exists on the card
- The data in block 1 is type 1 to 4 (as defined in Pr **11.038**)
- Pr **11.042** on the card set to Boot (4)

The drive will display 'Booting Parameters during this operation. If the drive mode is different from that on the card, the drive gives a 'Card Drive Mode' trip and the data is not transferred.

If 'Boot' mode is stored on the copying NV Media Card this makes the copying NV Media Card the master device. This provides a very fast and efficient way of re-programming a number of drives.

Note

'Boot' mode is saved to the card, but when the card is read, the value of Pr **11.042** is not transferred to the drive.

9.3.5 Booting up from the NV Media Card on every power up (Pr mm.000 = 2001)

It is possible to create a bootable parameter data block by setting Pr **mm.000** to 2001 and initiating a drive reset. This data block is created in one operation and is not updated when further parameter changes are made.

Setting Pr **mm.000** to 2001 will overwrite the data block 1 on the card if it already exists.

9.3.6 8yyy - Comparing the drive full parameter set with the NV Media Card values

Setting 8yyy in Pr **mm.000**, will compare the NV Media Card file with the data in the drive. If the compare is successful Pr **mm.000** is simply set to 0. If the compare fails a 'Card Compare' trip is initiated.

9.3.7 7yyy / 9999 - Erasing data from the NV Media Card values

Data can be erased from the NV Media Card either one block at a time or all blocks in one go.

- Setting 7yyy in Pr **mm.000** will erase NV Media Card data block yyy
- Setting 9999 in Pr **mm.000** will erase all the data blocks on a SMARTCARD, but not on an SD Card.

9.3.8 9666 / 9555 - Setting and clearing the NV Media Card warning suppression flag

If the option modules installed to the source and destination drive are different or are in different slots the drive will produce a 'Card Option' trip. If the data is being transferred to a drive of a different voltage or current rating a 'Card Rating' trip will occur. It is possible to suppress these trips by setting the warning suppression flag. If this flag is set the drive will not trip if the option module(s) or drive ratings are different between the source and destination drives. The options module or rating dependent parameters will not be transferred.

- Setting 9666 in Pr **mm.000** will set the warning suppression flag
- Setting 9555 in Pr **mm.000** will clear the warning suppression flag

9.3.9 9888 / 9777 - Setting and clearing the NV Media Card read only flag

The NV Media Card may be protected from writing or erasing by setting the read only flag. If an attempt is made to write or erase a data block when the read only flag is set, a 'Card Read Only' trip is initiated. When the read only flag is set only codes 6yyy or 9777 are effective.

- Setting 9888 in Pr **mm.000** will set the read only flag
- Setting 9777 in Pr **mm.000** will clear the read only flag

9.4 Data block header information

Each data block stored on a NV Media Card has header information detailing the following:

- *NV Media Card File Number* (11.037)
- *NV Media Card File Type* (11.038)
- *NV Media Card File Version* (11.039)
- *NV Media Card File Checksum* (11.040)

The header information for each data block which has been used can be viewed in Pr **11.038** to Pr **11.040** by increasing or decreasing the data block number set in Pr **11.037**. If there is no data on the card Pr **11.037** can only have a value of 0.

9.5 NV Media Card parameters

Table 9-2 Key to parameter table coding

RW	Read / Write	ND	No default value
RO	Read only	NC	Not copied
Num	Number parameter	PT	Protected parameter
Bit	Bit parameter	RA	Rating dependant
Txt	Text string	US	User save
Bin	Binary parameter	PS	Power-down save
FI	Filtered	DE	Destination

11.036 {00.029}	NV Media Card File Previously Loaded							
RO	Num				NC	PT		
OL / RFC-A / RFC-S	⇕	0 to 999	⇨	0				

This parameter shows the number of the data block last transferred from a NV Media Card to the drive. If defaults are subsequently reloaded this parameter is set to 0.

11.037	NV Media Card File Number							
RW	Num							
OL / RFC-A / RFC-S	⇕	0 to 999	⇨	0				

This parameter should have the data block number which the user would like the information displayed in Pr **11.038**, Pr **11.039** and Pr **11.040**.

11.038	NV Media Card File Type							
RO	Txt			ND	NC	PT		
OL / RFC-A / RFC-S	⇕	None (0), Open-loop (1), RFC-A (2), RFC-S (3), Regen (4), User Prog (5), Option App (6)	⇨					

Displays the type/mode of the data block selected with Pr **11.037**.

Pr 11.038	String	Type / mode
0	None	No file selected
1	Open-loop	Open-loop mode parameter file
2	RFC-A	RFC-A mode parameter file
3	RFC-S	RFC-S mode parameter file
4	Regen	Regen mode parameter file
5	User Prog	Onboard user program file
6	Option App	Option module application file

11.039	NV Media Card File Version							
RO	Num			ND	NC	PT		
OL / RFC-A / RFC-S	⇕	0 to 9999	⇨					

Displays the version number of the file selected in Pr **11.037**.

11.040	NV Media Card File Checksum							
RO	Num			ND	NC	PT		
OL / RFC-A / RFC-S	⇕	--2147483648 to 2147483647	⇨					

Displays the checksum of the data block selected in Pr **11.037**.

11.042	Parameter Cloning							
RW	Txt				NC		US*	
OL / RFC-A / RFC-S	⇕	None (0), Read (1), Program (2), Auto (3), Boot (4)	⇨	None (0)				

* Only a value of 3 or 4 in this parameter is saved.

Note

If Pr **11.042** is equal to 1 or 2, this value is not transferred to the drive or saved to the EEPROM. If Pr **11.042** is set to 3 or 4 the value is saved to the EEPROM

None (0) = Inactive

Read (1) = Read parameter set from the NV Media Card

Program (2) = Program a parameter set to the NV Media Card

Auto (3) = Auto save

Boot (4) = Boot mode

11.072	NV Media Card Create Special File							
RW	Num				NC			
OL / RFC-A / RFC-S	⇕	0 to 1	⇨	0				

If *NV Media Card Create Special File* (**11.072**) = 1 when a parameter file is transferred to an NV media card the file is created as a macro file. *NV Media Card Create Special File* (**11.072**) is reset to 0 after the file is created or the transfer fails.

11.073	NV Media Card Type							
RO	Txt			ND	NC	PT		
OL / RFC-A / RFC-S	⇕	None (0), SMART Card (1), SD Card (2)	⇨					

This will display the type of media card inserted; it will contain one of the following values:

"None" (0) - No NV Media Card has been inserted.

"SMART Card" (1) - A SMARTCARD has been inserted.

"SD Card" (2) - A FAT formatted SD card has been inserted.

11.075	NV Media Card Read-only Flag						
RO	Bit				ND	NC	PT
OL RFC-A RFC-S	⇕ Off (0) or On (1)				⇨		

NV Media Card Read-only Flag (**11.075**) shows the state of the read-only flag for the currently installed card.

11.076	NV Media Card Warning Suppression Flag						
RO	Bit				ND	NC	PT
OL RFC-A RFC-S	⇕ Off (0) or On (1)				⇨		

NV Media Card Warning Suppression Flag (**11.076**) shows the state of the warning flag for the currently installed card.

11.077	NV Media Card File Required Version						
RW	Num				ND	NC	PT
OL RFC-A RFC-S	⇕ 0 to 9999				⇨		

The value of *NV Media Card File Required Version* (**11.077**) is used as the version number for a file when it is created on an NV Media Card. *NV Media Card File Required Version* (**11.077**) is reset to 0 when the file is created or the transfer fails.

9.6 NV Media Card trips

After an attempt to read, write or erase data from a NV Media Card a trip is initiated if there has been a problem with the command.

See Chapter 12 *Diagnostics* on page 426 for more information on NV Media Card trips.

10 Advanced parameters

This is a quick reference to all parameters in the drive showing units, ranges limits etc, with block diagrams to illustrate their function. Full descriptions of the parameters can be found in the *Parameter Reference Guide*.

WARNING

These advanced parameters are listed for reference purposes only. The lists in this chapter do not include sufficient information for adjusting these parameters. Incorrect adjustment can affect the safety of the system, and damage the drive and or external equipment. Before attempting to adjust any of these parameters, refer to the *Parameter Reference Guide*.

Table 10-1 Menu descriptions

Menu	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, Temperature monitoring
8	Digital I/O
9	Programmable logic, motorized pot, binary sum, timers and scope
10	Status and trips
11	Drive set-up and identification, serial communications
12	Threshold detectors and variable selectors
13	Standard motion control
14	User PID controller
15	Option module slot 1 set-up menu
16	Option module slot 2 set-up menu
17	Option module slot 3 set-up menu
18	General option module application menu 1
19	General option module application menu 2
20	General option module application menu 3
22	Menu 0 set-up
23	Not allocated
28	Reserved menu
29	Reserved for pumping functions
Slot 1	Slot 1 option menus*
Slot 2	Slot 2 option menus*
Slot 3	Slot 3 option menus*

*** Only displayed when the option modules are installed.**

Table 10-2 Key to parameter table coding

Coding	Attribute
RW	Read/Write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter. 'On' or 'Off' on the display
Num	Number: can be uni-polar or bi-polar
Txt	Text: the parameter uses text strings instead of numbers.
Bin	Binary parameter
IP	IP Address parameter
Mac	Mac Address parameter
Date	Date parameter
Time	Time parameter
Chr	Character parameter
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 be transferred to the destination drive by non-volatile storage media when the rating of the destination drive is different from the source drive and the file is a parameter file. However, the values will be transferred if only the current rating is different and the file is a difference from default type file.
ND	No default: The parameter is not modified when defaults are loaded
NC	Not copied: not transferred to or from non-volatile media during copying.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) trip occurs.

10.1 Parameter ranges and Variable minimum/maximums:

Some parameters in the drive have a variable range with a variable minimum and a variable maximum values which is dependent on one of the following:

- The settings of other parameters
- The drive rating
- The drive mode
- Combination of any of the above

The tables below give the definition of variable minimum/maximum and the maximum range of these.

VM_AC_VOLTAGE	Range applied to parameters showing AC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 930
Definition	VM_AC_VOLTAGE[MAX] is drive voltage rating dependent. See Table 10-3 VM_AC_VOLTAGE[MIN] = 0

VM_AC_VOLTAGE_SET	Range applied to the AC voltage set-up parameters
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 690
Definition	VM_AC_VOLTAGE_SET[MAX] is drive voltage rating dependent. See Table 10-3 VM_AC_VOLTAGE_SET[MIN] = 0

VM_ACCEL_RATE	Maximum applied to the ramp rate parameters
Units	s / 100 Hz, s / 1000 rpm, s / 1000 mm/s
Range of [MIN]	Open-loop: 0.0 RFC-A, RFC-S: 0.000
Range of [MAX]	Open-loop: 0.0 to 3200.0 RFC-A, RFC-S: 0.000 to 3200.000
Definition	A maximum needs to be applied to the ramp rate parameters because the units are a time for a change of speed from zero to a defined level or to maximum speed. The defined level is 100 Hz for Open-loop mode and 1000 rpm or 1000 mm/s for RFC-A and RFC-S modes. If the change of speed is to the maximum speed then changing the maximum speed changes the actual ramp rate for a given ramp rate parameter value. The variable maximum calculation ensures that longest ramp rate (parameter at its maximum value) is not slower than the rate with the defined level, i.e. 3200.00 s / Hz for Open-loop mode, and 3200.000 s / 1000 rpm or 3200.000 s / 1000 mm/s for RFC-A and RFC-S modes. The maximum frequency/speed is taken from *Maximum Reference Clamp* (01.006) if *Select Motor 2 Parameters* (11.045) = 0, or *m² Maximum Reference Clamp* (**21.001**) if *Select Motor 2 Parameters* (**11.045**) = 1. Open-loop mode VM_ACCEL_RATE[MIN] = 0.0 If Ramp Rate Units (**02.039**) = 0: VM_ACCEL_RATE[MAX] = 3200.0 Otherwise: VM_ACCEL_RATE[MAX] = 3200.0 x Maximum frequency / 100.0 RFC-A, RFC-S modes VM_ACCEL_RATE[MIN] = 0.000 If Ramp Rate Units (**02.039**) = 0: VM_ACCEL_RATE[MAX] = 3200.000 Otherwise: VM_ACCEL_RATE[MAX] = 3200.000 x Maximum speed / 1000.0

VM_DC_VOLTAGE	Range applied to parameters showing DC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1190
Definition	VM_DC_VOLTAGE[MAX] is the full scale DC bus voltage feedback (over voltage trip level) for the drive. This level is drive voltage rating dependent. See Table 10-3 VM_DC_VOLTAGE[MIN] = 0

VM_DC_VOLTAGE_SET	Range applied to DC voltage reference parameters
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1150
Definition	VM_DC_VOLTAGE_SET[MAX] is drive voltage rating dependent. See Table 10-3 VM_DC_VOLTAGE_SET[MIN] = 0

VM_DRIVE_CURRENT	Range applied to parameters showing current in A
Units	A
Range of [MIN]	-99999.999 to 0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_DRIVE_CURRENT[MAX] is equivalent to the full scale (over current trip level) or Kc value for the drive and is given by *Full Scale Current Kc* (**11.061**). VM_DRIVE_CURRENT[MIN] = - VM_DRIVE_CURRENT[MAX]

VM_DRIVE_CURRENT_UNIPOLAR	Unipolar version of VM_DRIVE_CURRENT
Units	A
Range of [MIN]	0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_DRIVE_CURRENT_UNIPOLAR[MAX] = VM_DRIVE_CURRENT[MAX] VM_DRIVE_CURRENT_UNIPOLAR[MIN] = 0.000

VM_HIGH_DC_VOLTAGE	Range applied to parameters showing high DC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1500
Definition	VM_HIGH_DC_VOLTAGE[MAX] is the full scale DC bus voltage feedback for the high DC bus voltage measurement which can measure the voltage if it goes above the normal full scale value. This level is drive voltage rating dependent. See Table 10-3 VM_HIGH_DC_VOLTAGE[MIN] = 0

VM_LOW_UNDER_VOLTS	Range applied the low under-voltage threshold
Units	V
Range of [MIN]	24
Range of [MAX]	24 to 1150
Definition	If *Back-up Mode Enable* (**06.068**) = 0: VM_LOW_UNDER_VOLTS[MAX] = VM_STD_UNDER_VOLTS[MIN] If *Back-up Mode Enable* (**06.068**) = 1: VM_LOW_UNDER_VOLTS[MAX] = VM_STD_UNDER_VOLTS[MIN] / 1.1. VM_LOW_UNDER_VOLTS[MIN] = 24.

VM_MIN_SWITCHING_FREQUENCY	Range applied to the minimum switching frequency parameter
Units	User units
Range of [MIN]	0
Range of [MAX]	0 to 6
Definition	VM_MIN_SWITCHING_FREQUENCY[MAX] = *Maximum Switching Frequency* (**05.018**) VM_MIN_SWITCHING_FREQUENCY[MIN] = 0 for motor control modes, or 1 for Regen mode (subject to the maximum)

VM_MOTOR1_CURRENT_LIMIT **VM_MOTOR2_CURRENT_LIMIT**	Range applied to current limit parameters
Units	%
Range of [MIN]	0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_MOTOR1_CURRENT_LIMIT[MIN] = 0.0 Open-loop VM_MOTOR1_CURRENT_LIMIT[MAX] = (I_{Tlimit} / I_{Trated}) x 100 % Where: $I_{Tlimit} = I_{MaxRef} \times \cos(\sin^{-1}(I_{Mrated} / I_{MaxRef}))$ I_{Mrated} = Pr **05.007** sin ϕ I_{Trated} = Pr **05.007** x cos ϕ cos ϕ = Pr **05.010** I_{MaxRef} is 0.7 x Pr **11.061** when the motor rated current set in Pr **05.007** is the lower of 0.7 x Pr **11.061** or 1.1 x Pr **11.060** (i.e. Normal duty). RFC-A VM_MOTOR1_CURRENT_LIMIT[MAX] = (I_{Tlimit} / I_{Trated}) x 100 % Where: $I_{Tlimit} = I_{MaxRef} \times \cos(\sin^{-1}(I_{Mrated} / I_{MaxRef}))$ I_{Mrated} = Pr **05.007** x sin ϕ_1 ITrated = Pr 05.007 x cos ϕ_1 ϕ_1 = cos-1 (Pr **05.010**) + ϕ_2. ϕ_1 is calculated during an autotune. See the variable minimum / maximum calculations in the *Parameter Reference Guide* for more information regarding ϕ_2. I_{MaxRef} is 0.9 x Pr **11.061** when the motor rated current set in Pr **05.007** is the lower of 0.9 x Pr **11.061** or 1.1 x Pr **11.060** (i.e. Normal duty). RFC-S and Regen VM_MOTOR1_CURRENT_LIMIT[MAX] = (I_{MaxRef} / Pr **05.007**) x 100 % Where: I_{MaxRef} is 0.9 x Pr **11.061** when the motor rated current set in Pr **05.007** is the lower of 0.9 x Pr **11.061** or 1.1 x Pr **11.060** (i.e. Normal duty).

VM_NEGATIVE_REF_CLAMP1 **VM_NEGATIVE_REF_CLAMP2**	Limits applied to the negative frequency or speed clamp
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: -550.0 to 0.0 RFC-A, RFC-S: -50000.0 to 0.0
Range of [MAX]	Open-loop: 0.0 to 550.0 RFC-A, RFC-S: 0.0 to 50000.0
Definition	(see table below)

***Negative Reference Clamp Enable* (01.008)**	***Bipolar Reference Enable* (01.010)**	**VM_NEGATIVE_REF_CLAMP1[MIN]**	**VM_NEGATIVE_REF_CLAMP1[MAX]**
0	0	0.0	Pr **01.006**
0	1	0.0	0.0
1	X	-VM_POSITIVE_REF_CLAMP[MAX]	0.0

VM_POSITIVE_REF_CLAMP1 VM_POSITIVE_REF_CLAMP2	Limits applied to the positive frequency or speed reference clamp
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: 0.0 RFC-A, RFC-S: 0.0
Range of [MAX]	Open-loop: 550.0 RFC-A, RFC-S: 0.0 to 50000.0
Definition	VM_POSITIVE_REF_CLAMP1[MAX] defines the range of the positive reference clamp, *Maximum Reference Clamp* (**01.006**), which in turn limit the references. In RFC-A and RFC-S modes a limit is applied so that the position feedback does not exceed the speed where the drive can no longer interpret the feedback signal correctly as given in the table below. The limit is based on the position feedback device selected with *Motor Control Feedback Select* (**03.026**). It is possible to disable this limit if the *RFC Feedback Mode* (**03.024**) ≥ 1 so that the motor can be operated at a speed above the level where the drive can interpret the feedback in sensorless mode. It should be noted that the position feedback device itself may have a maximum speed limit that is lower than those given in the table. Care should be taken not to exceed a speed that would cause damage to the position feedback device. **Feedback device** / **VM_POSITIVE_REF_CLAMP1[MAX]**: AB, AB Servo: (500 kHz x 60 / rotary lines per revolution) rpm; (500 kHz / linear line pitch in mm) mm/s FD, FR, FD Servo, FR Servo: (500 kHz x 60 / rotary lines per revolution)/2 rpm; (500 kHz / linear line pitch in mm)/2 mm/s SC, SC Hiper, SC EnDat, SC SSI, SC Servo: (500 kHz x 60 / sine waves per revolution) rpm; (500 kHz x linear line pitch in mm) mm/s Any other device: 50000.0 rpm or mm/s In open-loop mode VM_POSITIVE_REF_CLAMP1[MAX] is fixed at 550.0 Hz In RFC mode a limit is applied to the speed reference of 550 x 60 / Motor pole pairs. Therefore, with a 4 pole motor the limit for VM_POSITIVE_REF_CLAMP1[MAX] will be 16,500 rpm. VM_POSITIVE_REF_CLAMP1[MIN] = 0.0 VM_POSITIVE_REF_CLAMP2 is defined in the same way as VM_POSITIVE_REF_CLAMP1 except VM_POSITIVE_REF_CLAMP2[MAX] defines the range of the positive reference clamp, *m² Maximum Reference Clamp* (**21.001**), which in turn limits the references.

Feedback device	VM_POSITIVE_REF_CLAMP1[MAX]
AB, AB Servo	(500 kHz x 60 / rotary lines per revolution) rpm (500 kHz / linear line pitch in mm) mm/s
FD, FR, FD Servo, FR Servo	(500 kHz x 60 / rotary lines per revolution)/2 rpm (500 kHz / linear line pitch in mm)/2 mm/s
SC, SC Hiper, SC EnDat, SC SSI, SC Servo	(500 kHz x 60 / sine waves per revolution) rpm (500 kHz x linear line pitch in mm) mm/s
Any other device	50000.0 rpm or mm/s

VM_POWER	Range applied to parameters that either set or display power
Units	kW
Range of [MIN]	-99999.999 to 0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_POWER[MAX] is rating dependent and is chosen to allow for the maximum power that can be output by the drive with maximum a.c. output voltage, at maximum controlled current and unity power factor. VM_POWER[MAX] = √3 x VM_AC_VOLTAGE[MAX] x VM_DRIVE_CURRENT[MAX] / 1000 VM_POWER[MIN] = -VM_POWER[MAX]

VM_RATED_CURRENT	Range applied to rated current parameters
Units	A
Range of [MIN]	0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_RATED_CURRENT [MAX] = *Maximum Rated Current* (**11.060**) and is dependent on the drive rating. This is the Normal Duty rating of the drive. VM_RATED_CURRENT [MIN] = 0.00

VM_SPEED	Range applied to parameters showing speed
Units	Open-loop, RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop, RFC-A, RFC-S: -50000.0 to 0.0
Range of [MAX]	Open-loop, RFC-A, RFC-S: 0.0 to 50000.0
Definition	This variable minimum/maximum defines the range of speed monitoring parameters. To allow headroom for overshoot the range is set to twice the range of the speed references. VM_SPEED[MAX] = 2 x VM_SPEED_FREQ_REF[MAX] VM_SPEED[MIN] = 2 x VM_SPEED_FREQ_REF[MIN]

VM_SPEED_FREQ_KEYPAD_REF	Range applied Keypad Control Mode Reference (01.017)
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: -550.0 to 550.0 RFC-A, RFC-S: -50000.0 to 50000.0
Range of [MAX]	Open-loop: 0.0 to 550.0 RFC-A, RFC-S: 0.0 to 50000.0
Definition	This variable maximum is applied to *Keypad Control Mode Reference* (**01.017**). The maximum applied to these parameters is the same as other frequency reference parameters. VM_SPEED_FREQ_USER_REFS [MAX] = VM_SPEED_FREQ_REF[MAX] However the minimum is dependent on *Negative Reference Clamp Enable* (**01.008)** and *Bipolar Reference Enable* (01.010).

Negative Reference Clamp Enable (01.008)	Bipolar Reference Enable (01.010)	VM_SPEED_FREQ_USER_REFS[MIN]
0	0	If *Select Motor 2 Parameters* (11.045) = 0 *Minimum Reference Clamp* (**01.007**), otherwise *m² Minimum Reference Clamp* **(21.002**)
0	1	-VM_SPEED_FREQ_REF[MAX]
1	0	0.0
1	1	-VM_SPEED_FREQ_REF[MAX]

VM_SPEED_FREQ_REF	Range applied to the frequency or speed reference parameters
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: -550.0 to 0.0 RFC-A, RFC-S: -50000.0 to 0.0
Range of [MAX]	Open-loop: 0.0 to 550.0 RFC-A, RFC-S: 0.0 to 50000.0
Definition	This variable minimum/maximum is applied throughout the frequency and speed reference system so that the references can vary in the range from the minimum to maximum clamps.

Negative Reference Clamp Enable (01.008)	VM_SPEED_FREQ_REF[MAX] if Select Motor 2 Parameters (11.045) = 0	VM_SPEED_FREQ_REF[MAX] if Select Motor 2 Parameters (11.045) = 1
0	*Maximum Reference Clamp* (**01.006**)	m² Maximum Reference Clamp (**21.001**)
1	*Maximum Reference Clamp* (**01.006**) or |*Minimum Reference Clamp* (**01.007**)| whichever the larger	*m² Maximum Reference Clamp* (**21.001**) or |m² *Minimum Reference Clamp* (**21.002**)| whichever the larger

VM_SPEED_FREQ_REF[MIN] = -VM_SPEED_FREQ_REF[MAX].

VM_SPEED_FREQ_REF_UNIPOLAR	Unipolar version of VM_SPEED_FREQ_REF
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: 0.0 RFC-A, RFC-S: 0.0
Range of [MAX]	Open-loop: 0.0 to 550.0 RFC-A, RFC-S: 0.0 to 50000.0
Definition	VM_SPEED_FREQ_REF_UNIPOLAR[MAX] = VM_SPEED_FREQ_REF[MAX] VM_SPEED_FREQ_REF_UNIPOLAR[MIN] = 0.0

VM_SPEED_FREQ_USER_REFS	Range applied to some analog reference parameters
Units	Open-loop: Hz RFC-A, RFC-S: rpm or mm/s
Range of [MIN]	Open-loop: -550.00 to 550.00 RFC-A, RFC-S: -50000.0 to 50000.0
Range of [MAX]	Open-loop: 0.00 to 550.00 RFC-A, RFC-S: 0.0 to 50000.0
Definition	VM_SPEED_FREQ_USER_REFS[MAX] = VM_SPEED_FREQ_REF[MAX]

***Negative Reference Clamp Enable* (01.008)**	***Bipolar Reference Enable* (01.010)**	**VM_SPEED_FREQ_USER_REFS [MIN]**
0	0	Pr **01.007**
0	1	-VM_SPEED_FREQ_REF[MAX]
1	0	0.0
1	1	-VM_SPEED_FREQ_REF[MAX]

VM_STD_UNDER_VOLTS	Range applied the standard under-voltage threshold
Units	V
Range of [MIN]	0 to 1150
Range of [MAX]	0 to 1150
Definition	VM_STD_UNDER_VOLTS[MAX] = VM_DC_VOLTAGE_SET / 1.1 VM_STD_UNDER_VOLTS[MIN] is voltage rating dependent. See Table 10-3.

VM_SUPPLY_LOSS_LEVEL	Range applied to the supply loss threshold
Units	V
Range of [MIN]	0 to 1150
Range of [MAX]	0 to 1150
Definition	VM_SUPPLY_LOSS_LEVEL[MAX] = VM_DC_VOLTAGE_SET[MAX] VM_SUPPLY_LOSS_LEVEL[MIN] is drive voltage rating dependent. See Table 10-3

VM_SWITCHING_FREQUENCY	Range applied to the maximum switching frequency parameters
Units	User units
Range of [MIN]	0
Range of [MAX]	0 to 6
Definition	VM_SWITCHING_FREQUENCY[MAX] = Power stage dependent VM_SWITCHING_FREQUENCY[MIN] = 0 for motor control modes, or 1 for Regen mode (subject to the maximum)

VM_TORQUE_CURRENT	Range applied to torque and torque producing current parameters (where this is used in Regen mode it refers to the active current)
Units	%
Range of [MIN]	-1000.0 to 0.0
Range of [MAX]	0.0 to 1000.0
Definition	

Select Motor 2 Parameters **(11.045)**	**VM_TORQUE_CURRENT [MAX]**
0	VM_MOTOR1_CURRENT_LIMIT[MAX]
1	VM_MOTOR2_CURRENT_LIMIT[MAX]

VM_TORQUE_CURRENT[MIN] = -VM_TORQUE_CURRENT[MAX]

VM_TORQUE_CURRENT_UNIPOLAR	Unipolar version of VM_TORQUE_CURRENT
Units	%
Range of [MIN]	0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_TORQUE_CURRENT_UNIPOLAR[MAX] = VM_TORQUE_CURRENT[MAX] VM_TORQUE_CURRENT_UNIPOLAR[MIN] =0.0 *User Current Maximum Scaling* (04.024) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (**04.020**), *Torque Reference* (**04.008**) and *Torque Offset* (**04.009**). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

VM_USER_CURRENT	Range applied to torque reference and percentage load parameters with one decimal place
Units	%
Range of [MIN]	-1000.0 to 0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_USER_CURRENT[MAX] = *User Current Maximum Scaling* (**04.024**) VM_USER_CURRENT[MIN] = -VM_USER_CURRENT[MAX] *User Current Maximum Scaling* (**04.024**) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (**04.020**), *Torque Reference* (**04.008**) and Torque Offset (**04.009**). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

VM_USER_CURRENT_HIGH_RES	Range applied to torque reference and percentage load parameters with two decimal places
Units	%
Range of [MIN]	-1000.00 to 0.00
Range of [MAX]	0.00 to 1000.00
Definition	VM_USER_CURRENT_HIGH_RES[MAX] = *User Current Maximum Scaling* (04.024) with an additional decimal place VM_USER_CURRENT_HIGH_RES[MIN] = -VM_USER_CURRENT_HIGH_RES[MAX] *User Current Maximum Scaling* (04.024) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (04.020), *Torque Reference* (04.008) and Torque Offset (04.009). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

Table 10-3 Voltage ratings dependant values

Variable min/max	Voltage level (V)			
	200 V	**400 V**	**575 V**	**690 V**
VM_DC_VOLTAGE_SET[MAX]	400	800	955	1150
VM_DC_VOLTAGE[MAX]	415	830	990	1190
VM_AC_VOLTAGE_SET[MAX]	265	530	635	765
VM_AC_VOLTAGE[MAX]	325	650	780	930
VM_STD_UNDER_VOLTS[MIN]	175	330	435	435
VM_SUPPLY_LOSS_LEVEL[MIN]	205	410	540	540
VM_HIGH_DC_VOLTAGE	1500	1500	1500	1500

10.2 Menu 1: Frequency / speed reference

Menu 1 Single Line Descriptions - *Frequency References*

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
01.001	Reference Selected	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]						RO	Num	ND	NC	PT	
01.002	Pre-skip Filter Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]						RO	Num	ND	NC	PT	
01.003	Pre-ramp Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]						RO	Num	ND	NC	PT	
01.004	Positive Minimum Reference Clamp	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			0.0			RW	Num				US
01.006	Maximum Reference Clamp	VM_POSITIVE_REF_CLAMP1[MIN] to VM_POSITIVE_REF_CLAMP1[MAX]			50 Hz: 50.0 60 Hz: 60.0	50 Hz: 1500.0 60 Hz: 1800.0		RW	Num				US
01.007	Minimum Reference Clamp	VM_NEGATIVE_REF_CLAMP1[MIN] to VM_NEGATIVE_REF_CLAMP1[MAX]			0.0			RW	Num				US
01.008	Negative Reference Clamp Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
01.010	Bipolar Reference Enable	Off (0) or On (1)			On (1)			RW	Bit				US
01.011	Reference On	Off (0) or On (1)						RO	Bit	ND	NC	PT	
01.015	Reference Selector	0 to 8			1			RW	Num				US
01.021	Auto Mode Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			0.0			RW	Num				US
01.022	Hand Mode Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: 25.0 60 Hz: 30.0	50 Hz: 750.0 60 Hz: 900.0		RW	Num				US
01.023	PID Disabled / Feedback Loss Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: 25.0 60 Hz: 30.0	50 Hz: 750.0 60 Hz: 900.0		RW	Num				US
01.024	Pipe Fill Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: 25.0 60 Hz: 30.0	50 Hz: 750.0 60 Hz: 900.0		RW	Num				US
01.025	Cleaning Phase 1 Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: -15.0 60 Hz: -18.0	50 Hz: -450.0 60 Hz: -540.0		RW	Num				US
01.026	Cleaning Phase 2 Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: 15.0 60 Hz: 18.0	50 Hz: 450.0 60 Hz: 540.0		RW	Num				US
01.027	Cleaning Phase 3 Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			50 Hz: 40.0 60 Hz: 54.0	50 Hz: 1200.0 60 Hz: 1440.0		RW	Num				US
01.028	Multi-leader Assist Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			0.0			RW	Num				US
01.029	Skip Reference 1	0.0 to 599.0	0 to 33000		0.0	0		RW	Num				US
01.030	Skip Reference Band 1	0.0 to 25.0	0 to 250		0.0	0		RW	Num				US
01.031	Skip Reference 2	0.0 to 599.0	0 to 33000		0.0	0		RW	Num				US
01.032	Skip Reference Band 2	0.0 to 25.0	0 to 250		0.0	0		RW	Num				US
01.033	Skip Reference 3	0.0 to 599.0	0 to 33000		0.0	0		RW	Num				US
01.034	Skip Reference Band 3	0.0 to 25.0	0 to 250		0.0	0		RW	Num				US
01.035	Reference In Rejection Zone	Off (0) or On (1)						RO	Bit	ND	NC	PT	
01.036	Hand Mode Analog Reference	VM_SPEED_FREQ_USER_REFS[MIN] to VM_SPEED_FREQ_USER_REFS[MAX]			0.00	0.0		RO	Num		NC		
01.038	Percentage Trim	±100.00 %			0.00 %			RW	Num		NC		
01.042	Analog Or Digital Speed Select	Off (0) or On (1)			On (1)			RW	Bit		NC		
01.050	Reference Selected Indicator	1 to 8						RO	Num	ND	NC	PT	
01.053	Fire Mode Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]			0.0			RW	Num				US
01.054	Fire Mode Activate	Off (0) or On (1)			Off (0)			RO	Bit		NC		

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-1 Menu 1 open loop logic diagrams

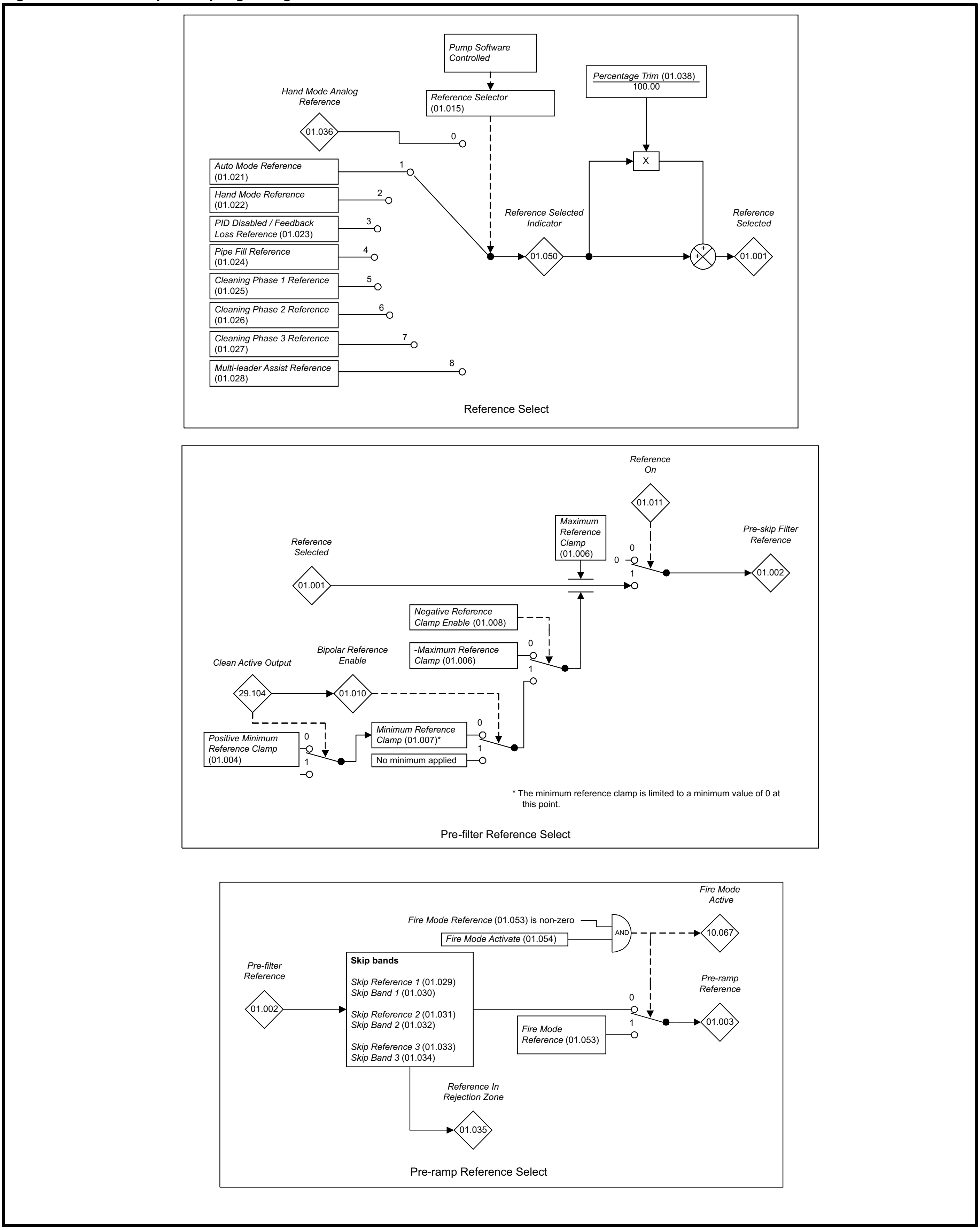
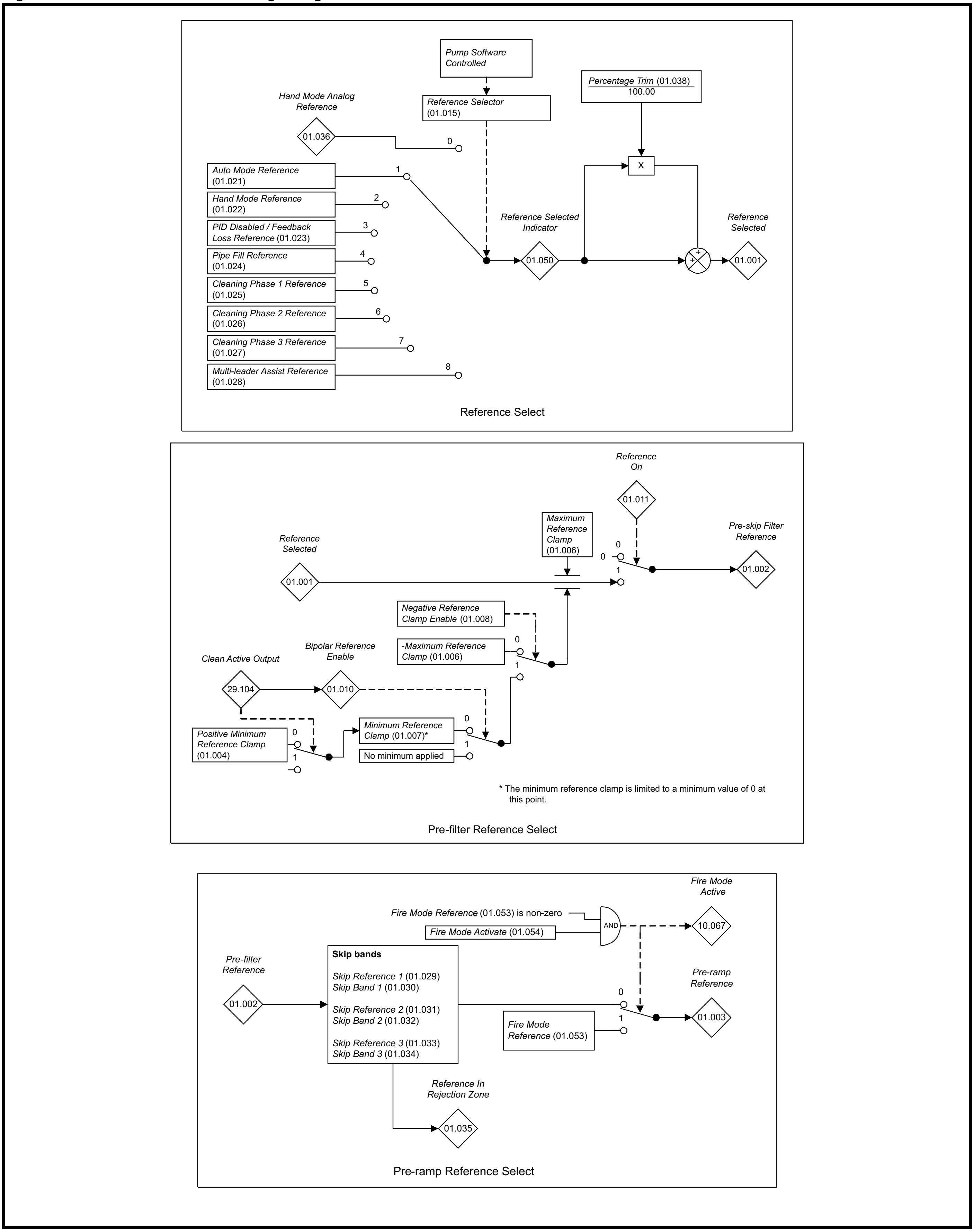


Figure 10-2 Menu 1 RFC-A / RFC-S logic diagrams



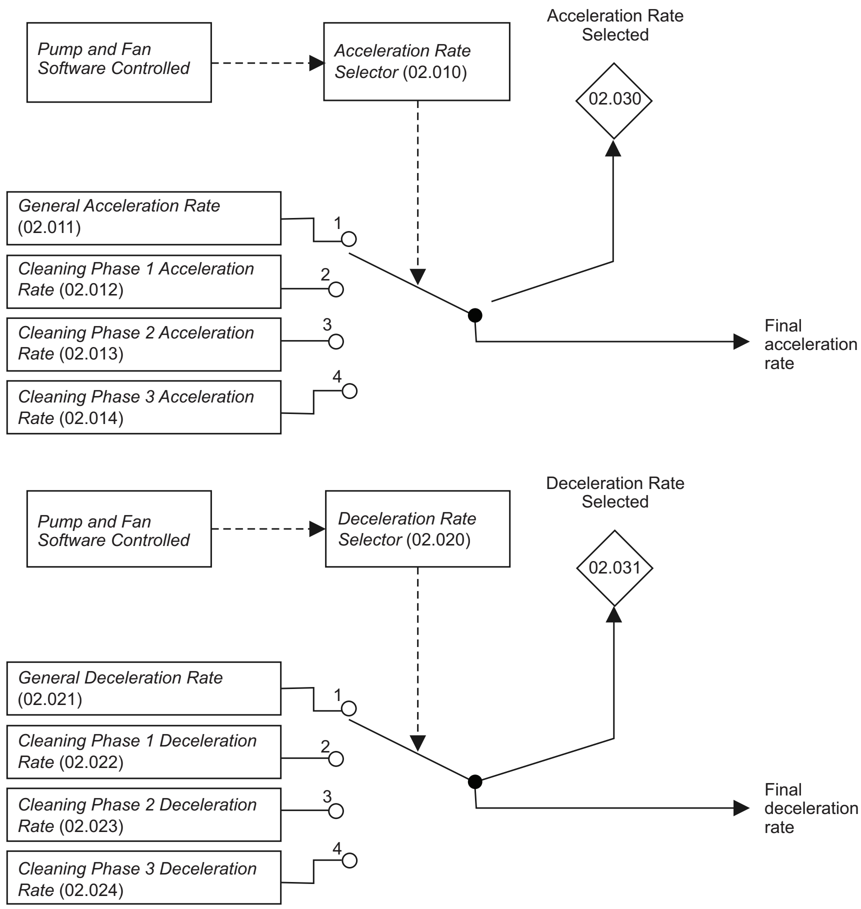
10.3 Menu 2: Frequency Ramps

Menu 2 Single Line Descriptions

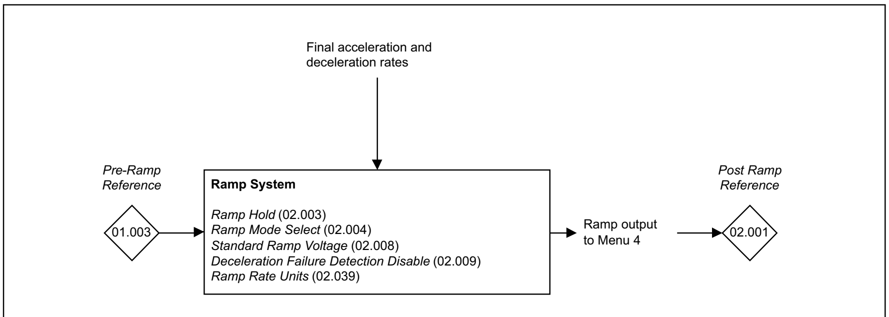
Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
02.001	Post Ramp Reference	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX]						RO	Num	ND	NC	PT	
02.003	Ramp Hold	Off (0) or On (1)			Off (0)			RW	Bit				US
02.004	Ramp Mode	Fast (0), Standard (1), Std boost (2)	Fast (0), Standard (1)		Std boost (2)	Standard (1)		RW	Txt				US
02.008	Standard Ramp Voltage	VM_DC_VOLTAGE_SET[MIN] to VM_DC_VOLTAGE_SET[MAX] V			200 V drive: 375 V 400 V drive 50 Hz: 750 V 400 V drive 60 Hz: 775 V 575 V drive: 895 V 690V drive: 1075 V			RW	Num		RA		US
02.009	Deceleration Fail Detection Disable	Off (0) or On (1)			Off (0)			RW	Bit				US
02.010	Acceleration Rate Selector	1 to 4			1			RW	Num				US
02.011	General Acceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			1.0 s	1.000 s		RW	Num				US
02.012	Cleaning Phase 1 Acceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.013	Cleaning Phase 2 Acceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.014	Cleaning Phase 3 Acceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.020	Deceleration Rate Selector	1 to 4			1			RW	Num				US
02.021	General Deceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			1.0 s	1.000 s		RW	Num				US
02.022	Cleaning Phase 1 Deceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.023	Cleaning Phase 2 Deceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.024	Cleaning Phase 3 Deceleration Rate	VM_ACCEL_RATE[MIN] to VM_ACCEL_RATE[MAX] s			5.0 s	5.000 s		RW	Num				US
02.030	Acceleration Rate Selected	0 to 8						RO	Num	ND	NC	PT	
02.031	Deceleration Rate Selected	0 to 8						RO	Num	ND	NC	PT	
02.039	Ramp Rate Units	Off (0) or On (1)			On (1)			RW	Bit				US

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-3 Menu 2 Open-Loop, RFC-A and RFC-S logic diagrams



Acceleration and deceleration rate selection



Ramp system

10.4 Menu 3: Speed Control and Position Feedback

Menu 3 Single Line Descriptions

Parameter		Range OL	Range RFC-A	Range RFC-S	Default OL	Default RFC-A	Default RFC-S	Type					
03.001	Final Speed Reference		VM_SPEED					RO	Num	ND	NC	PT	FI
03.002	Speed Feedback		VM_SPEED					RO	Num	ND	NC	PT	FI
03.003	Speed Error		VM_SPEED					RO	Num	ND	NC	PT	FI
03.004	Speed Controller Output		VM_TORQUE_CURRENT %					RO	Num	ND	NC	PT	FI
03.005	Zero Speed Threshold	0.0 to 20.0 Hz	0 to 200 rpm		1.0 Hz	5 rpm		RW	Num				US
03.006	At Speed Lower Limit	0.0 to 550.0 Hz	0 to 33000 rpm		1.0 Hz	5 rpm		RW	Num				US
03.007	At Speed Upper Limit	0.0 to 550.0 Hz	0 to 33000 rpm		1.0 Hz	5 rpm		RW	Num				US
03.008	Over Speed Threshold	0.0 to 550.0 Hz	0 to 40000 rpm		0.0 Hz	0 rpm		RW	Num				US
03.009	Absolute At Speed Select	Off (0) or On (1)			Off (0)			RW	Bit				US
03.010	Speed Controller Proportional Gain Kp1		0.0000 to 200.0000 s/rad			0.0300 s/rad		RW	Num				US
03.011	Speed Controller Integral Gain Ki1		0.00 to 655.35 s^2/rad			0.10 s^2/rad		RW	Num				US
03.012	RFC> Speed Controller Differential Feedback Gain Kd1		0.00000 to 0.65535 1/rad			0.00000 1/rad		RW	Num				US
03.024	RFC Feedback Mode		Feedback (0), Sensorless (1), Feedback NoMax (2), Sensorless NoMax (3)			Sensorless (1)		RW	Txt				US
03.025	Position Feedback Phase Angle			0.0 to 359.9 °				RW	Num	ND			US
03.026	Motor Control Feedback Select		P1 Slot1 (2), P2 Slot1 (3), P1 Slot2 (4), P2 Slot2 (5), P1 Slot3 (6), P2 Slot3 (7)			P1 Slot3 (6)		RW	Txt				US
03.078	Sensorless Mode Active		Off (0) or On (1)					RO	Bit	ND	NC	PT	
03.079	Sensorless Mode Filter		4 (0), 8 (1), 16 (2),32 (3), 64 (4) ms			4 (0) ms	64 (4) ms	RW	Txt				US
03.080	Sensorless Position		-2147483648 to 2147483647										

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-4 Menu 3 Open-Loop logic diagrams

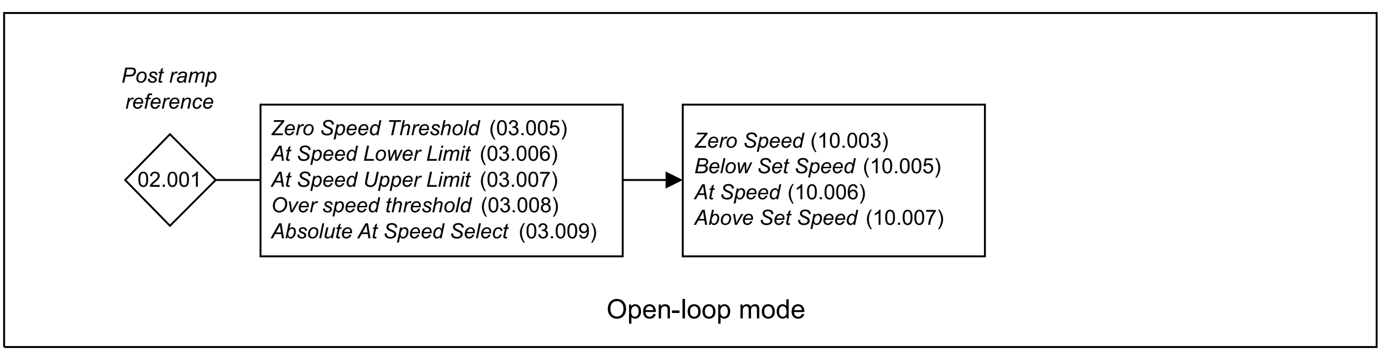
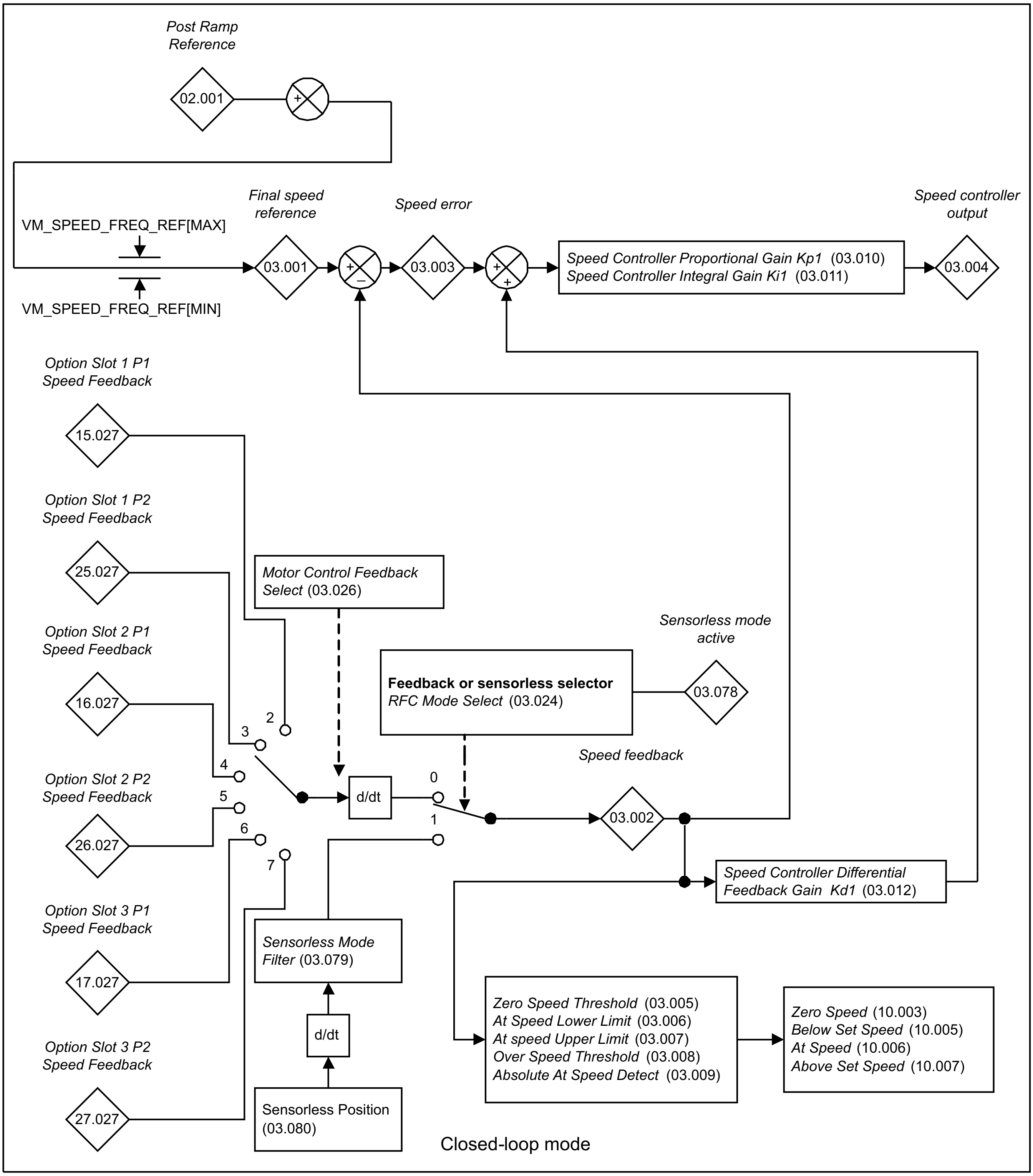


Figure 10-5 Menu 3 RFC-A / RFC-S logic diagrams



10.5 Menu 4: Torque and current control

Menu 4 Single Line Descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
04.001	Current Magnitude	VM_DRIVE_CURRENT_UNIPOLAR[MIN] to VM_DRIVE_CURRENT_UNIPOLAR[MAX] A						RO	Num	ND	NC	PT	FI
04.002	Open-Loop: Torque Producing Current	VM_DRIVE_CURRENT[MIN]0 to VM_DRIVE_CURRENT[MAX] A						RO	Num	ND	NC	PT	FI
	RFC-A: Torque Producing Current		VM_DRIVE_CURRENT [MIN] to VM_DRIVE_CU RRENT[MAX] A					RO	Num	ND	NC	PT	FI
	RFC-S: Iq			VM_DRIVE_CURRENT[MIN] to VM_DRIVE_CU RRENT[MAX] A				RO	Num	ND	NC	PT	FI
04.004	Final Current Reference		VM_TORQUE_CURRENT[MIN] to VM_TORQUE_CURRENT[MAX] %					RO	Num	ND	NC	PT	FI
04.005	Motoring Current Limit	VM_MOTOR1_CURRENT_LIMIT[MIN] to VM_MOTOR1_CURRENT_LIMIT[MAX] %			0.0 %			RW	Num				US
04.006	Regenerating Current Limit	VM_MOTOR1_CURRENT_LIMIT[MIN] to VM_MOTOR1_CURRENT_LIMIT[MAX] %			0.0 %			RW	Num				US
04.007	Symmetrical Current Limit	VM_MOTOR1_CURRENT_LIMIT[MIN] to VM_MOTOR1_CURRENT_LIMIT[MAX] %			0.0 %			RW	Num				US
04.012	Current Reference Filter 1 Time Constant		0.0 to 25.0 ms			1.0 ms		RW	Num				US
04.013	Current Controller Kp Gain	0 to 30000			20	150		RW	Num				US
04.014	Current Controller Ki Gain	0 to 30000			40	2000		RW	Num				US
04.015	Motor Thermal Time Constant 1	1.0 to 3000.0 s			89.0 s			RW	Num				US
04.016	Thermal Protection Mode	Motor Trip (0), Motor Limit (1), Drive Limit (2), Both Limit (3), Disabled (4)			Motor Trip (0)			RW	Txt				US
04.017	Open-Loop: Magnetising Current	VM_DRIVE_CURRENT[MIN] to VM_DRIVE_CURRENT[MAX] A						RO	Num	ND	NC	PT	FI
	RFC-A: Magnetising Current		VM_DRIVE_CURRENT [MIN] to VM_DRIVE_CURRENT [MAX] A					RO	Num	ND	NC	PT	FI
	RFC-S: Id			VM_DRIVE_CURRENT[MIN] to VM_DRIVE_CU RRENT[MAX] A				RO	Num	ND	NC	PT	FI
04.018	Final Current Limit	VM_TORQUE_CURRENT[MIN] to VM_TORQUE_CURRENT[MAX] %						RO	Num	ND	NC	PT	
04.019	Motor Protection Accumulator	0.0 to 200.0 %						RO	Num	ND	NC	PT	PS
04.020	Percentage Load	VM_USER_CURRENT[MIN] to VM_USER_CURRENT[MAX] %						RO	Num	ND	NC	PT	FI
04.021	Current Feedback Filter Disable	Off (0) or On (1)			Off (0)			RW	Bit				US
04.024	User Current Maximum Scaling	VM_TORQUE_CURRENT_UNIPOLAR[MIN] to VM_TORQUE_CURRENT_UNIPOLAR[MAX] %			165.0 %	175.0 %		RW	Num				US
04.025	Low Speed Thermal Protection Mode	0 to 1			1			RW	Num				US
04.026	Percentage Torque	VM_USER_CURRENT[MIN] to VM_USER_CURRENT[MAX] %						RO	Num	ND	NC	PT	FI
04.027	Low Load Detection Level	0.0 to 100.0 %			0.0 %			RW	Num				US
04.028	Low Load Detection Speed /Frequency Threshold	VM_SPEED_FREQ_REF_UNIPOLAR[MIN] to VM_SPEED_FREQ_REF_UNIPOLAR[MAX]			0.0			RW	Num				US
04.029	Enable Trip On Low Load	Off (0) or On (1)			Off (0)			RW	Bit				US
04.036	Motor Protection Accumulator Power-up Value	Power down (0), Zero (1), Real time (2)			Power down (0)			RW	Txt				US
04.037	Motor Thermal Time Constant 2	1.0 to 3000.0 s			89.0 s			RW	Num				US
04.038	Motor Thermal Time Constant 2 Scaling	0 to 100 %			0 %			RW	Num				US
04.039	Rated Iron Losses As Percentage Of Losses	0 to 100 %			0 %			RW	Num				US
04.041	Rated Torque	0.00 to 50000.00 Nm			0.00 Nm			RW	Num				US

04.049	Magnetising Current Limit		0.0 to 100.0 %		100.0 %	RW	Num				US
04.050	Low-pass Filter Cut-off Frequency		0 to 1000 Hz		0 Hz	RW	Num				US

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-6 Menu 4 Open-Loop logic diagrams

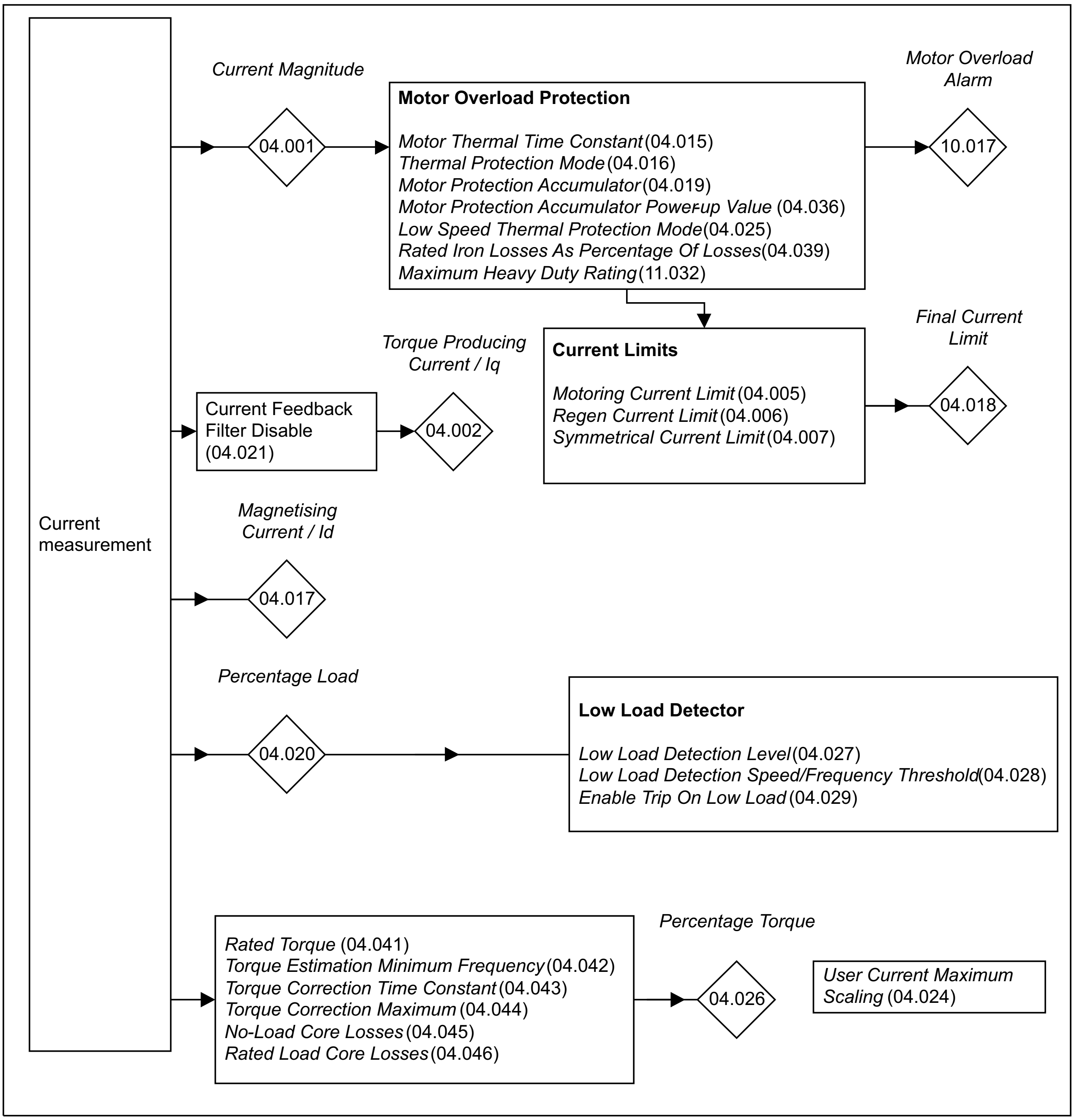


Figure 10-7

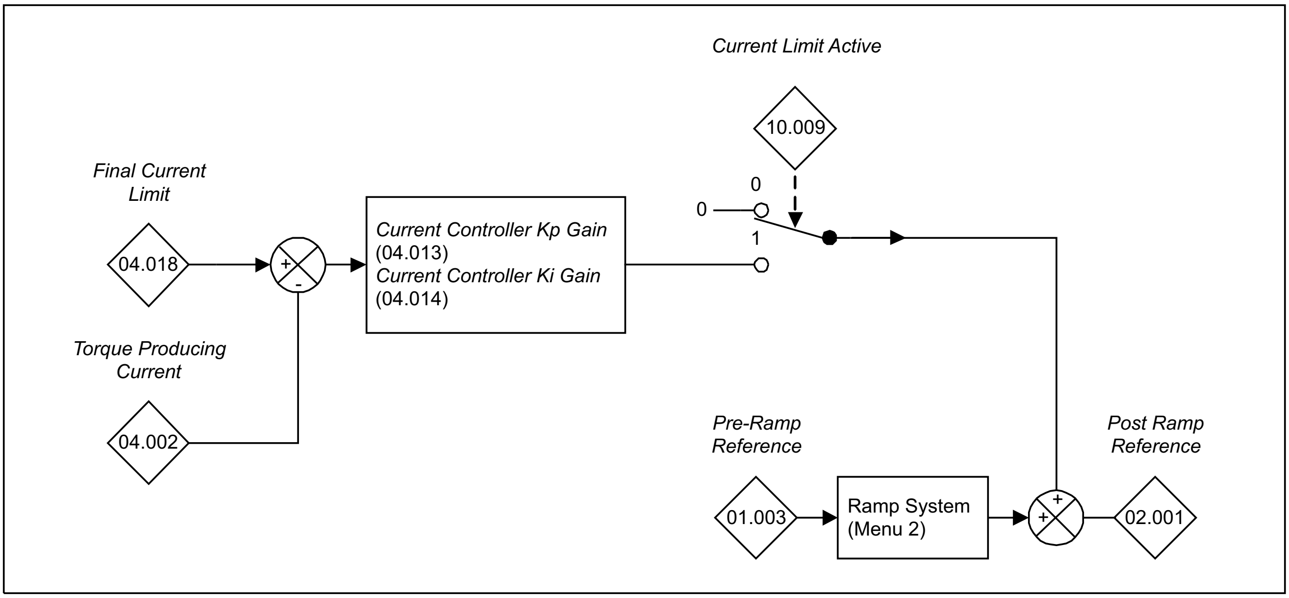

Current Limit Active
10.009
Final Current Limit
04.018
Torque Producing Current
04.002
Current Controller Kp Gain (04.013)
Current Controller Ki Gain (04.014)
0
0
1
Pre-Ramp Reference
01.003
Ramp System (Menu 2)
Post Ramp Reference
02.001

Figure 10-8 Menu 4 RFC-A and RFC-S logic diagram

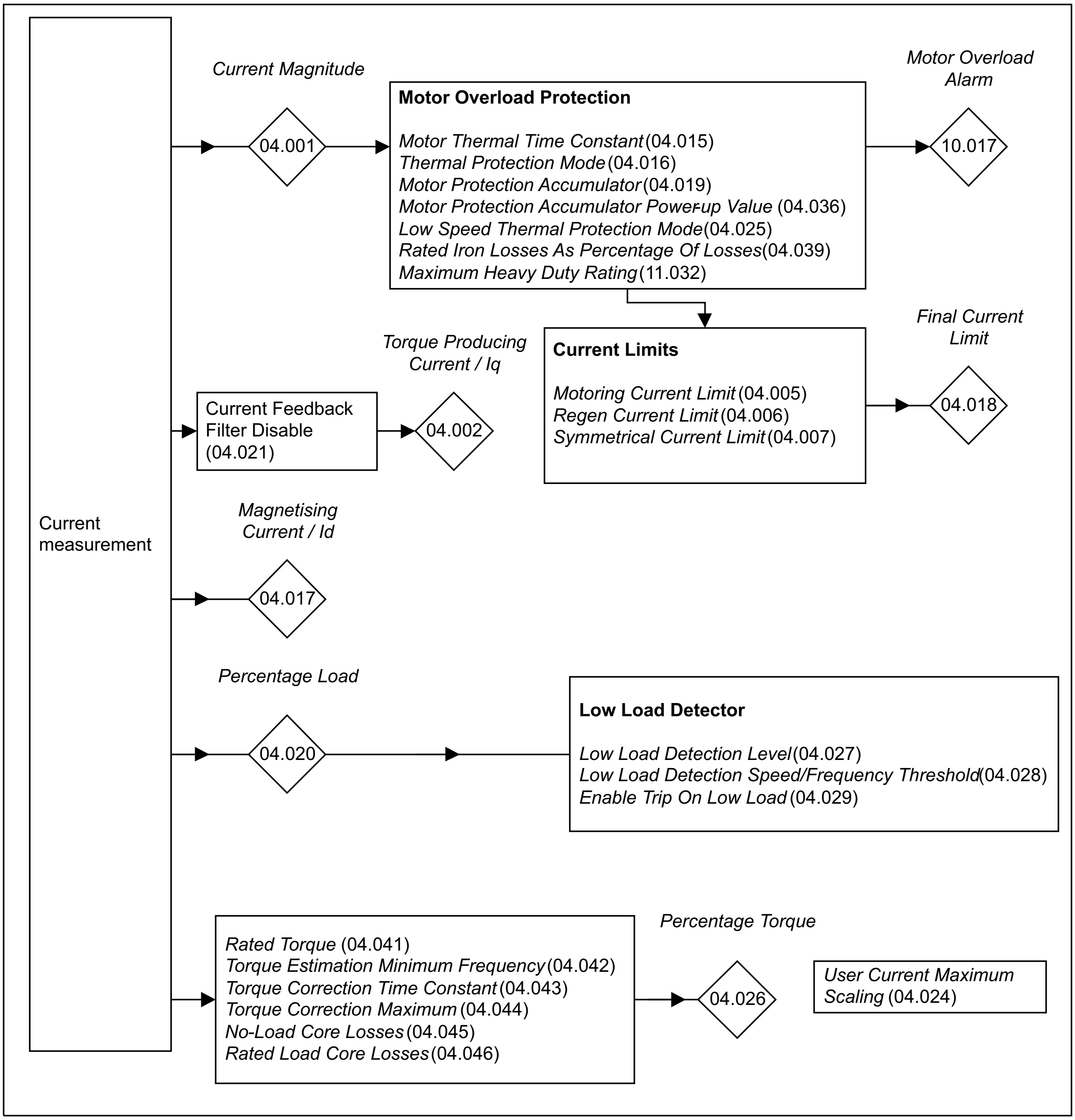


Figure 10-9 Menu 4 RFC-A logic diagram

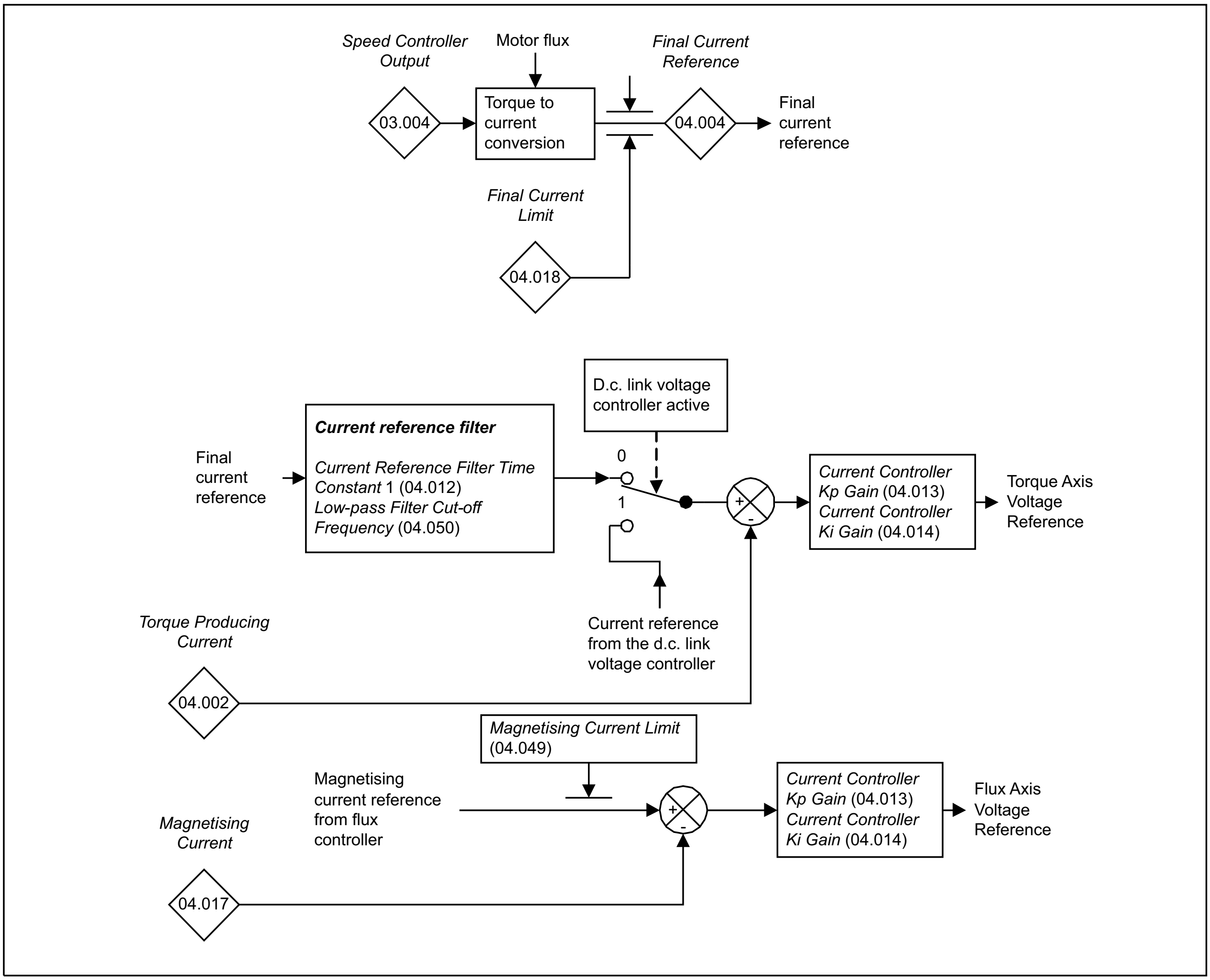
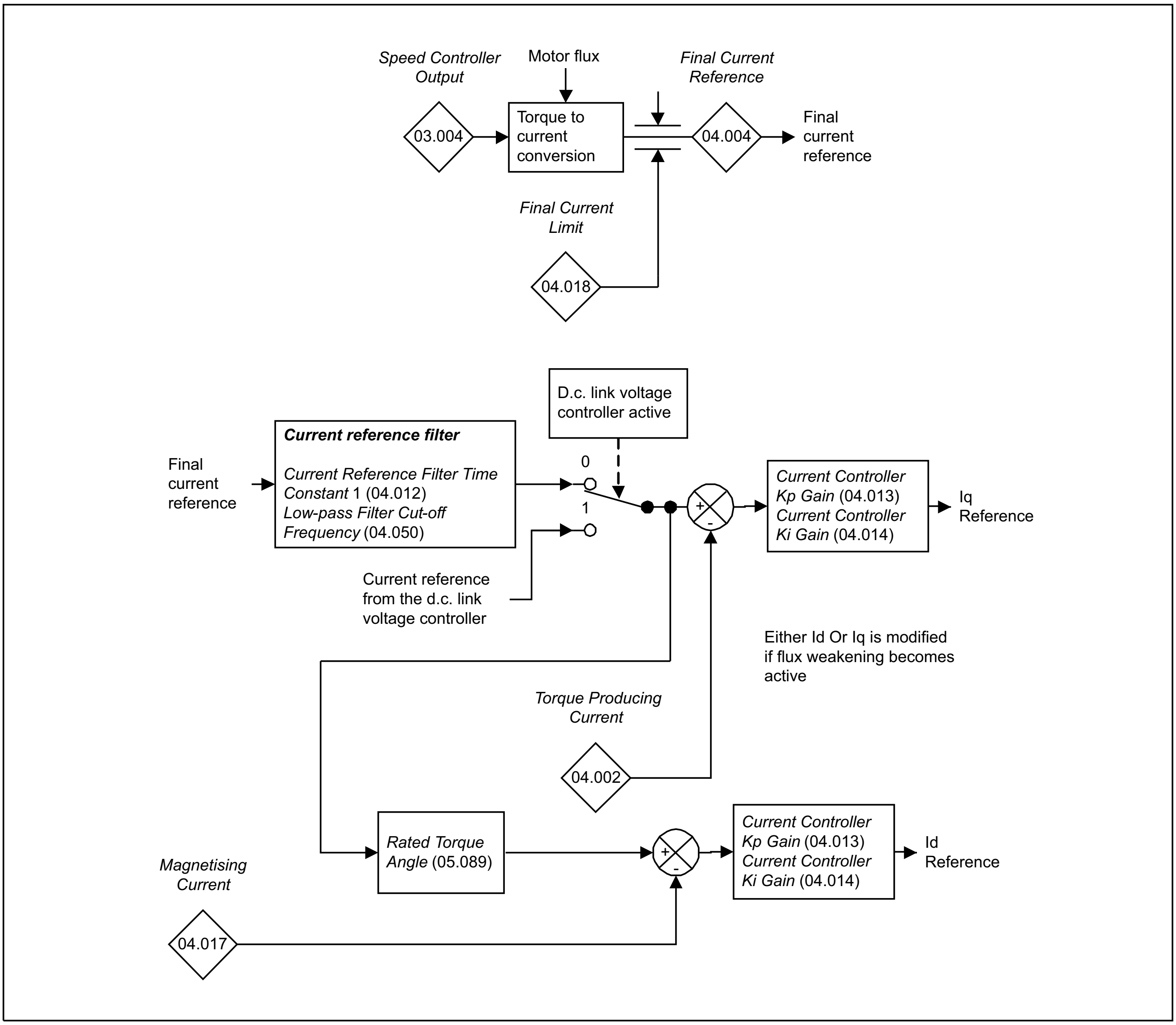


Figure 10-10 Menu 4 RFC-S logic diagram



10.6 Menu 5: Motor control

Menu 5 Single Line Descriptions

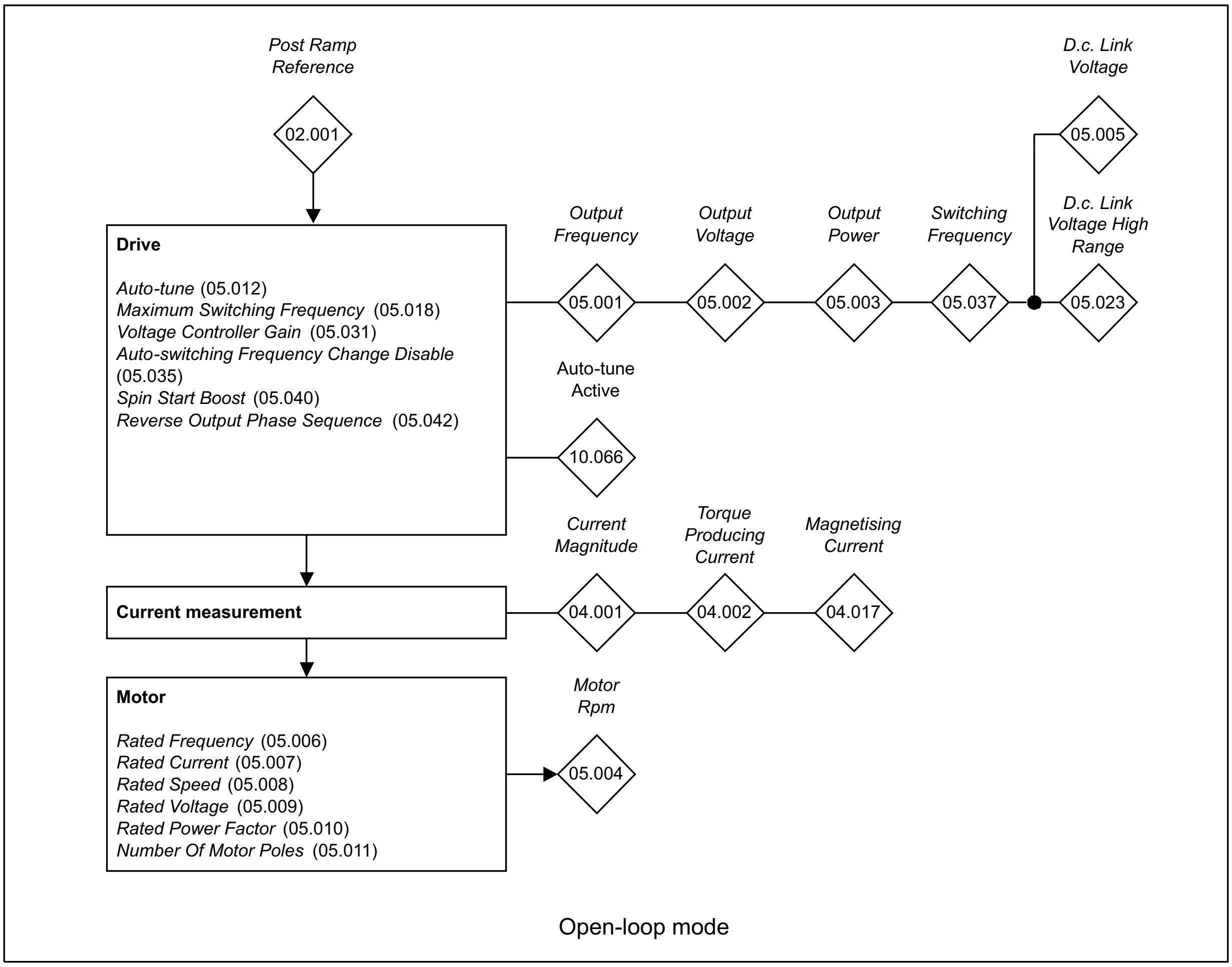
Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
05.001	Output Frequency	VM_SPEED_FREQ_REF[MIN] to VM_SPEED_FREQ_REF[MAX] Hz	±2000.0 Hz					RO	Num	ND	NC	PT	FI
05.002	Output Voltage	VM_AC_VOLTAGE[MIN] to VM_AC_VOLTAGE[MAX] V						RO	Num	ND	NC	PT	FI
05.003	Output Power	VM_POWER[MIN] to VM_POWER[MAX] kW						RO	Num	ND	NC	PT	FI
05.004	Motor Rpm	±180000 rpm						RO	Num	ND	NC	PT	FI
05.005	D.c. Bus Voltage	VM_DC_VOLTAGE[MIN] to VM_DC_VOLTAGE[MAX] V						RO	Num	ND	NC	PT	FI
05.006	Rated Frequency	0.0 to 599.0 Hz	0.0 to 550.0 Hz		50 Hz: 50.0 Hz 60 Hz: 60.0 Hz			RW	Num				US
05.007	Rated Current	VM_RATED_CURRENT[MIN] to VM_RATED_CURRENT[MAX] A			0.000 A			RW	Num				US
05.008	Rated Speed	0 to 35940 rpm	0.00 to 33000.00 rpm		50 Hz: 1500 rpm 60 Hz: 1750 rpm	1450.00 rpm	50Hz: 1500.00 rpm 60Hz: 1800.00 rpm	RW	Num				US
05.009	Rated Voltage	VM_AC_VOLTAGE_SET[MIN] to VM_AC_VOLTAGE_SET[MAX] V			200 V drive: 230 V 400 V drive 50Hz: 400 V 400 V drive 60Hz: 460 V 575 V drive: 575 V 690 V drive: 690 V			RW	Num				US
05.010	Rated Power Factor	0.000 to 1.000			0.850			RW	Num				US
05.011	Number Of Motor Poles	Automatic (0) to 480 (240) Poles			Automatic (0) Poles		8 (4) Poles	RW	Txt				US
05.012	Auto-tune	None (0), Basic (1), Improved (2)		None (0), Stationary (1), Full Stationary (5)	None (0)			RW	Txt		NC		
05.013	Open-Loop: Low Load Power Saving	Off (0) or On (1)			Off (0)			RW	Bit				US
	RFC-A: Flux Optimisation Select		Off (0) or On (1)			Off (0)		RW	Bit				US
	RFC-S: Minimal Movement Phasing Test Mode			Free x4 (-3), Free x3 (-2), Free x2 (-1), Free (0), Constrained (1)			Free (0)	RW	Txt				US
05.014	Open-Loop: Open-loop Control Mode	Ur S (0), Ur (1), Fixed (2), Ur Auto (3), Ur I (4), Square (5)			Fixed (2)			RW	Txt				US
	RFC-S: Phasing Test On Enable			Disabled (0), Short (1), Short Once (2), Long (3), Long Once (4)			Disabled (0)	RW	Txt				US
05.015	Open-Loop: Low Frequency Voltage Boost	0.0 to 25.0 %			1.0 %			RW	Num				US
	RFC-A: Low Frequency Voltage Boost		0.0 to 25.0 %			1.0 %		RW	Num				US
	RFC-S: Minimal Movement Phasing Test Current			1% (0), 2% (1), 3% (2), 6% (3), 12% (4), 25% (5), 50% (6), 100% (7)			1% (0)	RW	Txt				US
05.016	Minimal Movement Phasing Test Angle			0.00 to 25.00 °			0.00 °	RW	Num				US
05.017	Stator Resistance	0.000000 to 1000.000000 Ω			0.000000 Ω			RW	Num				US
05.018	Maximum Switching Frequency	0 to VM_SWITCHING_FREQUENCY kHz			3 (1) kHz			RW	Txt				US

05.019	Open-Loop: High Stability Space Vector Modulation	Off (0) or On (1)			Off (0)			RW	Bit				US
	RFC-S: Minimal Movement Phasing Test Mechanical Load Phase			-180 to 179 °			-180 °	RW	Num				US
05.020	Quasi-square Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
05.022	Enable High Speed Mode			Limit (-2), Limit (Servo) (-1), Disable (0), Enable (Servo) (1), Enable (2)			Limit (-2)	RW	Txt				US
05.024	Open-Loop: Transient Inductance	0.000 to 500.000 mH			0.000 mH			RW	Num				US
	RFC-A: Transient Inductance		0.000 to 500.000 mH			0.000 mH		RW	Num				US
	RFC-S: Ld			0.000 to 500.000 mH			0.000 mH	RW	Num				US
05.025	Stator Inductance	0.00 to 5000.00 mH			0.00 mH			RW	Num				US
05.027	Open-Loop: Enable Slip Compensation	Off (0) or On (1)			Off (0)			RW	Bit				US
	RFC-A: Flux Control Gain		±10.0			1.0		RW	Num				US
	RFC-S: Flux Control Gain			0.1 to 10.0			1.0	RW	Num				US
05.028	Torque Linearisation Disable			Off (0) or On (1)			On (1)	RW	Bit				US
05.031	Voltage Controller Gain	1 to 30			1			RW	Num				US
05.033	Volts Per 1000rpm			0 to 10000 V			98 V	RW	Num				US
05.034	Percentage Flux		0.0 to 150.0 %					RO	Num	ND	NC	PT	FI
05.035	Auto-switching Frequency Change	Enabled (0), Disabled (1), No Ripple Detect (2)			Enabled (0)			RW	Txt				US
05.036	Auto-switching Frequency Step Size	1 to 2			2			RW	Num				US
05.037	Switching Frequency	2 (0), 3 (1), 4 (2), 6 (3), 8 (4), 12 (5), 16 (6) kHz						RO	Txt	ND	NC	PT	
05.038	Minimum Switching Frequency	0 to VM_MIN_SWITCHING_FREQUENCY kHz			2 (0) kHz			RW	Txt				US
05.039	Maximum Inverter Temperature Ripple	20 to 60 °C			60 °C			RW	Num				US
05.040	Spin Start Boost	0.0 to 10.0			1.0			RW	Num				US
05.041	Voltage Headroom		0 to 20 %			0 %	5 %	RW	Num				US
05.042	Reverse Output Phase Sequence	Off (0) or On (1)			Off (0)			RW	Bit				US
05.063	Sensorless Mode Current Ramp			0.00 to 1.00 s			0.20 s	RW	Num				US
05.064	RFC Low Speed Mode			Injection (0), Current (1), Current (2), Current No Test (3), Current Step (4), Current Only (5)			Current (2)	RW	Txt				US
05.065	Saliency Torque Control Select			Disabled (0), Low (1), High (2), Auto (3)			Disabled (0)	RW	Txt				US
05.066	Active Saliency Torque Mode			Disabled (0), Low (1), High (2)				RO	Txt	ND	NC	PT	
05.068	Actual Over-current Trip Level			0 to 500 %				RO	Num	ND	NC	PT	
05.069	Over-current Trip Level as Percentage of Rated Current			0 to 1000 %			150 %	RW	Num				US
05.070	Inverted Saturation Characteristic			Off (0) or On (1)			Off (0)	RW	Bit				US
05.071	Low Speed Sensorless Mode Current			0.0 to 1000.0 %			100.0 %	RW	Num				US
05.072	No-load Lq			0.000 to 500.000 mH			0.000 mH	RW	Num				US
05.075	q Axis Current For Inductances			0 to 200 %			0 %	RW	Num				US
05.077	Phase Offset At Defined Iq Current			±90.0 °			0.0 °	RW	Num				US
05.078	Lq At The Defined Iq Current			0.000 to 500.000 mH			0.000 mH	RW	Num				US
05.082	d Axis Current For Inductances			-200 to 0 %			-100 %	RW	Num				US

05.084	Lq At The Defined Id Current		0.000 to 500.000 mH		0.000 mH	RW	Num				US
05.087	User Defined Rated Torque Angle		0 to 90 °		0 °	RW	Num				US
05.088	Estimated Lq		0.000 to 500.000 mH			RO	Num	ND	NC	PT	FI
05.089	Rated Torque Angle		0 to 90 °			RO	Num	ND	NC	PT	

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-11 Menu 5 Open-Loop logic diagrams



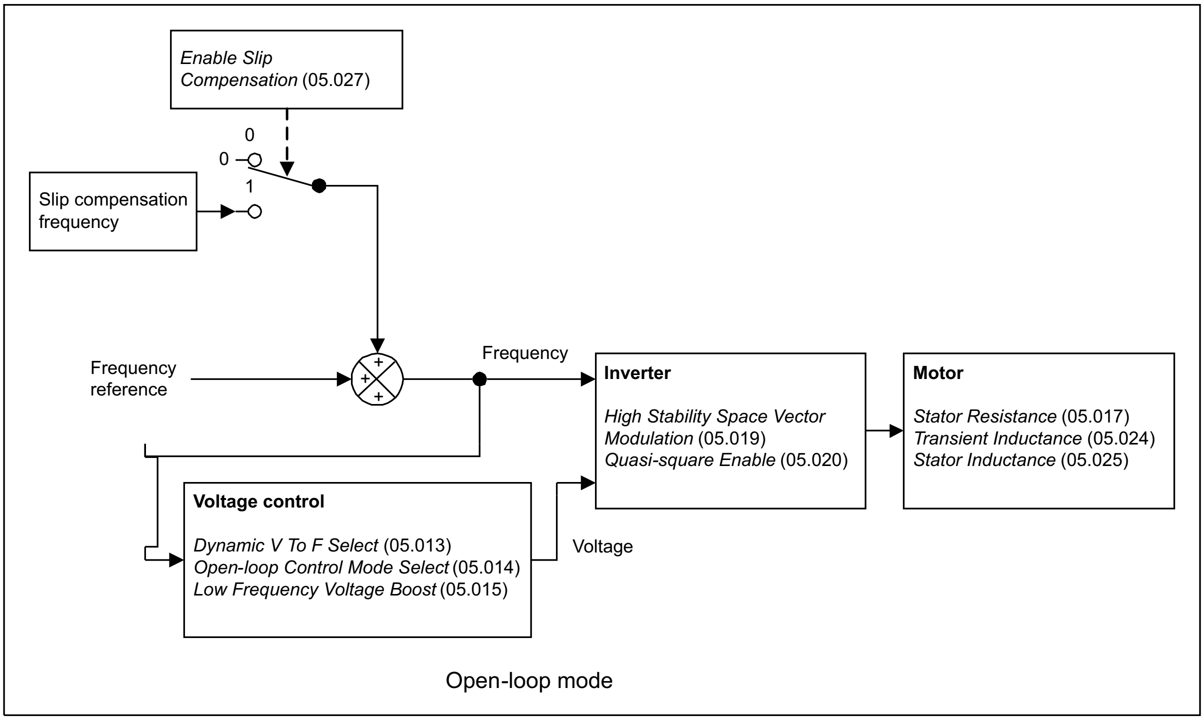
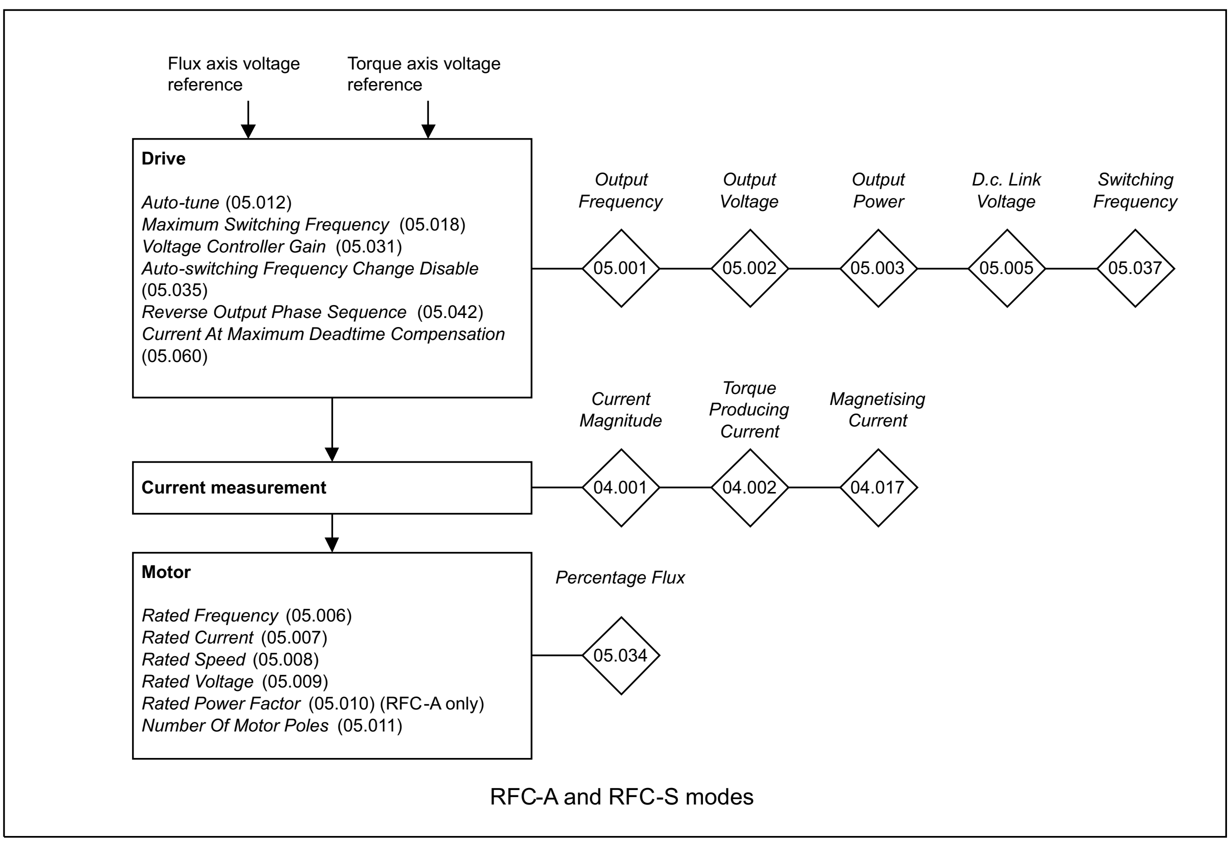
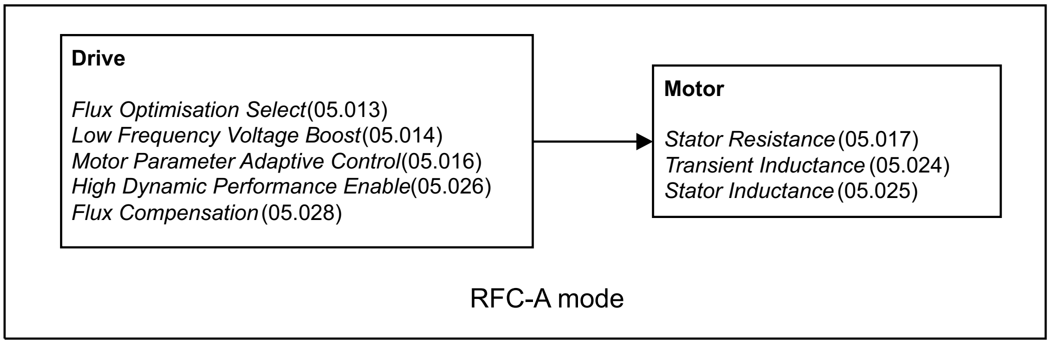
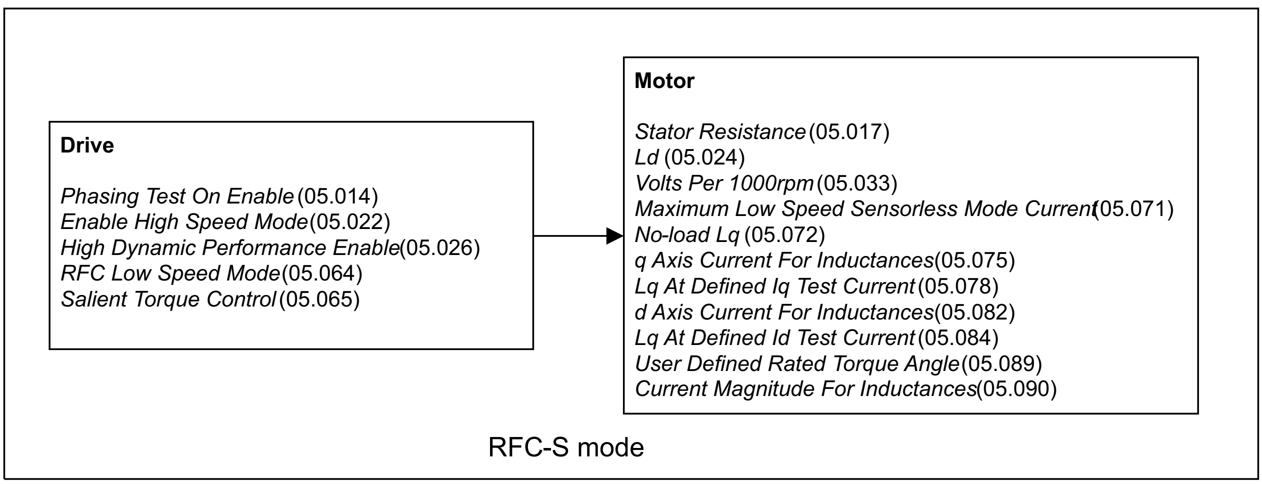


Figure 10-12 Menu 5 RFC-A and RFC logic diagrams




Drive
Flux Optimisation Select (05.013)
Low Frequency Voltage Boost (05.014)
Motor Parameter Adaptive Control (05.016)
High Dynamic Performance Enable (05.026)
Flux Compensation (05.028)
Motor
Stator Resistance (05.017)
Transient Inductance (05.024)
Stator Inductance (05.025)
RFC-A mode


Drive
Phasing Test On Enable (05.014)
Enable High Speed Mode (05.022)
High Dynamic Performance Enable (05.026)
RFC Low Speed Mode (05.064)
Salient Torque Control (05.065)
Motor
Stator Resistance (05.017)
Ld (05.024)
Volts Per 1000rpm (05.033)
Maximum Low Speed Sensorless Mode Current (05.071)
No-load Lq (05.072)
q Axis Current For Inductances (05.075)
Lq At Defined Iq Test Current (05.078)
d Axis Current For Inductances (05.082)
Lq At Defined Id Test Current (05.084)
User Defined Rated Torque Angle (05.089)
Current Magnitude For Inductances (05.090)
RFC-S mode

10.7 Menu 6: Sequencer and clock

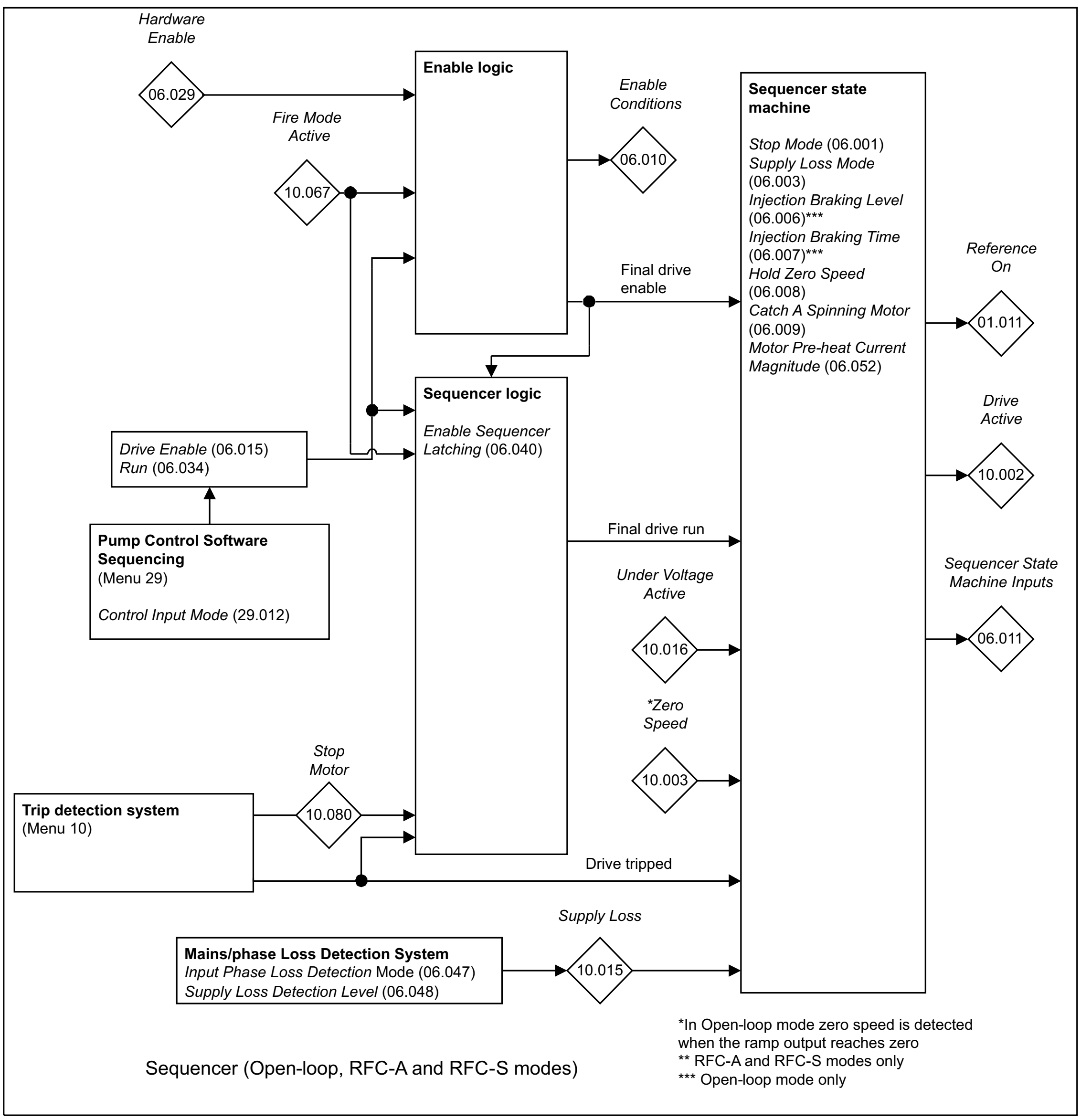
Menu 6 Single Line Descriptions

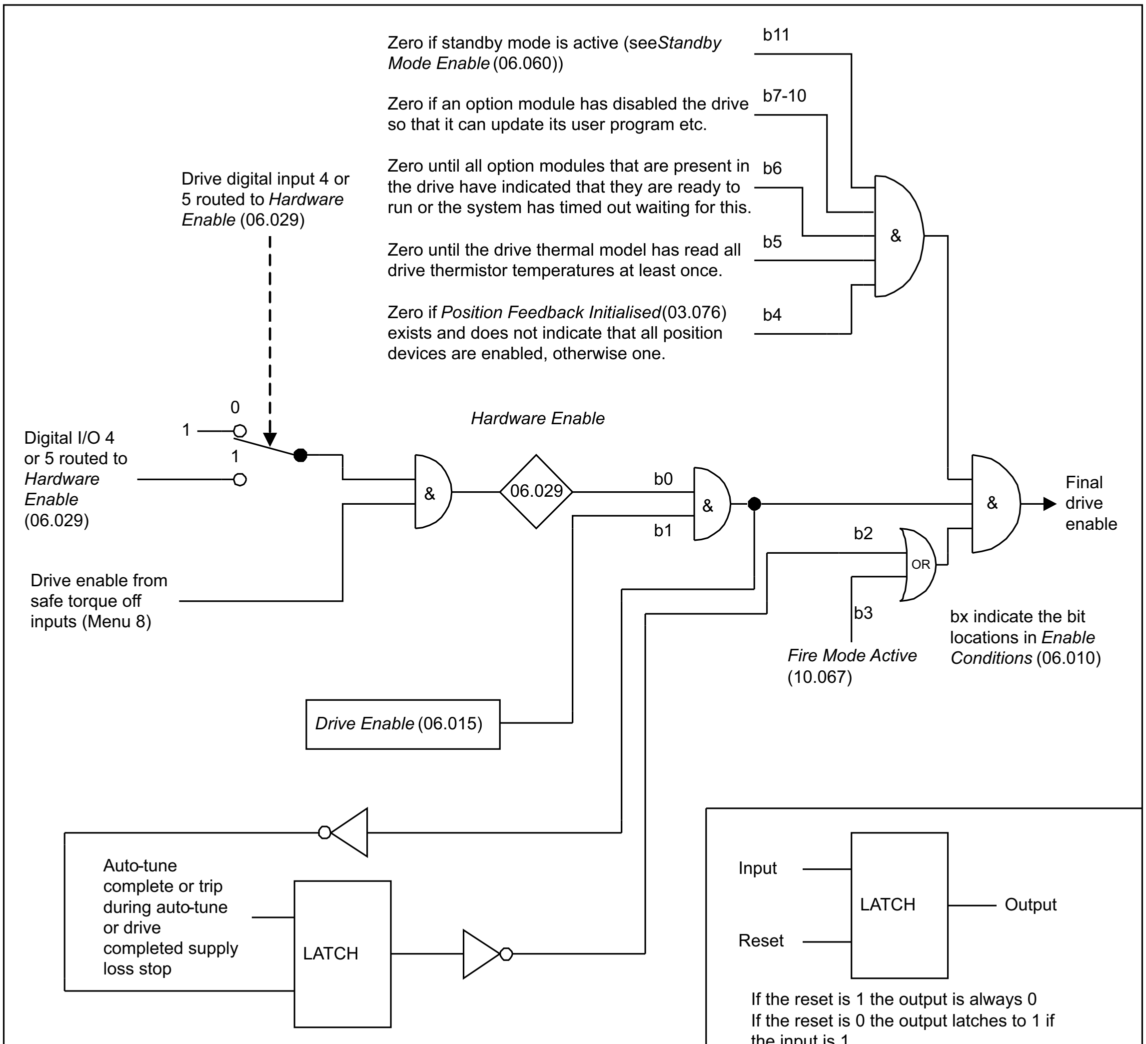
Parameter		Range Open-Loop	Range RFC-A	Range RFC-S	Default Open-Loop	Default RFC-A	Default RFC-S	Type					
06.001	Stop Mode	Coast (0), Ramp (1), Ramp dc I (2), dc I (3), Timed dc I (4)	Coast (0), Ramp (1)		Ramp (1)			RW	Txt				US
06.003	Supply Loss Mode	Disable (0), Ramp Stop (1), Ride Thru (2)	Disable (0), Ramp Stop (1), Ride Thru (2), Limit Stop (3)		Disable (0)			RW	Txt				US
06.006	Injection Braking Level	0.0 to 150.0 %			100.0 %			RW	Num				US
06.007	Injection Braking Time	0.0 to 100.0 s			1.0 s			RW	Num				US
06.008	Hold Zero Speed	Off (0) or On (1)			Off (0)			RW	Bit				US
06.009	Catch A Spinning Motor	Disable (0), Enable (1), Fwd Only (2), Rev Only (3)			Disable (0)			RW	Txt				US
06.010	Enable Conditions	000000000000 to 111111111111						RO	Bin	ND	NC	PT	
06.011	Sequencer State Machine Inputs	000000 to 111111						RO	Bin	ND	NC	PT	
06.015	Drive Enable	Off (0) or On (1)			On (1)			RW	Bit				US
06.016	Date	00-00-00 to 31-12-99						RW	Date	ND	NC	PT	
06.017	Time	00:00:00 to 23:59:59						RW	Time	ND	NC	PT	
06.018	Day Of Week	Sunday (0), Monday (1), Tuesday (2), Wednesday (3), Thursday (4), Friday (5), Saturday (6)						RO	Txt	ND	NC	PT	
06.019	Date/Time Selector	Set (0), Powered (1), Running (2), Acc Powered (3), Local Keypad (4), Remote Keypad (5)			Local Keypad (4)			RW	Txt				US
06.020	Date Format	Std (0), US (1)			Std (0)			RW	Txt				US
06.021	Time Between Filter Changes	0 to 30000 hours			0 hours			RW	Num				US
06.022	Filter Change Required / Change Done	Off (0) or On (1)						RW	Bit	ND	NC		
06.023	Time Before Filter Change Due	0 to 30000 hours						RO	Num	ND	NC	PT	PS
06.024	Reset Energy Meter	Off (0) or On (1)			Off (0)			RW	Bit				
06.025	Energy Meter: MWh	±999.9 MWh						RO	Num	ND	NC	PT	PS
06.026	Energy Meter: kWh	±99.99 kWh						RO	Num	ND	NC	PT	PS
06.027	Energy Cost Per kWh	0.0 to 600.0			0.0			RW	Num				US
06.028	Running Cost	±32000						RO	Num	ND	NC	PT	
06.029	Hardware Enable	Off (0) or On (1)						RO	Bit	ND	NC	PT	
06.034	Run	Off (0) or On (1)			Off (0)			RW	Bit		NC		
06.041	Drive Event Flags	00 to 11			00			RW	Bin		NC		
06.042	Legacy Control Word	000000000000000 to 111111111111111			000000000000000			RW	Bin		NC		
06.043	Legacy Control Word Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
06.044	Active Supply	Off (0) or On (1)						RO	Bit	ND	NC	PT	
06.045	Cooling Fan control	-10 to 11			10			RW	Num				US
06.046	Cooling Fan Speed	0 to 10						RO	Num	ND	NC	PT	
06.047	Input Phase Loss Detection Mode	Full (0), Ripple Only (1), Disabled (2)			Full (0)			RW	Txt				US
06.048	Supply Loss Detection Level	VM_SUPPLY_LOSS_LEVEL[MIN] to VM_SUPPLY_LOSS_LEVEL[MAX] V			200 V drive: 205 V 400 V drive: 410 V 575 V drive: 540 V 690 V drive: 540 V			RW	Num		RA		US
06.051	Hold Supply Loss Active	Off (0) or On (1)			Off (0)			RW	Bit		NC		
06.052	Motor Pre-heat Current Magnitude	0 to 100 %			0 %			RW	Num				US
06.058	Output Phase Loss Detection Time	0.5s (0), 1.0s (1), 2.0s (2), 4.0s (3)			0.5 s (0)			RW	Txt				US
06.059	Output Phase Loss Detection Enable	Disabled (0), Phases (1), Devices (2), Low Noise (3)			Disabled (0)			RW	Txt				US
06.060	Standby Mode Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
06.061	Standby Mode Mask	0000000 to 1111111			0000000			RW	Bin				US
06.065	Standard Under Voltage Threshold	VM_STD_UNDER_VOLTS[MIN] to VM_STD_UNDER_VOLTS[MAX] V			200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V			RW	Num		RA		US
06.066	Low Under Voltage Threshold	VM_LOW_UNDER_VOLTS[MIN] to VM_LOW_UNDER_VOLTS[MAX] V			200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V			RW	Num		RA		US
06.067	Low Under Voltage Threshold Select	Off (0) or On (1)			Off (0)			RW	Bit				US
06.068	Backup Supply Mode Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
06.069	Under-voltage System Contactor Close	Off (0) or On (1)						RO	Bit	ND	NC	PT	
06.070	Under-voltage System Contactor Closed	Off (0) or On (1)			Off (0)			RW	Bit				
06.071	Slow Rectifier Charge Rate Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
06.072	User Supply Select	Off (0) or On (1)			Off (0)			RW	Bit				US

06.073	Braking IGBT Lower Threshold	VM_DC_VOLTAGE_SET[MIN] to VM_DC_VOLTAGE_SET[MAX] V	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V	RW	Num		RA		US
06.074	Braking IGBT Upper Threshold	VM_DC_VOLTAGE_SET[MIN] to VM_DC_VOLTAGE_SET[MAX] V	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V	RW	Num		RA		US
06.075	Low Voltage Braking IGBT Threshold	VM_DC_VOLTAGE_SET[MIN] to VM_DC_VOLTAGE_SET[MAX] V	0 V	RW	Num		RA		US
06.076	Low Voltage Braking IGBT Threshold Select	Off (0) or On (1)	Off (0)	RW	Bit				
06.084	Date And Time Offset	±12.00 hours	0.00 hours	RW	Num				US
06.085	Control Word Override	000000000000000 to 111111111111111	000000000000000	RW	Bin		NC		
06.086	Control override enable	Disabled (0), Control Word (1), Enabled (2)	Disabled (0)	RW	Txt		NC		

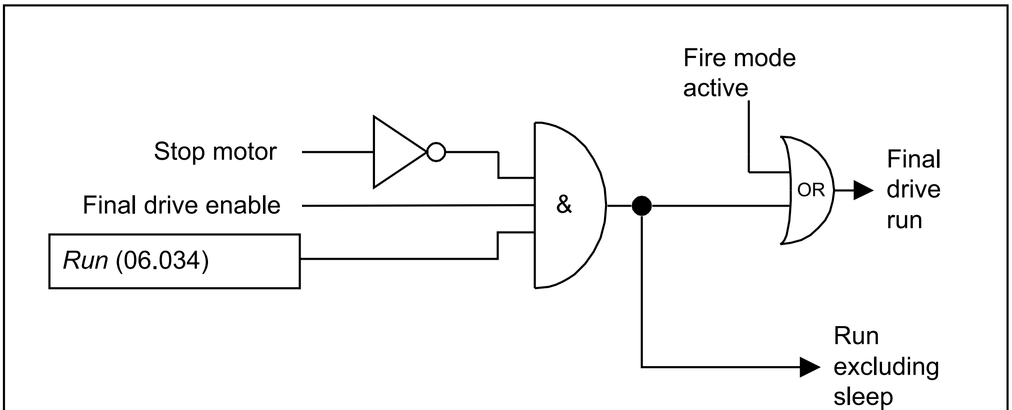
RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-13 Menu 6 Open-Loop and RFC logic diagrams





Enable logic



Sequencer logic (Open-loop, RFC-A and RFC-S modes)

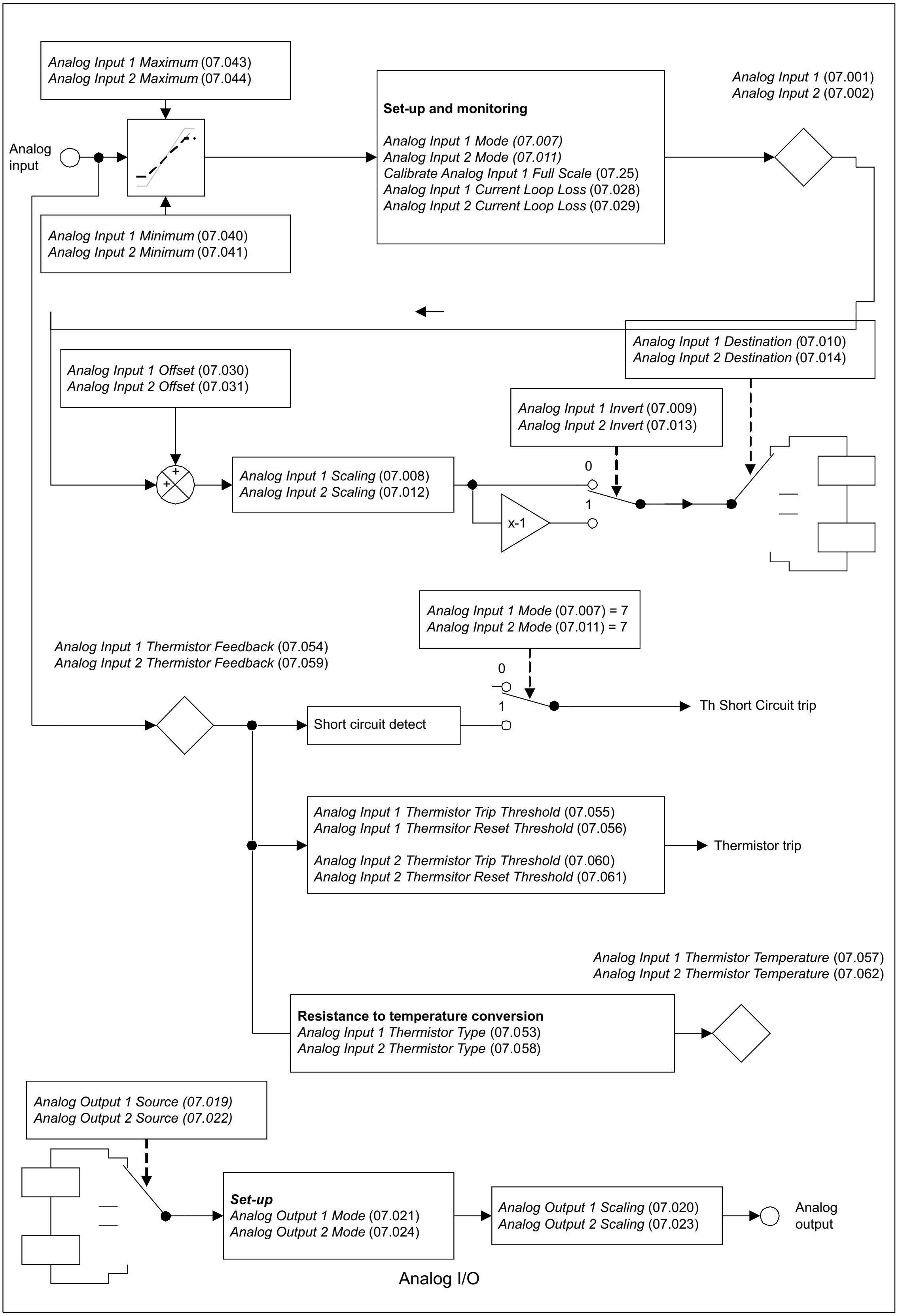
10.8 Menu 7: Analog I/O

Menu 7 Single line descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
07.001	Analog Input 1	±100.00 %						RO	Num	ND	NC	PT	FI
07.002	Analog Input 2	±100.00 %						RO	Num	ND	NC	PT	FI
07.004	Monitored Temperature 1	±250 °C						RO	Num	ND	NC	PT	
07.005	Monitored Temperature 2	±250 °C						RO	Num	ND	NC	PT	
07.006	Monitored Temperature 3	±250 °C						RO	Num	ND	NC	PT	
07.007	Analog Input 1 Mode	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)			4-20 mA (4)			RW	Txt				US
07.008	Analog Input 1 Scaling	0.000 to 10.000			1.000			RW	Num				US
07.009	Analog Input 1 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
07.010	Analog Input 1 Destination	0.000 to 59.999			29.034			RW	Num	DE		PT	US
07.011	Analog Input 2 Mode	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0 mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)			Volt (6)			RW	Txt				US
07.012	Analog Input 2 Scaling	0.000 to 10.000			1.000			RW	Num				US
07.013	Analog Input 2 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
07.014	Analog Input 2 Destination	0.000 to 59.999			1.036			RW	Num	DE		PT	US
07.019	Analog Output 1 Source	0.000 to 59.999			5.001	3.002		RW	Num			PT	US
07.020	Analog Output 1 Scaling	0.000 to 10.000			1.000			RW	Num				US
07.021	Analogue Output 1 Mode	Volts (0), 0-20 mA (1), 20-0 mA (2), 4-20 mA (3), 20-4 mA (4)			Volts (0)			RW	Txt				US
07.022	Analog Output 2 Source	0.000 to 59.999			4.002			RW	Num			PT	US
07.023	Analog Output 2 Scaling	0.000 to 10.000			1.000			RW	Num				US
07.024	Analogue Output 2 Mode	Volts (0), 0-20 mA (1), 20-0 mA (2), 4-20 mA (3), 20-4 mA (4)			Volts (0)			RW	Txt				US
07.025	Calibrate Analog Input 1 Full Scale	Off (0) or On (1)			Off (0)			RW	Bit		NC		
07.026	Analogue Input 1 Fast Update Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
07.027	Analogue Input 2 Fast Update Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
07.028	Analog Input 1 Current Loop Loss	Off (0) or On (1)						RO	Bit	ND	NC	PT	
07.029	Analog Input 2 Current Loop Loss	Off (0) or On (1)						RO	Bit	ND	NC	PT	
07.030	Analog Input 1 Offset	±100.00 %			0.00 %			RW	Num				US
07.031	Analog Input 2 Offset	±100.00 %			0.00 %			RW	Num				US
07.033	Power Output	±100.0 %						RO	Num	ND	NC	PT	
07.034	Inverter Temperature	±250 °C						RO	Num	ND	NC	PT	
07.035	Percentage Of d.c. Link Thermal Trip Level	0 to 100 %						RO	Num	ND	NC	PT	
07.036	Percentage Of Drive Thermal Trip Level	0 to 100 %						RO	Num	ND	NC	PT	
07.037	Temperature Nearest To Trip Level	0 to 20999						RO	Num	ND	NC	PT	
07.038	Temperature Monitor Select 1	0 to 1999			1001			RW	Num				US
07.039	Temperature Monitor Select 2	0 to 1999			1002			RW	Num				US
07.040	Analog Input 1 Minimum	±100.00 %			0.00 %			RW	Num				US
07.041	Analog Input 2 Minimum	±100.00 %			0.00 %			RW	Num				US
07.043	Analog Input 1 Maximum	±100.00 %			100.00 %			RW	Num				US
07.044	Analog Input 2 Maximum	±100.00 %			100.00 %			RW	Num				US
07.051	Analog Input 1 Full Scale	0 to 65535						RO	Num	ND	NC	PT	PS
07.052	Temperature Monitor Select 3	0 to 1999			1			RW	Num				US
07.053	Analog Input 1 Thermistor Type	DIN44082 (0), KTY84 (1), PT100 (2), PT1000 (3), PT2000 (4), NI1000 (5)			DIN44082 (0)			RW	Txt				US
07.054	Analog Input 1 Thermistor Feedback	0 to 5000 Ω						RO	Num	ND	NC	PT	
07.055	Analog Input 1 Thermistor Trip Threshold	0 to 5000 Ω			3300 Ω			RW	Num				US
07.056	Analog Input 1 Thermistor Reset Threshold	0 to 5000 Ω			1800 Ω			RW	Num				US
07.057	Analog Input 1 Thermistor Temperature	-50 to 300 °C						RO	Num	ND	NC	PT	
07.058	Analog Input 2 Thermistor Type	DIN44082 (0), KTY84 (1), PT100 (2), PT1000 (3), PT2000 (4), NI1000 (5)			DIN44082 (0)			RW	Txt				US
07.059	Analog Input 2 Thermistor Feedback	0 to 5000 Ω						RO	Num	ND	NC	PT	
07.060	Analog Input 2 Thermistor Trip Threshold	0 to 5000 Ω			3300 Ω			RW	Num				US
07.061	Analog Input 2 Thermistor Reset Threshold	0 to 5000 Ω			1800 Ω			RW	Num				US
07.062	Analog Input 2 Thermistor Temperature	-50 to 300 °C						RO	Num	ND	NC	PT	

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Menu 7 Open-Loop and RFC logic diagrams



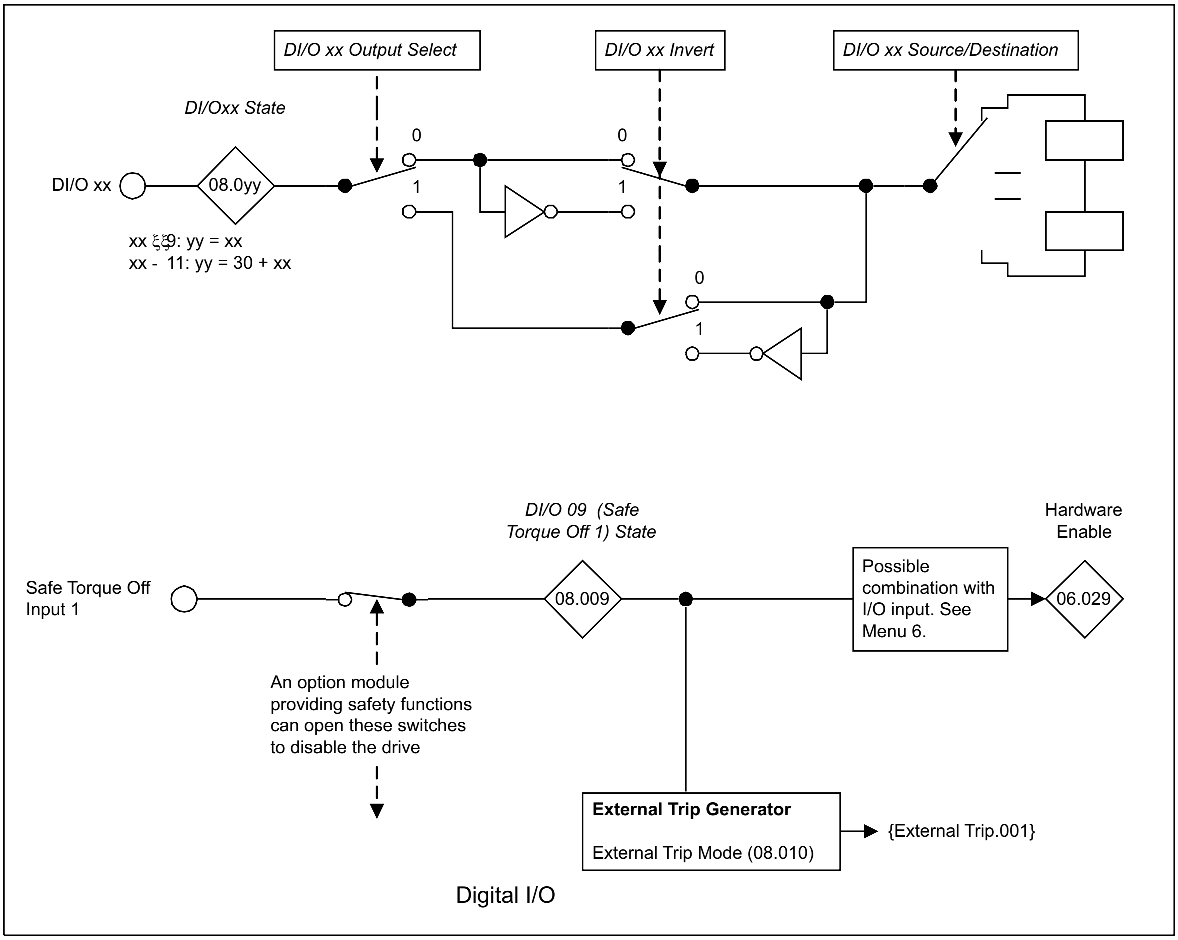
10.9 Menu 8: Digital I/O

Menu 8 Single line descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
08.001	Digital I/O 01 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.002	Digital I/O 02 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.003	Digital I/O 03 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.004	Digital Input 04 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.005	Digital Input 05 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.006	Digital Input 06 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.007	Relay Output State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.008	24V Supply Output State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.009	STO Input 01 State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.010	External Trip Mode	Disable (0), STO 1 (1), STO 2 (2), STO 1 OR STO 2 (3)			Disable (0)			RW	Txt				US
08.011	Digital I/O 01 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.012	Digital I/O 02 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.013	Digital I/O 03 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.014	Digital Input 04 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.015	Digital Input 05 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.016	Digital Input 06 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.017	Relay Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.018	24V Supply Output Invert	Not Invert (0), Invert (1)			Invert (1)			RW	Txt				US
08.020	Digital I/O Read Word	0 to 511						RO	Num	ND	NC	PT	
08.021	Digital I/O 01 Source/Destination	0.000 to 59.999			1.011			RW	Num	DE		PT	US
08.022	Digital I/O 02 Source/Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
08.023	Digital I/O 03 Source/Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
08.024	Digital Input 04 Destination	0.000 to 59.999			29.013			RW	Num	DE		PT	US
08.025	Digital Input 05 Destination	0.000 to 59.999			29.015			RW	Num	DE		PT	US
08.026	Digital Input 06 Destination	0.000 to 59.999			29.086			RW	Num	DE		PT	US
08.027	Relay Output Source	0.000 to 59.999			10.001			RW	Num			PT	US
08.028	24V Supply Output Source	0.000 to 59.999			0.000			RW	Num			PT	US
08.029	Input Logic Polarity	Negative Logic (0), Positive Logic (1)			Positive Logic (1)			RW	Txt				US
08.031	Digital I/O 01 Output Select	Off (0) or On (1)			On (1)			RW	Bit				US
08.032	Digital I/O 02 Output Select	Off (0) or On (1)			Off (0)			RW	Bit				US
08.033	Digital I/O 03 Output Select	Off (0) or On (1)			Off (0)			RW	Bit				US
08.041	Keypad Run Button State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.042	Keypad Auxiliary Button State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.043	24V Supply Input State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.044	Keypad Stop Button State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.045	Relay 2 Output State	Off (0) or On (1)						RO	Bit	ND	NC	PT	
08.051	Keypad Run Button Invert/Toggle	Not Invert (0), Invert (1), Toggle (2)			Not Invert (0)			RW	Txt				US
08.052	Keypad Auxiliary Button Invert/Toggle	Not Invert (0), Invert (1), Toggle (2)			Not Invert (0)			RW	Txt				US
08.053	24V Supply Input Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.055	Relay 2 Invert	Not Invert (0), Invert (1)			Not Invert (0)			RW	Txt				US
08.061	Keypad Run Button Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
08.062	Keypad Auxiliary Button Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
08.063	24V Supply Input Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
08.065	Relay 2 Source	0.000 to 59.999			0.000			RW	Num			PT	US
08.071	Digital I/O Output Enable Register 1	0000000000000000 to 1111111111111111			0000000000000000			RW	Bin			PT	US
08.072	Digital I/O Input Register 1	0000000000000000 to 1111111111111111						RO	Bin	ND	NC	PT	
08.073	Digital I/O Output Register 1	0000000000000000 to 1111111111111111			0000000000000000			RW	Bin			PT	

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-14 Menu 8 Open-Loop and RFC logic diagrams



10.10 Menu 9: Programmable logic, motorized pot, binary sum and timers

Menu 9 Single line descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
09.001	Logic Function 1 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
09.002	Logic Function 2 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
09.003	Motorised Pot Output	±100.00 %						RO	Num	ND	NC	PT	PS
09.004	Logic Function 1 Source 1	0.000 to 59.999			0.000			RW	Num			PT	US
09.005	Logic Function 1 Source 1 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.006	Logic Function 1 Source 2	0.000 to 59.999			0.000			RW	Num			PT	US
09.007	Logic Function 1 Source 2 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.008	Logic Function 1 Output Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.009	Logic Function 1 Delay	±25.0 s			0.0 s			RW	Num				US
09.010	Logic Function 1 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
09.014	Logic Function 2 Source 1	0.000 to 59.999			0.000			RW	Num			PT	US
09.015	Logic Function 2 Source 1 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.016	Logic Function 2 Source 2	0.000 to 59.999			0.000			RW	Num			PT	US
09.017	Logic Function 2 Source 2 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.018	Logic Function 2 Output Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.019	Logic Function 2 Delay	±25.0 s			0.0 s			RW	Num				US
09.020	Logic Function 2 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
09.021	Motorised Pot Mode	0 to 4			0			RW	Num				US
09.022	Motorised Pot Bipolar Select	Off (0) or On (1)			Off (0)			RW	Bit				US
09.023	Motorised Pot Rate	0 to 250 s			20 s			RW	Num				US
09.024	Motorised Pot Scaling	0.000 to 4.000			1.000			RW	Num				US
09.025	Motorised Pot Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
09.026	Motorised Pot Up	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.027	Motorised Pot Down	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.028	Motorised Pot Reset	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.029	Binary Sum Ones	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.030	Binary Sum Twos	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.031	Binary Sum Fours	Off (0) or On (1)			Off (0)			RW	Bit		NC		
09.032	Binary Sum Output	0 to 255						RO	Num	ND	NC	PT	
09.033	Binary Sum Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
09.034	Binary Sum Offset	0 to 248			0			RW	Num				US
09.035	Timer 1 Start Date	00-00-00 to 31-12-99			00-00-00			RW	Date				US
09.036	Timer 1 Start Time	00:00:00 to 23:59:59			00:00:00			RW	Time				US
09.037	Timer 1 Stop Date	00-00-00 to 31-12-99			00-00-00			RW	Date				US
09.038	Timer 1 Stop Time	00:00:00 to 23:59:59			00:00:00			RW	Time				US
09.039	Timer 1 Repeat Function	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)			None (0)			RW	Txt				US
09.040	Timer 1 Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
09.041	Timer 1 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.042	Timer 1 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
09.043	Timer 1 Destination	0.000 to 59.999			29.056			RW	Num	DE		PT	US
09.045	Timer 2 Start Date	00-00-00 to 31-12-99			00-00-00			RW	Date				US
09.046	Timer 2 Start Time	00:00:00 to 23:59:59			00:00:00			RW	Time				US
09.047	Timer 2 Stop Date	00-00-00 to 31-12-99			00-00-00			RW	Date				US
09.048	Timer 2 Stop Time	00:00:00 to 23:59:59			00:00:00			RW	Time				US
09.049	Timer 2 Repeat Function	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)			None (0)			RW	Txt				US
09.050	Timer 2 Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
09.051	Timer 2 Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
09.052	Timer 2 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
09.053	Timer 2 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-15 Menu 9 logic diagram: Logic Functions

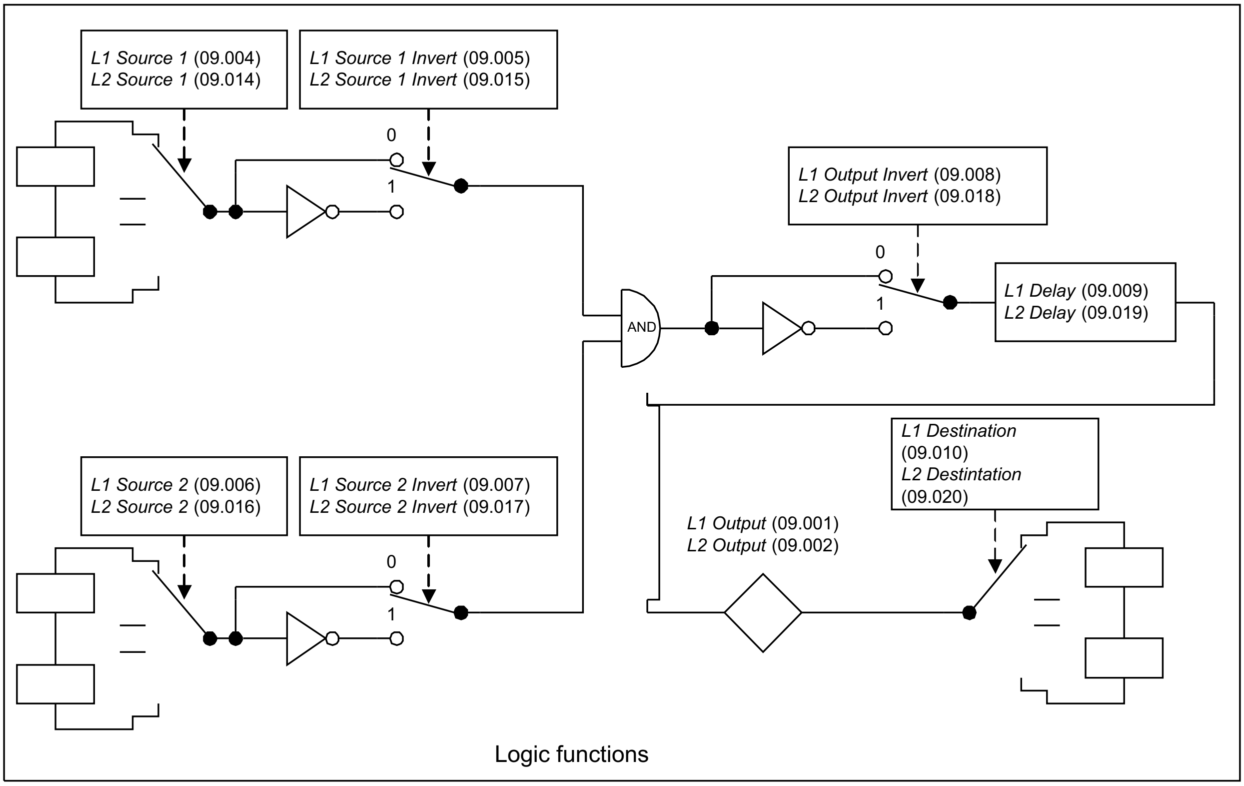


Figure 10-16 Menu 9 logic diagram: Motorised Pot

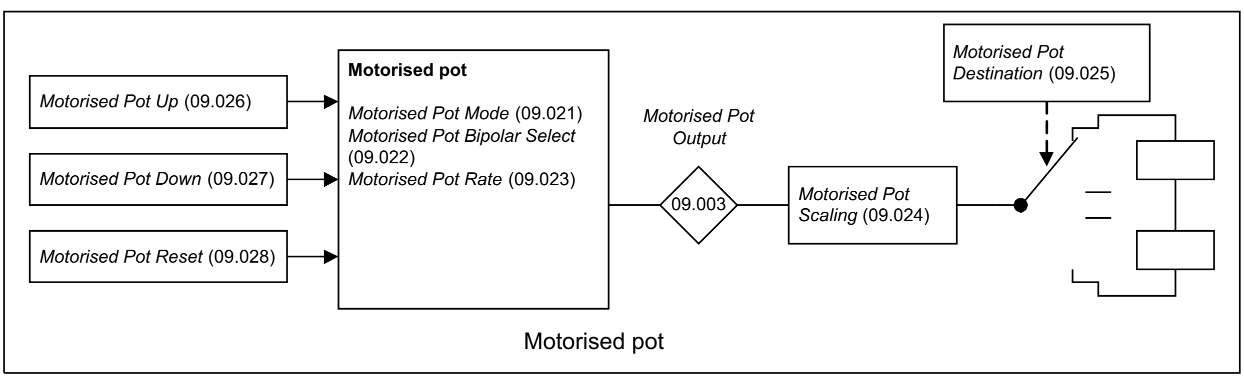


Figure 10-17 Menu 9 logic diagram: Binary Sum

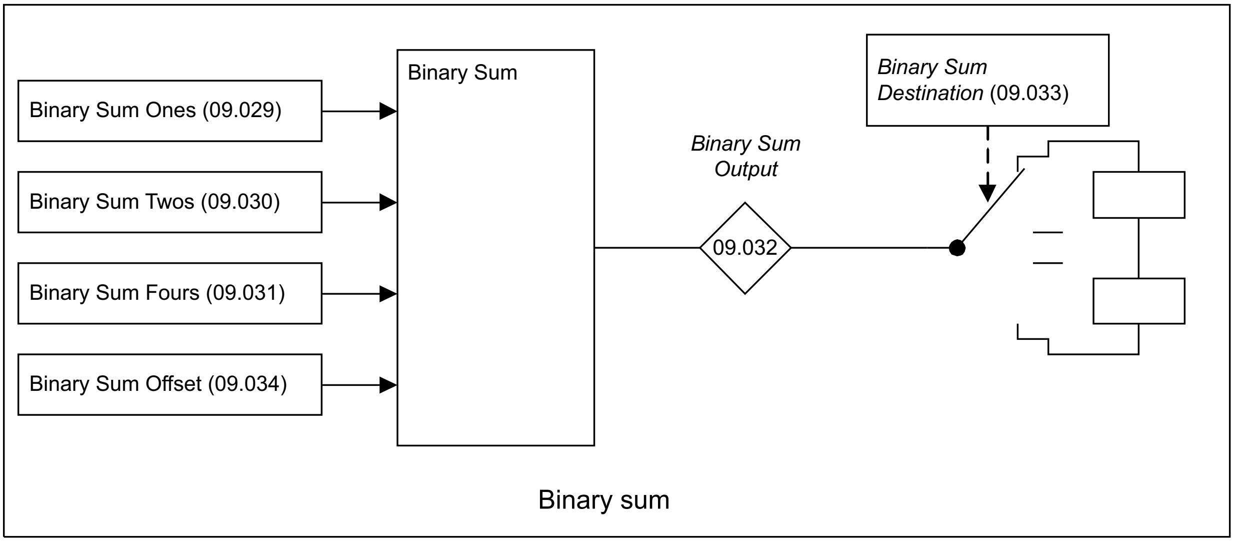
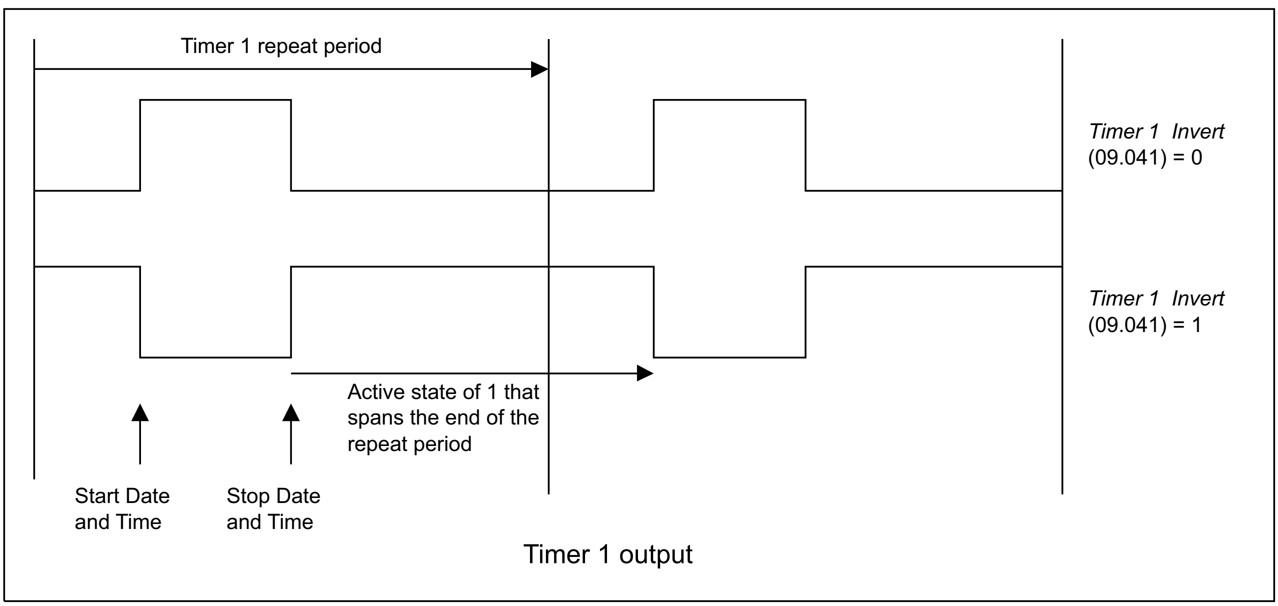


Figure 10-18 k



10.11 Menu 10: Status and trips

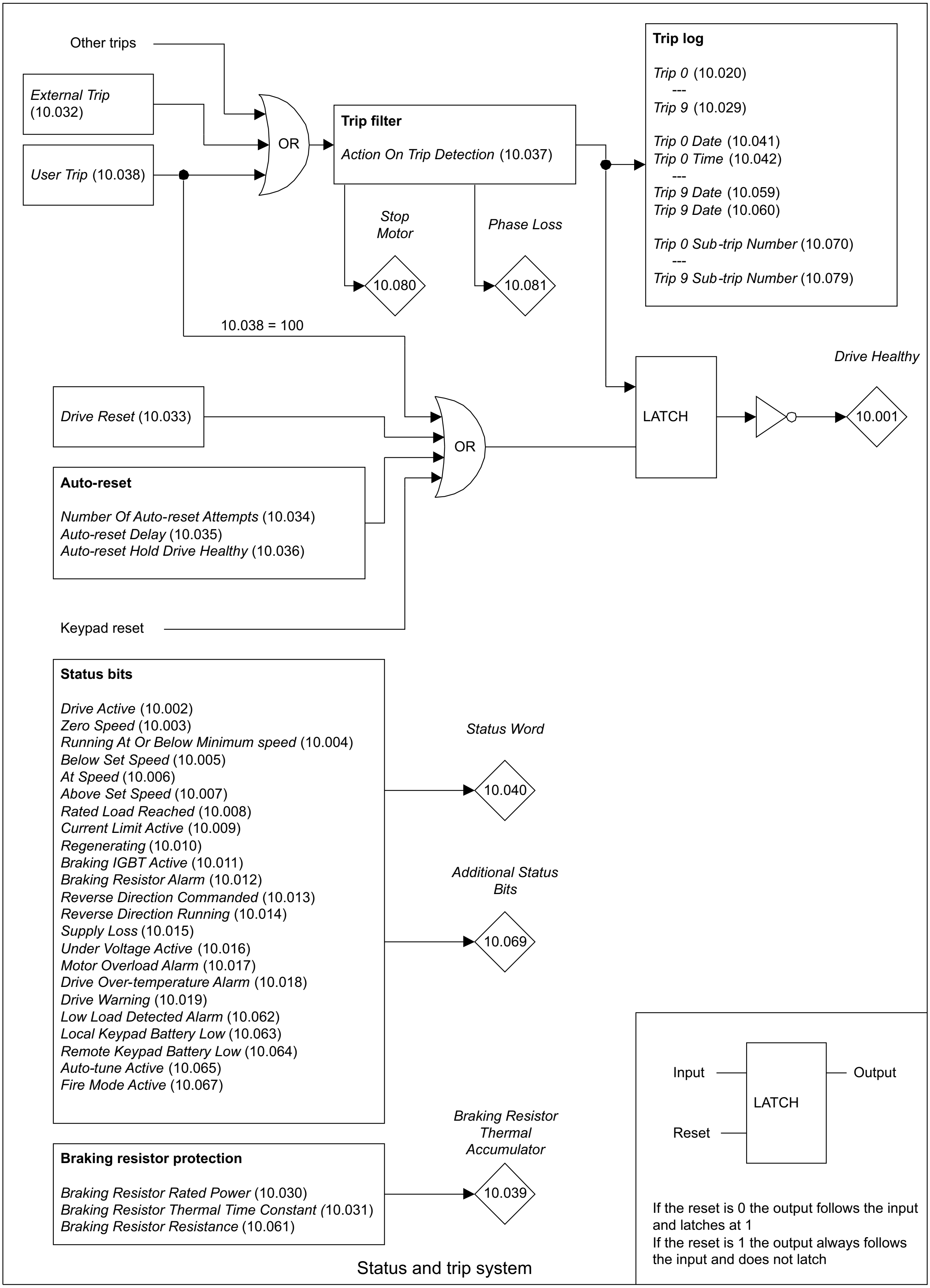
Menu 9 Single line descriptions

Parameter		Range Open-Loop	Range RFC-A	Range RFC-S	Default Open-Loop	Default RFC-A	Default RFC-S	Type					
10.001	Drive Healthy	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.002	Drive Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.003	Zero Speed	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.004	Running At Or Below Minimum Speed	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.005	Below Set Speed	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.006	At Speed	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.007	Above Set Speed	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.008	Rated Load Reached	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.009	Current Limit Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.010	Regenerating	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.011	Braking IGBT Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.012	Braking Resistor Alarm	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.013	Reverse Direction Commanded	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.014	Reverse Direction Running	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.015	Supply Loss	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.016	Under Voltage Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.017	Motor Overload Alarm	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.018	Drive Over-temperature Alarm	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.019	Drive Warning	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.020	Trip 0	0 to 255						RO	Txt	ND	NC	PT	PS
10.021	Trip 1	0 to 255						RO	Txt	ND	NC	PT	PS
10.022	Trip 2	0 to 255						RO	Txt	ND	NC	PT	PS
10.023	Trip 3	0 to 255						RO	Txt	ND	NC	PT	PS
10.024	Trip 4	0 to 255						RO	Txt	ND	NC	PT	PS
10.025	Trip 5	0 to 255						RO	Txt	ND	NC	PT	PS
10.026	Trip 6	0 to 255						RO	Txt	ND	NC	PT	PS
10.027	Trip 7	0 to 255						RO	Txt	ND	NC	PT	PS
10.028	Trip 8	0 to 255						RO	Txt	ND	NC	PT	PS
10.029	Trip 9	0 to 255						RO	Txt	ND	NC	PT	PS
10.030	Braking Resistor Rated Power	0.000 to 99999.999 kW			0.000 kW			RW	Num				US
10.031	Braking Resistor Thermal Time Constant	0.000 to 1500.000 s			0.000 s			RW	Num				US
10.032	External Trip	Off (0) or On (1)			Off (0)			RW	Bit		NC		
10.033	Drive Reset	Off (0) or On (1)			Off (0)			RW	Bit		NC		
10.034	Number Of Auto-reset Attempts	None (0), 1 (1), 2 (2), 3 (3), 4 (4), 5 (5), Infinite (6)			5 (5)			RW	Txt				US
10.035	Auto-reset Delay	1.0 to 600.0 s			10.0 s			RW	Num				US
10.036	Auto-reset Hold Drive Healthy	Off (0) or On (1)			Off (0)			RW	Bit				US
10.037	Action On Trip Detection	00000 to 11111			00000			RW	Bin				US
10.038	User Trip	0 to 255						RW	Num	ND	NC		
10.039	Braking Resistor Thermal Accumulator	0.0 to 100.0 %						RO	Num	ND	NC	PT	
10.040	Status Word	000000000000000 to 111111111111111						RO	Bin	ND	NC	PT	
10.041	Trip 0 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.042	Trip 0 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.043	Trip 1 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.044	Trip 1 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.045	Trip 2 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.046	Trip 2 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.047	Trip 3 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.048	Trip 3 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.049	Trip 4 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.050	Trip 4 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.051	Trip 5 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.052	Trip 5 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.053	Trip 6 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.054	Trip 6 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.055	Trip 7 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.056	Trip 7 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.057	Trip 8 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.058	Trip 8 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.059	Trip 9 Date	00-00-00 to 31-12-99						RO	Date	ND	NC	PT	PS
10.060	Trip 9 Time	00:00:00 to 23:59:59						RO	Time	ND	NC	PT	PS
10.061	Braking Resistor Resistance	0.00 to 10000.00 Ω			0.00 Ω			RW	Num				US
10.062	Low Load Detected Alarm	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.063	Local Keypad Battery Low	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.064	Remote Keypad Battery Low	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.065	Auto-tune Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	
10.067	Fire Mode Active	Off (0) or On (1)						RO	Bit	ND	NC	PT	

10.068	Hold Drive Healthy on Under Voltage	Off (0) or On (1)	Off (0)	RW	Bit				US
10.069	Additional Status Bits	0000000000 to 1111111111		RO	Bin	ND	NC	PT	
10.070	Trip 0 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.071	Trip 1 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.072	Trip 2 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.073	Trip 3 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.074	Trip 4 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.075	Trip 5 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.076	Trip 6 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.077	Trip 7 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.078	Trip 8 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.079	Trip 9 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.080	Stop Motor	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.081	Phase Loss	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.082	Miscellaneous Status Flags	000000000000000 to 111111111111111		RO	Bin	ND	NC	PT	
10.101	Drive Status	Inhibit (0), Ready (1), Stop (2), Scan (3), Run (4), Supply Loss (5), Deceleration (6), dc Injection (7), Position (8), Trip (9), Active (10), Off (11), Hand (12), Auto (13), Heat (14), Under Voltage (15), Phasing (16)		RO	Txt	ND	NC	PT	
10.102	Trip Reset Source	0 to 1023		RO	Num	ND	NC	PT	PS
10.103	Trip Time Identifier	-2147483648 to 2147483647 ms		RO	Num	ND	NC	PT	
10.104	Active Alarm	None (0), Brake Resistor (1), Motor Overload (2), Ind Overload (3), Drive Overload (4), Auto Tune (5), Limit Switch (6), Fire Mode (7), Low Load (8), Option Slot 1 (9), Option Slot 2 (10), Option Slot 3 (11), Option Slot 4 (12)		RO	Txt	ND	NC	PT	
10.106	Potential Drive Damage Conditions	0000 to 1111		RO	Bin	ND	NC	PT	PS
10.107	Auto-tune State	Not Active (0), Resistance (1), pLs (2), Ls (3), Flux (4), Flux Repeat (5), Ld Lq No-load (6), Lq (7), Ke (8), Inertia (9)		RO	Txt	ND	NC	PT	

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Menu 10 logic diagram



10.12 Menu 11: *Miscellaneous*

Menu 11 Single Line Descriptions

Parameter		Range (Open-Loop, RFC-A, RFC-S)	Default (Open-Loop, RFC-A, RFC-S)	Type					
11.018	Status Mode Parameter 1	0.000 to 59.999	29.003	RW	Num			PT	US
11.019	Status Mode Parameter 2	0.000 to 59.999	2.001	RW	Num			PT	US
11.020	Reset Serial Communications	Off (0) or On (1)		RW	Bit	ND	NC		
11.021	Parameter 00.030 Scaling	0.000 to 10.000	1.000	RW	Num				US
11.022	Parameter Displayed At Power-up	0.000 to 0.080	0.004	RW	Num			PT	US
11.023	Serial Address	1 to 247	1	RW	Num				US
11.024	Serial Mode	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)	8 2 NP (0)	RW	Txt				US
11.025	Serial Baud Rate	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 115200 (10)	19200 (6)	RW	Txt				US
11.026	Minimum Comms Transmit Delay	0 to 250 ms	2 ms	RW	Num				US
11.027	Silent Period	0 to 250 ms	0 ms	RW	Num				US
11.028	Drive Derivative	0 to 255		RO	Num	ND	NC	PT	
11.029	Software Version	0 to 99999999		RO	Num	ND	NC	PT	
11.030	User Security Code	0 to 2147483647		RW	Num	ND	NC	PT	US
11.031	Motor Control Mode	Open-loop (1), RFC-A (2), RFC-S (3)		RW	Txt	ND	NC	PT	
11.033	Drive Rated Voltage	200V (0), 400V (1), 575V (2), 690V (3)		RO	Txt	ND	NC	PT	
11.034	Software Sub-version	0 to 99		RO	Num	ND	NC	PT	
11.035	Number Of Power Modules Test	-1 to 20	-1	RW	Num				US
11.036	NV Media Card File Previously Loaded	0 to 999	0	RO	Num		NC	PT	
11.037	NV Media Card File Number	0 to 999	0	RW	Num				
11.038	NV Media Card File Type	None (0), Open-loop (1), RFC-A (2), RFC-S (3), Regen (4), User Prog (5)		RO	Txt	ND	NC	PT	
11.039	NV Media Card File Version	0 to 9999		RO	Num	ND	NC	PT	
11.041	NV Media Card Disable Booting	Off (0) or On (1)	Off (0)	RW	Bit				US
11.042	Parameter Cloning	None (0), Read (1), Program (2), Auto (3), Boot (4)	None (0)	RW	Txt		NC		US
11.043	Load Defaults	None (0), Standard (1), US (2)	None (0)	RW	Txt		NC		
11.044	Menu Access Level	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)		RW	Txt	ND		PT	
11.046	Defaults Previously Loaded	0 to 2000		RO	Num	ND	NC	PT	US
11.052	Serial Number LS	000000000 to 999999999		RO	Num	ND	NC	PT	
11.053	Serial Number MS	0 to 999999999		RO	Num	ND	NC	PT	
11.054	Drive Date Code	0 to 65535		RO	Num	ND	NC	PT	
11.056	Option Slot Identifiers	1234 (0), 1243 (1), 1324 (2), 1342 (3), 1423 (4), 1432 (5), 4123 (6), 3124 (7), 4132 (8), 2134 (9), 3142 (10), 2143 (11), 3412 (12), 4312 (13), 2413 (14), 4213 (15), 2314 (16), 3214 (17), 2341 (18), 2431 (19), 3241 (20), 3421 (21), 4231 (22), 4321 (23)	1234 (0)	RW	Txt			PT	
11.060	Maximum Rated Current	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
11.061	Full Scale Current Kc	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
11.062	Power Board Software Version Number	0.00 to 99.99		RO	Num	ND	NC	PT	
11.063	Product Type	0 to 255		RO	Num	ND	NC	PT	
11.064	Product Identifier Characters	1177956400 to 2147483647		RO	Num	ND	NC	PT	
11.065	Drive Rating And Configuration	00000000 to 99999999		RO	Num	ND	NC	PT	
11.066	Power Stage Identifier	0 to 255		RO	Num	ND	NC	PT	
11.067	Control Board Identifier	0.000 to 65.535		RO	Num	ND	NC	PT	
11.068	Internal I/O Identifier	0 to 255		RO	Num	ND	NC	PT	
11.069	Position Feedback Interface Identifier	0 to 255		RO	Num	ND	NC	PT	
11.070	Core Parameter Database Version	0.00 to 99.99		RO	Num	ND	NC	PT	
11.071	Number Of Power Modules Detected	0 to 20		RO	Num	ND	NC	PT	US
11.072	NV Media Card Create Special File	0 to 1	0	RW	Num		NC		

11.073	NV Media Card Type	None (0), SMART Card (1), SD Card (2)		RO	Txt	ND	NC	PT	
11.075	NV Media Card Read-only Flag	Off (0) or On (1)		RO	Bit	ND	NC	PT	
11.076	NV Media Card Warning Suppression Flag	Off (0) or On (1)		RO	Bit	ND	NC	PT	
11.077	NV Media Card File Required Version	0 to 9999		RW	Num	ND	NC	PT	
11.078	NV Media Card Action Status	None (0), Active (1), Card Slot 1 (2), Card Slot 2 (3), Card Slot 3 (4), Card Slot 4 (5), Card Product (6), Card User Prog (7), Card Busy (8), Card Data Exists (9), Card Option (10), Card Read Only (11), Card Error (12), Card No Data (13), Card Full (14), Card File Error (15), Card Rating (16), Card File Data (17), Card Derivative (18)		RO	Txt	ND	NC	PT	
11.079	Drive Name Characters 1-4	-2147483648 to 2147483647	0	RW	Num			PT	US
11.080	Drive Name Characters 5-8	-2147483648 to 2147483647	0	RW	Num			PT	US
11.081	Drive Name Characters 9-12	-2147483648 to 2147483647	0	RW	Num			PT	US
11.082	Drive Name Characters 13-16	-2147483648 to 2147483647	0	RW	Num			PT	US
11.084	Drive Mode	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)		RO	Txt	ND	NC	PT	US
11.085	Security Status	None (0), Read-only (1), Status-only (2), No Access (3)		RO	Txt	ND	NC	PT	PS
11.086	Menu Access Status	Menu 0 (0), All Menus (1)		RO	Txt	ND	NC	PT	PS
11.090	Keypad Port Serial Address	1 to 16	1	RW	Num				US
11.091	Additional Identifier Characters 1	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.092	Additional Identifier Characters 2	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.093	Additional Identifier Characters 3	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.095	Number Of Rectifiers Detected	0 to 9		RO	Num	ND	NC	PT	
11.096	Number Of Rectifiers Expected	0 to 9	0	RW	Num				US

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

10.13 Menu 12: User Functions 2

Menu 12 Single line diagram

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
12.001	Threshold Detector 1 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
12.002	Threshold Detector 2 Output	Off (0) or On (1)						RO	Bit	ND	NC	PT	
12.003	Threshold Detector 1 Source	0.000 to 59.999			0.000			RW	Num			PT	US
12.004	Threshold Detector 1 Level	0.00 to 100.00 %			0.00 %			RW	Num				US
12.005	Threshold Detector 1 Hysteresis	0.00 to 25.00 %			0.00 %			RW	Num				US
12.006	Threshold Detector 1 Output Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
12.007	Threshold Detector 1 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
12.008	Variable Selector 1 Source 1	0.000 to 59.999			0.000			RW	Num			PT	US
12.009	Variable Selector 1 Source 2	0.000 to 59.999			0.000			RW	Num			PT	US
12.010	Variable Selector 1 Mode	Input 1 (0), Input 2 (1), Add (2), Subtract (3), Multiply (4), Divide (5), Time Const (6), Ramp (7), Modulus (8), Powers (9), Sectional (10)			Input 1 (0)			RW	Txt				US
12.011	Variable Selector 1 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
12.012	Variable Selector 1 Output	±100.00 %						RO	Num	ND	NC	PT	
12.013	Variable Selector 1 Source 1 Scaling	±4.000			1.000			RW	Num				US
12.014	Variable Selector 1 Source 2 Scaling	±4.000			1.000			RW	Num				US
12.015	Variable Selector 1 Control	0.00 to 100.00			0.00			RW	Num				US
12.016	Variable Selector 1 Enable	Off (0) or On (1)			On (1)			RW	Bit				US
12.023	Threshold Detector 2 Source	0.000 to 59.999			0.000			RW	Num			PT	US
12.024	Threshold Detector 2 Level	0.00 to 100.00 %			0.00 %			RW	Num				US
12.025	Threshold Detector 2 Hysteresis	0.00 to 25.00 %			0.00 %			RW	Num				US
12.026	Threshold Detector 2 Output Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
12.027	Threshold Detector 2 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
12.028	Variable Selector 2 Source 1	0.000 to 59.999			0.000			RW	Num			PT	US
12.029	Variable Selector 2 Source 2	0.000 to 59.999			0.000			RW	Num			PT	US
12.030	Variable Selector 2 Mode	Input 1 (0), Input 2 (1), Add (2), Subtract (3), Multiply (4), Divide (5), Time Const (6), Ramp (7), Modulus (8), Powers (9), Sectional (10)			Input 1 (0)			RW	Txt				US
12.031	Variable Selector 2 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
12.032	Variable Selector 2 Output	±100.00 %						RO	Num	ND	NC	PT	
12.033	Variable Selector 2 Source 1 Scaling	±4.000			1.000			RW	Num				US
12.034	Variable Selector 2 Source 2 Scaling	±4.000			1.000			RW	Num				US
12.035	Variable Selector 2 Control	0.00 to 100.00			0.00			RW	Num				US
12.036	Variable Selector 2 Enable	Off (0) or On (1)			On (1)			RW	Bit				US

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-19 Menu 12 Single Line Descriptions: Threshold detectors

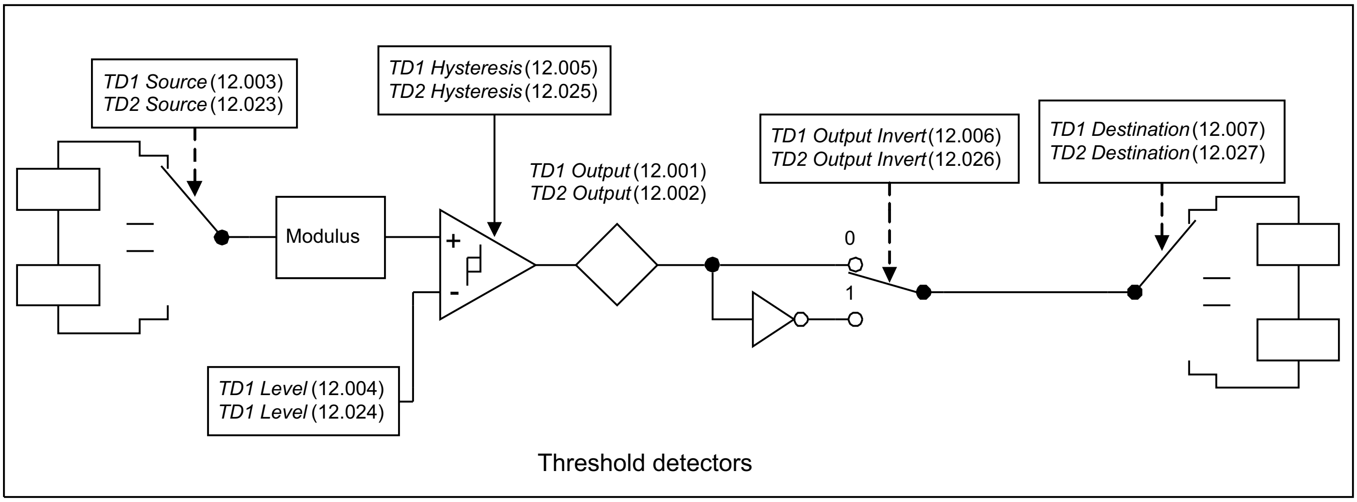
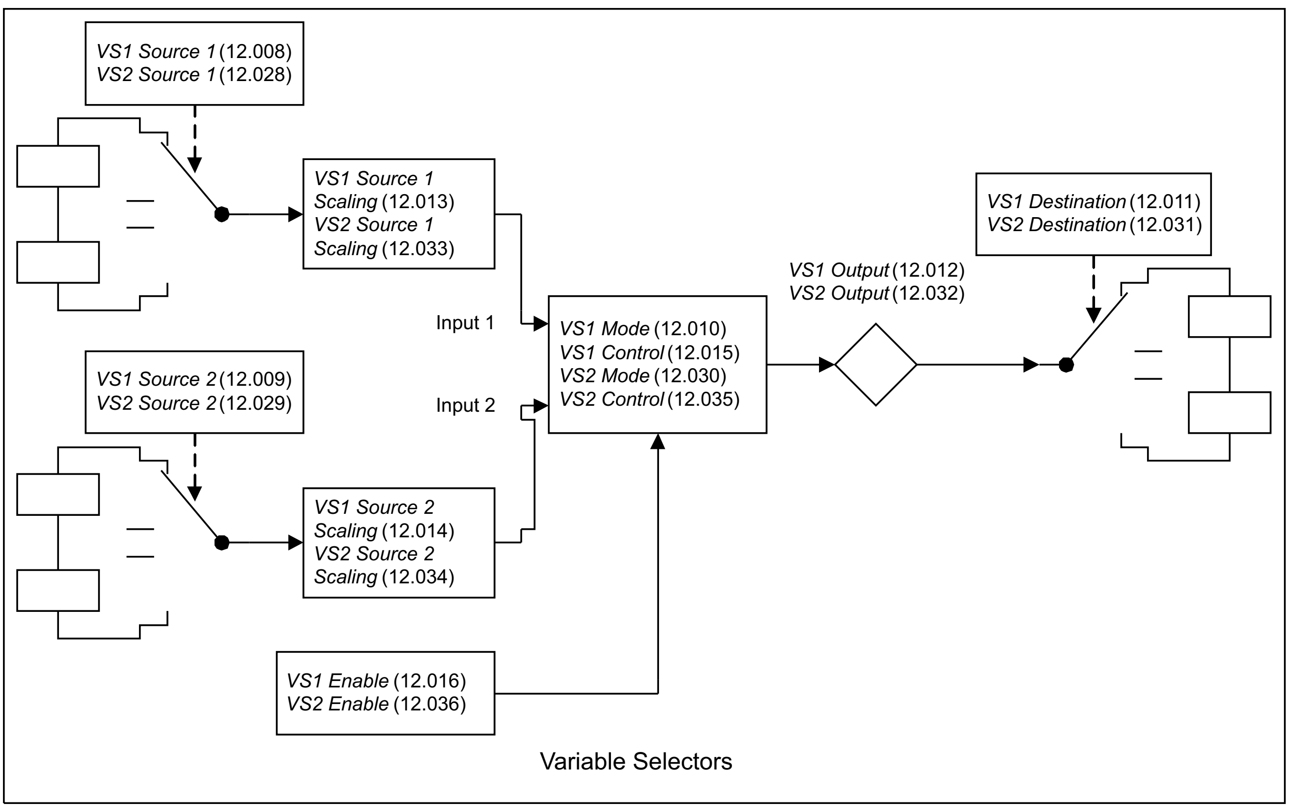


Figure 10-20 Menu 12 Single Line Descriptions: Variable Selectors



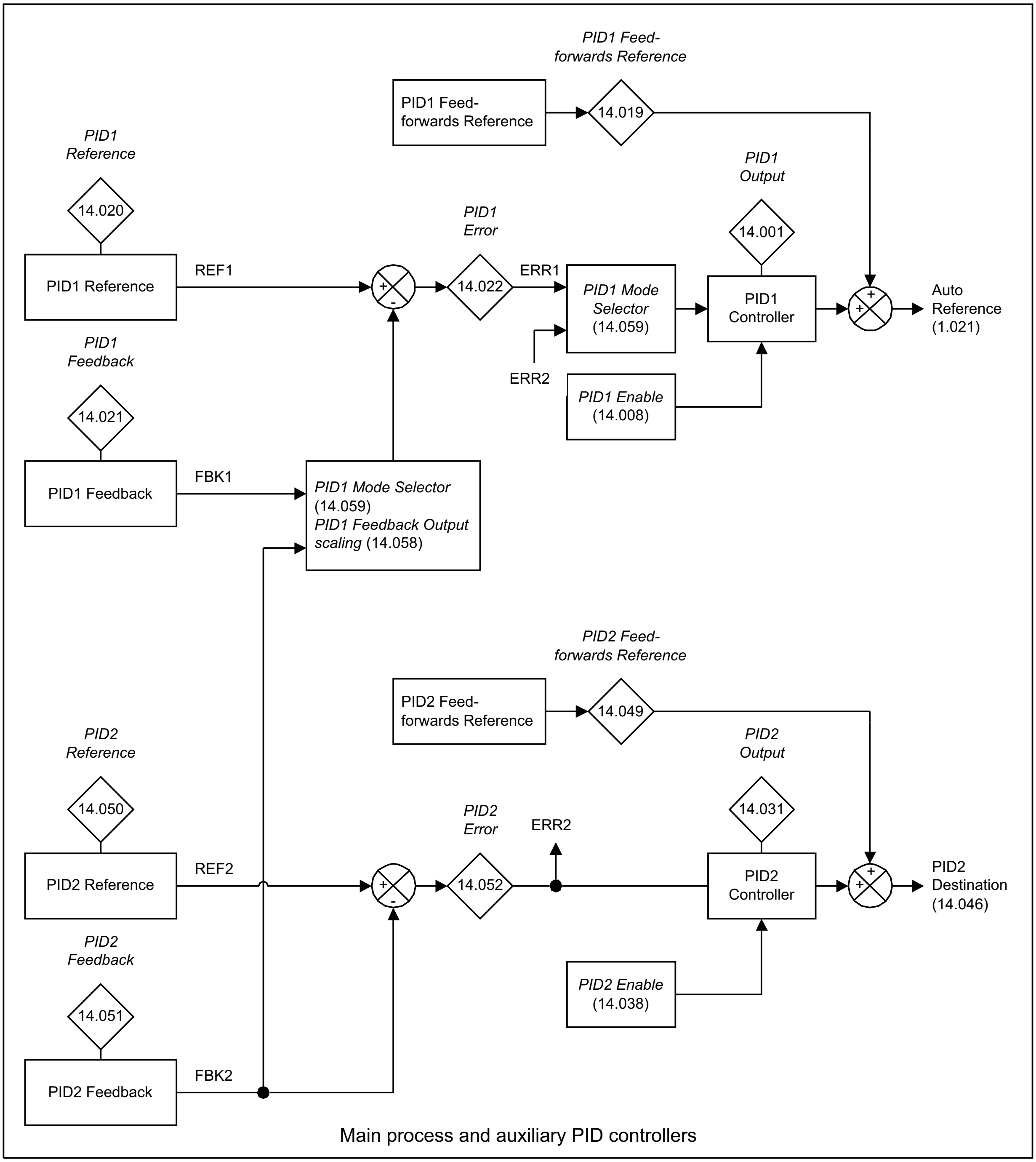
10.14 Menu 14: User PID controller

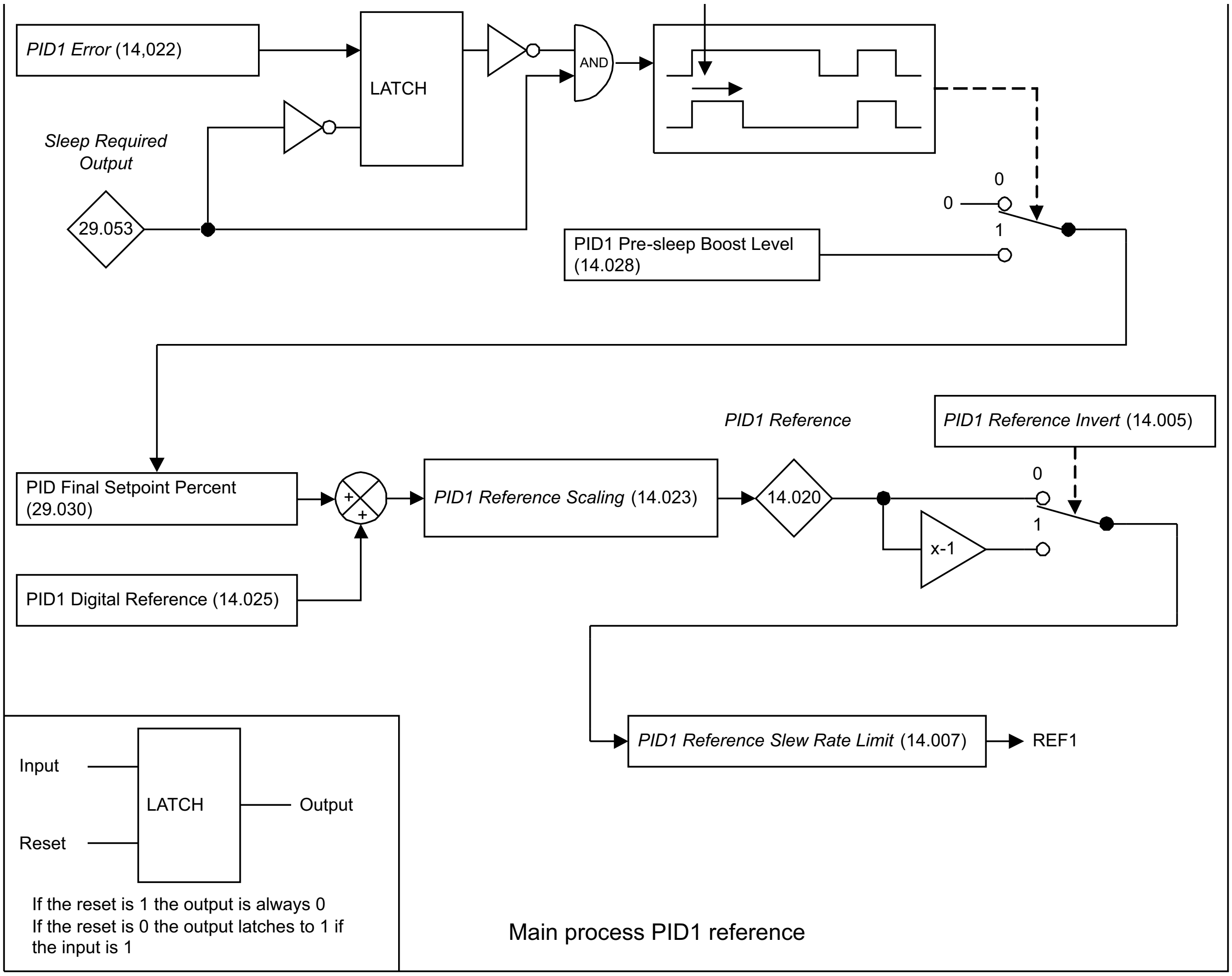
Menu 14 Single line Descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
14.001	PID1 Output	±100.00 %						RO	Num	ND	NC	PT	
14.002	PID1 Feed-forwards Reference Source	0.000 to 59.999			0.000			RW	Num			PT	US
14.003	PID1 Reference Source	0.000 to 59.999			29.030			RW	Num			PT	US
14.004	PID1 Feedback Source	0.000 to 59.999			29.035			RW	Num			PT	US
14.005	PID1 Reference Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
14.006	PID1 Feedback Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
14.007	PID1 Reference Slew Rate	0.0 to 3200.0 s			0.0 s			RW	Num				US
14.008	PID1 Enable	Off (0) or On (1)			On (1)			RW	Bit				US
14.009	PID1 Enable Source 1	0.000 to 59.999			29.038			RW	Num			PT	US
14.010	PID1 Proportional Gain	0.000 to 4.000			2.000			RW	Num				US
14.011	PID1 Integral Gain	0.000 to 4.000			1.000			RW	Num				US
14.012	PID1 Differential Gain	0.000 to 4.000			0.000			RW	Num				US
14.013	PID1 Output Upper Limit	0.00 to 100.00 %			100.00 %			RW	Num				US
14.014	PID1 Output Lower Limit	±100.00 %			0.00 %			RW	Num				US
14.015	PID1 Output Scaling	0.000 to 4.000			1.000			RW	Num				US
14.016	PID1 Destination	0.000 to 59.999			1.021			RW	Num	DE		PT	US
14.017	PID1 Integral Hold	Off (0) or On (1)			Off (0)			RW	Bit				
14.018	PID1 Symmetrical Limit Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
14.019	PID1 Feed-forwards Reference	±100.00 %						RO	Num	ND	NC	PT	
14.020	PID1 Reference	±100.00 %						RO	Num	ND	NC	PT	
14.021	PID1 Feedback	±100.00 %						RO	Num	ND	NC	PT	
14.022	PID1 Error	±100.00 %						RO	Num	ND	NC	PT	
14.023	PID1 Reference Scaling	0.000 to 4.000			1.000			RW	Num				US
14.024	PID1 Feedback Scaling	0.000 to 4.000			1.000			RW	Num				US
14.025	PID1 Digital Reference	±100.00 %			0.00 %			RW	Num				US
14.026	PID1 Digital Feedback	±100.00 %			0.00 %			RW	Num				US
14.027	PID1 Enable Source 2	0.000 to 59.999			10.002			RW	Num			PT	US
14.028	PID1 Pre-sleep Boost Level	0.00 to 100.00 %			0.00 %			RW	Num				US
14.029	PID1 Pre-Sleep Maximum Boost Time	0.0 to 250.0 s			0.0 s			RW	Num				US
14.031	PID2 Output	±100.00 %						RO	Num	ND	NC	PT	
14.032	PID2 Feed-forwards Reference Source	0.000 to 59.999			0.000			RW	Num			PT	US
14.033	PID2 Reference Source	0.000 to 59.999			0.000			RW	Num			PT	US
14.034	PID2 Feedback Source	0.000 to 59.999			0.000			RW	Num			PT	US
14.035	PID2 Reference Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
14.036	PID2 Feedback Invert	Off (0) or On (1)			Off (0)			RW	Bit				US
14.037	PID2 Reference Slew Rate Limit	0.0 to 3200.0 s			0.0 s			RW	Num				US
14.038	PID2 Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
14.039	PID2 Enable Source 1	0.000 to 59.999			0.000			RW	Num			PT	US
14.040	PID2 Proportional Gain	0.000 to 4.000			1.000			RW	Num				US
14.041	PID2 Integral Gain	0.000 to 4.000			0.500			RW	Num				US
14.042	PID2 Differential Gain	0.000 to 4.000			0.000			RW	Num				US
14.043	PID2 Output Upper Limit	0.00 to 100.00 %			100.00 %			RW	Num				US
14.044	PID2 Output Lower Limit	±100.00 %			-100.00 %			RW	Num				US
14.045	PID2 Output Scaling	0.000 to 4.000			1.000			RW	Num				US
14.046	PID2 Destination	0.000 to 59.999			0.000			RW	Num	DE		PT	US
14.047	PID2 Integral Hold	Off (0) or On (1)			Off (0)			RW	Bit				
14.048	PID2 Symmetrical Limit Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
14.049	PID2 Feed-forwards Reference	±100.00 %						RO	Num	ND	NC	PT	
14.050	PID2 Reference	±100.00 %						RO	Num	ND	NC	PT	
14.051	PID2 Feedback	±100.00 %						RO	Num	ND	NC	PT	
14.052	PID2 Error	±100.00 %						RO	Num	ND	NC	PT	
14.053	PID2 Reference Scaling	0.000 to 4.000			1.000			RW	Num				US
14.054	PID2 Feedback Scaling	0.000 to 4.000			1.000			RW	Num				US
14.055	PID2 Digital Reference	±100.00 %			0.00 %			RW	Num				US
14.056	PID2 Digital Feedback	±100.00 %			0.00 %			RW	Num				US
14.057	PID2 Enable Source 2	0.000 to 59.999			0.000			RW	Num			PT	US
14.058	PID1 Feedback Output Scaling	0.000 to 4.000			1.000			RW	Num				US
14.059	PID1 Mode Selector	Fbk1 (0), Fbk2 (1), Fbk1 + Fbk2 (2), Min Fbk (3), Max Fbk (4), Av Fbk (5), Min Error (6), Max Error (7)			Fbk1 (0)			RW	Txt				US
14.060	PID1 Feedback Square Root Enable 1	Off (0) or On (1)			Off (0)			RW	Bit				US
14.061	PID2 Feedback Square Root Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
14.062	PID1 Feedback Square Root Enable 2	Off (0) or On (1)			Off (0)			RW	Bit				US

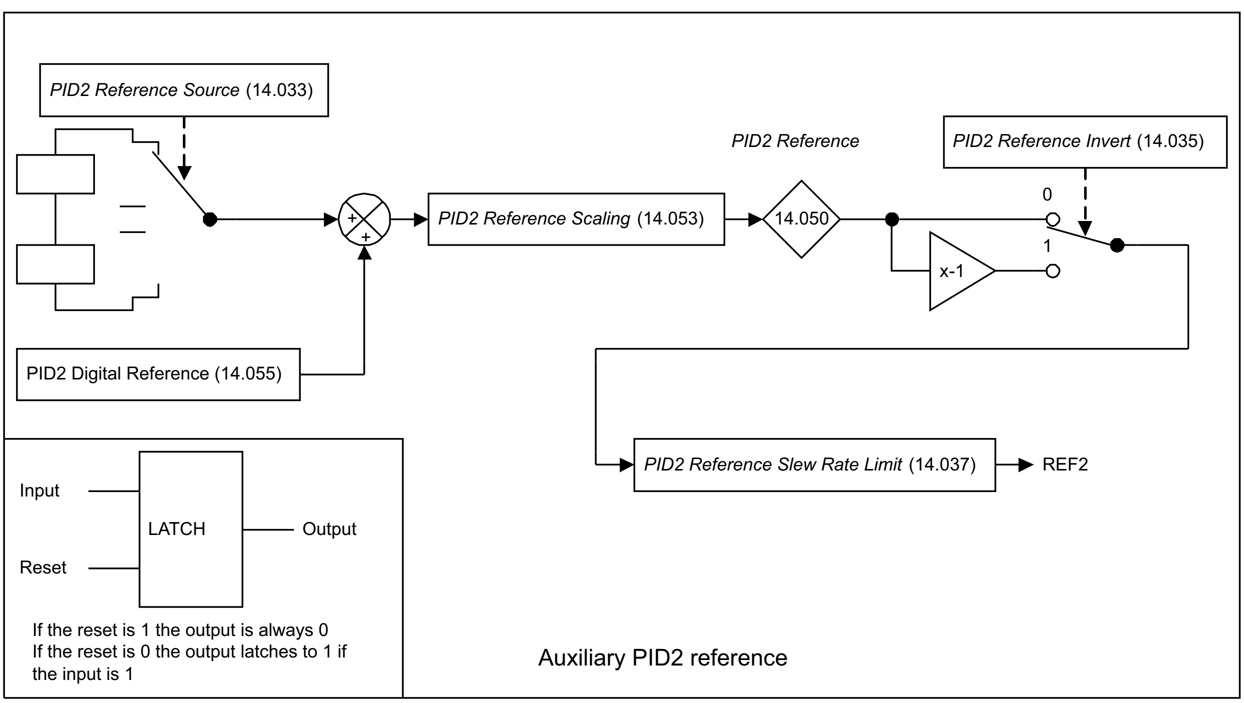
RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Figure 10-21 Menu 14 Logic diagrams

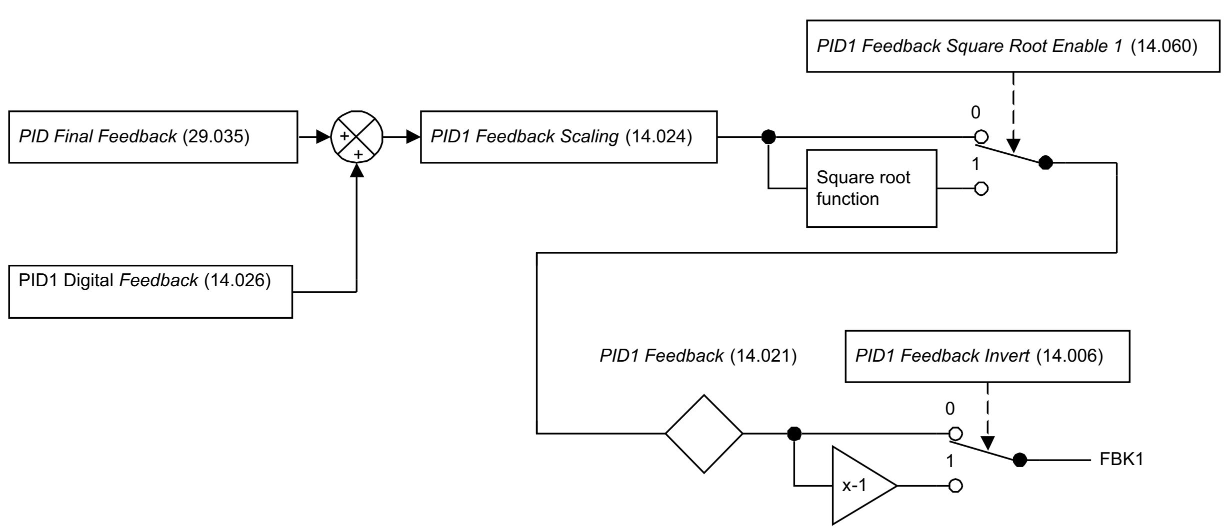




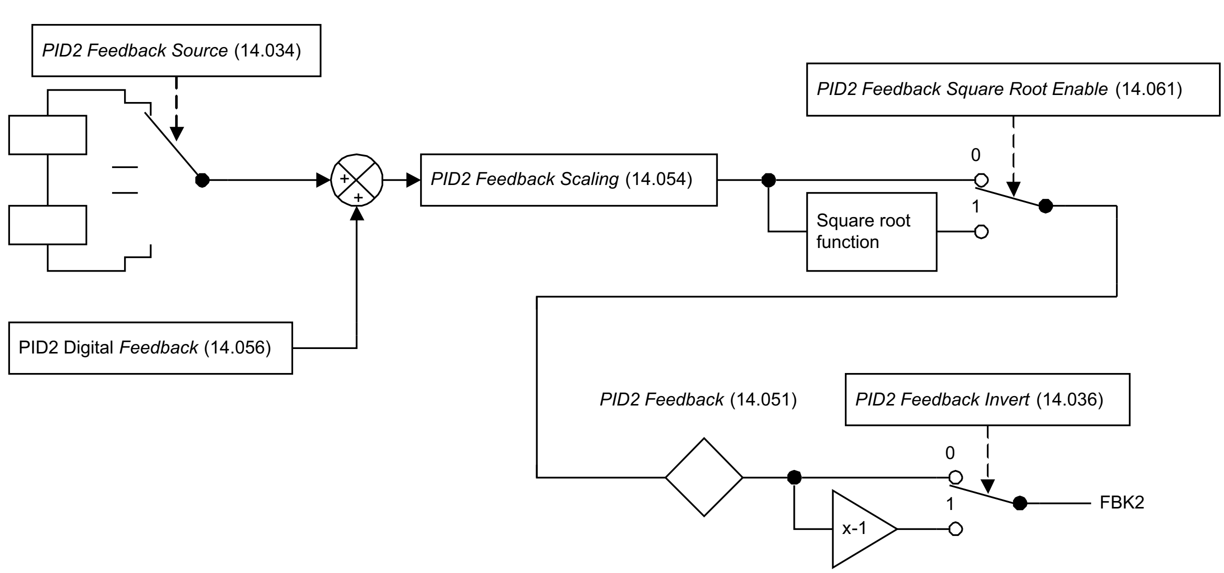
Main process PID1 reference



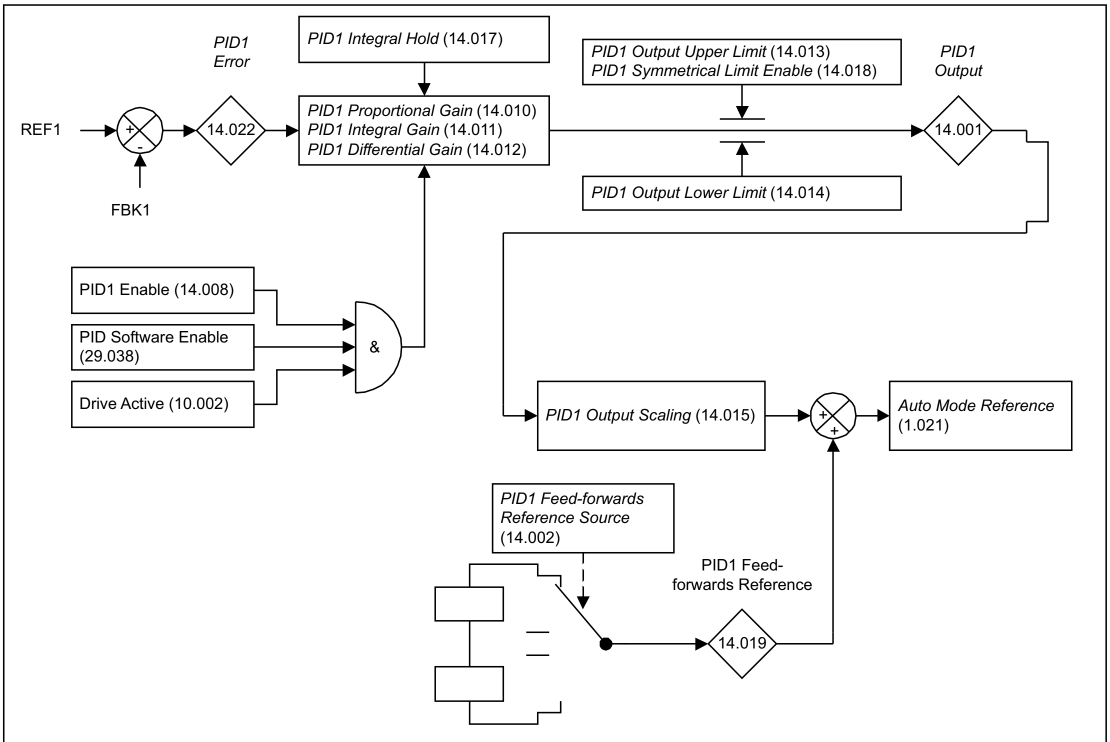
Auxiliary PID2 reference



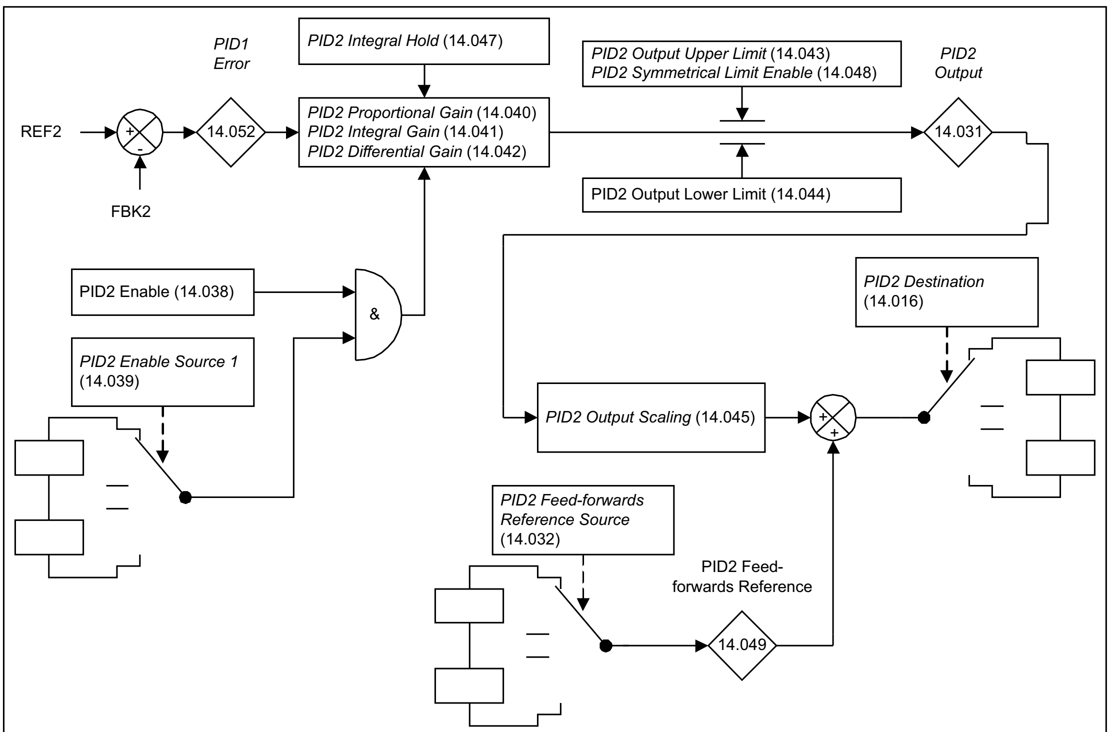
Main process PID1 feedback



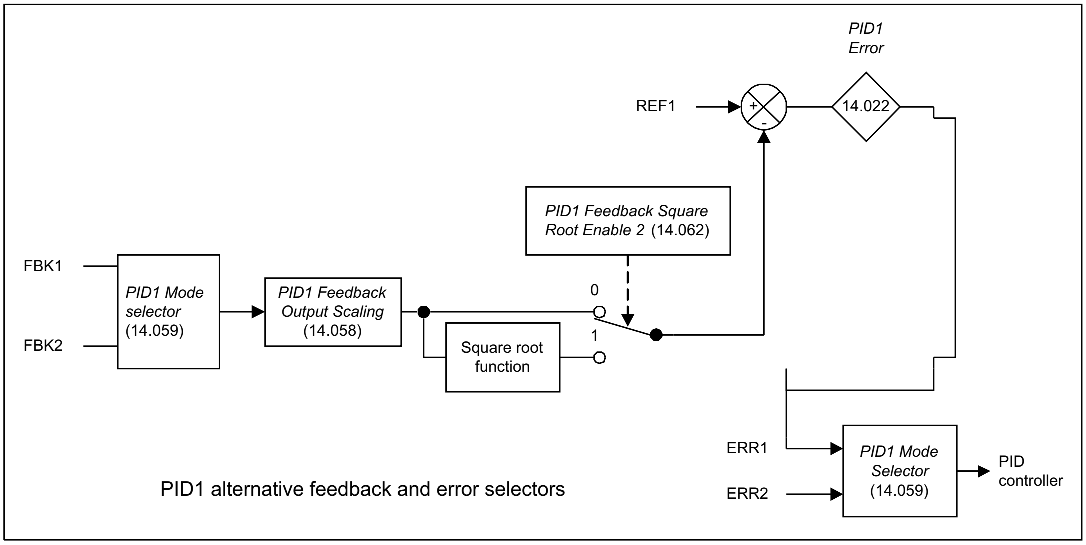
Auxiliary PID2 feedback



Main process PID1 controller (standard mode)

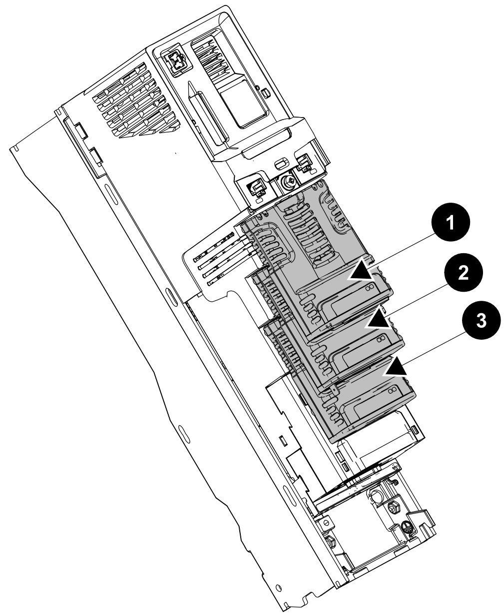


Auxiliary PID controller (standard mode)


PID1
Error
REF1
14.022
PID1 Feedback Square Root Enable 2 (14.062)
FBK1
FBK2
PID1 Mode selector (14.059)
PID1 Feedback Output Scaling (14.058)
0
1
Square root function
ERR1
ERR2
PID1 Mode Selector (14.059)
PID controller
PID1 alternative feedback and error selectors

10.15 Menus 15, 16 and 17: Option module set-up

Figure 10-22 Location of option module slots and their corresponding menu numbers



1. Solutions Module Slot 1 - Menu 15
2. Solutions Module Slot 2 - Menu 16
3. Solutions Module Slot 3 - Menu 17

10.15.1 Parameters common to all categories

Parameter		Range(⇕)	Default(⇨)	Type					
mm.001	Module ID	0 to 65535		RO	Num	ND	NC	PT	
mm.002	Software Version	00.00.00.00 to 99.99.99.99		RO	Num	ND	NC	PT	
mm.003	Hardware Version	0.00 to 99.99		RO	Num	ND	NC	PT	
mm.004	Serial Number LS	0 to 99999999		RO	Num	ND	NC	PT	
mm.005	Serial Number MS			RO	Num	ND	NC	PT	
mm.006	Module Status	-2 to 3		RO	Num	ND	NC	PT	
mm.007	Module Reset	Off (0) to On (1)	Off (0)	RW	Bit		NC		

The option module ID indicates the type of module that is installed in the corresponding slot. See the relevant option module user guide for more information regarding the module.

Option module ID	Module	Category
0	No module installed	
209	SI-I/O	Automation (I/O Expansion)
443	SI-PROFIBUS	Fieldbus
447	SI-DeviceNet	
448	SI-CANopen	
433	SI-Ethernet	
432	SI-PROFINET RT	
434	SI-PROFINET V2	
105	SI-Encoder	Feedback
106	SI-Universal Encoder	
311	MCi200	Automation (Applications)

10.16 Menu 18: Application menu 1

Parameter		Range(⇕) OL	Range(⇕) RFC-A / S	Default(⇨) OL	Default(⇨) RFC-A	Default(⇨) RFC-S	Type					
18.001	Application Menu 1 Power-down Save Integer	-32768 to 32767		0			RW	Num				PS
18.002 to 18.010	Application Menu 1 Read-only Integer	-32768 to 32767					RO	Num	ND	NC		US
18.011 to 18.030	Application Menu 1 Read-write Integer	-32768 to 32767		0			RW	Num				US
18.031 to 18.050	Application Menu 1 Read-write bit	Off (0) or On (1)		Off (0)			RW	Bit				US
18.051 to 18.054	Application Menu 1 Power-down Save long Integer	-2147483648 to 2147483647		0			RW	Num				PS

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination

10.17 Menu 19: Application menu 2

Parameter		Range(⇕) OL	Range(⇕) RFC-A / S	Default(⇨) OL	Default(⇨) RFC-A	Default(⇨) RFC-S	Type					
19.001	Application Menu 2 Power-down Save Integer	-32768 to 32767		0			RW	Num				PS
19.002 to 19.010	Application Menu 2 Read-only Integer	-32768 to 32767					RO	Num	ND	NC		US
19.011 to 19.030	Application Menu 2 Read-write Integer	-32768 to 32767		0			RW	Num				US
19.031 to 19.050	Application Menu 2 Read-write bit	Off (0) or On (1)		Off (0)			RW	Bit				US
19.051 to 19.054	Application Menu 2 Power-down Save long Integer	-2147483648 to 2147483647		0			RW	Num				PS

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination

10.18 Menu 20: Application menu 3

Parameter		Range(⇕) OL	Range(⇕) RFC-A / S	Default(⇨) OL	Default(⇨) RFC-A	Default(⇨) RFC-S	Type					
20.001 to 20.020	Application Menu 3 Read-write Integer	-32768 to 32767		0			RW	Num				
20.021 to 20.040	Application Menu 3 Read-write Long Integer	-2147483648 to 2147483647		0			RW	Num				

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination

10.19 Menu 22: Additional Menu 0 set-up

Parameter		Range(⇳)			Default(⇨)			Type					
		OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
22.001	Parameter 00.001 Set-up	0.000 to 59.999			11.044			RW	Num			PT	US
22.002	Parameter 00.002 Set-up				11.042			RW	Num			PT	US
22.003	Parameter 00.003 Set-up				0.000			RW	Num			PT	US
22.004	Parameter 00.004 Set-up				29.157			RW	Num			PT	US
22.005	Parameter 00.005 Set-up				5.006			RW	Num			PT	US
22.006	Parameter 00.006 Set-up				5.007			RW	Num			PT	US
22.007	Parameter 00.007 Set-up				5.008			RW	Num			PT	US
22.008	Parameter 00.008 Set-up				5.009			RW	Num			PT	US
22.009	Parameter 00.009 Set-up				5.010		0.000	RW	Num			PT	US
22.010	Parameter 00.010 Set-up				5.011			RW	Num			PT	US
22.011	Parameter 00.011 Set-up				5.015		0.000	RW	Num			PT	US
22.012	Parameter 00.012 Set-up				5.013	0.000		RW	Num			PT	US
22.013	Parameter 00.013 Set-up				0.000	5.012		RW	Num			PT	US
22.014	Parameter 00.014 Set-up				0.000		5.064	RW	Num			PT	US
22.015	Parameter 00.015 Set-up				0.000		5.071	RW	Num			PT	US
22.016	Parameter 00.016 Set-up				4.007	0.000		RW	Num			PT	US
22.017	Parameter 00.017 Set-up				29.087			RW	Num			PT	US
22.018	Parameter 00.018 Set-up				5.042			RW	Num			PT	US
22.019	Parameter 00.019 Set-up				0.000			RW	Num			PT	US
22.020	Parameter 00.020 Set-up				0.000			RW	Num			PT	US
22.021	Parameter 00.021 Set-up				29.011			RW	Num			PT	US
22.022	Parameter 00.022 Set-up				1.006			RW	Num			PT	US
22.023	Parameter 00.023 Set-up				1.004			RW	Num			PT	US
22.024	Parameter 00.024 Set-up				29.012			RW	Num			PT	US
22.025	Parameter 00.025 Set-up				29.016			RW	Num			PT	US
22.026	Parameter 00.026 Set-up				1.022			RW	Num			PT	US
22.027	Parameter 00.027 Set-up				2.011			RW	Num			PT	US
22.028	Parameter 00.028 Set-up				2.021			RW	Num			PT	US
22.029	Parameter 00.029 Set-up				29.022			RW	Num			PT	US
22.030	Parameter 00.030 Set-up				29.031			RW	Num			PT	US
22.031	Parameter 00.031 Set-up				29.032			RW	Num			PT	US
22.032	Parameter 00.032 Set-up				29.033			RW	Num			PT	US
22.033	Parameter 00.033 Set-up				29.048			RW	Num			PT	US
22.034	Parameter 00.034 Set-up				29.041			RW	Num			PT	US
22.035	Parameter 00.035 Set-up				29.042			RW	Num			PT	US
22.036	Parameter 00.036 Set-up				29.043			RW	Num			PT	US
22.037	Parameter 00.037 Set-up				29.044			RW	Num			PT	US
22.038	Parameter 00.038 Set-up				0.000			RW	Num			PT	US
22.039	Parameter 00.039 Set-up				0.000			RW	Num			PT	US
22.040	Parameter 00.040 Set-up				29.049			RW	Num			PT	US
22.041	Parameter 00.041 Set-up				29.050			RW	Num			PT	US
22.042	Parameter 00.042 Set-up				29.051			RW	Num			PT	US
22.043	Parameter 00.043 Set-up				29.052			RW	Num			PT	US
22.044	Parameter 00.044 Set-up				10.034			RW	Num			PT	US
22.045	Parameter 00.045 Set-up				10.035			RW	Num			PT	US

10.19 Menu 22: Additional Menu 0 set-up

Parameter		Range(⇳) OL	Range(⇳) RFC-A	Range(⇳) RFC-S	Default(⇨) OL	Default(⇨) RFC-A	Default(⇨) RFC-S	Type					
22.058	Parameter 00.058 Set-up	0.000 to 59.999			29.072			RW	Num			PT	US
22.059	Parameter 00.059 Set-up	0.000 to 59.999			29.073			RW	Num			PT	US
22.060	Parameter 00.060 Set-up	0.000 to 59.999			29.127			RW	Num			PT	US
22.061	Parameter 00.061 Set-up	0.000 to 59.999			29.128			RW	Num			PT	US
22.062	Parameter 00.062 Set-up	0.000 to 59.999			0.000			RW	Num			PT	US
22.063	Parameter 00.063 Set-up	0.000 to 59.999			0.000			RW	Num			PT	US
22.064	Parameter 00.064 Set-up	0.000 to 59.999			14.010			RW	Num			PT	US
22.065	Parameter 00.065 Set-up	0.000 to 59.999			14.011			RW	Num			PT	US
22.066	Parameter 00.066 Set-up	0.000 to 59.999			14.020			RW	Num			PT	US
22.067	Parameter 00.067 Set-up	0.000 to 59.999			14.021			RW	Num			PT	US
22.068	Parameter 00.068 Set-up	0.000 to 59.999			14.001			RW	Num			PT	US
22.069	Parameter 00.069 Set-up	0.000 to 59.999			5.001			RW	Num			PT	US
22.070	Parameter 00.070 Set-up	0.000 to 59.999			4.020			RW	Num			PT	US
22.071	Parameter 00.071 Set-up	0.000 to 59.999			5.003			RW	Num			PT	US
22.072	Parameter 00.072 Set-up	0.000 to 59.999			7.028			RW	Num			PT	US
22.073	Parameter 00.073 Set-up	0.000 to 59.999			29.003			RW	Num			PT	US
22.074	Parameter 00.074 Set-up	0.000 to 59.999			11.078			RW	Num			PT	US
22.075	Parameter 00.075 Set-up	0.000 to 59.999			29.036			RW	Num			PT	US
22.076	Parameter 00.076 Set-up	0.000 to 59.999			0.000			RW	Num			PT	US
22.077	Parameter 00.077 Set-up	0.000 to 59.999			29.001			RW	Num			PT	US
22.078	Parameter 00.078 Set-up	0.000 to 59.999			10.020			RW	Num			PT	US
22.079	Parameter 00.079 Set-up	0.000 to 59.999			10.021			RW	Num			PT	US
22.080	Parameter 00.080 Set-up	0.000 to 59.999			10.022			RW	Num			PT	US

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination

10.20 Menu 29: Pump Control

Menu 29 Single line Descriptions

Parameter		Range			Default			Type					
		Open-Loop	RFC-A	RFC-S	Open-Loop	RFC-A	RFC-S						
29.001	Pump Software Version	0 to 99999999						RW	Num	ND	NC	PT	
29.002	Total Run Time	0 to 65535 hours			0 hours			RW	Num		NC	PT	PS
29.003	Operating Status	Inhibit STO (0), Off (Ready) (1), Hand Run (2), Waking (3), Pipe Fill (4), Auto Run (5), Auto Run Leader (6), Auto Run Assist (7), Pre-sleep (8), Sleeping (9), Cleaning (10), Level Stop (11), Timer Stop (12), Hand Timeout (13), Over-cycle (14), Fbck Loss Run (15), Dry Well Run (16), Dry Well Stop (17), Auto Stop Assist (18)			Inhibit STO (0)			RW	Txt		NC	PT	
29.004	Volume	0 to 2147483647			0			RW	Num		NC	PT	
29.005	Flow	0.0 to 100000000.0			0.0			RW	Num		NC	PT	
29.006	Volume Scaling	0.000000 to 1000.000000			1.000000			RW	Num			PT	US
29.007	Flow Scaling	0.000000 to 1000.000000			1.000000			RW	Num			PT	US
29.008	Flow Meter Pulse Input	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.009	Flow Meter Pulse Count	0 to 2147483647			0			RW	Num		NC	PT	PS
29.010	Reset Volume Input	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.011	Pump Control Mode	Single Pump (0), Cascade (1), Multi-leader (2)			Single Pump (0)			RW	Txt				US
29.012	Control Input Mode	Input (0), Input & Keypad (1), Ctrl Wrd (2), Ctrl Wrd & Input (3)			Input & Keypad (1)			RW	Txt				US
29.013	Hand Select Input	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.015	Auto Select Input	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.016	Hand Mode Reference Select	Digital Speed (0), Analog Speed (1)			Digital Speed (0)			RW	Txt				US
29.017	Hand Mode Timeout	0.0 to 25.0 minutes			0.0 minutes			RW	Num				US
29.018	Auto Selected Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.019	Hand Selected Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.020	Auto Running Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.021	Auto Operational Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.022	PID Setpoint 0	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.023	PID Setpoint 1	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.024	PID Setpoint 2	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.025	PID Setpoint 3	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.026	PID Setpoint Select Input 0	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.027	PID Setpoint Select Input 1	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.028	PID Selected Setpoint	0.00 to 327.67 UU			0.00 UU			RW	Num		NC		
29.029	PID Final Setpoint	0.00 to 327.67 UU			0.00 UU			RW	Num		NC		
29.030	PID Final Setpoint Percent	0.00 to 100.00 %			0.00 %			RW	Num		NC		
29.031	PID Feedback Minimum Scaling	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.032	PID Feedback Maximum Scaling	0.01 to 327.67 UU	1.00 to 327.67 UU		100.00 UU			RW	Num				US
29.033	PID Feedback Filter Time Constant	0.00 to 327.67 s			1.00 s			RW	Num				US
29.034	PID Feedback Percent	±100.00 %			0.00 %			RW	Num				US
29.035	PID Final Feedback Percent	±100.00 %			0.00 %			RW	Num				US
29.036	PID Final Feedback	-327.68 to 327.67 UU			0.00 UU			RW	Num		NC		
29.037	PID Error	-327.68 to 327.67 UU			0.00 UU			RW	Num				
29.038	PID Software Enable	Off (0) or On (1)			Off (0)			RW	Bit		NC	PT	
29.039	PID Feedback High Alarm Threshold	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.040	PID Feedback High Alarm Output	Off (0) or On (1)			Off (0)			RW	Bit				
29.041	PID Feedback High Trip Threshold	0.00 to 327.67 UU			0.00 UU			RW	Num				US
29.042	PID Feedback Low Delay	0.0 to 6553.5 s			5.0 s			RW	Num				US
29.043	PID Feedback Low Mode	Disabled (0), Threshold (1), Bandwidth (2)			Disabled (0)			RW	Txt				US
29.044	PID Feedback Low Threshold	0.00 to 327.67 UU			2.00 UU			RW	Num				US
29.045	PID At Setpoint Band	0.00 to 327.67 UU			0.35 UU			RW	Num				US
29.046	PID At Setpoint Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.047	PID Feedback Low Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.048	PID Feedback Loss Action	Ignore (0), Trip (1), Fixed Speed (2)			Trip (1)			RW	Txt				US
29.049	Wake Detect Feedback Threshold	0.00 to 327.67 UU			1.00 UU			RW	Num				US
29.050	Wake Detect Delay	0.0 to 6553.5 s			5.0 s			RW	Num				US
29.051	Sleep Detect Speed Threshold	0.0 to 60.0	0.0 to 3000.0		25.0	750.0		RW	Num				US
29.052	Sleep Detect Delay	0.0 to 6553.5 s			5.0 s			RW	Num				US
29.053	Sleep Required Output	Off (0) or On (1)			Off (0)			RW	Bit		NC		
29.054	Sleep Active Output	Off (0), On (1)			Off (0)			RW	Txt		NC		
29.055	Time Schedule Run Input Enable	Off (0) or On (1)			Off (0)			RW	Bit				US
29.056	Time Schedule Run Input	Off (0), On (1)			Off (0)			RW	Txt		NC		
29.057	Dry Well Low Load Detection Threshold Percent	0.0 to 100.0 %			1.0 %			RW	Num				US
29.058	Dry Well Low Load Detection Delay	0.0 to 6553.5 s			5.0 s			RW	Num				US

29.059	Dry Well Low Load Mode	Disabled (0), Alarm Only (1), Trip (2), Lower PID Output (3)		Disabled (0)		RW	Txt				US
29.060	Dry Well Low Load PID Output Reduction	0.00 to 100.00 %		50.00 %		RW	Num				US
29.061	Dry Well Low Load Restart Delay	0.0 to 6553.5 s		5.0 s		RW	Num				US
29.062	Dry Well Low Load Alarm Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.063	Low Flow Meter Stop Threshold	0.0 to 214748364.7		0.0		RW	Num				US
29.064	Low Flow Meter Stop Delay	0.0 to 6553.5 s		5.0 s		RW	Num				US
29.065	Low Flow Meter Stop Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.066	Flow Switch Input	Off (0), On (1)		On (1)		RW	Txt		NC		US
29.067	No Flow Switch Delay	0.0 to 6553.5 s		5.0 s		RW	Num				US
29.068	No Flow Switch Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.069	No Flow Detection Threshold	0.0 to 60.0	0.0 to 3000.0	0.0		RW	Num				US
29.070	No Flow Detection Band	0.0 to 60.0	0.0 to 3000.0	5.0	150.0	RW	Num				US
29.071	No Flow Detection Delay	0.0 to 6553.5 s		5.0 s		RW	Num				US
29.072	No Flow Setpoint Settling Delay	0.0 to 6553.5 s		1.0 s		RW	Num				US
29.073	No Flow Setpoint Reduction	0.00 to 2.55 UU		0.06 UU		RW	Num				US
29.074	No Flow Output	Off (0), On (1)		Off (0)		RW	Txt				
29.075	Pipe Fill Mode	Disabled (0), Feedback Level (1), Flow Switch (2)		Disabled (0)		RW	Txt				US
29.076	Pipe Fill Threshold	0.00 to 327.67 UU		0.00 UU		RW	Num				US
29.077	Pipe Fill Maximum Time	0.0 to 6553.5 s		0.0 s		RW	Num				US
29.078	Pipe Fill Done Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.079	Level Switch High Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.080	Level Switch Low Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.081	Level Switch Hold Delay	0.0 to 6553.5 s		5.0 s		RW	Num				US
29.082	Level Switch Mode	High Only (0), High Low Toggle (1)		High Only (0)		RW	Txt				US
29.083	Maximum Drive Reference Band	0.0 to 60.0	0.0 to 3000.0	1.0	30.0	RW	Num				US
29.084	At Maximum Drive Reference	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.085	External Pump Fault Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.086	Motor Thermal Protection Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.087	Motor Thermal Protection Enable	Off (0) or On (1)		Off (0)		RW	Bit				US
29.088	Clean Manual Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.089	Clean On Start	Off (0) or On (1)		Off (0)		RW	Bit				US
29.090	Clean On Interval	Off (0) or On (1)		Off (0)		RW	Bit				US
29.091	Clean On Load Current Threshold	Off (0) or On (1)		Off (0)		RW	Bit				US
29.092	Clean On Motor Over-load	Off (0) or On (1)		Off (0)		RW	Bit				US
29.093	Cleaning Phase 1 Time At Reference	0.1 to 6553.5 s		15.0 s		RW	Num				US
29.094	Cleaning Phase 2 Time At Reference	0.1 to 6553.5 s		10.0 s		RW	Num				US
29.095	Cleaning Phase 3 Time At Reference	0.1 to 6553.5 s		10.0 s		RW	Num				US
29.096	Clean On Interval Time	1 to 65535 minutes		1440 minutes		RW	Num				US
29.097	Clean On Load Current Delay	0.1 to 6553.5 s		10.0 s		RW	Num				US
29.098	Clean On Load Current High Threshold	0.0 to 200.0 %		80.0 %		RW	Num				US
29.099	Clean On Load Current Low Threshold	0.0 to 50.0 %		10.0 %		RW	Num				US
29.100	Clean Per Hour Limit	1 to 30		5		RW	Num				US
29.101	Clean Per Hour Limit Mode	Alarm Only (0), Stop Cleaning (1), Trip (2)		Stop Cleaning (1)		RW	Txt				
29.102	Pre-clean Load Current	±1000.0 %		0.0 %		RW	Num		NC		
29.103	Post-clean Load Current	±1000.0 %		0.0 %		RW	Num		NC		
29.104	Clean Active Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.105	Clean Per Hour Alarm Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.106	Assist Control Mode	Run Only (0), Full I/O (1)		Run Only (0)		RW	Txt				US
29.107	Assist 1 Run Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.108	Assist 1 Ready Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.109	Assist 1 Running Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.110	Assist 1 Runtime	0 to 2147483647 minutes		0 minutes		RW	Num		NC		
29.111	Assist 1 Lockout Countdown	0.0 to 3600.0 s		0.0 s		RW	Num		NC		
29.112	Assist 1 Lockout Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.113	Assist 2 Run Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.114	Assist 2 Ready Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.115	Assist 2 Running Input	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.116	Assist 2 Runtime	0 to 2147483647 minutes		0 minutes		RW	Num		NC		
29.117	Assist 2 Lockout Countdown	0.0 to 3600.0 s		0.0 s		RW	Num		NC		
29.118	Assist 2 Lockout Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.119	Assist Last Failed Start	No Failed Starts (0), Assist 1 Fail (1), Assist 2 Fail (2)		No Failed Starts (0)		RW	Txt				
29.120	Assist Starts Per Hour	1 to 60		5		RW	Num				US
29.121	Assist Over-cycle Mode	Wait 1hr Cool (0), Trip (1)		Wait 1hr Cool (0)		RW	Txt				US
29.122	Add Assist Delay	0.0 to 6553.5 s		3.0 s		RW	Num				US
29.123	Add Assist Band	0.0 to 60.0	0.0 to 3000.0	1.0	30.0	RW	Num				US
29.124	Remove Assist Delay	0.0 to 6553.5 s		3.0 s		RW	Num				US
29.125	Alternation Time	0.0 to 3276.7 hours		24.0 hours		RW	Num				US
29.126	Alternation Time Elapsed	0.0 to 3276.7 hours		0.0 hours		RW	Num		NC		
29.127	Over-cycle Mode	Disabled (0), Alarm Only (1), Trip (2), Inc Setpoint (3)		Alarm Only (1)		RW	Txt				US
29.128	Over-cycle Starts Per Hour	0 to 255		5		RW	Num				US

29.129	Over-cycle Setpoint Increment	0.01 to 2.00 %		0.01 %		RW	Num				US
29.130	Over-cycle Setpoint Increment Maximum	0.01 to 15.00 %		0.60 %		RW	Num				US
29.131	Over-cycle Alarm Output	Off (0), On (1)		Off (0)		RW	Txt		NC		
29.132	Multi-leader Node ID	1 to 3		1		RW	Num				US
29.133	Multi-leader Network Loss Mode	Run Single Pump (0), Trip (1)		Run Single Pump (0)		RW	Txt				US
29.134	Multi-leader Node 1 Status Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.135	Multi-leader Node 1 PID Output	±60.0	-3276.8 to 3276.7	0.0		RW	Num		NC		
29.136	Multi-leader Node 1 Control Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.137	Multi-leader Node 1 Lead Drive	0 to 3		0		RW	Num		NC		
29.138	Multi-leader Node 1 PID Feedback	-327.68 to 327.67 %		0.00 %		RW	Num		NC		
29.139	Multi-leader Node 2 Status Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.140	Multi-leader Node 2 PID Output	±60.0	-3276.8 to 3276.7	0.0		RW	Num		NC		
29.141	Multi-leader Node 2 Control Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.142	Multi-leader Node 2 Lead Drive	0 to 3		0		RW	Num		NC		
29.143	Multi-leader Node 2 PID Feedback	-327.68 to 327.67 %		0.00 %		RW	Num		NC		
29.144	Multi-leader Node 3 Status Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.145	Multi-leader Node 3 PID Output	±60.0	-3276.8 to 3276.7	0.0		RW	Num		NC		
29.146	Multi-leader Node 3 Control Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.147	Multi-leader Node 3 Lead Drive	0 to 3		0		RW	Num		NC		
29.148	Multi-leader Node 3 PID Feedback	-327.68 to 327.67 %		0.00 %		RW	Num		NC		
29.150	Pump Control Word Watchdog Time	0.0 to 60.0 s		2.0 s		RW	Num				US
29.151	Pump Control Word 1	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.152	Pump Control Word 2	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.153	Pump Status Word 1	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.154	Pump Status Word 2	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.155	Pump Alarm Word	0000000000000000 to 1111111111111111		0000000000000000		RW	Bin		NC		
29.156	Pump Software Stop	Run Software (0), Stop Software (1)		Run Software (0)		RW	Txt				US
29.157	Motor Type	Induction (0), Permanent-magnet (1)		Induction (0)	Permanent-magnet (1)	RW	Txt				

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependent	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save						

Menu 29 Logic diagrams

Figure 10-23 Functional Overview

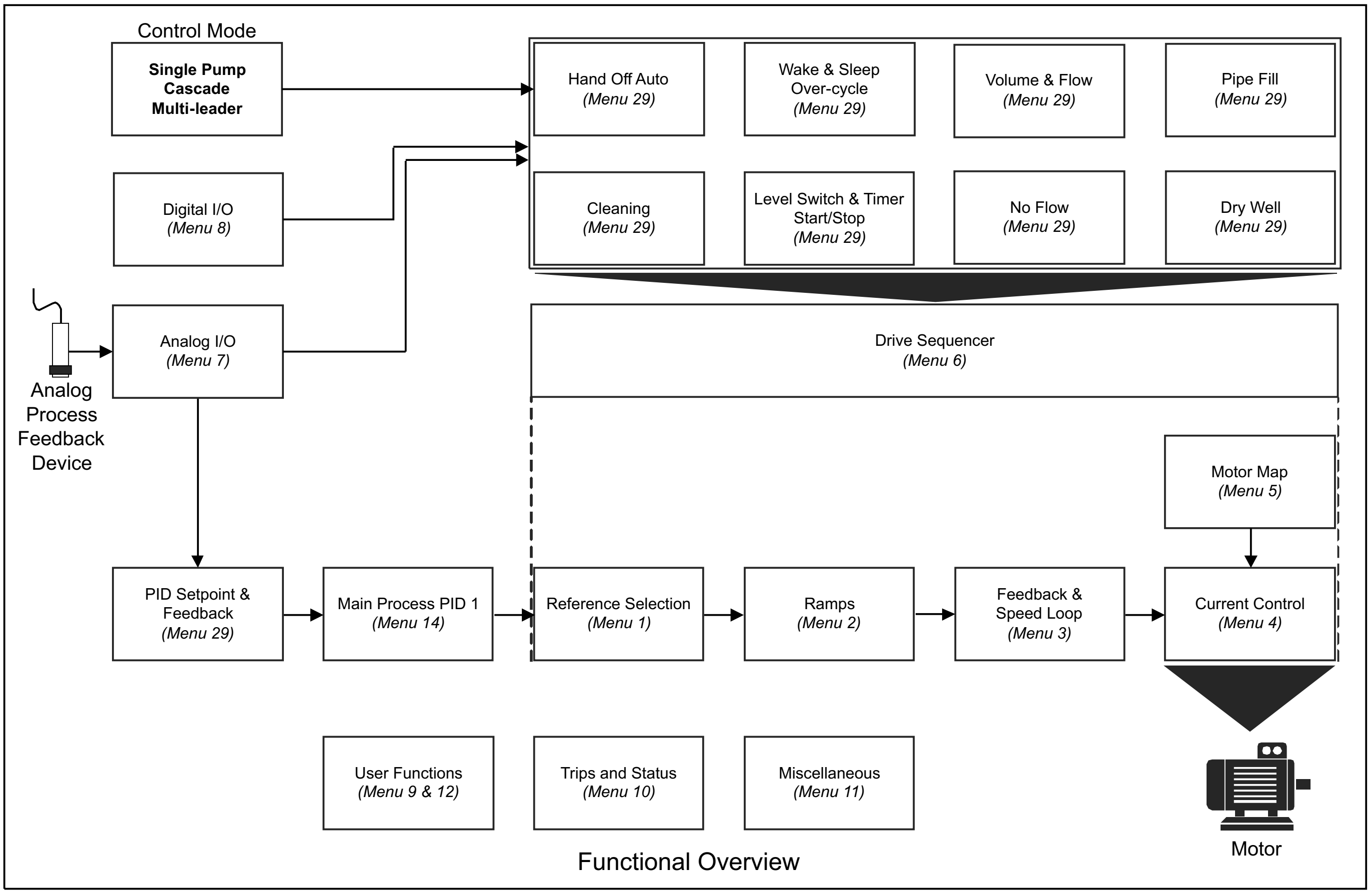


Figure 10-24 Main Control

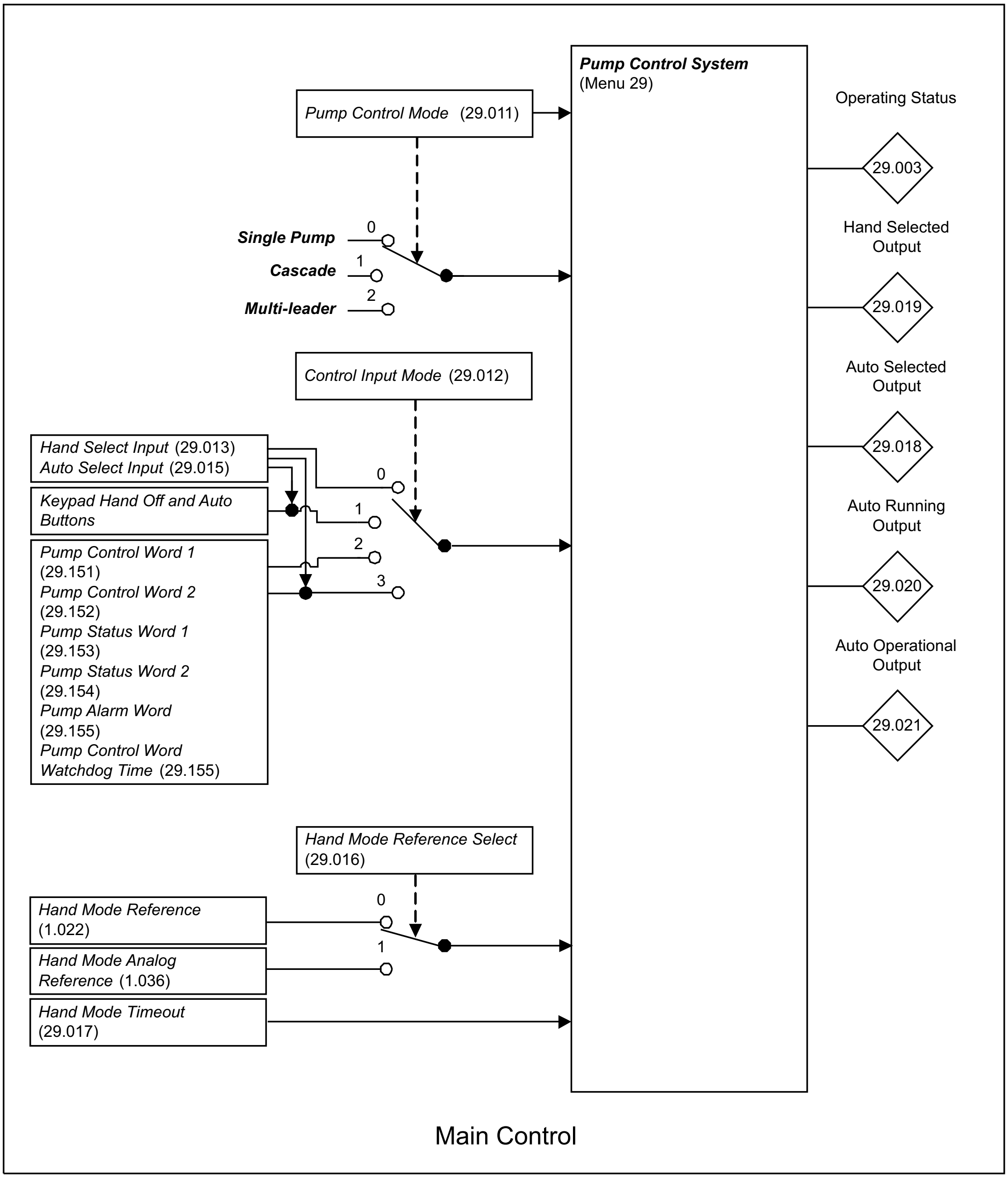
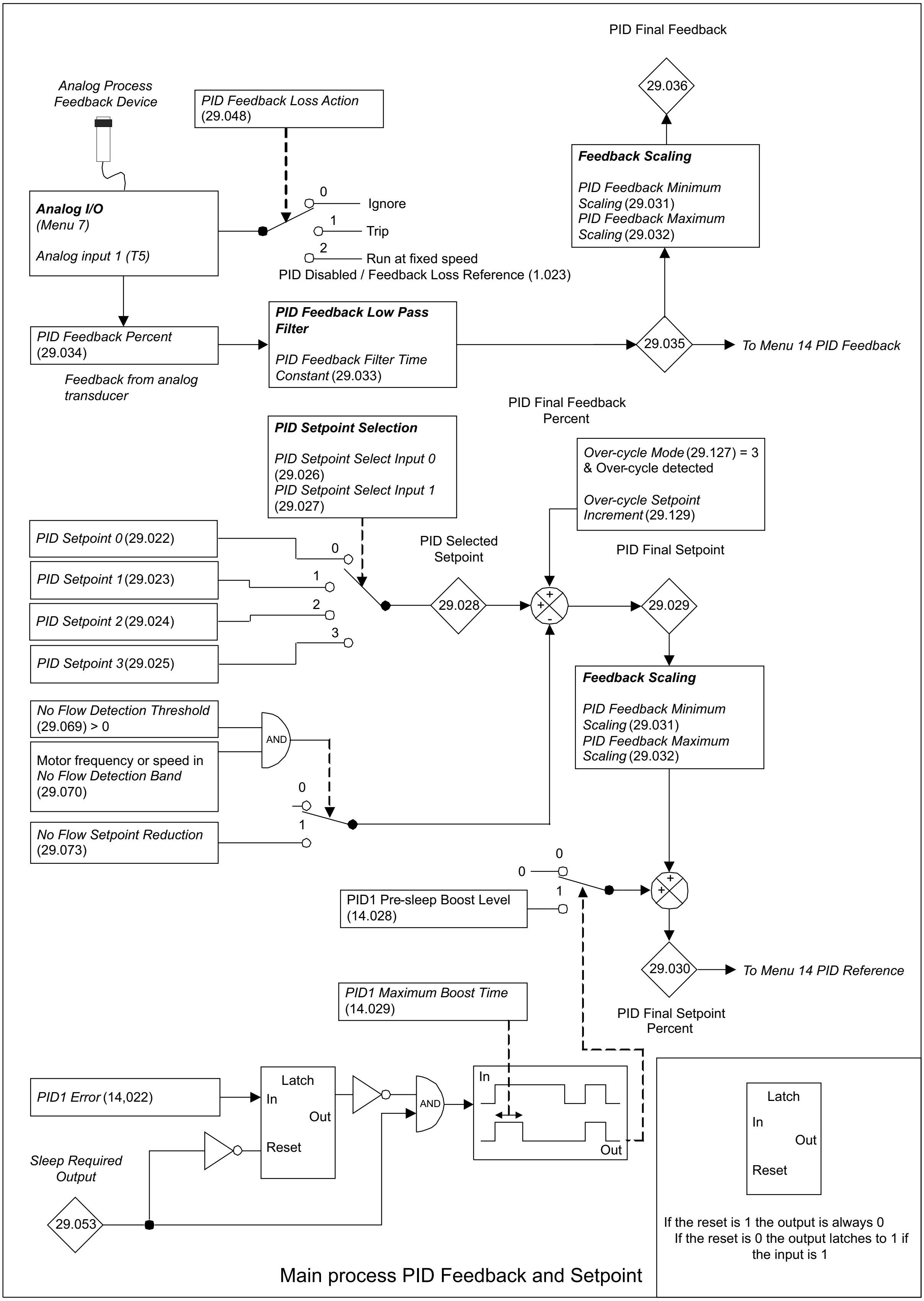


Figure 10-25 Main Process PID Feedback and Setpoint



Main process PID Feedback and Setpoint

Figure 10-26 Main Process PID Feedback High and Low detection

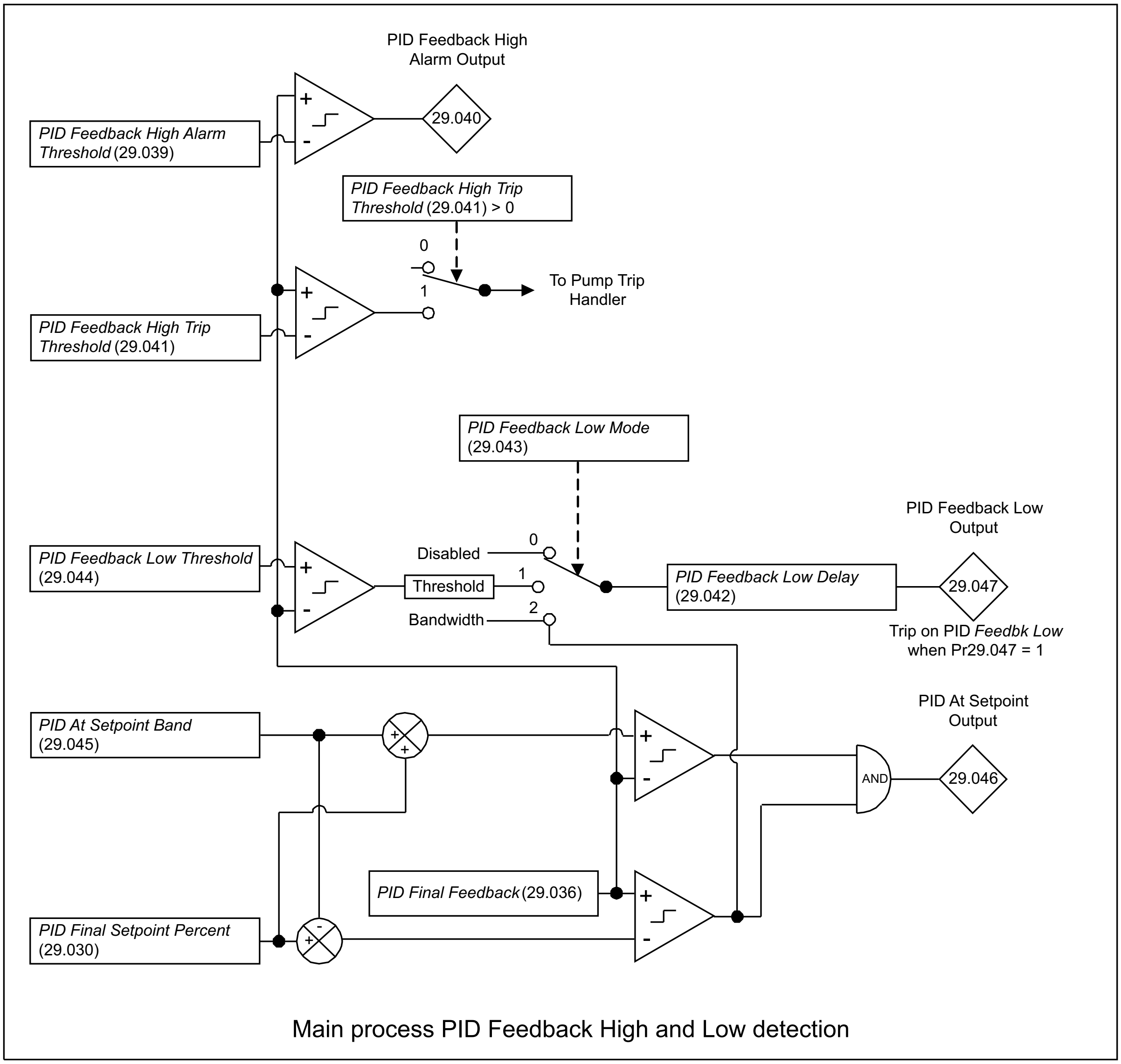


Figure 10-27 System Wake, Sleep & Over-cycle

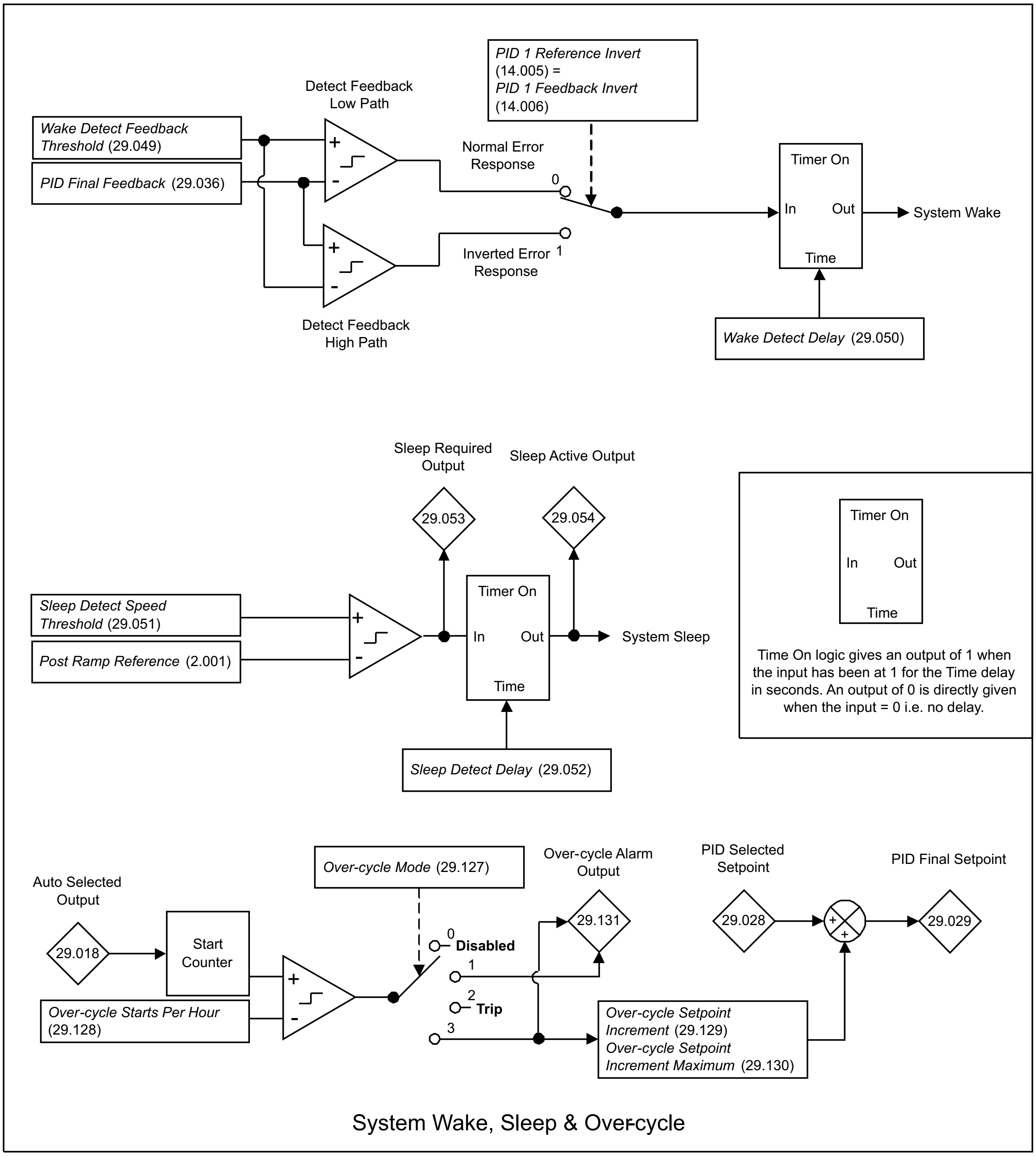


Figure 10-28 Dry Well Low Detection

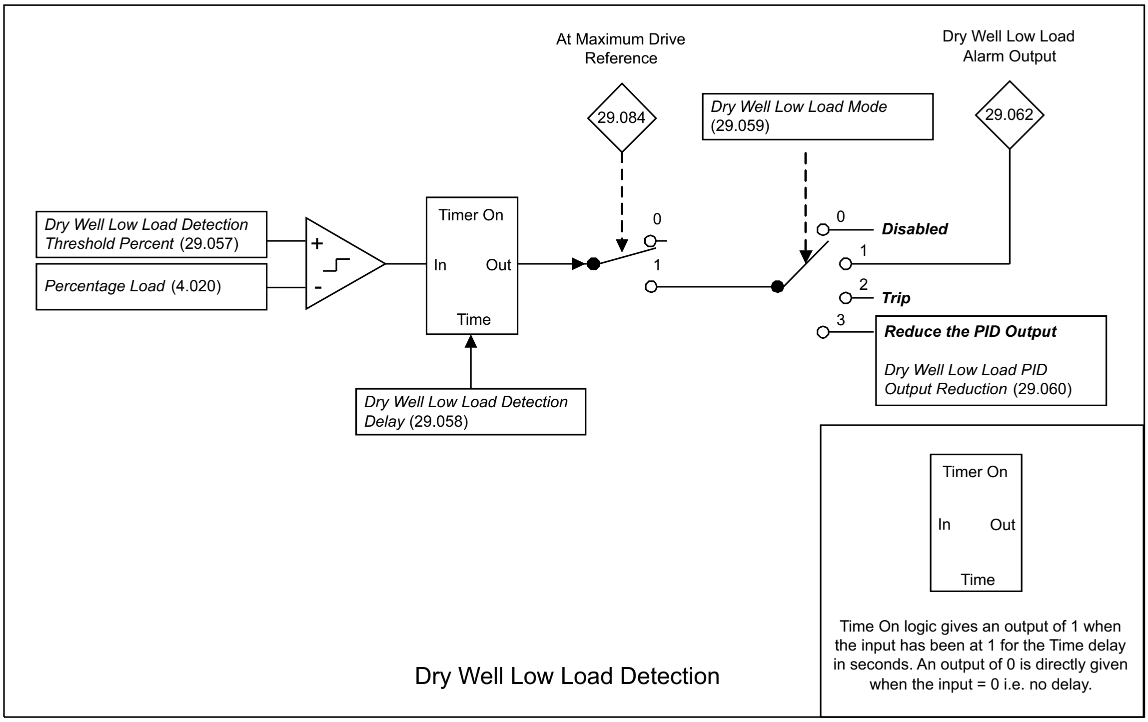


Figure 10-29 Volume and Flow

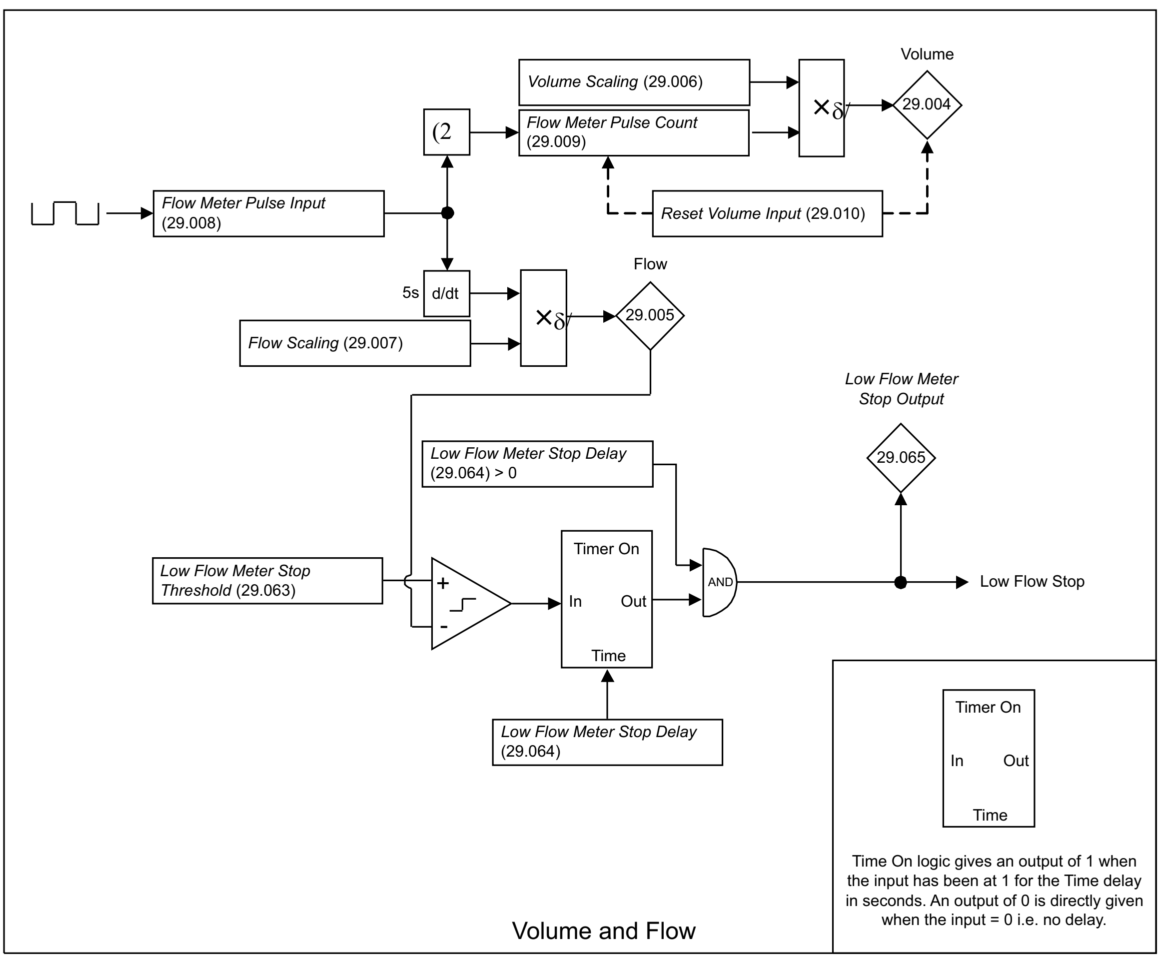


Figure 10-30 No Flow Detection

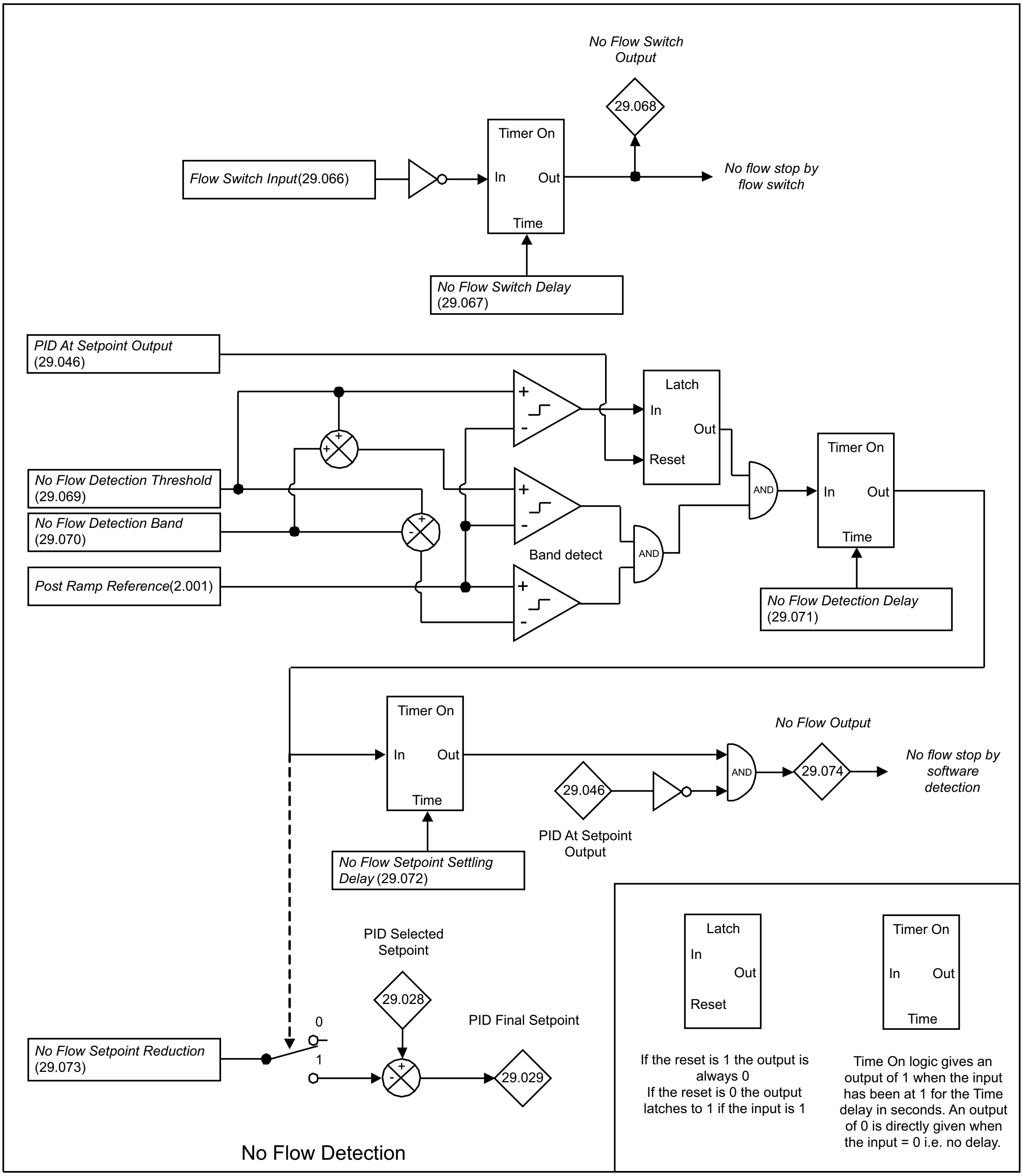


Figure 10-31 Pipe Fill On Start Logic

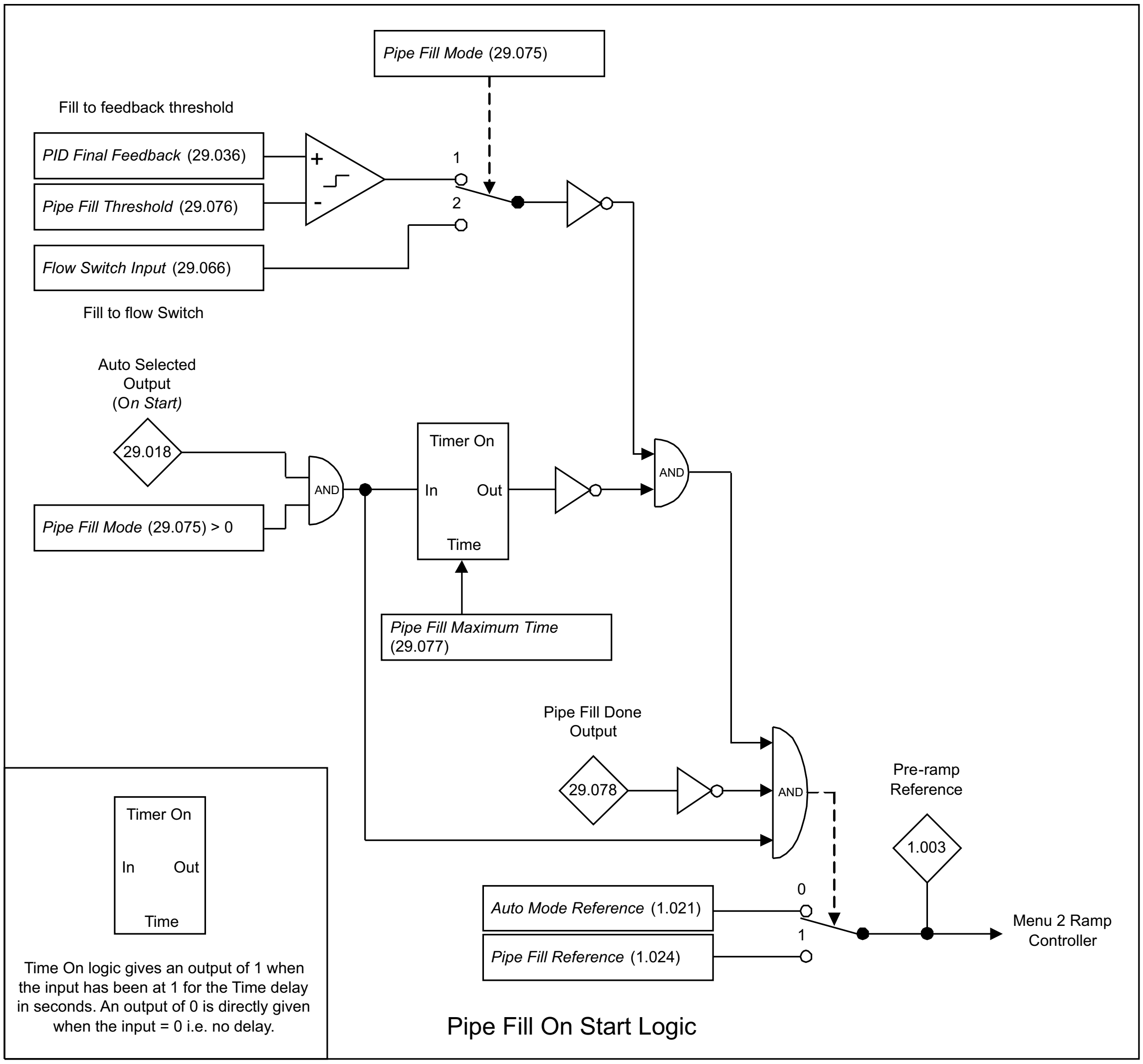


Figure 10-32 Cleaning System

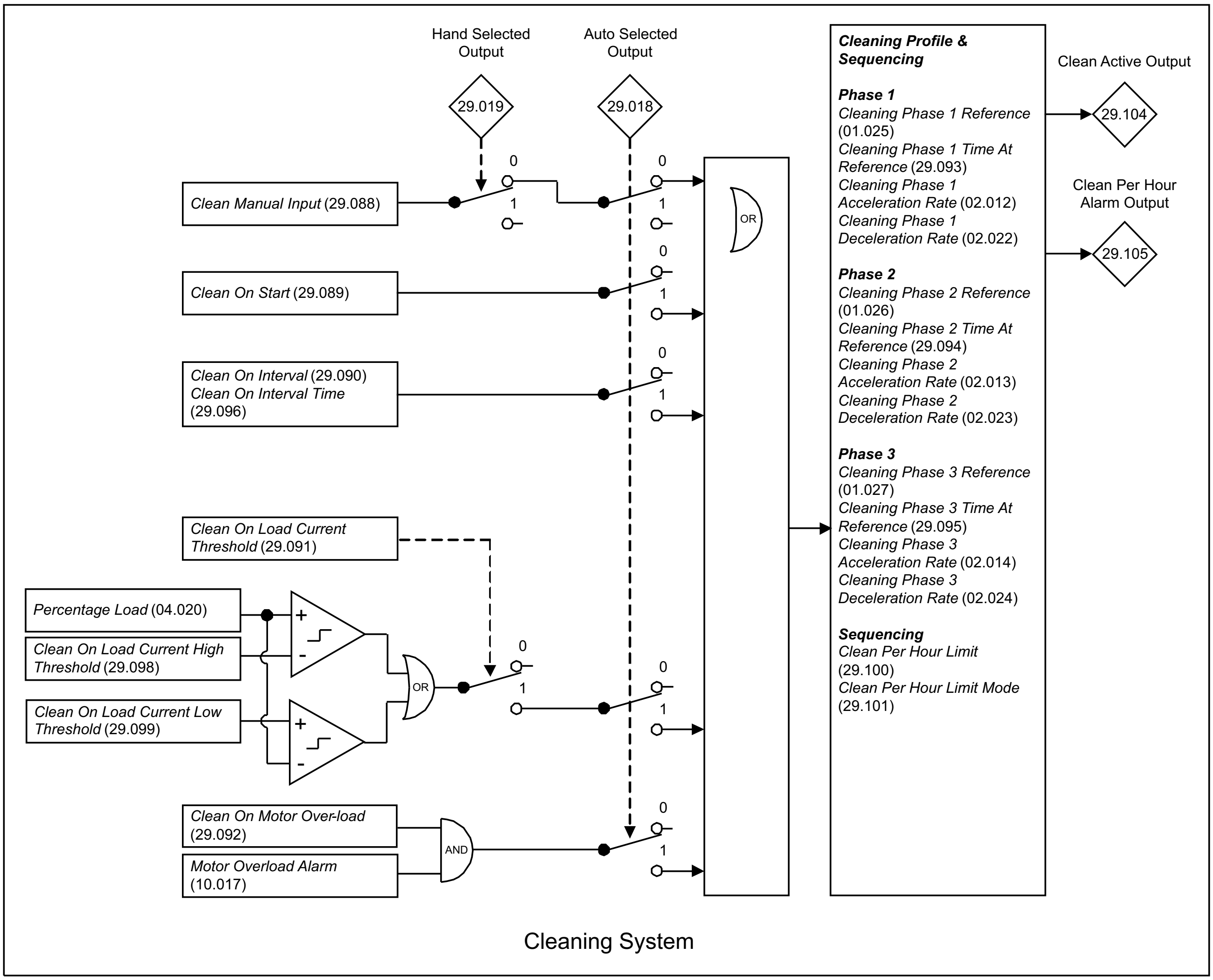


Figure 10-33 Cascade Mode

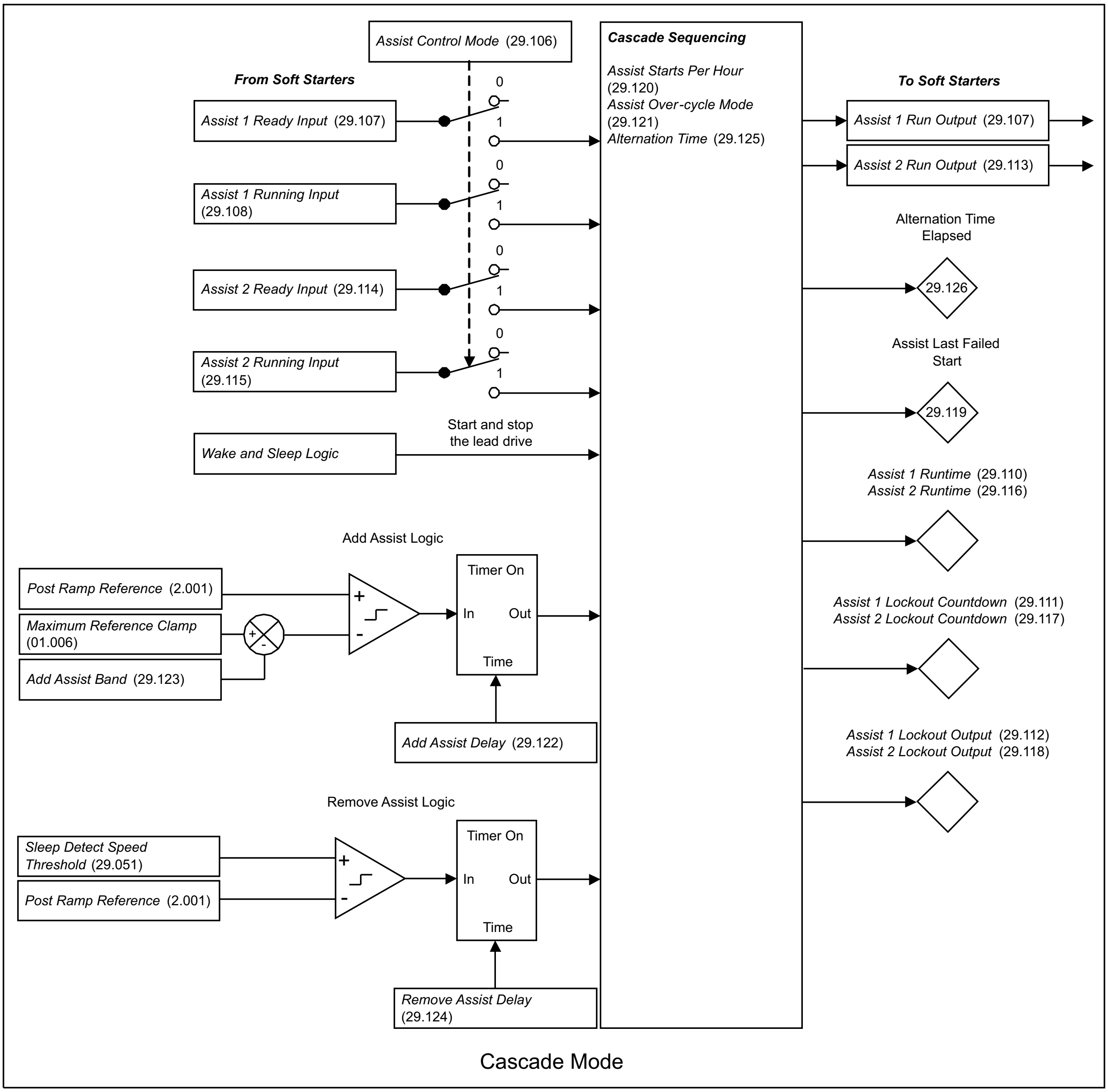
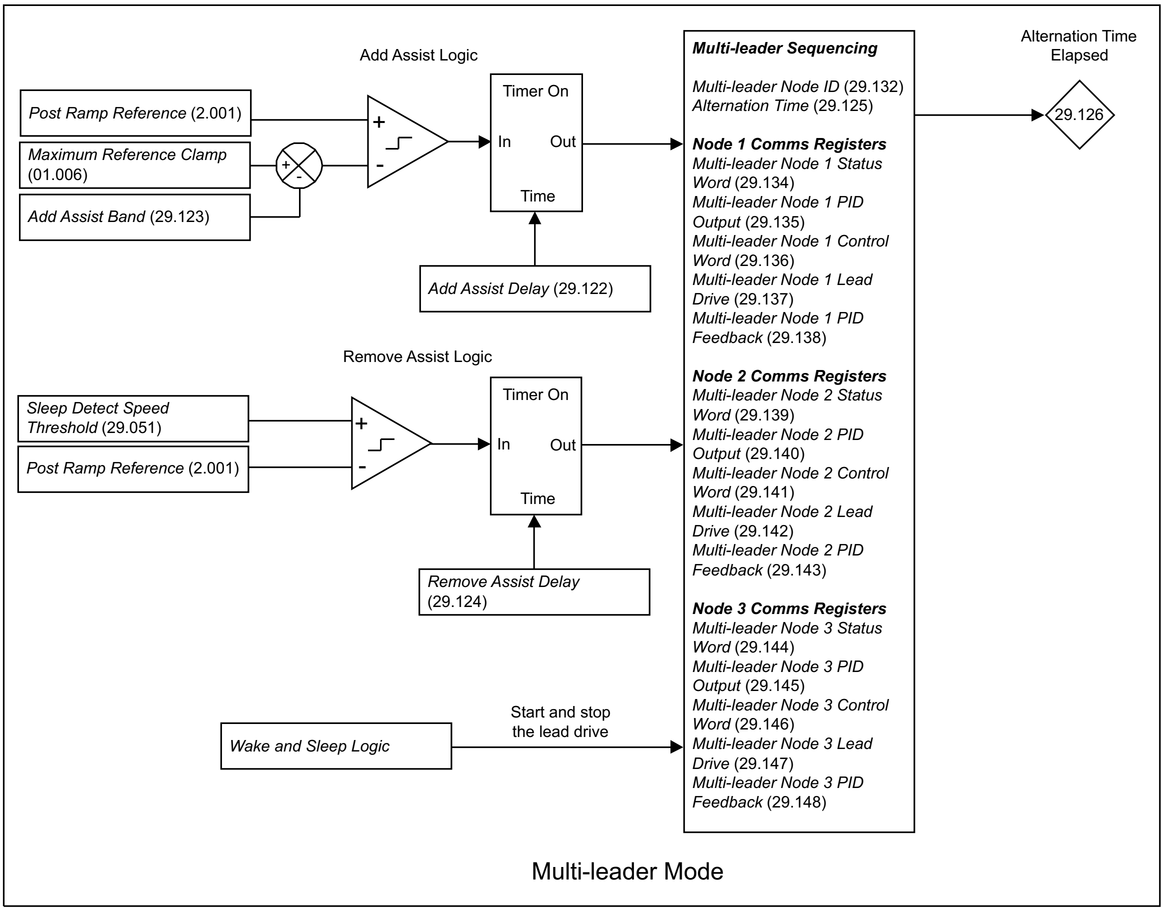


Figure 10-34 Multi-leader Mode



11 Technical data

11.1 Drive technical data

11.1.1 Power and current ratings (Derating for switching frequency and temperature)

For a full explanation of Normal Duty refer to Chapter 2.6 *Ratings* on page 16.

Table 11-1 Maximum permissible continuous output current @ 40 °C (104 °F) ambient

<table>
<tr><th rowspan="3">Model</th><th colspan="9">Normal Duty</th></tr>
<tr><th colspan="2">Nominal rating</th><th colspan="7">Maximum permissible continuous output current (A) for the following switching frequencies</th></tr>
<tr><th>kW</th><th>hp</th><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td colspan="10">200 V</td></tr>
<tr><td>03200066</td><td>1.1</td><td>1.5</td><td colspan="7">6.6</td></tr>
<tr><td>03200080</td><td>1.5</td><td>2.0</td><td colspan="7">8.0</td></tr>
<tr><td>03200110</td><td>2.2</td><td>3.0</td><td colspan="6">11</td><td>10.2</td></tr>
<tr><td>03200127</td><td>3.0</td><td>3.0</td><td colspan="5">12.7</td><td>12.1</td><td>10.2</td></tr>
<tr><td>04200180</td><td>4.0</td><td>5.0</td><td colspan="7">18</td></tr>
<tr><td>04200250</td><td>5.5</td><td>7.5</td><td colspan="5">25</td><td>24</td><td>22</td></tr>
<tr><td>05200300</td><td>7.5</td><td>10</td><td colspan="5">30</td><td>27.6</td><td>23.7</td></tr>
<tr><td>06200500</td><td>11</td><td>15</td><td colspan="5">50</td><td>42.3</td><td>24.5</td></tr>
<tr><td>06200580</td><td>15</td><td>20</td><td colspan="4">58</td><td>53</td><td>42.3</td><td>32.5</td></tr>
<tr><td>07200750</td><td>18.5</td><td>25</td><td colspan="5">75</td><td>74.3</td><td>59.7</td></tr>
<tr><td>07200940</td><td>22</td><td>30</td><td colspan="5">94</td><td>74.3</td><td>59.7</td></tr>
<tr><td>07201170</td><td>30</td><td>40</td><td colspan="3">117</td><td>114</td><td>96</td><td>74.3</td><td>59.7</td></tr>
<tr><td>08201490</td><td>37</td><td>50</td><td colspan="4">149</td><td>146</td><td>125.2</td><td>93</td></tr>
<tr><td>08201800</td><td>45</td><td>60</td><td colspan="3">180</td><td>160.2</td><td>148.8</td><td>126</td><td>93</td></tr>
<tr><td>09202160</td><td>55</td><td>75</td><td colspan="4">216</td><td>184</td><td>128</td><td>93</td></tr>
<tr><td>09202660</td><td>75</td><td>100</td><td colspan="2">266</td><td>258</td><td>218</td><td>184</td><td>128</td><td>93</td></tr>
<tr><td>10203250</td><td>90</td><td>125</td><td colspan="3">325</td><td>313</td><td>266</td><td>194</td><td>144</td></tr>
<tr><td>10203600</td><td>110</td><td>150</td><td colspan="3">360</td><td>313</td><td>266</td><td>194</td><td>144</td></tr>
<tr><td colspan="10">400 V</td></tr>
<tr><td>03400034</td><td>1.1</td><td>2.0</td><td colspan="7">3.4</td></tr>
<tr><td>03400045</td><td>1.5</td><td>2.0</td><td colspan="7">4.5</td></tr>
<tr><td>03400062</td><td>2.2</td><td>3.0</td><td colspan="6">6.2</td><td>5.0</td></tr>
<tr><td>03400077</td><td>3.0</td><td>5.0</td><td colspan="5">7.7</td><td>6.2</td><td>5.0</td></tr>
<tr><td>03400104</td><td>4.0</td><td>5.0</td><td colspan="5">10.4</td><td>7.6</td><td>5.7</td></tr>
<tr><td>03400123</td><td>5.5</td><td>7.5</td><td colspan="4">12.3</td><td>10.5</td><td>7.6</td><td>5.8</td></tr>
<tr><td>04400185</td><td>7.5</td><td>10</td><td colspan="5">18.5</td><td>14.6</td><td>11.1</td></tr>
<tr><td>04400240</td><td>11</td><td>15</td><td colspan="3">24</td><td>21.8</td><td>19.2</td><td>14.6</td><td>11.2</td></tr>
<tr><td>05400300</td><td>15</td><td>20</td><td colspan="3">30</td><td>25.8</td><td>22.2</td><td>17.1</td><td>13.5</td></tr>
<tr><td>06400380</td><td>18.5</td><td>25</td><td colspan="5">38</td><td>31</td><td>24.3</td></tr>
<tr><td>06400480</td><td>22</td><td>30</td><td colspan="4">48</td><td>41</td><td>31</td><td>24.5</td></tr>
<tr><td>06400630</td><td>30</td><td>40</td><td colspan="2">63</td><td>57</td><td>48</td><td>41</td><td>31</td><td>24.5</td></tr>
<tr><td>07400790</td><td>37</td><td>60</td><td colspan="5">79</td><td>63</td><td>53.6</td></tr>
<tr><td>07400940</td><td>45</td><td>60</td><td colspan="4">94</td><td>80.6</td><td>63</td><td>53.6</td></tr>
<tr><td>07401120</td><td>55</td><td>75</td><td colspan="3">112</td><td>95.2</td><td>80.6</td><td>63</td><td>53.8</td></tr>
<tr><td>08401550</td><td>75</td><td>100</td><td colspan="4">155</td><td>132</td><td>98</td><td>77</td></tr>
<tr><td>08401840</td><td>90</td><td>150</td><td colspan="3">184</td><td>169</td><td>142</td><td>106.7</td><td>77</td></tr>
</table>

Model	Normal Duty								
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09402210	110	150	221			192	159	108	77
09402660	132	200	266	255	231	192	160	109	77
10403200	160	250	320			285	238	173	124
10403610	200	300	361		339	285	238	173	126
11404370	225	350	437		415	336	272		
11404870	250	400	487	460	415	336	272		
11405070	280	400	507	460	415	336	272		
575 V									
05500039	2.2	3.0	3.9						
05500061	4.0	5.0	6.1						
05500100	5.5	7.5	10						
06500120	7.5	10.0	12						
06500170	11.0	15.0	17						14.8
06500220	15.0	20.0	22					20.5	15
06500270	18.5	25.0	27				26.2	20	16
06500340	22.0	30.0	34			31	26.2	20	16.8
06500430	30.0	40.0	43		39.6	31	26.2	20	16.8
07500530	45	50	53			51.8	40.2	27.7	21.2
07500730	55	60	73		71.5	51.8	40.2	27.7	21.2
08500860	75	75	86				73.1	49.7	37.8
08501080	90	100	108			91.8	73.1	49.7	37.8
09501250	110	125	125				101	71	54
09501500	110	150	150			126	100	70	54
10502000	130	200	200		168	126	100	70	54
11502480	185	250	248		220				
11502880	225	300	288	265	220				
11503150	250	350	315	265	220				
690 V									
07600230	18.5	25	23						21.2
07600300	22	30	30					27.9	21.2
07600360	30	40	36					28.1	21.2
07600460	37	50	46				40.5	28.1	21.2
07600520	45	60	52			51.5	40.6	28.1	21.2
07600730	55	75	73		71.5	51.8	40.6	28.1	21.2
08600860	75	100	86				72.2	49.7	37.8
08601080	90	125	108			91.8	72.4	49.7	37.8
09601250	110	150	125				100	71	54
09601550	132	175	155			126	100	71	54
10601720	160	200	172		169	126	100	71	55
10601970	185	250	197			154	114	75	55
11602250	200	250	225		220				
11602750	250	300	275	265	220				
11603050	280	400	305	265	220				

Table 11-2 Maximum permissible continuous output current @ 40 °C (104 °F) ambient with high IP insert installed

<table>
<tr><th rowspan="3">Model</th><th colspan="7">Normal Duty</th></tr>
<tr><th colspan="7">Maximum permissible continuous output current (A)
for the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td colspan="8">200 V</td></tr>
<tr><td>03200066</td><td colspan="7">6.6</td></tr>
<tr><td>03200080</td><td colspan="7">8.0</td></tr>
<tr><td>03200110</td><td colspan="6">11.0</td><td>9.7</td></tr>
<tr><td>03200127</td><td>12.3</td><td>11.9</td><td>11.1</td><td>10.0</td><td>9.0</td><td>6.4</td><td>4.7</td></tr>
<tr><td>04200180</td><td colspan="3">14.5</td><td>13.5</td><td>12.2</td><td>10.5</td><td>9.6</td></tr>
<tr><td>04200250</td><td colspan="3">14.5</td><td>13.5</td><td>12.2</td><td>10.5</td><td>9.6</td></tr>
<tr><td>05200300</td><td>25.5</td><td>25.2</td><td>24.9</td><td>24.3</td><td>23.7</td><td>22.5</td><td>21.6</td></tr>
<tr><td colspan="8">400 V</td></tr>
<tr><td>03400034</td><td colspan="6">3.4</td><td>3.3</td></tr>
<tr><td>03400045</td><td colspan="3">4.5</td><td>4.4</td><td>4.1</td><td>3.6</td><td>3.3</td></tr>
<tr><td>03400062</td><td>5.1</td><td>5.0</td><td>4.7</td><td>4.4</td><td>4.1</td><td>3.6</td><td>3.3</td></tr>
<tr><td>03400077</td><td colspan="2">7.7</td><td>7.4</td><td>6.7</td><td>6.2</td><td>5.7</td><td>5.0</td></tr>
<tr><td>03400104</td><td colspan="3">8.3</td><td>7.6</td><td>6.9</td><td>6.0</td><td>5.2</td></tr>
<tr><td>03400123</td><td colspan="3">8.3</td><td>7.6</td><td>6.9</td><td>6.0</td><td>5.2</td></tr>
<tr><td>04400185</td><td colspan="5">8.6</td><td>8.4</td><td>6.9</td></tr>
<tr><td>04400240</td><td colspan="5">8.6</td><td>8.4</td><td>6.9</td></tr>
<tr><td>05400300</td><td>17.1</td><td>15.6</td><td>14.4</td><td>12.6</td><td>11.4</td><td>9.6</td><td>8.7</td></tr>
<tr><td colspan="8">575 V</td></tr>
<tr><td>05500039</td><td colspan="7">3.9</td></tr>
<tr><td>05500061</td><td colspan="7">6.1</td></tr>
<tr><td>05500100</td><td colspan="7">10.0</td></tr>
</table>

Table 11-3 Maximum permissible continuous output current @ 50 °C (122 °F)

<table>
<tr><th rowspan="3">Model</th><th colspan="7">Normal Duty</th></tr>
<tr><th colspan="7">Maximum permissible continuous output current (A) for the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td colspan="8">200 V</td></tr>
<tr><td>03200066</td><td colspan="7">6.6</td></tr>
<tr><td>03200080</td><td colspan="7">8.0</td></tr>
<tr><td>03200110</td><td colspan="5">11</td><td>10.5</td><td>9.1</td></tr>
<tr><td>03200127</td><td colspan="2">12.7</td><td>12.6</td><td>12.2</td><td>11.7</td><td>10.5</td><td>9.1</td></tr>
<tr><td>04200180</td><td colspan="7">18</td></tr>
<tr><td>04200250</td><td colspan="6">22.2</td><td>20.2</td></tr>
<tr><td>05200300</td><td colspan="4">30</td><td>29.7</td><td>25.2</td><td>21.6</td></tr>
<tr><td>06200500</td><td colspan="4">50</td><td>49</td><td>38</td><td>30</td></tr>
<tr><td>06200580</td><td colspan="3">58</td><td>56</td><td>49</td><td>38</td><td>30.2</td></tr>
<tr><td>07200750</td><td colspan="5">75</td><td>59.7</td><td>48.8</td></tr>
<tr><td>07200940</td><td colspan="3">94</td><td>92.1</td><td>80</td><td>59.7</td><td>48.9</td></tr>
<tr><td>07201170</td><td colspan="2">117</td><td>112</td><td>92.4</td><td>80</td><td>59.7</td><td>49.1</td></tr>
<tr><td>08201490</td><td colspan="3">149</td><td>147</td><td>133</td><td>113</td><td>84</td></tr>
<tr><td>08201800</td><td colspan="2">180</td><td>167</td><td>148</td><td>133</td><td>113</td><td>84</td></tr>
<tr><td>09202160</td><td colspan="3">216</td><td>197</td><td>168</td><td>117</td><td>84</td></tr>
<tr><td>09202660</td><td>253</td><td>237</td><td>221</td><td>197</td><td>168</td><td>117</td><td>85</td></tr>
<tr><td>10203250</td><td>325</td><td>320</td><td>302</td><td>266</td><td>241</td><td>176</td><td>130</td></tr>
<tr><td>10203600</td><td>346</td><td>320</td><td>302</td><td>266</td><td>241</td><td>176</td><td>130</td></tr>
<tr><td colspan="8">400 V</td></tr>
<tr><td>03400034</td><td colspan="7">3.4</td></tr>
<tr><td>03400045</td><td colspan="7">4.5</td></tr>
<tr><td>03400062</td><td colspan="4">6.2</td><td>5.9</td><td>5.4</td><td>4.4</td></tr>
<tr><td>03400077</td><td>7.6</td><td>7.2</td><td>6.9</td><td>6.4</td><td>5.9</td><td>5.4</td><td>4.4</td></tr>
<tr><td>03400104</td><td colspan="3">10.4</td><td>9.3</td><td>8.5</td><td>6.9</td><td>5.1</td></tr>
<tr><td>03400123</td><td>11.9</td><td>11.2</td><td>10.5</td><td>9.3</td><td>8.5</td><td>6.9</td><td>5.2</td></tr>
<tr><td>04400185</td><td>18</td><td>17.5</td><td>17</td><td>16.3</td><td>15.8</td><td>12.2</td><td>9.3</td></tr>
<tr><td>04400240</td><td>18</td><td>17.5</td><td>17</td><td>16.3</td><td>15.8</td><td>12.2</td><td>9.3</td></tr>
<tr><td>05400300</td><td colspan="3">25.5</td><td>23.6</td><td>20.4</td><td>15.6</td><td>12.3</td></tr>
<tr><td>06400380</td><td colspan="4">38</td><td>37</td><td>28</td><td>21.4</td></tr>
<tr><td>06400480</td><td colspan="3">48</td><td>43</td><td>36.5</td><td>27.4</td><td>21.4</td></tr>
<tr><td>06400630</td><td>63</td><td>58</td><td>52</td><td>43</td><td>37</td><td>28</td><td>21.4</td></tr>
<tr><td>07400790</td><td colspan="4">79</td><td>73.5</td><td>57.7</td><td>49</td></tr>
<tr><td>07400940</td><td colspan="3">94</td><td>86.5</td><td>73.3</td><td>58.3</td><td>49</td></tr>
<tr><td>07401120</td><td colspan="2">112</td><td>109</td><td>87.4</td><td>72.8</td><td>58.3</td><td>49.3</td></tr>
<tr><td>08401550</td><td colspan="3">155</td><td>146</td><td>123</td><td>93</td><td>69</td></tr>
<tr><td>08401840</td><td colspan="2">184</td><td>180</td><td>146</td><td>123</td><td>93.8</td><td>69</td></tr>
<tr><td>09402210</td><td colspan="2">221</td><td>213</td><td>175</td><td>144</td><td>97</td><td>69</td></tr>
<tr><td>09402660</td><td>253</td><td>237</td><td>213</td><td>176</td><td>144</td><td>98</td><td>69</td></tr>
<tr><td>10403200</td><td colspan="2">320</td><td>300</td><td>259</td><td>217</td><td>154</td><td>112</td></tr>
<tr><td>10403610</td><td>343</td><td>321</td><td>300</td><td>260</td><td>217</td><td>155</td><td>112</td></tr>
<tr><td>11404370</td><td>437</td><td>415</td><td>374</td><td>298</td><td>240</td><td></td><td></td></tr>
<tr><td>11404870</td><td>462</td><td>415</td><td>374</td><td>298</td><td>240</td><td></td><td></td></tr>
</table>

<table>
<tr><th rowspan="3">Model</th><th colspan="7">Normal Duty</th></tr>
<tr><th colspan="7">Maximum permissible continuous output current (A) for the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>11405070</td><td>462</td><td>415</td><td>374</td><td>298</td><td>240</td><td></td><td></td></tr>
<tr><td colspan="8">575 V</td></tr>
<tr><td>05500039</td><td colspan="7">3.9</td></tr>
<tr><td>05500061</td><td colspan="7">6.1</td></tr>
<tr><td>05500100</td><td colspan="7">10</td></tr>
<tr><td>06500120</td><td colspan="7">12</td></tr>
<tr><td>06500170</td><td colspan="6">17</td><td>13.4</td></tr>
<tr><td>06500220</td><td colspan="5">22</td><td>17.8</td><td>13.4</td></tr>
<tr><td>06500270</td><td colspan="4">27</td><td>23.5</td><td>17.8</td><td>15</td></tr>
<tr><td>06500340</td><td colspan="3">34</td><td>28.2</td><td>23.5</td><td>18</td><td>15</td></tr>
<tr><td>06500430</td><td>43.0</td><td>41.7</td><td>36.1</td><td>28</td><td>23.7</td><td>18</td><td>15</td></tr>
<tr><td>07500530</td><td colspan="3">53</td><td>46.7</td><td>35.8</td><td>24.8</td><td>19</td></tr>
<tr><td>07500730</td><td colspan="2">73</td><td>65</td><td>46.7</td><td>35.8</td><td>24.8</td><td>19</td></tr>
<tr><td>08500860</td><td colspan="3">86</td><td>76.7</td><td>64.5</td><td>44.3</td><td>31.3</td></tr>
<tr><td>08501080</td><td>104</td><td>97.2</td><td>90.7</td><td>76.7</td><td>64.8</td><td>44.3</td><td>31.3</td></tr>
<tr><td>09501250</td><td colspan="3">125</td><td>114</td><td>90</td><td>62</td><td>48</td></tr>
<tr><td>09501500</td><td colspan="3">150</td><td>114</td><td>90</td><td>62</td><td>48</td></tr>
<tr><td>10502000</td><td>200</td><td>184</td><td>154</td><td>114</td><td>90</td><td>62</td><td>48</td></tr>
<tr><td>11502480</td><td colspan="2">226</td><td>198</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11502880</td><td>262</td><td>241</td><td>198</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11503150</td><td>296</td><td>241</td><td>198</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">690 V</td></tr>
<tr><td>07600230</td><td colspan="6">23</td><td>19</td></tr>
<tr><td>07600300</td><td colspan="5">30</td><td>24.8</td><td>19</td></tr>
<tr><td>07600360</td><td colspan="4">36</td><td>35.8</td><td>24.8</td><td>19</td></tr>
<tr><td>07600460</td><td colspan="4">46</td><td>35.8</td><td>24.8</td><td>19</td></tr>
<tr><td>07600520</td><td colspan="3">52</td><td>46.7</td><td>35.8</td><td>25</td><td>19</td></tr>
<tr><td>07600730</td><td colspan="2">73</td><td>65</td><td>46.7</td><td>35.8</td><td>25</td><td>19</td></tr>
<tr><td>08600860</td><td colspan="3">86</td><td>76.7</td><td>64.5</td><td>44.3</td><td>31.3</td></tr>
<tr><td>08601080</td><td>104</td><td>97.2</td><td>90.7</td><td>76.7</td><td>64.8</td><td>44.3</td><td>31.3</td></tr>
<tr><td>09601250</td><td colspan="3">125</td><td>114</td><td>90</td><td>62</td><td>48</td></tr>
<tr><td>09601550</td><td colspan="2">155</td><td>153</td><td>113</td><td>89</td><td>62</td><td>48</td></tr>
<tr><td>10601720</td><td colspan="2">172</td><td>153</td><td>114</td><td>89</td><td>62</td><td>48</td></tr>
<tr><td>10601970</td><td colspan="2">197</td><td>195</td><td>134</td><td>102</td><td>67</td><td>48</td></tr>
<tr><td>11602250</td><td colspan="2">205</td><td>198</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11602750</td><td>250</td><td>241</td><td>198</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11603050</td><td>296</td><td>241</td><td>198</td><td></td><td></td><td></td><td></td></tr>
</table>

Note

55 °C ratings are available on request.

11.1.2 Power dissipation

Table 11-4 Losses @ 40 °C (104 °F) ambient

Model	Normal Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V									
03200066	1.1	1.5	88	93	95	99	104	113	122
03200080	1.5	2	95	100	102	107	113	122	133
03200110	2.2	3	117	123	126	133	139	151	146
03200127	3	3	129	136	141	149	158	168	157
04200180	4	5	171	180	187	201	216	244	273
04200250	5.5	7.5	227	239	248	266	284	308	314
05200300	7.5	10	280	291	302	324	344	356	342
06200500	11	15	375	394	413	452	490	480	485
06200580	15	20	442	463	484	528	522	481	486
07200750	18.5	25	533	570	597	650	703	885	894
07200940	22	30	671	718	751	815	881	890	899
07201170	30	40	851	911	951	1004	911	920	929
08201490	37	50	1339	1433	1536	1765	1943	1962	1982
08201800	45	60	1638	1753	1894	1914	1985	2005	2025
09202160 (9A)	55	75	2028	2170	2312	2596	2448	2160	2031
09202660 (9A)	75	100	2585	2754	2822	2623	2448	2156	2034
09202160 (9E)	55	75	1889	2031	2174	2458	2348	2112	2006
09202660 (9E)	75	100	2375	2554	2625	2482	2348	2108	2009
10203250	90	125	2478	2672	2867	3123	2952	2701	2554
10203600	110	150	2802	3016	3230	3126	2957	2706	2554
400 V									
03400034	1.1	1.5	76	80	84	94	103	123	141
03400045	1.5	2	84	88	92	104	115	137	160
03400062	2.2	3	99	104	112	125	139	167	157
03400077	3	5	108	114	122	137	153	149	147
03400104	4	5	138	145	158	186	212	201	197
03400123	5	7.5	155	163	179	209	208	201	200
04400185	7.5	10	214	225	244	283	322	325	310
04400240	11	15	269	283	307	325	329	325	315
05400300	15	20	295	324	353	356	355	359	362
06400380	18.5	25	378	417	456	532	613	652	645
06400480	22	30	469	515	561	657	651	646	650
06400630	30	40	616	656	659	650	646	643	649
07400790	37	50	745	830	907	1062	1218	1230	1242
07400940	45	60	896	999	1088	1264	1241	1253	1266
07401120	55	75	1033	1152	1247	1218	1170	1182	1194
08401550	75	100	1482	1652	1817	2154	2121	2142	2164
08401840	90	125	1798	2004	2191	2333	2279	2302	2325
09402210 (9A)	110	150	2431	2710	2989	3075	2992	2842	2833
09402660 (9A)	132	200	3016	3191	3143	3063	3000	2856	2828
09402210 (9E)	110	150	2286	2565	2844	2966	2917	2807	2815
09402660 (9E)	132	200	2806	2998	2984	2955	2925	2821	2811
10403200	160	250	3210	3582	3954	4148	4034	3939	3843
10403610	200	300	3703	4121	4226	4154	4038	3947	3874
11404370	225	350	4182	4576	4708	4444	4246		

Model	Normal Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
11404870	250	400	4734	4843	4708	4444	4246		
11405070	280	400	4962	4843	4708	4444	4246		

Model	Normal Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
575 V									
05500039	2.2	3	82	92	102	121	142	183	223
05500061	4	5	120	135	150	180	209	269	328
05500100	5.5	7.5	173	194	215	260	302	388	474
06500120	7.5	10	191	215	239	287	334	430	525
06500170	11	15	253	284	315	376	438	563	569
06500220	15	20	325	362	399	484	569	575	580
06500270	18.5	25	391	448	505	596	682	689	696
06500340	22	30	534	623	712	810	822	830	839
06500430	30	40	675	798	836	813	823	831	840
07500530	45	50	867	1004	1139	1358	1262	1275	1287
07500730	55	60	1078	1248	1375	1209	1122	1133	1145
08500860	75	75	1607	1861	2180	2814	2982	3012	3042
08501080	90	100	2050	2374	2753	2947	2963	2993	3023
09501250 (9A)	110	125	1707	1977	2247	2787	2723	2731	2859
09501500 (9A)	110	150	2087	2410	2734	2810	2692	2697	2859
09501250 (9E)	110	125	1595	1865	2135	2675	2644	2687	2831
09501500 (9E)	110	150	1933	2256	2580	2696	2616	2654	2831
10502000	130	200	2692	3137	2923	2696	2616	2654	2831
11502480	185	250	3391	3999	4097				
11502880	225	300	4004	4296	4097				
11503150	250	350	4439	4296	4097				
690 V									
07600230	18.5	25	363	428	491	617	743	793	970
07600300	22	30	468	551	631	791	952	962	971
07600360	30	40	560	660	754	941	1129	1140	1152
07600460	37	50	725	854	971	1206	1271	1284	1297
07600520	45	60	836	985	1117	1350	1275	1288	1301
07600730	55	75	1059	1248	1375	1209	1122	1133	1145
08600860	75	100	1579	1861	2180	2814	2945	2974	3004
08601080	90	125	2015	2374	2753	2947	2935	2964	2994
09601250 (9A)	110	150	1878	2213	2548	3218	3155	3266	3465
09601550 (9A)	132	175	2384	2797	3211	3232	3155	3267	3474
09601250 (9E)	110	150	1730	2065	2400	3070	3058	3215	3434
09601550 (9E)	132	175	2160	2573	2986	3083	3058	3216	3443
10601720	160	200	2420	2882	3270	3083	3052	3192	3472
10601970	185	250	2614	3132	3649	3667	3495	3633	3993
11602250	200	250	3225	3893	4497				
11602750	250	300	4023	4640	4497				
11603050	280	400	4576	4684	4540				

Model	Normal Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
575 V									
05500039	2.2	3	82	92	102	121	142	183	223
05500061	4	5	120	135	150	180	209	269	328
05500100	5.5	7.5	173	194	215	260	302	388	474
06500120	7.5	10	191	215	239	287	334	430	525
06500170	11	15	253	284	315	376	438	563	569
06500220	15	20	325	362	399	484	569	575	580
06500270	18.5	25	391	448	505	596	682	689	696
06500340	22	30	534	623	712	810	822	830	839
06500430	30	40	675	798	836	813	823	831	840
07500530	45	50	867	1004	1139	1358	1262	1275	1287
07500730	55	60	1078	1248	1375	1209	1122	1133	1145
08500860	75	75	1607	1861	2180	2814	2982	3012	3042
08501080	90	100	2050	2374	2753	2947	2963	2993	3023
09501250 (9A)	110	125	1707	1977	2247	2787	2723	2731	2859
09501500 (9A)	110	150	2087	2410	2734	2810	2692	2697	2859
09501250 (9E)	110	125	1595	1865	2135	2675	2644	2687	2831
09501500 (9E)	110	150	1933	2256	2580	2696	2616	2654	2831
10502000	130	200	2692	3137	2923	2696	2616	2654	2831
11502480	185	250	3391	3999	4097				
11502880	225	300	4004	4296	4097				
11503150	250	350	4439	4296	4097				
690 V									
07600230	18.5	25	363	428	491	617	743	793	970
07600300	22	30	468	551	631	791	952	962	971
07600360	30	40	560	660	754	941	1129	1140	1152
07600460	37	50	725	854	971	1206	1271	1284	1297
07600520	45	60	836	985	1117	1350	1275	1288	1301
07600730	55	75	1059	1248	1375	1209	1122	1133	1145
08600860	75	100	1579	1861	2180	2814	2945	2974	3004
08601080	90	125	2015	2374	2753	2947	2935	2964	2994
09601250 (9A)	110	150	1878	2213	2548	3218	3155	3266	3465
09601550 (9A)	132	175	2384	2797	3211	3232	3155	3267	3474
09601250 (9E)	110	150	1730	2065	2400	3070	3058	3215	3434
09601550 (9E)	132	175	2160	2573	2986	3083	3058	3216	3443
10601720	160	200	2420	2882	3270	3083	3052	3192	3472
10601970	185	250	2614	3132	3649	3667	3495	3633	3993
11602250	200	250	3225	3893	4497				
11602750	250	300	4023	4640	4497				
11603050	280	400	4576	4684	4540				

Table 11-5 Losses @ 40 °C (104 °F) ambient with high IP insert installed

Model	Normal Duty						
	Drive losses (W) taking into consideration any current derating for the given conditions						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V							
03200066	88	93	95	99	104	113	122
03200080	95	100	102	107	113	122	133
03200110	117	123	126	133	140	158	157
03200127	122	128	124	122	118	98	84
04200180	138	145	151	151	146	142	146
04200250	204	215	205	194	189	187	199
05200300	188	194	201	212	222	240	262
400 V							
03400034	76	80	84	94	103	123	137
03400045	84	88	92	102	105	110	134
03400062	80	84	85	89	92	109	134
03400077	108	114	117	122	135	172	203
03400104	112	118	134	155	173	221	267
03400123	112	118	134	155	173	221	267
04400185	100	105	114	132	153	197	207
04400240	96	101	111	131	152	197	207
05400300	118	118	119	124	132	152	183
575 V							
05500039	32	42	52	71	92	133	173
05500061	70	85	100	130	159	219	278
05500100	123	144	165	210	252	338	424

Table 11-6 Losses @ 50 °C (122 °F) ambient

Model	Normal Duty						
	Drive losses (W) taking into account any current derating for the given conditions						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V							
03200066	88	93	95	99	104	113	122
03200080	95	100	102	107	113	122	133
03200110	117	123	126	133	139	144	139
03200127	129	136	140	143	147	151	150
04200180	171	180	187	201	216	253	297
04200250	203	214	223	244	265	312	334
05200300	280	291	302	324	341	325	312
06200500	375	394	413	452	480	431	594
06200580	442	463	484	510	483	432	451
07200750	538	570	597	650	703	710	717
07200940	678	718	751	799	750	758	765
07201170	848	898	898	805	751	759	766
08201490	1353	1433	1536	1741	1770	1788	1806
08201800	1640	1737	1740	1759	1771	1789	1807
09202160 (9A)	2028	2170	2312	2354	2256	2010	1910
09202660 (9A)	2431	2405	2368	2358	2245	2015	1922
09202160 (9E)	1889	2031	2174	2240	2172	1970	1889
09202660 (9E)	2241	2239	2223	2243	2161	1975	1900
10203250	2478	2625	2641	2625	2671	2490	2379
10203600	2666	2629	2643	2629	2678	2495	2374
400 V							
03400034	76	80	84	118	103	123	141
03400045	84	88	92	104	115	137	160
03400062	99	104	112	125	132	146	155
03400077	106	106	109	114	117	145	155
03400104	138	145	158	175	194	225	225
03400123	152	152	160	175	194	225	230
04400185	213	213	227	262	300	323	325
04400240	212	212	227	262	300	318	321
05400300	251	275	300	326	326	328	330
06400380	378	417	456	532	597	589	568
06400480	469	515	561	589	580	571	568
06400630	616	604	601	582	583	581	567
07400790	744	830	907	1062	1141	1152	1164
07400940	895	999	1087	1163	1138	1149	1161
07401120	1018	1136	1200	1118	1074	1085	1096
08401550	1480	1652	1815	2016	1970	1990	2010
08401840	1754	1957	2114	1998	1979	1999	2019
09402210 (9A)	2431	2710	2872	2799	2737	2639	2652
09402660 (9A)	2837	2926	2870	2814	2737	2660	2665
09402210 (9E)	2286	2565	2738	2709	2675	2611	2638
09402660 (9E)	2648	2760	2735	2723	2675	2632	2651

Model	Normal Duty						
	Drive losses (W) taking into account any current derating for the given conditions						
	2 kHz	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
10403200	3210	3582	3681	3765	3700	3597	3591
10403610	3482	3598	3676	3776	3694	3625	3589
11404370	4182	4329	4228	3988	3843		
11404870	4456	4329	4228	3988	3843		
11405070	4456	4329	4228	3988	3843		
575 V							
05500039	82	92	102	121	142	183	223
05500061	120	135	150	180	209	269	328
05500100	173	194	215	260	302	388	474
06500120	191	215	239	287	334	430	525
06500170	253	284	315	376	438	563	515
06500220	325	362	399	482	569	500	519
06500270	391	448	505	596	612	613	652
06500340	534	623	712	737	737	747	749
06500430	675	774	763	734	742	748	750
07500530	936	988	1115	1225	1144	1155	1167
07500730	1161	1225	1228	1098	1030	1040	1051
08500860	1753	1850	2172	2540	2672	2699	2726
08501080	1980	2090	2291	2540	2684	2711	2738
09501250 (9A)	1707	1977	2247	2538	2456	2495	2699
09501500 (9A)	2087	2410	2734	2544	2456	2482	2676
09501250 (9E)	1595	1865	2135	2443	2392	2460	2674
09501500 (9E)	1933	2256	2580	2448	2392	2447	2652
10502000	2692	2841	2654	2448	2392	2447	2652
11502480	3191	3678	3532				
11502880	3965	3678	3532				
11503150	3965	3678	3632				
690 V							
07600230	359	428	491	617	743	750	758
07600300	463	551	631	791	958	968	977
07600360	554	660	754	944	1144	1155	1167
07600460	717	854	965	1206	1144	1155	1167
07600520	814	969	1094	1225	1144	1155	1167
07600730	1029	1225	1228	1098	1030	1040	1051

Model	Normal Duty						
	Drive losses (W) taking into account any current derating for the given conditions						
	2 kHz	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
08600860	1553	1850	2172	2540	2672	2699	2726
08601080	1755	2090	2291	2540	2684	2711	2738
09601250 (9A)	1878	2213	2548	2933	2882	2974	3248
09601550 (9A)	2384	2797	3175	2918	2855	2974	3249
09601250 (9E)	1730	2065	2400	2810	2803	2934	3223
09601550 (9E)	2160	2573	2955	2796	2778	2934	3225
10601720	2420	2882	2947	2805	2789	2932	3229
10601970	2614	3132	3610	3243	3221	3420	3771
11602250	3225	3893	4048				
11602750	4023	4186	4048				
11603050	4421	4230	4091				

Table 11-7 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
3	≤ 50 W
4	≤ 75 W
5	≤ 100 W
6	≤ 100 W
7	≤ 204 W
8	≤ 347 W
9A/9E	≤ 480 W
10E/11E	≤ 480 W

11.1.3 Supply requirements

AC supply voltage:

200 V drive: 200 V to 240 V ±10 %
400 V drive: 380 V to 480 V ±10 %
575 V drive: 500 V to 575 V ±10 %
690 V drive: 500 V to 690 V ±10 %
Number of phases: 3

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

Frequency range: 45 to 66 Hz

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

11.1.4 Line reactors

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

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

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

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

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

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

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

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

03200066, 03200080, 03200110, 03200127
03400034, 03400045, 03400062, 03400077

Model sizes 03400104 to 07600730 have an internal DC choke and model sizes 08201490 to 0801080 and frame 9A have internal AC line chokes so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions. Drive sizes 9E,10E and 11E do not have internal input line reactors hence an external input line reactor must be used. For more information refer to section 4.2.3 *Drive model and input line reactor* on page 101.

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

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive
Repetitive peak current rating:

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

11.1.5 Motor requirements

No. of phases: 3

Maximum voltage:

200 V drive: 265 V
400 V drive: 530 V
575 V drive: 635 V
690 V drive: 765 V

11.1.6 Temperature, humidity and cooling method

Ambient temperature operating range:

- 20 °C to 55 °C (- 4 °F to 131 °F).
Output current derating must be applied at ambient temperatures > 40 °C (104 °F).

Cooling method: Forced convection

Maximum humidity: 95 % non-condensing at 40 °C (104 °F)

11.1.7 Storage

-40 °C (-40 °F) to +55 °C (131 °F) for long term storage, or to +70 °C (158 °F) for short term storage.
Storage time is 2 years.

Electrolytic capacitors in any electronic product have a storage period after which they require reforming or replacing.

The DC bus capacitors have a storage period of 10 years.

The low voltage capacitors on the control supplies typically have a storage period of 2 years and are thus the limiting factor.

Low voltage capacitors cannot be reformed due to their location in the circuit and thus may require replacing if the drive is stored for a period of 2 years or greater without power being applied.

It is therefore recommended that drives are powered up for a minimum of 1 hour after every 2 years of storage.

This process allows the drive to be stored for a further 2 years.

11.1.8 Altitude

Altitude range: 0 to 3,000 m (9,900 ft), subject to the following conditions:

1,000 m to 3,000 m (3,300 ft to 9,900 ft) above sea level: de-rate the maximum output current from the specified figure by 1 % per 100 m (330 ft) above 1,000 m (3,300 ft)
For example at 3,000 m (9,900 ft) the output current of the drive would have to be de-rated by 20 %.

11.1.9 IP / UL Rating

The drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP65 rating (sizes 3 to 8) or IP55 rating (size 9, 10 and 11) (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required).

In order to achieve the high IP rating at the rear of the heatsink with drive sizes 3,4 and 5 it is necessary to seal a heatsink vent by installing the high IP insert.

The IP rating of a product is a measure of protection against ingress and contact to foreign bodies and water. It is stated as IP XX, where the two digits (XX) indicate the degree of protection provided as shown in Table 11-8 *IP Rating degrees of protection* on page 407.

Table 11-8 IP Rating degrees of protection

First digit		Second digit	
Protection against foreign bodies and access to hazardous parts		Protection against ingress of water	
0	Non-protected	0	Non-protected
1	Protected against solid foreign objects of 50 mm Ø and greater (back of a hand)	1	Protected against vertically falling water drops
2	Protected against solid foreign objects of 12.5 mm Ø and greater (finger)	2	Protected against vertically falling water drops when enclosure tilted up to 15°
3	Protected against solid foreign objects of 2.5 mm Ø and greater (tool)	3	Protected against spraying water
4	Protected against solid foreign objects of 1.0 mm Ø and greater (wire)	4	Protected against splashing water
5	Dust-protected (wire)	5	Protected against water jets
6	Dust-tight (wire)	6	Protected against powerful water jets
7	-	7	Protected against the effects of temporary immersion in water
8	-	8	Protected against the effects of continuous immersion in water

Table 11-9 UL enclosure ratings

UL rating	Description
Type 1	Enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling dirt.
Type 12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids.

11.1.10 Corrosive gasses

Concentrations of corrosive gases must not exceed the levels given in:

- Table A2 of EN 50178:1998
- Class 3C2 of IEC 60721-3-3

This corresponds to the levels typical of urban areas with industrial activities and/or heavy traffic, but not in the immediate neighborhood of industrial sources with chemical emissions.

11.1.11 RoHS compliance

The drive meets EU directive 2011/65/EU for RoHS compliance.

11.1.12 Vibration

Maximum recommended continuous vibration level 0.14 g r.m.s. broad-band 5 to 200 Hz.

Note

This is the limit for broad-band (random) vibration. Narrow-band vibration at this level which coincides with a structural resonance could result in premature failure.

Bump Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-29: Test Eb:
Severity: 8 g, 6 ms, half sine
No. of Bumps: 600 (100 in each direction of each axis)

Random Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-64: Test Fh:
Severity: 1.0 m²/s³ (0.01 g²/Hz) ASD from 5 to 20 Hz
-3 dB/octave from 20 to 200 Hz
Duration: 30 minutes in each of 3 mutually perpendicular axes.

Sinusoidal Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-6: Test Fc:
Frequency range: 5 to 500 Hz
Severity: 3.5 mm peak displacement from 5 to 9 Hz
10 m/s² peak acceleration from 9 to 200 Hz
15 m/s² peak acceleration from 200 to 500 Hz
Sweep rate: 1 octave/minute
Duration: 15 minutes in each of 3 mutually perpendicular axes.
EN 61800-5-1:2007, Section 5.2.6.4. referring to IEC 60068-2-6
Frequency range: 10 to 150 Hz
Amplitude: 10 to 57 Hz at 0.075 mm pk
57 to 150 Hz at 1g p
Sweep rate: 1 octave/minute
Duration: 10 sweep cycles per axis in each of 3 mutually perpendicular axes

11.1.13 Starts per hour

By electronic control: unlimited

By interrupting the AC supply: ≤ 20 (equally spaced)

11.1.14 Start up time

This is the time taken from the moment of applying power to the drive, to the drive being ready to run the motor:

Sizes 3 to 6 = 2.5 s
Sizes 7 to 11 = 5 s

11.1.15 Output frequency / speed range

In all operating modes (Open loop, RFC-A, RFC-S) the maximum output frequency is limited to 550 Hz.

11.1.16 Accuracy and resolution

Speed:

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

The following data applies to the drive only; it does not include the performance of the source of the control signals.

Open loop resolution:

Preset frequency reference: 0.1 Hz
Precision frequency reference: 0.001 Hz

Closed loop resolution

Preset speed reference: 0.1 rpm
Precision speed reference: 0.001 rpm
Analog input 1: 11 bit plus sign
Analog input 2: 11 bit plus sign

Current:

The resolution of the current feedback is 10 bit plus sign.

Accuracy: typical 2 %
worst case 5 %

11.1.17 Acoustic noise

The heatsink fan generates the majority of the sound pressure level at 1 m produced by the drive. The heatsink fan on all drive sizes are a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system.

Table 11-10 gives the sound pressure level at 1 m produced by the drive for the heatsink fan running at the maximum and minimum speeds.

Table 11-10 Acoustic noise data

Size	Max speed dBA	Min speed dBA
3	62.8	42.9
4	62.6	45.8
5	61.1	41.9
6	65.3	48.2
7	66.8	49.6
8	67.9	49.8
9A/9E/10E	75	52.6
11E	82.5	58

11.1.18 Overall dimensions

H Height including surface mounting brackets
W Width
D Projection forward of panel when surface mounted
F Projection forward of panel when through-panel mounted
R Projection rear of panel when through-panel mounted

Table 11-11 Overall drive dimensions

Size	Dimension				
	H	W	D	F	R
3	382 mm (15.04 in)	83 mm (3.27 in)	200 mm (7.87 in)	134 mm (5.28 in)	67 mm (2.64 in)
4	391 mm (15.39 in)	124 mm (4.88 in)			67 mm (2.64 in)
5	391 mm (15.39 in)	143 mm (5.63 in)	200 mm (7.87 in)	135 mm (5.32 in)	67 mm (2.64 in)
6	391 mm (15.39 in)	210 mm (8.27 in)	227 mm (8.94 in)	131 mm (5.16 in)	96 mm (3.78 in)
7	557 mm (21.93 in)	270 mm (10.63 in)	280 mm (11.02 in)	187 mm (7.36 in)	92 mm (3.62 in)
8	804 mm (31.65 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)
9A	1108 mm (43.61 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)
9E and 10E	1069 mm (42.09 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	99 mm (3.90 in)
11E	1242 mm (48.9 in)	310 mm (12.21 in)	313 mm (12.32 in)	190 mm (7.48 in)	122 mm (4.8 in)

11.1.19 Weights

Table 11-12 Overall drive weights

Size	Model	kg	lb
3	03400104, 03400123	4.5	9.9
	All other variants	4.0	8.8
4	All variants	6.5	14.30
5		7.4	16.30
6		14	30.90
7		28	61.70
8		52	114.64
9A		66.5	146.6
9E/10E		46	101.40
11E		63	138.9

11.1.20 Input current, fuse and cable size ratings

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

Typical input current

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

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

Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance. The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the maximum supply fault current given in Table 11-13.

Table 11-13 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

WARNING

Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 11-14 to Table 11-17 shows the recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 11-14 AC Input current and fuse ratings (200 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating: IEC Nominal A	IEC Maximum A	IEC Class	UL / USA Nominal A	UL / USA Maximum A	UL / USA Class
03200066	8.2	10.4	15.8	16	25	gG	20	25	CC, J or T*
03200080	9.9	12.6	20.9	20					
03200110	14	17	25				25		
03200127	16	20	34	25					
04200180	17	20	30	25	25	gG	25	25	CC, J or T*
04200250	23	28	41	32	32		30	30	
05200300	24	31	52	40	40	gG	40	40	CC, J or T*
06200500	42	48	64	63	63	gG	60	60	CC, J or T*
06200580	49	56	85				60		
07200750	58	67	109	80	80	gG	80	80	CC, J or T*
07200940	73	84	135	100	100		100	100	
07201170	91	105	149	125	125		125	125	
08201490	123	137	213	200	200	gR	200	200	HSJ
08201800	149	166	243				225	225	
09202160	172	205	270	250	250	gR	250	250	HSJ
09202660	228	260	319	315	315		300	300	
10203250	277	305	421	400	400	gR	400	400	HSJ
10203600	333	361	494	450	450		450	450	

Table 11-15 AC Input current and fuse ratings (400 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating: IEC Nominal A	IEC Maximum A	IEC Class	UL / USA Nominal A	UL / USA Maximum A	UL / USA Class
03400034	5	5	7	10	10	gG	10	10	CC, J or T*
03400045	6	7	9						
03400062	8	9	13						
03400077	11	13	21	20	20		20	20	
03400104	12	13	20						
03400123	14	16	25						
04400185	17	19	30	25	25	gG	25	25	CC, J or T*
04400240	22	24	35	32	32		30	30	
05400300	26	29	52	40	40	gG	35	35	CC, J or T*
06400380	32	36	67	63	63	gG	40	60	CC, J or T*
06400480	41	46	80				50		
06400630	54	60	90				60		
07400790	67	74	124	100	100	gG	80	80	CC, J or T*
07400940	80	88	145				100	100	
07401120	96	105	188	125	125		125	125	
08401550	137	155	267	250	250	gR	225	225	HSJ
08401840	164	177	303						

09402210	211	232	306	315	315	gR	300	300	HSJ
09402660	245	267	359				350	350	
10403200	306	332	445	400	400	gR	400	400	HSJ
10403610	370	397	523	450	450		450	450	
11404370	424	449	579	500	500	gR	600	600	HSJ
11404870	455	492	613						
11405070	502	539	752	630	630				

Table 11-16 AC Input current and fuse ratings (575 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
05500039	4	4	7	10	20	gG	10	10	CC, J or T*
05500061	6	7	9						
05500100	9	11	15	20			20	20	
06500120	12	13	22	20	40	gG	20	30	CC, J or T*
06500170	17	19	33	32			25		
06500220	22	24	41	40			30		
06500270	26	29	50	50	63		35	50	
06500340	33	37	63				40		
06500430	41	47	76	63			50		
07500530	41	45	75	50	50	gG	50	50	CC, J or T*
07500730	57	62	94	80	80		80	80	
08500860	74	83	121	125	125	gR	100	100	HSJ
08501080	92	104	165	160	160		150	150	
09501250	145	166	190	150	150	gR	150	150	HSJ
09501500	145	166	221	200	200		175	175	
10502000	177	197	266	250	250	gR	250	250	HSJ
11502480	240	265	327	400	400	gR	400	400	HSJ
11502880	285	310	395						
11503150	313	338	473						

Table 11-17 AC Input current and fuse ratings (690 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
07600230	18	20	32	25	50	gG	25	50	CC, J or T*
07600300	23	26	41	32			30		
07600360	28	31	49	40			35		
07600460	36	39	65	50			50		
07600520	40	44	75		80			80	
07600730	57	62	92	80			80		
08600860	74	83	121	125	125	gR	100	100	HSJ
08601080	92	104	165	160	160		150	150	
09601250	124	149	194	150	150	gR	150	150	HSJ
09601550	145	171	226	200	200		200	200	
10601720	180	202	268	225	225	gR	250	250	HSJ
10601970	202	225	313	250	250	gR	250	250	
11602250	225	256	379	400	400	gR	400	400	HSJ
11602750	217	302	425						
11603050	298	329	465						

* These fuses are fast acting.

Note

Ensure cables used suit local wiring regulations.

CAUTION

The following nominal cable sizes are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.

Table 11-18 Cable ratings (200 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
03200066	1.5	4	B2	1.5	4	B2	14	10	14	10
03200080										
03200110	4			4			12		12	
03200127										
04200180	6	8	B2	6	8	B2	10	8	10	8
04200250	8			8			8		8	
05200300	10	10	B2	10	10	B2	8	8	8	8

06200500	16	25	B2	16	25	B2	4	3	4	3
06200580	25			25			3		3	
07200750	35	70	B2	35	70	B2	2	1/0	2	1/0
07200940							1		1	
07201170	70			70			1/0		1/0	
08201490	95	2 x 70	B2	95	2 x 70	B2	3/0	2 x 1	3/0	2 x 1
08201800	2 x 70			2 x 70			2 x 1		2 x 1	
09202160	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
09202660	2 x 95			2 x 120			2 x 4/0		2 x 4/0	
10203250	2 x 120	2 x 185	B1	2 x 120	2 x 150	C	2 x 250	2 x 500	2 x 250	2 x 350
10203600	2 x 150		C	2 x 120			2 x 300		2 x 300	

Table 11-19 Cable ratings (400 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
03400034	1.5	4	B2	1.5	4	B2	18	10	18	10
03400045							16		16	
03400062							14		14	
03400077	2.5			2.5						
03400104										
03400123							12		12	
04400185	4	6	B2	4	6	B2	10	8	10	8
04400240	6			6			8		8	
05400300	6	6	B2	6	6	B2	8	8	8	8
06400380	10	25	B2	10	25	B2	6	3	6	3
06400480	16			16			4		4	
06400630	25			25			3		3	
07400790	35	70	B2	35	70	B2	1	1/0	1	1/0
07400940	50			50			2		2	
07401120	70			70			1/0		1/0	
08401550	2 x 50	2 x 70	B2	2 x 50	2 x 70	B2	2 x 1	2 x 1/0	2 x 1	2 x 1/0
08401840	2 x 70			2 x 70			2 x 1/0		2 x 1/0	
09402210	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
09402660	2 x 95			2 x 120			2 x 4/0		2 x 4/0	
10403200	2 x 120	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 250	2 x 350
10403610	2 x 150			2 x 150			2 x 350		2 x 300	
11404370	4 x 95		C	2 x 185	2 x 185	C	4 x 3/0		2 x 400	
11404870				2 x 240	2 x 240		4 x 4/0			
11405070										

Table 11-20 Cable ratings (575 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
05500039	0.75	1.5	B2	0.75	1.5	B2	16	16	16	16
05500061	1			1			14		14	
05500100	1.5			1.5			14		14	
06500120	2.5	25	B2	2.5	25	B2	14	3	14	3
06500170	4			4			10		10	
06500220	6			6			10		10	
06500270	10			10			8		8	
06500340							6		6	
06500430	16						6		6	
07500530	16	25	B2	16	25	B2	4	3	4	3
07500730	25			25			3		3	
08500860	35	50	B2	35	50	B2	1	1	1	1
08501080	50			50						
09501250	2 x 70	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09501500				2 x 50					2 x 1	
10502000	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
11502480	2 x 70		C	2 x 70		C	2 x 3/0			
11502880	2 x 95			2 x 95			2 x 4/0			
11503150	2 x 120			2 x 120			2 x 250			

Table 11-21 Cable ratings (690 V)

Model	Cable size (IEC) mm²						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
07600230	10	25	B2	10	25	B2	8	3	8	3
07600300							6		6	
07600360							6		6	
07600460	16			16			4		4	
07600520	16			16			4		4	
07600730	25			25			3		3	
08600860	50	70	B2	50	70	B2	2	1/0	2	1/0
08601080	70			70			1/0		1/0	
09601250	2 x 50	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09601550	2 x 70			2 x 50			2 x 1/0		2 x 1	
10601720	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 1/0	2 x 350
10601970	2 x 95						2 x 3/0		2 x 2/0	
11602250	2 x 70		C	2 x 70		C	2 x 3/0			
11602750	2 x 95			2 x 95			2 x 4/0			
11603050							2 x 250			

11.1.21 Protective ground cable ratings

Table 11-22 Protective ground cable ratings

Input phase conductor size	Minimum ground conductor size
≤ 10 mm²	Either 10 mm² or two conductors of the same cross-sectional area as the input phase conductor.
> 10 mm² and ≤ 16 mm²	The same cross-sectional area as the input phase conductor
> 16 mm² and ≤ 35 mm²	16 mm²
> 35 mm²	Half of the cross-sectional area of the input phase conductor

11.1.22 Maximum motor cable lengths

Table 11-23 Maximum motor cable lengths (200 V drives)

<table>
<tr><th colspan="8">200 V Nominal AC supply voltage</th></tr>
<tr><th rowspan="2">Model</th><th colspan="7">Maximum permissible motor cable length for each of the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>03200066</td><td colspan="5">65 m (210 ft)</td><td rowspan="4">50 m (165 ft)</td><td rowspan="4">37 m (120 ft)</td></tr>
<tr><td>03200080</td><td colspan="4">100 m (330 ft)</td><td rowspan="3">75 m (245 ft)</td></tr>
<tr><td>03200110</td><td colspan="3">130 m (425 ft)</td><td rowspan="2">100 m (330 ft)</td></tr>
<tr><td>03200127</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td></tr>
<tr><td>04200180</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>04200250</td></tr>
<tr><td>05200300</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td><td>100 m (330 ft)</td><td>75 m (245 ft)</td><td>50 m (165 ft)</td><td>37 m (120 ft)</td></tr>
<tr><td>06200500</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>06200580</td></tr>
<tr><td>07200750</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td rowspan="3">62 m (203 ft)</td><td rowspan="3">46 m (151 ft)</td></tr>
<tr><td>07200940</td></tr>
<tr><td>07201170</td></tr>
<tr><td>08201490</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>08201800</td></tr>
<tr><td>09202160</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>09202660</td></tr>
<tr><td>10203250</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>10203600</td></tr>
</table>

Table 11-24 Maximum motor cable lengths (400 V drives)

<table>
<tr><th colspan="8">400 V Nominal AC supply voltage</th></tr>
<tr><th rowspan="2">Model</th><th colspan="7">Maximum permissible motor cable length for each of the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>03400034</td><td colspan="5">65 m (210 ft)</td><td rowspan="6">50 m (165 ft)</td><td rowspan="6">37 m (120 ft)</td></tr>
<tr><td>03400045</td><td colspan="4">100 m (330 ft)</td><td rowspan="5">75 m (245 ft)</td></tr>
<tr><td>03400062</td><td colspan="3">130 m (425 ft)</td><td rowspan="4">100 m (330 ft)</td></tr>
<tr><td>03400077</td><td colspan="2" rowspan="3">200 m (660 ft)</td><td rowspan="3">150 m (490 ft)</td></tr>
<tr><td>03400104</td></tr>
<tr><td>03400123</td></tr>
<tr><td>04400185</td><td colspan="2" rowspan="2">200 m (660 ft)</td><td rowspan="2">150 m (490 ft)</td><td rowspan="2">100 m (330 ft)</td><td rowspan="2">75 m (245 ft)</td><td rowspan="2">50 m (165 ft)</td><td rowspan="2">37 m (120 ft)</td></tr>
<tr><td>04400240</td></tr>
<tr><td>05400300</td><td colspan="2">200 m (660 ft)</td><td>150 m (490 ft)</td><td>100 m (330 ft)</td><td>75 m (245 ft)</td><td>50 m (165 ft)</td><td>37 m (120 ft)</td></tr>
<tr><td>06400380</td><td colspan="2" rowspan="3">200 m (660 ft)</td><td rowspan="3">150 m (490 ft)</td><td rowspan="3">100 m (330 ft)</td><td rowspan="3">75 m (245 ft)</td><td rowspan="3">50 m (165 ft)</td><td rowspan="3">37 m (120 ft)</td></tr>
<tr><td>06400480</td></tr>
<tr><td>06400630</td></tr>
<tr><td>07400790</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td rowspan="3">62 m (203 ft)</td><td rowspan="3">46 m (151 ft)</td></tr>
<tr><td>07400940</td></tr>
<tr><td>07401120</td></tr>
<tr><td>08401550</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>08401840</td></tr>
<tr><td>09402210</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>09402660</td></tr>
<tr><td>10403200</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>10403610</td></tr>
<tr><td>11404370</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td rowspan="3">125 m (410 ft)</td><td rowspan="3">93 m (305 ft)</td><td></td><td></td></tr>
<tr><td>11404870</td><td></td><td></td></tr>
<tr><td>11405070</td><td></td><td></td></tr>
</table>

Table 11-25 Maximum motor cable lengths (575 V drives)

<table>
<tr><th colspan="8">575 V Nominal AC supply voltage</th></tr>
<tr><th rowspan="2">Model</th><th colspan="7">Maximum permissible motor cable length for each of the following switching frequencies</th></tr>
<tr><th>2 kHz</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td>05500039</td><td colspan="2" rowspan="3">200 m (660 ft)</td><td rowspan="3">150 m (490 ft)</td><td rowspan="3">100 m (330 ft)</td><td rowspan="3">75 m (245 ft)</td><td rowspan="3">50 m (165 ft)</td><td rowspan="3">37 m (120 ft)</td></tr>
<tr><td>05500061</td></tr>
<tr><td>05500100</td></tr>
<tr><td>06500120</td><td colspan="2" rowspan="6">200 m (660 ft)</td><td rowspan="6">150 m (490 ft)</td><td rowspan="6">100 m (330 ft)</td><td rowspan="6">75 m (245 ft)</td><td rowspan="6">50 m (165 ft)</td><td rowspan="6">37 m (120 ft)</td></tr>
<tr><td>06500170</td></tr>
<tr><td>06500220</td></tr>
<tr><td>06500270</td></tr>
<tr><td>06500340</td></tr>
<tr><td>06500430</td></tr>
<tr><td>07500530</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>07500730</td></tr>
<tr><td>08500860</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>08501080</td></tr>
<tr><td>09501250</td><td colspan="2" rowspan="2">250 m (820 ft)</td><td rowspan="2">187 m (614 ft)</td><td rowspan="2">125 m (410 ft)</td><td rowspan="2">93 m (305 ft)</td><td rowspan="2">62 m (203 ft)</td><td rowspan="2">46 m (151 ft)</td></tr>
<tr><td>09501500</td></tr>
<tr><td>10502000</td><td colspan="2">250 m (820 ft)</td><td>187 m (614 ft)</td><td>125 m (410 ft)</td><td>93 m (305 ft)</td><td>62 m (203 ft)</td><td>46 m (151 ft)</td></tr>
<tr><td>11502480</td><td colspan="2" rowspan="3">250 m (820 ft)</td><td rowspan="3">187 m (614 ft)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11502880</td><td></td><td></td><td></td><td></td></tr>
<tr><td>11503150</td><td></td><td></td><td></td><td></td></tr>
</table>

Table 11-26 Maximum motor cable lengths (690 V drives)

690 V Nominal AC supply voltage							
Model	**Maximum permissible motor cable length for each of the following switching frequencies**						
	2 kHz	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
07600230 07600300 07600360 07600460 07600520 07600730	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
08600860 08601080	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
09601250 09601550	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
10601720 10601970	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
11602250 11602750 11603050	250 m (820 ft)		187 m (614 ft)				

- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
- The default switching frequency is 3 kHz for Open-loop and RFC-A and 6 kHz for RFC-S mode.

The maximum cable length is reduced from that shown in section 4.9.1 *Cable types and lengths* on page 112 if high capacitance or reduced diameter motor cables are used. For further information, refer to section 4.9.2 *High-capacitance / reduced diameter cables* on page 113.

Minimum resistances and power ratings for the braking resistor at 40 °C (104 °F)

Table 11-27 Braking resistor resistance and power rating (200 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
03200066	22	7.7	0.75
03200080			1.1
03200110			1.5
03200127			2.2
04200180	18	9.4	3
04200250			4
05200300	19	8.9	5.5
06200500	10	16.9	7.5
06200580			11
07200750	4.5	37.6	15
07200940			18.5
07201170	4.5	37.6	22
08201490	2.3	73.5	30
08201800			37
09202160 (9A)	2	84.5	45
09202660 (9A)			55
09202160 (9E)	1.4	120.8	45
09202660(9E)			55
10203250	1.7	99.5	75
10203600			90

Table 11-28 Braking resistor resistance and power rating (400 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
03400034	74	9.2	0.75
03400045			1.1
03400062			1.5
03400077			2.2
03400104	50	13.6	3
03400123			4
04400185	37	18.3	5.5
04400240			7.5
05400300	40	16.9	11
06400380	20	33.8	15
06400480			18.5
06400630			22
07400790	7.5	90.2	30
07400940			37
07401120			45
08401550	6.3	107.4	55
08401840			75
09402210 (9A)	3.6	187.8	90
09402660 (9A)			110
09402210 (9E)	2.6	260	90
09402660 (9E)			110
10403200	3.1	218.1	132
10403610			160
11404370	1.83	369.4	185
11404870	1.2	563.4	200
11405070			250

Table 11-29 Braking resistor resistance and power rating (575 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
05500039	80	12.1	1.5
05500061			2.2
05500100			4
06500120	15	64.1	5.5
06500170			7.5
06500220			11
06500270			15
06500340			18.5
06500430			22
07500530	11	87.4	30
07500730			37
08500860	5.5	174.8	45
08501080			55
09501250 (9A)	5.1	188.5	75
09501500(9A)			90
09501250 (9E)	3.3	291.3	75
09501500 (9E)			90
10502000	3.3	291.3	110
11502480	1.83	525.2	150
11502880			185
11503150			225

Table 11-30 Braking resistor resistance and power rating (690 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
07600230	13	107.3	15
07600300			18.5
07600360			22
07600460			30
07600520			37
07600730			45
08600860	5.5	253.5	55
08601080			75
09601250(9A)	6.5	214.5	90
09601500(9A)			110
09601250(9E)	4.2	331.9	90
09601500 (9E)			110
10601720	4.2	331.9	132
10601970	3.8	366.8	160
11602250	2.2	633.6	185
11602750			200
11603050			250

* Resistor tolerance: ±10 %

11.1.23 Torque settings

Table 11-31 Drive control and relay terminal data

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

Table 11-32 Drive power terminal data

Pump DrivePump Drive F600 frame size	AC and motor terminals		DC terminals		Ground terminals	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
3 and 4	Plug-in terminal block		T20 Torx (M4)		T20 Torx (M4) / M4 Nut (7 mm AF)	
	0.7 N m (0.5 lb ft)	0.8 N m (0.6 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)
5	Plug-in terminal block		T20 Torx (M4) / M4 Nut (7 mm AF)		M5 Nut (8 mm AF)	
	1.5 N m (1.1 lb ft)	1.8 N m (1.3 lb ft)	1.5 N m (1.1 lb ft)	2.5 N m (1.8 lb ft)	2.0 N m (1.4 lb ft)	5.0 N m (3.7 lb ft)
6	M6 Nut (10 mm AF)		M6 Nut (10 mm AF)		M6 Nut (10 mm AF)	
	6.0 N m (4.4 lb ft)	8.0 N m (6.0 lb ft)	6.0 N m (4.4 lb ft)	8.0 N m (6.0 lb ft)	6.0 N m (4.4 lb ft)	8.0 N m (6.0 lb ft)
7	M8 Nut (13 mm AF)		M8 Nut (13 mm AF)		M8 Nut (13 mm AF)	
	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)	12 N m (8.8 lb ft)	14 N m (10.0 lb ft)
8 to 11	M10 Nut (17 mm AF)		M10 Nut (17 mm AF)		M10 Nut (17 mm AF)	
	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)

Table 11-33 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm² (16 AWG)
	2 way relay connector	2.5 mm² (12 AWG)
3	6 way AC power connector	6 mm² (10 AWG)
4		
5	3 way AC power connector 3 way motor connector	8 mm² (8 AWG)
6	2 way low voltage power 24 V supply connector	1.5 mm² (16 AWG)
7		
8		
9A/9E		
10E/11E		

11.1.24 Electromagnetic compatibility (EMC)

This is a summary of the EMC performance of the drive. For full details, refer to the *EMC Data Sheet* which can be obtained from the supplier of the drive.

Table 11-34 Immunity compliance

Standard	Type of immunity	Test specification	Application	Level
IEC61000-4-2 EN61000-4-2	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC61000-4-3 EN61000-4-3	Radio frequency radiated field	10 V/m prior to modulation 80 - 1000 MHz 80 % AM (1 kHz) modulation	Module enclosure	Level 3 (industrial)
IEC61000-4-4 EN61000-4-4	Fast transient burst	5/50 ns 2 kV transient at 5 kHz repetition frequency via coupling clamp	Control lines	Level 4 (industrial harsh)
		5/50 ns 2 kV transient at 5 kHz repetition frequency by direct injection	Power lines	Level 3 (industrial)
IEC61000-4-5 EN61000-4-5	Surges	Common mode 4 kV 1.2/50 μs waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2 kV 1.2/50 μs waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground [1]	Level 2
IEC61000-4-6 EN61000-4-6	Conducted radio frequency	10V prior to modulation 0.15 - 80 MHz 80 % AM (1 kHz) modulation	Control and power lines	Level 3 (industrial)
IEC61000-4-11 EN61000-4-11	Voltage dips and interruptions	-30 % 10 ms +60 % 100 ms -60 % 1 s <-95 % 5 s	AC power ports	
IEC61000-6-1 EN61000-6-1:2007	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
IEC61000-6-2 EN61000-6-2:2005	Generic immunity standard for the industrial environment			Complies
IEC61800-3 EN61800-3:2004	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

[1] See section *Surge immunity of control circuits - long cables and connections outside a building* on page 130 for control ports for possible requirements regarding grounding and external surge protection

Emission

The drive contains an in-built filter for basic emission control.
An additional optional external filter provides further reduction of emission. The requirements of the following standards are met, depending on the motor cable length and switching frequency.

Table 11-35 Size 3 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 2	C3			C4			
Using internal filter and ferrite ring (2 turns):							
0 – 10	C3				C4		
10-20	C3			C4			
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-36 Size 3 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 5	C3			C4			
Using internal filter and ferrite ring (2 turns):							
0 – 10	C3					C4	
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-37 Size 4 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 2	C3				C4		
Using internal filter and ferrite ring (2 turns):							
0 – 4	C3		C4				
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-38 Size 4 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 4	C3			C4			
Using internal filter and ferrite ring (2 turns):							
0 – 10	C3		C4				
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-39 Size 5 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 2	C3		C4				
Using internal filter and ferrite ring (1 turn – no advantage to 2 turns):							
0 – 2	C3					C4	
0 – 5	C3			C4			
0 – 7	C3		C4				
0 – 10	C3	C4					
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-40 Size 5 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 4	C3			C4			
0 – 10	C3	C4					
No advantage to using ferrite ring							
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-41 Size 5 emission compliance (575 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
-	C4						
Using internal filter and ferrite ring (2 turns):							
0 – 4	C3			C4			
0 – 2	C3					C4	
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-42 Size 6 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 2	C3		C4				
Using internal filter and ferrite ring (1 turn – no advantage to 2 turns):							
0 – 2	C3					C4	
0 – 5	C3			C4			
0 – 7	C3		C4				
0 – 10	C3	C4					
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-43 Size 6 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
0 – 4	C3			C4			
0 – 10	C3	C4					
No advantage to using ferrite ring							
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-44 Size 6 emission compliance (575 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	**3**	**4**	**6**	**8**	**12**	**16**
Using internal filter:							
-	C4						
Using internal filter and ferrite ring (2 turns):							
0 – 4	C3			C4			
0 – 2	C3					C4	
Using external filter:							
0 – 20	C1	C1	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-45 Size 7 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 100	C4	C4	C4	C4	C4	C4	C4
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-46 Size 7 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 100	C4	C4	C4	C4	C4	C4	C4
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-47 Size 7 emission compliance (575 and 690 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 100	C4	C4	C4	C4	C4	C4	C4
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-48 Size 8 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 10	C3	C3	C3	C3	C3	C3	C3
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-49 Size 8 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 10	C3	C3	C3	C3	C3	C3	C3
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-50 Size 8 emission compliance (575 V and 690 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 100	C4	C4	C4	C4	C4	C4	C4
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-51 Size 9E and 10E emission compliance (all voltages)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 100	C3	C3	C3	C3	C3	C3	C3
Using external filter:							
0 – 20	C2	C2	C2	C2	C2	C2	C2
20 – 100	C2	C2	C3	C3	C3	C3	C3

Table 11-52 Size 11 emission compliance (all voltages)

Motor cable length (m)	Switching Frequency (kHz)				
	2	**3**	**4**	**6**	**8**
Using internal filter:					
0 – 50	C3	C3	C3	C3	C3
100	C3	C3	C3	C3	C4
Using external filter:					
20	C2	C2	C2	C2	C2
100	C2	C2	C3	C3	C3

Key (shown in decreasing order of permitted emission level):

E2R EN 61800-3 second environment, restricted distribution
(Additional measures may be required to prevent interference)

E2U EN 61800-3 second environment, unrestricted distribution

I Industrial generic standard EN 61000-6-4
EN 61800-3 first environment restricted distribution
(The following caution is required by EN 61800-3)

CAUTION

This is a product of the restricted distribution class according to IEC 61800-3. In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

R Residential generic standard EN 61000-6-3
EN 61800-3 first environment unrestricted distribution

EN 61800-3 defines the following:

- The first environment is one that includes residential premises. It also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for residential purposes.
- The second environment is one that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for residential purposes.
- Restricted distribution is defined as a mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives.

EN 61800-3:2004+A1:2012

The 2004 revision of the standard uses different terminology to align the requirements of the standard better with the EC EMC Directive.

Power drive systems are categorized C1 to C4:

Category	Definition	Corresponding code used above
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Intended for use in the second environment in a system rated at over 400 A, or in a complex system	E2R

Note that category 4 is more restrictive than E2R, since the rated current of the PDS must exceed 400 A or the supply voltage exceed 1000 V, for the complete PDS.

11.2 Optional external EMC filters

Table 11-53 EMC filter cross reference

Model	CT part number
200 V	
03200066 to 03200127	4200-3230
04200180 to 04200250	4200-0272
05200300	4200-0312
06200500 to 06200580	4200-2300
07200750 to 07201170	4200-1132
08201490 to 08201800	4200-1972
09202160 to 09202660 (9A)	4200-3021
09202160 to 09202660 (9E)	4200-4460
10203250 to 10203600	4200-4460
400 V	
03400034 to 03400123	4200-3480
04400185 to 04400240	4200-0252
05400300	4200-0402
06400380 to 06400630	4200-4800
07400790 to 07401120	4200-1132
08401550 to 08401840	4200-1972
09402210 to 09402660 (9A)	4200-3021
09402210 to 09402660 (9E)	4200-4460
10403200 to 10403610	4200-4460
11404370 to 11405070	4200-0400
575 V	
05500039 to 05500100	4200-0122
06500120 to 06500430	4200-3690
07500530 to 07500730	4200-0672
08500860 to 08501080	4200-1662
09501250 to 09501500 (9A)	4200-1660
09501250 to 09501500 (9E)	4200-2210
10502000	4200-2210
11502480 to 11503150	4200-0690
690 V	
07600230 to 07600730	4200-0672
08600860 to 08601080	4200-1662
09601250 to 09601550 (9A)	4200-1660
09601250 to 09601550 (9E)	4200-2210
10601720 to 10601970	4200-2210
11602250 to 11603050	4200-0690

11.2.1 EMC filter ratings

Table 11-54 Optional external EMC filter details

CT part number	Maximum continuous current		Voltage rating		IP rating	Power dissipation at rated current		Ground leakage		Discharge resistors
	@ 40 °C (104 °F)	@ 50 °C (122 °F)	IEC	UL		@ 40 °C (104 °F)	@ 50 °C (122 °F)	Balanced supply phase-to-phase and phase-to-ground	Worst case	
	A	A	V	V		W	W	mA	mA	MΩ
4200-3230	20	18.5	250	300	20	20	17	2.4	60	1.68
4200-0272	27	24.8	250	300		33	28	6.8	137	
4200-0312	31	28.5	250	300		20	17	2.0	80	
4200-2300	55	51	250	300		41	35	4.2	69	
4200-3480	16	15	528	600		13	11	10.7	151	
4200-0252	25	23	528	600		28	24	11.1	182	
4200-0402	40	36.8	528	600		47	40	18.7	197	
4200-4800	63	58	528	600		54	46	11.2	183	
4200-0122	12	11	760	600						
4200-3690	42	39	760	600		45	39	12	234	

11.2.2 Overall EMC filter dimensions

Table 11-55 Optional external EMC filter dimensions

CT part number	Dimension (mm)						Weight	
	H		W		D			
	mm	inch	mm	inch	mm	inch	kg	lb
4200-3230	426	16.77	83	3.27	41	1.61	1.9	4.20
4200-0272	437	17.20	123	4.84	60	2.36	4.0	8.82
4200-0312	437	17.20	143	5.63	60	2.36	5.5	12.13
4200-2300	434	17.09	210	8.27	60	2.36	6.5	14.30
4200-3480	426	16.77	83	3.27	41	1.61	2.0	4.40
4200-0252	437	17.20	123	4.84	60	2.36	4.1	9.04
4200-0402	437	17.20	143	5.63	60	2.36	5.5	12.13
4200-4800	434	17.09	210	8.27	60	2.36	6.7	14.80
4200-0122	437	17.20	143	5.63	60	2.36	5.5	12.13
4200-3690	434	17.09	210	8.27	60	2.36	7.0	15.40
4200-1132	270	10.63	90	3.54	205	5.9	6.0	13.20
4200-0672	270	10.63	90	3.54	205	5.9	6.2	13.70
4200-1972	300	11.81	120	4.72	170	6.69	9.6	21.10
4200-1662	270	10.63	90	3.54	205	8.07	9.4	20.70
4200-3021	339	13.34	230	9.06	120	4.72	11	24.25
4200-4460	105	4.13	360	14.2	245	9.65	12	26.50
4200-0400	135	5.32	386	15.2	260	10.2	14.7	32.41
4200-1660	360	14.7	245	9.65	105	4.13	5.2	11.46
4200-2210	105	4.13	360	14.2	245	9.65	10.3	22.71
4200-0690	135	5.32	386	15.2	260	10.2	16.75	36.90

11.2.3 EMC filter torque settings

Table 11-56 Optional external EMC Filter terminal data

CT part number	Power connections			Ground connections	
	Bar hole diameter	**Max cable size**	**Max torque**	**Ground stud size**	**Max torque**
4200-1132	N/A	50 mm² (1/0 AWG)	8.0 N m (6.0lb ft)	M10	18 N m (13.3 lb ft)
4200-0672					
4200-1972		95 mm² (3/0 AWG)	20 N m (14.8 lb ft)		
4200-1662					
4200-0122		16 mm² (6 AWG)	2.3 N m (1.7 lb ft)	M6	4.8 N m (2.8 lb ft)
4200-0252			1.8 N m (1.4 lb ft)		
4200-0272					
4200-0312					
4200-0402					
4200-3230		4 mm² (12 AWG)	0.8 N m (0.59 lb ft)	M5	3.0 N m (2.2 lb ft)
4200-3480		4 mm² (12 AWG)	0.8 N m (0.59 lb ft)	M5	
4200-2300		16 mm² (6 AWG)	2.3 N m (1.70 lb ft)	M6	4.8 N m (2.8 lb ft)
4200-4800					
4200-3690					
4200-3021	10.8 mm	N/A	30 N m (22.1 lb ft)	M10	18 N m (13.3 lb ft)
4200-4460	11 mm				
4200-1660	10.8 mm				
4200-2210	11 mm				
4200-0400	10.5 mm			M12	25 N m (18.4 lb ft)
4200-0690	10.5 mm				

12 Diagnostics

The keypad display on the drive gives various information about the status of the drive. The keypad display provides information on the following categories:

- Trip indications
- Alarm indications
- Status indications

12.1 Trip indications

The output of the drive is disabled under any trip condition so that the drive stops controlling the motor. If the motor is running when the trip occurs it will coast to a stop.

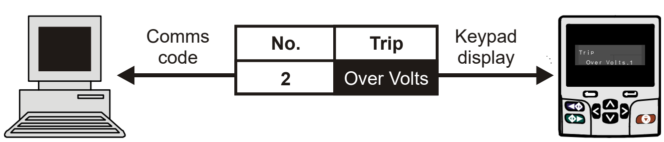
During a trip condition, where a KI-Keypad is being used, the upper row of the display indicates that a trip has occurred and the lower row of the keypad display will display the trip string. Some trips have a sub-trip number to provide additional information about the trip. If a trip has a sub-trip number, the sub-trip number is flashed alternately with the trip string unless there is space on the second row for both the trip string and the sub-trip number in which case both the trip string and sub-trip information is displayed separated by a decimal place.

The back-light of the KI-Keypad display will also flash during a trip condition. If a display is not being used, the drive LED Status indicator will flash with 0.5 s duty cycle if the drive has tripped. Refer to Figure 13-2.

Trips are listed alphabetically in Table 12-3 based on the trip indication shown on the drive display. Alternatively, the drive status can be read in Pr **10.001** 'Drive Healthy' using communication protocols. The most recent trip can be read in Pr **10.020** providing a trip number. It must be noted that the hardware trips (HF01 to HF20) do not have trip numbers. The trip number must be checked in Table 12-4 to identify the specific trip.

Example

1. Trip code 2 is read from Pr **10.020** via serial communications.
2. Checking Table 12-3 shows Trip 2 is an Over Volts trip.



3. Look up Over Volts in Table 12-3.
4. Perform checks detailed under *Diagnosis*.

12.2 Identifying a trip / trip source

Some trips only contain a trip string whereas some other trips have a trip string along with a sub-trip number which provides the user with additional information about the trip.

A trip can be generated from a control system or from a power system. The sub-trip number associated with the trips listed in Table 12-1 is in the form xxyzz and used to identify the source of the trip.

Table 12-1 Trips associated with xxyzz sub-trip number

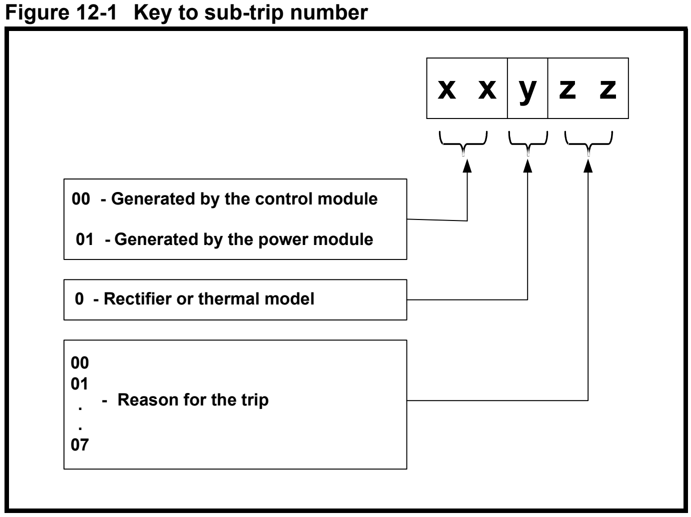
Over Volts	OHt dc bus
OI ac	Phase Loss
OI Brake	Power Comms
PSU	OI Snubber
OHt Inverter	Temp Feedback
OHt Power	Power Data
OHt Control	

The digits xx are 00 for a trip generated by the control system. For a single drive (not part of a multi-power module drive), if the trip is related to the power system then xx will have a value of 01, when displayed the leading zeros are suppressed.

The y digit is used to identify the location of a trip which is generated by a rectifier module connected to a power module (if xx is non zero). For a control system trip (xx is zero), the y digit, where relevant is defined for each trip. If not relevant, the y digit will have a value of zero.

The zz digits give the reason for the trip and are defined in each trip description.

Figure 12-1 Key to sub-trip number



For example, if the drive has tripped and the lower line of the display shows 'OHt Control.2', with the help Table 12-2 below the trip can be interpreted as; an over temperature has been detected; the trip was generated by fault in the control module, the control board thermistor 2 over temperature.

Table 12-2 Sub-trip identification

Source	xx	y	zz	Description
Control system	00	0	01	Control board thermistor 1 over temperature
Control system	00	0	02	Control board thermistor 2 over temperature
Control system	00	0	03	Control board thermistor 3 over temperature

12.3 Trips, Sub-trip numbers

Table 12-3 Trip indications

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>An Input 1 Loss</td><td>Analog input 1 current loss</td></tr>
<tr><td>28</td><td>An Input 1 Loss trip indicates that a current loss was detected in current mode on Analog input 1 (Terminal 5, 6). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA.
Recommended actions:
• Check control wiring is correct
• Check control wiring is undamaged
• Check the Analog Input 1 Mode (07.007)
• Current signal is present and greater than 3 mA</td></tr>
<tr><td>An Input 2 Loss</td><td>Analog input 2 current loss</td></tr>
<tr><td>29</td><td>An Input 2 Loss indicates that a current loss was detected in current mode on Analog input 2 (Terminal 7). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA.
Recommended actions:
• Check control wiring is correct
• Check control wiring is undamaged
• Check the Analog Input 2 Mode (07.011)
• Current signal is present and greater than 3 mA</td></tr>
<tr><td>An Output Calib</td><td>Analog output calibration failed</td></tr>
<tr><td>219</td><td>The zero offset calibration of one or both of the analogue outputs has failed. This indicates that the drive hardware has failed or a voltage is applied to the output via a low impedance, possibly due to a wiring error. The failed output can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Output 1 failed (Terminal 9)</td></tr>
<tr><td>2</td><td>Output 2 failed (Terminal 10)</td></tr>
</table>
Recommended actions:
• Check the wiring associated with analog outputs
• Remove all the wiring that is connected to analog outputs and perform a re-calibration by power cycling the drive.
• If trip persists replace the drive</td></tr>
<tr><td>App Menu Changed</td><td>Customization table for an application module has changed</td></tr>
<tr><td>217</td><td>The App Menu Changed trip indicates that the customization table for an application menu has changed. The menu that has been changed can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Menu 18</td></tr>
<tr><td>2</td><td>Menu 19</td></tr>
<tr><td>3</td><td>Menu 20</td></tr>
</table>
If more than one menu has changed the lowest menu has priority. Drive user parameters must be saved to prevent this trip on the next power-up.
Recommended actions:
• Reset the trip and perform a parameter save to accept the new settings</td></tr>
<tr><td>Assist 1 Cycle</td><td>Soft Starter Assist 1 starting too many times in an hour</td></tr>
<tr><td>121</td><td>This trip is called by the Pump software in the event of Soft Starter Assist 1 starting too many times in an hour as defined by Assist Starts Per Hour (29.120). This trip is only active when Assist Over-cycle Mode (29.121) = Trip and the Pump Control Mode (29.011) = Cascade.</td></tr>
<tr><td>Assist 2 Cycle</td><td>Soft Starter Assist 2 starting too many times in an hou</td></tr>
<tr><td>122</td><td>This trip is called by the Pump software in the event of Soft Starter Assist 2 starting too many times in an hour as defined by Assist Starts Per Hour (29.120). This trip is only active when Assist Over-cycle Mode (29.121) = Trip and the Pump Control Mode (29.011) = Cascade.</td></tr>
</table>

Trip	Diagnosis
Autotune 1	**Position feedback did not change or required speed could not be reached**
11	The drive has tripped during an autotune. The cause of the trip can be identified from the sub-trip number.

Sub-trip	Reason	Recommended actions
1	The position feedback did not change when position feedback is being used during rotating autotune.	Ensure that the motor is free to turn (i.e. mechanical brake is released). Check that the position feedback is selected correctly and operates correctly.
2	The motor did not reach the required speed during rotating autotune or mechanical load measurement.	Ensure that the motor is free to turn and that the static load plus inertia is not too large for the drive to accelerate within the test time.
3	The required commutation signal edge could not be found during a rotating auto-tune with a Commutation Only position feedback device.	Check that the position feedback signals are connected correctly.
4	The required movement angle cannot be produced during a minimal movement test.	Reduce the angular movement required.
5	The second part of the minimal movement test during auto-tuning cannot locate the motor flux position accurately.	Reduce the angular movement required.
6	The phasing offset angle is measured twice during a stationary auto-tune and the results are not within 30^{o} of each other.	If a minimal movement test is being used and excessive motor movement is occurring during the test reduce the required angle movement. Otherwise try and increase the required angle movement.
7	The motor is moving when a phasing test on enable is selected and the drive is enabled, but the motor is still moving at a speed above the zero speed threshold.	Ensure that the motor is stationary before the drive is enabled.
9	During the final stage of the minimal movement phasing test with a constrained motor it was not possible to achieve the required movement.	Reduce the angular movement required.

Trip	Diagnosis
Autotune 2	**Position feedback direction incorrect**
12	The drive has tripped during a rotating autotune. The cause of the trip can be identified from the associated sub-trip number.

Sub-trip	Reason
1	The position feedback direction is incorrect when position feedback is being used during a rotating autotune
2	A SINCOS encoder with comms is being used for position feedback and the comms position is rotating in the opposite direction to the sine wave based position.

Recommended actions:

- Check motor cable wiring is correct
- Check feedback device wiring is correct
- Swap any two motor phases

Trip	Diagnosis
Autotune 3	**Measured inertia has exceeded the parameter range or commutation signals changed in wrong direction**
13	The drive has tripped during a rotating autotune or mechanical load measurement test. The cause of the trip can be identified from the associated sub-trip number. **Sub-trip** / **Reason** 1: Measured inertia has exceeded the parameter range during a mechanical load measurement 2: The commutation signals changed in the wrong direction during a rotating autotune 3: The mechanical load test has been unable to identify the motor inertia **Recommended actions for sub-trip 2:** • Check motor cable wiring is correct • Check feedback device U,V and W commutation signal wiring is correct Recommended actions for sub-trip 3: • Increase the test level. • If the test was carried out at standstill repeat the test with the motor rotating within the recommended speed range.
Autotune 4	**U commutation signal did not change during a rotating auto-tune**
14	A position feedback device with commutation signals is being used (i.e AB Servo, FD Servo, FR Servo, SC Servo or Commutation Only encoder) and the U commutation signal did not change during a rotating auto-tune. **Recommended actions:** Check feedback device U commutation signal wiring is correct (Encoder terminals 7 and 8).
Autotune 5	**V commutation signal did not change during a rotating auto-tune**
15	A position feedback device with commutation signals is being used (i.e AB Servo, FD Servo, FR Servo, SC Servo or Commutation Only encoder) and the V commutation signal did not change during a rotating auto-tune. **Recommended actions:** Check feedback device V commutation signal wiring is correct (Encoder terminals 9 and 10).
Autotune 6	**W commutation signal did not change during a rotating auto-tune**
16	A position feedback device with commutation signals is being used (i.e AB Servo, FD Servo, FR Servo, SC Servo or Commutation Only encoder) and the W commutation signal did not change during a rotating auto-tune. **Recommended actions:** Check feedback device W commutation signal wiring is correct (Encoder terminals 11 and 12).
Autotune 7	**Motor number of poles / position feedback resolution set incorrectly**
17	An *Autotune 7* trip is initiated during a rotating autotune, if the motor poles or the position feedback resolution have been set up incorrectly where position feedback is being used. **Recommended actions:** • Check line per revolution for feedback device • Check the number of poles in Pr **05.011**
Autotune Stopped	**Autotune test stopped before completion**
18	The drive was prevented from completing an autotune test, because either the drive enable or the drive run were removed. **Recommended actions:** • Check the drive enable signal (Terminal 31) was active during the autotune • Check the run command was active in Pr **08.005** during autotune
Bkground Watchdg	**Background task taking longer than 15s to execute**
123	This trip is called by the Pump software in the event of the Background task taking longer than 15 s to execute.
Brake R Too Hot	**Braking resistor overload timed out (I^2t)**
19	The *Brake R Too Hot* indicates that braking resistor overload has timed out. The value in *Braking Resistor Thermal Accumulator* (**10.039**) is calculated using *Braking Resistor Rated Power* (**10.030**), *Braking Resistor Thermal Time Constant* (**10.031**) and *Braking Resistor Resistance* (**10.061**). The *Brake R Too Hot* trip is initiated when *Braking Resistor Thermal Accumulator* (**10.039**) reaches 100 %. **Recommended actions:** • Ensure the values entered in Pr **10.030**, Pr **10.031** and Pr **10.061** are correct • If an external thermal protection device is being used and the braking resistor software overload protection is not required, set Pr **10.030**, Pr **10.031** or Pr **10.061** to 0 to disable the trip.
CAM	**CAM**
99	Not applicable

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Card File Error</td><td>Card File Error</td></tr>
<tr><td>185</td><td>The information in the card header (or File /000 in the MCDF folder on an SD card) is out of range. This error can also occur when the file is from a SMART card if the internal file system header infomation is incorrrect (i.e. file type).</td></tr>
<tr><td>Card User Prog</td><td>Card User Prog</td></tr>
<tr><td>177</td><td>An attempt has been made to read a write-only user program.
An attempt has been made to transfer a user program from the drive to a card, but there is no user program present in the drive.</td></tr>
<tr><td>Card Busy</td><td>NV Media Card cannot be accessed as it is being accessed by an option module</td></tr>
<tr><td>178</td><td>The Card Busy trip indicates that an attempt has been made to access a file on NV Media Card, but the NV Media Card is already being accessed by an option module. No data is transferred.
Recommended actions:
• Wait for the option module to finish accessing the NV Media Card and re-attempt the required function</td></tr>
<tr><td>Card Derivative</td><td>NV Media Card file/data is different to the one in the drive</td></tr>
<tr><td>188</td><td>A parameter difference file is being written to the drive, but the value of Drive Derivative (11.028) in the file header is different to the value in the drive.</td></tr>
<tr><td>Card Data Exists</td><td>NV Media Card data location already contains data</td></tr>
<tr><td>179</td><td>An attempt is being made to write to a file that already exists.</td></tr>
<tr><td>Card File Data</td><td>NV Media Card parameter set not compatible with current drive mode</td></tr>
<tr><td>187</td><td>The drive mode, required defaults or product type in a parameter difference file are not compatible with the drive</td></tr>
<tr><td>Card Error</td><td>NV Media Card data structure error</td></tr>
<tr><td>182</td><td>The Card Error trip indicates that an attempt has been made to access a NV media card, but an error has been detected in the data structure on the card. Resetting this trip will cause the drive to erase the <MCDF> folder from the NV media card (if it exists) and create the correct folder structure. On an SD card, whilst this trip is still present, missing directories will be created, and if the header file is missing it will be created. The following sub-trip numbers are used with this trip:
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The required folder and file structure is not present</td></tr>
<tr><td>2</td><td>The <000> file is corrupted.</td></tr>
<tr><td>3</td><td>Two or more files in the <MCDF\> folder have the same file identification number.</td></tr>
</table>
Recommended actions:
• Erase all the data block and re-attempt the process
• Ensure the card is located correctly
• Replace the NV Media Card</td></tr>
<tr><td>Card Full</td><td>NV Media Card full</td></tr>
<tr><td>184</td><td>The Card Full trip indicates that an attempt has been made to create a data block on a NV Media Card, but there is not enough space left on the card.
Recommended actions:
• Delete a data block or the entire NV Media Card to create space
• Use a different NV Media Card</td></tr>
<tr><td>Card No Data</td><td>NV Media Card data not found</td></tr>
<tr><td>183</td><td>The Card No Data trip indicates that an attempt has been made to access non-existent file or block on a NV Media Card. No data is transferred.
Recommended actions:
• Ensure data block number is correct</td></tr>
<tr><td>Card Option</td><td>NV Media Card trip; option modules installed are different between source drive and destination drive</td></tr>
<tr><td>180</td><td>The Card Option trip indicates that parameter data or default difference data is being transferred from a NV Media Card to the drive, but the option module categories are different between source and destination drives. This trip does not stop the data transfer, but is a warning that the data for the option modules that are different will be set to the default values and not the values from the card. This trip also applies if a compare is attempted between the data block and the drive.
Recommended actions:
• Ensure the correct option modules are installed.
• Ensure the option modules are in the same option module slot as the parameter set stored.
• Press the red reset button to acknowledge that the parameters for one or more of the option modules installed will be at their default values
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Card Product</td><td>NV Media Card data blocks are not compatible with the drive derivative</td></tr>
<tr><td>175</td><td>If Drive Derivative (11.028) or Product Type (11.063) are different between the source and target drives then this trip is initiated either at power-up or when the card is accessed. It will have one of the following sub-trip numbers:
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>If Drive Derivative (11.028) is different between the source and target drives, this trip is initiated either at power-up or when the SD Card is accessed. Data is still transferred, since this is a warning trip; the trip can be suppressed by entering code 9666 in parameter xx.000, and resetting the drive (this applies the warning suppression flag to the card).</td></tr>
<tr><td>2</td><td>If Product Type (11.063) is different between the source and target drives or if corruption is detected in the parameter file, this trip is initiated either at power-up or when the SD Card is accessed. This trip can be reset but no data are transferred in either direction between the drive and the card.</td></tr>
<tr><td>3</td><td>A Unidrive SP parameter value was found that has no equivalent parameter on the destination drive. Data is still transferred, since this is a warning trip; the trip can be suppressed by entering code 9666 in Pr xx.000, and resetting the drive (this applies the warning suppression flag to the card).</td></tr>
</table>
Recommended actions:
• Use a different NV Media Card
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive</td></tr>
<tr><td>Card Rating</td><td>NV Media Card Trip; The voltage and / or current rating of the source and destination drives are different</td></tr>
<tr><td>186</td><td>The Card Rating trip indicates that parameter data is being transferred from a NV Media Card to the drive, but the current and / or voltage ratings are different between source and destination drives. This trip also applies if a compare (using Pr mm.000 set to 8yyy) is attempted between the data block on a NV Media Card and the drive. The Card Rating trip does not stop the data transfer but is a warning that rating specific parameters with the RA attribute may not be transferred to the destination drive.
Recommended actions:
• Reset the drive to clear the trip
• Ensure that the drive rating dependent parameters have transferred correctly
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
<tr><td>Card Read Only</td><td>NV Media Card has the Read Only bit set</td></tr>
<tr><td>181</td><td>The Card Read Only trip indicates that an attempt has been made to modify a read-only NV Media Card or a read-only data block. A NV Media Card is read-only if the read-only flag has been set.
Recommended actions:
• Clear the read only flag by setting Pr mm.000 to 9777 and reset the drive. This will clear the read-only flag for all data blocks in the NV Media Card
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
<tr><td>Card Slot</td><td>NV Media Card Trip; Option module application program transfer has failed</td></tr>
<tr><td>174</td><td>The Card Slot trip is initiated, if the transfer of an option module application program to or from an application module failed because the option module does not respond correctly. If this happens this trip is produced with the sub-trip indicating the option module slot number.
Recommended actions:
• Ensure the source / destination option module is installed on the correct slot</td></tr>
<tr><td>Clean Over-cycle</td><td>Pump cleaning cycle running too many times</td></tr>
<tr><td>120</td><td>This trip is called by the Pump software in the event of the pump cleaning cycle running too many times as defined by Clean Per Hour Limit (29.100). This trip is only active if Clean Per Hour Limit Mode (29.101) = Trip.</td></tr>
<tr><td>Cloning</td><td>Cloning system to back-up the drive and option modules</td></tr>
<tr><td>102</td><td>If an attempt is made to use the cloning system to back-up the drive and option modules (parameter mm.000 values from 40001 to 40999) or restore the drive and option modules (parameter mm.000 values from 60001 to 60999) and the action fails then a "Cloning" trip is initiated. The sub-trip value indicates the reason for the trip.</td></tr>
</table>

Trip	Diagnosis
Configuration	**The number of power modules installed is different from the modules expected**
111	The *Configuration* trip indicates that the *Number Of Power Modules Detected* (**11.071**) does not match the previous value stored. The sub-trip value indicates the number of power modules expected. **Recommended actions:** • Ensure that all the power modules are correctly connected • Ensure all the power modules have powered up correctly • Ensure that the value in Pr **11.071** is set to the number of power modules connected • Set Pr **11.035** to 0 to disable the trip if it is not required This trip is also initiated if the number of external rectifiers connected to each power module is less than the number defined by Number Of Rectifiers Expected (11.096). If this is the reason for the trip the sub-trip is 10x where x is the number of external rectifiers that should be connected. Recommended actions: • Ensure that all the external rectifiers are connected correctly. • Ensure that the value in *Number Of Rectifiers Expected* (**11.096**) is correct.
Control Word	**Trip initiated from the *Control Word* (06.042)**
35	The *Control Word* trip is initiated by setting bit 12 on the control word in Pr **06.042** when the control word is enabled (Pr **06.043** = On). **Recommended actions:** • Check the value of Pr **06.042.** • Disable the control word in *Control Word Enable* (Pr **06.043**) Bit 12 of the control word set to a one causes the drive to trip on Control Word When the control word is enabled, the trip can only be cleared by setting bit 12 to zero
Ctrl Wrd Watchdg	**Watchdog bit15 not being toggled for Pump Control Word Watchdog Time**
124	This trip is called by the Pump software in the event of Pump Control Word 1 (**29.151**) watchdog bit15 not being toggled for Pump Control Word Watchdog Time (**29.150**) seconds. This protects the system in the event that a HMI or PLC that is controlling the system becomes disconnected. This is only used when Control Input Mode (**29.012**) = Ctrl Wrd or Ctrl Wrd & Input.
Current Offset	**Current feedback offset error**
225	The current feedback offset is too large to be trimmed correctly. The sub-trip relates to the output phase for which the offset error has been detected. <table><tr><th>Sub-trip</th><th>Phase</th></tr><tr><td>1</td><td>U</td></tr><tr><td>2</td><td>V</td></tr><tr><td>3</td><td>W</td></tr></table> **Recommended actions:** • Ensure that there is no possibility of current flowing in the output phases of the drive when the drive is not enabled • Hardware fault – Contact the supplier of the drive
Data Changing	**Drive parameters are being changed**
97	A user action or a file system write is active that is changing the drive parameters and the drive has been commanded to enable, i.e. *Drive Active* (**10.002**) = 1.The user actions that change drive parameters are loading defaults, changing drive mode, or transferring data from an NV memory card or a position feedback device to the drive. The file system actions that will cause this trip to be initiated if the drive is enabled during the transfer are writing a parameter or macro file to the drive, or transferring a derivative or user program to the drive. It should be noted that none of these actions can be started if the drive is active, and so the trip only occurs if the action is started and then the drive is enabled. **Recommended actions:** Ensure the drive is not enabled when one of he following is being carried out: • Loading defaults • Changing drive mode • Transferring data from NV Media Card or position feedback device • Transferring user programs

Trip	Diagnosis
Derivative ID	**There is a problem with the identifier associated with derivative image which customizes the drive.**
247	There is a problem with the identifier associated with derivative image which customizes the drive. The reason for the trip is given by the sub-trip as follows:

Sub-trip	Reason
1	There should be a derivative image in the product but this has been erased.
2	The identifier is out of range.
3	The derivative image has been changed.

Trip	Diagnosis
Derivative Image	**Derivative Image error**
248	The *Derivative Image* trip indicates that an error has been detected in the derivative image. The sub-trip number indicates the reason for the trip.

Sub-trip	Reason	Comments
1	Divide by zero	
2	Undefined trip	
3	Attempted fast parameter access set-up with non-existent parameter	
4	Attempted access to non-existent parameter	
5	Attempted write to read-only parameter	
6	Attempted and over-range write	
7	Attempted read from write-only parameter	
30	The image has failed because either its CRC is incorrect, or there are less than 6 bytes in the image or the image header version is less than 5.	Occurs when the drive powers-up or the image is programmed. The image tasks will not run.
31	The image requires more RAM for heap and stack than can be provided by the drive.	As 30.
32	The image requires an OS function call that is higher than the maximum allowed.	As 30.
40	The timed task has not completed in time and has been suspended.	
41	Undefined function called, i.e. a function in the host system vector table that has not been assigned.	As 40.
51	Core menu customisation table CRC check failed	As 30.
52	Customisable menu table CRC check failed	As 30.
53	Customisable menu table changed	Occurs when the drive powers-up or the image is programmed and the table has changed. Defaults are loaded for the derivative menu and the trip will keep occurring until drive parameters are saved.
61	The option module fitted in slot 1 is not allowed with the derivative image.	As 30.
62	The option module fitted in slot 2 is not allowed with the derivative image.	As 30.
63	The option module fitted in slot 3 is not allowed with the derivative image.	As 30.
64	The option module fitted in slot 4 is not allowed with the derivative image.	As 30.
70	An option module that is required by the derivative image is not fitted in any slot.	As 30.
71	An option module specifically required to be fitted in slot 1 not present.	As 30.
72	An option module specifically required to be fitted in slot 2 not present.	As 30.
73	An option module specifically required to be fitted in slot 3 not present.	As 30.
74	An option module specifically required to be fitted in slot 4 not present.	As 30.
80	*Image is not compatible with the control board	Initiated from within the image code.
81	*Image is not compatible with the control board serial number	As 80.

Recommended action:

Contact the supplier of the drive

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Destination</td><td>Two or more parameters are writing to the same destination parameter</td></tr>
<tr><td>199</td><td>The Destination trip indicates that destination output parameters of two or more logic functions (Menus 5, 7, 8, 9, 12 or 14) within the drive are writing to the same parameter.
Recommended actions:
• Set Pr mm.000 to ‘Destinations’ or 12001 and check all visible parameters in all menus for parameter write conflicts</td></tr>
<tr><td>Drive Size</td><td>Power stage recognition: Unrecognized drive size</td></tr>
<tr><td>224</td><td>The Drive Size trip indicates that the control PCB has not recognized the drive size of the power circuit to which it is connected.
Recommended action:
• Ensure the drive is programmed to the latest firmware version
• Hardware fault - return drive to supplier</td></tr>
<tr><td>Dry Well</td><td>Dry Well Low Load detection</td></tr>
<tr><td>115</td><td>This trip is called by the Pump software in the event of a Dry Well Low Load detection when Dry Well Low Load Mode (29.059) = Trip.</td></tr>
<tr><td>EEPROM Fail</td><td>Default parameters have been loaded</td></tr>
<tr><td>31</td><td>The EEPROM Fail trip indicates that default parameters have been loaded. The exact cause/reason of the trip can be identified from the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The most significant digit of the internal parameter database version number has changed</td></tr>
<tr><td>2</td><td>The CRC's applied to the parameter data stored in internal non-volatile memory indicate that a valid set of parameters cannot be loaded</td></tr>
<tr><td>3</td><td>The drive mode restored from internal non-volatile memory is outside the allowed range for the product or the derivative image does not allow the previous drive mode</td></tr>
<tr><td>4</td><td>The drive derivative image has changed</td></tr>
<tr><td>5</td><td>The power stage hardware has changed</td></tr>
<tr><td>6</td><td>The internal I/O hardware has changed</td></tr>
<tr><td>7</td><td>The position feedback interface hardware has changed</td></tr>
<tr><td>8</td><td>The control board hardware has changed</td></tr>
<tr><td>9</td><td>The checksum on the non-parameter area of the EEPROM has failed</td></tr>
</table>
The drive holds two banks of user save parameters and two banks of power down save parameters in non-volatile memory. If the last bank of either set of parameters that was saved is corrupted a User Save or Power Down Save trip is produced. If one of these trips occurs the parameters values that were last saved successfully are used. It can take some time to save parameters when requested by the user and if the power is removed from the drive during this process it is possible to corrupt the data in the non-volatile memory.
If both banks of user save parameters or both banks of power down save parameters are corrupted or one of the other conditions given in the table above occurs EEPROM Fail.xxx trip is produced. If this trip occurs it is not possible to use the data that has been saved previously, and so the drive will be in lowest allowed drive mode with default parameters. The trip can only be reset if Pr mm.000 (mm.000) is set to 10, 11, 1233 or 1244 or if Load Defaults (11.043) is set to a non-zero value.
Recommended actions:
• Default the drive and perform a reset
• Allow sufficient time to perform a save before the supply to the drive is removed
• If the trip persists - return drive to supplier</td></tr>
<tr><td>Encoder 187 - 197</td><td>Not applicable</td></tr>
<tr><td>187 - 197</td><td></td></tr>
<tr><td>Encoder 12</td><td>Drive is communicating with the encoder</td></tr>
<tr><td>162</td><td>This trip indicates that the drive is communicating with the encoder but the encoder type is not recognised.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Drive position feedback interface 1</td></tr>
<tr><td>2</td><td>Drive position feedback interface 2</td></tr>
</table>
Recommended actions:
• Enter the encoder setup parameters manually.
• Check to see if the encoder supports auto-configuration.</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Encoder 13</td><td>Drive is communicating with the encoder</td></tr>
<tr><td>163</td><td>This trip indicates that the data read from the encoder was out of range during auto-configuration. No parameters will be modified with data read from the encoder as a result of auto-configuration. The tens in the sub-trip number indicate the interface number (i.e. 1 for P1 interface and 2 for P2 interface).
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>x1</td><td>Rotary lines per revolution error</td></tr>
<tr><td>x2</td><td>Linear comms pitch error</td></tr>
<tr><td>x3</td><td>Linear line pitch error</td></tr>
<tr><td>x4</td><td>Rotary turns bits error</td></tr>
<tr><td>x5</td><td>Communications bits error</td></tr>
<tr><td>x6</td><td>Calculation time is too long</td></tr>
<tr><td>x7</td><td>Line delay measured is longer than 5us</td></tr>
</table>
Recommended actions:
• Enter the encoder setup parameters manually.
• Check to see if the encoder supports auto-configuration.</td></tr>
<tr><td>Encoder 14</td><td>Drive is communicating with the encoder</td></tr>
<tr><td>164</td><td>The data given in the additional configuration parameter for a position feedback interface is out of range. If the sub-trip number is one then the data is out of range in P1 Additional Configuration (03.074), or if the sub-trip number is 2 the data is out of range in P2 Additional Configuration (03.174). Not all position feedback devices use the additional configuration, but those that do are listed below.
BiSS
Range checking is applied to the turns padding (decimal digits 5-3) and position padding (decimal digits 2-0). If these give a padding value outside +/-16 then the trip is initiated. Note that in each case the most significant digit indicates left (0) or right (1) padding, and the least significant 2 digits indicate the number of bits.</td></tr>
<tr><td>Ext Pump Fault</td><td>External Pump Fault Input</td></tr>
<tr><td>116</td><td>This trip is called by the Pump software in the event of the External Pump Fault Input (29.085) being set to On(1).</td></tr>
<tr><td>External Trip</td><td>An External trip is initiated</td></tr>
<tr><td>6</td><td>An External Trip has occurred. The cause of the trip can be identified from the sub trip number displayed after the trip string. See table below. An external trip can also be initiated by writing a value of 6 in Pr 10.038.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>External Trip Mode (08.010) = 1 or 3 and Safe Torque Off input 1 is low</td></tr>
<tr><td>2</td><td>External Trip Mode (08.010) = 2 or 3 and Safe Torque Off input 2 is low</td></tr>
<tr><td>3</td><td>External Trip (10.032) = 1</td></tr>
</table>
Recommended actions:
• Check the Safe Torque Off signal voltage on terminal 29 equals to 24 V
• Check the value of Pr 08.009 which indicates the digital state of terminal 29, equates to ‘on’.
• If external trip detection of the Safe Torque Off input is not required, set Pr 08.010 to Off (0).
• Check the value of Pr 10.032.
• Select ‘Destinations’ (or enter 12001) in Pr mm.000 and check for a parameter controlling Pr 10.032.
• Ensure Pr 10.032 or Pr 10.038 (= 6) is not being controlled by serial comms</td></tr>
<tr><td>HF01</td><td>Data processing error: CPU address error</td></tr>
<tr><td></td><td>The HF01 trip indicates that a CPU address error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
</table>

Trip	Diagnosis
HF02	**Data processing error: DMAC address error**
	The *HF02* trip indicates that a DMAC address error has occurred. This trip indicates that the control PCB on the drive has failed. Recommended actions: • Hardware fault – Contact the supplier of the drive
HF03	**Data processing error: Illegal instruction**
	The *HF03* trip indicates that an illegal instruction has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF04	**Data processing error: Illegal slot instruction**
	The *HF04* trip indicates that an illegal slot instruction has occurred.This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF05	**Data processing error: Undefined exception**
	The *HF05* trip indicates that an undefined exception error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF06	**Data processing error: Reserved exception**
	The *HF06* trip indicates that a reserved exception error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF07	**Data processing error: Watchdog failure**
	The *HF07* trip indicates that a watchdog failure has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF08	**Data processing error: CPU Interrupt crash**
	The *HF08* trip indicates that a CPU interrupt crash has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF09	**Data processing error: Free store overflow**
	The *HF09* trip indicates that a free store overflow has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF10	**Data processing error: Parameter routing system error**
	The *HF10* trip indicates that a Parameter routing system error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF11	**Data processing error: Access to EEPROM failed**
	The *HF11* trip indicates that access to the drive EEPROM has failed. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
HF12	**Data processing error: Main program stack overflow**
	The *HF12* trip indicates that the main program stack over flow has occurred. The stack can be identified by the sub-trip number. This trip indicates that the control PCB on the drive has failed.

Sub-trip	Stack
1	Background tasks
2	Timed tasks
3	Main system interrupts

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
HF13	**Data processing error: Firmware incompatible with hardware**
	The *HF13* trip indicates that the drive firmware is not compatible with the hardware. This trip indicates that the control PCB on the drive has failed. The sub-trip number gives the actual ID code of the control board hardware. **Recommended actions:** • Re-program the drive with the latest version of the drive firmware • Hardware fault – Contact the supplier of the drive
HF14	**Data processing error: CPU register bank error**
	The *HF14* trip indicates that a CPU register bank error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF15	**Data processing error: CPU divide error**
	The *HF15* trip indicates that a CPU divide error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF16	**Data processing error: RTOS error**
	The *HF16* trip indicates that a RTOS error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF17	**Data processing error: Clock supplied to the control board is out of specification**
	The *HF17* trip indicates that the clock supplied to the control board logic is out of specification. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF18	**Data processing error: Internal flash memory has failed**
	The *HF18* trip indicates that the internal flash memory has failed when writing option module parameter data. The reason for the trip can be identified by the sub-trip number.

Sub-trip	Reason
1	Programming error while writing menu in flash
2	Erase flash block containing setup menus failed
3	Erase flash block containing application menus failed

Recommended actions:

- Hardware fault - Contact the supplier of the drive.

Trip	Diagnosis
HF19	**Data processing error: CRC check on the firmware has failed**
	The *HF19* trip indicates that the CRC check on the drive firmware has failed. Recommended actions: • Re-program the drive • Hardware fault - Contact the supplier of the drive

Trip	Diagnosis
HF20	**Data processing error: ASIC is not compatible with the hardware**
	The *HF20* trip indicates that the ASIC version is not compatible with the drive firmware. The ASIC version can be identified from the sub-trip number. Recommended actions: • Hardware fault - Contact the supplier of the drive
HF23 to HF25	**Hardware fault**
	Recommended actions: • Hardware fault - Contact the supplier of the drive
I/O Overload	**Digital output overload**
26	The *I/O Overload* trip indicates that the total current drawn from 24 V user supply or from the digital output has exceeded the limit. A trip is initiated if one or more of the following conditions: • Maximum output current from one digital output is 100 mA. • The combined maximum output current from outputs 1 and 2 is 100 mA • The combined maximum output current from output 3 and +24 V output is 100 mA **Recommended actions:** • Check total loads on digital outputs • Check control wiring is correct • Check output wiring is undamaged

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Inductance</td><td>This trip occurs in RFC-S mode when the drive has detected that the motor inductances are not suitable.</td></tr>
<tr><td>8</td><td>
This trip occurs in RFC-S mode when the drive has detected that the motor inductances are not suitable for the operation being attempted. The trip is either caused because the ratio or difference between Ld and Lq is too small or because the saturation characteristic of the motor cannot be measured.
If the inductance ratio or difference is too small this is because one of the following conditions is true:
(No-load Lq (05.072)- Ld (05.024)) / Ld (05.024) < 0.2
(No-load Lq (05.072) - Ld (05.024)) < (K / Full Scale Current Kc (11.061))H
where:
<table>
<tr><th>Drive Rated voltage (11.033)</th><th>K</th></tr>
<tr><td>200 V</td><td>0.0073</td></tr>
<tr><td>400 V</td><td>0.0146</td></tr>
<tr><td>575 V</td><td>0.0174</td></tr>
<tr><td>690 V</td><td>0.0209</td></tr>
</table>
If the saturation characteristic of the motor cannot be measured this is because when the flux in the motor is changed the measured value of Ld does change sufficiently due to saturation to be measured. When half of Rated Current (05.007) is applied in the d axis of the motor in each direction the inductance must fall change at least (K / (2 x Full Scale Current Kc (11.061))) H.
The specific reasons for each of the sub-trips and recommended actions are given in the table below.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The inductance ratio or difference is too small when the drive has been started in sensorless mode.</td></tr>
<tr><td>2</td><td>The saturation characteristic of the motor cannot be measured when the drive has been started in sensorless mode.</td></tr>
<tr><td>3</td><td>The inductance ratio or difference is too small when an attempt is made to determine the location of the motor flux during a stationary auto-tune in RFC-S mode. This trip is also produced when the inductance ratio or inductance difference is too small when carrying out a phasing test on starting in RFC-S mode. If position feedback is being used the measured value for Position Feedback Phase Angle (03.025) may not be reliable. Also the measured values of Ld (05.024) and No-load Lq (05.072) may not correspond to the d and q axis respectively.</td></tr>
<tr><td>4</td><td>The direction of the flux in the motor is detected by the change of inductance with different currents. This trip is initiated if the change cannot be detected when an attempt is made to perform a stationary auto-tune when position feedback is being used, or to perform a phasing test on starting in RFC-S mode.</td></tr>
</table>
Recommended actions for sub-trip 1:
• Ensure that RFC Low Speed Mode (05.064) is set to Non-salient (1), Current (2) or Current No test (3).
Recommended Actions For Sub-trip 2:
• Ensure that RFC Low Speed Mode (05.064) is set to Non-salient (1), Current (2) or Current No test (3).
Recommended actions for sub-trip 3:
• None. The trip acts as a warning.
Recommended actions for sub-trip 4:
• Stationary autotune is not possible. Perform a minimal movement or rotating autotune.
• Phasing test on starting is not possible. Use a position feedback device with commutation signals or absolute position.
</td></tr>
<tr><td>Inductor Too Hot</td><td>Inductor Too Hot</td></tr>
<tr><td>93</td><td>Not applicable</td></tr>
<tr><td>Inter-connect</td><td>Multi-power module drive interconnection cable error</td></tr>
<tr><td>103</td><td>The sub-trip "xx.0.00" indicates which power module has detected the fault where xx is the power module number. It should be noted that this trip is also initiated if the communication fails either when a rectifier signals a fault or a trip is reset. In this case, the sub-trip is the number of modules that are still communicating correctly.</td></tr>
<tr><td>Island</td><td>System is connected to an island supply</td></tr>
<tr><td>160</td><td>This trip indicates that a regen system is connected to an island supply. The sub-trips indicate the reason for the trip.</td></tr>
<tr><td>Keypad Mode</td><td>Keypad has been removed when the drive is receiving the speed reference from the keypad</td></tr>
<tr><td>34</td><td>
The Keypad Mode trip indicates that the drive is in keypad mode [Reference Selector (01.049) = 4 or 6 or m^2 reference selector (21.003 = 4 or 6 if motor map 2 is selected] and the keypad has been removed or disconnected from the drive.
Recommended actions:
• Re-install keypad and reset
• Change Reference Selector (01.014) to select the reference from another source
</td></tr>
<tr><td></td><td></td></tr>
</table>

Trip	Diagnosis
Low Load	**Low load detector is set up to produce a trip on low load detection**
38	This trip is initiated if the low load detector is set up to produce a trip on low load detection and this condition occurs. See Enable Trip On Low Load (**04.029**).
Line Sync	**Line Sync**
39	Not applicable
Motor Over Temp	**Motor Over Temp**
118	This trip is called by the Pump software in the event of the Motor Thermal Protection Input (**29.086**) being set to Off(0) when Motor Thermal Protection Enable (**29.087**) = On(1)
Motor Too Hot	**Output current overload timed out (I^2t)**
20	The *Motor Too Hot* trip indicates a motor thermal overload based on the rated current (Pr **05.007**) and motor thermal time constant (Pr **04.015**). Pr **04.019** displays the motor temperature as a percentage of the maximum value. The drive will trip on *Motor Too Hot* when Pr **04.019** gets to 100 %. **Recommended actions:** • Ensure the load is not jammed / sticking • Check the load on the motor has not changed • If seen during an auto-tune test in RFC-S mode, ensure the motor rated current in Pr **05.007** is ≤ Heavy duty current rating of the drive • Tune the rated speed parameter (RFC-A mode only) • Check feedback signal for noise • Ensure the motor rated current is not zero
Name Plate	**Electronic nameplate transfer has failed**
176	The *Name Plate* trip is initiated if an electronic name plate transfer between the drive and the motor has failed. The exact reason for the trip can be identified from the sub-trip number.

Sub-trip	Reason	Details
1	A communication error with the encoder has been detected.	It is unlikely that this sub-trip will occur as most encoder errors will cause and encoder trip. It is possible that incorrect data in the nameplate could cause this trip, and so the nameplate data should be verified.
2	A data error has been detected in the nameplate. This is either because the number of entries is out of range, i.e. less than 1 or greater than 168, or the calculated CRC does not match the CRC from the nameplate.	Either there is no valid nameplate in the position feedback device or there is a data error in the nameplate area.
3	The exchange with the encoder has timed out.	If the encoder is connected to a drive interface, then this occurs because the encoder is not connected to the drive or is not initialised. If the encoder is connected to an option module interface, then this occurs because the position feedback interface (i.e. P1 or P2) is not present on the option module, or a suitable position feedback device is not selected, or because no device is connected, or it is not initialised.

Recommended actions:

- Ensure that the device encoder memory has at least 128 bytes to store the nameplate data
- When writing the motor object (xx.000 = 11000), ensure that the device encoder memory has at least 256 bytes to store all the nameplate data.
- When transferring between option module and encoder, ensure that the option slot has a feedback option module installed.
- Check if the encoder has been initialized, *Position Feedback Initialized* (**03.076**).
- Verify the encoder wiring.

Trip	Diagnosis
Network Loss	**Event of a loss Ethernet RTMoE comms from this drive to it's Leader in a Multi-leader system.**
	This trip is called by the Pump software in the event of a loss Ethernet RTMoE comms from this drive to it's Leader in a Multi-leader system. This trip is enabled when *Multi-leader Network Loss Mode* (**29.133**) = Trip. The trip may be disabled by setting *Multi-leader Network Loss Mode* (**29.133**) = Run Single Pump where instead of tripping the drive will run as a single pump, independent of the Leader.

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>OHt Brake</td><td>Braking IGBT over-temperature</td></tr>
<tr><td>101</td><td>The OHt Brake over-temperature trip indicates that braking IGBT over-temperature has been detected based on software thermal model.
Recommended actions:
• Check braking resistor value is greater than or equal to the minimum resistance value</td></tr>
<tr><td>OHt Control</td><td>Control stage over temperature</td></tr>
<tr><td>23</td><td>This OHt Control trip indicates that a control stage over-temperature has been detected. From the sub-trip ‘xxyzz’, the Thermistor location is identified by ‘zz’.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>01</td><td>Control board thermistor 1 over temperature</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>02</td><td>Control board thermistor 2 over temperature</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>03</td><td>I/O board thermistor over temperature</td></tr>
</table>
Recommended actions:
• Check enclosure / drive fans are still functioning correctly
• Check enclosure ventilation paths
• Check enclosure door filters
• Increase ventilation
• Reduce the drive switching frequency
• Check ambient temperature</td></tr>
<tr><td>OHt dc bus</td><td>DC bus over temperature</td></tr>
<tr><td>27</td><td>The OHt dc bus trip indicates a DC bus component over temperature based on a software thermal model. The drive includes a thermal protection system to protect the DC bus components within the drive. This includes the effects of the output current and DC bus ripple. The estimated temperature is displayed as a percentage of the trip level in Pr 07.035. If this parameter reaches 100 % then an OHt dc bus trip is initiated. The drive will attempt to stop the motor before tripping. If the motor does not stop in 10 seconds the drive trips immediately.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>2</td><td>00</td><td>DC bus thermal model gives trip with sub-trip 0</td></tr>
</table>
It is also possible in a multi-power module system for DC bus over-temperature to be detected from within the power stage. From this source the estimated temperature as a percentage of trip is not available and the trip is indicated as follows:
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>01</td><td>0</td><td>00</td><td>Power stage gives trip with sub-trip 0</td></tr>
</table>
Recommended actions:
• Check the AC supply voltage balance and levels
• Check DC bus ripple level
• Reduce duty cycle
• Reduce motor load
• Check the output current stability. If unstable;
Check the motor map settings with motor nameplate (Pr 05.006, Pr 05.007, Pr 05.008, Pr 05.009, Pr 05.010, Pr 05.011) – (All Modes)
Disable slip compensation (Pr 05.027 = 0) – (Open loop)
Disable dynamic V to F operation (Pr 05.013 = 0) - (Open loop)
Select fixed boost (Pr 05.014 = Fixed) – (Open loop)
Select high stability space vector modulation (Pr 05.020 = 1) – (Open loop)
Disconnect the load and complete a rotating autotune (Pr 05.012) – (RFC-A, RFC-S)
Reduce speed loop gains (Pr 03.010, Pr 03.011, Pr 03.012) – (RFC-A, RFC-S)
Add a speed feedback filter value (Pr 03.042) – (RFC-A, RFC-S)
Add a current demand filter (Pr 04.012) – (RFC-A, RFC-S)
Check encoder signals for noise with an oscilloscope (RFC-A, RFC-S)
Check encoder mechanical coupling - (RFC-A, RFC-S)</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>OHt Inverter</td><td>Inverter over temperature based on thermal model</td></tr>
<tr><td>21</td><td>
This trip indicates that an IGBT junction over-temperature has been detected based on a firmware thermal model. The sub-trip indicates which model has initiated the trip in the form xxyzz as given below:
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>1</td><td>00</td><td>Inverter thermal model</td></tr>
<tr><td>Control system</td><td>00</td><td>3</td><td>00</td><td>Braking IGBT thermal model</td></tr>
<tr><td>Control system</td><td>00</td><td>4</td><td>00</td><td>Rectifier thermal model</td></tr>
</table>
Recommended actions with sub-trip 100:
• Reduce the selected drive switching frequency
• Ensure Auto-switching Frequency Change Disable (05.035) is set to Off
• Reduce duty cycle
• Increase acceleration / deceleration rates
• Reduce motor load
• Check DC bus ripple
• Ensure all three input phases are present and balanced
Recommended actions with sub-trip 300:
• Reduce the braking load.
Recommended actions with sub-trip 400:
• Check the AC supply voltage balance and levels.
• Check the DC bus ripple level.
• Reduce duty cycle.
• Reduce motor load.
</td></tr>
</table>

Trip	Diagnosis
OHt Power	**Power stage over temperature**
22	This trip indicates that a power stage over-temperature has been detected. The sub-trip "xxyzz" indicates which thermistor is indicating the over-temperature. The thermsitor numbering is different for a single module type drive (i.e. no parallel board fitted) and a multi-module type drive (i.e. parallel board fitted with one or more power modules) as shown below:

Single module type drive:

Source	xx	y	zz	Description
Power system	01	0	zz	Thermistor location defined by zz in the power board
Power system	01	Rectifier number	zz	Thermistor location defined by zz in the rectifier

Multi-module type system:

Source	xx	y	zz	Description
Power system	power module number	0	01	U phase power device
Power system	power module number	0	02	V phase power device
Power system	power module number	0	03	W phase power device
Power system	power module number	0	04	Rectifier
Power system	power module number	0	05	General power system
Power system	power module number	0	00	Braking IGBT

Note that the power module that has caused the trip cannot be identified except for the braking IGBT temperature measurement

Recommended actions:

- Check enclosure / drive fans are still functioning correctly
- Force the heatsink fans to run at maximum speed
- Check enclosure ventilation paths
- Check enclosure door filters
- Increase ventilation
- Reduce the drive switching frequency
- Reduce duty cycle
- Decrease acceleration / deceleration rates
- Reduce motor load
- Check the derating tables and confirm the drive is correctly sized for the application.
- Use a drive with larger current / power rating

Trip	Diagnosis
OI ac	**Instantaneous output over current detected**
3	The instantaneous drive output current has exceeded VM_DRIVE_CURRENT_MAX. This trip cannot be reset until 10 s after the trip was initiated.

Source	xx	y	zz	Description
Control system	00	0	00	Instantaneous over-current trip when the measured a.c. current exceeds VM_DRIVE_CURRENT[MAX].
Power system	Power module number	0		

Recommended actions:

- Acceleration/deceleration rate is too short
- If seen during auto-tune reduce the voltage boost
- Check for short circuit on the output cabling
- Check integrity of the motor insulation using an insulation tester
- Check feedback device wiring
- Check feedback device mechanical coupling
- Check feedback signals are free from noise
- Is motor cable length within limits for the frame size
- Reduce the values in the speed loop gain parameters - (Pr **03.010**, **03.011**, **03.012**) or (Pr **03.013**, **03.014**, **03.015**)
- Has the phase angle autotune been completed? (RFC-S mode only)
- Reduce the values in current loop gain parameters (RFC-A, RFC-S modes only)

Trip	Diagnosis
OI Brake	**Braking IGBT over current detected: short circuit protection for the braking IGBT activated**
4	The *OI Brake* trip indicates that over current has been detected in braking IGBT or braking IGBT protection has been activated. This trip cannot be reset until 10 s after the trip was initiated.

Source	xx	y	zz	Description
Power system	Power module number	0	00	Braking IGBT instantaneous over-current trip

Recommended actions:

- Check brake resistor wiring
- Check braking resistor value is greater than or equal to the minimum resistance value
- Check braking resistor insulation

Trip	Diagnosis
OI dc	**Power module over current detected from IGBT on state voltage monitoring**
109	The *OI dc* trip indicates that the short circuit protection for the drive output stage has been activated. The table below shows where the trip has been detected..This trip cannot be reset until 10 s after the trip was initiated.

Source	xx	y	zz
Control system	00	0	00
Power system	Power module number	0	00

Recommended actions:

- Disconnect the motor cable at the drive end and check the motor and cable insulation with an insulation tester
- Replace the drive

Trip	Diagnosis
OI Snubber	**Snubber over-current detected**
92	The *OI Snubber* trip indicates that an over-current condition has been detected in the rectifier snubber circuit. The reason for the trip can be identified by the sub-trip number.

Source	xx	y	zz	Description
Power system	01	Rectifier number*	00	Rectifier snubber over-current trip detected.

*** For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.**

Recommended actions:

- Ensure the internal EMC Filter is installed
- Ensure the motor cable length does not exceed the maximum for selected switching frequency
- Check for supply voltage imbalance
- Check for supply disturbance such as notching from a DC drive
- Check the motor and motor cable insulation with an insulation tester
- Fit an output line reactor or sinusoidal filter

Trip	Diagnosis
Option Disable	**Option module does not acknowledge during drive mode changeover**
215	During drive mode changeover option modules must acknowledge that they have stopped accessing the communications system between the option slots and the drive. If an option module does not do this in the allowed time then this trip is produced.

Recommended trip:

- Reset the trip
- If the trip persists replace the option module

Trip	Diagnosis
Out Phase Loss	**Output phase loss detected**
98	The *Out Phase Loss* trip indicates that a phase loss has been detected at the drive output. Note that if Reverse Output Phase Sequence (**05.042**) = 1 the physical output phases are reversed, and so sub-trip 3 refers to physical output phase V and sub-trip 2 refers to physical output phase W.

Sub-trip	Reason
1	U phase detected as disconnected when drive enabled to run*
2	V phase detected as disconnected when drive enabled to run*
3	W phase detected as disconnected when drive enabled to run*
4	Output phase loss detected when the drive is running
5	U phase lower IGBT failure detection on drive enable
6	V phase lower IGBT failure detection on drive enable
7	W phase lower IGBT failure detection on drive enable

*These sub-trips could also indicate that the upper IGBT has failed in the indicated phase.

Recommended action:

- Check motor and drive connections
- To disable the trip set *Output Phase Loss Detection Enable* (**06.059**) = 0

Trip	Diagnosis
Over-Cycle	**Over-cycle**
117	This trip is called by the Pump software in the event of the over-cycle protection scheme counting too may starts per hour when *Over-cycle Mode* (**29.127**) = Trip.
Over Speed	**Motor speed has exceeded the over speed threshold**
7	In open loop mode, if the *Output Frequency* (**05.001**) exceeds the threshold set in *Over Speed Threshold* (**03.008**) in either direction an Over Speed trip is produced. In RFC-A and RFC-S mode, if the Speed Feedback (**03.002**) exceeds the Over Speed Threshold in Pr **03.008** in either direction an Over Speed trip is produced. If Pr **03.008** is set to 0.0 the threshold is then equal to 1.2 x the value set in Pr **01.006**. In RFC-A and RFC-S modes if an SSI encoder is being used and P1 SSI Incremental Mode (**03.047**) is set to Off, an Over Speed trip will be produced when the encoder passes through the boundary between its maximum position and zero. The above description relates to a standard over speed trip, however in RFC-S mode it is possible to produce an Overspeed trip with sub-trip 1. This is caused if the speed is allowed to exceed the safe level in RFC-S mode with flux weakening. See Enable High Speed Mode (**05.022**) for details. **Recommended actions:** • Check the motor is not being driven by another part of the system • Reduce the *Speed Controller Proportional Gain* (**03.010**) to reduce the speed overshoot (RFC-A, RFC-S modes only) • If an SSI encoder is being used set Pr **03.047** to 1 The above description relates to a standard Over Speed trip, however in RFC-S mode it is possible to produce an *Over Speed.1* trip. This is caused if the speed is allowed to exceed the safe level in RFC-S mode with flux weakening when *Enable High Speed Mode* (**05.022**) is set to -1.
Over Volts	**DC bus voltage has exceeded the peak level or maximum continuous level for 15 seconds**
2	The *Over Volts* trip indicates that the DC bus voltage has exceeded the VM_DC_VOLTAGE[MAX] or VM_DC_VOLTAGE_SET[MAX] for 15 s. The trip threshold varies depending on voltage rating of the drive as shown below.

Voltage rating	VM_DC_VOLTAGE[MAX]	VM_DC_VOLTAGE_SET[MAX]
200	415	410
400	830	815
575	990	970
690	1190	1175

Sub-trip Identification

Source	xx	y	zz
Control system	00	0	01: Instantaneous trip when the DC bus voltage exceeds VM_DC_VOLTAGE[MAX].
Control system	00	0	02: Time delayed trip indicating that the DC bus voltage is above VM_DC_VOLTAGE_SET[MAX].

Recommended actions:

- Increase deceleration ramp
- Decrease the 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
- Check motor insulation using an insulation tester

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Phase Loss</td><td>Supply phase loss</td></tr>
<tr><td>32</td><td>
This trip indicates that the drive has detected an input phase loss or large supply imbalance. Phase loss can be detected directly from the supply where the drive has a thyristor base charge system (Frame size 7 and above). If phase loss is detected using this method the drive trips immediately and the xx part of the sub-trip is set to 01. In all sizes of drive phase loss is also detected by monitoring the ripple in the DC bus voltage in which case the drive attempts to stop the drive before tripping unless bit 2 of Action On Trip Detection (10.037) is set to one. When phase loss is detected by monitoring the ripple in the DC bus voltage the xx part of the sub-trip is zero.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>00: Phase loss detected from DC bus ripple</td></tr>
<tr><td>Power system (1)</td><td>01</td><td>Rectifier number (2)</td><td>00: Phase loss detected directly from the supply</td></tr>
</table>
(1) Input phase loss detection can be disabled when the drive required to operate from the DC supply or from a single phase supply in Input Phase Loss Detection Mode (06.047).
(2) For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.
This trip does not occur in regen mode.
Recommended actions:

Check the AC supply voltage balance and level at full load
Check the DC bus ripple level with an isolated oscilloscope
Check the output current stability
Reduce the duty cycle
Reduce the motor load
Disable the phase loss detection, set Pr 06.047 to 2.
Check for mechanical resonance with the load

</td></tr>
<tr><td>Phasing error</td><td>This indicates that the phase offset angle is incorrect</td></tr>
<tr><td>198</td><td>
This indicates that the phase offset angle in Position Feedback Phase Angle (03.025) (or m² Position Feedback Phase Angle (21.020) if the second motor map is being used) is incorrect if position feedback is being used and the drive is unable to control the motor correctly.
Recommended actions:

Check the encoder wiring.
Check the encoder signals for noise with an oscilloscope.
Check encoder mechanical coupling.
Perform an auto-tune to measure the encoder phase angle or manually enter the correct phase angle into Position Feedback Phase Angle (03.025).
Spurious Phasing Error trips can sometimes be seen in very dynamic applications. This trip can be disabled by setting Over Speed Threshold (03.008) to a value greater than zero.

If sensorless control is being used this indicates that significant instability has occurred and the motor has accelerated without control. For low saliency motors (Active Saliency Torque Mode (05.066) < 2) this operates in the same way as when position feedback is used, based on the speed of the motor and the voltages applied. For high saliency motors (Active Saliency Torque Mode (05.066) = 2) this type of detection cannot be used and the over-speed trip should be used instead. However this trip is used for high saliency motors when low speed control using current injection is being used (Active Saliency Torque Mode (05.066) = 2) and control is lost because the motor has become non-salient. The saliency of most permanent magnet motors reduces with load, and so Low Speed Sensorless Mode Current (05.071) must be set to a level to limit the current so that the motor remains salient enough for control.Recommended actions:

Ensure that the motor parameters are set-up correctly.
Reduce the speed controller gains.
If high saliency control is being used ensure that Low Speed Sensorless Mode Current (05.071) is set to a low enough level, so that the motor remains salient at low speeds and higher loads.
This trip can be disabled by setting Over Speed Threshold (03.008) to a value greater than zero.

</td></tr>
<tr><td>PID Feedbk High</td><td>PID1 feedback going above the PID Feedback High Trip Threshold</td></tr>
<tr><td>113</td><td>This trip is called by the Pump software in the event of the main process PID1 feedback going above the PID Feedback High Trip Threshold (29.041). This trip can be disabled by setting PID Feedback High Trip Threshold (29.041) = 0.</td></tr>
<tr><td>PID Feedbk Loss</td><td>PID1 feedback when PID Feedback Loss Action</td></tr>
<tr><td>112</td><td>This trip is called by the Pump software in the event of a loss of main process PID1 feedback when PID Feedback Loss Action (29.048) = Trip and Analog Input 1 Current Loop Loss (07.028) = On(1).</td></tr>
</table>

Trip	Diagnosis
PID Feedbk Low	**PID1 feedback going below the PID Feedback Low Threshold**
114	This trip is called by the Pump software in the event of the main process PID1 feedback going below the *PID Feedback Low Threshold* (**29.044**). This trip can be disabled by setting *PID Feedback Low Mode* (**29.043**) to Disabled.
Power Comms	**A Power Comms trip indicates a communications problem within the power system of the drive**
90	A Power Comms trip indicates a communications problem within the power system of the drive. The reason for the trip can be identified by the sub-trip number.

Type of drive	xx	y	zz
Control system	Power module number	Rectifier number*	00: Excessive communications errors detected by the rectifier module

*** For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.**

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Power Data	**Power system configuration data error**
220	The *Power Data* trip indicates that there is an error in the configuration data stored in the power system.

Source	xx	y	zz	Description
Control system	00	0	02	There is no data table to be uploaded to the control board
Control system	00	0	03	The power system data table is bigger than the space available in the control pod to store it.
Control system	00	0	04	The size of the table given in the table is incorrect.
Control system	00	0	05	Table CRC error.
Control system	00	0	06	The version number of the generator software that produced the table is too low. i.e. a table from a newer generator is required that includes features that have been added to the table that may not be present.
Power system	01	0	00	The power data table used internally by the power module has an error. (For a multi-power module drive this indicates any error with the code tables in the power system).
Power system	01	0	01	The power data table that is uploaded to the control system on power up has an error.
Power system	01	0	02	The power data table used internally by the power module does not match the hardware identification of the power module.

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Power Down Save	**Power down save error**
37	The *Power Down Save* trip indicates that an error has been detected in the power down save parameters saved in non-volatile memory. **Recommended actions:** • Perform a 1001 save in Pr **mm.000** to ensure that the trip doesn't occur the next time the drive is powered up.

Trip	Diagnosis
PSU	**Internal power supply fault**
5	The *PSU* trip indicates that one or more internal power supply rails are outside limits or overloaded. **Source** | **xx** | **y** | **Description** Control system | 00 | 0 | 00: Internal power supply overload Power system | Power module number | Rectifier number* | 00: Rectifier internal power supply overload ***For a parallel power-module system the rectifier number will be zero as it is not possible to determine which rectifier has detected the fault.** **Recommended actions:** • Remove any option modules and perform a reset • Remove encoder connection and perform a reset • Hardware fault within the drive – return the drive to the supplier
PSU 24V	**24V internal power supply overload**
9	The total user load of the drive and option modules has exceeded the internal 24 V power supply limit. The user load consists of the drive digital outputs and main encoder supply. **Recommended actions:** • Reduce the load and reset • Provide an external 24 V power supply on control terminal 2 • Remove all option modules
Rectifier Set-up	**A rectifier has not been set-up correctly in a multi-power module system.**
94	A rectifier has not been set-up correctly in a multi-power module system. Recommended action: • Check the inter-power module wiring
Reset	**Reset**
100	This is not a valid trip number as this value is used in User Trip (**10.038**) to reset the drive.
Reset Logs	**Reset**
255	This is not a valid trip number as this value is used in User Trip (**10.038**) to reset the trip logs.
Reserved	**Reserved trips**
01, 95. 104 - 108, 161, 165 - 168, 170-173, 222 228-246	These trip numbers are reserved trip numbers for future use. These trips should not be used by the user application programs.

Trip	Diagnosis
Rating Mismatch	**Power stage recognition: Multi module voltage or current rating mismatch**
223	The *Rating Mismatch* trip indicates that there is a voltage rating or current rating mismatch in a multi-module drive system. This trip is only applicable to modular drives that are connected in parallel. A mixture of power modules with different voltage or current ratings within the same multi-module drive system is not allowed and will cause a Rating Mismatch trip. **Recommended action:** • Ensure that all modules in a multi-modular drive system are of the same frame size and rating (voltage and current) • Hardware fault – Contact the supplier of the drive
Resistance	**Measured resistance has exceeded the parameter range**
33	This trip indicates that either the value being used for motor stator resistance is too high or that an attempt to do a test involving measuring motor stator resistance has failed. The maximum for the stator resistance parameters is generally higher than the maximum value that can be used in the control algorithms. If the value exceeds (VFS / v2) / *Full Scale Current Kc* (**11.061**), where VFS is the full scale DC bus voltage then this trip is initiated. If the value is the result of a measurement made by the drive then sub-trip 1 is applied, or if it is because the parameter has been changed by the user then sub-trip 3 is applied. During the stator resistance section of auto-tuning an additional test is performed to measured the drive inverter characteristics to provide the compensation necessary for dead-times. If the inverter characteristic measurement fails then sub-trip 2 is applied. **Sub-trip** / **Reason** 1: Measured stator resistance exceeded the allowed range 2: It was not possible to measure the inverter characteristic 3: The stator resistance associated with the presently selected motor map exceeds the allowed range **Recommended actions:** • Check that the value that has been entered in the stator resistance does not exceed the allowed range (for the presently selected motor map) • Check the motor cable / connections • Check the integrity of the motor stator winding using an insulation tester • Check the motor phase to phase resistance at the drive terminals • Check the motor phase to phase resistance at the motor terminals • Ensure the stator resistance of the motor falls within the range of the drive model • Select fixed boost mode (Pr **05.014** = Fixed) and verify the output current waveforms with an oscilloscope • Replace the motor
Slot App Menu	**Application menu Customization conflict error**
216	The Slot App Menu trip indicates that more than one option slot has requested to customize the application menus 18, 19 and 20. The sub-trip number indicates which option slot has been allowed to customize the menus. **Recommended actions:** • Ensure that only one of the Application modules is configured to customize the application menus 18, 19 and 20
SlotX Different	**Option module in option slot X has changed**
204 209 214 254	The *SlotX Different* trip indicates that the option module in option slot X on the drive is a different type to that installed when parameters were last saved on the drive. The reason for the trip can be identified by the sub-trip number. **Sub-trip** / **Reason** 1: No module was installed previously 2: A module with the same identifier is installed, but the set-up menu for this option slot has been changed, and so default parameters have been loaded for this menu. 3: A module with the same identifier is installed, but the applications menu for this option slot has been changed, and so default parameters have been loaded for this menu. 4: A module with the same identifier is installed, but the set-up and applications menu for this option slot have been changed, and so default parameters have been loaded for these menus. >99: Shows the identifier of the module previously installed. **Recommended actions:** • Turn off the power, ensure the correct option modules are installed in the correct option slots and re-apply the power. • Confirm that the currently installed option module is correct, ensure option module parameters are set correctly and perform a user save in Pr **mm.000.**

Sub-trip table (Resistance):

Sub-trip	Reason
1	Measured stator resistance exceeded the allowed range
2	It was not possible to measure the inverter characteristic
3	The stator resistance associated with the presently selected motor map exceeds the allowed range

Sub-trip table (SlotX Different):

Sub-trip	Reason
1	No module was installed previously
2	A module with the same identifier is installed, but the set-up menu for this option slot has been changed, and so default parameters have been loaded for this menu.
3	A module with the same identifier is installed, but the applications menu for this option slot has been changed, and so default parameters have been loaded for this menu.
4	A module with the same identifier is installed, but the set-up and applications menu for this option slot have been changed, and so default parameters have been loaded for these menus.
>99	Shows the identifier of the module previously installed.

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>SlotX Error</td><td>Option module in option slot X has detected a fault</td></tr>
<tr><td>202
207
212
252</td><td>The SlotX Error trip indicates that the option module in option slot X on the drive has detected an error. The reason for the error can be identified by the sub-trip number.
Recommended actions:
• See relevant Option Module User Guide for details of the trip</td></tr>
<tr><td>SlotX HF</td><td>Option module X hardware fault</td></tr>
<tr><td>200
205
210
250</td><td>The SlotX HF trip indicates that the option module in option slot X on the drive has indicated a hardware fault. The possible causes of the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The module category cannot be identified</td></tr>
<tr><td>2</td><td>All the required customized menu table information has not been supplied or the tables supplied are corrupt</td></tr>
<tr><td>3</td><td>There is insufficient memory available to allocate the comms buffers for this module</td></tr>
<tr><td>4</td><td>The module has not indicated that it is running correctly during drive power-up</td></tr>
<tr><td>5</td><td>Module has been removed after power-up or it has stopped working</td></tr>
<tr><td>6</td><td>The module has not indicated that it has stopped accessing drive parameters during a drive mode change</td></tr>
<tr><td>7</td><td>The module has failed to acknowledge that a request has been made to reset the drive processor</td></tr>
<tr><td>8</td><td>The drive failed to correctly read the menu table from the module during drive power up</td></tr>
<tr><td>9</td><td>The drive failed to upload menu tables from the module and timed out (5 s)</td></tr>
<tr><td>10</td><td>Menu table CRC invalid</td></tr>
</table>
Recommended actions:
• Ensure the option module is installed correctly.
• If the option module has been reprogrammed check that this process was follwed correctly.
• Replace the option module.</td></tr>
<tr><td>SlotX Not Fitted</td><td>Option module in option slot X has been removed</td></tr>
<tr><td>203
208
213
253</td><td>The SlotX Not Fitted trip indicates that the option module in option slot X on the drive has been removed since the last power up.
Recommended actions:
• Ensure the option module is installed correctly.
• Re-install the option module.
• To confirm that the removed option module is no longer required perform a save function in Pr mm.000.</td></tr>
<tr><td>SlotX Watchdog</td><td>Option module watchdog function service error</td></tr>
<tr><td>201
206
211
251</td><td>The SlotX Watchdog trip indicates that the option module installed in Slot X has started the option watchdog function and then failed to service the watchdog correctly.
Recommended actions:
• Replace the option module</td></tr>
<tr><td>Soft Start</td><td>Soft start relay failed to close, soft start monitor failed</td></tr>
<tr><td>226</td><td>The Soft Start trip indicates that the soft start relay in the drive failed to close or the soft start monitoring circuit has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Stored HF</td><td>Hardware trip has occurred during last power down</td></tr>
<tr><td>221</td><td>The Stored HF trip indicates that a hardware trip (HF01 –HF19) has occurred and the drive has been power cycled. The sub-trip number identifies the HF trip i.e. stored HF.17.
Recommended actions:
• Enter 1299 in Pr mm.000 and press reset to clear the trip</td></tr>
</table>

Trip	Diagnosis
Sub-array RAM	**RAM allocation error**
227	An option module, derivative image or user program image has requested more parameter RAM than is allowed. The RAM allocation is checked in order of resulting sub-trip numbers, and so the failure with the highest sub-trip number is given. The sub-trip is calculated as (parameter size x 1000) + (parameter type x 100) + sub-array number. Note that if this trip occurs, all menu customisation provided by option modules, the derivative image or the user program image is not used. The tables below show the values corresponding to the parts of the sub-trip number.

Parameter size	Value
1 bit	1
8 bit	2
16 bit	3
32 bit	4
64 bit	5

Parameter type	Value
Volatile	0
User save	1
Power-down save	2

Sub-array	Menus	Value
Applications menus	18-20	1
Derivative image	29	2
User program image	30	3
Option slot 1 set-up	15	4
Option slot 1 applications	25	5
Option slot 2 set-up	16	6
Option slot 2 applications	26	7
Option slot 3 set-up	17	8
Option slot 3 applications	27	9
Option slot 4 set-up	24	10
Option slot 4 applications	28	11

Trip	Diagnosis
Temp Feedback	**Internal thermistor has failed**
218	The *Temp Feedback* trip indicates that an internal thermistor has failed. The thermistor location can be identified by the sub-trip number.

Source	xx	y	zz
Control board	00	00	01: Control board thermistor 1 02: Control board thermistor 2 03: I/O board thermistor
Power system	Power module number	0	Zero for temperature feedback provided via power system comms.21, 22 and 23 for direct ELV temperature feedback.
Power system	01	Rectifier number*	Always zero

*** For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.**

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Th Brake Res	**Brake resistor over temperature**
10	The *Th Brake Res* is initiated, If hardware based braking resistor thermal monitoring is connected and the resistor overheats. If the braking resistor is not used then this trip must be disabled with bit 3 of Action *On Trip Detection* (**10.037**) to prevent this trip. **Recommended actions:** • Check brake resistor wiring • Check braking resistor value is greater than or equal to the minimum resistance value • Check braking resistor insulation

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Th Short Circuit</td><td>Motor thermistor short circuit</td></tr>
<tr><td>25</td><td>This trip indicates that a temperature sensor connected to an analogue input or terminal 15 on the position feedback interface has a low impedance (i.e. < 50 Ω). The cause of the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Source</th></tr>
<tr><td>1</td><td>Analogue input 1</td></tr>
<tr><td>2</td><td>Analogue input 2</td></tr>
<tr><td>3</td><td>Analogue input 3</td></tr>
<tr><td>4</td><td>Position feedback interface</td></tr>
</table>
Recommended actions:
Check temperature feedback connection.
Replace sensor.</td></tr>
<tr><td>Thermistor</td><td>Motor thermistor over-temperature</td></tr>
<tr><td>24</td><td>The Thermistor trip indicates that the motor thermistor connected to terminal 8 (analog input 3) on the control connections or terminal 15 on the encoder terminal (15 way D-type connector) has indicated a motor over temperature. The cause of the trip can be identified by the sub-trip number
<table>
<tr><th>Sub-trip</th><th>Source</th></tr>
<tr><td>1</td><td>Analogue input 1</td></tr>
<tr><td>2</td><td>Analogue input 2</td></tr>
<tr><td>3</td><td>Analogue input 3</td></tr>
<tr><td>4</td><td>Position feedback interface</td></tr>
</table>
Recommended actions:
Check why the temperature measured by the sensor is too high temperature.
Check temperature sensor connection</td></tr>
<tr><td>Undefined</td><td>Drive has tripped and the cause of the trip is Undefined</td></tr>
<tr><td>110</td><td>The Undefined trip indicates that the power system has generated but did not identify the trip the power system. The cause of the trip is unknown.
Recommended actions:
Hardware fault – return the drive to the supplier</td></tr>
<tr><td>User 24V</td><td>User 24 V supply is not present on control terminals (1,2)</td></tr>
<tr><td>91</td><td>A User 24 V trip is initiated, if User Supply Select (Pr 06.072) is set to 1 or Low Under Voltage Threshold Select (06.067) = 1 and no user 24 V supply is present on control terminals 1 and 2.
Recommended actions:
Ensure the user 24 V supply is present on control terminals 1 (0 V) and 2 (24 V)</td></tr>
<tr><td>User Program</td><td>On board user program error (Cont)</td></tr>
<tr><td>249 (Cont)</td><td>The following table gives the differences when compared to the derivative product image.
<table>
<tr><th>Sub-trip</th><th>Difference</th></tr>
<tr><td>40, 41</td><td>Onboard User Program: Enable (11.047) is reset to zero when the trip is initiated.</td></tr>
<tr><td>51</td><td>Not applicable as core menu customisation not allowed</td></tr>
<tr><td>6x</td><td>Not applicable as option module restrictions not allowed</td></tr>
<tr><td>7x</td><td>Not applicable as option module restrictions not allowed</td></tr>
<tr><td>100</td><td>Image has detected and prevented attempted pointer access outside of the IEC task's heap area.</td></tr>
<tr><td>101</td><td>Image has detected and prevented misaligned pointer usage.</td></tr>
<tr><td>102</td><td>Image has detected an array bounds violation and prevented its access.</td></tr>
<tr><td>103</td><td>Image has attempted to convert a data type to or from an unknown data type, has failed and has shut itself down.</td></tr>
<tr><td>104</td><td>Image has attempted to use an unknown user service function.</td></tr>
<tr><td>200</td><td>User program has invoked a "divide" service with a denominator of zero. (Note that this is raised by the downloaded image and has therefore been given a distinct error code despite being the same fundamental problem as sub-trip 1.)</td></tr>
</table></td></tr>
</table>

Trip	Diagnosis
User Prog Trip	**Trip generated by an onboard user program**
96	This trip can be initiated from within an onboard user program using a function call which defines the sub-trip number. **Recommended actions:** • Check the user program
User Save	**User Save error / not completed**
36	The *User Save* trip indicates that an error has been detected in the user save parameters saved in non-volatile memory. For example, following a user save command, If the power to the drive was removed when the user parameters were being saved. **Recommended actions:** • Perform a user save in Pr **mm.000** to ensure that the trip doesn't occur the next time the drive is powered up. • Ensure that the drive has enough time to complete the save before removing the power to the drive.
User Trip	**User generated trip**
40 -89 125 -159	These trips are not generated by the drive and are to be used by the user to trip the drive through an application program. **Recommended actions:** • Check the user program
Voltage Range	**Voltage Range**
169	Not Applicable
Watchdog	**Control word watchdog has timed out**
30	The *Watchdog* trip indicates that the control word has been enabled and has timed out **Recommended actions:** Once Pr **06.042** bit 14 has been changed from 0 to 1 to enable the watchdog, this must be repeated every 1s or a Watchdog trip will be initiated. The watchdog is disabled when the trip occurs and must be re-enabled if required when the trip is reset.

Table 12-4 Serial communications look up table

No	Trip	No	Trip	No	Trip
1	Reserved 001	101	OHt Brake	199	Destination
2	Over Volts	102	Cloning	200	Slot1 HF
3	OI ac	103	Inter-connect	201	Slot1 Watchdog
4	OI Brake	104 - 108	Reserved 104 - 108	202	Slot1 Error
5	PSU	109	OI dc	203	Slot1 Not Fitted
6	External Trip	110	Undefined	204	Slot1 Different
7	Over Speed	111	Configuration	205	Slot2 HF
8	Inductance	112	PID Feedbk Loss	206	Slot2 Watchdog
9	PSU 24 V	113	PID Feedbk High	207	Slot2 Error
10	Th Brake Res	114	PID Feedbk Low	208	Slot2 Not Fitted
11	Autotune 1	115	Dry Well	209	Slot2 Different
12	Autotune 2	116	Ext Pump Fault	210	Slot3 HF
13	Autotune 3	117	Over-cycle	211	Slot3 Watchdog
14	Autotune 4	118	Motor Over Temp	212	Slot3 Error
15	Autotune 5	119	Network Loss	213	Slot3 Not Fitted
16	Autotune 6	120	Clean Over-cycle	214	Slot3 Different
17	Autotune 7	121	Assist 1 Cycle	215	Option Disable
18	Autotune Stopped	122	Assist 2 Cycle	216	Slot App Menu
19	Brake R Too Hot	123	Bkground Watchdg	217	App Menu Changed
20	Motor Too Hot	124	Ctrl Wrd Watchdg	218	Temp Feedback
21	OHt Inverter	125 - 159	User Trip 125 - 159	219	An Output Calib
22	OHt Power	160	Island	220	Power Data
23	OHt Control	161	Reserved	221	Stored HF
24	Thermistor	162 - 164	Encoder 12 - 14	222	Reserved 222
25	Th Short Circuit	165 - 168	Reserved 165 - 168	223	Rating Mismatch
26	I/O Overload	169	Voltage Range	224	Drive Size
27	OHt dc bus	170 - 173	Reserved 170 - 173	225	Current Offset
28	An Input Loss 1	174	Card Slot	226	Soft Start
29	An Input Loss 2	175	Card Product	227	Sub-array RAM
30	Watchdog	176	Name Plate	228 - 246	Reserved 228 - 246
31	EEPROM Fail	177	Card User Prog	247	Derivative ID
32	Phase Loss	178	Card Busy	248	Derivative Image
33	Resistance	179	Card Data Exists	249	User Program
34	Keypad Mode	180	Card Option	250	Slot4 HF
35	Control Word	181	Card Read Only	251	Slot4 Watchdog
36	User Save	182	Card Error	252	Slot4 Error
37	Power Down Save	183	Card No Data	253	Slot4 Not Fitted
38	Low Load	184	Card Full	254	Slot4 Different
39	Line Sync	185	Card File Error	255	Reset Logs
40 -89	User Trip 40 - 89	186	Card Rating		
90	Power Comms	187	Card File Data		
91	User 24V	188	Card Derivative		
92	OI Snubber	189	Encoder 1		
93	Inductor Too Hot	190	Encoder 2		
94	Rectifier Set-Up	191	Encoder 3		
95	Reserved 95	192	Encoder 4		
96	User Prog Trip	193	Encoder 5		
97	Data Changing	194	Encoder 6		
98	Out Phase Loss	195	Encoder 7		
99	CAM	196	Encoder 8		
100	Reset	197	Encoder 9		

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

Table 12-5 Trip categories

Priority	Category	Trips	Comments
1	Internal faults	HF01 - HF26	These are fatal problems that cannot be reset. All drive features are inactive after any of these trips occur. If a basic keypad is fitted it will show the trip, but the keypad will not function. These trips are not stored in the trip log.
1	Stored HF trip	Stored HF	This trip cannot be cleared unless 1299 is entered into Parameter mm.000 (mm.000) and a reset is initiated.
2	Non-resettable trips	Trip numbers 218 to 247, {Slot1 HF}, {Slot2 HF}, {Slot3 HF} or {Slot4 HF}	These trips cannot be reset.
3	Volatile memory failure	{EEPROM Fail}	This can only be reset if Parameter **mm.000** is set to 1233 or 1244, or if *Load Defaults* (**11.043**) is set to a non-zero value.
4	Internal 24 V power supply	{PSU 24}	
5	Non-volatile media trips	Trip numbers 174, 175 and 177 to 188	These trips are priority 6 during power-up.
5	Position feedback interface power supply	Encoder 1	This trip can override Encoder 2 to Encoder 6 trips.
6	Trips with extended reset times	OI ac, OI Brake, and OI dc	These trips cannot be reset until 10s after the trip was initiated.
6	Phase loss and d.c. link power circuit protection	Phase Loss and OHt dc bus	The drive will attempt to stop the motor before tripping if a Phase Loss.000 trip occurs unless this feature has been disabled (see Action On Trip Detection (**10.037**). The drive will always attempt to stop the motor before tripping if an OHt dc bus occurs
6	Standard trips	All other trips	

12.4 Internal / Hardware trips

Trips {HF01} to {HF20} are internal faults that do not have trip numbers. If one of these trips occurs, the main drive processor has detected an irrecoverable error. All drive functions are stopped and the trip message will be displayed on the drive keypad. If a non permanent trip occurs this may be reset by power cycling the drive. On power up after it has been power cycled the drive will trip on Stored HF. Enter 1299 in **mm.000** to clear the Stored HF trip.

12.5 Alarm indications

In any mode, an alarm is an indication given on the display by alternating the alarm string with the drive status string on the first row and showing the alarm symbol in the last character in the first row. If an action is not taken to eliminate any alarm except "Auto Tune and Limit Switch" the drive may eventually trip. Alarms are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

Table 12-6 Alarm indications

Alarm string	Description
Brake Resistor	Brake resistor overload. *Braking Resistor Thermal Accumulator* (**10.039**) in the drive has reached 75.0 % of the value at which the drive will trip.
Motor Overload	*Motor Protection Accumulator* (**04.019**) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is > 100 %.
Drive Overload	Drive over temperature. *Percentage Of Drive Thermal Trip Level* (**07.036**) in the drive is greater than 90 %.
Auto Tune	The autotune procedure has been initialized and an autotune in progress.

12.6 Status indications

Table 12-7 Option module and NV Media Card and other status indications at power-up

First row string	Second row string	Status
Booting	Parameters	Parameters are being loaded
Drive parameters are being loaded from a NV Media Card		
Booting	Option Program	User program being loaded
User program is being loaded from a NV Media Card to the option module in slot X		
Writing To	NV Card	Data being written to NV Media Card
Data is being written to a NV Media Card to ensure that its copy of the drive parameters is correct because the drive is in Auto or Boot mode		
Waiting For	Power System	Waiting for power stage
The drive is waiting for the processor in the power stage to respond after power-up		
Waiting For	Options	Waiting for an option module
The drive is waiting for the Options Modules to respond after power-up		
Uploading From	Options	Loading parameter database
At power-up it may be necessary to update the parameter database held by the drive because an option module has changed or because an applications module has requested changes to the parameter structure. This may involve data transfer between the drive an option modules. During this period 'Uploading From Options' is displayed		

12.7 Programming error indications

Following are the error message displayed on the drive keypad when an error occurs during programming of drive firmware.

Table 12-8 Programming error indications

Error String	Reason	Solution
Error 1	There is not enough drive memory requested by all the option modules.	Power down drive and remove some of the option modules until the message disappears.
Error 2	At least one option module did not acknowledge the reset request.	Power cycle drive
Error 3	The boot loader failed to erase the processor flash.	Power cycle drive and try again. If problem persists, return drive
Error 4	The boot loader failed to program the processor flash.	Power cycle drive and try again. If problem persists, return drive
Error 5	One option module did not initialize correctly. Option module did not set Ready to Run flag.	Remove faulty option module.

12.8 Displaying the trip history

The drive retains a log of the last ten trips that have occurred. *Trip 0* (**10.020**) to *Trip 9* (**10.029**) store the most recent 10 trips that have occurred where *Trip 0* (**10.020**) is the most recent and *Trip 9* (**10.029**) is the oldest. When a new trip occurs it is written to *Trip 0* (**10.020**) and all the other trips move down the log, with oldest being lost. The date and time when each trip occurs are also stored in the date and time log, i.e. *Trip 0 Date* (**10.041**) to *Trip 9 Time* (**10.060**). The date and time are taken from *Date* (**06.016**) and *Time* (**06.017**). The date / time source can be selected with *Date / Time Selector* (**06.019**). Some trips have sub-trip numbers which give more detail about the reason for the trip. If a trip has a sub-trip number its value is stored in the sub-trip log, i.e. *Trip 0 Sub-trip Number* (**10.070**) to *Trip 9 Sub-trip Number* (**10.079**). If the trip does not have a sub-trip number then zero is stored in the sub-trip log.

If any parameter between Pr **10.020** and Pr **10.029** inclusive is read by serial communication, then the trip number in Table 12-3 is the value transmitted.

Note

The trip logs can be reset by writing a vale of 255 in Pr **10.038**.

12.9 Behaviour of the drive when tripped

If the drive trips, the output of the drive is disabled so the load coasts to a stop. If any trip occurs the following read only parameters are frozen until the trip is cleared. This is to help in diagnose the cause of the trip.

Parameter	Description
01.001	Frequency / speed reference
01.002	Pre-skip filter reference
01.003	Pre-ramp reference
02.001	Post-ramp reference
03.001	Final speed ref
03.002	Speed feedback
03.003	Speed error
03.004	Speed controller output
04.001	Current magnitude
04.002	Active current
04.017	Reactive current
05.001	Output frequency
05.002	Output voltage
05.003	Power
05.005	DC bus voltage
07.001	Analog input 1
07.002	Analog input 2

If the parameters are not required to be frozen then this can be disabled by setting bit 4 of Pr **10.037**.

13 UL listing information

13.1 UL file reference

These products are cUL Listed to Canadian and US requirements.

UL file reference is: NMMS/7 E171230.

Products that incorporate the Safe Torque Off (STO) function are Certified for Functional Safety.

UL file reference: FSPC E171230.

13.2 Operating environment

Pollution Degree

Products must be installed in a Pollution Degree 2 environment or better (dry, non-conductive pollution only).

Ambient temperature

The drives have been evaluated for use at ambient temperatures up to 40 °C. The drives have additionally been evaluated for 50 °C and 55 °C ambient air temperatures with a derated output.

The maximum surrounding air temperature is 55 °C.

13.3 Enclosure ratings

Open Type

The products are Open Type as supplied.

Type 1

When fitted with a conduit box, the products meet the requirements for UL Enclosed Type 1. Suitable conduit boxes are available.

13.4 Through-panel (Type 12) mounting

Mounting hole access

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

13.5 Mounting bracket torque setting

Frame sizes 3 & 4

Through panel mounting brackets should be tightened to a maximum torque of 2 N m (16.8 lb in).

13.6 Installation in air handling spaces (plenum rating)

These products have been evaluated in accordance with the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and their Accessories Installed in Air-Handling Spaces, UL 2043.

Products installed in air handling spaces must be Enclosed Type 1 as a minimum. A conduit box must be fitted. Alternatively, the product can be through-panel mounted in a Type 12 enclosure with the heatsink protruding through the wall of the enclosure into the air-handling space.

13.7 Mechanical Installation

Mounting

Products can be mounted on a vertical surface using the brackets provided. Several products may be mounted side by side without airspace between them.

In installations where space is limited, products with frame sizes 3, 4 and 5 may be 'Tile Mounted'. In this configuration, the unit is mounted sideways with the side panel against the mounting surface. A Tile Mounting Kit is available but must be ordered separately.

13.8 Terminal Torque

Torque settings are specified in relevant sections of this guide.

13.9 Electrical Installation

Overvoltage category

Drives have been evaluated for OVC III

Branch circuit Protection

Branch circuit protection must be provided in accordance with the National Electrical Code (NEC), The Canadian Electrical Code, and any additional local codes.

The recommended fuses are specified within this guide.

Opening of branch circuit protective device

The opening of the branch-circuit protective device may be an indication that a fault has been interrupted. To reduce the risk of fire or electric shock, the equipment may be examined and replaced if damaged.
If burnout of the current element of an overload relay occurs, the complete overload relay must be replaced. Integral solid-state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code and any additional local “codes”, or the equivalent.

Cables

Field wiring must use 75 °C rated copper wire only.

Ground connections

UL Listed closed-loop connectors sized according to the field wiring must be used for all ground connections.

Power connections

Frame sizes 3, 4 and 5: These frame sizes use plug-in terminal blocks for the power connections.

Frame sizes 6 to 11: UL Listed closed loop connectors sized according to the field wiring must be used for all power connections.

13.10 Motor overload protection

All models incorporate internal overload protection for the motor load that does not require the use of an external or remote overload protection device. The protection level is adjustable with the maximum current overload being dependent on the values entered into the current limit parameters (Pr **4.005** motoring current limit, Pr **4.006** regenerative current limit and Pr **4.007** symmetrical current limit entered as percentage) and Pr **5.007** motor rated current parameter (entered in Amperes). The duration of the overload is dependent on Pr **4.015** motor thermal time constant.

13.11 Thermal memory retention

All models are provided with thermal memory retention.

13.12 Motor protection using an external sensor

User terminals are provided that can be connected to a motor thermistor to protect the motor from high temperature, in the event of a motor cooling fan failure.

13.13 Transient Surge Suppression

Frames sizes 7 & 8 – 575 V ratings

Transient surge suppression shall be installed on the line side of this equipment and shall be rated to 575 Vac (phase to ground), 575 Vac (phase to phase), suitable for overvoltage category III, and shall provide protection for an impulse withstand voltage peak of 6 kV and a clamping voltage of maximum 2400 V.

13.14 Dynamic braking

The drives have not been evaluated for dynamic braking.

13.15 External Class 2 supply

Frame sizes 7 to 11

The external power supply shall be marked with the following: "Class 2" and the power supply shall not exceed 24 Vdc.

13.16 Modular Drive Systems

Products with DC+ and DC- supply connections have been investigated for use in Modular Drive Systems as inverters when supplied by the converter sections from the Unidrive-M or Mentor MP range. In these applications the inverters are required to be additionally protected by supplemental fuses.

13.17 AC supply, AC supply fuses and short circuit current rating (SCCR)

Frame sizes 3 & 4

Suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, 480 Volts AC maximum when protected by the specified fuses.

UL Listed closed-loop connectors sized according to the field wiring shall be used for grounding connections. Frame size 6 only for closed loop connectors on all power connections (size 4 has a power connector like size 3 not studs)

Frame sizes 5 & 6

Suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, 575 Volts AC maximum when protected by the specified fuses.

Frame size 7 & 8

Suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, (rated voltage in the ratings table or the product label) Volts AC Maximum when protected by the specified fuses.

Frame sizes 9 & 10

Suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, (voltage rating in ratings table or the product label) Volts AC Maximum when protected by the specified fuses.

Frame size 11

Suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical Amperes, (voltage rating in ratings table or the product label) Volts AC Maximum when protected by the specified fuses.

13.18 Modular / group / parallel installation

Supply wiring

When used in modular drives/group / parallel installation applications the supply wires are not to be larger than 125 % of full load current of the device ratings

CSA (Canadian Standards Authority) approval

Frame sizes 9 to 11 are not certified for CSA approval when used in a modular / parallel setup.

Supply from converters

These devices are only intended to be supplied by converters manufactured by Control Techniques Ltd. when used as inverters.

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Symbols

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