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Control User Guide

Unidrive M700
Unidrive M701
Unidrive M702

Universal Variable Speed AC drive for induction and permanent magnet motors

Part Number: 0478-0353-02
Issue: 2

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.

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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.

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

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Drive Firmware: 01.17.00.00 onwards

Ethernet Firmware: 02.02.02.00 onwards

For patent and intellectual property related information please go to: www.ctpatents.info.

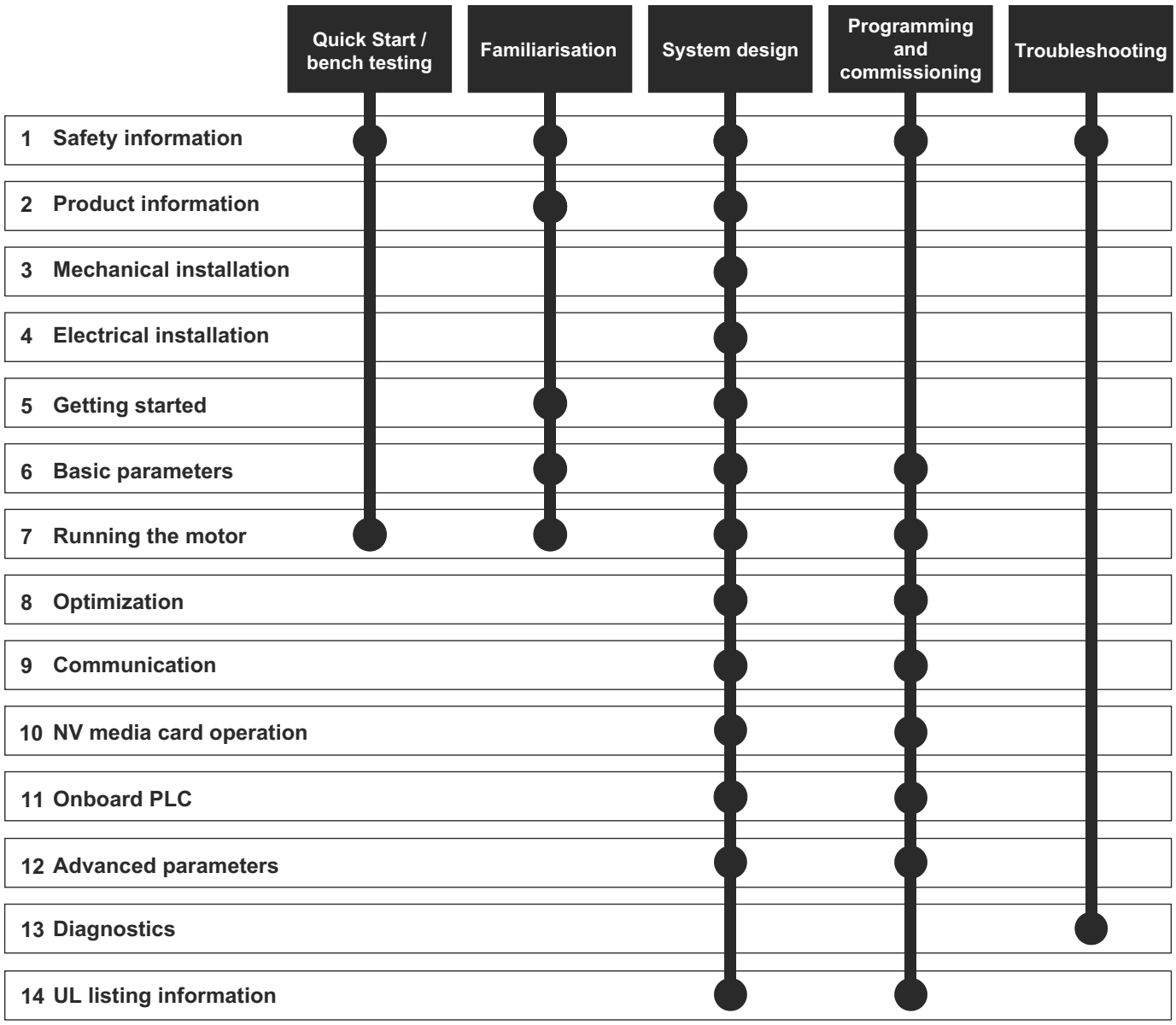
How to use this guide

This guide is intended to be used in conjunction with the appropriate *Power Installation Guide*. The *Power Installation Guide* gives information necessary to physically install the drive. This guide gives information on drive configuration, operation and optimization.

NOTE

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

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



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EU Declaration of Conformity

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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 European 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, M708, M709, M751, M753, M754, F300, 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).



G Williams
Vice President, Technology
Date: 6th September 2017

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 ddddde
aaaa	Basic series	M600, M700, M701, M702, M708, M709, M751, M753, M754, F300, H300, E200, E300, 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

The harmonized standards used are shown below:

EC type-examination certificate numbers:

01/205/5270.02/17 dated 2017-08-28

Notified body identification number: 0035

EN 61800-5-1:2016	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional
EN 61800-5-1:2016 (in extracts)	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 ISO 13849-1:2015	Safety of Machinery, Safety-related parts of control systems, General principles for design
EN 62061:2005 + AC:2010 + A1:2013 + A2:2015	Safety of machinery, Functional safety of safety related electrical, electronic and programmable electronic control systems
IEC 61508 Parts 1 - 7:2010	Functional safety of electrical/ electronic/programmable electronic safety-related systems

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P Knight

Conformity Engineer

Newtown, Powys, UK

DoC authorised by:



G. Williams

Vice President, Technology

Date: 6th September 2017

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. It is the responsibility of the installer to ensure that the design of the complete machine, including its safety-related control system, is carried out in accordance with the requirements of the Machinery Directive and any other relevant legislation. The use of a safety-related drive in itself does not ensure the safety of the machine. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters. The drive must be installed only by professional installers who are familiar with requirements for safety and EMC. The assembler is responsible for ensuring that the end product or system complies with all relevant laws in the country where it is to be used. For more information regarding Safe Torque Off, refer to the Product Documentation.

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 Mechanical brake control

Any brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

1.13 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.

1.14 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 Introduction

Universal AC and servo drive

This product family consists of *Unidrive M700*, *Unidrive M701* and *Unidrive M702*, these deliver maximum machine performance.

Common features (Unidrive M700, 701 and 702)

- Universal high performance open and closed loop control for induction, servo, permanent magnet and linear motors
- Automation and motion option module for direct migration of SyPTPro / SM-Applications programs
- Onboard IEC 61131-3 programmable automation and motion control
- Flexibility with speed and position measurement, supporting multiple devices and all common interfaces
- NV Media Card for parameter copying and data storage

Optional features (Unidrive M700, 701 and 702)

- Select up to three option modules including programmable automation and motion control.

Unidrive M700

- Ethernet fieldbus communications
- Single channel Safe Torque Off (STO) input

Unidrive M701

- Provides a direct replacement / upgrade for Unidrive SP
- EIA 485 serial communications interface
- Single channel Safe Torque Off (STO) input

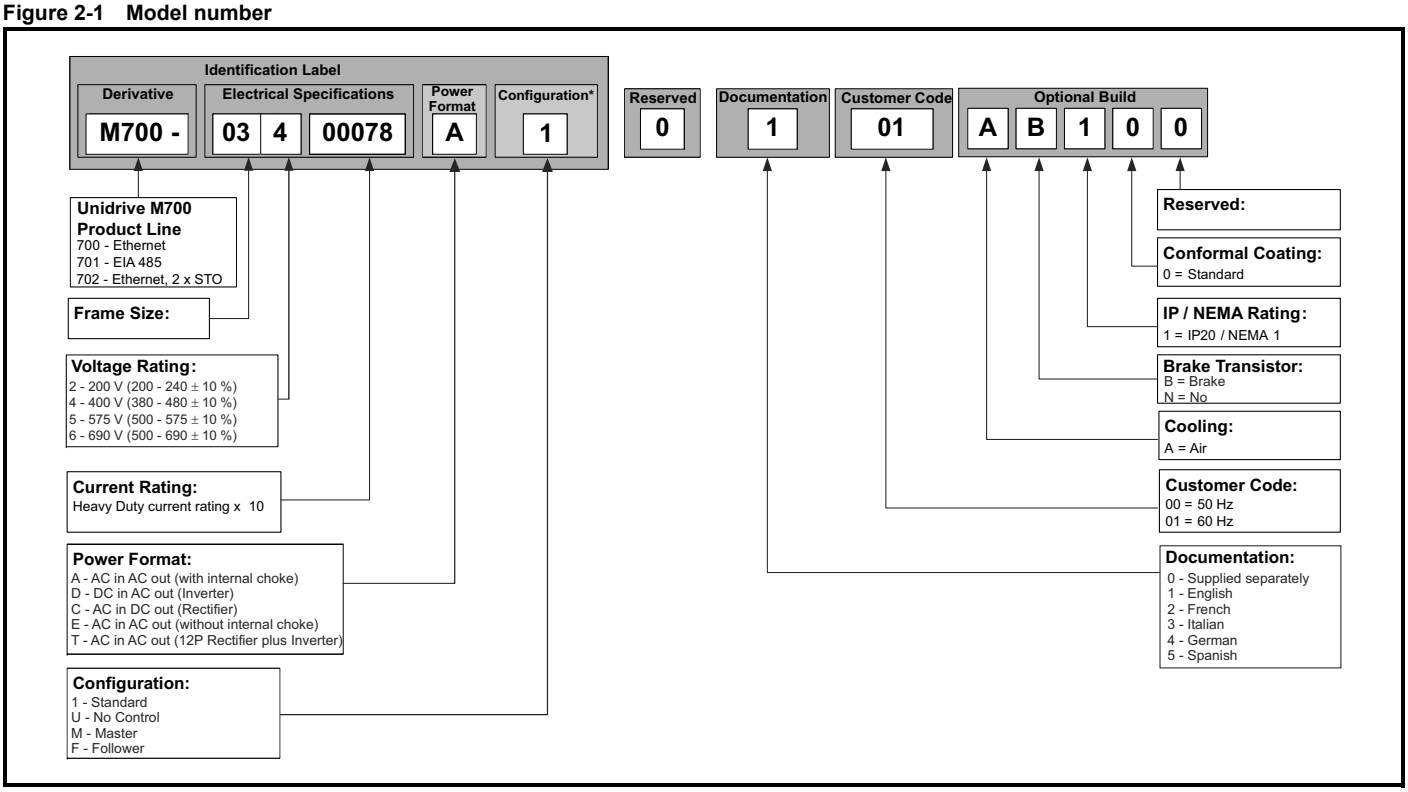
Unidrive M702

- Ethernet fieldbus communications
- Dual channel Safe Torque Off (STO) input

2.2 Model number

The way in which the model numbers for the *Unidrive M700* range are formed is illustrated below:

Figure 2-1 Model number



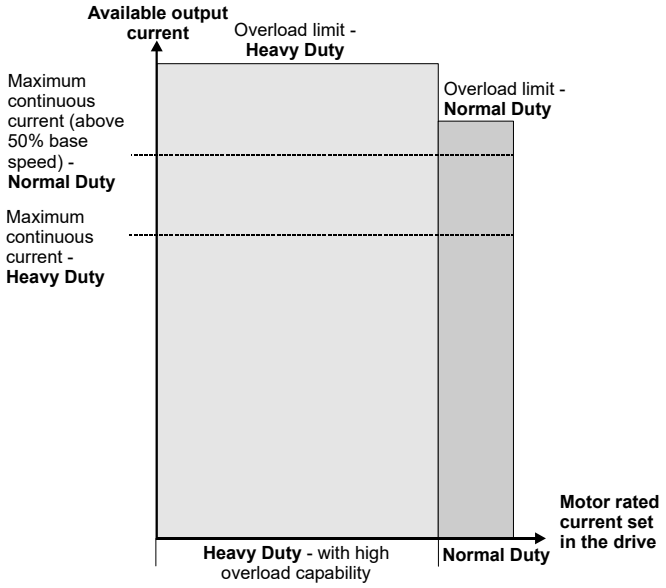
* Only shown on Frame size 9, 10 and 11 identification label.

NOTE

For simplicity a Frame 9 drive with no internal choke (i.e. model 09xxxxxE) is referred to as a Frame 9E and a Frame 9 drive with an internal choke (i.e. model 09xxxxxA) is referred to as a Frame 9A. Any reference to Frame 9 is applicable to both sizes 9E and 9A.

2.3 Ratings

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



Normal Duty

For applications which use Self ventilated (TENV/TEFC) induction motors and require a low overload capability, and full torque at low speeds is not required (e.g. fans, pumps).
Self ventilated (TENV/TEFC) induction motors require increased protection against overload due to the reduced cooling effect of the fan at low speed. To provide the correct level of protection the I^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* (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.

Heavy Duty (default)

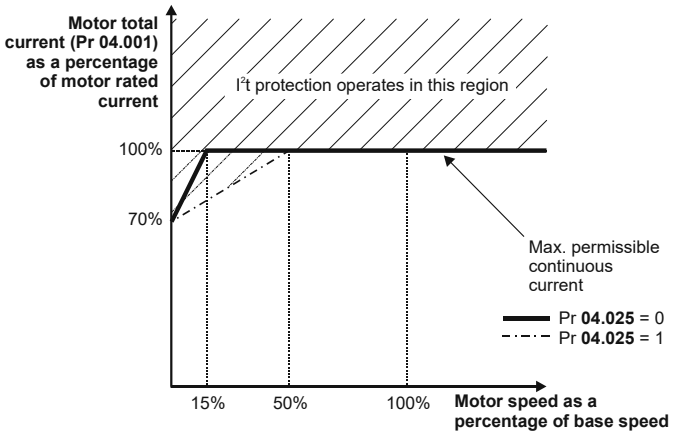
For constant torque applications or applications which require a high overload capability, or full torque is required at low speeds (e.g. winders, hoists).
The thermal protection is set to protect force ventilated induction motors and permanent magnet servo motors by default.

NOTE

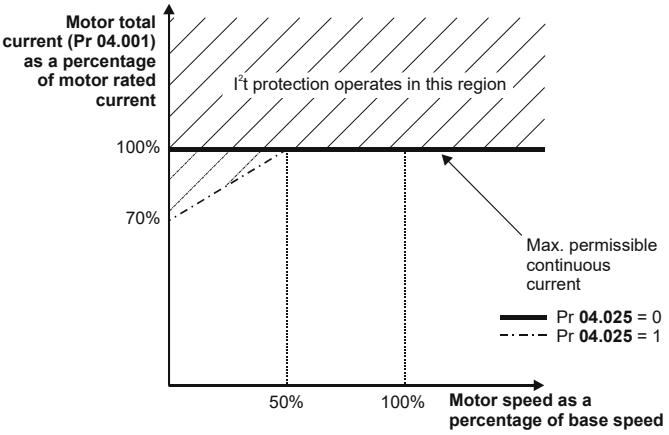
If the application uses a self ventilated (TENV/TEFC) induction motor and increased thermal protection is required for speeds below 50 % base speed, then this can be enabled by setting *Low Speed Thermal Protection Mode* (04.025) = 1.

Operation of motor I^2t protection

Motor I^2t protection is fixed as shown below and is compatible with:
- Self ventilated (TENV/TEFC) induction motors



Motor I^2t protection defaults to be compatible with:
- Forced ventilation induction motors
- Permanent magnet servo motors



2.4 Operating modes

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

1. Open loop mode
   - Open loop vector mode
   - Fixed V/F mode (V/Hz)
   - Quadratic V/F mode (V/Hz)
2. RFC - A
   - With position feedback sensor
   - Without position feedback sensor (Sensorless)
3. RFC - S
   - With position feedback sensor
   - Without position feedback sensor (Sensorless)
4. Regen mode

2.4.1 Open loop mode

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

Open loop vector mode

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

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

Fixed V/F mode

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

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

Quadratic V/F mode

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

2.4.2 RFC-A mode

Rotor **F**lux **C**ontrol for Asynchronous (induction) motors (**RFC-A**) encompasses closed loop vector control with a position feedback device

With position feedback

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

Without position feedback (Sensorless)

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

2.4.3 RFC- S mode

Rotor **F**lux **C**ontrol for Synchronous (permanent magnet brushless) motors (**RFC-S**) provides closed loop control with position feedback device.

With position feedback

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

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

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

Without position feedback

For use with permanent magnet brushless motors without a feedback device installed.

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 all the way down to zero speed, with salient motors.

2.4.4 Regen mode

For use as a regenerative front end for four quadrant operation.

Regen operation allows bi-directional power flow to and from the AC supply. This provides far greater efficiency levels in applications which would otherwise dissipate large amounts of energy in the form of heat in a braking resistor.

The harmonic content of the input current is negligible due to the sinusoidal nature of the waveform when compared to a conventional bridge rectifier or SCR/thyristor front end.

NOTE

Contact the supplier of the drive for further information.

2.5 Compatible position feedback devices

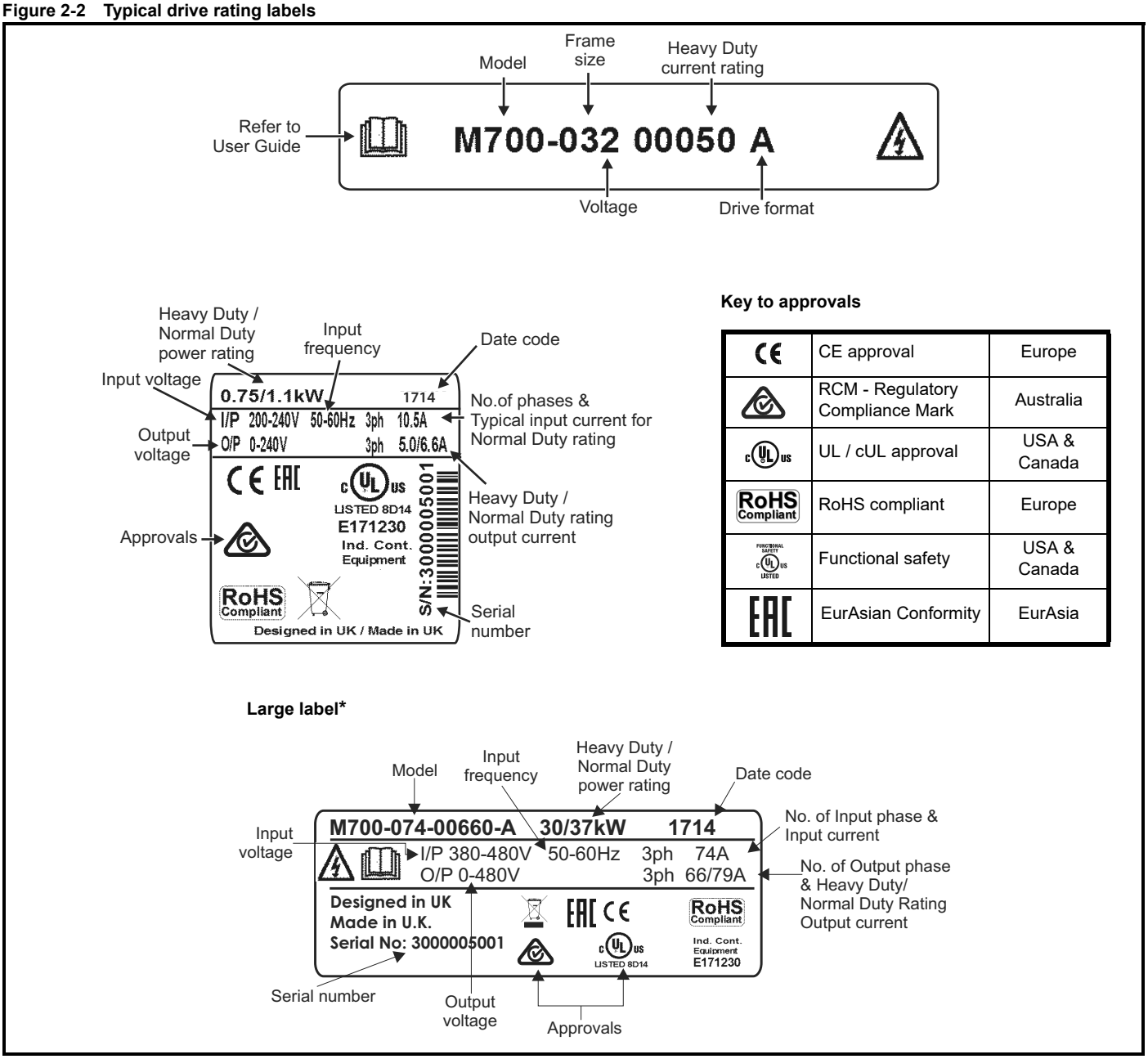
Table 2-1 Supported feedback devices

Encoder type	Pr 3.038 setting
Quadrature incremental encoders with or without marker pulse	AB (0)
Quadrature incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	AB Servo (3)
Forward / reverse incremental encoders with or without marker pulse	FR (2)
Forward / reverse incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FR Servo (5)
Frequency and direction incremental encoders with or without marker pulse	FD (1)
Frequency and direction incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FD Servo (4)
Sincos incremental encoders	SC (6)
Sincos incremental with commutation signals	SC Servo (12)
Heidenhain sincos encoders with EnDat comms for absolute position	SC EnDat (9)
Stegmann sincos encoders with Hiperface comms for absolute position	SC Hiperface (7)
Sincos encoders with SSI comms for absolute position	SC SSI (11)
Sincos encoders with BiSS (type C) comms for absolute position	SC BiSS (17)
Sincos incremental with absolute position from single sin and cosine signals	SC SC (15)
SSI encoders (Gray code or binary)	SSI (10)
EnDat communication only encoders	EnDat (8)
BiSS (type C) communication only encoders	BiSS (13)
Resolver	Resolver (14)
UVW commutation only encoders*	Commutation only (16)
Provided by option module	Option Slot 1 (18) Option Slot 2 (19) Option Slot 3 (20) Option Slot 4 (21)

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

2.6 Nameplate description

Figure 2-2 Typical drive rating labels



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

Refer to Figure 2-1 *Model number* on page 11 for further information relating to the labels.

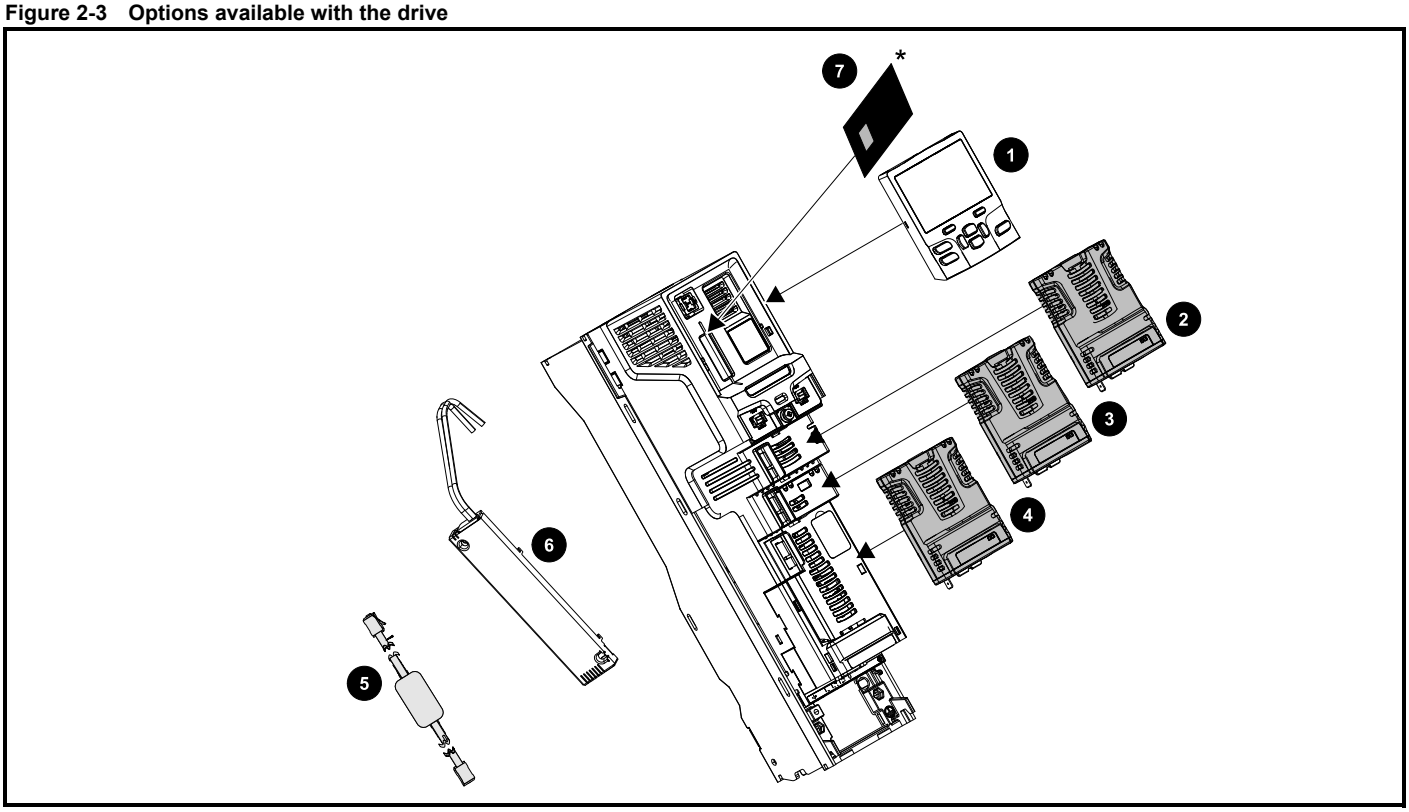
Date code format

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

Example:
A date code of **1714** would correspond to week 14 of the year 2017.

2.7 Options

Figure 2-3 Options available with the drive



1. Keypad
2. Option module slot 1
3. Option module slot 2
4. Option module slot 3
5. CT USB Comms cable
6. Internal braking resistor (available on size 3, 4 and 5)
7. NV media card

* For further information, refer to Chapter 10 *NV Media Card Operation* on page 139.

Unidrive M option modules come in two different formats, a standard option module and a large option module. All standard option modules are color-coded in order to make identification easy, whereas the larger option module is black. 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, whereas the large option modules can only be installed to option slot 3. The following tables shows the color-code key and gives further details on their function.

Table 2-2 Option module identification

Type	Option module	Color	Name	Further Details
Feedback		N/A	15-way D-type converter	**Drive encoder input converter** Provides screw terminal interface for encoder wiring and spade terminal for shield
		N/A	Single ended encoder interface (15V or 24V)	**Single ended encoder interface** Provides an interface for single ended ABZ encoder signals, such as those from hall effect sensors. 15 V and 24 V versions are available
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 V2 option** PROFINET V2 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
Automation (Applications)		Moss Green	MCi200	**Machine Control Studio Compatible Applications Processor** 2nd processor for running pre-defined and/or customer created application software.
		Moss Green	MCi210	**Machine Control Studio Compatible Applications Processor (with Ethernet communications)** 2nd processor for running pre-defined and/or customer created application software with Ethernet communications.
		Black	SI-Applications Plus	**SyPTPro Compatible Applications Processor (with CTNet)** 2nd processor for running pre-defined and/or customer created application software with CTNet support (can only be used on Slot 3).
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.
Safety		Yellow	SI-Safety	Safety module that provides an intelligent, programmable solution to meet the IEC 61800-5-2 functional safety standard

Table 2-3 Keypad identification

Type	Keypad	Name	Further Details
Keypad		KI-Keypad	**LCD keypad option** Keypad with a LCD display
		KI-Keypad RTC	**LCD keypad option** Keypad with a LCD display and real time clock
		Remote-Keypad RTC	**Remote LCD keypad option** Remote Keypad with a LCD display and real time clock
		Remote-Keypad	**Remote LCD keypad option** Remote Keypad with a LCD display

Table 2-4 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

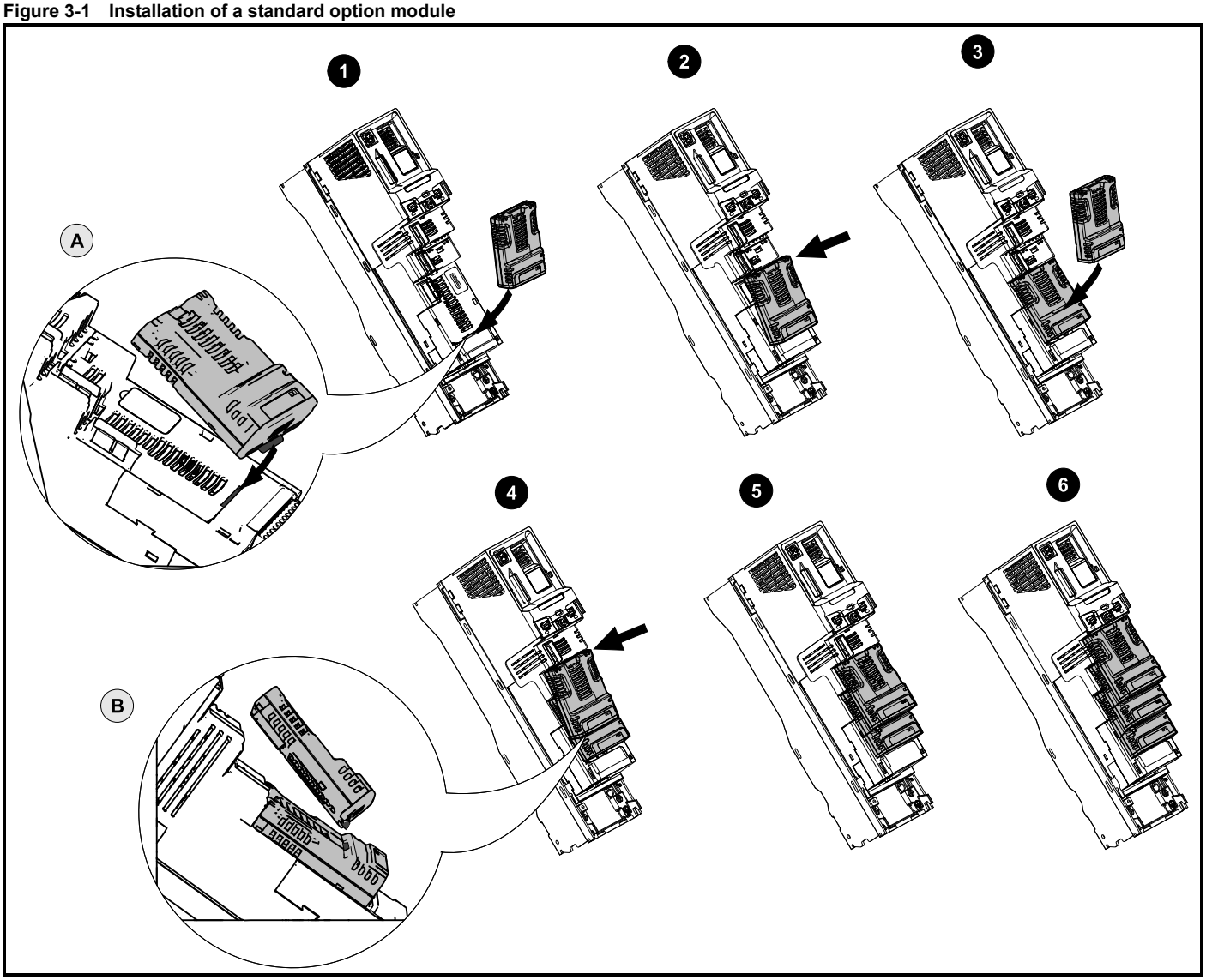
3 Mechanical installation

3.1 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 3-1 Installation of a standard 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 section 2.7 *Options* on page 16 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

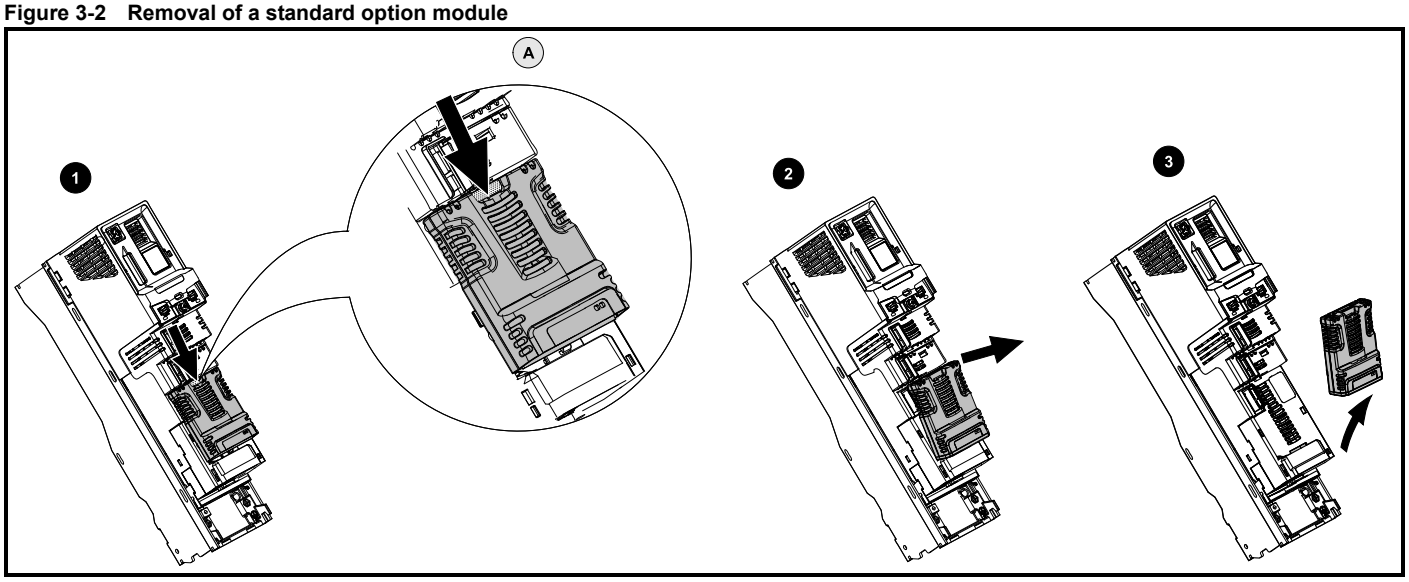
- Move the option module in direction shown (3).
- Align and insert the option module tab in to the slot provided on the already installed option module (4), this is highlighted in the detailed view (B).
- Press down on the option module until it clicks into place. Image (5) shows two option modules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

Installing the third option module

- Repeat the above process.

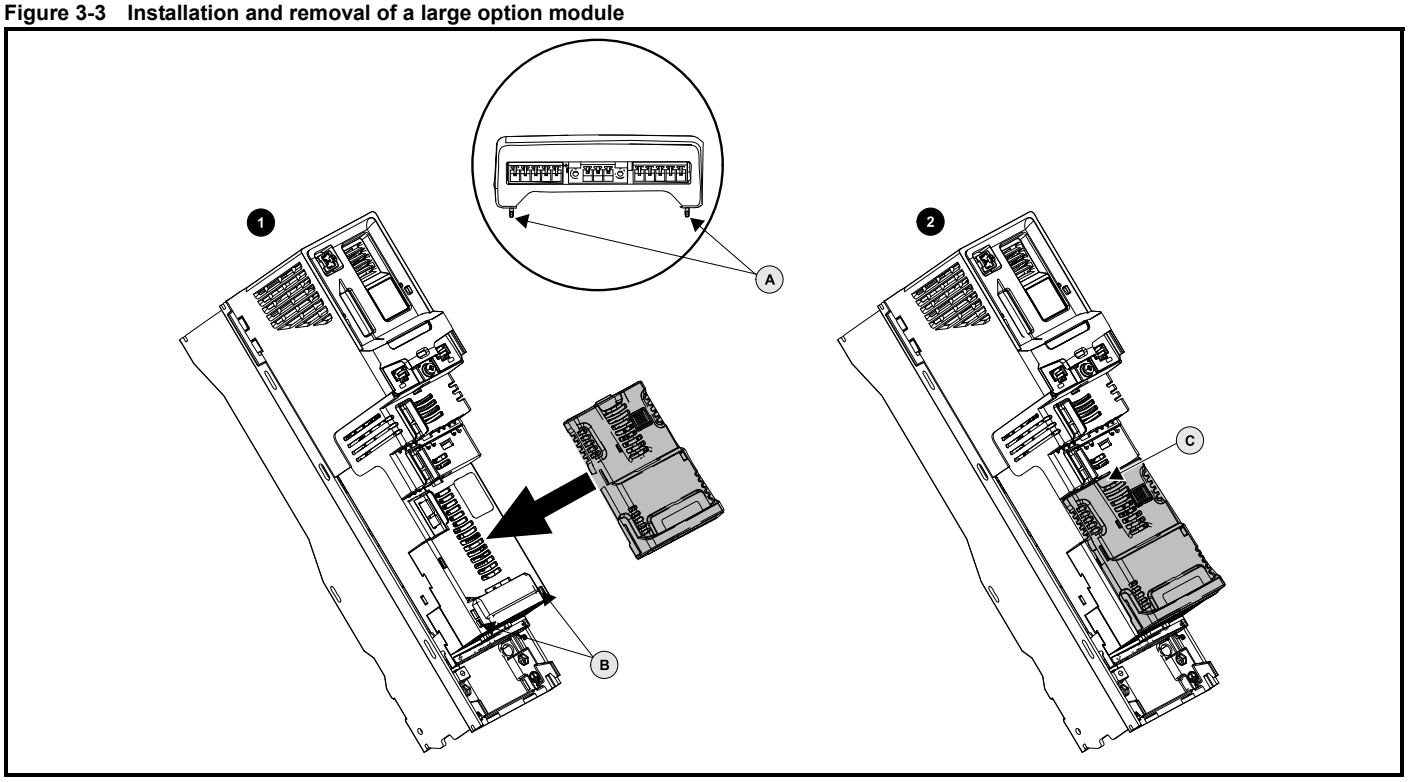
The drive has the facility for all three option module slots to be used at the same time, image (6) shows the three option modules installed.

Figure 3-2 Removal of a standard 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 3-3 Installation and removal of a large option module



Installing a large option module

- Move the option module in direction shown (1).
- Align and insert the option module tabs (A) into the slot provided (B).
- Press down on the option module until it clicks into place.

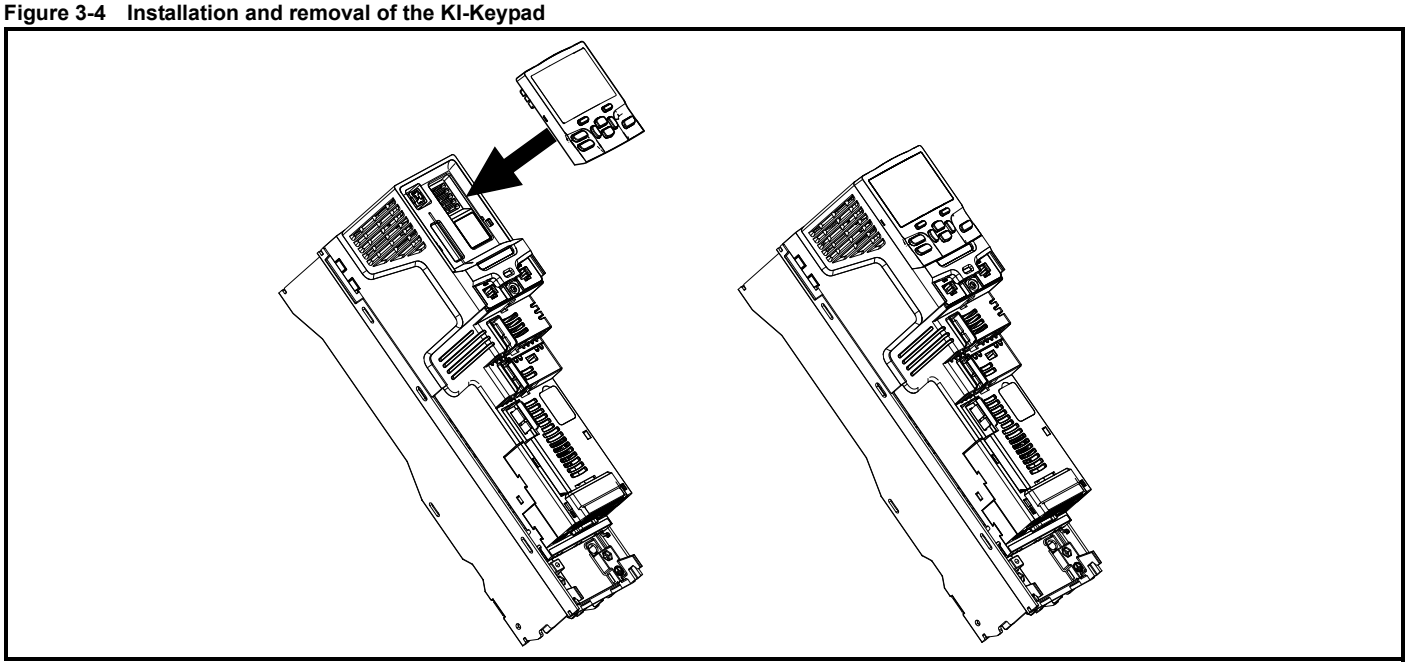
Removing a large option module

- Press down on the tab (2C), tilt the option module towards you and remove.

NOTE

The large option module can only be inserted into slot 3. Additional standard option modules can still be installed and used in slot 2 and slot 1.

Figure 3-4 Installation and removal of the KI-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.

3.2 Real time clock battery replacement

Those keypads which have 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 3-5 KI-Keypad RTC (rear view)

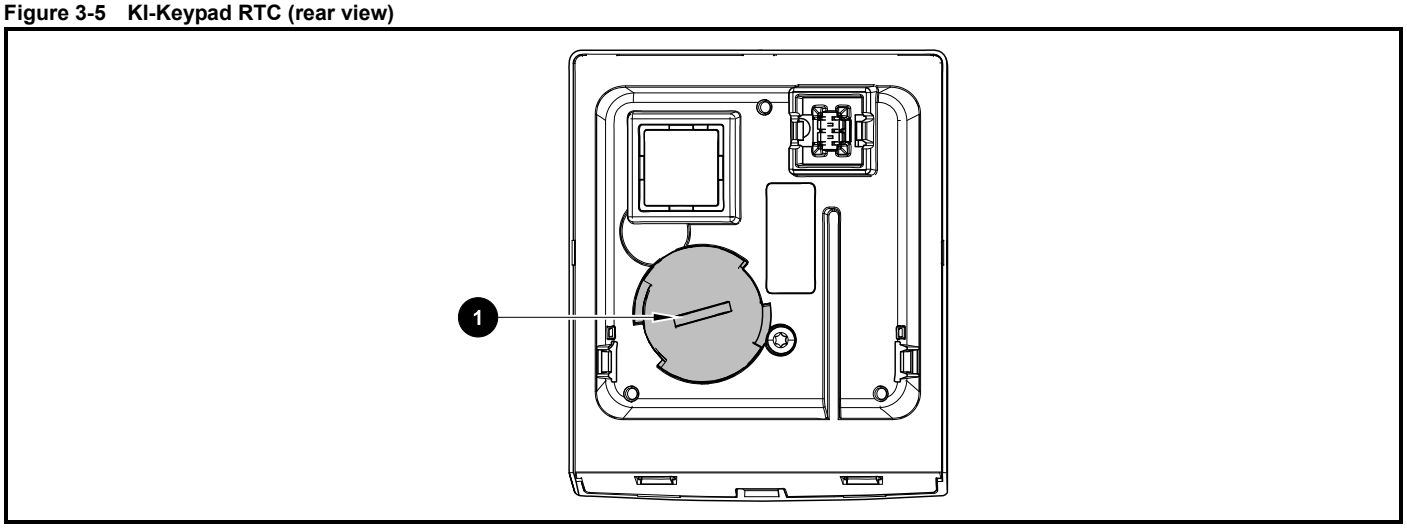


Figure 3-5 above illustrates the rear view of the KI-Keypad RTC.

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.

4 Electrical installation

4.1 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, encoders or serial communications to continue to operate.
- It can be used to commission the drive when the line power supply is not available, as the display operates correctly. However, the drive will be in the 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 V dc 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 Systems" will be displayed on the keypad and no drive operations are possible. The location of the power 24 Vdc can be identified from Figure 4-1 *Location of the 24 Vdc power supply connection on size 6* on page 22.

Table 4-1 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:

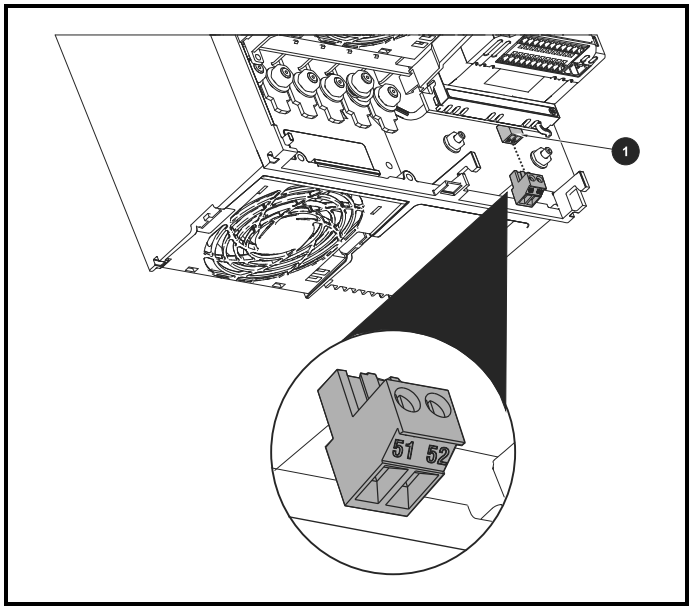
1	**0V (Common connection for all external devices)**
2	**+24 Vdc**
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 V
Maximum continuous operating voltage	28.0 V
Minimum start up voltage	21.6 V
Maximum power supply requirement at 24 V	40 W
Recommended fuse	3 A, 50 Vdc

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 connection for all external devices)**
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 4-1 Location of the 24 Vdc power supply connection on size 6



1. 24 Vdc power supply connection

Figure 4-2 Location of the 24 Vdc power supply connection on size 7

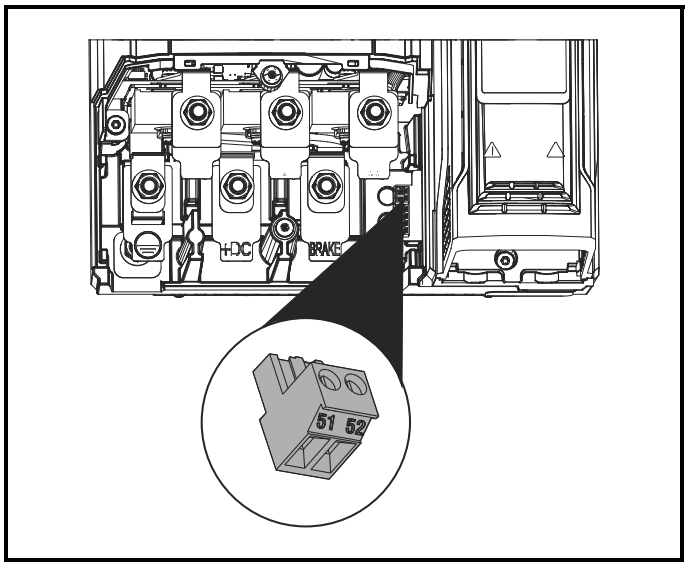
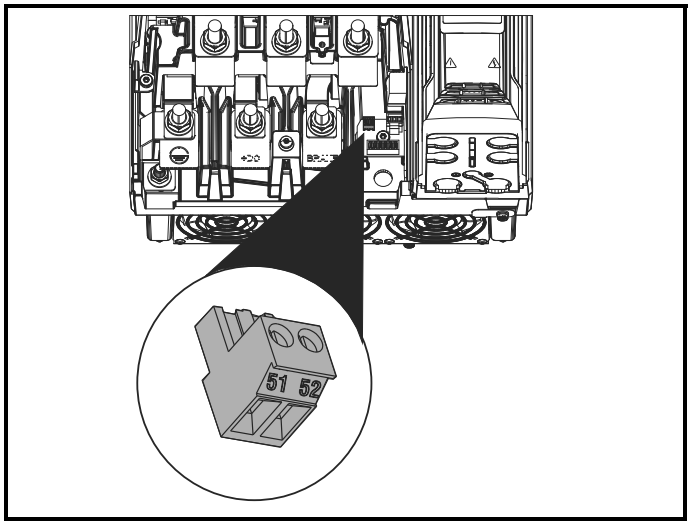


Figure 4-3 Location of the 24 Vdc power supply connection on size 8 to 11



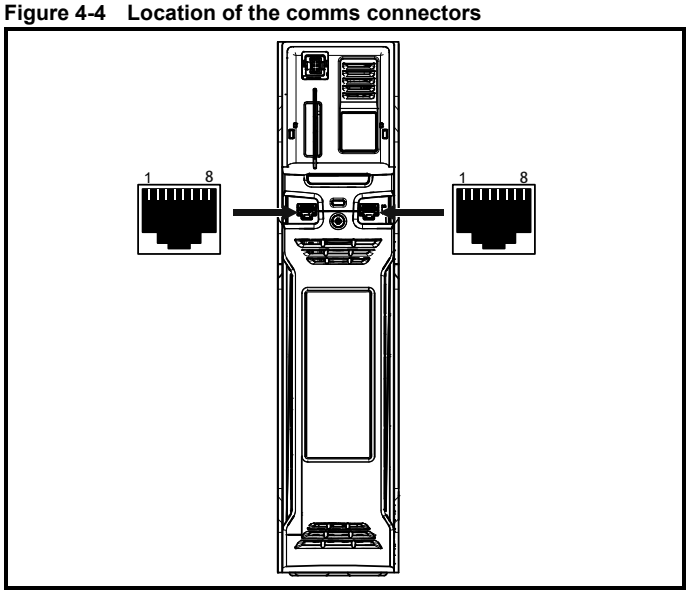
4.2 Communication connections

The *Unidrive M700 / M702* drive offers Ethernet fieldbus communications and the *Unidrive M701* drive offers a 2 wire EIA 485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required.

Care must be taken to ensure the correct interface is fitted before a connection is made to the interface, failure to ensure this may result in damage to the interface and/or communication device.

Both the Ethernet and EIA 485 interfaces use an RJ45 connector, the EIA 485 interface is identified by the number “485” printed on the front panel, and the Ethernet interface has the network logo.

Figure 4-4 Location of the comms connectors



4.2.1 *Unidrive M700 / M702* Ethernet fieldbus communications

The Ethernet option provides two RJ45 connections with an Ethernet switch for easy network creation.

Standard UTP (unshielded twisted pair) or STP (shielded twisted pair) cables are supported. It is recommended that a minimum specification CAT5e is used in new installations. As the drive supports the ‘Auto cross-over detection’ a cross-over cable is not required.

NOTE

The shell of the RJ45 connector is isolated from the 0V of the drive control terminals but it is connected to ground.

Table 4-2 Ethernet port pin-outs

Pin	Description
1	Transmit +
2	Transmit -
3	Receive +
4	N/A
5	N/A
6	Receive -
7	N/A
8	N/A

4.2.2 *Unidrive M701* EIA 485 serial communications

The EIA 485 interface provides two parallel RJ45 connectors allowing easy daisy chaining. The drive only supports Modbus RTU protocol. See Table 4-3 for the connection details.

NOTE

Standard Ethernet cables are not recommended for use when connecting drives on a EIA 485 network as they do not have the correct twisted pairs for the pinout of the serial comms port.

CAUTION

If an Ethernet network adaptor is inadvertently connected to a Unidrive-M701 EIA 485 drive, a low impedance load across the EIA 485 24 V is applied and if connected for a significant period of time can introduce the potential risk of damage.

Table 4-3 Serial communication port pin-outs

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

Minimum number of connections are 2, 3, 7 and shield.

4.2.3 *Unidrive M701* Isolation of the EIA 485 serial communications port

The serial communications port is double insulated and meets the requirements for SELV in EN 50178:1998.

WARNING

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

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

Table 4-4 Isolated serial comms lead details

Part number	Description
4500-0096	CT USB Comms cable

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

4.2.4 Communication networks and cabling

Any isolated signal circuit has the capability to become live through accidental contact with other conductors; as such they should always be double-insulated from live parts. The routing of network and signal wires should be done so as to avoid close proximity to mains voltage cabling.

4.2.5 *Unidrive M701* EIA 485 Port polarization (biasing)

The *Unidrive M701* EIA 485 serial communications port requires polarization (biasing) of the data lines.

The Modbus standard specifies that to prevent spurious triggering when there is no data being transmitted, the data lines are polarized (biased) with pull-apart resistors, one resistor from the RJ45 pin 2 connection (RX TX) to +V and the other resistor from the RJ45 pin 7 connection (/RX / TX) to 0V. These resistors should be in the range 450 to 650 Ohms and fitted in the master controller.

4.2.6 *Unidrive M701* EIA 485 Network termination

When a long-distance multi-drop EIA 485 system is used with high baud rates (above 38400) it may be necessary to fit a termination resistor of 120 Ω across the transmit and receive pair in order to reduce signal reflections.

4.3 Control connections

4.3.1 *Unidrive M700* / *M701* control connections

Table 4-5 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Differential analog input	1	Mode, offset, invert, scaling	5, 6
Single ended analog input	2	Mode, offset, invert, scaling, destination	7, 8
Analog output	2	Source, scaling	9, 10
Digital input	3	Destination, invert	27, 28, 29
Digital input / output	3	Input / output mode select, destination / source, invert, logic select	24, 25, 26
Relay	1	Source, invert	41, 42
Drive enable (Safe Torque Off)	1		31
+10 V User output	1		4
+24 V User output	1	Source, invert	22
0V common	6		1, 3, 11, 21, 23, 30, 51 (size 6 and larger)
+24V 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 or motor brake) then suitable suppression (i.e. diode or varistor) should be used on the coil of the load. If no suppression is used then over voltage spikes can cause damage to the digital inputs and outputs on the drive.

CAUTION

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

NOTE

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

NOTE

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

NOTE

The common 0V from analog signals should, wherever possible, not be connected to the same 0V terminal as the common 0V from digital signals. Terminals 3 and 11 should be used for connecting the 0V common of analog signals and terminals 21, 23 and 30 for digital signals. This is to prevent small voltage drops in the terminal connections causing inaccuracies in the analog signals.

NOTE

A two wire motor thermistor can be connected to analog input 3 by connecting the thermistor between terminal 8 and any 0V common terminal. It is possible to connect a 4-wire thermistor to analog input 3 as shown below. Pr **07.015** and Pr **07.046** need to be set-up for the thermistor type required.

Figure 4-5 Connection for PT100, PT1000 and PT2000 thermistors

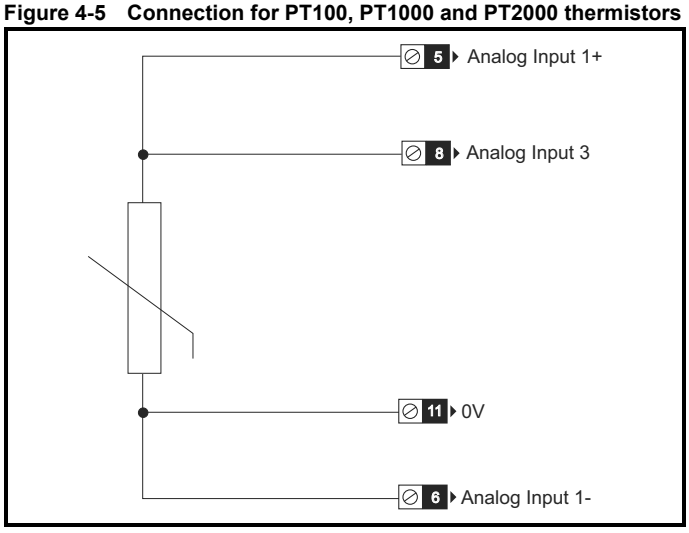
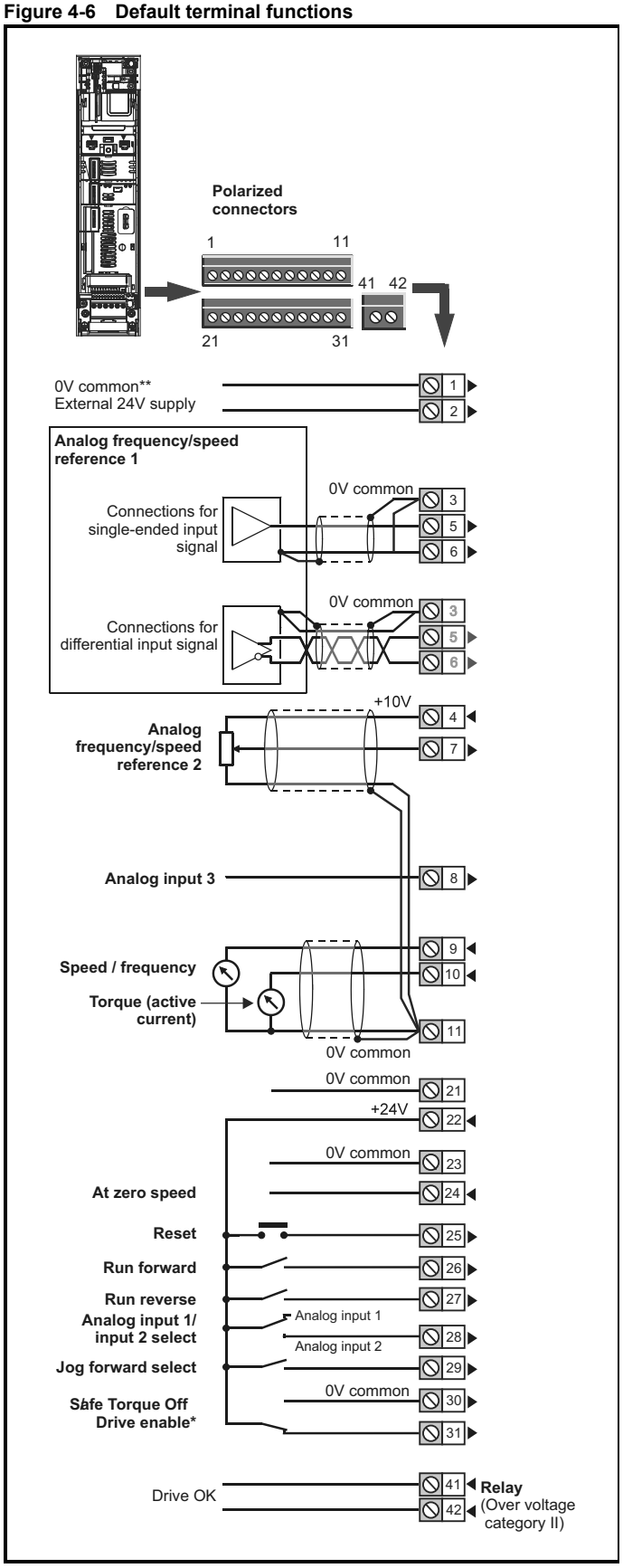


Figure 4-6 Default terminal functions



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

NOTE

The 0V terminals on the Safe Torque Off are not isolated from each other and the 0V common.

4.3.2 *Unidrive M700 / M701* 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 used as digital input when using an external 24 V supply
Sample / update	2 ms
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	0V common
Function	**Common connection for all external devices**

4	+10V user output
Function	**Supply for external analog devices**
Voltage	10.2 V nominal
Voltage tolerance	±1 %
Nominal output current	10 mA
Protection	Current limit and trip @ 30 mA

	Precision reference Analog input 1
5	Non-inverting input
6	Inverting input
Default function	**Frequency/speed reference**
Type of input	Bipolar differential analog voltage or current, thermistor input
Mode controlled by:	Pr **07.007**
Operating in Voltage mode	
Full scale voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0V
Working common mode voltage range	±13 V relative to 0V
Input resistance	≥100 kΩ
Monotonic	Yes (including 0V)
Dead band	None (including 0V)
Jumps	None (including 0V)
Maximum offset	20 mV
Maximum non linearity	0.3% of input
Maximum gain asymmetry	0.5 %
Input filter bandwidth single pole	~3 kHz
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 %
Maximum offset	250 µA
Absolute maximum voltage (reverse biased)	±36 V relative to 0V
Equivalent input resistance	≤300 Ω
Absolute maximum current	±30 mA
Operating in thermistor input mode (in conjunction with analog input 3), refer to Pr 07.046 and Figure 4-5 for further details.	
Trip threshold resistance	User defined in Pr **07.048**
Short-circuit detection resistance	50 Ω ±40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	250 µs with destinations Pr **01.036**, Pr **01.037**, Pr **03.022** or Pr **04.008** in RFC-A and RFC-S modes. 4 ms for open loop mode and all other destinations in RFC-A or RFC-S modes.

7	Analog input 2
Default function	**Frequency / speed reference**
Type of input	Bipolar single-ended analog voltage or unipolar current
Mode controlled by...	Pr **07.011**
Operating in voltage mode	
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
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 %
Maximum offset	250 µA
Absolute maximum voltage (reverse bias)	±36 V relative to 0V
Absolute maximum current	±30 mA
Equivalent input resistance	≤ 300 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. 4ms for open loop mode and all other destinations in RFC-A or RFC-S mode.

8	Analog input 3
Default function	**Voltage input**
Type of input	Bipolar single-ended analog voltage, or thermistor input
Mode controlled by...	Pr **07.015**
Operating in Voltage mode (default)	
Voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0V
Input resistance	≥100 k Ω
Operating in thermistor input mode	
Supported thermistor types	Din 44082, KTY 84, PT100, PT 1000, PT 2000, 2.0 mA
Trip threshold resistance	User defined in Pr **07.048**
Reset resistance	User defined in Pr **07.049**
Short-circuit detection resistance	50 Ω ±40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	4 ms

9	Analog output 1
10	**Analog output 2**
Terminal 9 default function	**OL> Motor FREQUENCY output signal RFC> SPEED output signal**
Terminal 10 default function	**Motor active current**
Type of output	Bipolar single-ended analog voltage
Operating in Voltage mode	
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
Resolution	10-bit
Sample / update period	250 µs (output will only change at update the rate of the source parameter if slower)

11	0V common
Function	**Common connection for all external devices**

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

22	+24 V user output (selectable)
Terminal 22 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)

23	0V common
Function	**Common connection for all external devices**

24	**Digital I/O 1**
25	**Digital I/O 2**
26	**Digital I/O 3**

Terminal 24 default function	**AT ZERO SPEED output**
Terminal 25 default function	**DRIVE RESET input**
Terminal 26 default function	**RUN FORWARD input**
Type	Positive or negative logic digital inputs, positive 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 (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (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	0V to +24 V
Sample / Update period	2 ms (output will only change at the update rate of the source parameter)

27	**Digital Input 4**
28	**Digital Input 5**

Terminal 27 default function	**RUN REVERSE input**
Terminal 28 default function	**Analog INPUT 1 / INPUT 2 select**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 600 µs when configured as an input with destination Pr **06.029**. 2 ms in all other cases.

29	**Digital Input 6**

Terminal 29 default function	**JOG SELECT input**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	2 ms

30	**0V common**

Function	**Common connection for all external devices**

Refer to section 4.5 *Safe Torque Off (STO)* on page 37 for further information.

31	**Safe Torque Off function (drive enable)**

Type	Positive logic only digital input
Voltage range	0V 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 (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.

41 **42**	**Relay contacts**

Default function	**Drive OK 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	Normally open
Default contact condition	Closed when power applied and drive OK
Update period	4 ms

51	**0V (Common connection for all external devices)**
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



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.

4.3.3 *Unidrive M702* control connections

Table 4-6 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Single ended analog input*	1	Mode, destination	8
Digital input*	2	Destination, invert, logic select	7, 8
Digital output	2	source, invert	4, 5
Relay	1	Source, invert	41, 42
Drive enable (Safe Torque Off)	2		11, 13
+24 V User output	1	Source, invert	2
0V common	5		1, 3, 6, 10, 12
+24 V External input	1	Destination, invert	9

* From date code 1710, control terminal 8 on the Unidrive M702 can be a dual-purpose input which can be configured as either a motor thermistor input (Analog Input 3) or a digital input (Digital Input 5).

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 thermistor protection (disabled, temperature, temperature and short).

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 or motor brake) then suitable suppression (i.e. diode or varistor) should be used on the coil of the load. If no suppression is used then over voltage spikes can cause damage to the digital inputs and outputs on the drive.

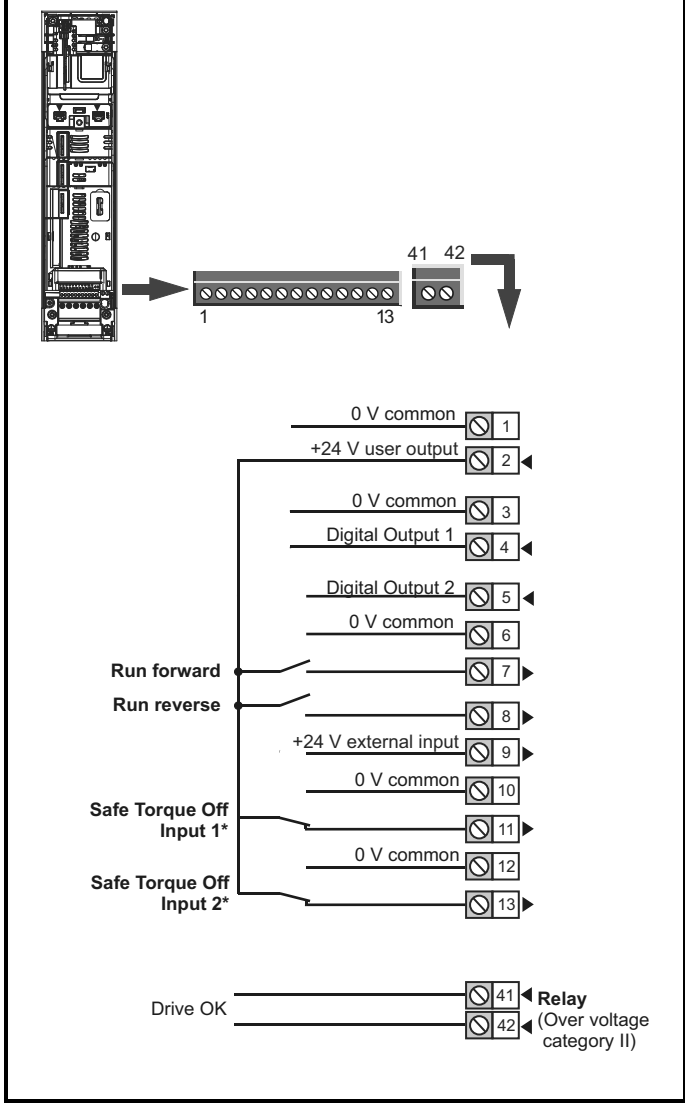
CAUTION

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

NOTE

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

Figure 4-7 Default terminal functions



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

4.3.4 *Unidrive M702* control terminal specification

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

2	+24 V user output (selectable)
Terminal 2 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
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)

3	0V common
Function	**Common connection for all external devices**

4	Digital Output 1
5	Digital Output 2
Terminal 4 default function	**AT ZERO SPEED output**
Terminal 5 default function	
Type	Positive logic voltage source outputs
Operating as an output	
Nominal maximum output current	100 mA (DO1 & 2 combined)
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Common to all modes	
Voltage range	0V to +24 V
Sample / Update period	2 ms (output will only change at the update rate of the source parameter

6	0V common
Function	**Common connection for all external devices**

7	Digital Input 4
8	Digital Input 5
Terminal 7 default function	**RUN FORWARD input**
Terminal 8 default function	**RUN REVERSE input**
Type	Positive logic only digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 600 µs when configured as an input with destination Pr **06.029**. 2 ms in all other cases.

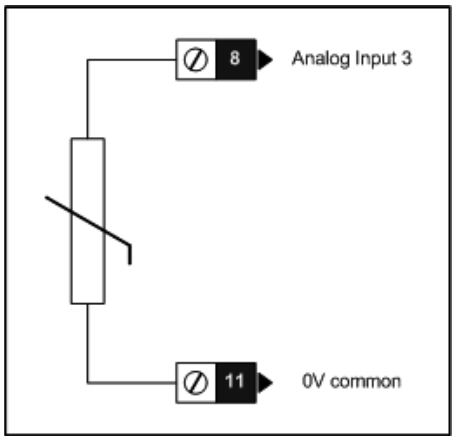
From date code 1710, control terminal 8 on the Unidrive M702 can be a dual purpose input which can be configured as either a motor thermistor input (Analog Input 3) or a digital input (Digital Input 5).

Terminal 8, by default, is set as a digital input (RUN REVERSE) but can be configured to be a motor protection thermistor input by changing *Analog Input 3 Mode* (07.015) from *Disable* (10) to either *Therm Short Cct* (7) or *Thermistor* (8).

8	Analog Input 3
Function	**Thermistor input**
Supported thermistor types	DIN44082, KTY84, PT100 (2W), PT1000 (2W), PT2000 (2W)
Trip threshold resistance	User defined in Pr **07.048**
Reset resistance	User defined in Pr **07.049**
Short-circuit detection resistance	50 Ω ±40 %
Resolution	12 bits (11 bits plus sign)
Sample / update period	4 ms

The thermistor is connected between terminal 8 and any 0V common terminal.

Figure 4-8 Motor thermistor connection



9	+24 V external input
Function	**To supply the control circuit without providing a supply to the power stage**
Programmability	Can be used as a digital input when using an external 24 Vdc
Sample / Update period	2 ms
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

10	0V common
Function	**Common connection for all external devices**

12	0V common
Function	**Common connection for all external devices**

11	Safe Torque Off function input 1 (drive enable)	
13	Safe Torque Off function input 2 (drive enable)	
Type		Positive logic only digital input
Voltage range		0V 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 (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, these terminals are used for enabling the drive.		

Refer to section 4.5 *Safe Torque Off (STO)* on page 37 for further information.

41 42	Relay contacts
Default function	**Drive OK 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	Normally open
Default contact condition	Closed when power applied and drive OK
Update period	4 ms

51	0V (Common connection for all external devices)	
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

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.

4.4 Position feedback connections

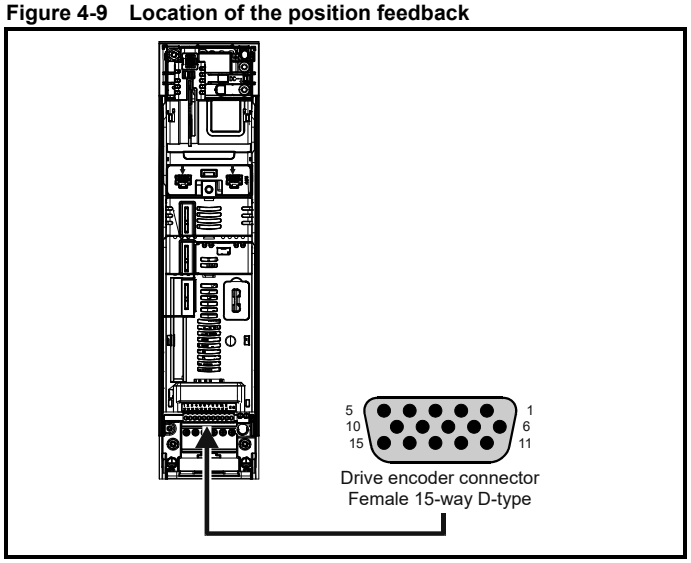
The following functions are provided via the 15-way high density D-type connector on the drive:

- Two position feedback interfaces (P1 and P2).
- One encoder simulation output.
- Two freeze trigger inputs (marker inputs).
- One thermistor input.

The P1 position interface is always available but the availability of the P2 position interface and the encoder simulation output depends on the position feedback device used on the P1 position interface, as shown in Table 4-9.

4.4.1 Location of position feedback connector

Figure 4-9 Location of the position feedback



4.4.2 Compatible position feedback devices

Table 4-7 Supported feedback devices on the P1 position interface

Encoder type	Pr 3.038 setting
Quadrature incremental encoders with or without marker pulse	AB (0)
Quadrature incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	AB Servo (3)
Forward / reverse incremental encoders with or without marker pulse	FR (2)
Forward / reverse incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FR Servo (5)
Frequency and direction incremental encoders with or without marker pulse	FD (1)
Frequency and direction incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FD Servo (4)
Sincos incremental encoders	SC (6)
Sincos incremental with commutation signals	SC Servo (12)
Heidenhain sincos encoders with EnDat comms for absolute position	SC EnDat (9)
Stegmann sincos encoders with Hiperface comms for absolute position	SC Hiperface (7)
Sincos encoders with SSI comms for absolute position	SC SSI (11)
Sincos encoders with BiSS (type C) comms for absolute position	SC BiSS (17)
Sincos incremental with absolute position from single sin and cosine signals	SC SC (15)
SSI encoders (Gray code or binary)	SSI (10)
EnDat communication only encoders	EnDat (8)
BiSS (type C) communication only encoders	BiSS (13)
Resolver	Resolver (14)
UVW commutation only encoders*	Commutation only (16)

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

Table 4-8 Supported feedback devices on the P2 position interface

Encoder type	Pr 3.138 setting
Quadrature incremental encoders with or without marker pulse	AB (1)
Frequency and direction incremental encoders with or without marker pulse	FD (2)
Forward / reverse incremental encoders with or without marker pulse	FR (3)
EnDat communication only encoders	EnDat (4)
SSI encoders (Gray code or binary)	SSI (5)
BiSS communication only encoders	BiSS (6)

Table 4-9 shows the possible combinations of position feedback device types connected to the P1 and P2 position interfaces and the availability of the encoder simulation output.

Table 4-9 Availability of the P2 position feedback interface and the encoder simulation output

Functions		
P1 Position feedback interface	**P2 Position feedback interface**	**Encoder Simulation Output**
AB Servo FD Servo FR Servo SC Servo SC SC Commutation only	None	None
AB FD FR SC Resolver SC Hiperface	AB, FD, FR EnDat, BiSS, SSI	None
	None	Full
SC EnDat SC SSI	AB, FD, FR (No Z marker pulse input)	None
	EnDat, BiSS, SSI (with freeze input)	
	None	No Z marker pulse output
EnDat BiSS SSI	AB, FD, FR EnDat, BiSS, SSI (with freeze input)	None
	None	Full
	EnDat, BiSS, SSI	No Z marker pulse output

The priority of the position feedback interfaces and the encoder simulation output on the 15-way D-type is assigned in the following order from the highest priority to the lowest.

- P1 position interface (highest)
- Encoder simulation output
- P2 position interface (lowest)

For example, if an AB Servo type position feedback device is selected for use on the P1 position interface, then both the encoder simulation output and the P2 position interface will not be available as this device uses all connections of the 15-way D-type connector. Also, if an AB type position feedback device is selected for use on the P1 position interface and Pr **03.085** is set to a valid source for the encoder simulation output, then the P2 position interface will not be available.

Depending on the device type used on the P1 position interface, the encoder simulation output may not be able support a marker pulse output (e.g. SC EnDat or SC SSI device types). Pr **03.086** shows the status of the encoder simulation output indicating whether the output is disabled, no marker pulse is available or full encoder simulation is available.

NOTE

When using the P1 and P2 position interfaces and the encoder simulation output together, the P2 position interface uses alternative connections on the 15-way D-type connector. Pr **03.172** shows the status of the P2 position interface and indicates if alternative connections are being used for the P2 position interface.

4.4.3 Position feedback connection details

Table 4-10 P1 Position feedback connection details

P1 Position feedback interface Pr 03.038	Connections														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AB (0)	A	A\	B	B\	Z	Z\							+V	0V	Th
FD (1)	F	F\	D	D\	Z	Z\									
FR (2)	F	F\	R	R\	Z	Z\									
AB Servo (3)	A	A\	B	B\	Z	Z\	U	U\	V	V\	W	W\			
FD Servo (4)	F	F\	D	D\	Z	Z\	U	U\	V	V\	W	W\			
FR Servo (5)	F	F\	R	R\	Z	Z\	U	U\	V	V\	W	W\			
SC (6)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\									
SC Hiperface (7)	Cos	Cosref	Sin	Sinref	DATA	DATA\									
EnDat (8)	DATA	DATA\	CLK	CLK\	Freeze	Freeze\									
SC EnDat (9)	A	A\	B	B\	DATA	DATA\					CLK	CLK\			
SSI (10)	DATA	DATA\	CLK	CLK\	Freeze	Freeze\									
SC SSI (11)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	DATA	DATA\					CLK	CLK\			
SC Servo (12)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\	U	U\	V	V\	W	W\			
BiSS (13)	DATA	DATA\	CLK	CLK\	Freeze	Freeze\									
Resolver (14)	Cos H	Cos L	Sin H	Sin L	Ref H	Ref L									
SC SC (15)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\	C*1	C*1	D*2	D*2	Freeze2	Freeze2\			
Commutation Only (16)							U	U\	V	V\	W	W\			
SC BiSS (17)	A	A\	B	B\	DATA	DATA\					CLK	CLK\			

*1 - One cosine wave per revolution

*2 - One sine wave per revolution

Greyed cells are for P2 position feedback connections or simulated encoder outputs.

NOTE

Freeze and Freeze\ on terminals 5 and 6 are for Freeze input 1. Freeze2 and Freeze2\ on terminals 11 and 12 are for Freeze input 2.

Table 4-11 P2 Position feedback and encoder simulation output connection details

P1 Position feedback interface Pr 03.038	P2 Position feedback interface Pr 03.138	Encoder Simulation Output	Connections							
			5	6	7	8	9	10	11	12
AB (0) FD (1) FR (2) SC (6) SC Hiperface (7) Resolver (14)	AB (1)	Disabled*1			A	A\	B	B\	Z	Z\
	FD (2)				F	F\	D	D\	Z	Z\
	FR (3)				F	F\	R	R\	Z	Z\
	EnDat (4) SSI (5) BiSS (6)				DATA	DATA\	CLK	CLK\	Freeze2	Freeze2\
	None (0)	AB			Asim	Asim\	Bsim	Bsim\	Zsim	Zsim\
		FD			Fsim	Fsim\	Dsim	Dsim\	Zsim	Zsim\
		FR			Fsim	Fsim\	Rsim	Rsim\	Zsim	Zsim\
		SSI			DATAsim	DATAsim\	CLKsim	CLKsim\		
SC EnDat (9) SC SSI (11)	AB (1)	Disabled*1			A	A\	B	B\		
	FD (2)				F	F\	D	D\		
	FR (3)				F	F\	R	R\		
	EnDat (4) SSI (5) BiSS (6)				DATA	DATA\	CLK	CLK\		
	None (0)	AB			Asim	Asim\	Bsim	Bsim\		
		FD			Fsim	Fsim\	Dsim	Dsim\		
		FR			Fsim	Fsim\	Rsim	Rsim\		
		SSI			DATAsim	DATAsim\	CLKsim	CLKsim\		
EnDat (8) SSI (10) BiSS (13)	AB (1)	Disabled*1			A	A\	B	B\	Z	Z\
	FD (2)				F	F\	D	D\	Z	Z\
	FR (3)				F	F\	R	R\	Z	Z\
	EnDat (4) SSI (5) BiSS (6)				DATA	DATA\	CLK	CLK\	Freeze2	Freeze2\
	None (0)	AB			Asim	Asim\	Bsim	Bsim\	Zsim	Zsim\
		FD			Fsim	Fsim\	Dsim	Dsim\	Zsim	Zsim\
		FR			Fsim	Fsim\	Rsim	Rsim\	Zsim	Zsim\
		SSI			DATAsim	DATAsim\	CLKsim	CLKsim\		
EnDat (8) SSI (10) BiSS (13) (with no Freeze inputs)	EnDat (4) SSI (5) BiSS (6)	AB	DATA	DATA\	Asim	Asim\	Bsim	Bsim\	CLK	CLK\
		FD	DATA	DATA\	Fsim	Fsim\	Dsim	Dsim\	CLK	CLK\
		FR	DATA	DATA\	Fsim	Fsim\	Rsim	Rsim\	CLK	CLK\
		SSI	DATA	DATA\	DATAsim	DATAsim\	CLKsim	CLKsim\	CLK	CLK\

*1 The encoder simulation output is disabled when Pr **03.085** is set to zero.

NOTE

The termination resistors are always enabled on the P2 position interface. Wire break detection is not available when using AB, FD or FR position feedback device types on the P2 position interface.

4.4.4 Position feedback terminal specifications

1	**A,F, Cosref, Data, Cos H**
2	**A\,F\ Cosref\, Data\, Cos L**

AB (0), FD (1), FR (2), AB Servo (3), FD Servo(4), FR Servo (5)	
Type	EIA 485 differential receivers
Maximum input frequency	500 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V

SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12), SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-12
Maximum applied differential voltage and common mode voltage range	±4 V

Resolution: The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table 4-12 shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port

EnDat (8), SSI (10), BiSS (13)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V

Resolver (14)	
Type	2 Vrms sinusoidal signal
Operating Frequency	6 - 8 kHz
Input voltage	0.6 Vrms
Minimum impedance	85 Ω

Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

NOTE

The position feedback input will accept 5 V TTL differential signals.

3	**B, D, R Sinref, Clock, Sin H**
4	**B\, D\, R\, Sinref\, Clock\, Sin L**

AB (0), FD (1), FR (2), AB Servo (3), FD Servo(4), FR Servo (5)	
Type	EIA 485 differential receivers
Maximum input frequency	500 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V

SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12), SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-12
Maximum applied differential voltage and common mode voltage range	±4 V

Resolution: The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table 4-12 shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port

EnDat (8), SSI (10), BiSS (13)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V

Resolver (14)	
Type	2 Vrms sinusoidal signal
Operating Frequency	6 – 8 kHz
Input voltage	0.6 Vrms
Minimum impedance	85 Ω

Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

5	Z, Data, Freeze, Ref H
6	Z\, Data\, Freeze\, Ref L

AB (0), FD (1), FR (2), AB Servo (3), FD Servo(4), FR Servo (5), SC SC (15)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
EnDat (8), SSI (10), BiSS (13)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
Resolver (14)	
Type	Differential voltage
Nominal voltage	0 – 2 Vrms depending on turns ratio
Operating frequency	6 - 8 KHz
Minimum impedance	85 Ω
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

7	U, C, Not used, Not used
8	U\, C\, Not used, Not used

AB Servo (3), FD Servo(4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-12
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10), BiSS (13)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

9	V, D, Not used, Not used
10	V\, D\, Not used, Not used

AB Servo (3), FD Servo(4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-12
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10), BiSS (13)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

11	W, Clock, Not used, Not used
12	W\, Clock\, Not used, Not used

AB Servo (3), FD Servo(4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	–7 V to +12 V
SC EnDat (9), SC SSI (11)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 4-12
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10), BiSS (13)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

Common to all Feedback types

13	Feedback device supply
Supply voltage	5.15 V ±2 %, 8 V ± 5 % or 15 V ± 5 %
Maximum output current	300 mA for 5 V and 8 V 200 mA for 15 V
The voltage on Terminal 13 is controlled by Pr **03.036**. The default for this parameter is 5 V (0) but this can be set to 8 V (1) or 15 V (2). Setting the encoder voltage too high for the encoder could result in damage to the feedback device. The termination resistors should be disabled if the outputs from the encoder are higher than 5 V.	

14	0V Common

15	Motor thermistor input
Thermistor type is selected in *P1 Thermistor Type* (03.118).	

Sincos encoder resolution

The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table 4-12 shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port. The total resolution in bits per revolution is the ELPR plus the number of bits of interpolated information. Although it is possible to obtain 11 bits of interpolation information, the nominal design value is 10 bits.

Table 4-12 Feedback resolution based on frequency and voltage level

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

4.5 Safe Torque Off (STO)

The *Unidrive M700 / M701* has a single channel STO, whereas the *Unidrive M702* has a dual channel 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 behaviour 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 number	Date of issue	Models
01.205/5270.01/14	11-11-2014	M700, M701, M702

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	
$MTTF_D$ (STO1)	>2500 years	High
$MTTF_D$ (STO2)	>2500 years	High
MTTFD (Single channel STO)	>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.

Lift (Elevator) Applications

The Safe Torque Off function has been independently assessed for use as a safety component in lift (elevator) applications by Notified Body, TüV Nord:

The Unidrive M drives series with Safe Torque Off (STO) function if applied according to the "Conditions of application" fulfil the safety requirements of the standards EN81-1, EN81-2, EN 81-50 and EN60664-1and are in conformity with all relevant requirements of the Directive 95/16/EC.

Certificate of Conformity number	Date of issue	Models
44799 13196202	04-08-2015	M700, M701, M702

The Safe Torque Off function can be used to eliminate electro-mechanical contactors, including special safety contactors, which would otherwise be required for safety applications.

For further information contact the supplier of the drive.

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)	4.43×10^{-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

Two-channel Safe Torque Off

Models M700 and M701 have a single channel STO, whereas the M702 has dual channel STO.

The dual channel STO has two fully independent channels.

Each input meets the requirements of the standards as defined above.

If either or both inputs are set at a logic low state, there are no single faults in the drive which can permit the motor to be driven.

It is not necessary to use both channels to meet the requirements of the standards. The purpose of the two channels is to allow connection to machine safety systems where two channels are required, and to facilitate protection against wiring faults.

For example, if each channel is connected to a safety-related digital output of a safety related controller, computer or PLC, then on detection of a fault in one output the drive can still be disabled safely through the other output.

Under these conditions, there are no single wiring faults which can cause a loss of the safety function, i.e. inadvertent enabling of the drive.

In the event that the two-channel operation is not required, the two inputs can be connected together to form a single Safe Torque Off input.

One-channel Safe Torque Off (Including Two- channel Safe Torque off with the inputs connected together.)

In a single channel Safe Torque Off application 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 might occur through a fault in the wiring. This can be excluded according to 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 (0V of the Drive) 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.

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.

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 0 V wiring cannot exceed this value under any loading condition. It is strongly recommended that the Safe Torque Off circuit be provided with a dedicated 0 V conductor which should be connected to terminal 30 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

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

5.1 Understanding the display

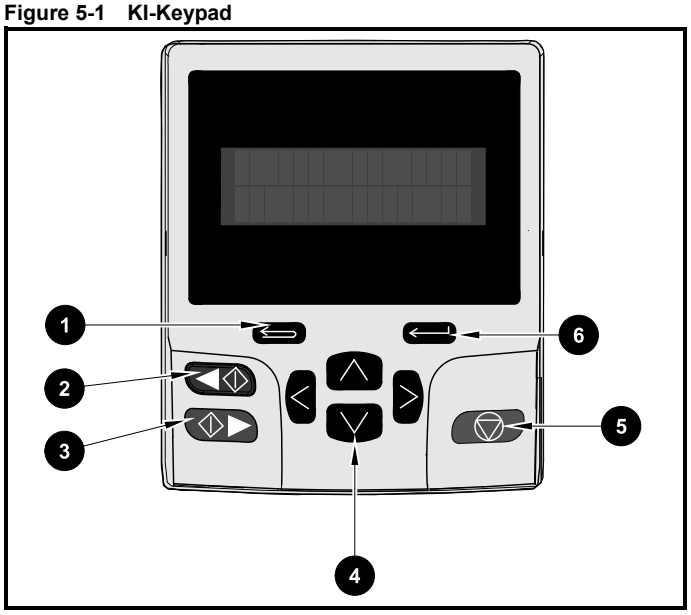
The keypad can only be mounted on the drive.

5.1.1 KI-Keypad

The KI-Keypad display 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-Keypad



1. Escape button
2. Start reverse (Auxiliary button)
3. Start forward
4. Navigation keys (x4)
5. Stop / Reset (red) button
6. Enter button

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	Priority
	Alarm active	
	Keypad real-time clock battery low	
	Accessing non-volatile media card	
or	Drive security active and locked or unlocked	
	Motor map 2 active	
	User program running	
	Keypad reference active	

5.2 Keypad operation

5.2.1 Control buttons

The keypad consists of:

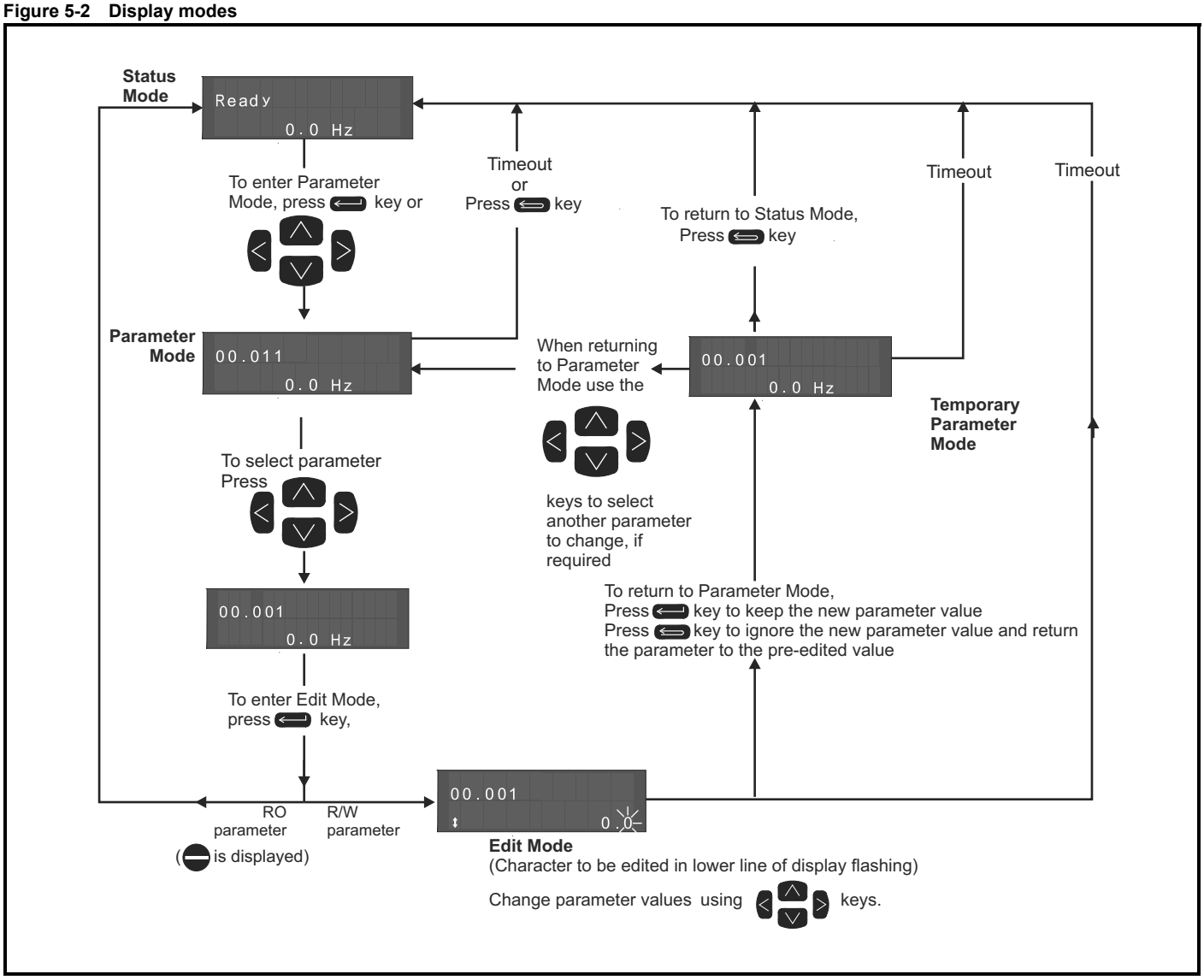
- Navigation Keys - Used to navigate the parameter structure and change parameter values.
- Enter / Mode button - Used to toggle between parameter edit and view mode.
- Escape / Exit button - Used to exit from parameter edit or view mode. In parameter edit mode, if parameter values are edited and the exit button pressed the parameter value will be restored to the value it had on entry to edit mode.
- Start forward button - Use to provide a 'Run' command if keypad mode is selected.
- Start reverse button - Used to control the drive if keypad mode is selected and the reverse button is activated. If *Enable Auxiliary Key* (06.013) = 1, then the keypad reference is toggled between run forward and run reverse each time the button is pressed. If *Enable Auxiliary Key* (06.013) = 2, then the button functions as a run reverse key.
- Stop / Reset button - Used to reset the drive. In keypad mode can be used for 'Stop'.

NOTE

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

Figure 5-2 overleaf shows an example on moving between menus and editing parameters.

Figure 5-2 Display modes



NOTE

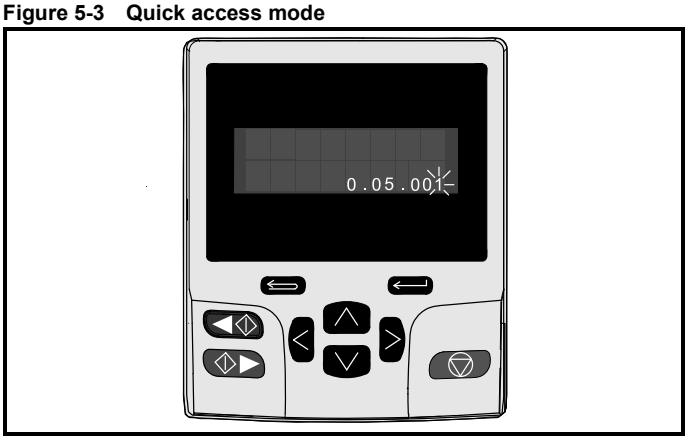
The navigation keys can only be used to move between menus if Pr **00.049** has been set to show 'All Menus'. Refer to section 5.9 *Parameter access level and security* on page 46.

5.2.2 Quick access mode

The quick access mode allows direct access to any parameter without scrolling through menus and parameters.

To enter the quick access mode, press and hold the Enter button on the keypad while in 'parameter mode'.

Figure 5-3 Quick access mode



5.2.3 Keypad shortcuts

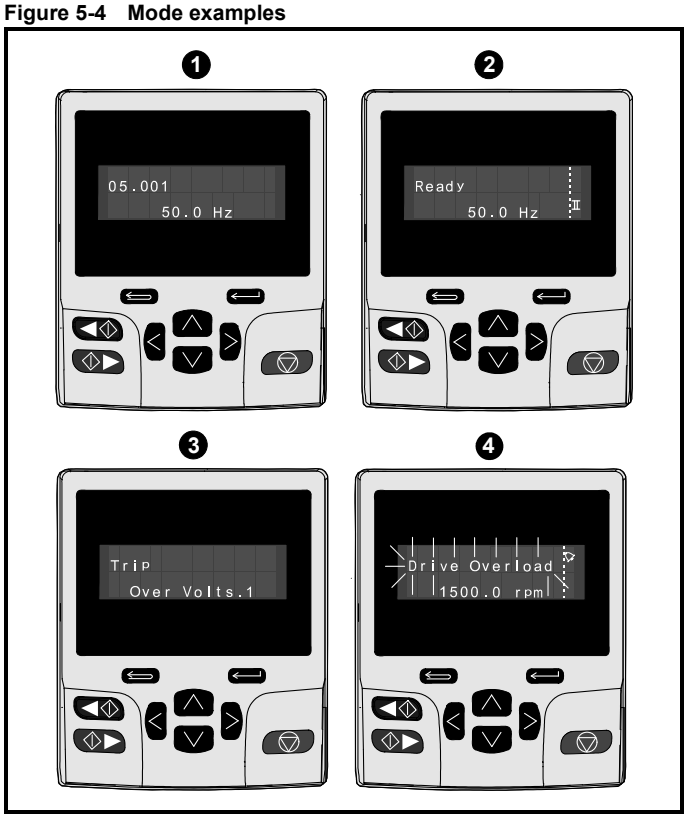
In 'parameter mode':

- If the up and down keypad buttons are pressed together, then the keypad display will jump to the start of the parameter menu being viewed, i.e. Pr **05.005** being viewed, when the above buttons pressed together will jump to Pr **05.000**.
- If the left and right keypad buttons are pressed together, then the keypad display will jump to the last viewed parameter in Menu 0.

In 'parameter edit mode':

- If the up and down keypad buttons are pressed together, then the parameter value of the parameter being edited will be set to 0.
- If the left and right keypad buttons are pressed together, the least significant digit (furthest right) will be selected on the keypad display for editing.

Figure 5-4 Mode examples



1. Parameter view mode: Read write or Read only

2. Status mode: Drive OK status

If the drive is ok and the parameters are not being edited or viewed, the upper row of the display will show one of the following:

- 'Inhibit', 'Ready' or 'Run'.

3. Status mode: Trip status

When the drive is in trip condition, the upper row of the display will indicate that the drive has tripped and the lower row of the display will show the trip code. For further information regarding trip codes. refer to Table 13-4 *Trip indications* on page 247**.**

4. Status mode: Alarm status

During an 'alarm' condition the upper row of the display flashes between the drive status (Inhibit, Ready or Run, depending on what is displayed) and the alarm.

WARNING

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

NOTE

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

NOTE

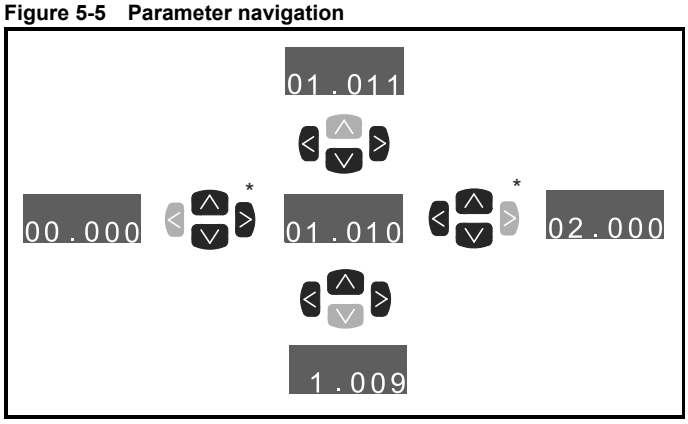
For new parameter-values to apply after the line power supply to the drive is interrupted, new values must be saved. Refer to section 5.7 *Saving parameters* on page 45.

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 **00.049** has been set to 'All Menus' the left and right buttons are used to navigate between menus. For further information, refer to section 5.9 *Parameter access level and security* on page 46.

Figure 5-5 Parameter navigation



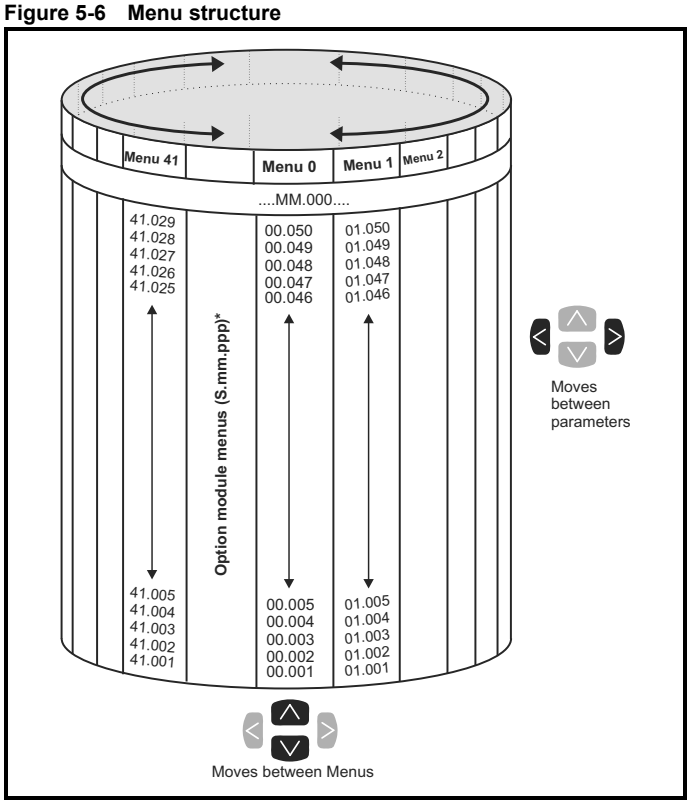
* Can only be used to move between menus if all menus have been enabled (Pr **00.049**). Refer to section 5.9 *Parameter access level and security* on page 46.

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 5-6 Menu structure



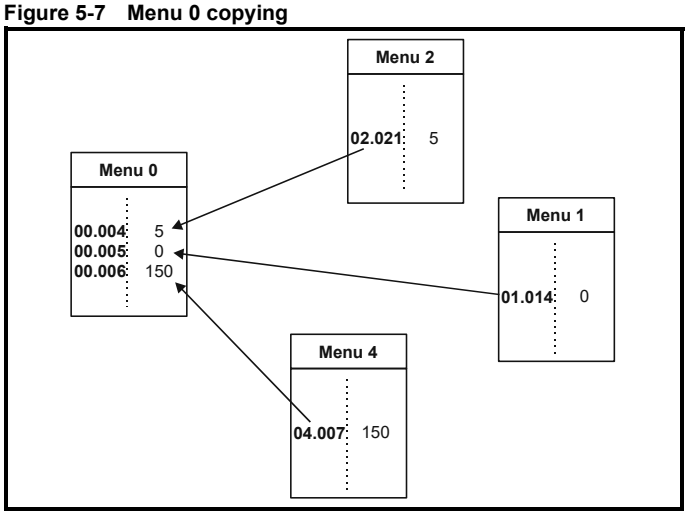
* The option module menus (S.mm.ppp) are only displayed if option modules are installed. Where S signifies the option module slot number and the mm.ppp signifies the menu and the parameter number of the option module's internal menus and parameter.

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 49.

Figure 5-7 Menu 0 copying



5.5 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. Menus 0 to 41 can be viewed on the KI-Keypad.

The option module menus (S.mm.ppp) are only displayed (except for *Unidrive M700 / M702* 4.mm.ppp) 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.

On *Unidrive M700 / M702,* menu 4.00.xxx is the same as menu 24.xxx.

Table 5-3 Advanced menu descriptions

Menu	Description
0	Commonly used basic set up parameters for quick / easy programming
1	Frequency / Speed reference
2	Ramps
3	Frequency slaving, speed feedback and speed control
4	Torque and current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
9	Programmable logic, motorized pot, 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
21	Second motor parameters
22	Menu 0 set-up
23	Not allocated
24	Ethernet module (slot 4) set-up menu*
25	Option module slot 1 application parameters
26	Option module slot 2 application parameters
27	Option module slot 3 application parameters
28	Option module slot 4 application parameters
29	Reserved menu
30	Onboard user programming application menu
31-41	Advanced motion controller set-up parameters
Slot 1	Slot 1 option menus**
Slot 2	Slot 2 option menus**
Slot 3	Slot 3 option menus**
Slot 4	Slot 4 option menus**

* Only displayed on *Unidrive M700 / M702*.

** Only displayed when the option modules are installed.

5.5.1 KI-Keypad set-up menu

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 5-4 KI-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 or on	RW

* The languages available will depend on the keypad software version.

NOTE

It is not possible to access the keypad parameters via any communications channel.

5.5.2 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 5-5 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 %.
Ind Overload	Regen inductor overload. *Inductor 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.
Limit Switch	Limit switch active. Indicates that a limit switch is active and that is causing the motor to be stopped.

5.5.3 Display messages

The following tables indicate the various possible mnemonics which can be displayed by the drive and their meaning.

Table 5-6 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
Scan	The drive is enabled in Regen mode and is trying to synchronize to the supply	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
Position	Positioning / position control is active during an orientation stop	Enabled
Trip	The drive has tripped and no longer controlling the motor. The trip code appears in the lower display.	Disabled
Active	The Regen unit is enabled and synchronized to the supply	Enabled
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

Table 5-7 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	**User Program**	User program being loaded
User program is being loaded from a NV Media Card to the drive		
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		

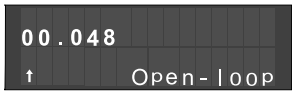
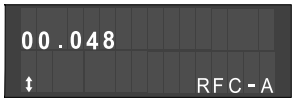
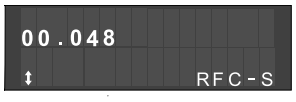
5.6 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. *User security status* (00.049) and *User security code* (00.034) 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 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702* 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 **00.048** as follows:

Pr 00.048 setting		Operating mode
	1	Open-loop
	2	RFC-A
	3	RFC-S
	4	Regen

The figures in the second column apply when the communications interface is used.

4. Either:
- Press the red reset button
- Toggle the reset digital input
- Carry out a drive reset through the communications interface by setting Pr **10.038** to 100.

NOTE

Entering 1253 or 1254 in Pr **mm.000** will only load defaults if the setting of Pr **00.048** has been changed.

5.7 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 the communications interface by setting Pr **10.038** to 100

5.8 Restoring parameter defaults

Restoring parameter defaults by this method saves the default values in the drives memory. *User security status* (00.049) and *User security code* (00.034) are not affected by this procedure).

Procedure

1. Ensure the drive is not enabled, i.e. terminal 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702* 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 the communications interface by setting Pr **10.038** to 100

5.9 Parameter access level and security

The parameter access level determines whether the user has access to Menu 0 only or to all the advanced menus (Menus 1 to 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 5-8.

Table 5-8 Parameter access level and security

User security status (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.

5.9.1 User Security Level / Access Level

The drive provides a number of different levels of security that can be set by the user via *User Security Status* (11.044); these are shown below.

User Security Status (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

5.9.2 Changing the User Security Level /Access Level

The security level is determined by the setting of Pr **00.049** or Pr **11.044**. The Security Level can be changed through the keypad even if the User Security Code has been set.

5.9.3 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 **00.034** 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 **00.049**. 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 **00.034** 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 **00.034** 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.

5.10 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 5.9 *Parameter access level and security* on page 46 for further information regarding access level.

5.11 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 5.9 *Parameter access level and security* on page 46 for further information regarding access level.

5.12 Communications

The *Unidrive M700 / M702* drives offer Ethernet fieldbus communications and the *Unidrive M701* drive offers a 2 wire EIA 485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required.

5.12.1 *Unidrive M700 / M702* - Ethernet communications

The drive offers fieldbus communications via Ethernet, this enables the drive set-up, operation and monitoring to be carried out with a PC or controller. The drive provides two RJ45 connections with an Ethernet switch for easy network creation. The Ethernet option provides support for the following protocols:

- Modbus TCP
- EtherNet/IP or Profinet IO
- Web pages*
- Email**
- Synchronization with IEEE1588
- RTMoE

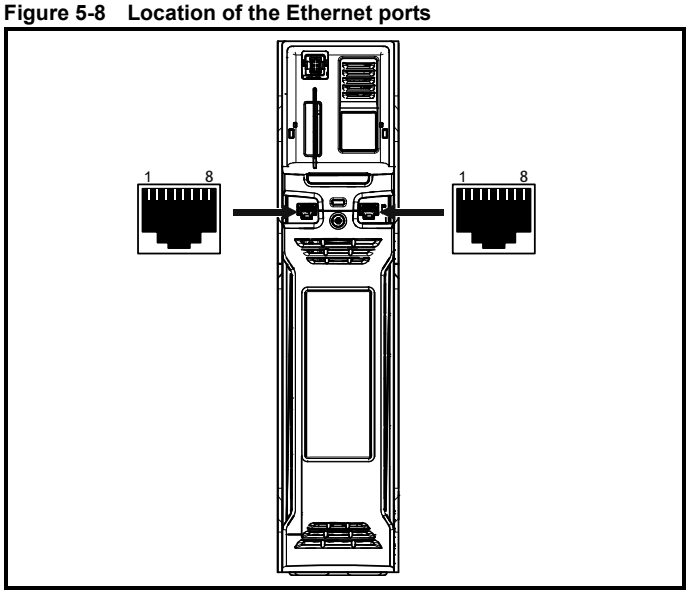
*Basic Web page functionality only

**Features have not been implemented but will be available soon.

In addition to two RJ45 connectors, each port provides a status LED for diagnostic / information purposes.

LED status	Description
Off	Ethernet connection not detected
Solid green	Ethernet connection detected but no data
Flashing green	Ethernet connection detected and data flow

Figure 5-8 Location of the Ethernet ports



NOTE
The shell of the RJ45 connector is isolated from the 0V of the drive control terminals but it is connected to ground.

NOTE
Modbus TCP/IP has a maximum number of 4 client connections. Refer to Pr **4.15.006** (Maximum Connections) in the *Parameter Reference Guide.* The default value of Pr **4.15.006** is 2 client connections, but the maximum number of client connections is 10.

Recommended cable

It is recommended that a minimum specification of CAT5e is used in new installations. If the existing cabling is used this may limit the maximum data rate depending on the cable ratings. In noisy environments the use of STP cable will offer additional noise immunity.

Maximum network lengths

The main restriction imposed on the Ethernet cabling is the length of a single segment of the cable, for Copper - UTP/STP CAT 5 cable type, maximum trunk cable length should be limited to 100 m. If distances greater than this are required it may be possible to extend the network with additional switches.

Ethernet set-up parameters

This section covers the parameters necessary to establish an Ethernet connection to the drive.

Table 5-9 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
IP	IP Address	Mac	Mac Address
Date	Date parameter	Time	Time parameter
Chr	Character parameter		

4.00.007 {24.007}	**Reset**								
RW	Bit							US	
⇳	Off (0) or On (1)				⇨	Off (0)			

Changes to the Ethernet set-up parameters will not take effect until a *Reset* (4.00.007) has been performed.

4.00.010 {24.010}	**Active IP Address**								
RO	IP							US	
⇳	128.000.000.000 to 127.255.255.255				⇨				

This parameter displays the Active IP Address. The Active IP Address can also be viewed in Pr **00.037**.

4.02.005	**DHCP Enable**								
RW	Bit							US	
⇳	Off (0) or On (1)				⇨	On (1)			

If *DHCP Enable* (4.02.005) is set to On (1), the IP address is acquired from the DHCP server and written to *IP Address* (4.02.006).

NOTE
When using manual / static IP address configuration, ensure *Subnet Mask* (4.02.007) and *Default Gateway* (4.02.008) should also be set manually.

NOTE
If *Protocol Mode Select* (4.02.018) is set to Profinet (2) and the IP address is assigned to a Profinet Controller, *DHCP Enable* (4.02.005) will be ignored and set to Off (0) on initialisation.

4.02.006	**IP Address**								
RW	IP							US	
⇳	000.000.000.000 to 255.255.255.255				⇨	192.168.001.100			

This parameter controls and displays the IP address of the drive. If *DHCP Enable* (4.02.005) is set to On (1) this parameter will become read-only.

4.02.007	Subnet Mask								
RW	IP							US	
⇳	000.000.000.000 to 255.255.255.255				⇨	255.255.255.000			

This parameter controls and displays the *Subnet Mask* (4.02.007) of the drive.

4.02.008	Default Gateway								
RW	IP							US	
⇳	000.000.000.000 to 255.255.255.255				⇨	192.168.1.254			

This parameter controls and displays the *Default Gateway* (4.02.008) of the drive.

PC Tools support

The discovery protocol feature, which is supported by the Unidrive M PC tools, is able to discover the drives that are connected to a PC, independent of above parameter settings.

5.12.2 *Unidrive M701* - EIA 485 Serial communications

The EIA 485 option provides two parallel RJ45 connectors allowing easy daisy chaining. The drive only supports Modbus RTU protocol.

The serial communications port of the drive is a RJ45 socket, which is isolated from the power stage and the other control terminals (see section 4.2 *Communication connections* on page 23 for connection and isolation details).

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. Therefore a suitable converter is required.

Suitable USB to EIA 485 and EIA 232 to EIA 485 isolated converters are available from Control Techniques as follows:

- CT USB Comms cable (CT Part No. 4500-0096)
- CT EIA 232 Comms cable (CT Part No. 4500-0087)

NOTE

When using the CT EIA 232 Comms cable the available baud rate is limited to 19.2 k baud.

When using one of the above 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 'link out' the terminating resistor within the converter depending on which type is used. The information on how to link out the terminating resistor will normally be contained in the user information supplied with the converter.

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) {00.035}	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 (if installed) on the drive. This parameter can be changed via the drive keypad, via a option module or via the comms interface itself.
Serial Baud Rate (11.025) {00.036}	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 a 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) {00.037}	1 to 247	This parameter defines the serial address and an addresses between 1 and 247 are permitted.

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 Parameter ranges and variable minimum / maximums

Some parameters in the drive have a variable range with a variable minimum and a variable maximum value 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

For more information, refer to section 12.1 *Parameter ranges and Variable minimum/maximums* on page 148

6.2 Menu 0: Basic parameters

Parameter			Range			Default			Type					
			OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
00.001	Minimum Reference Clamp	**{01.007}**	VM_NEGATIVE_REF_CLAMP1 Hz / rpm			0.0 Hz	0.0 rpm		RW	Num				US
00.002	Maximum Reference Clamp	**{01.006}**	VM_POSITIVE_REF_CLAMP1 Hz / rpm			50 Hz default: 50.0 Hz 60 Hz default: 60.0 Hz	50 Hz default: 1500.0 rpm 60 Hz default: 1800.0 rpm	3000.0 rpm	RW	Num				US
00.003	Acceleration Rate 1	**{02.011}**	0.0 to VM_ACCEL_RATE s/100 Hz	0.000 to VM_ACCEL_RATE s/1000 rpm		5.0 s/100 Hz	2.000 s/1000 rpm	0.200 s/1000 rpm	RW	Num				US
00.004	Deceleration Rate 1	**{02.021}**	0.0 to VM_ACCEL_RATE s/100 Hz	0.000 to VM_ACCEL_RATE s/1000 rpm		10.0 s/100 Hz	2.000 s/1000 rpm	0.200 s/1000 rpm	RW	Num				US
00.005	Reference Selector	**{01.014}**	A1 A2 (0), A1 Preset (1), A2 Preset (2), Preset (3), Keypad (4), Precision (5), Keypad Ref (6)			A1 A2 (0) / Preset (3)***			RW	Txt				US
00.006	Symmetrical Current Limit	**{04.007}**	0.0 to VM_MOTOR1_CURRENT_LIMIT %			165.0 %[1]	175.0 %[2]		RW	Num		RA		US
00.007	Open-loop Control Mode	**{05.014}**	Ur S (0), Ur (1), Fixed (2), Ur Auto (3), Ur I (4), Square (5)			Ur I (4)			RW	Txt				US
	Speed Controller Proportional Gain Kp1	**{03.010}**		0.0000 to 200.000 s/rad			0.0300 s/rad	0.0100 s/rad	RW	Num				US
00.008	Low Frequency Voltage Boost	**{05.015}**	0.0 to 25.0 %			3.0 %			RW	Num				US
	Speed Controller Integral Gain Ki1	**{03.011}**		0.00 to 655.35 s^2/rad			0.10 s^2/rad	1.00 s^2/rad	RW	Num				US
00.009	Dynamic V to F Select	**{05.013}**	Off (0) or On (1)			Off (0)			RW	Bit				US
	Speed Controller Differential Feedback Gain Kd 1	**{03.012}**		0.00000 to 0.65535 1/rad			0.00000 1/rad		RW	Num				US
00.010	Motor Rpm	**{05.004}**	±180000 rpm						RO	Bit				US
	Speed Feedback	**{03.002}**		VM_SPEED rpm					RO	Num	ND	NC	PT	FI
00.011	Output Frequency	**{05.001}**	VM_SPEED_FREQ_REF Hz	± 2000.0 Hz					RO	Num	ND	NC	PT	FI
	P1 Position	**{03.029}**			0 to 65535				RO	Num	ND	NC	PT	FI
00.012	Current Magnitude	**{04.001}**	0.000 to VM_DRIVE_CURRENT_UNIPOLAR A						RO	Bit	ND	NC	PT	FI
00.013	Torque Producing Current	**{04.002}**	VM_DRIVE_CURRENT A						RO	Bit	ND	NC	PT	FI
00.014	Torque Mode Selector	**{04.011}**	0 or 1	0 to 5		0			RW	Num				US
00.015	Ramp Mode	**{02.004}**	Fast (0), Standard (1), Std boost (2)	Fast (0), Standard (1)		Standard (1)			RW	Txt				US
00.016	Ramp Enable	**{02.002}**		Off (0) or On (1)			On (1)		RW	Bit				US
00.017	Digital Input 6 Destination****	**{08.026}**	00.000 to 59.999			06.031			RW	Num	DE		PT	US
	Current Reference Filter 1 Time Constant	**{04.012}**		0.0 to 25.0 ms			0.0 ms		RW	Num				US
00.018	P1 Thermistor Fault Detection	**{03.123}**	None (0), Temperature (1), Temp or Short (2)			None (0)			RW	Txt				US
00.019	Analog Input 2 Mode****	**{07.011}**	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)			Volt (6)			RW	Txt				US
00.020	Analog Input 2 Destination****	**{07.014}**	00.000 to 59.999			01.037			RW	Num	DE		PT	US
00.021	Analog Input 3 Mode****	**{07.015}**	**M700, M701**: Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9) **M702**: Therm Short Cct (7), Thermistor (8), Therm No Trip (9), Disabled (10)			**M700, M701**: Volt (6) **M702**: Disabled (10)			RW	Txt				US
00.022	Bipolar Reference Enable	**{01.010}**	Off (0) or On (1)			Off (0)			RW	Bit				US
00.023	Jog Reference	**{01.005}**	0.0 to 400.0 Hz	0.0 to 4000.0 rpm		0.0			RW	Num				US
00.024	Preset Reference 1	**{01.021}**	VM_SPEED_FREQ_REF			0.0			RW	Num				US
00.025	Preset Reference 2	**{01.022}**	VM_SPEED_FREQ_REF			0.0			RW	Num				US
00.026	Preset Reference 3	**{01.023}**	VM_SPEED_FREQ_REF Hz			0.0			RW	Num				US
	Overspeed Threshold	**{03.008}**		0 to 40000 rpm			0.0		RW	Num				US

Parameter			Range			Default			Type					
			OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
00.027	Preset Reference 4	**{01.024}**	VM_SPEED_FREQ_REF Hz			0.0			RW	Num				US
	P1 Rotary Lines Per Revolution	**{03.034}**		1 to 100000			1024	4096	RW	Num				US
00.028	Enable Auxiliary Key	**{06.013}**	Disabled (0), Forward/Reverse (1), Run Reverse (2)			Disabled (0)			RW	Txt				US
00.029	NV Media Card File Previously Loaded	**{11.036}**	0 to 999						RO	Num		NC	PT	
00.030	Parameter Cloning	**{11.042}**	None (0), Read (1), Program (2), Auto (3), Boot (4)			None (0)			RW	Txt		NC		US
00.031	Drive Rated Voltage	**{11.033}**	200 V (0), 400 V (1), 575 V (2), 690 V (3)						RO	Txt	ND	NC	PT	
00.032	Maximum Heavy Duty Rating	**{11.032}**	0.000 to 99999.999 A						RO	Num	ND	NC	PT	
00.033	Catch A Spinning Motor	**{06.009}**	Disable (0), Enable (1), Fwd Only (2), Rev Only (3)			Disable (0)			RW	Txt				US
	Rated Speed Optimisation Select	**{05.016}**		Disabled (0), Classic Slow (1), Classic Fast (2), Combined (3), VARs Only (4), Voltage Only (5)			Disabled (0)		RW	Txt				US
00.034	User Security Code	**{11.030}**	0 to 2^{31}-1			0			RW	Num	ND	NC	PT	US
00.035	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)			8 2 NP (0)			RW	Txt				US
00.036	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)			19200 (6)			RW	Txt				US
00.037	Serial Address*	**{11.023}**	1 to 247			1			RW	Num				US
	Active IP Address**	**{24.010}**	0.0.0.0 to 255.255.255.255						RO	IP		NC	PT	
00.038	Current Controller Kp Gain	**{04.013}**	0 to 30000			20	150		RW	Num				US
00.039	Current Controller Ki Gain	**{04.014}**	0 to 30000			40	2000		RW	Num				US
00.040	Auto-tune	**{05.012}**	0 to 2	0 to 5	0 to 6	0			RW	Num		NC		
00.041	Maximum Switching Frequency	**{05.018}**	2 kHz (0), 3 kHz (1), 4 kHz (2), 6 kHz (3), 8 kHz (4), 12 kHz (5), 16 kHz (6)			3 kHz (1)		6 kHz (3)	RW	Txt		RA		US
00.042	Number Of Motor Poles	**{05.011}**	Automatic (0) to 480 Poles (240)			Automatic (0)		6 Poles (3)	RW	Num				US
00.043	Rated Power Factor*****	**{05.010}**	0.000 to 1.000			0.850			RW	Num		RA		US
	Position Feedback Phase Angle	**{03.025}**			0.0 to 359.9 °			0.0 °	RW	Num	ND			US
00.044	Rated Voltage	**{05.009}**	0 to VM_AC_VOLTAGE_SET V			200 V drive: 230 V 50 Hz default 400V drive: 400 V 60 Hz default 400V drive: 460 V 575 V drive: 575 V 690 V drive: 690 V			RW	Num		RA		US
00.045	Rated Speed	**{05.008}**	0 to 35940 rpm	0.00 to 33000.00 rpm		50 Hz default: 1500 rpm 60 Hz default: 1800rpm	50 Hz default: 1450.00 rpm 60 Hz default: 1750.00 rpm	3000.00 rpm	RW	Num				US
00.046	Rated Current	**{05.007}**	0.000 to VM_RATED_CURRENT A			Maximum Heavy Duty Rating (11.032)			RW	Num		RA		US
00.047	Rated Frequency	**{05.006}**	0.0 to 599.0 Hz	0.0 to 550.0 Hz		50Hz: 50.0 60Hz: 60.0			RW	Num				US
	Volts per 1000 rpm	**{05.033}**			0 to 10000 V / 1000 rpm			98 V / 1000 rpm	RW	Num				US
00.048	User Drive Mode	**{11.031}**	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)			Open-loop (1)	RFC-A (2)	RFC-S (3)	RW	Txt	ND	NC	PT	
00.049	User Security Status	**{11.044}**	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)			Menu 0 (0)			RW	Txt	ND		PT	
00.050	Software Version	**{11.029}**	0 to 99999999						RO	Num	ND	NC	PT	
00.051	Action On Trip Detection	**{10.037}**	0 to 31			0			RW	Bin				US
00.052	Reset Serial Communications*	**{11.020}**	Off (0) or On (1)			Off (0)			RW	Bit	ND	NC		
00.053	Motor Thermal Time Constant 1	**{04.015}**	1.0 to 3000.0 s			89.0 s			RW	Num				US

* Only applicable to *Unidrive M701.*

** Only applicable to *Unidrive M700 / M702.*

*** Only applicable to *Unidrive M702*.

**** Only applicable to *Unidrive M700 / M701*.

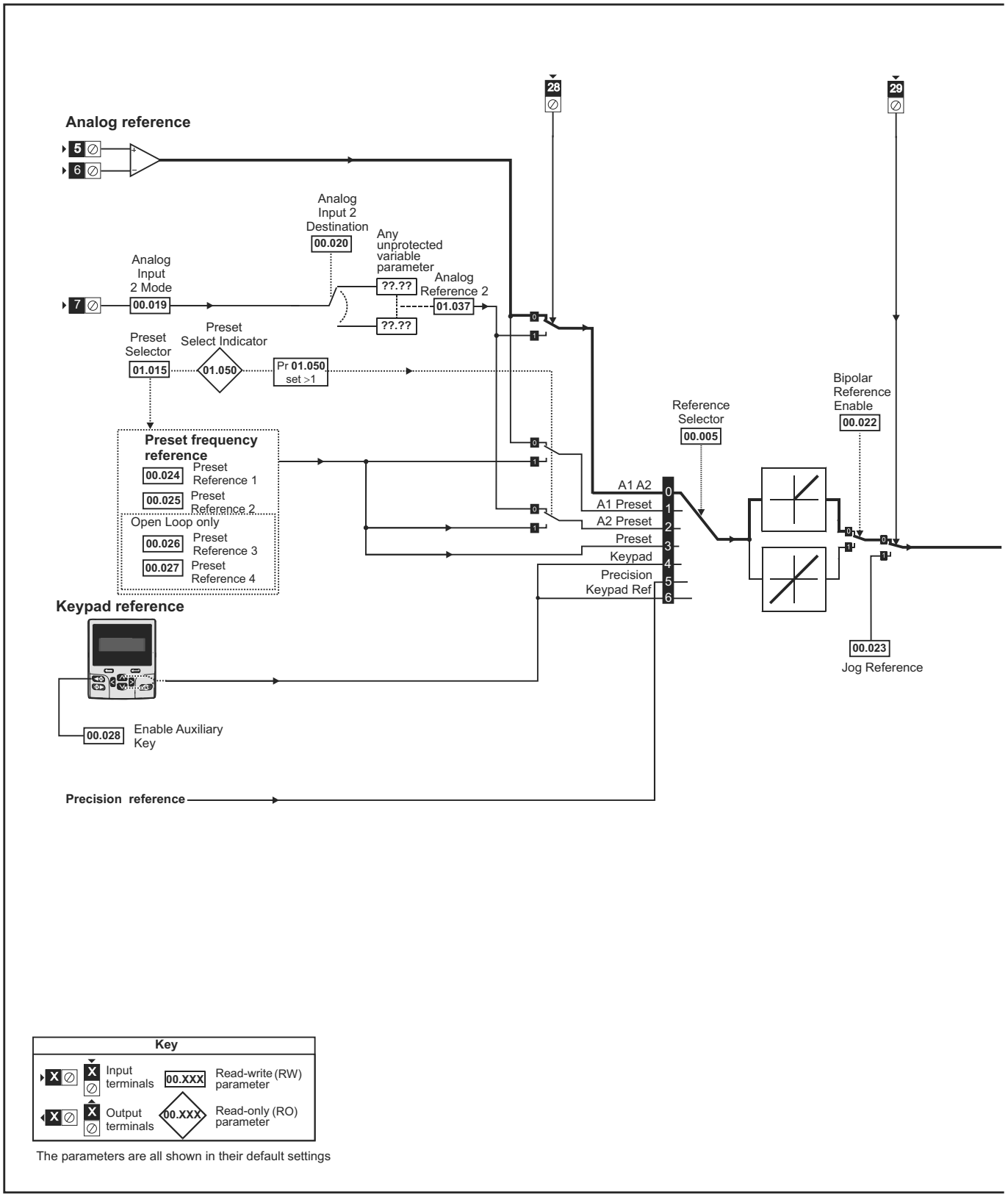
***** Following a rotating autotune Pr **00.043** {05.010} is continuously written by the drive, calculated from the value of Stator Inductance (Pr **05.025**). To manually enter a value into Pr **00.043** {05.010}, Pr **05.025** will need to be set to 0. Please refer to the description of Pr **05.010** in the *Parameter Reference Guide* for further details.

[1] For size 9 and above the default is 141.9 %.

[2] For size 9 and above the default is 150.0 %.

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						

Figure 6-1 Menu 0 logic diagram (*Unidrive M700 / 701*)



The parameters are all shown in their default settings

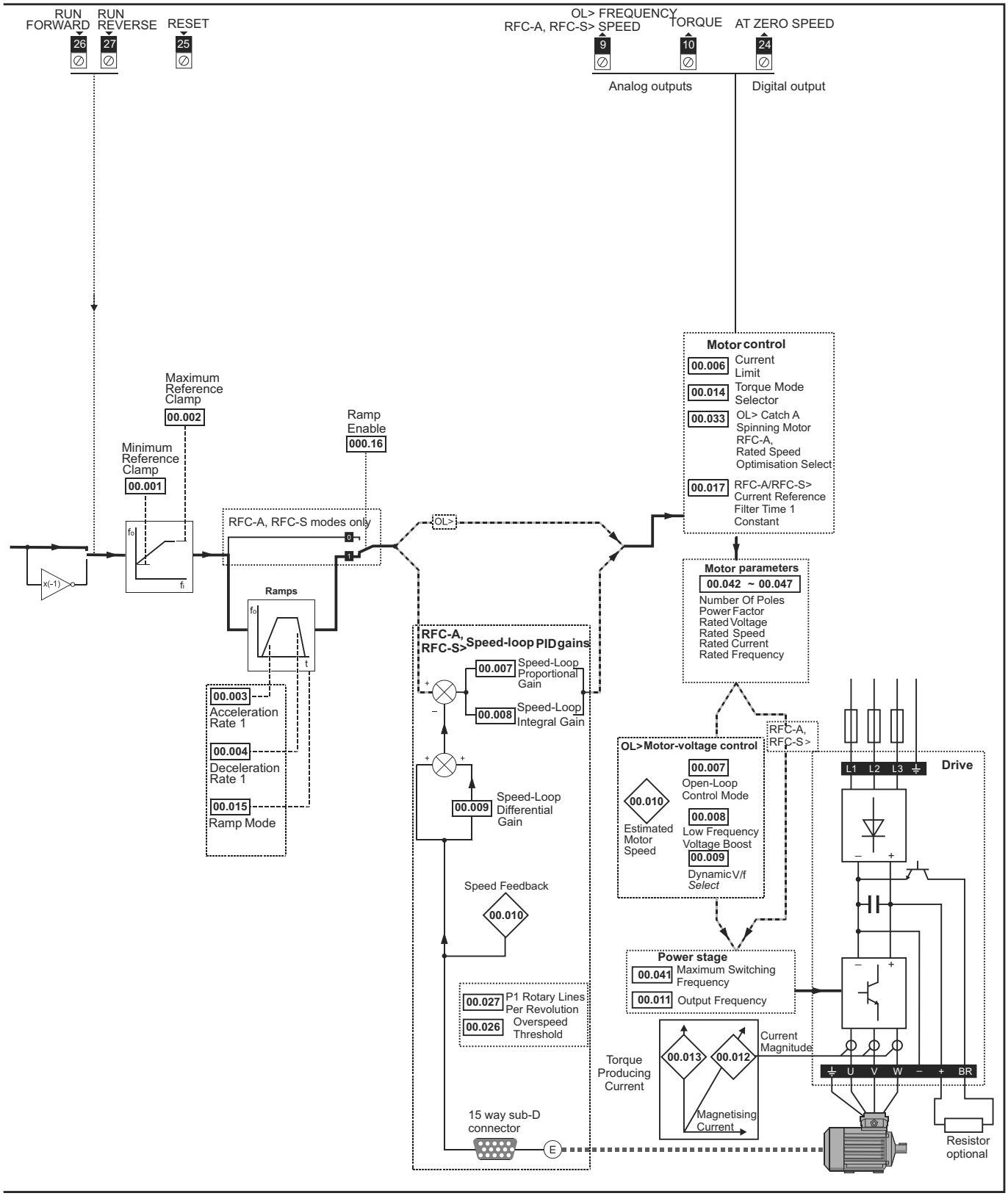
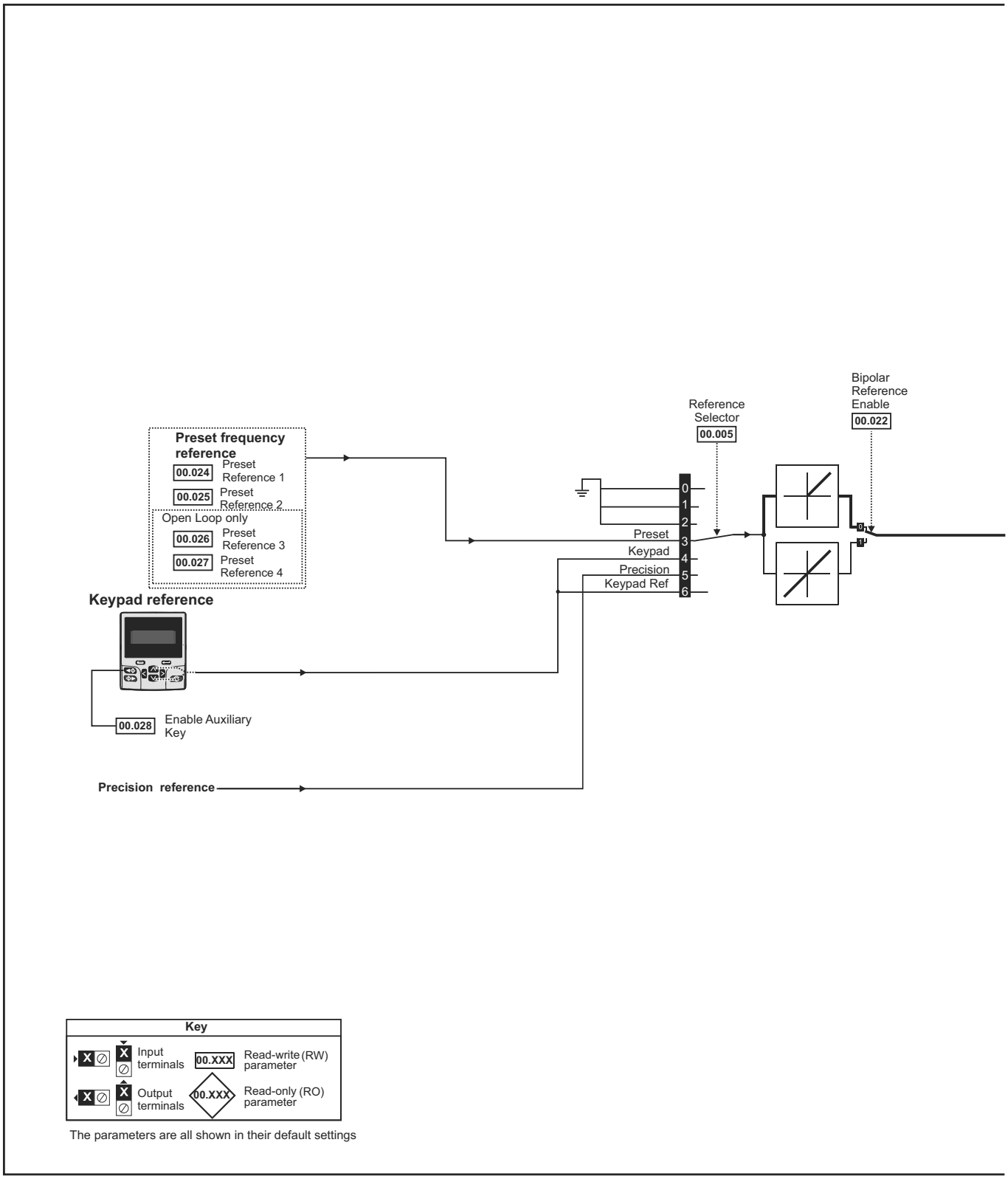
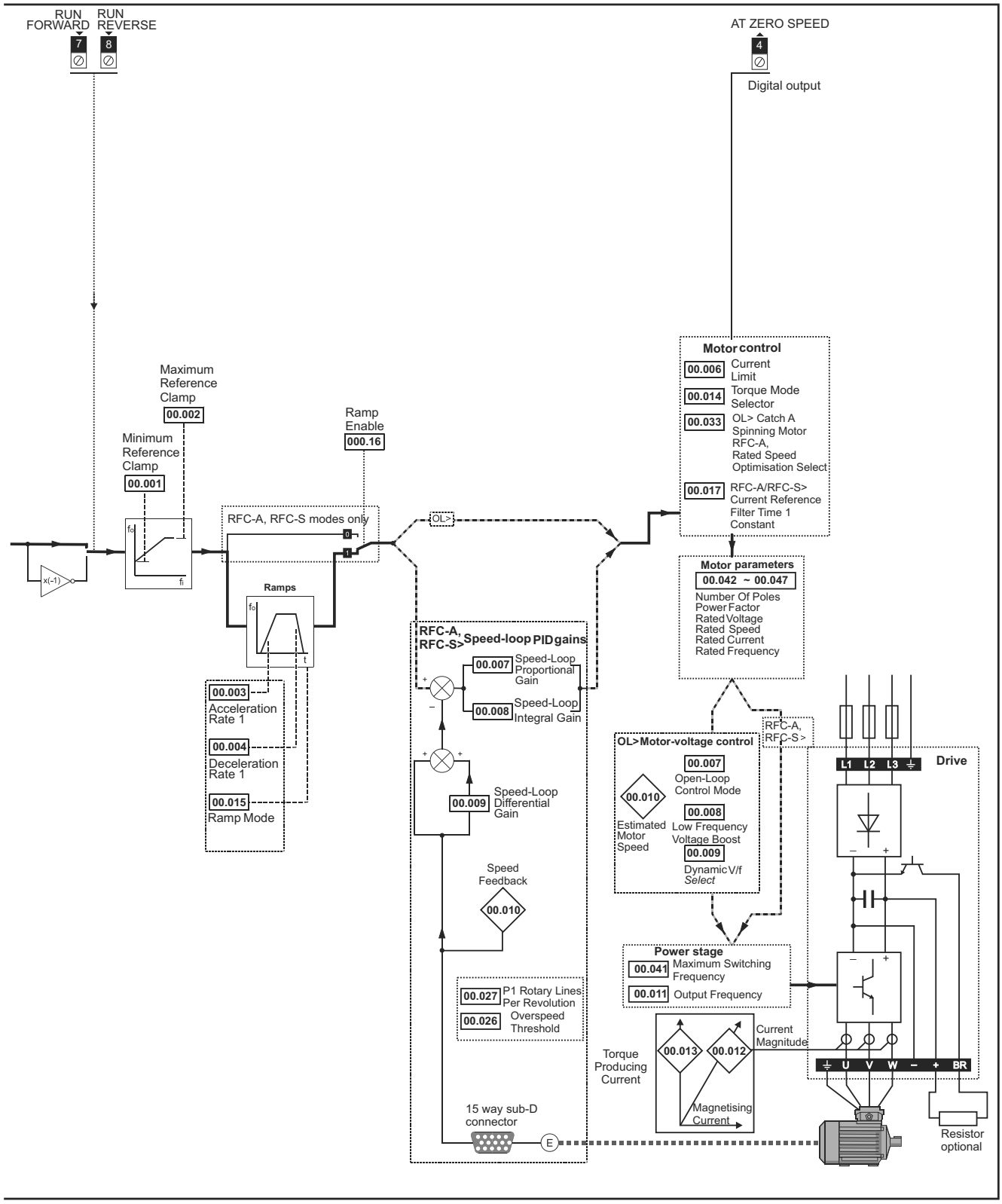

RUN FORWARD
RUN REVERSE
RESET
26
27
25
OL> FREQUENCY
RFC-A, RFC-S> SPEED
TORQUE
AT ZERO SPEED
9
10
24
Analog outputs
Digital output
Motor control
00.006 Current Limit
00.014 Torque Mode Selector
00.033 OL> Catch A Spinning Motor RFC-A, Rated Speed Optimisation Select
00.017 RFC-A/RFC-S> Current Reference Filter Time 1 Constant
Maximum Reference Clamp
00.002
Minimum Reference Clamp
00.001
Ramp Enable
000.16
RFC-A, RFC-S modes only
OL>
Ramps
00.003 Acceleration Rate 1
00.004 Deceleration Rate 1
00.015 Ramp Mode
Motor parameters
00.042 ~ 00.047
Number Of Poles
Power Factor
Rated Voltage
Rated Speed
Rated Current
Rated Frequency
RFC-A, RFC-S> Speed-loop PID gains
00.007 Speed-Loop Proportional Gain
00.008 Speed-Loop Integral Gain
00.009 Speed-Loop Differential Gain
Speed Feedback
00.010
OL> Motor-voltage control
00.007 Open-Loop Control Mode
00.010 Estimated Motor Speed
00.008 Low Frequency Voltage Boost
00.009 Dynamic V/f Select
RFC-A, RFC-S>
Drive
L1 L2 L3
Power stage
00.041 Maximum Switching Frequency
00.011 Output Frequency
00.027 P1 Rotary Lines Per Revolution
00.026 Overspeed Threshold
Torque Producing Current
00.013
00.012
Current Magnitude
Magnetising Current
15 way sub-D connector
E
U V W BR
Resistor optional

Figure 6-2 Menu 0 logic diagram (*Unidrive M702*)



The parameters are all shown in their default settings


RUN FORWARD
7
RUN REVERSE
8
AT ZERO SPEED
4
Digital output
Maximum Reference Clamp
00.002
Minimum Reference Clamp
00.001
Ramp Enable
000.16
RFC-A, RFC-S modes only
OL>
Ramps
00.003
Acceleration Rate 1
00.004
Deceleration Rate 1
00.015
Ramp Mode
Motor control
00.006
Current Limit
00.014
Torque Mode Selector
00.033
OL> Catch A Spinning Motor RFC-A, Rated Speed Optimisation Select
00.017
RFC-A/RFC-S> Current Reference Filter Time 1 Constant
Motor parameters
00.042 ~ 00.047
Number Of Poles
Power Factor
Rated Voltage
Rated Speed
Rated Current
Rated Frequency
RFC-A, RFC-S>
Speed-loop PID gains
00.007
Speed-Loop Proportional Gain
00.008
Speed-Loop Integral Gain
00.009
Speed-Loop Differential Gain
Speed Feedback
00.010
00.027
P1 Rotary Lines Per Revolution
00.026
Overspeed Threshold
15 way sub-D connector
E
OL> Motor-voltage control
00.007
Open-Loop Control Mode
00.010
Estimated Motor Speed
00.008
Low Frequency Voltage Boost
00.009
Dynamic V/f Select
RFC-A, RFC-S >
Power stage
00.041
Maximum Switching Frequency
00.011
Output Frequency
Torque Producing Current
00.013
00.012
Current Magnitude
Magnetising Current
Drive
L1 L2 L3
U V W – + BR
Resistor optional

6.3 Parameter descriptions

6.3.1 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 6-1. The functions in Table 6-1 can also be selected by entering the appropriate numeric values (as shown in Table 6-2) in Pr **mm.000**. For example, enter 4001 in Pr **mm.000** to store drive parameters on an NV Media Card.

Table 6-1 Commonly used functions in xx.000

Value	Equivalent value	String	Action
0	0	**[No Action]**	
1001	1	**[Save parameters]**	Save parameters under all conditions
6001	2	**[Load file 1]**	Load the drive parameters or user program file from NV Media Card file 001
4001	3	**[Save to file 1]**	Transfer the drive parameters to parameter file 001
6002	4	**[Load file 2]**	Load the drive parameters or user program file from NV Media Card file 002
4002	5	**[Save to file 2]**	Transfer the drive parameters to parameter file 002
6003	6	**[Load file 3]**	Load the drive parameters or user program file from NV Media Card file 003
4003	7	**[Save to file 3]**	Transfer the drive parameters to parameter file 003
12000	8	**[Show non-default]**	Displays parameters that are different from defaults
12001	9	**[Destinations]**	Displays parameters that are set
1233	10	**[Reset 50Hz defs]**	Load parameters with standard (50 Hz) defaults
1244	11	**[Reset 60Hz defs]**	Load parameters with US (60 Hz) defaults
1070	12	**[Reset modules]**	Reset all option modules
11001	13	**[Read enc. NP P1]**	Transfer electronic nameplate motor parameters to the drive from the P1 encoder
11051	14	**[Read enc. NP P2]**	Transfer electronic nameplate motor parameters to the drive from the P2 encoder

Table 6-2 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 parameters 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
110S1	Transfer electronic nameplate data from an encoder connected to the P1 position feedback interface on the drive or option module in slot ‘S’ into drive parameters.
110S2	As 110S1, but for the P2 position feedback interface
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.
15xxx*	Transfer the user program in an option module installed in slot 1 to a non-volatile media card file xxx
16xxx*	Transfer the user program in an option module installed in slot 2 to a non-volatile media card file xxx
17xxx*	Transfer the user program in an option module installed in slot 3 to a non-volatile media card file xxx
18xxx*	Transfer the user program from file xxx in a non-volatile media card to an option module installed in slot 1.
19xxx*	Transfer the user program from file xxx in a non-volatile media card to an option module installed in slot 2.
20xxx*	Transfer the user program from file xxx in a non-volatile media card to an option module installed in slot 3.
21xxx*	Transfer the user program in an option module installed in slot 4 to a non-volatile media card file xxx.
22xxx*	Transfer the user program from file xxx in a non-volatile media card to an option module installed in slot 4.

* See Chapter 10 *NV Media Card Operation* on page 139 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. Equivalent values and strings are also provided in the table above.

6.4 Full descriptions

Table 6-3 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) state occurs.

6.4.1 Parameter x.00

00.000 {mm.000}	**Parameter zero**								
RW	Num				ND	NC	PT		
⇳	0 to 65,535				⇨				

6.4.2 Speed limits

00.001 {01.007}	**Minimum Reference Clamp**								
RW	Num							US	
OL	⇳	VM_NEGATIVE_REF_ CLAMP1 Hz / rpm					⇨	0.0 Hz	
RFC-A								0.0 rpm	
RFC-S									

(When the drive is jogging, [**00.001**] has no effect.)

Open-loop

Set Pr **00.001** at the required minimum output frequency of the drive for both directions of rotation. The drive speed reference is scaled between Pr **00.001** and Pr **00.002**. [**00.001**] is a nominal value; slip compensation may cause the actual frequency to be higher.

RFC-A / RFC-S

Set Pr **00.001** at the required minimum motor speed for both directions of rotation. The drive speed reference is scaled between Pr **00.001** and Pr **00.002**.

00.002 {01.006}	**Maximum Reference Clamp**								
RW	Num							US	
OL	⇳	VM_POSITIVE_REF_ CLAMP1 Hz / rpm					⇨	50Hz default: 50.0 Hz 60Hz default: 60.0 Hz	
RFC-A								50Hz default:1500.0 rpm 60Hz default:1800.0 rpm	
RFC-S								3000.0 rpm	

(The drive has additional over-speed protection).

Open-loop

Set Pr **00.002** at the required maximum output frequency for both directions of rotation. The drive speed reference is scaled between Pr **00.001** and Pr **00.002**. [**00.002**] is a nominal value; slip compensation may cause the actual frequency to be higher.

RFC-A / RFC-S

Set Pr **00.002** at the required maximum motor speed for both directions of rotation. The drive speed reference is scaled between Pr **00.001** and Pr **00.002**.

For operating at high speeds see section 8.6 *High speed operation* on page 109.

6.4.3 Ramps, speed reference selection, current limit

00.003 {02.011}	**Acceleration Rate 1**								
RW	Num							US	
OL	⇳	0.0 to VM_ACCEL_RATE s/100 Hz					⇨	5.0 s/100 Hz	
RFC-A		0.000 to VM_ACCEL_RATE s/1000 rpm						2.000 s/1000 rpm	
RFC-S								0.200 s/1000 rpm	

Set Pr **00.003** at the required rate of acceleration.

Note that larger values produce lower acceleration. The rate applies in both directions of rotation.

00.004 {02.021}	**Deceleration Rate 1**								
RW	Num							US	
OL	⇳	0.0 to VM_ACCEL_RATE s/100 Hz					⇨	10.0 s/100 Hz	
RFC-A		0.000 to VM_ACCEL_RATE s/1000 rpm						2.000 s/1000 rpm	
RFC-S								0.200 s/1000 rpm	

Set Pr **00.004** at the required rate of deceleration.

Note that larger values produce lower deceleration. The rate applies in both directions of rotation.

00.005 {01.014}	**Reference Selector**								
RW	Txt							US	
OL **RFC-A** **RFC-S**	⇳	A1 A2 (0)*, A1 Preset (1)*, A2 Preset (2)*, Preset (3), Keypad (4), Precision (5), Keypad Ref (6)					⇨	M700 / M701: A1 A2 (0) M702: Preset (3)	

* Available on *Unidrive M700 / M701* only.

Use Pr **00.005** to select the required frequency/speed reference as follows:

Setting		Description
A1 A2*	0	Analog input 1 OR analog input 2 selectable by digital input, terminal 28
A1 Preset*	1	Analog input 1 OR preset frequency/speed
A2 Preset*	2	Analog input 2 OR preset frequency/speed
Preset (3)	3	Pre-set frequency/speed
Keypad (4)	4	Keypad mode
Precision (5)	5	Precision reference
Keypad Ref (6)	6	Keypad Reference

* Available on *Unidrive M700 / M701* only.

00.006 {04.007}	**Symmetrical Current Limit**			
RW	Num			US
OL	⇳	0.0 to VM_MOTOR1_CURRENT_LIMIT %	⇨	165.0 %
RFC-A				175.0 %
RFC-S				

Pr **00.006** limits the maximum output current of the drive (and hence maximum motor torque) to protect the drive and motor from overload.

Set Pr **00.006** at the required maximum torque as a percentage of the rated torque of the motor, as follows:

$$[\mathbf{00.006}] = \frac{T_R}{T_{RATED}} \times 100\ (\%)$$

Where:

T_R Required maximum torque

T_{RATED} Motor rated torque

Alternatively, set Pr **00.006** at the required maximum active (torque-producing) current as a percentage of the rated active current of the motor, as follows:

$$[\mathbf{00.006}] = \frac{I_R}{I_{RATED}} \times 100\ (\%)$$

Where:

I_R Required maximum active current

I_{RATED} Motor rated active current

6.4.4 Voltage boost, (open-loop), Speed-loop PID gains (RFC-A / RFC-S)

00.007 {05.014}	**Open-loop Control Mode (OL)**			
00.007 {03.010}	**Speed Controller Proportional Gain Kp1 (RFC)**			
RW	Txt / Num			US
OL	⇳	Ur S (0), Ur (1), Fixed (2), Ur Auto (3), Ur I (4), Square (5)	⇨	Ur I (4)
RFC-A	⇳	0.0000 to 200.000 s/rad	⇨	0.0300 s/rad
RFC-S				0.0100 s/rad

Open-loop

There are six voltage modes available, which fall into two categories, vector control and fixed boost. For further details, refer to *Pr 00.007 {05.014} Open Loop Control Mode* on page 96.

RFC-A/ RFC-S

Pr **00.007** (**03.010**) operates in the feed-forward path of the speed-control loop in the drive. See Figure 12-4 on page 166 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 95.

00.008 {05.015}	**Low Frequency Voltage Boost (OL)**			
00.008 {03.011}	**Speed Controller Integral Gain Ki1 (RFC)**			
RW	Num			US
OL	⇳	0.0 to 25.0 %	⇨	3.0 %
RFC-A	⇳	0.00 to 655.35 s^2/rad	⇨	0.10 s^2/rad
RFC-S				1.00 s^2/rad

Open-loop

When *Open-loop Control Mode* (00.007) is set at **Fd** or **SrE**, set Pr **00.008** (**05.015**) at the required value for the motor to run reliably at low speeds.

Excessive values of Pr **00.008** can cause the motor to be overheated.

RFC-A/ RFC-S

Pr **00.008** (**03.011**) operates in the feed-forward path of the speed-control loop in the drive. See Figure 12-4 on page 166 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 95.

00.009 {05.013}	**Dynamic V to F Select (OL)**			
00.009 {03.012}	**Speed Controller Differential Feedback Gain Kd 1 (RFC)**			
RW	Bit			US
OL	⇳	Off (0) or On (1)	⇨	Off (0)
RFC-A	⇳	0.00000 to 0.65535 1/rad	⇨	0.00000 1/rad
RFC-S				

Open-loop

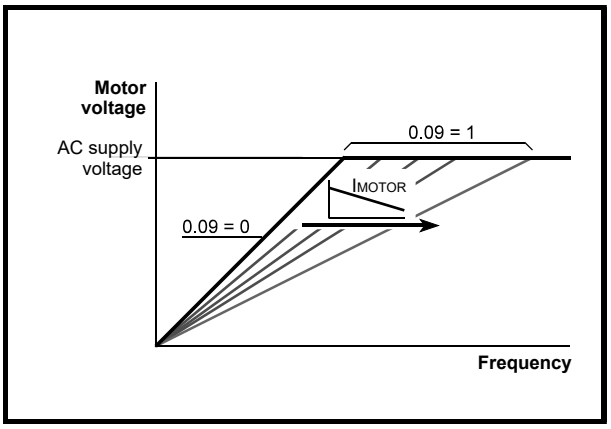
Set Pr **00.009** (**05.013**) at 0 when the V/f characteristic applied to the motor is to be fixed. It is then based on the rated voltage and frequency of the motor.

Set Pr **00.009** at 1 when reduced power dissipation is required in the motor when it is lightly loaded. The V/f characteristic is then variable resulting in the motor voltage being proportionally reduced for lower motor currents. Figure 6-3 shows the change in V/f slope when the motor current is reduced.

RFC-A / RFC-S

Pr **00.009** (**03.012**) operates in the feedback path of the speed-control loop in the drive. See Figure 12-4 *Menu 3 RFC-A, RFC-S logic diagram* on page 166 for a schematic of the speed controller. For information on setting up the speed controller gains, refer to Chapter 8 *Optimization* on page 95.

Figure 6-3 Fixed and variable V/f characteristics



6.4.5 Monitoring

00.010 {05.004}	Motor Rpm									
RO		Bit							US	
OL	⇳	±180000 rpm							⇨	

Open-loop

Pr **00.010** (**05.004**) indicates the value of motor speed that is estimated from the following:

02.001 *Post Ramp Reference*
00.042 *Number Of Motor Poles*

00.010 {03.002}	Speed Feedback									
RO		Num	FI			ND	NC	PT		
RFC-A RFC-S	⇳	VM_SPEED rpm				⇨				

RFC-A / RFC-S

Pr **00.010** (**03.002**) indicates the value of motor speed that is obtained from the speed feedback.

00.011 {05.001}	Output Frequency (OL)									
00.011 {03.029}	P1 Position (RFC)									
RO		Num	FI			ND	NC	PT		
OL RFC-A	⇳	VM_SPEED_FREQ_ REF Hz				⇨				
RFC-S	⇳	0 to 65535				⇨				

Open-loop and RFC-A

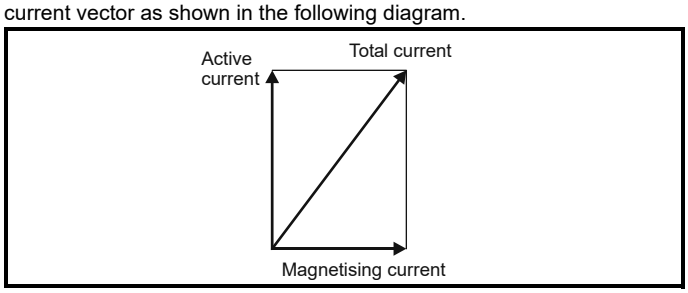
Pr **00.011** displays the frequency at the drive output.

RFC-S

Pr **00.011** displays the position of the encoder in mechanical values of 0 to 65,535. There are 65,536 units to one mechanical revolution.

00.012 {04.001}	Current Magnitude									
RO		Bit	FI			ND	NC	PT		
OL RFC-A RFC-S	⇳	0.000 to VM_DRIVE_CURRENT_ UNIPOLAR A				⇨				

Pr **00.012** displays the rms value of the output current of the drive in each of the three phases. The phase currents consist of an active component and a reactive component, which can form a resultant current vector as shown in the following diagram.



The active current is the torque producing current and the reactive current is the magnetizing or flux-producing current.

00.013 {04.002}	Torque Producing Current									
RO		Bit	FI			ND	NC	PT		
OL RFC-A RFC-S	⇳	VM_DRIVE_CURRENT A				⇨				

When the motor is being driven below its rated speed, the torque is proportional to [**00.013**].

6.4.6 Jog reference, Ramp mode selector, Stop and torque mode selectors

Pr **00.014** is used to select the required control mode of the drive as follows:

00.014 {04.011}	Torque Mode Selector									
RW		Num							US	
OL	⇳	0 or 1				⇨	0			
RFC-A RFC-S	⇳	0 to 5				⇨	0			

Setting	Open-Loop	RFC-A/S
0	Frequency control	Speed control
1	Torque control	Torque control
2		Torque control with speed override
3		Coiler/uncoiler mode
4		Speed control with torque feed-forward
5		Bi-directional torque control with speed override

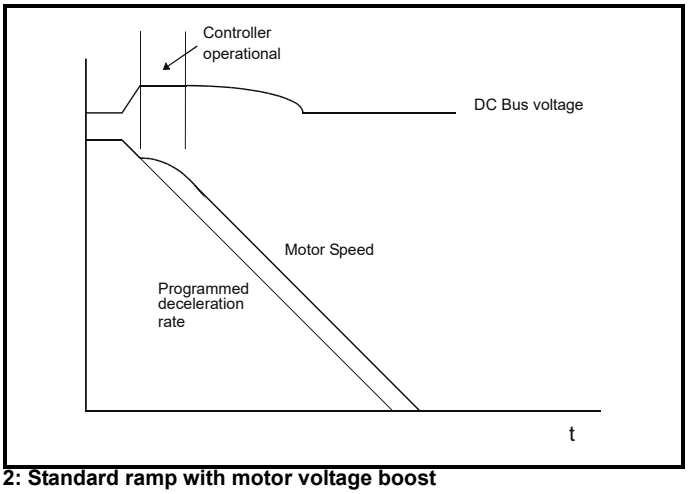
00.015 {02.004}	Ramp Mode Select									
RW		Txt							US	
OL	⇳	Fast (0), Standard (1), Std boost (2)				⇨	Standard (1)			
RFC-A RFC-S	⇳	Fast (0), Standard (1)				⇨	Standard (1)			

Pr **00.015** sets the ramp mode of the drive as shown below:

0: Fast ramp
Fast ramp is used where the deceleration follows the programmed deceleration rate subject to current limits. This mode must be used if a braking resistor is connected to the drive.

1: Standard ramp

Standard ramp is used. During deceleration, if the voltage rises to the standard ramp level (Pr **02.008**) it causes a controller to operate, the output of which changes the demanded load current in the motor. As the controller regulates the link voltage, the motor deceleration increases as the speed approaches zero speed. When the motor deceleration rate reaches the programmed deceleration rate the controller ceases to operate and the drive continues to decelerate at the programmed rate. If the standard ramp voltage (Pr **02.008**) is set lower than the nominal DC bus level the drive will not decelerate the motor, but it will coast to rest. The output of the ramp controller (when active) is a current demand that is fed to the frequency changing current controller (Open-loop modes) or the torque producing current controller (RFC-A or RFC-S modes). The gain of these controllers can be modified with Pr **00.038** and Pr **00.039**.



2: Standard ramp with motor voltage boost

This mode is the same as normal standard ramp mode except that the motor voltage is boosted by 20 %. This increases the losses in the motor, dissipating some of the mechanical energy as heat giving faster deceleration.

00.016 {02.002}	Ramp Enable									
RW		Bit							US	
OL	⇳					⇨				
RFC-A, RFC-S	⇳	Off (0) or On (1)				⇨	On (1)			

Setting Pr **00.016** to 0 allows the user to disable the ramps. This is generally used when the drive is required to closely follow a speed reference which already contains acceleration and deceleration ramps.

00.017 {08.026}	Digital Input 6 Destination*								
RW	Num		DE				PT	US	
OL	⇳	00.000 to 59.999				⇨	06.031		

* Not applicable to *Unidrive M702*.

Open-loop

Pr **00.017** sets the destination of digital input T29.

00.017 {04.012}	Current Reference Filter Time Constant								
RW	Num							US	
RFC-A, RFC-S	⇳	0.0 to 25.0 ms				⇨	0.0 ms		

RFC-A / RFC-S

A first order filter, with a time constant defined by Pr **00.017**, is provided on the current demand to reduce acoustic noise and vibration produced as a result of position feedback quantisation noise. The filter introduces a lag in the speed loop, and so the speed loop gains may need to be reduced to maintain stability as the filter time constant is increased.

00.018 {03.123}	P1 Thermistor Fault Detection									
RW	Txt									
OL, RFC-A, RFC-S	⇳	None (0) Temperature (1) Temperature and short (2)				⇨	Temperature (1)			

Defines the fault detection for the P1 thermistor input:

P1 Thermistor Fault Detection (03.123)	Fault detection
0: None	No detection active
1: Temperature	Over temperature detection
2: Temp and short	Over temperature and short circuit detection

If over temperature detection is enabled a *Thermistor*.001 trip is initiated if *P1 Thermistor Feedback* (03.119) is above the level defined by *P1 Thermistor Trip Threshold* (03.120). The trip cannot be reset until *P1 Thermistor Feedback* (03.119) is below *P1 Thermistor Reset Threshold* (03.121).

If short circuit detection is enabled then a *Th Short Circuit*.001 is initiated if *P1 Thermistor Feedback* (03.119) is below 50 Ohms.

00.019 {07.011}	Analog Input 2 Mode*									
RW	Num								US	
OL, RFC-A, RFC-S	⇳	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)				⇨	Volt (6)			

* Not applicable to *Unidrive M702*.

In modes 2 and 3 a current loop loss trip is generated if the current falls below 3 mA.

In modes -4, -3, 2 and 3 the analog input level goes to 0.0 % if the input current falls below 3 mA.

In modes -2 and -1 the analog input remains at the value it had in the previous sample before the current fell below 3mA.

Pr Value	Pr string	Comments
-4	4-20 mA Low	4-20 mA low value on current loss (1)
-3	20-4 mA Low	20-4 mA low value on current loss (1)
-2	4-20 mA Hold	4-20 mA hold at level before loss on current loss
-1	20-4 mA Hold	20-4 mA hold at level before loss on current loss
0	0-20 mA	
1	20-0 mA	
2	4-20 mA Trip	4-20 mA trip on current loss
3	20-4 mA Trip	20-4 mA trip on current loss
4	4-20 mA	
5	20-4 mA	
6	Volt	

00.020 {07.014}	**Analog Input 2 Destination***								
RW		Num		DE				PT	US
OL	⇳	00.000 to 59.999	⇨	01.037					
RFC-A									
RFC-S									

* Not applicable to *Unidrive M702*.

Pr **00.020** sets the destination of analog input 2.

00.021 {07.015}	**Analog Input 3 Mode***								
RW		Txt							US
OL	⇳	Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)	⇨	Volt (6)					
RFC-A									
RFC-S									

* Not applicable to *Unidrive M702*.

Pr value	Pr string	Comments
6	Volt	
7	Therm Short Cct	Temperature measurement input with short circuit detection
8	Thermistor	Temperature measurement without short circuit detection
9	Therm No Trip	Temperature measurement input with no trips

00.022 {01.010}	**Bipolar Reference Enable**								
RW		Bit							US
OL	⇳	OFF (0) or On (1)	⇨	OFF (0)					
RFC-A									
RFC-S									

Pr **00.022** determines whether the reference is uni-polar or bi-polar as follows:

Pr 00.022	Function	
0	Unipolar speed/frequency reference	
1	Bipolar speed/frequency reference	

00.023 {01.005}	**Jog Reference**								
RW		Num							US
OL	⇳	0.0 to 400.0 Hz	⇨	0.0					
RFC-A	⇳	0.0 to 4000.0 rpm	⇨	0.0					
RFC-S									

Enter the required value of jog frequency/speed.

The frequency/speed limits affect the drive when jogging as follows:

Frequency-limit parameter	Limit applies
Pr **00.001** Minimum reference clamp	No
Pr **00.002** Maximum reference clamp	Yes

00.024 {01.021}	**Preset Reference 1**								
RW		Num							US
OL	⇳	VM_SPEED_FREQ_REF	⇨	0.0					
RFC-A									
RFC-S									

00.025 {01.022}	**Preset Reference 2**								
RW		Num							US
OL	⇳	VM_SPEED_FREQ_REF	⇨	0.0					
RFC-A									
RFC-S									

00.026 {01.023}	**Preset Reference 3 (OL)**								
00.026 {03.008}	**Overspeed Threshold (RFC)**								
RW		Num							US
OL	⇳	VM_SPEED_FREQ_REF Hz	⇨	0.0					
RFC-A	⇳	0 to 40000 rpm							
RFC-S									

Open-loop

If the preset reference has been selected (see Pr **00.005**), the speed at which the motor runs is determined by these parameters.

RFC-A / RFC-S

If the speed feedback (Pr **00.010**) exceeds this level in either direction, an overspeed trip is produced. If this parameter is set to zero, the overspeed threshold is automatically set to 120 % x SPEED_FREQ_MAX.

00.027 {01.024}	**Preset Reference 4 (OL)**								
00.027 {03.034}	**P1 Rotary Lines Per Revolution (RFC)**								
RW		Num							US
OL	⇳	VM_SPEED_FREQ_REF Hz	⇨	0.0					
RFC-A	⇳	1 to 100000	⇨	1024					
RFC-S				4096					

Open-loop

Refer to Pr **00.024** to Pr **00.026**.

RFC-A / RFC-S

Enter in Pr **00.027** the number of lines per revolution of the drive encoder.

00.028 {06.013}	**Enable Auxiliary Key**								
RW		Txt							US
OL	⇳	Disabled (0), Forward/Reverse (1), Run Reverse (2)	⇨	Disabled (0)					
RFC-A									
RFC-S									

When a keypad is installed, this parameter enables the forward/reverse key.

00.029 {11.036}	NV Media Card File Previously Loaded									
RO	Num					NC	PT			
OL	⇳	0 to 999			⇨					
RFC-A										
RFC-S										

This parameter shows the number of the data block last transferred from a NV Media Card to the drive.

00.030 {11.42}	Parameter Cloning								
RW	Txt					NC		US*	
OL	⇳	None (0), Read (1), Program (2), Auto (3), Boot (4)			⇨	None (0)			
RFC-A									
RFC-S									

* Only a value of 3 or 4 in this parameter is saved.

NOTE

If Pr **00.030** is equal to 1 or 2 this value is not transferred to the EEPROM or the drive. If Pr **00.030** is set to a 3 or 4 the value is transferred.

Pr String	Pr value	Comment
None	0	Inactive
Read	1	Read parameter set from the NV Media Card
Program	2	Programming a parameter set to the NV Media Card
Auto	3	Auto save
Boot	4	Boot mode

For further information, please refer to Chapter 10 *NV Media Card Operation* on page 139.

00.031 {11.033}	Drive Rated Voltage									
RO	Txt					ND	NC	PT		
OL	⇳	200 V (0), 400 V (1), 575 V (2), 690 V (3)			⇨					
RFC-A										
RFC-S										

Pr **00.031** indicates the voltage rating of the drive.

00.032 {11.032}	Maximum Heavy Duty Rating									
RO	Num					ND	NC	PT		
OL	⇳	0.000 to 99999.999 A			⇨					
RFC-A										
RFC-S										

Pr **00.032** indicates the maximum continuous Heavy Duty current rating.

00.033 {06.009}	Catch A Spinning Motor (OL)									
00.033 {05.016}	Rated Speed Optimisation Select (RFC-A)									
RW	Txt							US		
OL	⇳	Disable (0), Enable (1), Fwd Only (2), Rev Only (3)			⇨	Disable (0)				
RFC-A	⇳	Disabled (0), Classic Slow (1), Classic Fast (2), Combined (3), VARs Only (4), Voltage Only (5)			⇨	Disabled (0)				

Open-loop

When the drive is enabled with Pr **00.033** = 0, the output frequency starts at zero and ramps to the required reference. When the drive is enabled when Pr **00.033** has a non-zero value, the drive performs a start-up test to determine the motor speed and then sets the initial output frequency to the synchronous frequency of the motor. Restrictions may be placed on the frequencies detected by the drive as follows:

Pr 00.033	Pr string	Function
0	Disable	Disabled
1	Enable	Detect all frequencies
2	Fwd only	Detect positive frequencies only
3	Rev only	Detect negative frequencies only

RFC-A

The *Rated Frequency* (00.047) and *Rated Speed* (00.045) are used to define the rated slip of the motor. The rated slip is used in sensorless mode (*Sensorless Mode Active* (03.078) = 1) to correct the motor speed with load. When this mode is active *Rated Speed Optimisation Select* (00.033) has no effect.

If sensorless mode is not active (*Sensorless Mode Active* (03.078) = 0) the rated slip is used in the motor control algorithm and an incorrect value of slip can have a significant effect on the motor performance. If *Rated Speed Optimisation Select* (00.033) = 0 then the adaptive control system is disabled. However, if *Rated Speed Optimisation Select* (00.033) is set to a non-zero value the drive can automatically adjust the *Rated Speed* (00.045) to give the correct value of rated slip. R*ated Speed* (00.045) is not saved at power-down, and so when the drive is powered-down and up again it will return to the last value saved by the user. The rate of convergence and the accuracy of the adaptive controller reduces at low output frequency and low load. The minimum frequency is defined as a percentage of *Rated Frequency* (00.047) by *Rated Speed Optimisation Minimum Frequency* (05.019). The minimum load is defined as a percentage of rated load by *Rated Speed Optimisation Minimum Load* (05.020). The adaptive controller is enabled when a motoring or regenerative load rises above *Rated Speed Optimisation Minimum Load* (05.020) + 5 %, and is disabled again when it falls below *Rated Speed Optimisation Minimum Load* (05.020). For best optimisation results the correct values of *Stator Resistance* (05.017), *Transient Inductance* (05.024), *Stator Inductance* (05.025), *Saturation Breakpoint 1* (05.029), *Saturation Breakpoint 2* (05.062), *Saturation Breakpoint 3* (05.030) and *Saturation Breakpoint 4* (05.063) should be used.

00.034 {11.030}	User security code									
RW	Num					ND	NC	PT	US	
OL	⇳	0 to 2^{31}-1			⇨	0				
RFC-A										
RFC-S										

If any number other than 0 is programmed into this parameter, user security is applied so that no parameters except Pr **00.049** can be adjusted with the keypad. When this parameter is read via a keypad it appears as zero. For further details refer to section 5.9.3 *User Security Code* on page 46.

00.035 {11.024}	**Serial Mode***									
RW	Txt							US		
OL	⇳	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)						
RFC-A										
RFC-S										

* Only applicable to *Unidrive M701*.

This parameter defines the communications protocol used by the EIA485 comms port on the drive. This parameter can be changed via the drive keypad, via a Solutions Module or via the comms interface itself. If it is changed via the comms interface, the response to the command uses the original protocol. The master should wait at least 20 ms before send a new message using the new protocol. (Note: ANSI uses 7 data bits, 1 stop bit and even parity; Modbus RTU uses 8 data bits, 2 stops bits and no parity).

Pr Value	Pr String
0	8 2 NP
1	8 1 NP
2	8 1 EP
3	8 1 OP
4	8 2 NP M
5	8 1 NP M
6	8 1 EP M
7	8 1 OP M
8	7 2 NP
9	7 1 NP
10	7 1 EP
11	7 1 OP
12	7 2 NP M
13	7 1 NP M
14	7 1 EP M
15	7 1 OP M

The core drive always uses the Modbus rtu protocol and is always a slave. *Serial Mode* (00.035) defines the data format used by the serial comms interface. The bits in the value of *Serial Mode* (00.035) define the data format as follows. Bit 3 is always 0 in the core product as 8 data bits are required for Modbus rtu. The parameter value can be extended in derivative products which provide alternative communications protocols if required.

Bits	3	2	1 and 0
Format	Number of data bits 0 = 8 bits 1 = 7 bits	Register mode 0 = Standard 1 = Modified	Stop bits and Parity 0 = 2 stop bits, no parity 1 = 1 stop bit, no parity 2 = 1 stop bit, even parity 3 = 1 stop bit, odd parity

Bit 2 selects either standard or modified register mode. The menu and parameter numbers are derived for each mode as given in the following table. Standard mode is compatible with Unidrive SP. Modified mode is provided to allow register numbers up to 255 to be addressed. If any menus with numbers above 63 should contain more than 99 parameters, then these parameters cannot be accessed via Modbus rtu.

Register mode	Register address
Standard	(mm x 100) + ppp - 1 where mm ≤ 162 and ppp ≤ 99
Modified	(mm x 256) + ppp - 1 where mm ≤ 63 and ppp ≤ 255

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

00.036 {11.025}	**Serial Baud Rate***									
RW	Txt							US		
OL	⇳	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 115200 (10)	⇨	19200 (6)						
RFC-A										
RFC-S										

* Only applicable to *Unidrive M701*.

This parameter can be changed via the drive keypad, via a Solutions Module or via the comms interface itself. If it is changed via the comms interface, the response to the command uses the original baud rate. The master should wait at least 20 ms before send a new message using the new baud rate.

00.037 {11.023}	**Serial Address***									
RW	Num							US		
OL	⇳	1 to 247	⇨	1						
RFC-A										
RFC-S										

* Only applicable to *Unidrive M701*.

Used to define the unique address for the drive for the serial interface. The drive is always a slave address 0 is used to globally address all slaves, and so this address should not be set in this parameter

00.037 {24.010}	**Active IP Address***									
RO	IP						NC	PT		
OL	⇳	0.0.0.0 to 255.255.255.255	⇨							
RFC-A										
RFC-S										

* Only applicable to *Unidrive M700* and *Unidrive M702*.

00.038 {04.013}	**Current Controller Kp Gain**									
RW	Num							US		
OL	⇳	0 to 30000	⇨	20						
RFC-A				150						
RFC-S										

00.039 {04.014}	**Current Controller Ki Gain**									
RW	Num							US		
OL	⇳	0 to 30000	⇨	40						
RFC-A										
RFC-S	⇳		⇨	2000						

These parameters control the proportional and integral gains of the current controller used in the open loop drive. The current controller either provides current limits or closed loop torque control by modifying the drive output frequency. The control loop is also used in its torque mode during line power supply loss, or when the controlled mode standard ramp is active and the drive is decelerating, to regulate the flow of current into the drive.

00.040 {05.012}		**Auto-tune**								
RW		Num					NC			
OL	⇳	0 to 2			⇨	0				
RFC-A	⇳	0 to 5			⇨					
RFC-S	⇳	0 to 6			⇨					

Open-Loop

There are two autotune tests available in open loop mode, a stationary and a rotating test. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive.

- 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* (05.017), *Transient Inductance* (05.024), *Maximum Deadtime Compensation* (05.059) and *Current At Maximum Deadtime Compensation* (05.060) 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 **00.043**. To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 and 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).
- 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* (00.043). To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).

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 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702*, 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).

RFC-A

There are four autotune tests available in RFC-A mode, a stationary test, a rotating test, two mechanical load measurement tests. 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. A mechanical load measurement test should be performed separately to a stationary or rotating autotune.

NOTE

It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2).

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** 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 **00.043**. To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).
- 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 which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (00.047) 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), and the motor saturation breakpoints (Pr **05.029**, Pr **05.030**, Pr **06.062** and Pr **05.063**) are modified by the drive. The *Motor Rated Power Factor* (00.043) is also modified by the *Stator Inductance* (05.025). The No-Load motor core losses are measured and written to *No-Load Core Loss* (04.045). To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 and 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).

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 31 on *Unidrive M700 / M701* and terminal 11 and 13 on *Unidrive M702*, setting the *Drive Enable* (06.015) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**).

RFC-S

There are five autotune tests available in RFC-S mode, a stationary autotune, a rotating autotune, two mechanical load measurement tests and a locked rotor test to measure load dependent parameters.

- *Stationary Autotune*

The stationary autotune can be used when the motor is loaded and it is not possible uncouple the load from motor shaft. This test can be used to measure all the necessary parameters for basic control. During the stationary autotune, a test is performed to locate the flux axis of the motor. However this test may not be able to calculate such an accurate value for the *Position Feedback Phase Angle* (00.043) as compared to rotating autotune. A stationary test is performed to measure *Stator Resistance* (05.017), *Ld* (05.024), *Maximum Deadtime Compensation* (05.059), *Current At Maximum Deadtime Compensation* (05.060), *No Load Lq* (05.072). If *Enable Stator Compensation* (05.049) = 1 then *Stator Base Temperature* (05.048) is made equal to *Stator Temperature* (05.046). The *Stator Resistance* (05.017) and the *Ld* (05.024) are then used to set up *Current controller Kp Gain* (00.038) and *Current Controller Ki Gain* (00.039). If sensorless mode is not selected then *Position Feedback Phase Angle* (00.043) is set up for the position from the position feedback interface selected with *Motor Control Feedback Select* (03.026). To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).

- *Rotating Autotune*

The rotating autotune must be performed on unloaded motor. This test can be used to measure all the necessary parameters for the basic control and parameters for cancelling the effects of the cogging torque.

During the rotating autotune, *Rated Current* (00.046) is applied and the motor is rotated by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the required direction. If sensorless mode is not selected then the *Position Feedback Phase Angle* (00.043) is set-up for the position from the position feedback interface selected with *Motor Control Feedback Select* (03.026). A stationary test is then performed to measure *Stator Resistance* (05.017), *Ld* (05.024), *Maximum Deadtime Compensation* (05.059), *Current At Maximum Deadtime Compensation* (05.060) and *No Load Lq* (05.072). *Stator Resistance* (05.017) and *Ld*

(05.024) are used to set up *Current Controller Kp Gain* (00.038) and *Current Controller Ki Gain* (00.039). This is only done once during the test, and so the user can make further adjustments to the current controller gains if required. To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on *Unidrive M700 / M701* and terminal 11 and 13 on *Unidrive M702*) and a run signal (terminal 26 or 27 on *Unidrive M700 / M701* and terminal 7 or 8 on *Unidrive M702*).

00.041 {05.018}	**Maximum Switching Frequency**									
RW		Txt				RA	NC			
OL	⇳	2 kHz (0), 3 kHz (1), 4 kHz (2), 6 kHz (3), 8 kHz (4), 12 kHz (5), 16 kHz (6)				⇨	3 kHz (1)			
RFC-A										
RFC-S						⇨	6 kHz (3)			

This parameter defines the required switching frequency. The drive may automatically reduce the actual switching frequency (without changing this parameter) if the power stage becomes too hot. A thermal model of the IGBT junction temperature is used based on the heatsink temperature and an instantaneous temperature drop using the drive output current and switching frequency. The estimated IGBT junction temperature is displayed in Pr **07.034**. If the temperature exceeds 135 °C the switching frequency is reduced if this is possible (i.e >3 kHz). Reducing the switching frequency reduces the drive losses and the junction temperature displayed in Pr **07.034** also reduces. If the load condition persists the junction temperature may continue to rise again above 145 °C and the drive cannot reduce the switching frequency further the drive will initiate an 'OHt Inverter' trip. Every second the drive will attempt to restore the switching frequency to the level set in Pr **00.041**.

The full range of switching frequencies is not available on all ratings of Unidrive M. See section 8.5 *Switching frequency* on page 109, for the maximum available switching frequency for each drive rating.

6.4.7 Motor parameters

00.042 {05.011}	**Number Of Motor Poles**									
RW		Num							US	
OL	⇳	Automatic (0) to 480 Poles (240)				⇨	Automatic (0)			
RFC-A										
RFC-S						⇨	6 Poles (3)			

Open-loop

This parameter is used in the calculation of motor speed, and in applying the correct slip compensation. When Automatic (0) is selected, the number of motor poles is automatically calculated from the *Rated Frequency* (00.047) and the *Rated Speed* rpm (00.045). The number of poles = 120 * rated frequency / rpm rounded to the nearest even number.

RFC-A

This parameter must be set correctly for the vector control algorithms to operate correctly. When Automatic (0) is selected, the number of motor poles is automatically calculated from the *Rated Frequency* (00.047) and the *Rated Speed* (00.045) rpm. The number of poles = 120 * rated frequency / rpm rounded to the nearest even number.

RFC-S

This parameter must be set correctly for the vector control algorithms to operate correctly. When Automatic (0) is selected the number of poles is set to 6.

00.043 {05.010}	**Rated Power Factor (OL)**									
00.043 {03.025}	**Position Feedback Phase Angle (RFC)**									
RW		Num							US	
OL	⇳	0.000 to 1.000				⇨	0.850			
RFC-A	⇳	0.000 to 1.000				⇨	0.850			
RFC-S	⇳	0.0 to 359.9 °				⇨	0.0 °			

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current.

Open-loop

The power factor is used in conjunction with the motor rated current (Pr **00.046**) to calculate the rated active current and magnetizing current of the motor. The rated active current is used extensively to control the drive, and the magnetizing current is used in vector mode Rs compensation. It is important that this parameter is set up correctly.

This parameter is obtained by the drive during a rotational autotune. If a stationary autotune is carried out, then the nameplate value should be entered in Pr **00.043**.

RFC-A

If the stator inductance (Pr **05.025**) contains a non-zero value, the power factor used by the drive is continuously calculated and used in the vector control algorithms (this will not update Pr **00.043**).

If the stator inductance is set to zero (Pr **05.025**) then the power factor written in Pr **00.043** is used in conjunction with the motor rated current and other motor parameters to calculate the rated active and magnetizing currents which are used in the vector control algorithm.

This parameter is obtained by the drive during a rotational autotune. If a stationary autotune is carried out, then the nameplate value should be entered in Pr **00.043**.

RFC-S

The phase angle between the rotor flux in a servo motor and the encoder position is required for the motor to operate correctly. If the phase angle is known it can be set in this parameter by the user. Alternatively the drive can automatically measure the phase angle by performing a phasing test (see autotune in RFC-S mode Pr **00.040**). When the test is complete the new value is written to this parameter. The encoder phase angle can be modified at any time and becomes effective immediately. This parameter has a factory default value of 0.0 °, but is not affected when defaults are loaded by the user.

00.044 {05.009}	**Rated Voltage**									
RW		Num				RA			US	
OL	⇳	0 to VM_AC_VOLTAGE_SET				⇨	200 V drive: 230 V 50Hz default 400 V drive: 400 V 60Hz default 400 V drive: 460 V 575 V drive: 575 V 690 V drive: 690 V			
RFC-A										
RFC-S										

Enter the value from the rating plate of the motor.

00.045 {05.008}	**Rated Speed**									
RW		Num							US	
OL	⇳	0 to 35940 rpm				⇨	50 Hz default: 1500 rpm 60 Hz default: 1800 rpm			
RFC-A	⇳	0.00 to 33000.00 rpm				⇨	50 Hz default: 1450.00 rpm 60 Hz default: 1750.00 rpm			
RFC-S	⇳					⇨	3000.00 rpm			

Open-loop

This is the speed at which the motor would rotate when supplied with its base frequency at rated voltage, under rated load conditions (= synchronous speed - slip speed). Entering the correct value into this parameter allows the drive to increase the output frequency as a

function of load in order to compensate for this speed drop.

Slip compensation is disabled if Pr **00.045** is set to 0 or to synchronous speed, or if Pr **05.027** is set to 0.

If slip compensation is required this parameter should be set to the value from the rating plate of the motor, which should give the correct rpm for a hot machine. Sometimes it will be necessary to adjust this when the drive is commissioned because the nameplate value may be inaccurate. Slip compensation will operate correctly both below base speed and within the field weakening region. Slip compensation is normally used to correct for the motor speed to prevent speed variation with load. The rated load rpm can be set higher than synchronous speed to deliberately introduce speed droop. This can be useful to aid load sharing with mechanically coupled motors.

RFC-A

Rated speed is used with motor rated frequency to determine the full load slip of the motor which is used by the vector control algorithm. Incorrect setting of this parameter can result in the following:

- Reduced efficiency of motor operation
- Reduction of maximum torque available from the motor
- Failure to reach maximum speed
- Over-current trips
- Reduced transient performance
- Inaccurate control of absolute torque in torque control modes

The nameplate value is normally the value for a hot machine, however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate.
The rated speed rpm can be optimized by the drive (For further information, refer to section 8.1.2 *RFC-A mode* on page 98).

RFC-S

Rated Speed (00.045) is used as follows:

1. Operation without position feedback, i.e. Sensorless Mode Active (03.078) = 1.
2. Where the motor operates above this speed and flux weakening is active.
3. In the motor thermal model.

The units for *Rated Speed* (00.045) are always rpm even if a linear motor is used and *Linear Speed Select* (01.055) = 1.

00.046 {05.007}	Rated Current									
RW	Num				RA			US		
OL / RFC-A / RFC-S	⇳	0.000 to VM_RATED_CURRENT			⇨	Maximum Heavy Duty Rating (00.032)				

Enter the name-plate value for the motor rated current.

00.047 {05.006}	Rated Frequency									
RW	Num							US		
OL	⇳	0.0 to 599.0 Hz				⇨	50 Hz default: 50.0 Hz 60 Hz default: 60.0 Hz			
RFC-A	⇳	0.0 to 550.0 Hz				⇨				
RFC-S	⇳					⇨				

Open-loop and RFC-A

Enter the value from the rating plate of the motor.

6.4.8 Operating-mode selection

00.048 {11.031}	User Drive Mode									
RW	Txt					ND	NC	PT		
OL	⇳	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)				⇨	Open-loop (1)			
RFC-A						⇨	RFC-A (2)			
RFC-S						⇨	RFC-S (3)			
Regen						⇨	Regen (4)			

The settings for Pr **00.048** are as follows:

Setting	Operating mode
1	Open-loop
2	RFC-A
3	RFC-S
4	Regen

This parameter defines the drive operating mode. Pr **mm.000** must be set to '1253' (European defaults) or '1254' (USA defaults) before this parameter can be changed. When the drive is reset to implement any change in this parameter, the default settings of all parameters will be set according to the drive operating mode selected and saved in memory.

6.4.9 Status information

00.049 {11.044}	User Security Status									
RW	Txt						ND	PT		
OL / RFC-A / RFC-S	⇳	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)			⇨	Menu 0 (0)				

This parameter controls access via the drive keypad as follows:

Security level	Description
0 (Menu 0)	All writable parameters are available to be edited but only parameters in Menu 0 are visible.
1 (All Menus)	All writable parameters are visible and available to be edited.
2 (Read-only Menu 0)	All parameters are read-only. Access is limited to Menu 0 parameters only.
3 (Read-only)	All parameters are read-only however all menus and parameters are visible.
4 (Status Only)	The keypad remains in status mode and no parameters can be viewed or edited.
5 (No Access)	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.

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

00.050 {11.029}	Software Version									
RO	Num					ND	NC	PT		
OL / RFC-A / RFC-S	⇳	0 to 99999999			⇨					

The parameter displays the software version of the drive.

00.051 {10.037}	**Action On Trip Detection**								
RW	Bin							US	
OL	⇳	0 to 31			⇨	0			
RFC-A									
RFC-S									

Each bit in this parameter has the following functions:

Bit	Function
0	Stop on non-important trips
1	Disable braking resistor overload detection
2	Disable phase loss stop
3	Disable braking resistor temperature monitoring
4	Disable parameter freeze on trip

Example
Pr **00.051** =8 (1000_{binary}) Th Brake Res trip is disabled

Pr **00.051** =12 (1100_{binary}) Th Brake Res and phase loss trip is disabled

Stop on non-important trips
If bit 0 is set to one the drive will attempt to stop before tripping if any of the following trip conditions are detected: I/O Overload, An Input 1 Loss, An Input 2 Loss or Keypad Mode.

Disable braking resistor overload detection
For details of braking resistor overload detection mode see Pr **10.030**.

Disable phase loss trip
Normally the drive will stop when the input phase loss condition is detected. If this bit is set to 1 the drive will continue to run and will only trip when the drive is brought to a stop by the user.

Disable braking resistor temperature monitoring
Size 3, 4 and 5 drives have an internal user install braking resistor with a thermistor to detect overheating of the resistor. As default bit 3 of Pr **00.051** is set to zero, and so if the braking resistor and its thermistor is not installed the drive will produce a trip (Th Brake Res) because the thermistor appears to be open-circuit. This trip can be disabled so that the drive can run by setting bit 3 of Pr **00.051** to one. If the resistor is installed then no trip is produced unless the thermistor fails, and so bit 3 of Pr **00.051** can be left at zero. This feature only applies to size 3, 4 and 5 drives. For example if Pr **00.051** = 8, then Th Brake Res trip will be disabled.

Disable parameter freeze on trip
If this bit is 0 then the parameters listed below are frozen on trip until the trip is cleared. If this bit is 1 then this feature is disabled.

Open-loop mode	RFC-A and RFC-S modes
Reference Selected (01.001)	*Reference Selected* (01.001)
Pre-skip Filter Reference (01.002)	*Pre-skip Filter Reference* (01.002)
Pre-ramp Reference (01.003)	*Pre-ramp Reference* (01.003)
Post Ramp Reference (02.001)	*Post Ramp Reference* (02.001)
Frequency Slaving Demand (03.001)	*Final Speed Reference* (03.001)
	Speed Feedback (00.010)
	Speed Error (03.003)
	Speed Controller Output (03.004)
Current Magnitude (00.012)	*Current Magnitude* (00.012)
Torque Producing Current (00.013)	*Torque Producing Current* (00.013)
Magnetising Current (04.017)	*Magnetising Current* (04.017)
Output Frequency (00.011)	*Output Frequency* (00.011)
Output Voltage (05.002)	*Output Voltage* (05.002)
Output Power (05.003)	*Output Power* (05.003)
D.c. Bus Voltage (05.005)	*D.c. Bus Voltage* (05.005)
Analog Input 1 (07.001)*	*Analog Input 1* (07.001)*
Analog Input 2 (07.002)*	*Analog Input 2* (07.002)*
Analog Input 3 (07.003)*	*Analog Input 3* (07.003)*

*Not applicable to *Unidrive M702*

00.052 {11.020}	**Reset Serial Communications***								
RW	Bit				ND	NC			
OL	⇳	Off (0) or On (1)			⇨	Off (0)			
RFC-A									
RFC-S									

* Only applicable to *Unidrive M701*.

When *Serial Address* (00.037), *Serial Mode* (00.035), *Serial Baud Rate* (00.036), *Minimum Comms Transmit Delay* (11.026) or *Silent Period* (11.027) are modified the changes do not have an immediate effect on the serial communications system. The new values are used after the next power-up or if *Reset Serial Communications* (00.052) is set to one. *Reset Serial Communications* (00.052) is automatically cleared to zero after the communications system is updated.

00.053 {04.015}	**Motor Thermal Time Constant**								
RW	Num							US	
OL	⇳	1.0 to 3000.0 s			⇨	89.0 s			
RFC-A									
RFC-S									

Pr **00.053** is the motor thermal time constant of the motor, and is used (along with the motor rated current Pr **00.046**, and total motor current Pr **00.012**) in the thermal model of the motor in applying thermal protection to the motor.

For further details, refer to section 8.4 *Motor thermal protection* on page 108.

7 Running the motor

This chapter takes the new user through all the essential steps to running a motor for the first time, in each of the possible operating modes.

For information on tuning the drive for the best performance, see *Chapter 8 Optimization* on page 95.

WARNING

Ensure that no damage or safety hazard could arise from the motor starting unexpectedly.

CAUTION

The values of the motor parameters affect the protection of the motor.
The default values in the drive should not be relied upon.
It is essential that the correct value is entered in Pr **00.046** *Rated Current*. This affects the thermal protection of the motor.

CAUTION

If the drive is started using the keypad it will run to the speed defined by the keypad reference (Pr **01.017**). This may not be acceptable depending on the application. The user must check in Pr **01.017** and ensure that the keypad reference has been set to 0.

WARNING

If the intended maximum speed affects the safety of the machinery, additional independent over-speed protection must be used.

7.1 Quick start connections

7.1.1 Basic requirements

This section shows the basic connections which must be made for the drive to run in the required mode. For minimal parameter settings to run in each mode please see the relevant part of section 7.3 *Quick start commissioning / start-up* on page 78.

Table 7-1 Minimum control connection requirements for each control mode

Drive control method	Requirements
Terminal mode	Drive enable Speed / Torque reference Run forward / Run reverse
Keypad mode	Drive enable
Communications link	Drive enable Communications link

Table 7-2 Minimum control connection requirements for each mode of operation

Operating mode	Requirements
Open loop mode	Induction motor
RFC – A mode (with speed feedback)	Induction motor with speed feedback
RFC - S mode (with speed and position feedback)	Permanent magnet motor with speed and position feedback

Speed feedback
Suitable devices are:
- Incremental encoder (A, B or F, D with or without Z)
- Incremental encoder with forward and reverse outputs (F, R with or without Z)
- SINCOS encoder (with, or without Stegmann Hiperface, EnDat or SSI communications protocols)
- EnDat absolute encoder
- Resolver

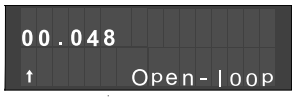
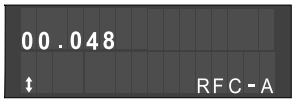
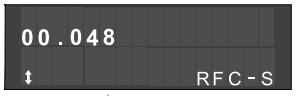
Speed and position feedback
Suitable devices are:
- Incremental encoder (A, B or F, D with or without Z) with commutation signals (U, V, W)
- Incremental encoder with forward and reverse outputs (F, R with or without Z) and commutation outputs (U, V, W)
- SINCOS encoder (with Stegmann Hiperface, EnDat or SSI communications protocols)
- EnDat absolute encoder
- Resolver

7.2 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. *User Security Status* (Pr **00.049**) and *User Security Code* (Pr **00.034**) are not affected by this procedure).

Procedure
Use the following procedure only if a different operating mode is required:

1. Enter either of the following values in Pr **mm.000**, as appropriate:
   1253 (50 Hz AC supply frequency)
   1254 (60 Hz AC supply frequency)
2. Change the setting of Pr **00.048** as follows:

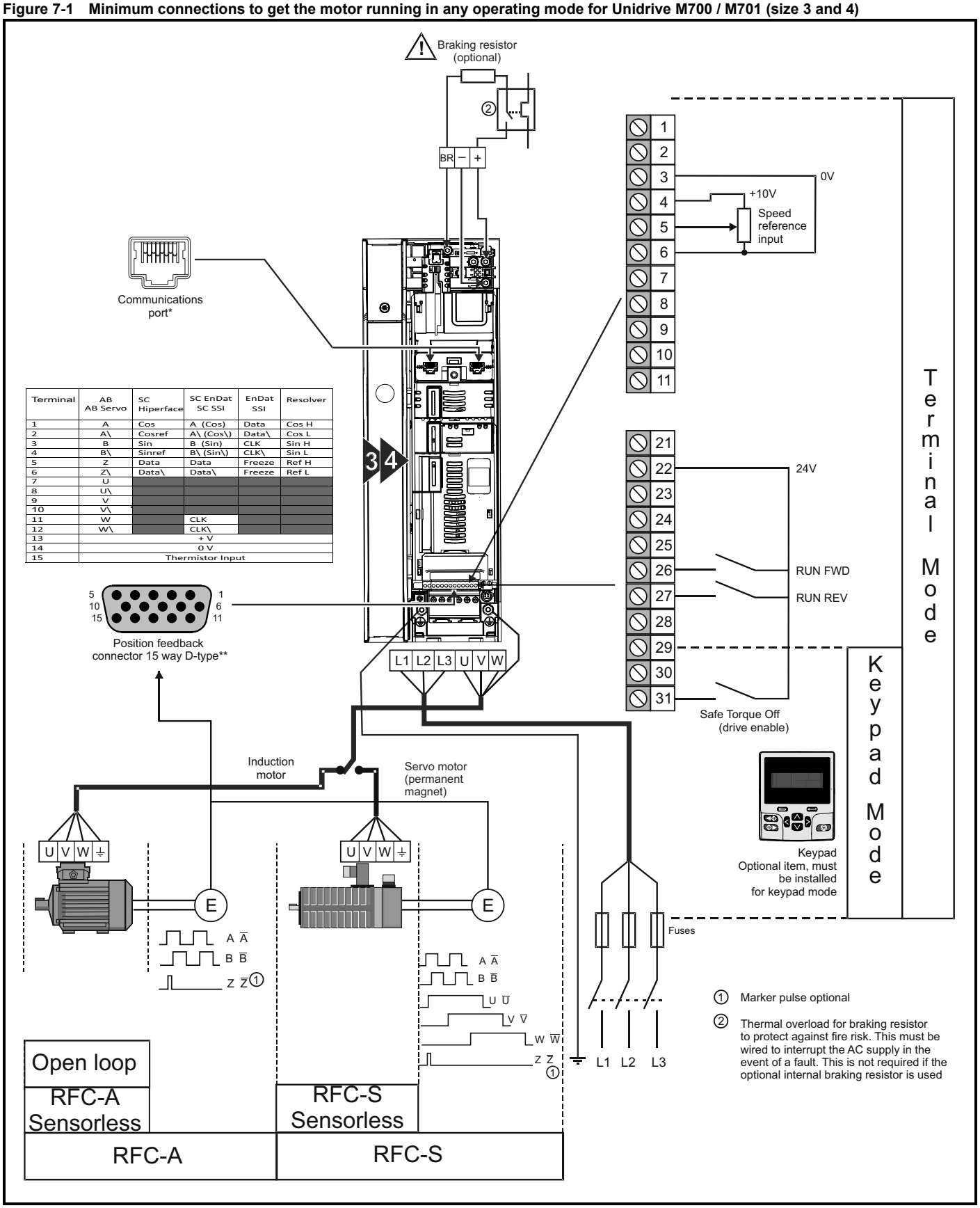
Pr 00.048 setting		Operating mode
	1	Open-loop
	2	RFC-A
	3	RFC-S
	4	Regen

The figures in the second column apply when the communications interface is used.

3. Either:

- Press the red  reset button
- Toggle the reset digital input
- Carry out a drive reset through the communications interface by setting Pr **10.038** to 100 (ensure that Pr. **mm.000** returns to 0).

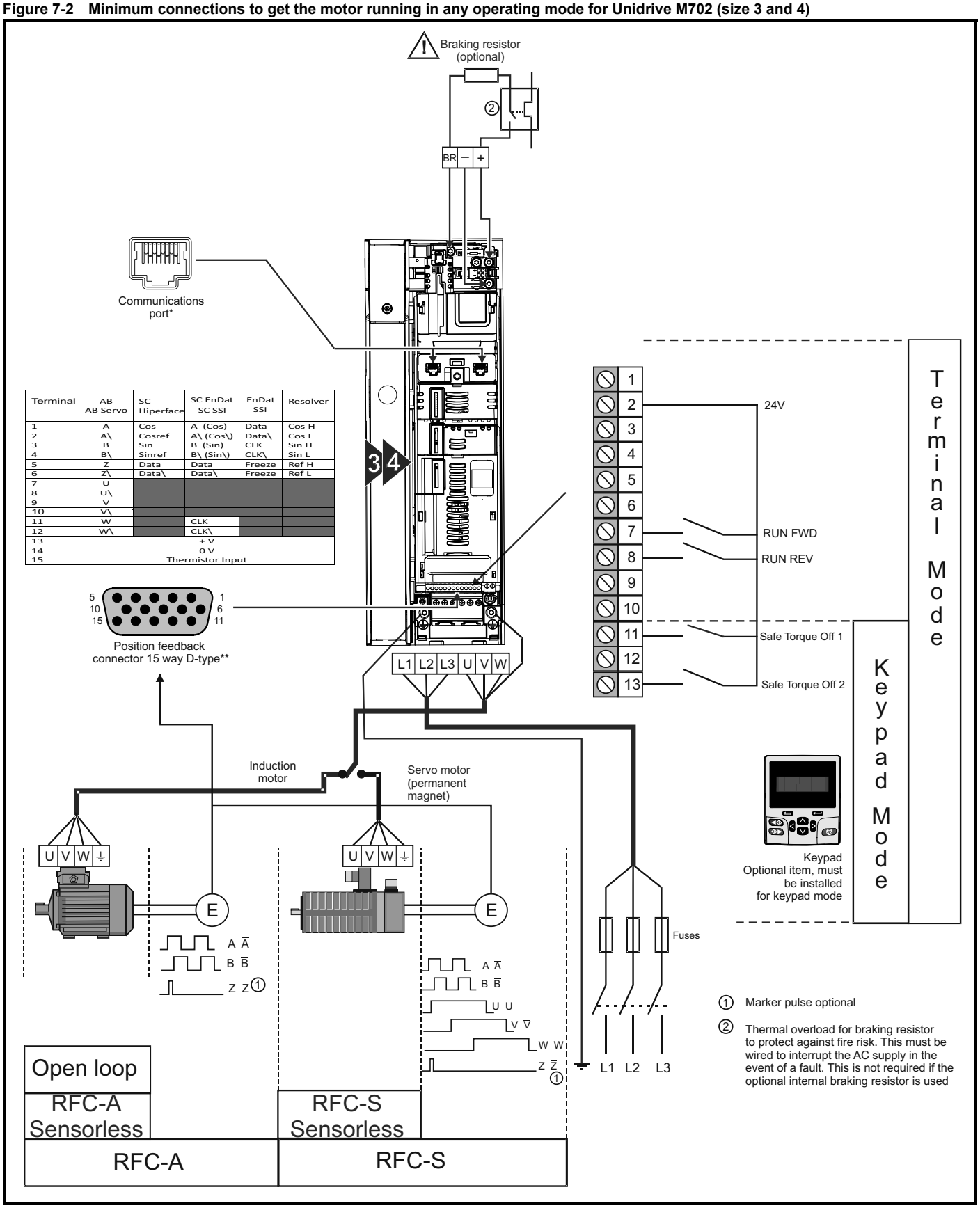
Figure 7-1 Minimum connections to get the motor running in any operating mode for Unidrive M700 / M701 (size 3 and 4)



* Ethernet fieldbus communication ports on *Unidrive M700* and EIA 485 serial communication ports on *Unidrive M701*.

** Position feedback port.

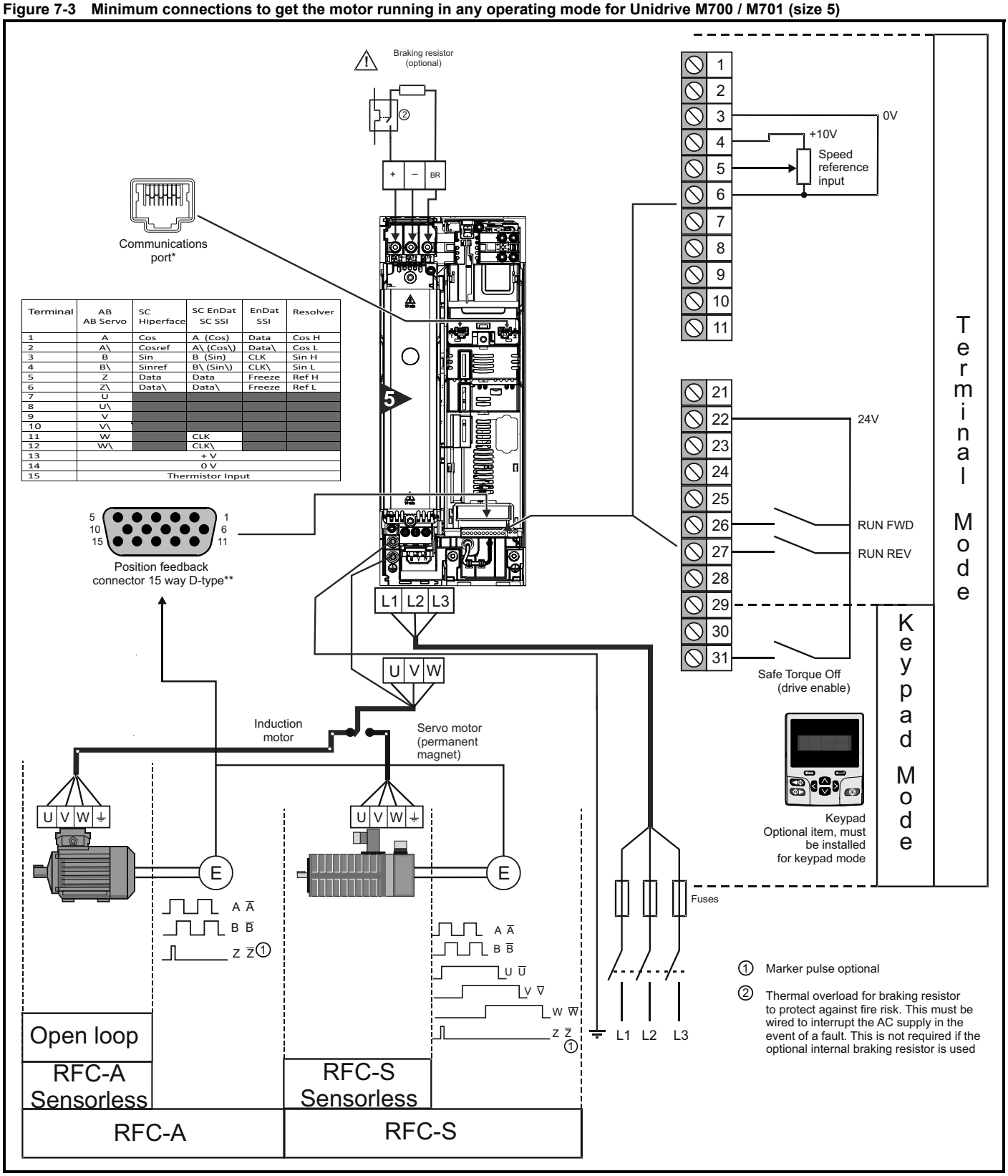
Figure 7-2 Minimum connections to get the motor running in any operating mode for Unidrive M702 (size 3 and 4)



* Ethernet fieldbus communication ports.

** Position feedback port.

Figure 7-3 Minimum connections to get the motor running in any operating mode for Unidrive M700 / M701 (size 5)

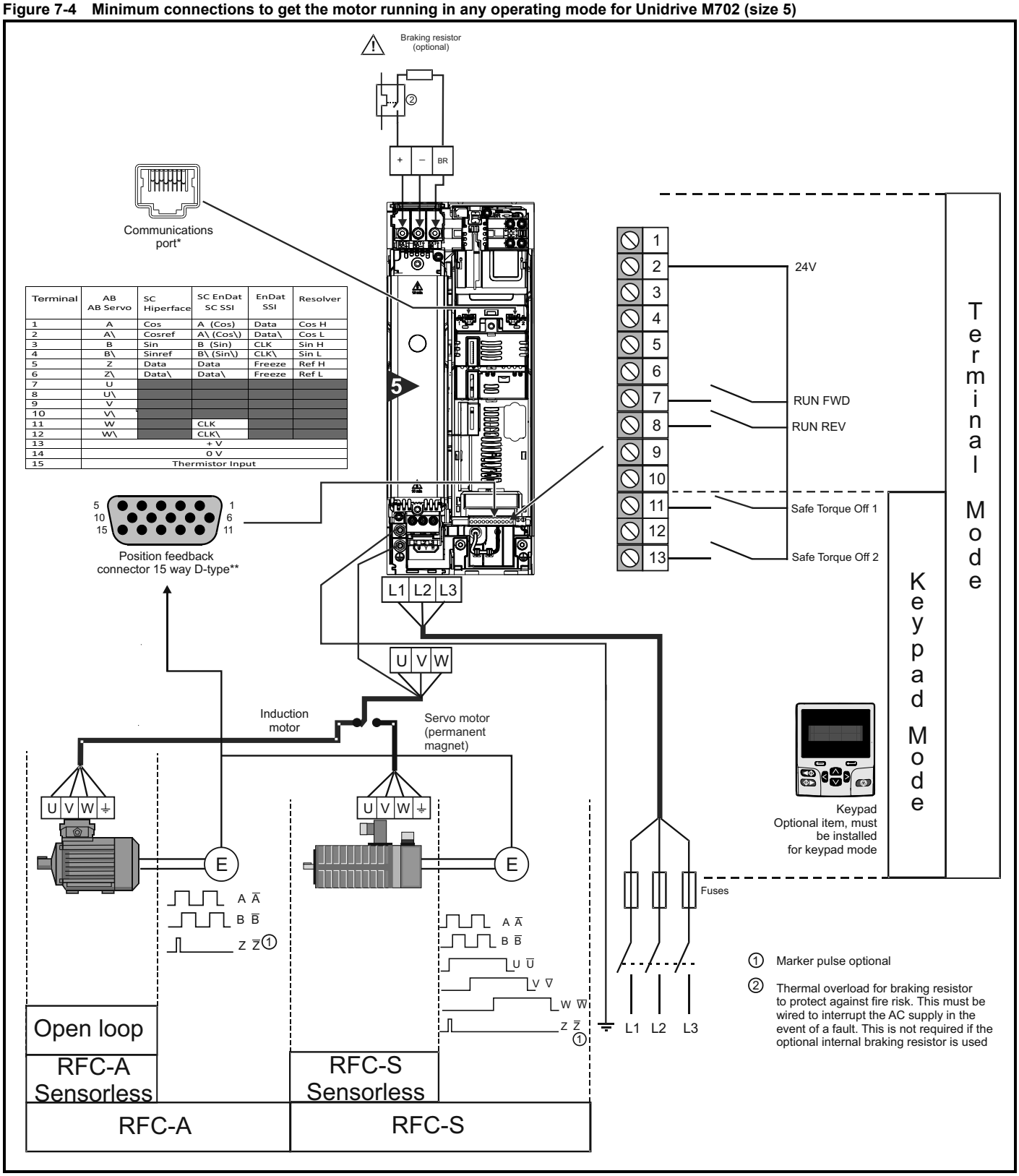


Terminal	AB AB Servo	SC Hiperface	SC EnDat SC SSI	EnDat SSI	Resolver
1	A	Cos	A (Cos)	Data	Cos H
2	A\	Cosref	A\ (Cos\)	Data\	Cos L
3	B	Sin	B (Sin)	CLK	Sin H
4	B\	Sinref	B\ (Sin\)	CLK\	Sin L
5	Z	Data	Data	Freeze	Ref H
6	Z\	Data\	Data\	Freeze	Ref L
7	U				
8	U\				
9	V				
10	V\				
11	W		CLK		
12	W\		CLK\		
13	+ V				
14	0 V				
15	Thermistor Input				

* Ethernet fieldbus communication ports on *Unidrive M700* and EIA 485 serial communication ports on *Unidrive M701*.

** Position feedback port.

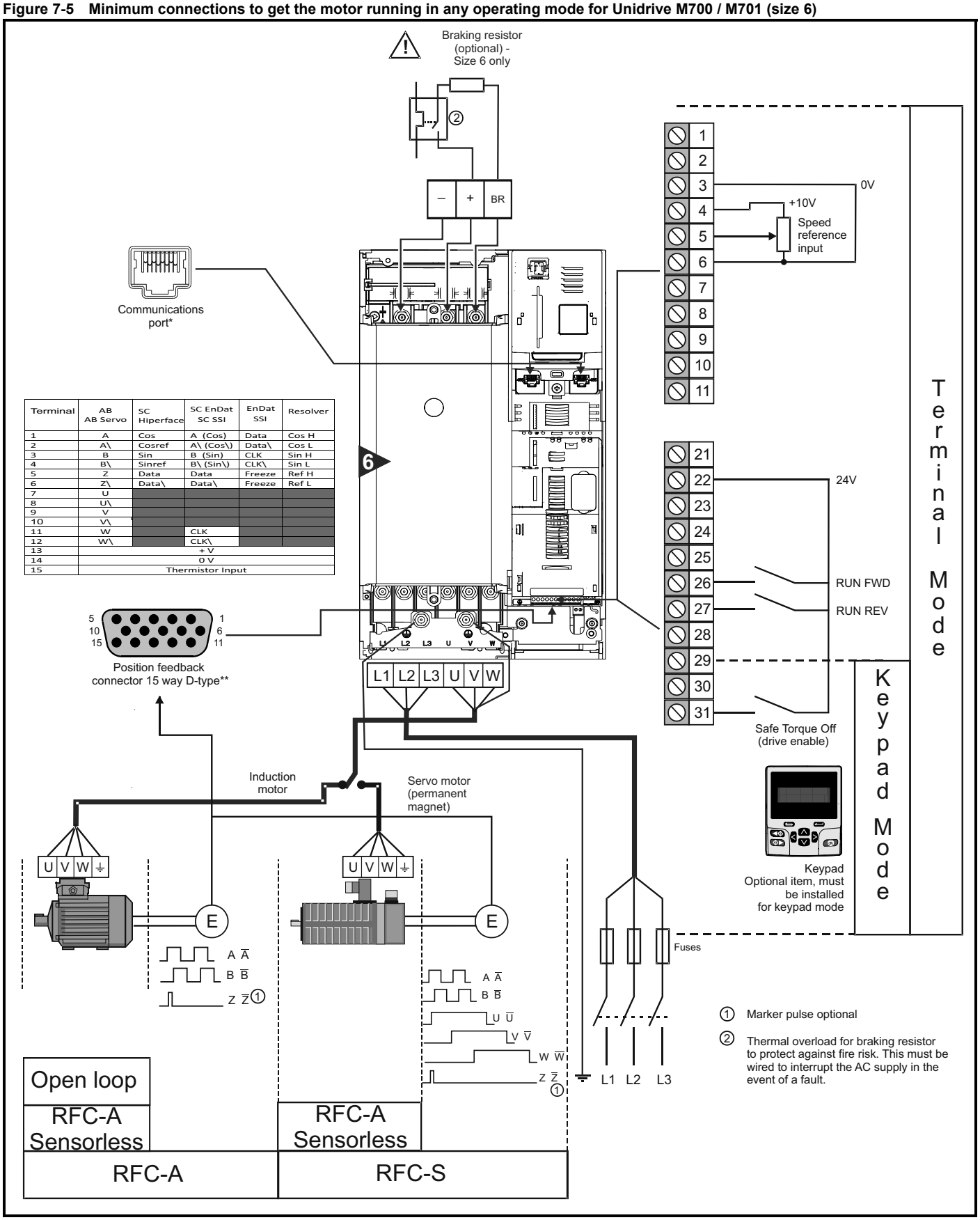
Figure 7-4 Minimum connections to get the motor running in any operating mode for Unidrive M702 (size 5)



* Ethernet fieldbus communication ports.

** Position feedback port.

Figure 7-5 Minimum connections to get the motor running in any operating mode for Unidrive M700 / M701 (size 6)

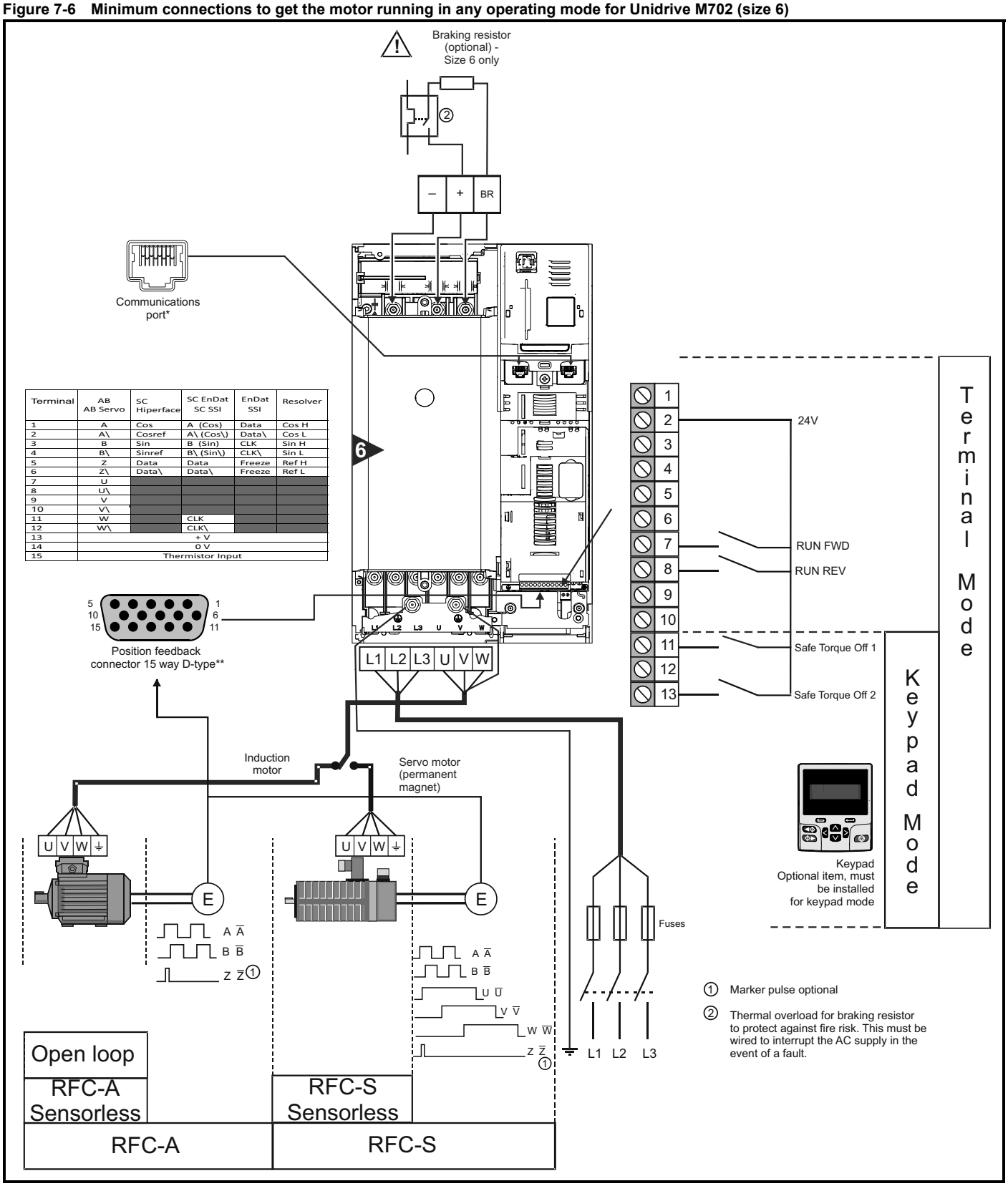


Terminal	AB AB Servo	SC Hiperface	SC EnDat SC SSI	EnDat SSI	Resolver
1	A	Cos	A (Cos)	Data	Cos H
2	A\	Cosref	A\ (Cos\)	Data\	Cos L
3	B	Sin	B (Sin)	CLK	Sin H
4	B\	Sinref	B\ (Sin\)	CLK\	Sin L
5	Z	Data	Data	Freeze	Ref H
6	Z\	Data\	Data\	Freeze	Ref L
7	U				
8	U\				
9	V				
10	V\				
11	W		CLK		
12	W\		CLK\		
13	+ V				
14	0 V				
15	Thermistor Input				

* Ethernet fieldbus communication ports on *Unidrive M700* and EIA 485 serial communication ports on *Unidrive M701*.

** Position feedback port.

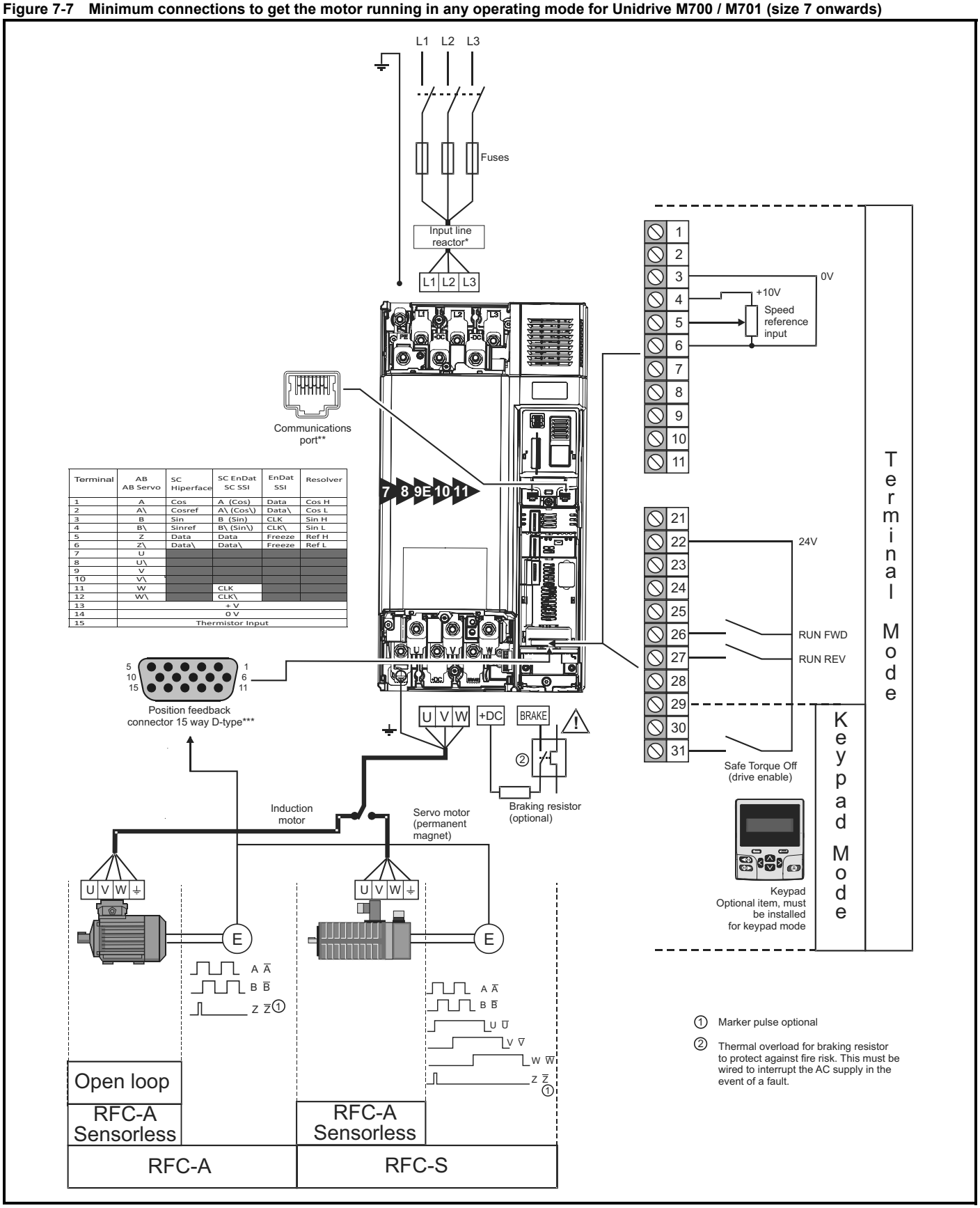
Figure 7-6 Minimum connections to get the motor running in any operating mode for Unidrive M702 (size 6)



* Ethernet fieldbus communication ports.

** Position feedback port.

Figure 7-7 Minimum connections to get the motor running in any operating mode for Unidrive M700 / M701 (size 7 onwards)

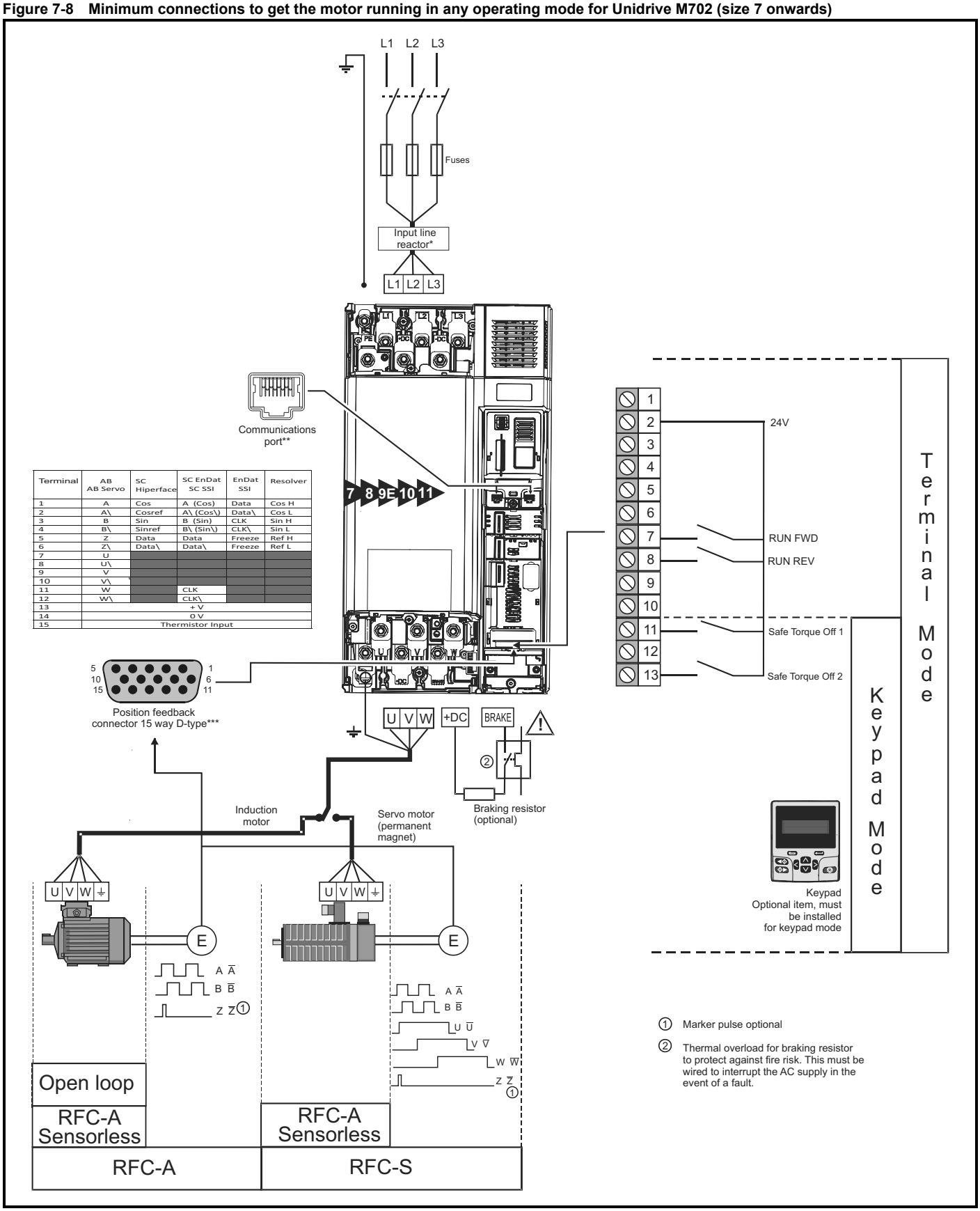


* Required for size 9E, 10 and 11.

** Ethernet fieldbus communication ports on *Unidrive M700* and EIA 485 serial communication ports on *Unidrive M701*.

*** Position feedback port.

Figure 7-8 Minimum connections to get the motor running in any operating mode for Unidrive M702 (size 7 onwards)



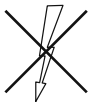
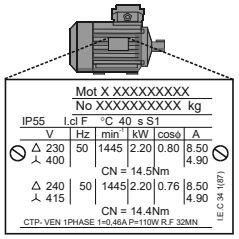
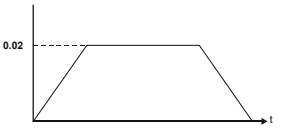
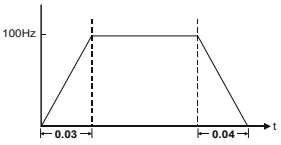
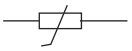
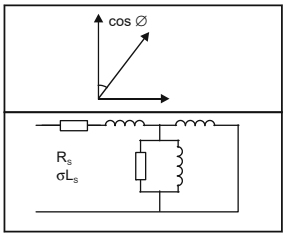
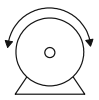
* Required for size 9E, 10 and 11.

** Ethernet fieldbus communication ports.

*** Position feedback port.

7.3 Quick start commissioning / start-up

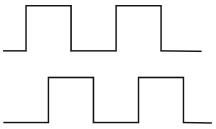
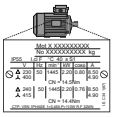
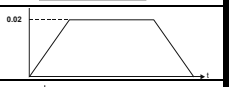
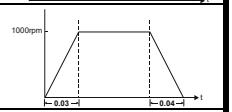
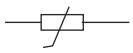
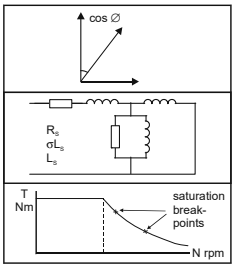
7.3.1 Open loop

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). • Run signal is not given • Motor is connected	
Power-up the drive	Verify that Open Loop mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 45. Ensure: • Drive displays 'Inhibit' If the drive trips, see section 13 *Diagnostics* on page 245.	
Enter motor nameplate details	Enter: • Motor rated frequency in Pr **00.047** (Hz) • Motor rated current in Pr **00.046** (A) • Motor rated speed in Pr **00.045** (rpm) • Motor rated voltage in Pr **00.044** (V) - check if ⅄ or △ connection	
Set maximum frequency	Enter: • Maximum frequency in Pr **00.002** (Hz)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s/100 Hz) • Deceleration rate in Pr **00.004** (s/100 Hz) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030** and Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Motor thermistor set-up	The motor thermistor connection is made through the drive encoder port (terminal 15). The thermistor type is selected in *P1 Thermistor Type* (03.118). On Unidrive M700 / M701, the motor thermistor can be selected in Pr **07.015**. Refer to Pr **07.015** for further information.	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive. **WARNING** A rotating autotune will cause the motor to accelerate up to $^2/_3$ base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. A stationary autotune measures the stator resistance and the transient inductance in the motor. These are required for good performance in vector control modes. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. • A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at $^2/_3$ base speed in the direction selected. The rotating autotune measures the power factor of the motor. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune or set Pr **00.040** = 2 for a rotating autotune • Close the Drive Enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). The drive will display 'Ready'. • Close the run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702). The upper row of the display will flash 'Auto Tune' while the drive is performing the autotune. • Wait for the drive to display 'Ready' or 'Inhibit' and for the motor to come to a standstill. If the drive trips, see Chapter 13 *Diagnostics* on page 245. • Remove the drive enable and run signal from the drive.	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press the red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.3.2 RFC - A mode (with position feedback)

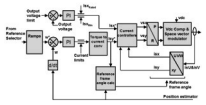
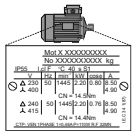
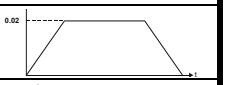
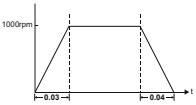
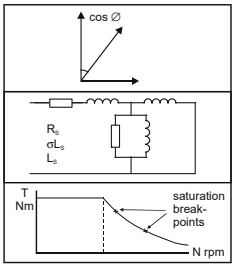
Induction motor with position feedback

For simplicity only an incremental quadrature encoder will be considered here. For information on setting up one of the other supported speed feedback devices, refer to section 7.3.5 *RFC-Sensorless* on page 83.

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). • Run signal is not given • Motor and feedback device are connected	
Power-up the drive	Verify that RFC-A mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 45. Ensure: • Drive displays 'Inhibit' If the drive trips, see Chapter 13 *Diagnostics* on page 245.	
Set motor feedback parameters	**Incremental encoder basic set-up** Enter: • Drive encoder type in Pr **03.038** = AB (0): Quadrature encoder • Encoder power supply in Pr. **03.036** = 5 V (0), 8 V (1) or 15 V (2). **NOTE** If output voltage from the encoder is >5 V, then the termination resistors must be disabled Pr **03.039** to 0. **CAUTION** Setting the encoder voltage supply too high for the encoder could result in damage to the feedback device. • Drive encoder Lines Per Revolution (LPR) in Pr **03.034** (set according to encoder) • Drive encoder termination resistor setting in Pr **03.039**: **0** = A-A\, B-B\, Z-Z\ termination resistors disabled **1** = A-A\, B-B\, termination resistors enabled, Z-Z\ termination resistors disabled **2** = A-A\, B-B\, Z-Z\ termination resistors enabled	
Enter motor nameplate details	• Motor rated frequency in Pr **00.047** (Hz) • Motor rated current in Pr **00.046** (A) • Motor rated speed in Pr **00.045** (rpm) • Motor rated voltage in Pr **00.044** (V) - check if ⅄ or Δ connection	
Set maximum speed	Enter: Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s/1000 rpm) • Deceleration rate in Pr **00.004** (s/1000 rpm) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030**, Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Motor thermistor set-up	The motor thermistor connection is made through the drive encoder port (terminal 15). The thermistor type is selected in *P1 Thermistor Type* (03.118). On Unidrive M700 / M701, the motor thermistor can be selected in Pr **07.015**. Refer to Pr **07.015** for further information.	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. **WARNING** A rotating autotune will cause the motor to accelerate up to $^2/_3$ base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference.The drive can be stopped at any time by removing the run signal or removing the drive enable. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. The stationary autotune measures the stator resistance and transient inductance of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** 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 **00.043**. • A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at $^2/_3$ base speed in the direction selected. The rotating autotune measures the stator inductance of the motor and calculates the power factor. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune or set Pr **00.040** = 2 for a rotating autotune • Close the drive enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). The drive will display 'Ready'. • Close the run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702). The upper row of the display will flash 'Auto Tune' while the drive is performing the autotune. • Wait for the drive to display 'Ready' or 'Inhibit' and for the motor to come to a standstill. If the drive trips, see Chapter 13 *Diagnostics* on page 245. • Remove the drive enable and run signal from the drive.	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.3.3 RFC-A mode (Sensorless control)

Induction motor with sensorless control

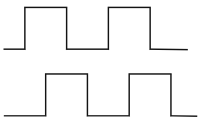
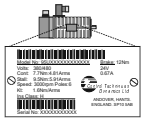
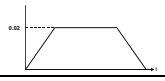
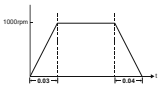
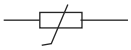
Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). • Run signal is not given • Motor is connected	
Power-up the drive	Verify that RFC-A mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 45. Ensure: • Drive displays 'Inhibit' If the drive trips, see Chapter 13 *Diagnostics* on page 245.	
Select RFC-A (Sensorless control) mode and disable encoder wire-break trip	• Set Pr **03.024** = 1 or 3 to select RFC-A Sensorless mode • Set Pr **03.040** = 0000 to disable the wire break	
Enter motor nameplate details	Enter: • Motor rated frequency in Pr **00.047** (Hz) • Motor rated current in Pr **00.046** (A) • Motor rated speed in Pr **00.045** (rpm) • Motor rated voltage in Pr **00.044** (V) - check if ⅄ or △ connection	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s/1000rpm) • Deceleration rate in Pr **00.004** (s/1000rpm) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030**, Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Motor thermistor set-up	The motor thermistor connection is made through the drive encoder port (terminal 15). The thermistor type is selected in *P1 Thermistor Type* (03.118). On Unidrive M700 / M701, the motor thermistor can be selected in Pr **07.015**. Refer to Pr **07.015** for further information.	
Select or deselect catch a spinning motor mode	If catch a spinning motor mode is not required then set Pr **06.009** to 0. If catch a spinning motor mode is required then leave Pr **06.009** at the default of 1, but depending on the size of the motor the value in Pr **05.040** may need to be adjusted. Pr **05.040** defines a scaling function used by the algorithm that detects the speed of the motor. The default value of Pr **05.040** is 1 which is suitable for small motors (<4 kW). For larger motors the value in Pr **05.040** will need to be increased. Approximate values of Pr **05.040** for different motor sizes are as follows, 2 for 11 kW, 3 for 55 kW and 5 for 150 kW. If the value of Pr **05.040** is too large the motor may accelerate from standstill when the drive is enabled. If the value of this parameter is too small the drive will detect the motor speed as zero even if the motor is spinning.	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. **NOTE** It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2). **WARNING** A rotating autotune will cause the motor to accelerate up to $^2/_3$ base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. The stationary autotune measures the stator resistance and transient inductance of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** 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 **00.043**. • A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at 2/3 base speed in the direction selected. The rotating autotune measures the stator inductance of the motor and calculates the power factor. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune or set Pr **00.040** = 2 for a rotating autotune • Close the drive enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). The drive will display 'Ready' or 'Inhibit'. • Close the run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702). The upper row of the display will flash 'Auto Tune' while the drive is performing the autotune. • Wait for the drive to display 'Ready' or 'Inhibit' and for the motor to come to a standstill. If the drive trips, see Chapter 13 *Diagnostics* on page 245. • Remove the drive enable and run signal from the drive.	

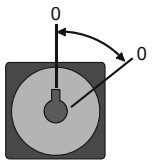
Action	Detail	
Save parameters	Select 'Save Parameters' in Pr **MM.000** (alternatively enter a value of 1001 in Pr **MM.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.3.4 RFC-S mode (with position feedback)

Permanent magnet motor with position feedback

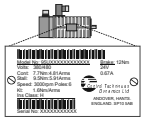
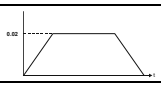
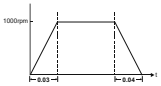
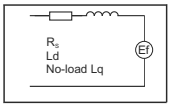
For simplicity only an incremental quadrature encoder with commutation outputs will be considered here. For information on setting up one of the other supported speed feedback devices, refer to section 7.3.5 *RFC-Sensorless* on page 83.

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). • Run signal is not given • Motor and feedback device are connected	
Power-up the drive	Verify that RFC-S mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 45. Ensure: • Drive displays 'inhibit' If the drive trips, see Chapter 13 *Diagnostics* on page 245.	
Set motor feedback parameters	**Incremental encoder basic set-up** Enter: • Drive encoder type in Pr. **03.038** = AB Servo (3): Quadrature encoder with commutation outputs • Encoder power supply in Pr. **03.036** = 5 V (0), 8 V (1) or 15 V (2). **NOTE** If output voltage from the encoder is >5 V, then the termination resistors must be disabled Pr **03.039** to 0. **CAUTION** Setting the encoder voltage supply too high for the encoder could result in damage to the feedback device. • Drive encoder Pulses Per Revolution in Pr **03.034** (set according to encoder) • Drive encoder termination resistor setting in Pr **03.039**: **0** = A-A\, B-B\, Z-Z\ termination resistors disabled **1** = A-A\, B-B\, termination resistors enabled, Z-Z\ termination resistors disabled **2** = A-A\, B-B\, Z-Z\ termination resistors enabled	
Enter motor nameplate details	Enter: • Motor rated current in Pr **00.046** (A) Ensure that this equal to or less than the Heavy Duty rating of the drive otherwise 'Motor Too Hot' trips may occur during the autotune. • Number of poles in Pr **00.042** • Motor rated voltage in Pr **00.044** (V)	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s/1000 rpm) • Deceleration rate in Pr **00.004** (s/1000 rpm) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030**, Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Motor thermistor set-up	The motor thermistor connection is made through the drive encoder port (terminal 15). The thermistor type is selected in *P1 Thermistor Type* (03.118). On Unidrive M700 / M701, the motor thermistor can be selected in Pr **07.015**. Refer to Pr **07.015** for further information.	

Action	Detail	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive.The drive is able to perform a stationary, rotating, mechanical load measurement or locked rotor test autotune. The motor must be at a standstill before an autotune is enabled. It is suggested that a rotating auto tune is used for accurate measurement for position feedback phase angle. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. A stationary autotune is performed to locate the flux axis of the motor. The stationary autotune measures the stator resistance, inductance in flux axis, maximum deadtime compensation, inductance in torque axis with no load on the motor and current at maximum deadtime compensation of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. If Sensorless mode is not selected then *Position Feedback Phase Angle* (00.043) is set-up for the selected position feedback. • A rotating autotune should only be used if the motor is uncoupled. The rotating autotune will rotate the motor by up to 2 mechanical revolutions in the direction selected, regardless of the reference provided to obtain the position feedback phase angle. A stationary autotune is then performed to obtain stator resistance, inductance in flux axis, maximum deadtime compensation, inductance in torque axis with no load on the motor and current at maximum deadtime compensation of the motor. From the above obtained parameters the current loop gains are calculated, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. **WARNING** The rotating autotune will rotate the motor by up to 2 mechanical revolutions in the direction selected, regardless of the reference provided. After a short delay, the motor is further rotated through a electrical revolution. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune, Pr **00.040** = 2 for a rotating autotune. • Close the run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702). • Close the drive enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702). The upper row of the display will flash 'Auto Tune' while the drive is performing the test. • Wait for the drive to display 'Ready' or 'Inhibit' and for the motor to come to a standstill. If the drive trips it cannot be reset until the drive enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) has been removed. See section 13 *Diagnostics* on page 245. • Remove the drive enabled and run signal from the drive.	
Save parameters	Select 'Save Parameters' in Pr **MM.000** (alternatively enter a value of 1001 in Pr **MM.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.3.5 RFC-Sensorless

Permanent magnet motor without position feedback

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 31 on Unidrive M700/M701 and terminal 11 & 13 on Unidrive M702). • Run signal is not given • Motor is connected	
Power-up the drive	Verify that RFC-S mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 45, otherwise restore parameter defaults (see section 5.8 *Restoring parameter defaults* on page 45). Ensure: • Drive displays 'inhibit' If the drive trips, see Chapter 13 *Diagnostics* on page 245.	
Enter motor nameplate details	Enter: • Motor rated current in Pr **00.046** (A) Ensure that this equal to or less than the Heavy Duty rating of the drive otherwise 'Motor Too Hot' trips may occur during the autotune. • Number of poles in Pr **00.042** • Motor rated voltage in Pr **00.044** (V)	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s/1000 rpm). It is recommended that the ramp rates are increased from the default value of 0.200 s/1000 rpm. • Deceleration rate in Pr **00.004** (s/1000 rpm) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030**, Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Set stop mode	Enter: • Set Stop Mode to Ramp in Pr **06.001**	
Set hold zero speed	Enter: • Set Hold Zero Speed to Off (0) in Pr **06.008**.	
Autotune	The drive is able to perform a stationary autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance. • A stationary autotune is performed to locate the flux axis of the motor. The stationary autotune measures the stator resistance, inductance in flux axis, inductance in torque axis with no load on the motor and values relating to deadtime compensation from the drive. Measured values are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. To perform an autotune: • Set Pr **00.040** = 1 or 2 for a stationary autotune. (Both perform the same tests). • Close the run signal (terminal 26 or 27 on Unidrive M700/M701 and terminal 7 or 8 on Unidrive M702). • Close the drive enable signal (terminal 31 on Unidrive M700/M701 and terminal 11 & 13 on Unidrive M702). The upper row of the display will flash 'Auto Tune' while the drive is performing the test. • Wait for the drive to display 'Ready' or 'Inhibit' and for the motor to come to a standstill. If the drive trips it cannot be reset until the drive enable signal (terminal 31) has been removed. See Chapter 13 *Diagnostics* on page 245. • Remove the drive enabled and run signal from the drive.	
Check Saliency	In sensorless mode, when the motor speed is below Pr **00.045** / 10, a special low speed algorithm must be used to control the motor. There are two modes available, with the mode chosen based on the saliency of the motor. The ratio No-load Lq (Pr **00.056**) / Ld (Pr **05.024**) provides a measure of the saliency. If this value is > 1.1, then Injection (0) mode may be used. Current (2) mode may be used (but with limitations). If this value is < 1.1, then Current (2) mode must be used (this is the default of Pr **05.064**).	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.4 Setting up a feedback device

7.4.1 P1 position interface

This section shows the parameter settings which must be made to use each of the compatible feedback device types with P1 position interface on the drive. For more information on the parameters listed here please refer to the *Parameter Reference Guide*.

Table 7-3 Parameters required for feedback device set-up on the P1 position interface

Parameter	AB, FD, FR, AB Servo, FD Servo, FR Servo, SC, SC Servo	SC Hiperface	SC EnDat	EnDat	SC SSI	SSI	SC BiSS	BiSS	Resolver
P1 Marker Mode (03.031)	✓								
P1 Rotary Turns Bits (03.033)		●	●	●	✓	✓	✓	✓	
P1 Rotary Lines Per Revolution (03.034)	✓	●	●		✓		✓		
P1 Comms Bits (03.035)		●	●	●	✓	✓	✓	✓	
P1 Supply Voltage (03.036)*	✓	✓	✓	✓	✓	✓	✓	✓	
P1 Comms Baud Rate (03.037)			✓	✓	✓	✓	✓	✓	
P1 Device Type (03.038)	✓	✓	✓	✓	✓	✓	✓	✓	✓
P1 Auto−configuration Select (03.041)		✓	✓	✓					
P1 SSI Binary Mode (03.048)					✓	✓	✓	✓	
P1 Resolver Poles (03.065)									✓
P1 Resolver Excitation (03.066)									✓
P1 Additional Configuration (03.074)							✓	✓	

✓ Information required to be entered by the user.

● Parameter can be set-up automatically by the drive through auto-configuration parameter. Must be set by the user if auto-configuration is disabled (i.e. Pr **03.041** = Disabled (0)).

* Pr **03.036**: If the output voltage from the encoder is >5 V, then termination resistors must be disabled by setting Pr **03.039** to 0.

Table 7-3 shows a summary of the parameters required to set-up each feedback device. More detailed information follows.

7.4.2 P1 position interface: Detailed feedback device commissioning / start-up information

Standard quadrature encoder with or without commutation signals (A, B, Z or A, B, Z, U, V, W), or Sincos encoder with or without UVW commutation signals

Device Type (03.038)	**AB** (0) for a quadrature encoder without commutation signals * **AB Servo** (3) for a quadrature encoder with commutation signals **SC** (6) for a Sincos encoder without commutation signals * **SC Servo** (12) for a Sincos encoder with commutation signals
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2) **NOTE** If output voltage from the encoder is >5 V, then the termination resistors must be disabled. Set Pr **03.039** to 0
Rotary Line Per Revolution (03.034)	Set to the number of lines or sine waves per revolution of the encoder.
Termination Select (03.039) (AB or AB Servo only)	**0** = A, B, Z termination resistors disabled **1** = A, B termination resistors enabled and Z termination resistors disabled **2** = A, B, Z termination resistors enabled
Marker Mode (03.031)	See table below
Error Detection Level (03.040)	See table below

Bit 3	Bit 2	Bit 1	Bit 0	Description
x	x	x	1	No action is taken unless marker flag is zero before marker event occurs
x	x	1	x	Pr **03.028** and Pr **03.058** are set to zero
x	1	x	x	Pr **03.028**, Pr **03.029**, Pr **03.030** and the related part of Pr **03.058** are not reset. Pr **03.058** is transferred to Pr **03.059** and Pr **03.032** is set to 1.
1	x	x	x	Undefined state region range is reduced from -30 mV to 30 mV. The marker pulse is only recognized if the pulse is 10 µs wide.

Bit 3	Bit 2	Bit 1	Bit 0	Description
x	x	x	1	Enable wire break detection
1	x	x	x	Disable trips *Encoder 1* to *Encoder 6*

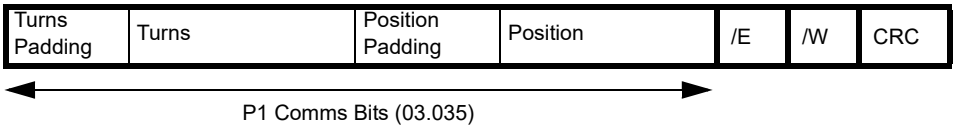
* These settings should only be used in RFC-A mode. If used in RFC-S mode a phase offset test must be performed after every power up.

Incremental encoder with Frequency and Direction (F and D) or Forward and Reverse (CW and CCW) signals with or without commutation signals.	
Device Type (03.038)	**FD** (1) for frequency and direction signals without commutation signals* **FR** (3) for forward and reverse signals without commutation signals* **FD** Servo (4) for frequency and direction signals with commutation signals **FR** Servo (5) for forward and reverse signals with commutation signals
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2) **NOTE** If output voltage from the encoder is >5 V, then the termination resistors must be disabled. Set Pr **03.039** to 0
Rotary Line Per Revolution (03.034)	Set to the number of pulses per revolution of the encoder divided by 2.
Termination Select (03.039)	0 = F or CW, D or CCW, Z termination resistors disabled 1 = F or CW, D or CCW termination resistors enabled and Z termination resistors disabled 2 = For CW, D or CCW, Z termination resistors enabled
Marker Mode (03.031)	**Bit** 3 2 1 0 / **Description** x x x 1 — No action is taken unless marker flag is zero before marker event occurs x x 1 x — Pr **03.028** and Pr **03.058** are set to zero x 1 x x — Pr **03.028**, Pr **03.029**, Pr **03.030** and the related part of Pr **03.058** are not reset. Pr **03.058** is transferred to Pr **03.059** and Pr **03.032** is set to 1. 1 x x x — Undefined state region range is reduced from -30 mV to 30 mV. The marker pulse is only recognized if the pulse is 10 µs wide.
Error Detection Level (03.040)	**Bit** 3 2 1 0 / **Description** x x x 1 — Enable wire break detection 1 x x x — Disable trips *Encoder 1* to *Encoder 7*

* These settings should only be used in RFC-A mode. If used in RFC-S mode a phase offset test must be performed after every power up.

Absolute Sincos encoder with Hiperface or EnDat serial communication, or Absolute EnDat communication only encoder	
Device Type (03.038)	**SC Hiperface** (7) for a Sincos encoder with Hiperface serial communications **EnDat** (8) for an EnDat communications only encoder **SC EnDat** (9) for a Sincos encoder with EnDat serial communications
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2)
Auto-configuration Select (03.041)	Auto-configuration is enabled at default and automatically sets up the following parameters. *Rotary Turns Bits* (03.033) *Rotary Lines Per Revolutions* (03.034) *Comms Bits* (03.035) These parameters can be entered manually when Pr 03.041 is set to Disabled (0).
Comms Baud Rate (03.037)	100 k, 200 k, 300 k, 400 k, 500 k, 1 M, 1.5 M, 2 M, 4 M
Error Detection Level (03.040)	**Bit** 3 2 1 0 / **Description** x x x 1 — Enable wire break detection x x 1 x — Enable phase error detection 1 x x x — Disable trips *Encoder 1* to *Encoder 6* So for example, to enable the wire break and phase error detection, set Pr **03.040** to 0011.

<table>
<tr><th colspan="2">Absolute SSI communications only encoder, or Absolute Sincos encoder with SSI communications</th></tr>
<tr><td>Device Type (03.038)</td><td>SSI (10) for a SSI communications only encoder
SC SSI (11) for a Sincos encoder with SSI serial communications</td></tr>
<tr><td>Supply Voltage (03.036)</td><td>5 V (0), 8 V (1) or 15 V (2)</td></tr>
<tr><td>Rotary Line Per Revolution (03.034)</td><td>Set the number of sine waves per revolution of the encoder</td></tr>
<tr><td>SSI Binary Mode (03.048)</td><td>Off = Gray Code
On = Binary Mode</td></tr>
<tr><td>Rotary Turns Bits (03.033)</td><td>Set to the number of turns bits for the encoder (this is normally 12 bits for a SSI encoder)</td></tr>
<tr><td>Comms Bits (03.035)</td><td>Total number of bits of position information (this is usually 25 bits for a SSI encoder)</td></tr>
<tr><td>Comms Baud Rate (03.037)</td><td>100 k, 200 k, 300 k, 400 k, 500 k, 1 M, 1.5 M, 2 M, 4 M</td></tr>
<tr><td>Error Detection Level (03.040)</td><td>
<table>
<tr><th colspan="4">Bit</th><th rowspan="2">Description</th></tr>
<tr><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>x</td><td>x</td><td>x</td><td>1</td><td>Enable wire break detection</td></tr>
<tr><td>x</td><td>x</td><td>1</td><td>x</td><td>Enable phase error detection</td></tr>
<tr><td>x</td><td>1</td><td>x</td><td>x</td><td>Enable SSI power supply alarm bit monitor</td></tr>
<tr><td>1</td><td>x</td><td>x</td><td>x</td><td>Disable trips Encoder 1 to Encoder 6</td></tr>
</table>
So for example, to enable the wire break and phase error detection, set Pr 03.040 to 0011.
</td></tr>
</table>

BiSS or SC BiSS setup	
P1 Device Type (03.038)	**BiSS** (13) for a BiSS communications only encoder **SC BiSS** (17) for Sincos encoder with BiSS communications
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2)
P1 Rotary Turns Bits (03.033)	Set to the number of turns bits for the encoder. Some BiSS encoders include zero padding either before or after the turns information (see *P1 Additional Configuration* (03.074) below). *P1 Rotary Turns Bits* (03.033) should include the actual turns bits and the additional padding.
P1 Rotary Lines Per Revolution (03.034)	*SC BiSS only* Set to the number sine waves per revolution for the encoder.
P1 Comms Bits (03.035)	Set to the Total number of bits of position information in the comms message from the encoder excluding the warning and error bits. It is always assumed there is one warning bit and one error bit. The length of the position information includes any zero padding that is included by the encoder. 
Comms Baud Rate (03.037)	*BiSS only* Set the baud required baud rate. 2Mbaud or 4Mbaud is likely to be required. Any baud rate that is within the range specified for the encoder may be used. The line delay is measured during initialisation, and is used to compensate this delay during communications with the encoder. Therefore there is no timing based restriction on the length of the cable between the position feedback interface and the encoder. However, care should be taken to ensure that the wiring arrangement and the type of cable used are suitable for the selected baud rate and the distance between the position interface and the encoder. See *P1 Low Speed Update Rate Active* (03.063) in the *Parameter Reference Guide* for more details on timing restrictions related to the drive sample times.
P1 Calculation Time (03.060)	The calculation time (t_{cal}) may be longer than the default given in parameter 03.060. This time is referred to as t_{busy} in the BiSS specification and is the time from the first rising edge of the MA signal to the rising edge of the start bit. It may be necessary to check this time with a scope if the encoder does not communicate and the data is not available from the encoder datasheet.
P1 Additional Configuration (03.074)	The CRC polynomial and rotary turns and position padding need to be configured in this parameter. This information should be available on the encoder datasheet. *P1 Additional Configuration* (03.074) provides configuration information, not covered by the other set-up parameters, for the position feedback device connected to the P1 position feedback interface and is specific to the type of device being used. This parameter is split into 3 fields as shown below. **Decimal Digits** | **9-6** | **5-3** | **2-0** CRC polynomial | Rotary Turns Padding | Rotary Position Padding Commonly used value | 0067 | 000 | 000 **CRC polynomial** The CRC polynomial is a bit representation of the terms of a polynomial used to generate the CRC applied to the position and the additional data transferred to/from the encoder via the BiSS communications channel. The standard value is 0067 which in hexadecimal is 0x0043, or in binary form is 0000 0000 0100 0011. The bits that are set to one show which terms exist in the polynomial. The standard value has bits 6, 1 and 0 set to one and gives the polynomial normally used with BiSS encoders which is X^6+X^1+1. If the encoder uses a different polynomial then this can be selected with the four digits (9-6). The maximum value is 511 (0x01FF), and so a polynomial up to degree 10 can be set up. **Rotary Turns Padding and Rotary Position Padding** The turns, and position within a turn, provided by a rotary encoder may not completely fill the number of bits provided. The unfilled bits will be padded with zeros. The total number of bits provided for the turns including zero padding is given by *P1 Rotary Turns Bits* (03.033). The zero padding is given by decimal digits 5 to 3 of *P1 Additional Configuration* (03.074). Digits 4 and 3 give the number of bits and digit 5 specifies whether the padding is on the left (0) or on the right (1). For example a value of 104 would specify 4 padding bits on the right of the turns data. The default value of 000 specifies no padding. If the padding value is outside the range +/-16 then an *Encoder 14* is initiated. The total number of bits provided for position within a turn is given by: *P1 Comms Bits* (03.035) - *P1 Rotary Turns Bits* (03.033). The zero padding is given by decimal digits 2 to 0 of *P1 Additional Configuration* (03.074) in the same manner as is used for the turns padding. It is not possible to specify zero padding for linear encoders.

UVW commutation signal only encoders*	
Device Type (03.038)	Commutation Only (16) for a quadrature encoder with commutation signals*
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2)
Error Detection Level (03.040)	Set to zero to disable wire break detection

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

Due to the low resolution of UVW communication only encoders, it is recommended that the *P1 Feedback Filter* (03.042) is set to its maximum value. A value of 1 ms to 2 ms may also be required in the *Current Reference Filter* (00.017) and it is also recommended that the speed loop gains are set to a low value to obtain stable operation.

Resolver

Device Type (03.038): Resolver (14)

Resolver Poles (03.065): Set number of Resolver poles
2 poles (1) to 20 poles (10)

Resolver Excitation (03.066): Set Resolver excitation voltage and frequency
6kHz 3V (0), 8kHz 3V (1), 6kHz 2V (2), 8kHz 2V (3)

Error Detection Level (03.040):

Bit				Description
3	2	1	0	
x	x	x	1	Enable wire break detection
1	x	x	x	Disable trips *Encoder 1* to *Encoder 6*

So for example, to enable the wire break error detection, set Pr **03.040** to 0001.

7.4.3 P2 position interface

This section shows the parameter settings which must be made to use each of the compatible feedback device types with the P2 position interface on the drive. For more information on the parameters listed here please refer to the *Parameter Reference Guide*. If the position feedback device connected to the P2 position interface is required to be used for motor control feedback then Pr **03.026** will need to be set to P2 Drive (1).

Table 7-4 Parameters required for feedback device set-up on the P2 position interface

Parameter	AB, FD, FR	EnDat	SSI	BiSS
P2 Marker Mode (03.131)	✓			
P2 Rotary Turns Bits (03.133)		●	●	✓
P2 Rotary Lines Per Revolution (03.134)	✓			
P2 Comms Bits (03.135)		●	●	✓
P2 Comms Baud Rate (03.137)		✓	✓	✓
P2 Device Type (03.138)	✓	✓	✓	✓
P2 Auto−configuration Select (03.141)		✓		
P2 Additional Configuration (03.174)				✓

✓ Information required to be entered by the user.

● Parameter can be set-up automatically by the drive through auto-configuration. Parameter must be set by the user if auto-configuration is disabled (i.e. Pr **03.141** = Disabled (0)).

The P2 position interface does not have its own independent power supply output. Therefore, any position feedback device connected to the P2 position interface must either share the P1 power supply output on pin 13 of the 15-way D-type, or be supplied from an external source.

NOTE

The termination resistors are always enabled on the P2 position interface. Wire break detection is not available when using AB, FD or FR position feedback device types on the P2 position interface.

Table 7-4 shows a summary of the parameters required to set-up each feedback device. More detailed information follows.

Standard quadrature encoder (A, B, Z)

Device Type (03.138)	**AB** (1) for a quadrature encoder
Rotary Line Per Revolution (03.134)	Set to the number of lines per revolution of the encoder

Marker Mode (03.131)

Bit 3	Bit 2	Bit 1	Bit 0	Description
x	x	x	1	No action is taken unless marker flag is zero before marker event occurs
x	x	1	x	Pr **03.128** and Pr **03.158** are set to zero
x	1	x	x	Pr **03.128**, Pr **03.129**, Pr **03.130** and the related part of Pr **03.158** are not reset. Pr **03.158** is transferred to Pr **03.159** and Pr **03.132** is set to 1.
1	x	x	x	This Bit in has no effect.

Incremental encoder with Frequency and Direction (F and D), or Forward and Reverse (CW and CCW) signals

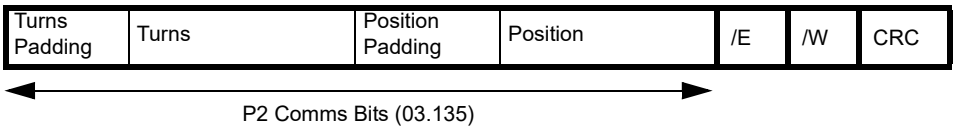
Device Type (03.138)	**FD** (2) for frequency and direction signals without commutation signals **FR** (3) for forward and reverse signals without commutation signals
Rotary Line Per Revolution (03.134)	Set to the number of pulses per revolution of the encoder divided by 2

Marker Mode (03.131)

Bit 3	Bit 2	Bit 1	Bit 0	Description
x	x	x	1	No action is taken unless marker flag is zero before marker event occurs
x	x	1	x	Pr **03.128** and Pr **03.158** are set to zero
x	1	x	x	Pr **03.128**, Pr **03.129**, Pr **03.130** and the related part of Pr **03.158** are not reset. Pr **03.158** is transferred to Pr **03.159** and Pr **03.132** is set to 1.
1	x	x	x	This Bit in has no effect.

Absolute EnDat communication only encoder	
Device Type (03.138)	**EnDat** (4) for an EnDat communications only encoder
Auto-configuration Select (03.141)	Auto-configuration is enabled at default and automatically sets up the following parameters: *Rotary Turns Bits* (03.133) *Comms Bits* (03.135) These parameters can be entered manually when Pr **03.141** is set to Disabled (0).
Comms Baud Rate (03.137)	100 k, 200 k, 300 k, 400 k, 500 k, 1 M, 1.5 M, 2 M, 4 M
Error Detection Level (03.140)	**Bit** 3 2 1 0 / **Description** 1 x x x — Disable trips *Encoder 4* to *Encoder 6*

Absolute SSI communications only encoder	
Device Type (03.138)	**SSI** (5) for a SSI communications only encoder
SSI Binary Mode (03.148)	**Off** (0) = Gray Code **On** (1) = Binary Mode
Rotary Turns Bits (03.133)	Set to the number of turns bits for the encoder (this is usually 12 bits for a multi-turn SSI encoder)
Comms Bits (03.135)	Total number of bits of position information for the encoder (this is usually 25 bits for a multi-turn SSI encoder)
Comms Baud Rate (03.137)	100 k, 200 k, 300 k, 400 k, 500 k, 1 M, 1.5 M, 2 M, 4 M
Error Detection Level (03.140)	**Bit** 3 2 1 0 / **Description** x 1 x x — *Enable SSI power supply alarm bit monitor* 1 x x x — Disable trips *Encoder 4* to *Encoder 6*

BiSS or SC BiSS setup	
P2 Device Type (03.138)	**BiSS** (6) for a BiSS communications only encoder
Supply Voltage (03.036)	**5 V** (0), **8 V** (1) or **15 V** (2)
P2 Rotary Turns Bits (03.133)	Set to the number of turns bits for the encoder. Some BiSS encoders include zero padding either before or after the turns information (see *P2 Additional Configuration* (03.174) below). *P2 Rotary Turns Bits* (03.133) should include the actual turns bits and the additional padding.
P2 Comms Bits (03.135)	Set to the Total number of bits of position information in the comms message from the encoder excluding the warning and error bits. It is always assumed there is one warning bit and one error bit. The length of the position information includes any zero padding that is included by the encoder. 
P2 Comms Baud Rate (03.137)	*BiSS only* Set the baud required baud rate. 2Mbaud or 4Mbaud is likely to be required. Any baud rate that is within the range specified for the encoder may be used. The line delay is measured during initialisation, and used to compensate this delay during communications with the encoder. Therefore there is no timing based restriction on the length of the cable between the position feedback interface and the encoder. However, care should be taken to ensure that the wiring arrangement and the type of cable used are suitable for the selected baud rate and the distance between the position interface and the encoder. See *P2 Low Speed Update Rate Active* (03.163) in the *Parameter Reference Guide* for more details on timing restrictions related to the drive sample times.
P2 Calculation Time (03.160)	The calculation time (t_{cal}) may be longer than the default given in parameter 03.160. This time is referred to as t_{busy} in the BiSS specification and is the time from the first rising edge of the MA signal to the rising edge of the start bit. It may be necessary to check this time with a scope if the encoder does not communicate and the data is not available from the encoder datasheet.
P2 Additional Configuration (03.174)	The CRC polynomial and rotary turns and position padding need to be configured in this parameter. This information should be available on the encoder datasheet. *P2 Additional Configuration* (03.174) provides configuration information, not covered by the other set-up parameters, for the position feedback device connected to the P2 position feedback interface and is specific to the type of device being used. This parameter is split into 3 fields as shown below. **Decimal Digits** | **9-6** | **5-3** | **2-0** CRC polynomial | Rotary Turns Padding | Rotary Position Padding Commonly used value | 0067 | 000 | 000 **CRC polynomial** The CRC polynomial is a bit representation of the terms of a polynomial used to generate the CRC applied to the position and the additional data transferred to/from the encoder via the BiSS communications channel. The standard value is 0067 which in hexadecimal is 0x0043, or in binary form is 0000 0000 0100 0011. The bits that are set to one show which terms exist in the polynomial. The standard value has bits 6, 1 and 0 set to one and gives the polynomial normally used with BiSS encoders which is X^6+X^1+1. If the encoder uses a different polynomial then this can be selected with the four digits (9-6). The maximum value is 511 (0x01FF), and so a polynomial up to degree 10 can be set up. **Rotary Turns Padding and Rotary Position Padding** The turns, and position within a turn, provided by a rotary encoder may not completely fill the number of bits provided. The unfilled bits will be padded with zeros. The total number of bits provided for the turns including zero padding is given by *P2 Rotary Turns Bits* (03.133). The zero padding is given by decimal digits 5 to 3 of *P2 Additional Configuration* (03.174). Digits 4 and 3 give the number of bits and digit 5 specifies whether the padding is on the left (0) or on the right (1). For example a value of 104 would specify 4 padding bits on the right of the turns data. The default value of 000 specifies no padding. If the padding value is outside the range +/-16 then an *Encoder 14* is initiated. The total number of bits provided for position within a turn is given by: *P2 Comms Bits* (03.135) – *P2 Rotary Turns Bits* (03.133). The zero padding is given by decimal digits 2 to 0 of *P2 Additional Configuration* (03.174) in the same manner as is used for the turns padding. It is not possible to specify zero padding for linear encoders.

7.5 Encoder Simulation Output Set-up

The drive supports four modes of encoder simulation output.

- Hardware mode - Incremental signals (AB, FD, FR)
- Software mode - Incremental signals (AB, FD, FR)
- Software mode - Ratio
- Software mode - Absolute SSI data

The availability of the encoder simulation output on the 15-way D-type on the drive is dependent on the type of feedback device connected to the P1 position interface. See Table 4-9 on page 32 for more information on the availability of the encoder simulation output. The status of the encoder simulation output can be seen in *Encoder Simulation Status* (03.086) as follows:

None (0) The encoder simulation output is not enabled or is not available
Full (1) Full encoder simulation with marker output is available
No Marker (2) Encoder simulation without marker output is available

This section shows the parameter settings which must be made to use the encoder simulation output on the drive. For more information on the parameters listed here please refer to the Parameter Reference Guide.

7.5.1 Hardware mode - Incremental signals (AB, FD, or FR)

Hardware mode provides incremental signals derived via hardware from the P1 position feedback interface on the drive, with negligible delay. The supported incremental output signals are AB, FD and FR. Hardware mode only produces an output when the input device connected to the P1 position interface is AB, FD, FR, SC, SC Hiperface, SC EnDat or SC SSI type devices. It should be noted that with a SINCOS source device the output is based on the zero crossings of the sine wave inputs and does not include interpolation.

Hardware mode set-up	
Encoder Simulation Source (03.085)	This parameter must be set to **03.029** to select the P1 position interface as the source.
Encoder Simulation Mode (03.088)	Set to a value of **Hardware (0)**
Encoder Simulation Hardware Divider (03.089)	This parameter defines the divider ratio between the device connected to the P1 position feedback interface and the output. **0** = 1/1 **1** = 1/2 **2** = 1/4 **3** = 1/8 **4**= 1/16 **5** = 1/32 **6** = 1/64 **7** = 1/128
Encoder Simulation Hardware Marker Lock (03.090)	**0** = The marker output is derived directly from the marker input **1** = The incremental output signals are adjusted on each marker event so that the A and B are high with an AB type output, or F is high with an FD or FR type output
Encoder Simulation Output Mode (03.098)	**AB/Gray** (0) for a AB quadrature output signals **FD/Binary** (1) for Frequency and Direction output signals **FR/Binary** (2) for Forward and Reverse output signals

7.5.2 Software mode - Incremental signals (AB, FD, or FR)

In software mode the encoder simulation output is derived via software from the selected source with a minimum delay of 250 µs which may be extended with *Encoder Simulation Sample Period* (03.087). For incremental output signals, the resolution of the output can be defined by either selecting the required output lines per revolution or by an output ratio.

Lines per revolution

The output resolution of the encoder simulation output is defined by *Encoder Simulation Output Lines Per Revolution* (03.092).

AB quadrature output signals, software mode setup – Lines per revolution	
Encoder Simulation Source (03.085)	Set to the parameter number of the position source Pr **03.029** to use the P1 position interface on the drive as the source. Pr **03.129** to use the P2 position interface on the drive as the source. This parameter can be set to any other valid position reference generated by the drive or an option module.
Encoder Simulation Mode (03.088)	Set to a value of **Lines Per Rev (1)**
Encoder Simulation Output Lines Per Revolution (03.092)	Set to the required output lines per revolution. The maximum output lines per revolution are 16384.
Encoder Simulation Output Mode (03.098)	**AB/Gray** (0) for a AB quadrature output signals

Frequency and Direction or Forward and Reverse output signals, software mode setup – Lines per revolution	
Encoder Simulation Source (03.085)	Set to the parameter number of the position source Pr **03.029** to use the P1 position interface on the drive as the source. Pr **03.129** to use the P2 position interface on the drive as the source. This parameter can be set to any other valid position reference generated by the drive or an option module.
Encoder Simulation Mode (03.088)	Set to a value of **Lines Per Rev (1)**
Encoder Simulation Output Lines Per Revolution (03.092)	Set to the required output pulse per revolution divided by 2. For example if 2000 pulses per revolution is required, set this parameter to 1000.
Encoder Simulation Output Mode (03.098)	**FD/Binary** (1) for Frequency and Direction output signals **FR/Binary** (2) for Forward and Reverse output signals

Ratio

In ratio mode the resolution of the input source is based on a 16 bit position feedback device (i.e. equivalent to an AB quadrature encoder with a resolution of 16384 lines per revolution). The output resolution of the encoder simulation output is defined by the ratio of *Encoder Simulation Numerator* (03.093) and *Encoder Simulation Denominator* (03.094).

AB quadrature output signals, software mode setup – Ratio Frequency and Direction or Forward and Reverse output signals, software mode setup	
Encoder Simulation Source (03.085)	Set to the parameter number of the position source Pr **03.029** to use the P1 position interface on the drive as the source. Pr **03.129** to use the P2 position interface on the drive as the source. This parameter can be set to any other valid position reference generated by the drive or an option module.
Encoder Simulation Mode (03.088)	Set to a value of **Ratio (2)**
Encoder Simulation Numerator (03.093) and Encoder Simulation Denominator (03.094)	Set these two parameters to give the required output ratio.
Encoder Simulation Output Mode (03.098)	**AB/Gray** (0) for a AB quadrature output signals **FD/Binary** (1) for Frequency and Direction output signals **FR/Binary** (2) for Forward and Reverse output signals

Software mode - Absolute SSI data

In software mode the encoder simulation output is derived via software from the selected source with a minimum delay of 250 µs which may be extended with *Encoder Simulation Sample Period* (03.087). In SSI output mode drive will simulate an SSI encoder, where the number of bits and the format of the position message can be adjusted.

Absolute SSI data, software mode setup	
Encoder Simulation Source (03.085)	Set to the parameter number of the position source Pr **03.029** to use the P1 position interface on the drive as the source. Pr **03.129** to use the P2 position interface on the drive as the source. This parameter can be set to any other valid position reference generated by the drive or an option module.
Encoder Simulation Mode (03.088)	Set to a value of **SSI (3)**
Encoder Simulation SSI Turns Bits (03.096)	Set to the number of bits representing the number of turns in the position message.
Encoder Simulation SSI Comms Bits (03.097)	Set to the number bits in the whole position message.
Encoder Simulation Output Mode (03.098)	**AB/Gray** (0) for position data in Gray code format **FD/Binary** (1) or **FR/Binary** (2) for position data in binary format

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

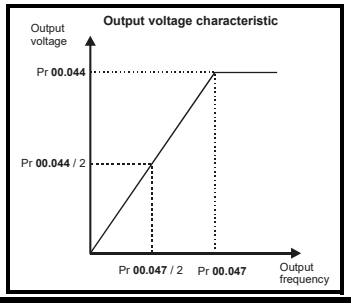
8.1.1 Open loop motor control

Pr 00.046 {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. (See section 8.2 *Maximum motor rated current* on page 108, for information about setting this parameter higher than the maximum Heavy Duty current rating). The motor rated current is used in the following:
- Current limits (see section 8.3 *Current limits* on page 108, for more information)
- Motor thermal overload protection (see section 8.4 *Motor thermal protection* on page 108, for more information)
- Vector mode voltage control (see *Open Loop Control Mode* (00.007), later in this table)
- Slip compensation (see *Enable Slip Compensation* (05.027), later in this table)
- Dynamic V/F control

Pr 00.044 {05.009} *Rated Voltage*	**Defines the voltage applied to the motor at rated frequency**
Pr 00.047 {05.006} *Rated Frequency*	**Defines the frequency at which rated voltage is applied**

The *Rated Voltage* (00.044) and the *Rated Frequency* (00.047) are used to define the voltage to frequency characteristic applied to the motor (see *Open Loop Control Mode* (00.007), later in this table). The *Rated Frequency* (00.047) is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see *Rated Speed* (00.045), later in this table).



Pr 00.045 {05.008} *Rated Speed*	**Defines the full load rated speed of the motor**
Pr 00.042 {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]) = **00.047** $= \left(\frac{\mathbf{00.042}}{\mathbf{2}} \times \frac{\mathbf{00.045}}{\mathbf{60}}\right)$

If Pr **00.045** 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 **00.042** is also used in the calculation of the motor speed display by the drive for a given output frequency. When Pr **00.042** is set to 'Automatic', the number of motor poles is automatically calculated from the rated frequency Pr **00.047**, and the motor rated speed Pr **00.045**.

Number of poles = 120 x (*Rated Frequency* (00.047) / *Rated Speed* (00.045)) rounded to the nearest even number.

Pr 00.043 {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* (00.046), 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 00.040), overleaf).

Pr 00.040 {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* (05.017), *Transient Inductance* (05.024), *Maximum Deadtime Compensation* (05.059) and *Current At Maximum Deadtime Compensation* (05.060) 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 **00.043**. To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

- 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 **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

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 31 on *Unidrive M700 / M701* and terminal 11 & 13 on *Unidrive M702*, 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 00.007 {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* (00.047), 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* (00.043), *Stator Resistance* (05.017) are all required to be set up accurately. The drive can be made to measure these by performing an autotune (see Pr 00.040 *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 is 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.

(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* (00.007) is changed to Ur mode. The *Stator Resistance* (05.017) parameter is written to, and along with the *Open Loop Control Mode* (00.007), are saved in the drive's EEPROM. If the test fails, the voltage mode changes to Ur mode but *Stator Resistance* (05.017) is not updated.

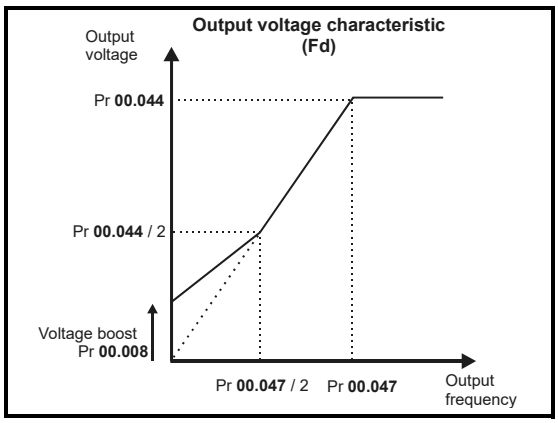
(4) **Ur I** = The stator resistance is measured when the drive is first made to run after each power-up. This test can only be done with a stationary motor. Therefore this mode should only be used if the motor is guaranteed to be stationary the first time the drive is made to run after each power-up. The new value of stator resistance is not automatically saved to the drive's EEPROM.

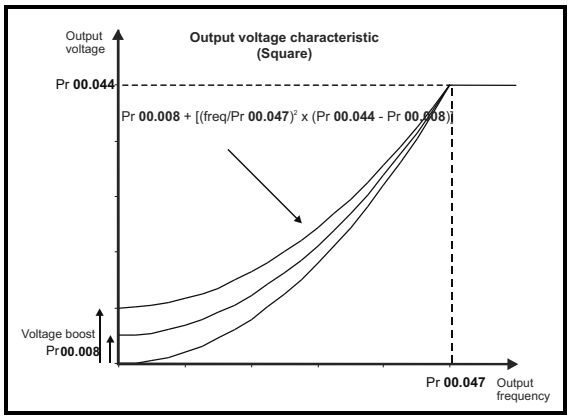
Pr 00.007 {05.014} *Open Loop Control Mode (cont)*

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* (00.047), 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* (00.047), and then a constant voltage above rated frequency. This mode is suitable for variable torque applications like fans and pumps where the load is proportional to the square of the speed of the motor shaft. This mode should not be used if a high starting torque is required.

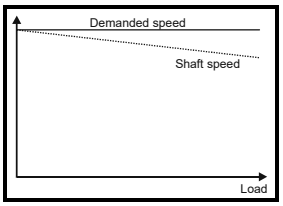
For both these modes, at low frequencies (from 0Hz to ½ x Pr **00.047**) a voltage boost is applied defined by Pr **00.008** as shown below:





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 **00.045** (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 **00.045**, slip compensation will be disabled. If too small a value is entered in Pr **00.045**, 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 mode

Induction motor with Position feedback

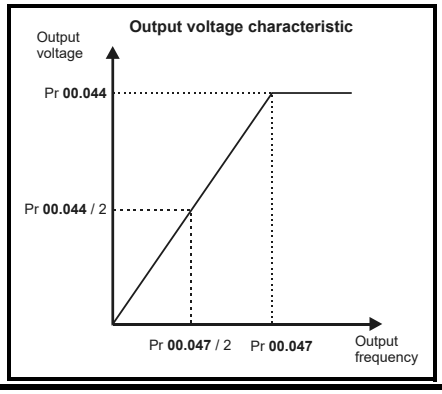
Pr 00.046 {05.007} *Motor Rated Current*	**Defines the maximum motor continuous current**

The motor rated current parameter must be set to the maximum continuous current of the motor. (See section 8.2 *Maximum motor rated current* on page 108, for information about setting this parameter higher than the maximum Heavy Duty current rating.) The motor rated current is used in the following:

- Current limits (see section 8.3 *Current limits* on page 108, for more information).
- Motor thermal overload protection (see section 8.4 *Motor thermal protection* on page 108, for more information)
- Vector control algorithm

Pr 00.044 {05.009} *Rated Voltage*	**Defines the voltage applied to the motor at rated frequency**
Pr 00.047 {05.006} *Rated Frequency*	**Defines the frequency at which rated voltage is applied**

The *Rated Voltage* (00.044) and the *Rated Frequency* (00.047) are used to define the voltage to frequency characteristic applied to the motor (see *Open Loop Control Mode* (00.007), later in this table). The motor rated frequency is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see motor *Rated Speed (*00.045), later in this table).



Pr 00.045 {05.008} *Rated Speed*	**Defines the full load rated speed of the motor**
Pr 00.042 {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. Either a fixed value can be entered in this parameter or an optimization system may be used to automatically adjust this parameter (see *Rated Speed Optimisation Select* (00.033), later in this table).

When Pr **00.042** is set to 'Automatic', the number of motor poles is automatically calculated from the motor *Rated Frequency* (00.047), and the motor *Rated Speed* (00.045).

Number of poles = 120 x (Motor *Rated Frequency* (00.047 / Motor *Rated Speed* (00.045) rounded to the nearest even number.

Pr 00.043 {5.10} *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* (00.046) 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 00.040), later in this table).

Pr 00.040 {05.012} *Autotune*

There are four autotune tests available in RFC-A mode, a stationary autotune, a rotating autotune, two mechanical load measurement tests. 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. A mechanical load measurement test should be performed separately to a stationary or rotating autotune.

NOTE

It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2).

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** 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 **00.043**. To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).
- 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 which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (00.047) 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), and the motor saturation breakpoints (Pr **05.029**, Pr **05.030**, Pr **06.062** and Pr **05.063**) are modified by the drive. The *Motor Rated Power Factor* (00.043) is also modified by the *Stator Inductance* (05.025). The No-Load motor core losses are measured and written to *No-Load Core Losses* (04.045). To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).
- Mechanical load measurement test using signal injection.
  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 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 (*Autotune* (00.040) = 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) is set-up.

To perform this autotune test, set Pr **00.040** to 3 and provide the drive with both an enable signal (on terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

- *Mechanical load measurement test using applied torque*.

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 *Rated Speed* (00.045) 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, an *Autotune 1* 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 60 s is allowed for the motor to reach 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.

To perform this autotune test, set Pr **00.040** to 4 and provide the drive with both an enable signal (on terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

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 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702, setting the *Drive Enable* (06.015) to Off (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**).

Pr 00.033 {05.016} *Rated Speed Optimisation Select*

The *Rated Frequency* (00.047) and *Rated Speed* (00.045) are used to define the rated slip of the motor. The rated slip is used in sensorless mode (*Sensorless Mode Active* (03.078) = 1) to correct the motor speed with load. When this mode is active *Rated Speed Optimisation Select* (00.033) has no effect.

If sensorless mode is not active (*Sensorless Mode Active* (03.078) = 0) the rated slip is used in the motor control algorithm and an incorrect value of slip can have a significant effect on the motor performance. If *Rated Speed Optimisation Select* (00.033) = 0 then the adaptive control system is disabled. However, if *Rated Speed Optimisation Select* (00.033) is set to a non-zero value the drive can automatically adjust the *Rated Speed* (00.045) to give the correct value of rated slip. *Rated Speed* (00.045) is not saved at power-down, and so when the drive is powered-down and up again it will return to the last value saved by the user. The rate of convergence and the accuracy of the adaptive controller reduces at low output frequency and low load. The minimum frequency is defined as a percentage of *Rated Frequency* (00.047) by *Rated Speed Optimisation Minimum Frequency* (05.019). The minimum load is defined as a percentage of rated load by *Rated Speed Optimisation Minimum Load* (05.020). The adaptive controller is enabled when a motoring or regenerative load rises above *Rated Speed Optimisation Minimum Load* (05.020) + 5%, and is disabled again when it falls below *Rated Speed Optimisation Minimum Load* (05.020). For best optimisation results the correct values of *Stator Resistance* (05.017), *Transient Inductance* (05.024), *Stator Inductance* (05.025), *Saturation Breakpoint 1* (05.029), *Saturation Breakpoint 2* (05.062), *Saturation Breakpoint 3* (05.030) and *Saturation Breakpoint 4* (05.063) should be used.

Pr 00.038 {04.013} / Pr 00.039 {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* (00.038) 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 00.040, earlier in this table) the drive measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) 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 (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {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. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr **03.016**. If Pr **03.016** = 0, gains Kp1, Ki1 and Kd1 (Pr **00.007** to Pr **00.009)** are used, and if Pr **03.016** = 1, gains Kp2, Ki2 and Kd2 (Pr **03.013** to Pr **03.015**) are used. Pr **03.016** may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains to give a required compliance angle or bandwidth dependant on the setting of Pr **03.017**.

Speed Controller Proportional Gain (Kp), Pr **00.007** {**03.010**} and Pr **03.013**

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 **00.008** {**03.011**} and Pr **03.014**

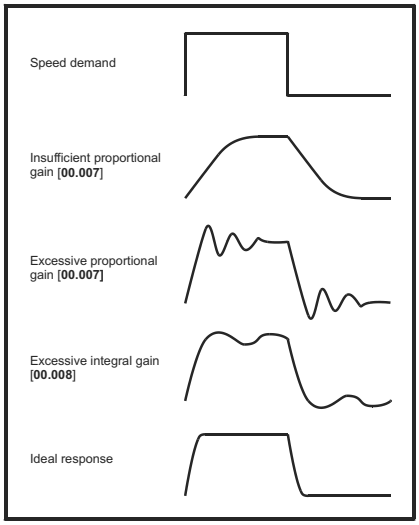
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of 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 **00.009** {**0 3.012**} and Pr **03.015**

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.

There are six methods of tuning the speed loop gains dependant on the setting of Pr **03.017**:

1. Pr **03.017** = 0, User set-up.
   This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.
   Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.
   The proportional gain (Kp) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.
   The integral gain (Ki) should then be increased up to the point where the speed becomes unstable and then reduced slightly.
   It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.
   The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
2. Pr **03.017** = 1, Bandwidth set-up
   If bandwidth based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.020** - Required bandwidth,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia.
   The drive can be made to measure the motor and load inertia by performing a mechanical load measurement autotune (see Autotune Pr **00.040**, earlier in this table).
3. Pr **03.017** = 2, Compliance angle set-up
   If compliance angle based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.019** - Required compliance angle,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia The drive can be made to measure the motor and load inertia by performing a mechanical load measurement autotune (see *Autotune* Pr 00.040, earlier in this table).
4. Pr **03.017** = 3, Kp gains times 16
   If *Speed Controller Set-up Method* (03.017) = 3 the selected proportional gain used by the drive is multiplied by 16.



Pr **03.017** = 4 - 6

If *Speed Controller Set-up Method* (03.017) is set to a value from 4 to 6 the *Speed Controller Proportional Gain Kp1* (03.010) and *Speed Controller Integral Gain Ki1* (03.011) are automatically set up to give the bandwidths given in the table below and a damping factor of unity. These settings give low, standard or high performance.

Speed Controller Set-up Method (03.017)	Performance	Bandwidth
4	Low	5 Hz
5	Standard	25 Hz
6	High	100 Hz

6. Pr **03.017** = 7

If *Speed Controller Set-up Method* (03.017) = 7 then *Speed Controller Proportional Gain Kp1* (03.010), *Speed Controller Integral Gain Ki1* (03.011) and *Speed Controller Differential Feedback Gain Kd1* (03.012) are set up to give a closed-loop speed controller response that approximates to a first order system with a transfer function of $1 / (s\tau + 1)$, where $\tau = 1/\omega bw$ and $\omega bw = 2\pi \times$ *Bandwidth* (03.020). In this case the damping factor is meaningless, and *Damping Factor* (03.021) and *Compliance Angle* (03.019) have no effect.

8.1.3 RFC-A Sensorless mode

Induction motor without position feedback

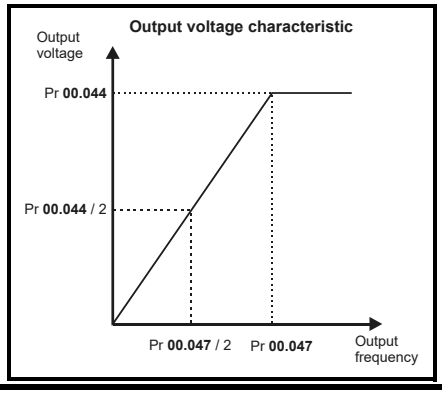
Pr 00.046 {05.007} *Motor Rated Current*	**Defines the maximum motor continuous current**

The motor rated current parameter must be set to the maximum continuous current of the motor. (See section 8.2 *Maximum motor rated current* on page 108, for information about setting this parameter higher than the maximum Heavy Duty current rating.) The motor rated current is used in the following:

- Current limits (see section 8.3 *Current limits* on page 108, for more information).
- Motor thermal overload protection (see section 8.4 *Motor thermal protection* on page 108, for more information)
- Vector control algorithm

Pr 00.044 {05.009} *Rated Voltage*	**Defines the voltage applied to the motor at rated frequency**
Pr 00.047 {05.006} *Rated Frequency*	**Defines the frequency at which rated voltage is applied**

The *Rated Voltage* (00.044) and the *Rated Frequency* (00.047) are used to define the voltage to frequency characteristic applied to the motor (see *Open Loop Control Mode* (00.007), later in this table). The motor rated frequency is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see motor *Rated Speed* (00.045), later in this table).



Pr 00.045 {05.008} *Rated Speed*	**Defines the full load rated speed of the motor**
Pr 00.042 {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. Either a fixed value can be entered in this parameter or an optimization system may be used to automatically adjust this parameter (see *Rated Speed Optimization Select* (05.016), later in this table).

When Pr **00.042** is set to 'Automatic', the number of motor poles is automatically calculated from the motor *Rated Frequency* (00.047), and the motor *Rated Speed* (00.045).

Number of poles = 120 x (Motor *Rated Frequency* (00.047 / Motor *Rated Speed* (00.045) rounded to the nearest even number.

Pr 00.043 {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* (00.046) 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 00.040), later in this table).

Pr 00.040 {05.012} *Autotune*

There are three autotune tests available in RFC-A mode, a stationary test, a rotating test and a mechanical load measurement test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. A mechanical load measurement test should be performed separately to a stationary or rotating autotune.

It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2).

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. *Maximum Deadtime Compensation* (05.059) and *Current At Maximum Deadtime Compensation* (05.060) for the drive are also measured. Additionally, if *Enable Stator Compensation* (05.049) = 1, then *Stator Base Temperature* (05.048) is made equal to *Stator Temperature* (05.046). A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. To perform a stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).
- 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* (00.047) 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), and the motor saturation breakpoints (Pr **05.029**, Pr **05.030**, Pr **06.062** and Pr **05.063**) are modified by the drive. The power factor is also modified for user information only, but is not used after this point as the stator inductance is used in the vector control algorithm instead. To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).
- The mechanical load measurement test can measure the total inertia of the load and the motor. This is used to set the speed loop gains (see Speed loop gains) and to provide torque feed-forwards when required during acceleration.
  Applied torque (sensorless mode) This test may give inaccurate results, if the motor rated speed is not set to the correct value for the motor, or if standard ramp mode is active. During the mechanical load measurement test 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 *Rated Speed* (00.045) 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 an Autotune 1 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 60 s is allowed for the motor to reach 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 quickly enough. If this is the case, the maximum speed reference should be reduced. To perform a mechanical load measurement autotune, set Pr **00.040** to 4, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

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 31, setting the *Drive Enable* (06.015) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**)

Pr 00.038 {04.013} / Pr 00.039 {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* (00.038) 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 **00.040**, earlier in this table) the drive measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) 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 (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {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. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr **03.016**. If Pr **03.016** = 0, gains Kp1, Ki1 and Kd1 (Pr **00.007** to Pr **00.009)** are used, and if Pr **03.016** = 1, gains Kp2, Ki2 and Kd2 (Pr **03.013** to Pr **03.015**) are used. Pr **03.016** may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains to give a required compliance angle or bandwidth dependant on the setting of Pr **03.017**.

Speed Controller Proportional Gain (Kp), Pr **00.007** {**03.010**} and Pr **03.013**

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 **00.008** {**03.011**} and Pr **03.014**

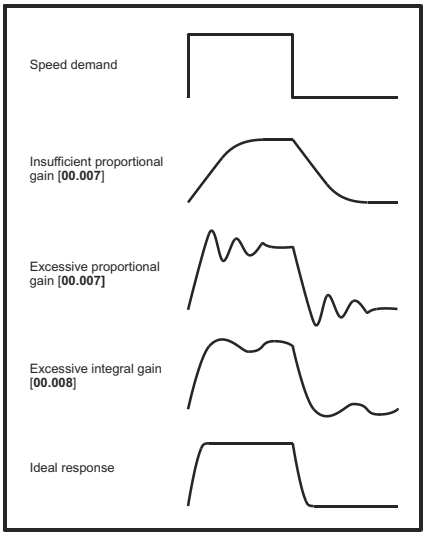
The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of 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 **00.009** {**0 3.012**} and Pr **03.015**

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.

There are six methods of tuning the speed loop gains dependant on the setting of Pr **03.017**:

1. Pr **03.017** = 0, User set-up.
   This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.
   Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.
   The proportional gain (Kp) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.
   The integral gain (Ki) should then be increased up to the point where the speed becomes unstable and then reduced slightly.
   It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.
   The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
2. Pr **03.017** = 1, Bandwidth set-up
   If bandwidth based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.020** - Required bandwidth,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia.
   The drive can be made to measure the motor and load inertia by performing a mechanical load measurement autotune (see Autotune Pr **00.040**, earlier in this table).
3. Pr **03.017** = 2, Compliance angle set-up
   If compliance angle based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.019** - Required compliance angle,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia The drive can be made to measure the motor and load inertia by performing a mechanical load measurement autotune (see *Autotune* Pr 00.040, earlier in this table).
4. Pr **03.017** = 3, Kp gains times 16
   If *Speed Controller Set-up Method* (03.017) = 3 the selected proportional gain used by the drive is multiplied by 16.



5. Pr **03.017** = 4 - 6

If *Speed Controller Set-up Method* (03.017) is set to a value from 4 to 6 the *Speed Controller Proportional Gain Kp1* (03.010) and *Speed Controller Integral Gain Ki1* (03.011) are automatically set up to give the bandwidths given in the table below and a damping factor of unity. These settings give low, standard or high performance.

Pr 03.017	Performance	Bandwidth
4	Low	5 Hz
5	Standard	25 Hz
6	High	100 Hz

6. Pr **03.017** = 7

If *Speed Controller Set-up Method* (03.017) = 7 then *Speed Controller Proportional Gain Kp1* (03.010), *Speed Controller Integral Gain Ki1* (03.011) and *Speed Controller Differential Feedback Gain Kd1* (03.012) are set up to give a closed-loop speed controller response that approximates to a first order system with a transfer function of $1 / (s\tau + 1)$, where $\tau = 1/\omega bw$ and $\omega bw = 2\pi \times$ *Bandwidth* (03.020). In this case the damping factor is meaningless, and *Damping Factor* (03.021) and *Compliance Angle* (03.019) have no effect.

8.1.4 RFC-S mode

Permanent magnet motor with Position feedback

Pr 00.046 {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:

- Current limits (see section 8.3 *Current limits* on page 108, for more information)
- Motor thermal overload protection (see section 8.4 *Motor thermal protection* on page 108, for more information)

Pr 00.042 {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 **00.042** is set to "Automatic" the number of poles is 6.

Pr 00.040 {05.012} *Autotune*

There are four autotune tests available in RFC-S mode, a stationary autotune, a rotating autotune, mechanical load measurement tests to measure load dependent parameters.

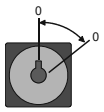
- *Stationary Autotune*

The stationary autotune can be used when the motor is loaded and it is not possible uncouple the load from motor shaft. This test can be used to measure all the necessary parameters for basic control. During the stationary autotune, a test is performed to locate the flux axis of the motor. However this test may not be able to calculate such an accurate value for the *Position Feedback Phase Angle* (00.043) as compared to rotating autotune. A stationary test is performed to measure *Stator Resistance* (05.017), *Ld* (05.024), *Maximum Deadtime Compensation* (05.059), *Current At Maximum Deadtime Compensation* (05.060), *No Load Lq* (05.072). If *Enable Stator Compensation* (05.049) = 1 then *Stator Base Temperature* (05.048) is made equal to *Stator Temperature* (05.046). The *Stator Resistance* (05.017) and the *Ld* (05.024) are then used to set up *Current controller Kp Gain* (00.038) and *Current Controller Ki Gain* (00.039). If sensorless mode is not selected then *Position Feedback Phase Angle* (00.043) is set up for the position from the position feedback interface selected with *Motor Control Feedback Select* (03.026). To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

- *Rotating Autotune*

The rotating autotune must be performed on unloaded motor. This test can be used to measure all the necessary parameters for the basic control and parameters for cancelling the effects of the cogging torque.

During the rotating autotune, *Rated Current* (00.046) is applied and the motor is rotated by 2 electrical revolutions (i.e. up to 2 mechanical revolutions) in the required direction. If sensorless mode is not selected then the *Position Feedback Phase Angle* (00.043) is set-up for the position from the position feedback interface selected with *Motor Control Feedback Select* (03.026). A stationary test is then performed to measure *Stator Resistance* (05.017), *Ld* (05.024), *Maximum Deadtime Compensation* (05.059), *Current At Maximum Deadtime Compensation* (05.060) and *No Load Lq* (05.072). *Stator Resistance* (05.017) and *Ld* (05.024) are used to set up *Current Controller Kp Gain* (00.038) and *Current Controller Ki Gain* (00.039). This is only done once during the test, and so the user can make further adjustments to the current controller gains if required. To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).



- *Mechanical load measurement test using signal injection*

The mechanical load measurement test using signal injection, 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 (including *Torque Per Amp* (05.032)) 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 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 (*Autotune* (00.040) = 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. *Motor And Load Inertia* (03.018) and *Inertia Times 1000* (04.033) are set up.

To perform this autotune test, set Pr **00.040** to 3 and provide the drive with both an enable signal (on terminal 31 on Unidrive M700 / M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700 / M701 and terminal 7 or 8 on Unidrive M702).

- *Mechanical load measurement using applied torque*

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 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 *Rated Speed* (00.045) to determine the inertia from the acceleration/deceleration time. The test attempts to reach the required speed within 5s, 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 60 s 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. To perform this autotune test, set Pr 00.040 to 4 and provide the drive with both an enable signal (on terminal 31 on Unidrive M700/M701 and terminal 11 & 13 on Unidrive M702) and a run signal (terminal 26 or 27 on Unidrive M700/M701 and terminal 7 or 8 on Unidrive M702).

Pr 00.038 {04.013} / Pr 00.039 {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 proportional gain (Pr 00.038) 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 00.040, earlier in this table) the drive measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) 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 (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {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. The drive holds two sets of these gains and either set may be selected for use by the speed controller with Pr **03.016**. If Pr **03.016** = 0, gains Kp1, Ki1 and Kd1 (Pr **00.007** to Pr **00.009**) are used, and if Pr **03.016** = 1, gains Kp2, Ki2 and Kd2 (Pr **03.013** to Pr **03.015**) are used. Pr **03.016** may be changed when the drive is enabled or disabled. If the load is predominantly a constant inertia and constant torque, the drive can calculate the required Kp and Ki gains to give a required compliance angle or bandwidth dependant on the setting of Pr **03.017**.

Speed Controller Proportional Gain (Kp), Pr **00.007** {**03.010**} and Pr **03.013**

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 **00.008** {**03.011**} and Pr **03.014**

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.

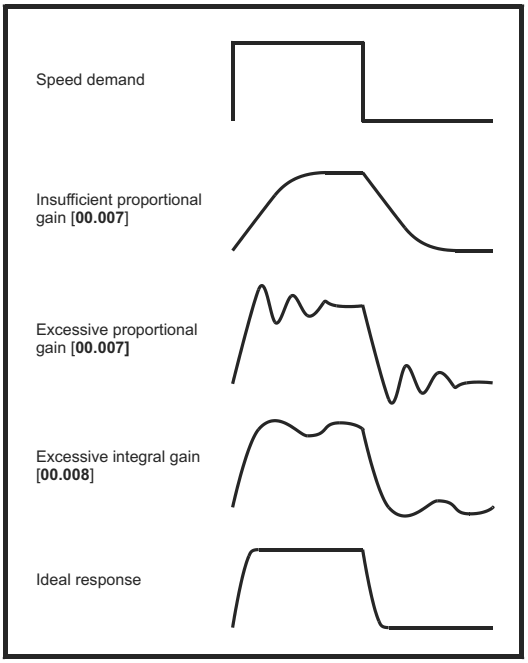
Differential Gain (Kd), Pr **00.009** {**03.012**} and Pr **03.015**

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.

Speed loop gains (cont) (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {03.012})

There are three methods of tuning the speed loop gains dependant on the setting of Pr **03.017**:

1. Pr **03.017** = 0, User set-up.
   This involves the connecting of an oscilloscope to analog output 1 to monitor the speed feedback.
   Give the drive a step change in speed reference and monitor the response of the drive on the oscilloscope.
   The proportional gain (Kp) should be set up initially. The value should be increased up to the point where the speed overshoots and then reduced slightly.
   The integral gain (Ki) should then be increased up to the point where the speed becomes unstable and then reduced slightly.
   It may now be possible to increase the proportional gain to a higher value and the process should be repeated until the system response matches the ideal response as shown.
   The diagram shows the effect of incorrect P and I gain settings as well as the ideal response.
2. Pr **03.017** = 1, Bandwidth set-up
   If bandwidth based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.020** - Required bandwidth,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia.
   The drive can be made to measure the motor and load inertia by performing a mechanical load measurement autotune (see *Autotune* Pr 00.040, earlier in this table).
3. Pr **03.017** = 2, Compliance angle set-up
   If compliance angle based set-up is required, the drive can calculate Kp and Ki if the following parameters are set up correctly:
   Pr **03.019** - Required compliance angle,
   Pr **03.021** - Required damping factor,
   Pr **03.018** - Motor and load inertia The drive can be made to measure the motor and load inertia by performing a mechanical load autotune (see *Autotune* Pr 00.040, earlier in this table).
4. Pr **03.017** = 3, Kp gains times 16
   If *Speed Controller Set-up Method* (03.017) = 3 the selected proportional gain used by the drive is multiplied by 16.



5. Pr **03.017** = 4 - 6
   If *Speed Controller Set-up Method* (03.017) is set to a value from 4 to 6 the *Speed Controller Proportional Gain Kp1* (03.010) and *Speed Controller Integral Gain Ki1* (03.011) are automatically set up to give the bandwidths given in the table below and a damping factor of unity. These settings give low, standard or high performance.

Speed Controller Set-up Method (03.017)	Performance	Bandwidth
4	Low	5 Hz
5	Standard	25 Hz
6	High	100 Hz

6. Pr **03.017** = 7
   If *Speed Controller Set-up Method* (03.017) = 7 then *Speed Controller Proportional Gain Kp1* (03.010), *Speed Controller Integral Gain Ki1* (03.011) and *Speed Controller Differential Feedback Gain Kd1* (03.012) are set up to give a closed-loop speed controller response that approximates to a first order system with a transfer function of $1 / (s\tau + 1)$, where $\tau = 1/\omega bw$ and $\omega bw = 2\pi \times$ *Bandwidth* (03.020). In this case the damping factor is meaningless, and *Damping Factor* (03.021) and *Compliance Angle* (03.019) have no effect.

8.2 Maximum motor rated current

The maximum motor rated current allowed by the drive is greater than the *Maximum Heavy Duty Current Rating* (00.032). The ratio between the Normal Duty rating and the *Maximum Heavy Duty Current Rating* (00.032) varies between drive sizes. The values for the Normal and Heavy Duty rating can be found in the *Power Installation Guide.* If the motor *Rated Current* (00.046) is set above the *Maximum Heavy Duty Current Rating* (00.032), the current limits and the motor thermal protection scheme are modified (see section 8.3 *Current limits* on page 108 and section 8.4 *Motor thermal protection* on page 108 for more information).

8.3 Current limits

The default setting for the current limit parameters is:

- 165 % (141.9 % for frame 9 and above) x motor rated torque producing current for open loop mode
- 175 % (150 % for frame 9 and above) x motor rated torque producing current for RFC-A and RFC-S modes

There are three parameters which control the current limits:

- Motoring current limit: power flowing from the drive to the motor
- Regen current limit: power flowing from the motor to the drive
- Symmetrical current limit: current limit for both motoring and regen operation

The lowest of either the motoring and regen current limit, or the symmetrical current limit applies.

The maximum setting of these parameters depends on the values of motor rated current, drive rated current and the power factor.

Increasing the motor rated current (Pr **00.046**/**05.007**) above the Heavy Duty rating (default value), will automatically reduce the current limits in Pr **04.005** to Pr **04.007**. If the motor rated current is then set to or below the Heavy Duty rating, the current limits will be left at their reduced values.

The drive can be oversized to permit a higher current limit setting to provide higher accelerating torque as required up to a maximum of 1000 %.

8.4 Motor thermal protection

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* (00.012)

I_{Rated} = *Rated Current* (00.046)

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 $[(1 - K_2) (1 - e^{-t/\tau 1}) + K_2 (1 - e^{-t/\tau 2})]$

Where:

T = *Motor Protection Accumulator* (04.019)

K_2 = *Motor Thermal Time Constant 2 Scaling* (04.038) / 100 %

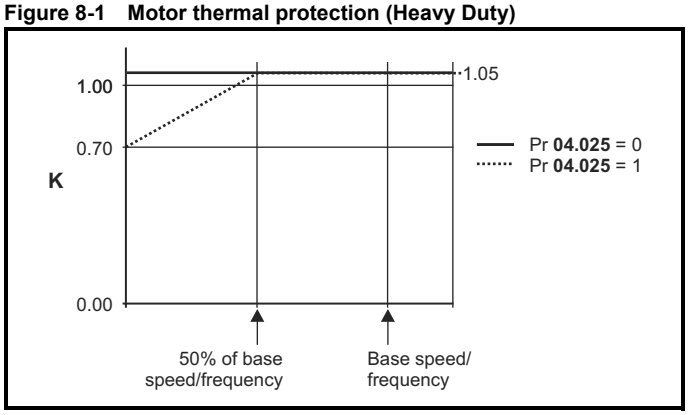
$\tau 1$ = *Motor Thermal Time Constant 1* (00.053)

$\tau 2$ = *Motor Thermal Time Constant 2* (04.037)

K_1 = Varies, see below

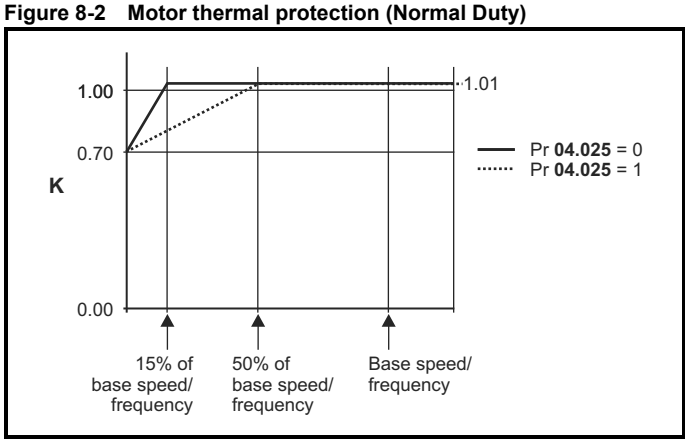
If *Rated Current* (00.046) ≤ *Maximum Heavy Duty Current* (00.032)

Figure 8-1 Motor thermal protection (Heavy Duty)



If Pr **04.025** is 0 the characteristic is for a motor which can operate at rated current over the whole speed range. Induction motors with this type of characteristic normally have forced cooling. If Pr **04.025** is 1 the characteristic is intended for motors where the cooling effect of motor fan reduces with reduced motor speed below 50 % of base speed/ frequency. The maximum value for K1 is 1.05, so that above the knee of the characteristics the motor can operate continuously up to 105 % current.

Figure 8-2 Motor thermal protection (Normal Duty)



Both settings of Pr **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 accumulates the temperature of the motor while the drive remains powered-up. By default, the accumulator is set to the power down value at power-up. If the rated current defined by Pr **00.046** is altered, the accumulator is reset to zero.

The default setting of the thermal time constant (Pr **00.053**) is 89 s which is equivalent to an overload of 150 % for 60 s from cold.

8.5 Switching frequency

The default switching frequency is 3 kHz (6 kHz in RFC-S mode), however this can be increased up to a maximum of 16 kHz by Pr **00.041** (dependent on drive size). The available switching frequencies are shown below.

Table 8-1 Available switching frequencies

Drive size	Model	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
3	All	✓	✓	✓	✓	✓	✓	✓
4								
5								
6								
7								
8								
9E								
10	10202830 to 10203000	✓	✓	✓	✓	✓	✓	✓
	10501520 to 10501900							
	10601500 to 10601780							
	10402700 to 10403200	✓	✓	✓	✓			
11	400 V	✓	✓	✓	✓	✓		
11	575 and 690 V	✓	✓	✓				

If 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 the *Power Installation Guide*.
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 8-1 Sample rates for various control tasks at each switching frequency

Level	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 - 250 µs 16 kHz - 250 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	

8.6 High speed operation

8.6.1 Encoder feedback limits

The maximum encoder frequency should be prevented from exceeding 500 kHz. In RFC-A and RFC-S modes the maximum speed that can be entered in to the speed reference clamps (Pr **00.002** and Pr **00.001**) can be limited by the drive. This is defined by the following (subject to an absolute maximum of 33,000 rpm):

$$\text{Maximum speed limit (rpm)} = \frac{500\text{ kHz} \times 60}{\text{ELPR}}$$

$$= \frac{3.0 \times 10^7}{\text{ELPR}}$$

Where:

ELPR is the equivalent encoder lines per revolution and is the number of lines that would be produced by a quadrature encoder.

- Quadrature encoder ELPR = number of lines per revolution
- F and D encoder ELPR = number of lines per revolution / 2
- SINCOS encoder ELPR = number of sine waves per revolution

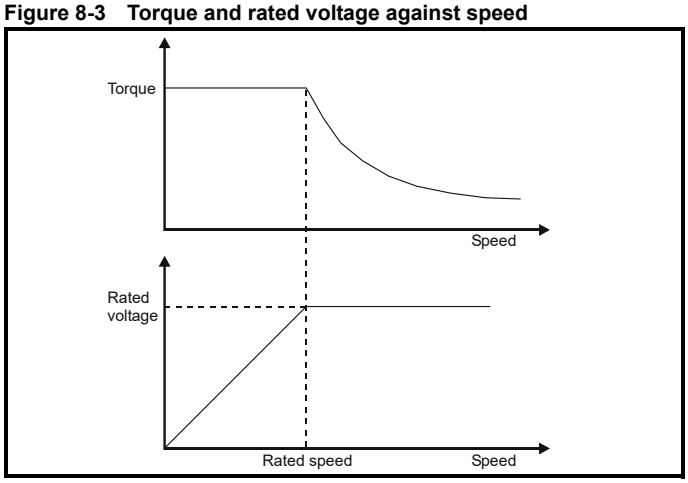
This maximum speed limit is defined by the device selected with the speed feedback selector (Pr **03.026**), and the ELPR set for the position feedback device. In RFC-A mode it is possible to disable this limit via Pr **03.024**, so that the drive can be switched between operation with and without feedback when the speed becomes too high for the feedback device.

8.6.2 Field weakening (constant power) operation

(Open loop and RFC-A mode only)

The drive can be used to run an induction machine above synchronous speed into the constant power region. The speed continues to increase and the available shaft torque reduces. The characteristics below show the torque and output voltage characteristics as the speed is increased above the rated value.

Figure 8-3 Torque and rated voltage against speed



Care must be taken to ensure the torque available above base speed is sufficient for the application to run satisfactorily. The saturation breakpoint parameters (Pr **05.029**, Pr **05. 030**, Pr **05.062** and Pr **05.063**) found during the autotune in RFC-A mode ensure the magnetizing current is reduced in the correct proportion for the specific motor. (In open loop mode the magnetizing current is not actively controlled).

8.6.3 Permanent magnet motor high speed operation

High speed servo mode is enabled by setting Pr **05.022** =1. Care must be taken when using this mode with permanent magnet motor to avoid damaging the drive. The voltage produced by the permanent magnet motor magnets is proportional to speed. For high speed operation the drive must apply currents to the motor to counter-act the flux produced by the magnets. It is possible to operate the motor at very high speeds

that would give a very high motor terminal voltage, but this voltage is prevented by the action of the drive.

If however, the drive is disabled (or tripped) when the motor voltages would be higher than the rating of the drive without the currents to counter-act the flux from the magnets, it is possible to damage the drive. If high speed mode is enabled the motor speed must be limited to the levels given in the table below unless an additional hardware protection system is used to limit the voltages applied to the drive output terminals to a safe level.

Drive voltage rating	Maximum motor speed (rpm)	Maximum safe line to line voltage at the motor terminals (V rms)
200	400 x 1000 / (Ke x √2)	400 / √2
400	800 x 1000 / (Ke x √2)	800 / √2
575	955 x 1000 / (Ke x √2)	955 / √2
690	1145 x 1000 / (Ke x √2)	1145 / √2

Ke is the ratio between r.m.s. line to line voltage produced by the motor and the speed in V/1000 rpm. Care must also be taken not to de-magnetize the motor. The motor manufacturer should always be consulted before using this mode.

By default, high speed operation is disabled (Pr **05.022** = 0).

It is also possible to enable high speed operation and allow the drive to automatically limit the motor speed to the levels specified in the table and generate an *Overspeed.1* trip if the level is exceeded (Pr **05.022** = -1).

8.6.4 Switching frequency

With a default switching frequency of 3 kHz the maximum output frequency should be limited to 250 Hz. Ideally a minimum ratio of 12:1 should be maintained between the switching frequency and the output frequency. This ensures the number of switchings per cycle is sufficient to ensure the output waveform quality is maintained at a minimum level. If this is not possible, quasi-square switching should be enabled (Pr **05.020** =1). The output waveform will be quasi square above base speed ensuring a symmetrical output waveform, which results in a better quality output than would otherwise result.

8.6.5 Maximum speed / frequency

In all operating modes (Open loop, RFC-A and RFC-S) the maximum output frequency is limited to 550 Hz. However, in RFC-S mode the speed is also limited by the voltage constant (Ke) of the motor. Ke is a specific constant for the servo motor being used. It can normally be found on the motor data sheet in V/k rpm (volts per 1,000 rpm).

8.6.6 Quasi-Square wave (open-loop only)

The maximum output voltage level of the drive is normally limited to an equivalent of the drive input voltage minus voltage drops within the drive (the drive will also retain a few percent of the voltage in order to maintain current control). If the motor rated voltage is set at the same level as the supply voltage, some pulse deletion will occur as the drive output voltage approaches the rated voltage level. If Pr **05.020** (Quasi-square wave enable) is set to 1 the modulator will allow over modulation, so that as the output frequency increases beyond the rated frequency the voltage continues to increase above the rated voltage. The modulation depth will increase beyond unity; first producing trapezoidal and then quasi-square waveforms.

This can be used for example:

- To obtain high output frequencies with a low switching frequency which would not be possible with space vector modulation limited to unity modulation depth,

or

- In order to maintain a higher output voltage with a low supply voltage.

The disadvantage is that the machine current will be distorted as the modulation depth increases above unity, and will contain a significant amount of low order odd harmonics of the fundamental output frequency. The additional low order harmonics cause increased losses and heating in the motor.

9 Drive communication

This section details the communication protocols supported on the drives.

The drive is supplied with either an Ethernet interface (Unidrive M700 / M702), or an EIA 485 serial communication interface (Unidrive M701).

For more information on the parameters associated with each interface and the connection details please refer to section 5.12 *Communications* on page 46.

9.1 CT Modbus RTU specification (Unidrive M701)

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.

9.1.1 MODBUS RTU

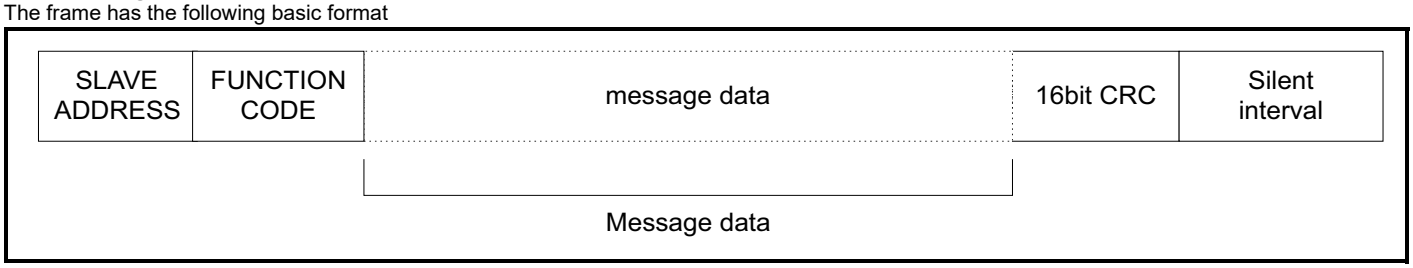
Physical layer

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

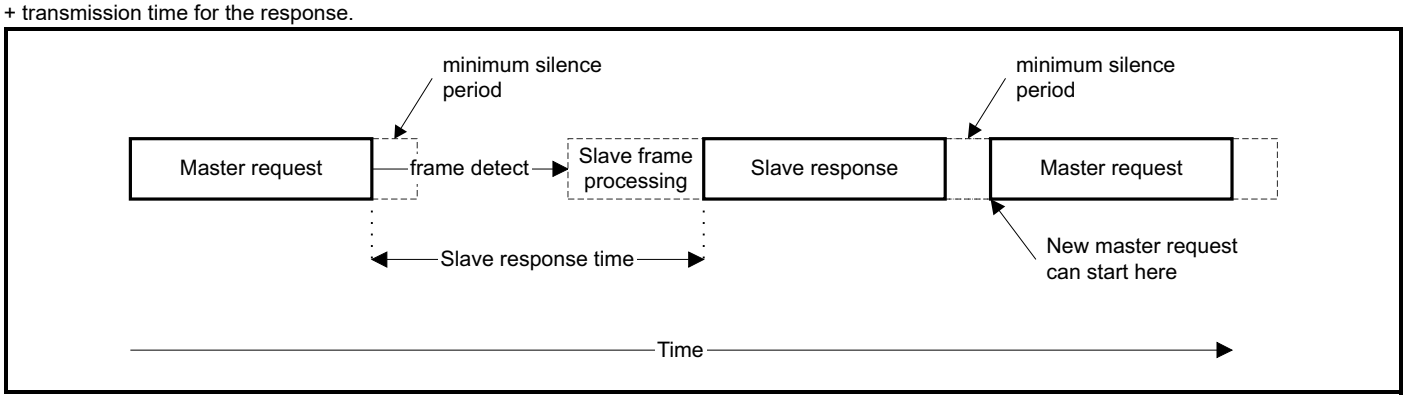


The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2 ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without 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 Nidec Industrial Automation's 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.



9.1.2 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.

9.1.3 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 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* (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* (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 9.1.7 *Extended data types* on page 114 for detail on accessing 32 bit register data.

9.1.4 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.

9.1.5 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

9.1.6 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 9-1 Master request

Byte	Description
0	Slave destination node address 1 through 247, 0 is global
1	Function code 0x03
2	Start register address MSB
3	Start register address LSB
4	Number of 16 bit registers MSB
5	Number of 16 bit registers LSB
6	CRC LSB
7	CRC MSB

Table 9-2 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x03
2	Length of register data in read block (in bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

FC06 Write single register

Writes a value to a single 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 9-3 Master request

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

Table 9-4 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x06
2	Register address MSB
3	Register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

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 9-5 Master request

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 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 9-6 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 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 9-7 Master request

Byte	Description
0	Slave node address 1 through 247, 0 is global
1	Function code 0x17
2	Start register address to read MSB
3	Start register address to read LSB
4	Number of 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 9-8 Slave response

Byte	Description
0	Slave source node address
1	Function code 0x17
2	Length of register data in read block (in bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

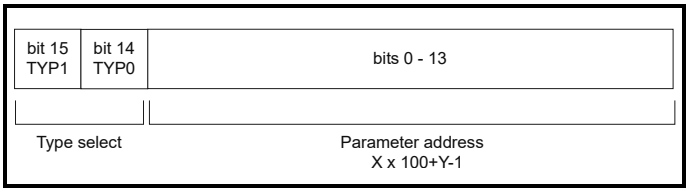
9.1.7 Extended data types

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.



The 2 bit 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 9-9 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 9-10 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

9.1.8 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.

9.1.9 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.

9.1.10 Device compatibility parameters

All devices have the following compatibility parameters defined:

Parameter	Description
Device ID	Unique device identification code
Minimum slave response time	The minimum delay between the end of a message from the master and the time at which the master is ready to receive a response from the slave. Refer to Pr **11.029** (*Minimum Comms Transmit Delay*).
Maximum slave response time	When global addressing, the master must wait for this time before issuing a new message. In a network of devices, the slowest time must be used.
Maximum baud rate	
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.

9.2 Ethernet communication (Unidrive M700 / M702)

This section describes the adaptation of the Ethernet interface offered on the Unidrive M700 and M702 drives. The portable software class which implements this protocol is also defined.

9.2.1 Features

The following list gives an overview of the functionality available:

- Dual RJ45 connectivity with support for shielded twisted pair.
- 100 Mbs Ethernet with auto-negotiation.
- Full and half duplex operation with auto-negotiation.
- Auto crossover detection.
- TCP/IP.
- Modbus TCP/IP.
- EtherNet/IP or Profinet IO.
- Switch or Gateway mode.
- VLAN tagging.
- SyPTPro.
- Unidrive M Connect.
- Machine Control Studio.
- Static IP configuration or DHCP client.
- Non-cyclic data transfer with user program.
- Up to 3 transmit and 3 receive cyclic links (easy mode).
- IEEE1588 Precision Time Protocol synchronization.
- RTMoE (Real Time Motion over Ethernet).

9.2.2 Backup/auxiliary supply

Some drives provide a method of powering up the control circuits (and therefore any option module installed) if the AC supply is removed, this allows Ethernet communication to continue operating when the main AC supply is switched off.

9.2.3 Network design considerations

Ethernet is an open system allowing many different vendors to design and supply equipment. When designing an industrial network you must carefully consider the topology and data traffic on the network to avoid potential problems.

To avoid bandwidth issues it is recommended that the control network is logically separate from any other network. Where possible a physically separate network should be used. If this is not possible, the use of managed network devices should be considered to prevent unnecessary traffic such as broadcasts reaching the control network.

NOTE The use of un-switched hubs is not supported.

9.2.4 Addressing

The addressing system used on Ethernet uses two essential numbers for making connection, these are the IP address and the subnet mask. The address allows a specific device to be located and the subnet mask defines how many bits represent the subnet part of the address and how many bits represent the node address (*see section 9.2.7 Generating the complete address* on page 116). Generally devices on different subnets can only communicate by using a gateway (*typically a router or firewall*).

9.2.5 Where do IP addresses come from?

Every address on a network must be unique. If you do not connect your network to any other networks the assignment of IP addresses is not critical (*although using a standard system is recommended*), as you have full control of the addresses used. The issue of addressing becomes important when connecting multiple networks together or connecting to the Internet where there is a strong possibility of duplication of addresses if a scheme is not followed.

9.2.6 Addressing etiquette

The following list details some points that should be considered when selecting addresses:

- **Reserve address space:** Ensure you have enough reserve address space on your chosen addressing scheme to allow for future expansion.
- **Uniqueness:** Ensure your addresses are unique, every device on a subnet must have a unique address.
- **Avoid reserved addresses:** For example the address 127.0.0.1 is reserved as the loop back address.
- **Broadcast and system addresses:** The highest and lowest host address on a subnet are reserved addresses.
- **Use a system:** Have a scheme for assigning your addresses, for example typically servers may have a low IP address and routers a high IP address. It is not necessary to allocate consecutive IP addresses so it is possible to reserve ranges for specific uses such as servers, work stations or routers.

9.2.7 Generating the complete address

A complete IP address consists of an IP address and a subnet mask, these two numbers are required to allow communication on Ethernet using TCP/IP.

The IP address

The IP address is made up from four 8 bit decimal numbers (*octets*) and is written as follows:

w.x.y.z for example 192.168.0.1

The subnet mask

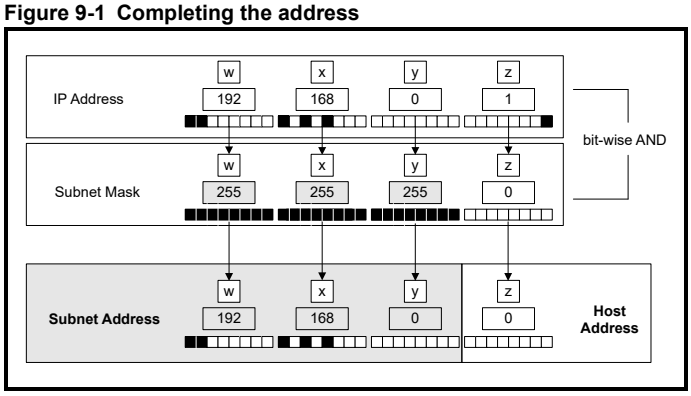
The subnet mask defines what part of the address constitutes the subnet within the IP address and what part of the address constitutes the host address. The subnet mask is bit-wise ANDed with the address to give the subnet to which the host belongs. A typical subnet mask would be 255.255.255.0, this may alternatively be written as '/24' as in the example below, showing an IP address of 192.168.0.1 with a subnet mask of 255.255.255.0. This alternative notation indicates the number of bits representing the subnet part of the address, starting from the most significant bit.

Alternative subnet mask notation: *192.168.0.1 /24*

Completing the address

To determine which part of the address constitutes the network address and which part constitutes the node address, the IP address is bit-wise ANDed with the subnet mask. Figure 9-1 shows how the IP address and subnet mask are used to determine the subnet address and the host address.

Figure 9-1 Completing the address



9.2.8 DHCP considerations

Using fixed IP addressing

Using fixed IP addresses (*manually configured*) means that if a module fails, the IP address can be restored to a replacement module without the need to reconfigure the DHCP server. Using fixed addresses also prevents the DHCP server from changing the address. When using fixed IP addresses, it is vital that the IP address is reserved on the DHCP server to prevent duplicate addressing.

NOTE If using manual IP address configuration please note that the IP address subnet mask and the default gateway must also be set manually.

NOTE In Profinet mode, Pr **4.02.004** (*DHCP Enable*) will be forced off on initialisation.

9.2.9 Basic principles of routing

Routing is required to get TCP/IP packets from one subnet to another. In an IP network, nodes from one subnet cannot communicate directly with nodes on a different subnet. To allow nodes to communicate, a router (*or similar device*) is required to allow the two subnets to exchange data. This means that any node wishing to communicate with a node that is not on its own subnet, must know the address of a router that is on its own subnet. This is sometimes called a gateway or default gateway.

9.3 CT Modbus TCP/IP specification (Unidrive M700 / M702)

Modbus TCP/IP

Modbus TCP/IP is one of the most widely supported industrial Ethernet based protocols offering the functionality and simplicity of the Modbus protocol, with the flexibility of Ethernet. Table 9-11 shows the supported Modbus function codes.

Modbus TCP/IP uses the standard Modbus RTU Protocol Data Unit (PDU) but without the CRC bytes and encapsulates it within a Modbus TCP/IP Application Data Unit (ADU) for transmission. This means that the Modbus PDU is the same for both standard (RTU) and Ethernet based transmission.

Table 9-11 Supported Modbus function codes

Code	Description
3	Read multiple 16 bit registers.
6	Write single 16 bit register.
16	Write multiple 16 bit registers.
23	Read and write multiple 16 bit registers.

9.3.1 Data structure

Communication between devices is based upon Modbus Application Data Units (ADUs), the ADU consists of 2 parts, the Modbus Application Protocol (MBAP) header and the Modbus Protocol Data Unit (PDU).

Figure 9-2 Modbus Data Structure

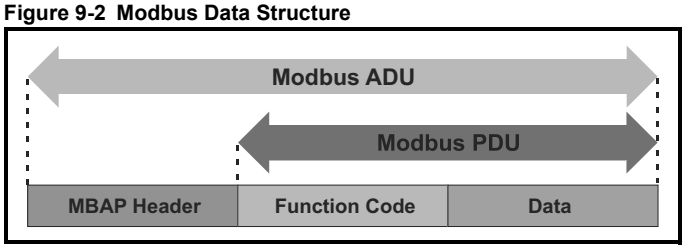


Table 9-12 MBAP Header

Field	Length (Bytes)	Description
Transaction Identifier	2	Uniquely identifies the transaction (0 to 65535)
Protocol Identifier	2	Identifies the protocol (0 = Modbus)
Length	2	Number of following bytes in the message
Unit Identifier	1	Uniquely identifies the destination node (0 to 255)

The unit identifier within the MBAP header is used to identify whether the destination node is the host drive or an option module (not available on the onboard Ethernet interface with firmware versions prior to V01.02.01.10).

Table 9-13 MBAP Unit Identifier

Unit Identifier	Destination
0 or 255	Drive
1	Slot 1
2	Slot 2
3	Slot 3
4	Slot 4 (onboard Ethernet)
254	Self

9.3.2 Data access

Data access using Modbus TCP/IP takes the form of a request for data by the master, followed by a response from the slave indicating success or failure. If no response is received this indicates that the message has not been received or the message is invalid or the node is unable to reply.

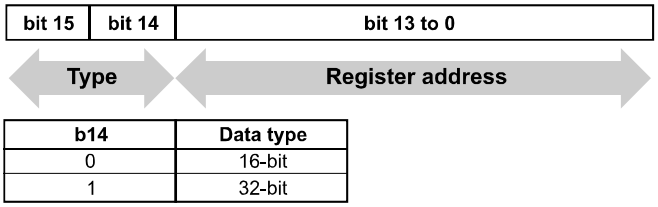
Each drive or option module parameter is internally mapped to a single 16-bit Modbus register, all Modbus function codes access 16-bit registers only. To access a 32-bit parameter, two contiguous Modbus registers must be specified in the request and the 32-bit data access scheme must be used.

9.3.3 32-bit data access

Standard Modbus registers are 16 bits in size and reference a single drive/option module parameter. To access a 32-bit data value the multiple read/write services must be used to transfer a contiguous array of 16-bit registers. To instruct the client to select either 16-bit or 32-bit access bit 14 of the register address is used.

NOTE Bit b15 of the register address is reserved for future use.

Figure 9-3 Data type selection



b14	Data type
0	16-bit
1	32-bit

If 32-bit data type is selected then this effectively adds 16384 (0x4000) to the start register address.

e.g. For drive parameter Pr **01.021** in standard addressing mode, the start register value is 16384 + 120 = 16504 (0x4078)

9.3.4 Supported Modbus function codes

The following table details the supported Modbus function codes.

Table 9-14 Supported Modbus function codes

Function Code		Description
Decimal	Hex (0x)	
3	03	Read multiple 16-bit registers
6	06	Write single 16-bit register
16	10	Write multiple 16-bit registers
23	17	Read and write multiple 16-bit registers

9.3.5 Register addressing

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 *Modbus Register Addressing Mode* (**S.15.013**)) is used.

To access a parameter number above 99 then the modified addressing mode must be used (see *Modbus Register Addressing Mode* (**S.15.013**)), this will allow access to parameter numbers up to 255 but also limit the maximum menu number to 63.

NOTE A reset is not required to activate the change, the addressing mode is effectively made active immediately on changing.

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 9-15 shows how the start register address is calculated for both addressing modes.

Table 9-15 Start register addressing

CT Parameter	Addressing mode	Protocol register			
s.mm.ppp	Standard	mm * 100 + ppp - 1			
	Modified	mm * 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
3.70.001	Standard	7000	1B 58	23384	5B 58
	Modified	N/A	N/A	N/A	N/A
0.03.161	Standard	N/A	N/A	N/A	N/A
	Modified	928	03 A0	17312	43 A0

9.3.6 FC03 – Read multiple registers

This function code allows a contiguous array of registers to be read. The maximum number of registers that can be read is 120, this allows up to 120 16-bit parameters or 60 32-bit parameters to be read in a single transaction. If this is exceeded the server will issue an exception response code 2.

Master request data

Byte	Description
7	Function code 0x03
8	Start register address (MSB)
9	Start register address (LSB)
10	Number of 16-bit registers (MSB)
11	Number of 16-bit registers (LSB)

Slave response data

Byte	Description
7	Function code 0x03
8	Length of data in read block (Bytes)
9	Register data (MSB)
10	Register data (LSB)

The normal response includes the function code, number of data bytes in the read block followed by the register data (unless an exception occurs).

If 32-bit parameter addressing is used, then for each parameter read:

- Two 16-bit registers must be used in the request
- The register data in the response will contain 4 bytes of data

Example

To read drive parameters **0.20.021** to **0.20.023** (transaction ID = 42) with 32-bit data access and standard addressing:

Master request data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 06	Length (Bytes=6)
6	FF	Unit identifier (FF= Drive)
7	03	Function code (3)
8-9	47 E4	Start register (20.20)
10-11	00 06	Number of registers (6)

Slave response data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 0F	Length (Bytes=15)
6	FF	Unit identifier (FF= Drive)
7	03	Function code (3)
8	0C	Data length (Bytes=12)
9-12	?	Pr **0.20.021** data
13-16	?	Pr **0.20.022** data
17-20	?	Pr **0.20.023** data

9.3.7 FC06 – Write single register

This function code writes a single 16-bit value to a register. The normal response is an echo of the request (unless an exception occurs) returned after the parameter has been written.

The register address can be a 32-bit parameter address but only the lower 16 bits of the value will be written.

Master request data

Byte	Description
7	Function code 0x06
8	Start register address (MSB)
9	Start register address (LSB)
10	Register data (MSB)
11	Register data (LSB)

Slave response data

Byte	Description
7	Function code 0x06
8	Start register address (MSB)
9	Start register address (LSB)
10	Register data (MSB)
11	Register data (LSB)

Example

To write the value 12345 to drive parameter **0.20.001** (transaction ID = 42) using standard addressing:

Master request data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 06	Length (Bytes=6)
6	FF	Unit identifier (FF= Drive)
7	06	Function code (06)
8-9	07 D0	Start register (**20.000**)
10-11	30 39	Register data (12345)

Slave response data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 06	Length (Bytes=6)
6	FF	Unit identifier (FF= Drive)
7	06	Function code (6)
8-9	07 D0	Start register (**20.000**)
10-11	30 39	Register data (12345)

9.3.8 FC16 – Write multiple registers

This function code allows a contiguous series of registers to be written. The maximum number of registers that can be written is 120, this allows up to 120 16-bit parameters or 60 32-bit parameters to be read in a single transaction. If this is exceeded the server will issue an exception response code 2.The normal response includes the function code, start register address and number of 16-bit registers written (unless an exception occurs), returned after the parameters have been written.

If 32-bit parameter addressing is used, then for each parameter written:

- Two 16-bit registers must be used in the request
- Four bytes must be specified in the request
- The number of registers written in the response will be twice the number of parameters written

Master request data

Byte	Description
7	Function code 0x10
8	Start register address (MSB)
9	Start register address(LSB)
10	Number of 16-bit registers (MSB)
11	Number of 16-bit registers (LSB)
12	Length of register data to write (Bytes)
13	Register data (MSB)
14	Register data (LSB)

Slave response data

Byte	Description
7	Function code 0x10
8	Start register address (MSB)
9	Start register address (LSB)
10	Number of 16-bit registers written (MSB)
11	Number of 16-bit registers written (LSB)

Example

To write the value 12345 to drive parameters **0.20.021** through **0.20.023** (Transaction ID=42) using standard 32-bit addressing:

Master request data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 13	Length (Bytes=19)
6	FF	Unit identifier (FF= Drive)
7	10	Function code (16)
8-9	47 E4	Start register (**20.020**)
10-11	00 06	Number of registers (6)
12	0C	Register data length (Bytes)
13-16	00 00 30 39	Register data 0
17-20	00 00 30 39	Register data 1
21-24	00 00 30 39	Register data 2

Slave response data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 06	Length (Bytes=6)
6	FF	Unit identifier (FF= Drive)
7	10	Function code (16)
8-9	47 E4	Start register (**20.020**)
10-11	00 06	Registers written (6)

9.3.9 FC23 - Read/Write multiple registers

This function code allows a contiguous series of registers to be written and another contiguous series of registers to be read. The maximum number of registers that can be read is 120 and similarly the maximum number of registers that can be written is 120, this allows up to 120 16-bit parameters or 60 32-bit parameters to be read and / or written in a single transaction. If this is exceeded the server will issue an exception response code 2.

Master request dataSlave response data

Byte	Description
7	Function code 0x17
8	Start read register address (MSB)
9	Start read register address (LSB)
10	Number of registers to read (MSB)
11	Number of registers to read (LSB)
12	Start write register address (MSB)
13	Start write register address (LSB)
14	Number of registers to write (MSB)
15	Number of registers to write (LSB)
16	Length of register data to write (Bytes)
17	Register data 0 (MSB)
18	Register data 0 (LSB)

Byte	Description
7	Function code 0x17
8	Length of data in read block (Bytes)
9	Register data (MSB)
10	Register data (LSB)

The normal response includes the function code, number of data bytes in the read block followed by the register data (unless an exception occurs).

If 32-bit parameter addressing is used:

- For each parameter read or written, two 16-bit registers must be used in the request
- For each parameter written, four bytes must be specified in the request
- For each parameter read, four bytes of data will be used in the response

Example

To write the value 12345 to drive parameters **0.20.021** through **0.20.023** and read the values of parameters **0.20.024** through **0.20.026** (Transaction ID=42) using standard addressing:

Master request data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 17	Length (Bytes=6)
6	FF	Unit identifier (FF= Drive)
7	17	Function code (23)
8-9	47 E7	Start read register (**20.023**)
10-11	00 06	Number of read registers (6)
12-13	47 E4	Start write register (**20.020**)
14-15	00 06	Number of write registers (6)
16	0C	Length of register data to write (Bytes=12)
17-20	00 00 30 39	Register data 0 (12345)
21-24	00 00 30 39	Register data 1 (12345)
25-28	00 00 30 39	Register data 2 (12345)

Slave response data

Byte	Hex value	Description
0-1	00 2A	Transaction ID (42)
2-3	00 00	Protocol ID (0=TCP/IP)
4-5	00 0F	Length (Bytes=15)
6	FF	Unit identifier (FF= Drive)
7	17	Function code (23)
8	0C	Length of data (Bytes=12)
9-12	?? ?? ?? ??	Register data 0 (Pr **20.024**)
13-16	?? ?? ?? ??	Register data 1 (Pr **20.025**)
17-20	?? ?? ?? ??	Register data 2 (Pr **20.026**)

9.3.10 Modbus Exception Response Message

If the master request is rejected then an exception response message will be eturned.

Exception Response Message

Byte	Hex value	Description
0-1	?? ??	Transaction ID (defined by Modbus Master)
2-3	00 00	Protocol ID
4-5	00 03	Number of data bytes to follow
6	??	Unit identifier
7	??	Function code (request FC with bit b7 set to 1)
8	??	Exception code 01 = Function code not supported 02 = Invalid register address

The master request function code will be returned but with bit b7 set (e.g. function code 0x03 will be returned as 0x83).

9.4 RTMoE (Real Time Motion over Ethernet) (Unidrive M700 / M702)

This is a communication protocol developed to provide Ethernet synchronisation and data transfer between Control Techniques drives.

RTMoE provides:

- Drive synchronization using the Precision Time Protocol (PTP) otherwise known as IEEE1588 V2

  Each PTP device has a tuneable clock running. Following an arbitration process the devices select a master and tune their clocks until they are synchronized to that master. This process may take several seconds to complete.
- Data transfer
  - Cyclic data (synchronous and non-synchronous) is sent using the User Datagram Protocol (UDP)
  - Non-cyclic data is sent using the Transmission Control Protocol (TCP)
- Cycle time down to 250 µs (Using Machine Control Studio)
- Jitter less than 1 µs

RTMoE can be configured in two ways:

- Via Machine Control Studio using the Advanced link editor or
- Via parameters using the Easy Mode menus (10 and 11)

The full capabilities of RTMoE are available only when using Machine Control Studio.

Table 9-16 shows the comparison between Easy Mode and Machine Control Studio support levels.

Table 9-16 RTMoE Support levels

Capability	Support Level	
	Easy Mode	**Machine Control Studio (1) (3)**
Non-cyclic communication	No	Yes
Total number of transmit cyclic links	3	11
Total number of receive cyclic links	3	11
Max transmit synchronous links	1	1
Max receive synchronous links	1	1
Max length of non-synchronous link	10 x 32-bit	10 x 32-bit(2)
Max length of synchronous link	3 x 32-bit	3 x 32-bit
Minimum transmission period (non-synchronised)	1 ms	1 ms
Maximum transmission period (non-synchronised)	100 ms	100 ms(3)
Minimum transmission period (Synchronised)	1 ms	250 µs
Maximum transmission period (Synchronised)	8 ms	8 ms
Synchronised with onboard program	Yes (when cycle time = 4 ms)	Yes (when cycle time = 4 ms)
Max parameter accesses per second	6000	6000
Max messages per second (**S.02.004**)	8000	8000

(1) MCi2x0 firmware version V01.08.04.06 and later.

(2) Maximum number of parameter in a non-synchronous links between two MCi210 modules (V01.08.04.06 and later) is 20.

(3) Currently the Ethernet interface only supports cyclic links using Easy Mode (Menu 10), cyclic links using Machine Control Studio will be available in a future release of the Ethernet interface firmware.

NOTE The number of cyclic links is limited to a maximum of 2 when accessing the option module internal parameters (e.g. the PLC register menus 7x).

9.4.1 RTMoE Message rate capability

When designing a network, the message loading for each device should be checked to ensure the number of messages do not exceed the maximum recommended value.

Consider the following example where a Unidrive M700 is communicating with three other devices over Ethernet using Modbus TCP/IP (10 parameters read every 100 ms), EtherNet/IP (5 parameters read every 10 ms and 5 parameters written every 10 ms) and RTMoE (2 parameters written every 500 µs).

Protocol	Number of Parameters	Rate	Parameters accessed / second	Message rate / second
Modbus TCP/IP	10 x read	100 ms	100	10
EtherNet/IP	5 x read	10 ms	500	100
	5 x write	10 ms	500	100
RTMoE	2 x write	500 µs	4000	2000
Total			5100	2210
Maximum supported			6000	8000
Within capability?			✓	✓

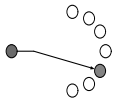
9.4.2 RTMoE Message type

From the system design, it should be known how many drives will be used and what data needs to be sent where. There are two fundamental ways of sharing data:

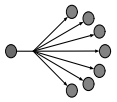
- Cyclic data – use cyclic links for important information relating to the dynamic behavior of the machine (e.g. control word, speed reference, etc.)
- Non-cyclic data – used for non time-critical information (e.g. drive setup data) A user program must be used to control the transfer of non-cyclic messages. (see *Non cyclic enable* (**S.02.035**) and *Non cyclic base parameter* (**S.02.036**))

Each cyclic message can be one of three types:

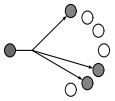
1 Unicast – used if data needs to go from one device to another



2 Broadcast – used if data needs to go from one device to all other devices



3 Multicast – used if data needs to go from one device to a subset of the other devices



By choosing the most appropriate transmission type an efficient and reliable network can be designed.

For example:

- Three drives must use an ELS (Electronic Line Shaft) to follow a Smart Drive. In this case a **multicast** message should be used to transmit the reference position from the Smart Drive.
- Three drives need to return general status information to the Smart Drive. In this case, each drive should send a **unicast** message to the Smart Drive.
- The Smart Drive needs to command all other drives to stop/ start. The Smart Drive should use a broadcast message to transmit the command to all the other drives.

NOTE Broadcast messages should be used with care, bottlenecks in the network can be easily created by using broadcast messages, this will reduce the performance of the network and, in extreme situations, seriously impair the system operation.

9.4.3 Checking for bottlenecks

There are three main reasons why a bottleneck occurs:

1. A drive is receiving more Ethernet messages than it can handle (8000 frames per second).
2. A drive is being asked to access more parameters than it can handle (6000 parameters per second).
3. A segment of the network has reached it's bandwidth limit.
   For a full duplex 100Mbit/sec Ethernet network, assuming all Ethernet messages are the maximum 1500 bytes in length, the bandwidth is 8000 frames/sec in each direction.

NOTE
- It is unrealistic to assume that all messages will be full frames
- In reality the maximum number of frames/sec will be higher
- A more detailed frame analysis may be performed if necessary but the values stated can be used to quickly determine whether bottlenecks could be a problem

9.4.4 RTMoE Message synchronization

Cyclic messages can be synchronized or non-synchronized.

Only one synchronized cyclic link in each direction (one transmit and one receive) is possible so these should only be used for high precision applications where the motion of multiple drives must be closely coupled (e.g. printing applications). All other messages should be sent using a non-synchronized cyclic link.

Synchronized cyclic data links utilise the IEEE1588 clock time distributed across the network. The IEEE1588 clock can synchronize the drive's control loops to within a 1 µs accuracy, Pr **0.11.002** *Option Synchronisation Active* displays the active option slot providing synchronization. With synchronized control loops the Ethernet interface can be used to transfer drive parameters containing motion information, including those from the AMC.

With normal Ethernet there are a number of variables that can impact upon the performance of the network. These include:

- Delays through switches - Ethernet is a switched network and messages are typically copied completely into a switch before being forwarded on. *This is fundamental to modern Ethernet and cannot be influenced by system design.*
- Message length – the longer a message, the longer it will take to transmit and copy into a switch before forwarding it on. For a synchronous cyclic link frame this delay is 12 µs, for a full Ethernet frame it is 120 µs.
  Message length can be controlled, but to maximise compatibility with other Ethernet traffic, it is sensible to allow for full frame Ethernet messages where possible.
- Length of daisy chain - A daisy chain with Ethernet is really a chain of three port switches.
  This can be controlled through physical network design e.g. using a tree structure to limit the length of daisy chains.

The above delays (Latency) are managed in software, in conjunction with PTP, to ensure that all device use synchronous data at the same time, but the length of the daisy chain must be controlled by careful network design.

9.4.5 General guidelines for synchronous cyclic data

The following guidelines provide a simple way of specifying a network supporting synchronous cyclic data that offers accurate synchronization and guaranteed determinism, whilst maintaining compatibility with standard Ethernet traffic.

- Limit daisy chains to 10 drives
- Where more than 10 drives are used, create a tree structure using a switch
- Any Ethernet switches must support IEEE1588 V2
- Segregate the network using VLANs and gateways
- Assign one device to be the synchronization master for each segregated network

9.4.6 Segregating the network

If synchronous cyclic links are used, for best reliability it is sensible to segregate the network. This means:

- Assign one (or more) drive(s) to be a gateway, which ensures messages entering the segregated section are stripped of any existing prioritisation information. (See *Gateway Mode* (**S.02.025**)
- Ensure that **VLAN** (Virtual Local Area Network) is enabled on all devices so that synchronous data can be prioritized as it is passed between switches. (See *VLAN Enable* (**S.02.030**))
- Use multiple Master Clock Domains. (See *Master Clock Domain* (**S.11.002**))

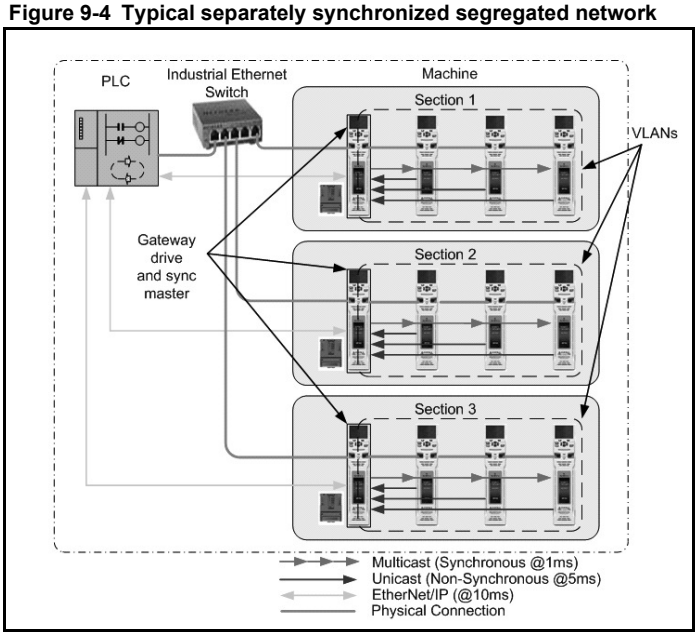
9.4.7 Synchronization master

If a synchronous cyclic link is used then one device must be a synchronous master, if this is an existing 3rd party device then, to minimize the initialization time, all other devices/drives on the network should not be allowed to become the synchronous master. To disable the drive from becoming the synchronous master then set the value in *Preferred Sync Master* (**S.11.001**) to 0, this ensures the drive does not become the synchronous master.

If there is no existing synchronous master then a suitable drive should be chosen (see *Preferred Sync Master* (**S.11.001**)), in choosing which drive to be the synchronous master, the physical position of the drives and network layout should be considered so as to minimize the number of switches each message has to pass through.

A typical segregated network using VLANs and gateways consisting of three separate sections of a machine controlled by one master PLC is shown in the following diagram.

Figure 9-4 Typical separately synchronized segregated network



NOTE Configuring a single drive to act as both gateway and synchronization master will increase the message loading on that drive, in some situations this may result in a reduction of the network performance. In these situations, separate drives should be used for the gateway and synchronization master.

NOTE For the gateway mode to operate correctly, the standard Ethernet network must be connected to port 1 on the drive and the real-time Ethernet to port 2 as shown in Figure 9-4.

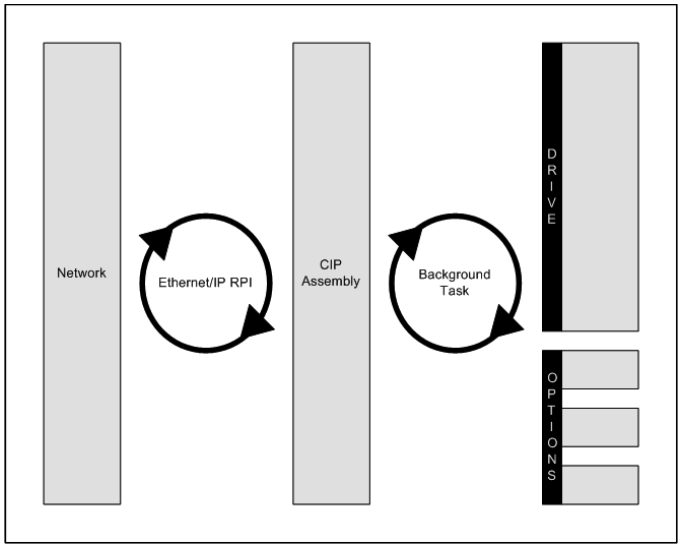
9.4.8 VLANs

To guarantee the timing of synchronous links VLANs must be enabled using *VLAN Enable (**S.02.030**)*. VLANs include a priority field that is applied to all messages. This field is used to apply a higher priority to synchronous cyclic data than other non-deterministic traffic.

9.4.9 Parameter Update Rate

Parameters are exchanged over the network. The value exchanged over the network must be exchanged with the drive or option parameter. The rate of data exchange differs for synchronous and non-synchronous cyclic links as well as for drive and option destinations.

The diagram below depicts the update cycles used within the Ethernet interface. Cyclic link mappings being exchanged with the drive will be updated at the background task rate. This rate (*Background cycles per second* (**S.09.008**)) varies with the load on the Ethernet interface; EtherNet/IP data exchange also takes place in the background task.



9.5 EtherNet/IP specification (Unidrive M700 / M702)

The Ethernet interface supports the EtherNet/IP protocol and conforms to the EtherNet/IP adaptation of the Common Industrial Protocol (CIP) Specification. This is the same upper-layer protocol and object model as used in DeviceNet.

The Ethernet interface module will operate as a slave device and the following functionality is supported:

- Variable length input assembly object (instance 100) with consistency for up to 32 parameters
- Variable length output assembly object (instance 101) with consistency for up to 32 parameters
- User selectable RPI timeout action
- Identity object (class 0x01)
- Motor data object (class 0x28)
- Control supervisor object (class 0x29)
- AC/DC Drive object (class 0x2A)
- Control Techniques objects (classes 0x64 to 0x69)
- Explicit (non-cyclic) access to parameters

9.5.1 Requested Packet Interval (RPI) timeout

This timeout is defined by the EtherNet/IP protocol and is configured in the PLC master. If enabled, the Ethernet interface will monitor the data traffic once the cyclic data has been established, and if data is not received within the specified time, it will perform the requested action as defined by Pr **S.20.011** *RPI timeout action*. This indicates that the interface has detected that the cyclic data communication has been interrupted.

NOTE The RPI timeout action will only occur on a loss of cyclic data message, i.e. after cyclic data has been established and subsequently lost. No action will be taken if no cyclic data has been detected.

9.5.2 Read consistency

Under normal conditions, cyclic data is sampled and transmitted at the Requested Packet Interval (RPI). However, if an option module was in the process of modifying the mapped parameters while these parameters were being sampled, then the data transmitted across the network may not be consistent across the entire assembly object. If read consistency is enabled (**S.20.026** *In Consistency Enable*) and a trigger parameter specified in *In Consistency Trigger Param* (**S.20.027**) then data will only be sampled and transmitted when the trigger parameter *In Consistency Trigger Param* (**S.20.027**) contains a non-zero value. This trigger parameter will then be set to zero after the data has been sampled.

It is therefore possible, by controlling the trigger parameters, that a user program in the drive or option module can ensure that the values in the cyclic data parameters are not sampled until all values are updated.

Whether consistency is enabled or not, data will always be consistent for an individual parameter, i.e. all 4 bytes of a 32-bit value will be consistent.

9.5.3 Write consistency

Under normal conditions, cyclic data is sampled and written at the Requested Packet Interval (RPI). However, if an option module was in the process of reading the mapped parameters while these parameters were being written, then the data obtained may not be consistent across the entire assembly object. If write consistency is enabled (*Out Consistency Enable* (**S.20.028**)) and a trigger parameter specified in *Out Consistency Trigger Param* (**S.20.029**) then new data will only be written to the drive (or option module) when the trigger parameter *Out Consistency Trigger Param* (**S.20.029**) contains a value of zero. This trigger parameter will then be set to one after the data has been written.

It is therefore possible, by controlling the trigger parameters, that a user program in the drive or option module can ensure that the values in the cyclic data parameters are not sampled until all values are updated.

Whether consistency is enabled or not, data will always be consistent for an individual parameter, i.e. all 4 bytes of a 32-bit value will be consistent.

Example

In this example, Pr **0.18.031** is set as the input trigger and Pr **0.18.032** is set as the output trigger. The EtherNet/IP master is configured to check the values of Pr **0.20.011** and Pr **0.20.012** are equal and write the same value to Pr **0.20.021.** The SI-Applications Plus module is configured to generate a ramp value between -32768 and 32767 to write to Pr **0.20.011** and Pr **0.20.012** when the value of Pr **0.20.021** is equal to the ramp value.

With the input and output consistency enabled, parameters Pr **0.20.011** and Pr **0.20.012** will be sampled and transmitted to the EtherNet/IP master when the input trigger parameter Pr **0.18.031** is a non-zero value, Pr **0.20.021** will be written to when the output trigger parameter Pr **0.18.032** is a value of zero.

The parameter changes required are:

S.20.020 *Input assembly object size*	= 8 (bytes)
S.20.021 *Output assembly object size*	= 4 (bytes)
S.20.026 *In Consistency Enable*	= On
S.20.027 *In Consistency Trigger Param*	= 0.18.031
S.20.028 *Out Consistency Enable*	= On
S.20.029 *Out Consistency Trigger Param*	= 0.18.032
S.21.001 *Input mapping parameter 1*	= 0.20.011
S.21.002 *Input mapping parameter 2*	= 0.20.012
S.22.001 *Output mapping parameter 1*	= 0.20.021

The user program in the SI-Applications Plus module may be written as follows (some changes may be necessary to account for bus cycle times and parameter update rates):

```
Initial{
        // Initialise variables
        NewValue% = 0
        #86.03 = 0    // Set digital output0 off
        #86.04 = 0    // Set digital output1 off
        #20.011 = 0   // Set input parameter 1 to 0
        #20.012 = 0   // Set input parameter 2 to 0
        #20.021 = 0   // Set output parameter 1 to 0
        REINIT        // Initialise configuration

} //Initial

Background{
top:

IF #18.32 = 1 THEN
        // Output trigger set
        // Check first sum value against NewValue
        IF #20.021 = NewValue% THEN
                // OK increment values by 1
                NewValue% = NewValue% + 1
                IF NewValue% > 32767 THEN NewValue = -32768
                #20.011 = NewValue%
                #20.012 = NewValue%

                // Set input trigger – Read input parameters and
                transmit to master
                #18.031 = 1

                // Delay for PLC to get inputs - depends on cycle
                time and parameter access time
                DO WHILE #18.031 = 1
                        // Dummy command
                        NewValue% = NewValue%
                LOOP

                // Reset output trigger
                #18.032 = 0

                // Delay for outputs to be written - depends on
                parameter access time
                DO WHILE #18.032 = 0
                        // Dummy command
                        NewValue% = NewValue%
                LOOP

        ELSE
                // ERROR - set DOP0 ON
                #86.03 = 1
        ENDIF
ENDIF

goto top: // main background loop
} //Background
```

9.5.4 Non-cyclic (explicit) data transfer

Non-cyclic or explicit messaging is used to read and write parameters non-cyclically by means of assembly objects. All of the AC Drives profile attributes can be accessed using explicit messaging.

The *Control Techniques* objects provide access to all drive and slot parameters using the following format.

Object	CT Group	CT This Slot	CT Slot 1	CT Slot 2	CT Slot 3	CT Slot 4
Class code	100 (0x64)	101 (0x65)	102 (0x66)	103 (0x67)	104 (0x68)	105 (0x69)
Instance	Menu					
Attribute	Parameter					
Read code	14 (0x0E) Get_Attribute_Single					
Write code	16 (0x10) Set_Attribute_Single					

NOTE An instance value of 0 is not a valid value in this context, therefore an instance value of 200 (0xC8) should be used to access menu 0 parameters. For more information on the *Control Techniques* object see section 9.5.21 *Control Techniques objects* on page 134.

9.5.5 Cyclic (implicit or polled) data transfer

Cyclic data is a method of data transfer that must be setup during network configuration, but is transmitted automatically at the determined rate once configuration is complete.

EtherNet/IP transfers cyclic data using assembly objects, “cyclic data” is sometimes referred to as “Polled data” or “implicit data”.

The terms “input” and “output” refer to data from the perspective of the PLC, an “output” assembly object transfers data from the PLC to the drive, an “input” assembly object transfers data from the drive to the PLC.

NOTE Some PLCs provide the option of transmitting a configuration assembly object. The Ethernet interface does not use a configuration object; if one is required by the PLC then instance 1 should be specified with a length of 0 bytes.

9.5.6 Configuring EtherNet/IP cyclic parameters

In order to use cyclic data over EtherNet/IP, the EtherNet/IP interface must be configured to map the required parameter data to the assembly object.

For drive parameter access, object 100 (0x64) is used for reading parameters and object 101 (0x65) is used for writing parameters. The pre-defined assembly objects as listed in Table 9-17 *Supported drive assembly objects* can also be configured as cyclic data.

9.5.7 Assembly objects

An assembly object is an object which contains a group of attributes to control or monitor the drive operation. These attributes can be members of EtherNet/IP objects or drive parameters. The Ethernet interface supports a series of standard assembly objects and two *Control Techniques* objects (100 and 101) to access the drive parameters (see Table 9-17 *Supported drive assembly objects* on page 125).

NOTE Conformance with the pre-defined assembly objects specification can only be guaranteed if the speed reference configuration of the drive has not been changed from the default settings. For information on setting default values, refer to the appropriate drive user guide.

Table 9-17 Supported drive assembly objects

Assembly object name	Class		Length (Bytes)	Type	Default Mappings	
	Decimal	Hex (0x)			Bytes 0 to 3	Bytes 4 to 7
PrimaryI	100	64	4 to 80	Input	**0.10.040**	**0.02.001**
BscSpdCtrlI	70	46	4	Input		
ExtSpdCtrlI	71	47	4	Input		
SpdTrqCtrlI	72	48	6	Input		
ExtSpdTrqCtrlI	73	49	6	Input		
PrimaryO	101	65	4 to 80	Output	**0.06.042**	**0.01.021**
BscSpdCtrlO	20	14	4	Output		
ExtSpdCtrlO	21	15	4	Output		
SpdTrqCtrlO	22	16	6	Output		
ExtSpdTrqCtrlO	23	17	6	Output		

9.5.8 Basic speed control

Output assembly object 0x14 (20_{10})

The PLC or scanner must be configured for 4 output bytes (or 2 output words) if this assembly object is to be used.

Table 9-18 Basic speed control

Data word	Function
Word 0	Basic control word.
Word 1	Speed reference (*SpeedRef*).

Basic control word

The basic control word consists of 2 bytes (16 bits), with only 2 bits of the low byte being used as shown below.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
					FaultRst		RunFwd

The individual bit functions are described as follows:

Name	Control Word	Description
RunFwd	b0	Set this bit to command the drive to run in the forward direction.
FaultRst	b2	A 0 to 1 transition will reset the drive if the drive was in a trip state.

NOTE For the drive to run at the speed specified in Word 1, Pr **0.06.043** must be *ON* and bit 0, bit 7 and bit 8 of the drive control word (Pr **0.06.042**) must all be set to 1 and the external hardware enable signal must be present.

The individual bit functions for the drive control word are shown in Table 9-19 below.

Table 9-19 Drive control word bit functions

Bit	Function	Equivalent parameter
0	Drive enable	Pr **0.06.015**
1	Run forward	Pr **0.06.030**
2	Jog forward	Pr **0.06.031**
3	Run reverse	Pr **0.06.032**
4	Forward/reverse	Pr **0.06.033**
5	Run	Pr **0.06.034**
6	Not stop	Pr **0.06.039**
7	Auto/manual	N/A
8	Analog/preset reference	Pr **0.01.042**
9	Jog reverse	Pr **0.06.037**
10	Reserved	N/A
11	Reserved	N/A
12	Trip drive	N/A
13	Reset drive	Pr **0.10.033**
14	Keypad watchdog	N/A

Speed reference (*SpeedRef*)

The speed reference word utilises 2 bytes (16 bits) as shown bel**ow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedRef (low byte)							

For more information on the setting of the speed reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.9 Extended speed control

Output assembly object 0x15 (21_{10})

The PLC or scanner must be configured for 4 output bytes (or 2 output words) if this assembly object is to be used.

Table 9-20 Extended speed control

Data word	Function
Word 0	Extended control word.
Word 1	Speed reference (*SpeedRef*).

Extended control word

The extended control word consists of 2 bytes (16 bits), with only the low byte used as shown.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
	NetRef	NetCtrl			FaultRst	RunRev	RunFwd

The individual bit functions are described as follows:

Name	Control Word	Description
RunFwd	b0	Set this bit to command the drive to run in the forward direction.
RunRev	b1	Set this bit to command the drive to run in the reverse direction.
FaultRst	b2	A 0 to 1 transition will reset the drive if the drive was in a trip state.
NetCtrl	b5	Used in conjunction with Pr **0.06.043** to enable the drive control word bits b0-b6 and bit 9 (Pr **0.06.042**).
NetRef	b6	Set this bit to command the drive to use the remote speed reference value specified in Word 1.

NOTE For the drive to run at the speed specified in Word 1, Pr **0.06.043** must be *ON* and bit 0, bit 7 and bit 8 of the drive control word (Pr **0.06.042**) must all be set to 1 and the external hardware enable signal must be present.

NOTE For information on the drive control word see Table 9-19 *Drive control word bit functions* on page 126.

NOTE Conformance with the pre-defined assembly objects specification can only be guaranteed if the speed reference configuration of the drive has not been changed from the default settings. For information on setting default values, refer to the appropriate drive user guide.

Speed reference (*SpeedRef*)

The speed reference word utilises 2 bytes (16 bits) as shown b**elow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedRef (low byte)							

For more information on the setting of the speed reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.10 Basic speed and torque control

Output assembly object 0x16 (22_{10})

The PLC or scanner must be configured for 6 output bytes (or 3 output words) if this assembly object is to be used.

Table 9-21 Basic speed and torque control

Data Word	Function
Word 0	Basic control word.
Word 1	Speed reference (*SpeedRef*).
Word 2	Torque reference (*TorqueRef*).

Basic control word

The basic control word consists of 2 bytes (16 bits), with only 2 bits of the low byte being used as shown below.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
					FaultRst		RunFwd

The individual bit functions are described as follows:

Name	Control Word	Description
RunFwd	b0	Set this bit to command the drive to run in the forward direction.
FaultRst	b2	A 0 to 1 transition will reset the drive if the drive was in a trip state.

NOTE For the drive to run at the speed specified in Word 1, Pr **0.06.043** must be *ON* and bit 0, bit 7 and bit 8 of the drive control word (Pr**0.06.043**) must all be set to 1.

NOTE For information on the drive control word see Table 9-19 *Drive control word bit functions* on page 126.

Speed reference (*SpeedRef*)

The speed reference word utilises 2 bytes (16 bits) as shown b**elow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedRef (low byte)							

For more information on the setting of the speed reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

Torque reference (*TorqueRef*)

The torque reference word utilises 2 bytes (16 bits) as shown below.

b15	b14	b13	b12	b11	b10	b9	b8
TorqueRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
TorqueRef (low byte)							

For more information on the setting of the torque reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.11 Extended speed and torque control

Output assembly object 0x17 (23_{10})

The PLC or scanner must be configured for 6 output bytes (or 3 output words) if this assembly object is to be used.

Table 9-22 Extended speed and torque control

Data word	Function
Word 0	Extended control word.
Word 1	Speed reference (*SpeedRef*).
Word 2	Torque reference (*TorqueRef*).

Extended control word

The extended control word consists of 2 bytes (16 bits), with only 5 bits of the low byte used as shown below.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
	NetRef	NetCtrl			FaultRst	RunRev	RunFwd

The individual bit functions are described as follows:

Name	Control Word	Description
RunFwd	b0	Set this bit to command the drive to run in the forward direction.
RunRev	b1	Set this bit to command the drive to run in the reverse direction.
FaultRst	b2	A 0 to 1 transition will reset the drive if the drive was in a trip state.
NetCtrl	b5	Used in conjunction with Pr **06.043** to enable the drive control word bits b0-b6 and bit 9 (Pr **06.042**).
NetRef	b6	Set this bit to command the drive to use the remote speed reference value specified in Word 1.

NOTE For the drive to run at the speed specified in Word 1, Pr **06.043** must be *ON* and bit 0, bit 7 and bit 8 of the drive control word (Pr **06.042**) must all be set to 1 and the external hardware enable signal must be present.

NOTE For information on the drive control word see Table 9-19 *Drive control word bit functions* on page 126.

Speed reference (*SpeedRef*)

The speed reference word utilises 2 bytes (16 bits) as shown b**elow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedRef (low byte)							

For more information on the setting of the speed reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

Torque reference (*TorqueRef*)

The torque reference word utilises 2 bytes (16 bits) as shown belo**w.**

b15	b14	b13	b12	b11	b10	b9	b8
TorqueRef (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
TorqueRef (low byte)							

For more information on the setting of the torque reference see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.12 Basic speed feedback

Input assembly object 0x46 (70_{10})

The PLC or scanner must be configured for 4 input bytes (or 2 input words) if this assembly object is to be used.

Table 9-23 Basic speed feedback

Data word	Function
Word 0	Basic status word.
Word 1	Speed feedback (*SpeedActual*).

Basic status word

The basic status word consists of 2 bytes (16 bits), with only 2 bits of the low byte used as shown below.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
					Running 1 (Fwd)		Faulted

The individual bit functions are described as follows:

Bit	Name	Description
b0	Faulted	Indicates whether the drive is OK or tripped (0=OK, 1=Tripped).
b2	Running1 (Fwd)	Indicates if the drive is running in the forward direction (0=False, 1=True).

Speed feedback (*SpeedActual*)

The speed feedback word utilises 2 bytes (16 bits) as shown be**low.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedActual (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedActual (low byte)							

For more information on the speed feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.13 Extended speed feedback

Input assembly object 0x47 (71_{10})

The PLC or scanner must be configured for 4 input bytes (or 2 input words) if this assembly object is to be used.

Table 9-24 Extended speed feedback

Data word	Function
Word 0	Extended status word.
Word 1	Speed feedback (*SpeedActual*).

Extended status word

The extended status word consists of 2 bytes (16 bits), with the bits having functions as shown below.

b15	b14	b13	b12	b11	b10	b9	b8
DriveState							

b7	b6	b5	b4	b3	b2	b1	b0
At Reference	RefFrom Net	CtrlFrom Net	Ready	Running2 (Rev)	Running1 (Fwd)	Warning	Faulted

The DriveState byte returns a code to indicate the operating state of the drive as shown in Table 9-25 following.

Table 9-25 DriveState codes

Code	b15 - b8	State	Description
1	00000001	Startup	This state is skipped over on CT drives.
2	00000010	Not_Ready	Inhibit.
3	00000011	Ready	Ready.
4	00000100	Enabled	Run or Stop.
5	00000101	Stopping	Deceleration or Injection.
6	00000110	Fault_Stop	AC_UU (this will only occur if Mains Loss is enabled).
7	00000111	Faulted	Tripped.
0	00000000	Vendor Specific	All other DriveType states, e.g. Scan, Orienting, Regen Active, etc.

The individual bits of the low byte of the extended status word are described below.

Extended status word (low byte)

Name	Bit	Description
Faulted	b0	Indicates whether the drive is OK or tripped. 0=OK (Pr **0.10.001**=1). 1=Tripped (Pr **0.10.001**=0).
Warning	b1	Indicates if one of the drive alarms is active.
Running1 (Fwd)	b2	Indicates if the drive is running in the forward direction. 0=False, 1=True.
Running2 (Rev)	b3	Indicates if the drive is running in the reverse direction. 0=False, 1=True.
Ready	b4	The 'Ready' bit is set depending on which state the drive is in. Ready = True. Enabled = True. Stopping = True. All others = False.
CtrlFromNet	b5	Indicates if the drive is being controlled from the 'Drive Control Word'. 0=False, 1=True.
RefFromNet	b6	Indicates if the speed reference is derived from Pr **0.01.021.** 0=False (Pr **0.01.050**<>1 OR Pr **0.01.049**<>3). 1=True (Pr **0.01.050**=1 AND Pr **0.01.049**=3).
AtReference	b7	Indicates if the drive speed has reached the set reference. 0=False (Pr **0.10.006**=0). 1=True (Pr **0.10.006**=1).

Speed feedback (*SpeedActual*)

The speed feedback word utilises 2 bytes (16 bits) as shown bel**ow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedActual (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedActual (low byte)							

For more information on the speed feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.14 Basic speed and torque feedback

Input assembly object 0x48 (72_{10})

The PLC or scanner must be configured for 6 input bytes (or 3 input words) if this assembly object is to be used.

Table 9-26 Basic speed and torque feedback

Data word	Function
Word 0	Basic status word.
Word 1	Speed feedback (*SpeedActual*).
Word 2	Torque feedback (*TorqueActual*).

Basic status word

The basic status word consists of 2 bytes (16 bits), with only the low byte used as shown below.

b15	b14	b13	b12	b11	b10	b9	b8

b7	b6	b5	b4	b3	b2	b1	b0
					Running1 (Fwd)		Faulted

The individual bit functions are described as follows:

Bit	Name	Description
b0	Faulted	Indicates whether the drive is OK or tripped (0=OK, 1=Tripped).
b2	Running1 (Fwd)	Indicates if the drive is running in the forward direction (0=False, 1=True).

Speed feedback (*SpeedActual*)

The speed feedback word utilises 2 bytes (16 bits) as shown b**elow.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedActual (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedActual (low byte)							

For more information on the speed feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

Torque feedback (*TorqueActual*)

The torque feedback word utilises 2 bytes (16 bits) as shown below.

b15	b14	b13	b12	b11	b10	b9	b8
TorqueActual (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
TorqueActual (low byte)							

For more information on the torque feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.15 Extended speed and torque feedback

Input assembly object 0x49 (73_{10})

The PLC or scanner must be configured for 6 input bytes (or 3 input words) if this assembly object is to be used.

Table 9-27 Basic speed and torque feedback

Data word	Function
Word 0	Extended status word.
Word 1	Speed feedback (*SpeedActual*).
Word 2	Torque feedback (*TorqueActual*).

Extended status word

The extended status word consists of 2 bytes (16 bits), with the bits having functions as shown below.

b15	b14	b13	b12	b11	b10	b9	b8
DriveState							

b7	b6	b5	b4	b3	b2	b1	b0
At Reference	RefFrom Net	CtrlFrom Net	Ready	Running2 (Rev)	Running1 (Fwd)	Warning	Faulted

The DriveState byte returns a code to indicate the operating state of the drive as shown in Table 9-28.

Table 9-28 DriveState codes

Code	b15 - b8	State	Description
1	00000001	Startup	This state is skipped over on CT drives.
2	00000010	Not_Ready	Inhibit.
3	00000011	Ready	Ready.
4	00000100	Enabled	Run or Stop.
5	00000101	Stopping	Deceleration or Injection.
6	00000110	Fault_Stop	AC_UU (this will only occur if Mains Loss is enabled).
7	00000111	Faulted	Tripped.
0	00000000	Vendor Specific	All other DriveType states, e.g. Scan, Orienting, Regen Active, etc.

The individual bits of the low byte of the extended status word are described in Table 9-29 *Extended status word (low byte)* on page 129.

Table 9-29 Extended status word (low byte)

Name	Bit	Description
Faulted	b0	Indicates whether the drive is OK or tripped. 0=OK (Pr **0.10.001**=1). 1=Tripped (Pr **0.10.001**=0).
Warning	b1	Indicates if one of the drive alarms is active.
Running1 (Fwd)	b2	Indicates if the drive is running in the forward direction. 0=False, 1=True.
Running2 (Rev)	b3	Indicates if the drive is running in the reverse direction. 0=False, 1=True.
Ready	b4	The 'Ready' bit is set depending on which state the drive is in. Ready = True. Enabled = True. Stopping = True. All others = False.
CtrlFromNet	b5	Indicates if the drive is being controlled from the 'Drive Control Word'. 0=False, 1=True.
RefFromNet	b6	Indicates if the speed reference is derived from Pr **0.01.021.** 0=False (Pr **0.01.050**<>1 OR Pr **0.01.049**<>3). 1=True (Pr **0.01.050**=1 AND Pr **0.01.049**=3).
AtReference	b7	Indicates if the drive speed has reached the set reference. 0=False (Pr **0.10.006**=0). 1=True (Pr **0.10.006**=1).

Speed feedback (*SpeedActual*)

The speed feedback word utilises 2 bytes (16 bits) as shown be**low.**

b15	b14	b13	b12	b11	b10	b9	b8
SpeedActuall(high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
SpeedActual (low byte)							

For more information on the speed feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

Torque feedback (*TorqueActual*)

The torque feedback word utilises 2 bytes (16 bits) as shown below.

b15	b14	b13	b12	b11	b10	b9	b8
TorqueActual (high byte)							

b7	b6	b5	b4	b3	b2	b1	b0
TorqueActual (low byte)							

For more information on the torque feedback see Table 9-40 *AC/DC Drive object attributes* on page 133.

9.5.16 Object Model

The Object Model has the following object classes present.

Table 9-30 Supported Objects

Object Class	Class Code		Number of Instances	Effect
	Decimal	Hex (0x)		
Identity	1	01	1	Provides device specific information.
Assembly	4	04	16	Defines the I/O data format (parameter mapping).
Motor Data	40	28	2	Defines the motor data.
Control Supervisor	41	29	1	Provides drive control and monitoring information.
AC/DC Drive	42	2A	1	Provides drive configuration and running state information.
CT Group	100	64	<No. of menus>	Provides access to drive parameters.
CT This Slot	101	65	<No. of menus>	Provides access to the local option module parameters.
CT Slot 1	102	66	<No. of menus>	Provides access to the option module parameters in slot 1.
CT Slot 2	103	67	<No. of menus>	Provides access to the option module parameters in slot 2.
CT Slot 3	104	68	<No. of menus>	Provides access to the option module parameters in slot 3.
CT Slot 4	105	69	<No. of menus>	Provides access to the onboard Ethernet interface parameters.

9.5.17 Identity object

Class: 0x01 (1_{10})

The identity object provides identification of and general information about the device.

Table 9-31 Identity object

Attribute	Access	Name	Data Type
1	Get	VendorID	UINT
2	Get	DeviceType	UINT
3	Get	ProductCode	UINT
4	Get	Revision	USINT
6	Get	SerialNumber	UDINT
7	Get	ProductName	SHORT_STRING

Vendor ID

Name:	VendorID		
Class	0x01	Default	0x101 (257_{10})
Instance	0x01	Data Type	UINT
Attribute	0x01	Access	Get

Returns the vendor ID code 0x101 (257_{10}) for *Control Techniques*.

Device type

Name:	DeviceType		
Class	0x01	Default	0x02
Instance	0x01	Data Type	UINT
Attribute	0x02	Access	Get

Returns the device type code. The following codes are used:

Device Type code	Drive type
0x02	AC Drive

Product code

Name:	Product Code		
Class	0x01	Default	See below
Instance	0x01	Data Type	UINT
Attribute	0x03	Access	Get

Returns a 16 bit value to identify the drive type and drive mode and also links a node to the installed EDS files. The product code is calculated as shown in Table 9-32 *Product code bit allocation* below.

Table 9-32 Product code bit allocation

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Drive Type					Drive Derivative					Drive Mode			CIP code		

Drive Type (b15 to b11)

The drive type is defined as follows:

Value	Drive Type
2	Unidrive M

Drive Derivative (b10 to b6)
The drive derivative as shown in Pr **0.11.028**.

For more information on the drive derivative codes please refer to the relevant drive documentation.

Drive Mode (b5 to b3)
The drive operating mode is defined as follows:

Value	Operating Mode
0	Open-loop
1	RFC-A
2	RFC-S
3	Regen

CIP code (b2 to b0)
The CIP (Common Industrial Protocol) interface code is defined as follows:

Value	Interface ID	Description
0	430	Unidrive M700 onboard Ethernet
1	447	SI-DeviceNet
2	310	MCi210
3	433	SI-Ethernet

Revision

Name:	Revision		
Class	0x01	Default	N/A
Instance	0x01	Data Type	ARRAY of USINT
Attribute	0x04	Access	Get

Returns 2 bytes to indicate the major and minor revision numbers of the Ethernet interface firmware version.

The Ethernet interface firmware version (**MM.002**) consists of four 2-digit decimal numbers with the following significance:

[Major].[Minor].[Bugfix].[Build].

The revision code returns the major and minor revisions of the Ethernet interface firmware version in two unsigned bytes, the major revision being returned first followed by the minor revision.

Table 9-33 Revision specification

b7	b6	b5	b4	b3	b2	b1	b0
Major revision (**MM.002** / 1000000)							
R	Minor revision (**MM.002** / 10000) Mod 100						

Where “Mod 100” refers to the fractional value of the result from **MM.002/**10000, (the value after the decimal point).

e.g. For a value of 12345678 in Pr **MM.002** (12.34.56.78 on the keypad display), the major revision is 12 and the minor revision is 34.

The returned data will consist of 2 unsigned bytes, the first byte will be the major revision value 12 (0x0C) and the second byte will be the minor revision value 34 (0x22).

Major revision

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	1	1	0	0
Major revision = 12 (0x0C)							

Minor revision

	b6	b5	b4	b3	b2	b1	b0
	0	1	0	0	0	1	0
	Minor revision = 34 (0x22)						

Serial Number

Name:	SerialNumber		
Class	0x01	Default	N/A
Instance	0x01	Data Type	UDINT
Attribute	0x06	Access	Get

Returns the lower 4 bytes (32 bits) of the Ethernet interface serial number.

The Ethernet interface serial number is contained within two adjacent parameters, Pr **MM.004** *Serial Number LS* displays the least 8 significant decimal digits and Pr **MM.005** *Serial Number MS* displays the most 8 significant decimal digits.

For example, if the serial number of the onboard Ethernet interface is 123456789 then Pr **MM.005** *Serial Number MS* will display 1 and Pr **MM.004** *Serial Number LS* will display 23456789.

The Ethernet interface serial number is set during manufacture and cannot be changed.

Product Name

Name:	ProductName			
Class	0x01	Default	Onboard Ethernet	Factory Fitted Ethernet
			SI-Ethernet	SI-Ethernet
Instance	0x01	Data Type	SHORT_STRING	
Attribute	0x07	Access	Get	

Returns the product name as a short string of ASCII Bytes. The first byte specifies the number of following bytes that constitute the product name.

9.5.18 Motor data object

Class: 0x28 (40_{10})

There are 2 instances of the Motor data object. Instance 1 will represent menu 5 motor information (motor 1) and instance 2 will represent menu 21 motor information (motor 2). The instance being used by the other dependant objects will be determined by Pr **0.11.045**, to use the second motor map objects (instance 2), Pr **0.11.045** should be set to *Motor 2*. Pr **0.11.045** is polled in the background task, so the user should be

aware that during motor map changeover, the RPM speed reference may not be accurate. The available attributes and associated functions for the AC motor data object are shown in Table 9-34 *AC Motor data object attributes* below.

Table 9-34 AC Motor data object attributes

AC Motor Instance Attributes			Drive Parameter	
Attribute ID	**Name**	**Access**	**Instance 1**	**Instance 2**
0x03 (3_{10})	MotorType (*)	Get/Set	None	None
0x06 (6_{10})	RatedCurrent	Get/Set	**Pr 0.05.007** (scaled to 100 mA units)	**Pr 0.21.007** (scaled to 100 mA units)
0x07 (7_{10})	RatedVoltage	Get/Set	**Pr 0.05.009**	**Pr 0.21.009**
0x09 (9_{10})	RatedFreq	Get/Set	**Pr 0.05.006** (scaled to Hz)	**Pr 0.21.006 (scaled to Hz)**
0x0F (15_{10})	BaseSpeed	Get/Set	**Pr 0.05.008** (scaled to rpm units)	**Pr 0.21.008** (scaled to rpm units)
0x64 (100_{10})	Motor2Select	Get	**Pr 0.21.015**	**Pr 0.21.015**
		Set	**Pr 0.11.045**	**Pr 0.11.045**

(* The MotorType attribute has no effect on drive operation, it is only used to provide information to the user as shown in Table 9-35 *Supported motor types* below).

Table 9-35 Supported motor types

Value	Motor Type
6	Wound rotor induction motor
7	Squirrel cage induction motor (default)
9	Sinusoidal PM BL motor
10	Trapezoidal PM BL motor

NOTE In Open loop mode, only values 6 and 7 will be supported.

Motor type

Name:	**MotorType1**		
Class	0x28	**Default**	7
Instance	0x01	**Data Type**	USINT
Attribute	0x03	**Access**	Get/Set

Returns or sets the motor type to be used by the drive for instance 1.

Name:	**MotorType2**		
Class	0x28	**Default**	7
Instance	0x02	**Data Type**	USINT
Attribute	0x03	**Access**	Get/Set

Returns or sets the motor type to be used by the drive for instance 2.

Rated current

Name:	**RatedCurrent1**		
Class	0x28	**Default**	Pr **0.05.007** / 10
Instance	0x01	**Data Type**	USINT
Attribute	0x06	**Access**	Get/Set

Returns or sets the rated motor current in Amps for instance 1. This attribute is linked to Pr **0.05.007**.

Set Pr **0.05.007** = RatedCurrent1 * 10.

Get RatedCurrent1 = Pr **0.05.007** / 10.

Name:	**RatedCurrent2**		
Class	0x28	**Default**	Pr **0.21.007** / 10
Instance	0x02	**Data Type**	USINT
Attribute	0x06	**Access**	Get/Set

Returns or sets the rated motor current in Amps for instance 2. This attribute is linked to Pr **0.21.007**.

Set Pr **0.21.007** = RatedCurrent2 * 10.

Get RatedCurrent2 = Pr **0.21.007** / 10.

Rated voltage

Name:	**RatedVoltage1**		
Class	0x28	**Default**	Pr **0.05.009**
Instance	0x01	**Data Type**	USINT
Attribute	0x07	**Access**	Get/Set

Returns or sets the rated motor voltage in Volts for instance 1. This attribute is linked to Pr **0.05.009**.

Name:	**RatedVoltage2**		
Class	0x28	**Default**	Pr **0.21.009**
Instance	0x02	**Data Type**	USINT
Attribute	0x07	**Access**	Get/Set

Returns or sets the rated motor voltage in Volts for instance 2. This attribute is linked to Pr **0.21.009**.

Rated frequency

Name:	**RatedFreq1**		
Class	0x28	**Default**	Pr **0.05.006** / 10
Instance	0x01	**Data Type**	USINT
Attribute	0x09	**Access**	Get/Set

Returns or sets the rated motor frequency in Hertz for instance 1. This attribute is linked to Pr **0.05.006**.

Set Pr **0.05.006** = RatedFreq1 * 10.

Get RatedFreq1 = Pr **0.05.006** / 10.

Name:	**RatedFreq2**		
Class	0x28	**Default**	Pr **0.21.006** / 10
Instance	0x02	**Data Type**	USINT
Attribute	0x09	**Access**	Get/Set

Returns or sets the rated motor frequency in Hertz for instance 2. This attribute is linked to Pr **21.006**.

Set Pr **0.21.006** =RatedFreq2 * 10.

Get RatedFreq2 = Pr **0.21.006** / 10.

Base speed

Name:	**BaseSpeed1**		
Class	0x28	**Default**	**Pr 0.05.008**
Instance	0x01	**Data Type**	USINT
Attribute	0x0F	**Access**	Get/Set

Returns or sets the base speed of the motor in RPM for instance 1. This attribute is linked to Pr **0.05.008**.

Name:	**BaseSpeed2**		
Class	0x28	**Default**	Pr **0.21.008**
Instance	0x02	**Data Type**	USINT
Attribute	0x0F	**Access**	Get/Set

Returns or sets the base speed of the motor in RPM for instance 2. This attribute is linked to Pr **0.21.008**.

Motor2Select

Name:	**Motor2Select**		
Class	0x28	**Default**	
Instance	0x01	**Data Type**	USINT
Attribute	0x64	**Access**	Get/Set

Selects between Motor 1 and Motor 2. This attribute is linked to Pr **0.11.045**. When this bit is set to 1, Motor 2 will be active.

NOTE Any change in this attribute will be implemented when the drive is disabled.

9.5.19 Control Supervisor object

Class: 0x29 (41_{10})

The Control Supervisor object provides access to various attributes which control or monitor the drive running state. The available attributes and their associated functions are shown in Table 9-36 following.

Table 9-36 Control Supervisor object attribute

Attribute ID		Access	Name		Parameter dependence
Decimal	Hex (0x)				
3	03	Get/Set	RunFwd		**0.06.042** bit1
4	04	Get/Set	RunRev		**0.06.042** bit3
5	05	Get/Set	NetCtrl		**0.06.042** bit7
6	06	Get	State		See *Table 9-37 Control Supervisor state attributes* on page 132
7	07	Get	RunningFwd	1	(**0.10.040** AND 0x2002) = 0x0002
				0	(**0.10.040** AND 0x2002) <> 0x0002
8	08	Get	RunningRev	1	(**0.10.040** AND 0x2002) = 0x2002
				0	(**0.10.040** AND 0x2002) <> 0x2002
9	09	Get	Ready		See *Table 9-37 Control Supervisor state attributes* on page 132
10	0A	Get	Faulted		Inverse of **0.10.001**
11	0B	Get	Warning		**0.10.019**
12	0C	Get/Set	FaultRst		Sets **0.10.038** to 100 on a 0 to 1 transition
13	0D	Get	FaultCode		See *Table 9-37 Control Supervisor state attributes* on page 132
15	0F	Get	CtrlFromNet		**0.06.042** bit7 AND **0.06.043**
102	66	Get/Set	DriveEnable		**0.06.042** bit0

RunFwd

Name:	RunFwd		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x03	Access	Get/Set

Set to 1 to run the drive in the forward direction.

Get/Set Pr **0.06.042** (bit 1).

RunRev

Name:	RunRev		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x04	Access	Get/Set

Set to 1 to run the drive in the reverse direction.

Get/Set Pr **0.06.042** (bit 3).

NetCtrl

Name:	NetCtrl		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x05	Access	Get/Set

Switches between terminal and fieldbus control.

Get/Set Pr **0.06.042** (bit 7)

0 = Terminal control.

1 = Fieldbus control.

State

Name:	State		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x06	Access	Get

This returns a code to indicate the current running state of the drive as shown in Table 9-37 following.

Table 9-37 Control Supervisor state attributes

Code	State	Parameter Dependence	Description
1	Startup	N/A	This state is skipped over
2	Not_Ready	**0.10.101** = 0	Inhibit
3	Ready	**0.10.101** = 1	Ready
4	Enabled	**0.10.101** = 2 OR **0.10.101** = 4	Stop or Run
5	Stopping	**0.10.101** = 6 OR **0.10.101** = 7	Decelerating or DC injection braking
6	Fault_Stop	**0.10.101** = 5	AC supply loss
7	Faulted	**0.10.101** = 9	Tripped
0	Vendor Specific	**0.10.101** = All other drive states	See parameter reference guide

RunningFwd

Name:	RunningFwd		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x07	Access	Get

Indicates that the drive is running in the forward direction.

This attribute will be set to 1 when Pr **0.10.014** = 0 and Pr **0.10.002** = 1.

RunningRev

Name:	RunningRev		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x08	Access	Get

Indicates that the drive is running in the reverse direction.

This attribute will be set to 1 when Pr **0.10.014** = 0 and Pr **0.10.002** = 1.

Ready

Name:	Ready		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x09	Access	Get

The Ready attribute will be set in accordance with the state as shown in Table 9-38.

Table 9-38 Control Supervisor Ready attributes

Code	State	Ready state
3	Ready	True
4	Enabled	True
5	Stopping	True
All others		False

Faulted

Name:	Faulted		
Class	0x29	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x0A	Access	Get

Indicates that the drive is tripped, i.e. not OK (inverse of Pr **0.10.001**).

Get 1 = Pr **0.10.001** = 0.

Get 0 = Pr **0.10.001** = 1.

Warning

Name:	Warning		
Class	0x29	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x0B	**Access**	Get

Indicates that one of the drive alarms is active.

Get Pr **0.10.019.**

FaultRst

Name:	FaultRst		
Class	0x29	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x0C	**Access**	Get/Set

Resets the drive from a tripped condition.

Sets Pr **0.10.038** to 100 on a 0 to 1 transition.

FaultCode

Name:	FaultCode		
Class	0x29	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x0D	**Access**	Get

The fault code attribute will return the ODVA fault code as follows:

If the drive is not OK, the drive fault code is obtained from Pr **0.10.020**, if the drive fault code is listed in Table 9-39, then the ODVA fault code as shown in Table 9-39 below will be returned.

If the drive fault code is not listed in Table 9-39 then the Ethernet interface will return the ODVA code as follows:

ODVA Fault Code = 0x1000 + drive fault code.

Table 9-39 Control Supervisor fault code attributes

Drive Fault Code	ODVA Fault Code	Drive Fault Code	ODVA Fault Code
1	0x3220	20	0x2310
2	0x3210	21	0x4300
3	0x2300	26	0x5112
4	0x7112	32	0x3130
6	0x9000		

CtrlFromNet

Name:	CtrlFromNet		
Class	0x29	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x0F	**Access**	Get

Indicates whether the drive is operating under fieldbus or terminal control.

This attribute will be set to 1 if Pr **0.06.042** (bit 7) = 1 and Pr **0.06.043** = 1 (fieldbus).

DriveEnable

Name:	DriveEnable		
Class	0x29	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x66	**Access**	Get/Set

Enables the drive. This puts the drive into the “Ready” state, allowing the **RunFwd** and **RunRev** attributes to control the drive. **RunFwd** and **RunRev** will have no effect if **DriveEnable** is not set to 1.

Get/Set Pr **0.06.042** bit 0.

NOTE The external hardware enable signal must also be present before the drive will enter the Ready state.

9.5.20 AC/DC Drive object

Class: 0x2A (42_{10})

The AC/DC Drive object provides information on the drive running state and supports the following attributes:

Table 9-40 AC/DC Drive object attributes

Attribute ID	Name	Access	Parameter dependence	
0x03 (3_{10})	AtReference	Get		Pr **0.10.006**
0x04 (4_{10})	NetRef	Get/Set		Pr **0.06.042** (bit 8)
0x06 (6_{10})	DriveMode	Get/Set		(See Table 9-41 on page 134)
0x07 (7_{10})	SpeedActual	Get	RFC-A or RFC-S	Pr **0.03.002**
			Open Loop	Pr **0.05.004**
0x08 (8_{10})	SpeedRef	Get/Set	RFC-A or RFC-S	Pr **0.01.021** (scaled to 0 decimal places)
		Get	Open Loop	Pr **0.01.021** * 60 / *NofPP* (scaled to 0 decimal places)
		Set	Open Loop	Pr **0.01.021** = SpeedRef * *NofPP* / 60 (scaled to 0 decimal places)
0x0B (11_{10})	TorqueActual	Get		Pr **0.04.020** (scaled to 1 decimal place)
0x0C (12_{10})	TorqueRef	Get/Set		Pr **0.04.008** (scaled to 1 decimal place)
0x1D (29_{10})	RefFromNet	Get	1	Pr **0.01.049**=3 AND Pr **0.01.050**=1
			0	Pr **0.01.049**<>3 OR Pr **0.01.050**<>1

NOTE *NofPP* = Number of Pole Pairs.

AtReference

Name:	AtReference		
Class	0x2A	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x03	**Access**	Get

Indicates that the drive is running at the requested speed.

Get Pr **0.10.006**

0 = Drive not running at requested speed.

1 = Drive running at requested speed.

NetRef

Name:	NetRef		
Class	0x2A	**Default**	N/A
Instance	0x01	**Data Type**	USINT
Attribute	0x04	**Access**	Get/Set

Selects the source of the speed reference.

Get/Set Pr **0.06.042** bit 8

0 = analog speed reference.

1 = digital speed reference.

NOTE The NetRef can only be changed between local and remote when the drive is configured in speed control mode. If a change is requested when in torque mode then a ‘Device State Conflict’ error code 0x10 will be returned.

DriveMode

Name:	DriveMode		
Class	0x2A	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x06	Access	Get/Set

DriveMode does not allow the operating mode of the drive to be changed. Pr **0.04.011** will be written to as shown in Table 9-41 below, provided that the drive is already in the correct operating mode.

Table 9-41 AC/DC Drive object DriveMode attribute (Get)

Access	DriveMode		Actual Drive Mode	Torque Mode (0.4.011)
	Value	Mode		
Get	1	Open Loop Speed	Open-loop	Speed control mode (0)
	2	Closed Loop Speed	RFC-A	
			RFC-S	
	3	Torque Control	Open-loop	Torque control (3)
			RFC-A	
			RFC-S	
	0	User Defined	Regen	Don't care
			Don't care	Torque control with speed override (2) or Coiler / uncoiler mode (3) or Speed control with torque feed-forward (4)

Table 9-42 AC/DC Drive object DriveMode attribute (Set)

Access	DriveMode		Actual Drive Mode	Action
	Value	Mode		
Set	0	User Defined	Don't care	Return Invalid Attribute Value' (0x09)
	1	Open Loop Speed	Open-loop	Pr **0.04.011** = Speed control mode (0)
			RFC-A or RFC-S or Regen	Return 'Drive state conflict' error (0x10)
	2	Closed Loop Speed	RFC-A or RFC-S	Pr **0.04.011** = Speed control mode (0)
			Open-loop or Regen	Return 'Drive state conflict' error (0x10)
	3	Torque Control	Open-loop or RFC-A or RFC-S	Pr **0.04.011** = Torque control mode (1)
			Regen	Return 'Drive state conflict' error (0x10)

NOTE Pr **0.11.031** will never be changed by setting the DriveMode attribute. An error (0x10) will be generated if the requested DriveMode value does not correspond to the current DriveType operating mode.

SpeedActual

Name:	SpeedActual		
Class	0x2A	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x07	Access	Get

Returns the actual speed of the motor in RPM. The source of the motor speed depends on the operating mode of the drive.

Get Pr **0.05.004** (Open Loop).

Get Pr **0.03.002** (RFC-A or RFC-S).

SpeedRef

Name:	SpeedRef		
Class	0x2A	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x08	Access	Get/Set

Sets or returns the speed reference in RPM.

RFC-A or RFC-S

Get/Set SpeedRef = Pr **0.01.021** (Scaled to 0 decimal places).

Open loop

Get SpeedRef = (Pr **0.01.021** * 60) / Pole Pairs (Scaled to 0 decimal places).

Set Pr **0.01.021** = (SpeedRef * Pole Pairs) / 60 (Scaled to 0 decimal places).

TorqueActual

Name:	TorqueActual		
Class	0x2A	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x0B	Access	Get

Returns the actual load on the motor as a percentage of the rated motor load. This attribute has 1 decimal place precision, a value of 1000 represents 100.0 % load.

Get Pr **0.04.020** (Scaled to 1 decimal place).

TorqueRef

Name:			
Class	0x2A	Default	N/A
Instance	0x01	Data Type	USINT
Attribute	0x0C	Access	Get/Set

Sets the load (torque) reference as % of rated motor load (torque). This attribute has 1 decimal place precision, so a value of 1000 represents 100.0 % load.

Set Pr **0.04.008** = TorqueRef / 10 (Scaled to 1 decimal place).

Get TorqueRef = Pr **0.04.008** * 10 (Scaled to 1 decimal place).

RefFromNet

Name:	RefFromNet		
Class	0x2A	Default	
Instance	0x01	Data Type	USINT
Attribute	0x1D	Access	Get

Indicates the source of the speed reference.

TRUE if Pr **0.01.049** = 3 and Pr **0.01.050** = 1.

FALSE otherwise.

9.5.21 Control Techniques objects

The Control Techniques objects (classes 0x64 to 0x69) allow access to all drive and option module parameters. The class instance number is used to reference the drive or option module menu number (except menu 0) and the class attribute number references the parameter within that menu.

For example, the drive parameter *Percentage Load* (**0.04.020**) would be accessed as class 0x64, instance 0x04 and attribute 0x14.

An instance value of 0 is invalid therefore to allow access to menu 0 parameters, the instance value 200 (0xC8) must be used.

The number of instances and therefore the number of menus for each class depends on the destination device. If the drive is the destination then the number of menus will depend on the drive operating mode. If the destination is one of the option slots (or onboard Ethernet interface) then the number of menus depends on the type of option module fitted (or the onboard Ethernet interface).

Six individual classes are provided, the following table shows the classes used when accessing the drive or option module parameters.

Table 9-43 Control Techniques object classes

Class Code		Name	Description
Dec	Hex (0x)		
100	64	CT Group	Provides access to all drive parameters
101	65	CT This Slot	Provides access to the connected Ethernet interface parameters
102	66	CT Slot 1	Provides access to the option module in slot 1 parameters
103	67	CT Slot 2	Provides access to the option module in slot 2 parameters
104	68	CT Slot 3	Provides access to the option module in slot 3 parameters
105	69	CT Slot 4	Provides access to the onboard Ethernet interface parameters

9.6 Profinet IO specification (Unidrive M700 / M702)

9.6.1 What is PROFINET?

PROFINET is an Ethernet based industrial network protocol adapting Ethernet hardware and protocols to the real time needs of industrial automation. Profinet enables distributed IO control from a PLC.

9.6.2 Features / Specification

- Dual 100 BASE-TX RJ45 connectors with support for shielded twisted pair, full-duplex 100 M bps connectivity with auto crossover correction
- Both RJ45 ports operate in full duplex mode as a network switch
- PROFINET Real Time class RT_Class_1 and conformance class A
- Cycle times from 1 ms to 512 ms specified during configuration
- Automatic device replacement using the LLDP protocols
- LED indication of network port activity
- Up to 64 cyclic IO module slots (maximum 32 inputs and 32 outputs configured by network configuration tool and GSDML file)
- Identification and Maintenance functions I&M0 to I&M4 supported

NOTE When referring to the cyclic data, the terms input and output are with respect to the PROFINET IO controller (PLC).

NOTE The terms 'network controller' and 'PLC' are mutually used in this manual to refer to the PROFINET network controller. This is generally a PLC with a PROFINET interface and possibly a programming interface to connect to the programming device or PC. However this interface is not necessary, as the PROFINET interface can be used to program the PLC.

9.6.3 GSDML Files

A GSDML (General Station Description Markup Language) file is required to describe the drive interface to a PROFINET controller or PLC. This is an XML file, the structure of which is specified by the PROFIBUS INTERNATIONAL organization (www.profibus.org).

The GSDML file is used in conjunction with the network configuration software to configure the Profinet interface for cyclic data exchange. Many commonly used drive parameters are available as direct mapping 'modules' to be added to the cyclic data 'slots'.

Non-specific 'Flexible modules' are also provided so that the user can allocate a parameter within the drive (or option module), that is not directly available as a specific 'module'. These options will be available from a drop-down selection list within the 'Parameters' tab of the 'module' properties.

The GSDML file can be downloaded from the main Control Techniques company website (www.controltechniques.com), providing you are registered or, alternatively, requested from your local Drive Centre or supplier.

NOTE For further information regarding the use of the GSDML file please refer to the PLC documentation

9.6.4 Network topology

The Ethernet interface has two Ethernet ports with integrated switches to allow the use of line networks. However, when using line networks, a break in the connection (for example when replacing a device) will cause all devices downstream from the failure to also stop communicating with the controller.

Other Ethernet network topologies can be used but care must be taken to ensure that the system still operates within the constraints specified by the designer.

Generally a star or tree network structure using switches gives improved availability in the event of a device failure or replacement.

Although the Profinet protocol does support all major topologies, line networks are normally used for practical or financial reasons, other topologies (e.g. star) may not be suitable for real time communications due to their inherent use of switches or other network equipment.

Any network devices used, such as switches, must be capable of real time communication. Standard office grade equipment is not normally suitable and should not be used in an industrial environment.

NOTE For the device replacement feature to work, the physical network topology must be configured in the controller. For further information please refer to the controller or network configuration software documentation.

9.6.5 Configuring the PROFINET IO communications

No module parameters need to be configured by the user in order to achieve PROFINET cyclic communications. All the necessary configuration is undertaken by the network controller or PLC during the start-up sequence, and after the network configuration is programmed into the network controller or PLC.

It must be noted that when configuring the cyclic data modules, if a module is configured but the associated drive parameter does not actually exist in the drive, then the PLC will not start up correctly and will indicate a configuration fault.

Parameters of slot option module menus can also be configured for cyclic data communication via correctly configured 'Flexible Modules'. The source of the associated parameter can be set to drive or any possible slot within the 'Flexible Module' parameter properties.

9.6.6 Setting the Profinet device name

Each Profinet device must have it's own unique device name assigned during network configuration. Device names are used by the controller to communicate with the device for real time messages and alarms. Without a device name the device will not enter data exchange with the controller.

The actual device name is not important to the Profinet system itself, however, a suitable name should be chosen so that it is easily recognised on the network and identifies the location and function of the device.

A typical device name may contain up to four labels, each label is separated by a dot (.) and may be up to 63 characters in length.

The following rules must be observed when choosing the device name:

- Maximum length of 127 characters
- Characters must be lower case letters, numbers, dashes (-) or dots (.)
- The device name must start with a letter and end with either a letter or number
- The device name must not be in the format n.n.n.n (where n is a number from 0 to 999)
- The device name must not begin with the character sequence 'port-xyz (where x, y and z are numbers from 0 to 9).

A typical example of a device name may be:
motor-1.conveyor-2.line-3.ct-4

The default device name is specified in the GSDML file under the section 'DNS_CompatibleName'.

9.6.7 Profinet transmission cycle (send cycle)

The Profinet transmission cycle is the time required to update all the devices on the Profinet network, the duration of the transmission cycle is determined by the Profinet device with the slowest update rate.

The transmission cycle can be split into a number of phases, where each phase contains one or more devices with similar update rates, the duration of each phase will be equal to the fastest update rate.

Base clock
The base clock is the minimum time unit used and is equal to 31.25 µs.

Send clock factor
The send clock factor determines the duration of each phase and is the number of base clock periods within each phase.

The following table illustrates the relationship between the supported send clock values and the phase duration.

Send Clock Factor	Phase Duration (ms)
32	1
64	2
128	4

Phase duration
The duration (or length) of each phase is determined by the formula:

Phase duration = Send clock factor x Base clock.

Reduction ratio
The reduction ratio acts as a multiplier of the minimum update time (or phase duration) and is determined for each device by the formula:

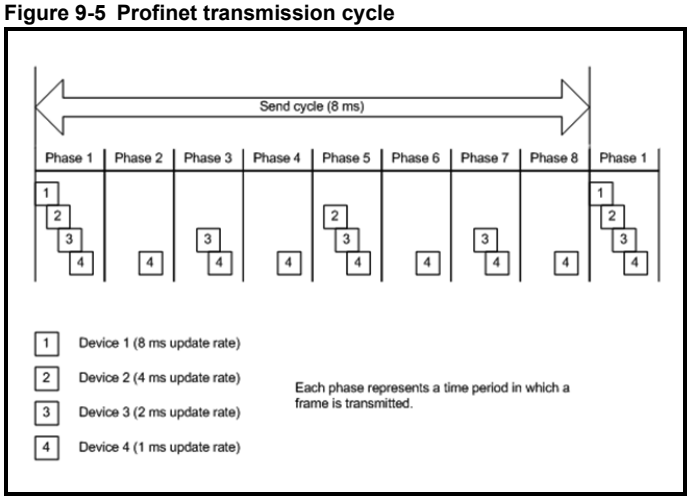
Reduction ratio = Device update time / Phase duration

Number of phases
The number of phases is determined by the formula:

Number of phases = Send cycle / fastest update rate.

Example:
In the following example, a system uses four devices, device 1 has an update rate of 8 ms, device 2 has an update rate of 4 ms, device 3 has an update rate of 2 ms and device 4 has an update rate of 1 ms.

Figure 9-5 Profinet transmission cycle



The Profinet transmission cycle is effectively the slowest update rate (8 ms in this example), and the phase duration is effectively the quickest update rate (1 ms in this example).

Phase duration = Send clock factor x Base clock
= 32 x 31.25 µs = 1 ms

Reduction ratio = Device update time / Phase duration

Reduction ratio $_{(device1)}$ = 8 ms / 1 ms = 8

Reduction ratio $_{(device2)}$ = 4 ms / 1 ms = 4

Reduction ratio $_{(device3)}$ = 2 ms / 1 ms = 2

Reduction ratio $_{(device4)}$ = 1 ms / 1 ms = 1

Number of phases = Send cycle / fastest update rate
= 8 ms / 1 ms = 8

9.6.8 Update rates

In contrast to some other fieldbus networks, Profinet devices can be configured with different update rates, these rates are specified in the device GSDML file. The Profinet interface on the M700 and M702 supports update rates of 1, 2, 4, 8, 16, 32, 64, 128, 256 and 512 ms.

It is recommended that to avoid the possibility of overloading any sections of the Profinet network, the slowest update rate necessary is used.

The update rate can be configured in one of three ways:

- **Automatic** – the update rate selected is the time calculated by the I/O system that can be reliably achieved, based on the configuration.
- **Fixed update time** – the update rate is selected by the user from a list of supported rates specified in the GSDML file
- **Fixed factor** – the update rate is selected by the user from a list of supported rates specified in the GSDML file

NOTE This information only applies to the Siemens I/O configuration system (TIA Portal/SIMATIC STEP7), other I/O configuration systems may provide different configuration options.

9.6.9 Link Layer Discovery Protocol (LLDP)

LLDP is a manufacturer independent layer 2 protocol defined in accordance with the IEEE802.1AB standard.

During start-up and at regular intervals, LLDP messages are used to transfer device information between neighbouring devices. This information includes the device name and connection port numbers. LLDP messages use a special multicast destination MAC address that the IEEE802.1D compliant bridges and switches should not forward.

If all devices in a network support LLDP messages then an accurate network topology view can be presented in the I/O system configuration / diagnostic tool.

9.6.10 Discovery and Configuration Protocol (DCP)

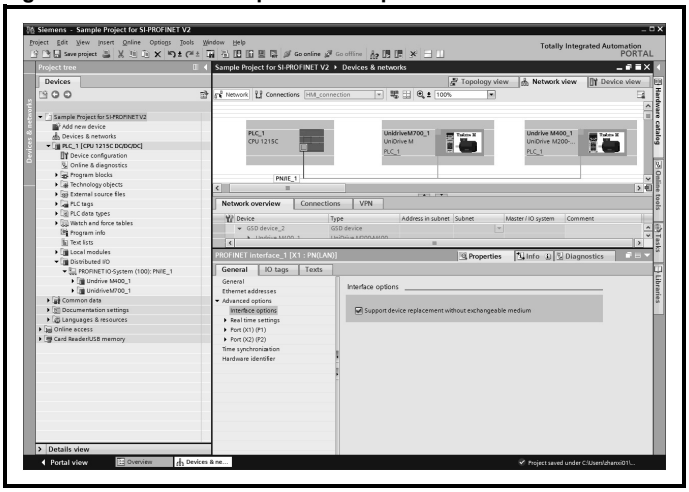
The Discovery and Configuration Protocol is used in the event of a device replacement to automatically configure the new device. All the necessary configuration is done by an appropriate neighbouring device when the new device is detected.

In order to use the network discovery and configuration protocol, the PLC must be correctly configured and programmed with the physical network topology, the following information is intended as a guide only, for more specific information (in particular for other types of PLC's), then please consult the PLC documentation.

NOTE Although the Siemens PLC is mentioned in this manual, Control Techniques does not recommend or endorse any particular PLC or controller manufacturer.

The following information relates to the Siemens S7-1215C PLC.
The PLC must be configured to support device replacement, this is an option in the properties of the PROFINET port. In the device configuration screen of the TIA PORTAL application, open the properties of the PLC PROFINET port, click 'Interface options' under 'Advanced options' as shown in Figure 9-6. Ensure the option 'Support device replacement without exchangeable medium' is selected.

Figure 9-6 PLC device replacement option



The network topology must now be configured. From the hardware configuration screen, select the port, right click it and select 'PROFINET IO Topology…', the topology editor will be displayed, select the 'Graphic view' tab and using 'drag and drop', connect the relevant device ports together to match the physical network wiring. The program must then be compiled and downloaded to the PLC in the normal manner.
Once the PLC has been configured, if a device is replaced then the new device will be automatically configured with the original device's properties, including the device name and IP address.

NOTE For the discovery protocol to work, the replacement device must not have a device name programmed, i.e. it must be blank or unused. If a device name exists in the module and that name is different to the device name set in the network configuration then the PLC will indicate a configuration error and will not enter data exchange with it.

9.6.11 Identification and Maintenance (I&M)

Identification and Maintenance (I&M) functions can be used to read and change various information about devices, such as manufacturer, ordering information, serial number, etc. This information can be used to assist the user in tracking the drive's life cycle through commissioning/start-up, parameterization, diagnosis, repair, etc. The Ethernet interface supports I&M0 to I&M4 inclusively; I&M0 is mandatory for all PROFINET devices, I&M1 to I&M4 are optional. Each I&M function returns specific information about the device and is explained in the following tables.

I&M0

Table 9-44 I&M0 Description

Attribute	Value (Read only)
Manufacturer ID	0x0160
Order ID	SI-PROFINET
Serial number	(Pr **S.00.005** x **1,000,000,000** + Pr **S.00.004**)
Hardware revision	(Pr **S.00.003**)
Software revision	(Pr **S.00.002**)
Revision counter	(Pr **S.24.006**)
Profile ID	(as read)
Profile specific type	(as read)
I&M version	(as read)
I&M supported	(as read)

Manufacturer ID: 2-byte unsigned hexadecimal number assigned by the PROFIBUS business office and specified in the GSDML file.
For Control Techniques this value is 0x0160.

Order ID: 20-byte string to identify the device.
This value is specified in the GSDML file.
For the Ethernet interface this value is 'SI-PROFINET'.

Serial number: 16 character string indicating the module serial number. This value is read from Pr **S.00.004** and Pr **S.00.005** of the Ethernet interface.

Hardware revision: 2-byte unsigned hexadecimal number indicating the hardware revision of the Ethernet interface.
This value is read from Pr **S.00.003** of the Ethernet interface.

Software revision: 4-byte value consisting of a single character 'V' and 3 unsigned 8-bit decimal numbers indicating the software revision of the Ethernet interface.
This value is taken from Pr **S.00.002** of the Ethernet interface.

Revision counter: 2-byte unsigned decimal number.
This value will increment by one for each of the following conditions:
> Drive parameter save
> Drive parameter default
> Drive mode change

Will wrap back to 1 after a value of 65535.

Profile ID: 2-byte unsigned hexadecimal number indicating the application profile.
Devices not following any particular profile use the generic profile value 0xF600.

Profile specific type: 2-byte unsigned hexadecimal number indicating the application profile specific type. This value is not applicable to devices using the generic profile and in these instances this value will be zero.

I&M version: 2 unsigned 8-bit numbers indicating the version of the implemented I&M functions.

I&M supported: 2-byte unsigned number indicating the availability of the implemented I&M functions as shown in Table 9-45.

Table 9-45 Supported I&M bit descriptions

Bit	Value	Description
0		Profile specific I&M
1	0	I&M1 Not supported
	1	I&M1 Supported
2	0	I&M2 Not supported
	1	I&M2 Supported
3	0	I&M3 Not supported
	1	I&M3 Supported
4	0	I&M4 Not supported
	1	I&M4 Supported
5 to 15		Reserved

I&M1

Table 9-46 I&M1 Description

Attribute	Value (Read/Write)
Drive function (32 bytes)	(User defined)
Drive location (22 bytes)	(User defined)

Drive function: 32-byte string indicating the drive function.
Drive location: 22-byte string indicating the drive location.

I&M2

Table 9-47 I&M2 Description

Attribute	Value (Read/Write)
Installation date	(User defined)

Installation date: 16-byte string indicating the installation or commissioning date of the device. The installation date is in the format DD/MM/YYYY.

I&M3

Table 9-48 I&M3 Description

Attribute	Value (Read/Write)
Descriptor (54 bytes)	(User defined)

Descriptor: 54-byte string used to store additional information on the location, function or maintenance status of the device.

I&M4

Table 9-49 I&M4 Description

Attribute	Value (Read/Write)
Signature (54 bytes)	(User defined)

Signature: 54-byte octet string used to allow parameterization tools to store a security code as a reference for a particular parameterization session and audit trail tools to retrieve the code for integrity checks.

NOTE

All unused bytes of the I&M functions will be set to 0x20 (space).

10 NV Media Card Operation

10.1 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 and supports NV Media Cards formatted with either FAT16 or FAT32 file system.

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.

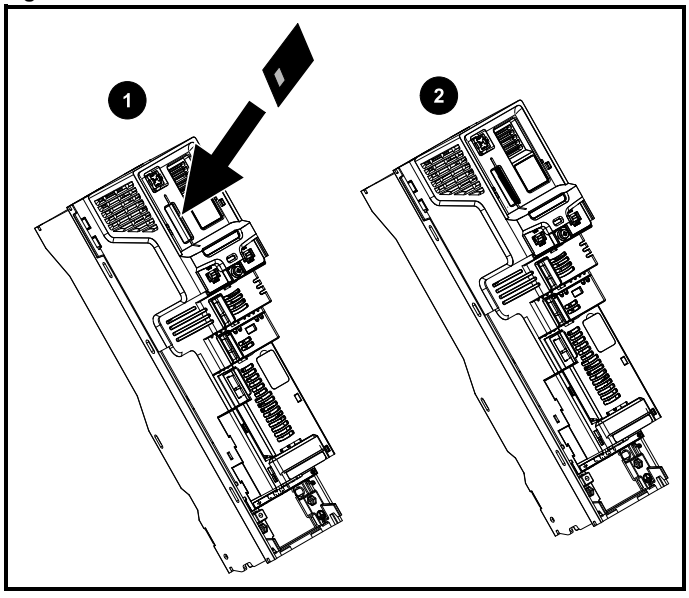
Ensure the NV Media Card is inserted with the contacts facing the left-hand side of the drive.

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 10-1 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)	82400000016400
8 kB SMARTCARD	2214-4246-03
64 kB SMARTCARD	2214-1006-03

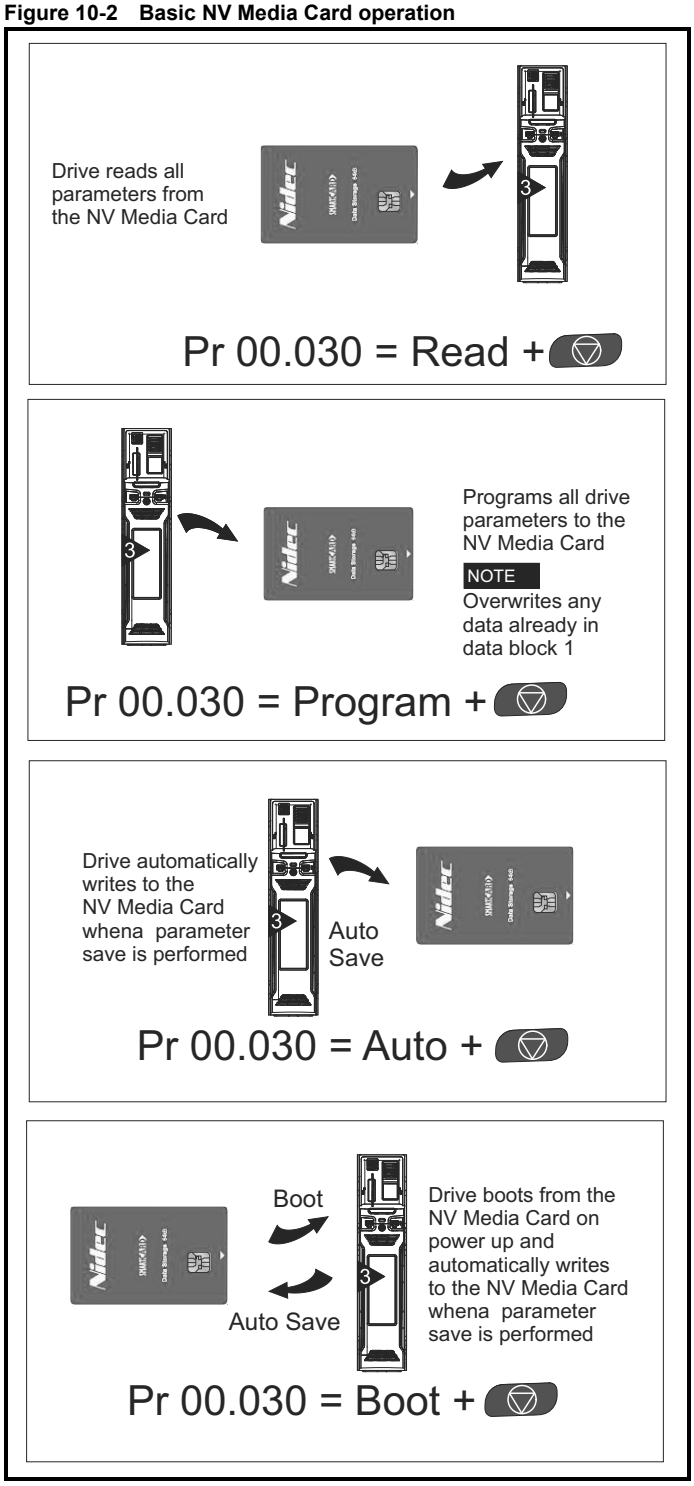
10.2 NV Media Card support

The NV Media Card can be used to store drive parameter sets and / or PLC programs set from the Unidrive M in data blocks 001 to 499 on the card.

The Unidrive M 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 Unidrive M. 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 Unidrive M 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 Unidrive M, 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 10-2 Basic NV Media Card operation



The whole card may be protected from writing or erasing by setting the read-only flag as detailed section 10.3.9 *9888 / 9777 - Setting and clearing the NV Media Card read only flag* on page 141.

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.

10.3 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 10-1.

Table 10-1 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.	✓	✓
5yyy	Transfer the onboard user program to onboard user program file yyy.	✓	✓
6yyy	Load the drive parameters from parameter file yyy or the onboard user program from onboard user program file yyy.	✓	✓
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.

10.3.1 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 00.030 = Program (2))

Setting Pr **00.030** 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).

10.3.2 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** and Pr **21.027** to Pr **21.029** *Motoring Current Limits*

Pr **04.024**, *User Current Maximum Scaling*

Pr **05.007**, Pr **21.007** *Rated Current*

Pr **05.009**, Pr **21.009** *Rated Voltage*

Pr **05.010**, Pr **21.010** *Rated Power Factor*

Pr **05.017**, Pr **21.012** *Stator Resistance*

Pr **05.018** *Maximum Switching Frequency*

Pr **05.024**, Pr **21.014** *Transient Inductance*

Pr **05.025**, Pr **21.024** *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*

Pr **06.073** *Braking IGBT Lower Threshold*

Pr **06.074** *Braking IGBT Upper Threshold*

Pr **06.075** *Low Voltage Braking IGBT Threshold*

Reading a parameter set from the NV Media Card (Pr 00.030 = Read (1))

Setting Pr **00.030** 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.

10.3.3 Auto saving parameter changes (Pr 00.030 = 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 **00.030** 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 **00.030** is set to 3 Pr **00.030** is then automatically set to None (0).

When a new NV Media Card is installed Pr **00.030** 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 **00.030** 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 **00.030** 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 **00.030** is set to Auto (3) the setting of Pr **00.030** itself is saved to the drive EEPROM but not the NV Media Card.

10.3.4 Booting up from the NV Media Card on every power up (Pr 00.030 = Boot (4))

When Pr **00.030** 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 **00.030** 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 **00.030** is not transferred to the drive.

10.3.5 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.

10.3.6 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.

10.3.7 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 data blocks on a SMARTCARD, but not on a SD Card.

10.3.8 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

10.3.9 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

10.4 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.

10.5 NV Media Card parameters

Table 10-2 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	⇳	0 to 999			⇨	0			
RFC-S									

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 {00.030}	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.

10.6 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 13 *Diagnostics* on page 245 for more information on NV Media Card trips.

11 Onboard PLC

11.1 Onboard PLC and Machine Control Studio

The drive has the ability to store and execute a 16 kB Onboard PLC user program without the need for additional hardware in the form of an option module.

Machine Control Studio is an IEC61131-3 development environment designed for use with Unidrive M and compatible application modules. Machine Control Studio is based on CODESYS from 3S-Smart Software Solutions.

All of the programming languages defined in the IEC standard IEC 61131-3 are supported in the Machine Control Studio development environment.

- ST (Structured text)
- LD (Ladder diagram)
- FBD (Function block diagram)
- IL (Instruction list)
- SFC (Sequential function chart)
- CFC (Continuous Function Chart). CFC is an extension to the standard IEC programming languages

Machine Control Studio provides a complete environment for the development of user programs. Programs can be created, compiled and downloaded to a Unidrive M for execution, via the communications port on the front of the drive. The run-time operation of the compiled program on the target can also be monitored using Machine Control Studio and facilities are provided to interact with the program on the target by setting new values for target variables and parameters.

The Onboard PLC and Machine Control Studio form the first level of functionality in a range of programmable options for Unidrive M.

Machine Control Studio can be downloaded from www.controltechniques.com.

See the Machine Control Studio help file for more information regarding using Machine Control Studio, creating user programs and downloading user programs to the drive.

11.2 Benefits

The combination of the Onboard PLC and Machine Control Studio, means that the drive can replace nano and some micro PLCs in many applications

Machine Control Studio benefits from access to the standard CODESYS function and function block libraries as well as those from third parties. Functions and function blocks available as standard in Machine Control Studio include, but not limited to, the following:

- Arithmetic blocks
- Comparison blocks
- Timers
- Counters
- Multiplexers
- Latches
- Bit manipulation

Typical applications for the Onboard PLC include:

- Ancillary pumps
- Fans and control valves
- Interlocking logic
- Sequences routines
- Custom control words.

11.3 Features

The Unidrive M Onboard PLC user program has the following features:

11.3.1 Tasks

The Onboard PLC allows use of two tasks.

- Clock: A high priority real time task. The clock task interval can be set from 4 ms to 262 s in multiples of 4 ms. The parameter *Onboard User Program: Clock Task Time Used* (11.051) shows the percentage of the available time used by clock task. A read or write of a drive parameter by the user program takes a finite period of time. It is possible to select up to 10 parameters as fast access parameter which reduced the amount of time it takes for the user program to read from or write to a drive parameter. This is useful when using a clock task with a fast update rate as selecting a parameter for fast access reduces the amount of the clock task resource required to access parameters.
- Freewheeling: A non-real time background task. The freewheeling task is scheduled for a short period once every 64 ms. The time for which the task is scheduled will vary depending on the loading of the drive's processor. When scheduled, several scans of the user program may be performed. Some scans may execute in microseconds. However, when the main drive functions are scheduled there will be a pause in the execution of the program causing some scans to take many milliseconds. The parameter *Onboard User Program: Freewheeling Tasks Per Second* (11.050) shows the number of times the freewheeling task has started per second.

11.3.2 Variables

The Onboard PLC supports the use of variables with the data types of Boolean, integer (8 bit, 16 bit and 32 bit, signed and unsigned), floating point (64 bit only), strings and time.

11.3.3 Custom menu

Machine Control Studio can construct a custom drive menu to reside in menu 30 on the drive. The following properties of each parameter can be defined using Machine Control Studio:

- Parameter name
- Number of decimal places
- The units for the parameter to be display on the keypad.
- The minimum, maximum and default values
- Memory handling (i.e. power down save, user save or volatile)
- Data type. The drive provides a limited set of 1 bit, 8 bit, 16 bit and 32 bit integer parameters to create the customer menu.

Parameters in this customer menu can be accessed by the user program and will appear on the keypad.

11.3.4 Limitations

The Onboard PLC user program has the following limitations:

- The flash memory allocated to the Onboard PLC is 16 kB which includes the user program and its header which results in a maximum user program size of about 12 kB
- The Onboard PLC is provided with 2 kB of RAM.
- The drive is rated for 100 program downloads. This limitation is imposed by the flash memory used to store the program within the drive.
- There is only one real-time task with a minimum period of 4 ms.
- The freewheeling background task runs at a low priority. The drive is prioritized to perform the clock task and its major functions first, e.g. motor control, and will use any remaining processing time to execute the freewheeling task as a background activity. As the drive's processor becomes more heavily loaded, less time is spent executing the freewheeling task.
- Breakpoints, single stepping and online program changes are not possible.
- The Graphing tool is not supported.
- The variable data types REAL (32 bit floating point), LWORD (64 bit integer) and WSTRING (Unicode string), and retained variables are not supported.

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