EMERSON
Industrial Automation

User Guide

SI-EtherCAT

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Original Instructions

For the purposes of compliance with the EU Machinery Directive 2006/42/EC.

General Information

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

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

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

Firmware Statement

This product is supplied with the latest firmware version. When retro-fitting to an existing system, all firmware versions should be verified to confirm the same functionality as products of the same type already present. This also applies to products returned from a Emerson Industrial Automation's Service Centre or Repair Centre. If there is any doubt please contact the supplier of the product.

The firmware version of the product can be identified by looking at Pr **MM.002** where **MM** is the relevant menu number for the module slot being used.

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1 Safety information

1.1 Warnings, cautions and notes

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

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 Electrical safety - general warning

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.

Specific warnings are given at the relevant places in this User Guide.

1.3 System design and safety of personnel

The drive is intended as a component for professional incorporation into complete equipment or a system. If installed incorrectly, the drive 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, start up and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this User Guide carefully.

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

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.

Careful consideration must be given to the functions of the drive which might result in a hazard, either through their intended behavior 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.

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.**

1.4 Environmental limits

Instructions regarding transport, storage, installation and use of the drive must be complied with, including the specified environmental limits. Drives must not be subjected to excessive physical force.

1.5 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.

For instructions in achieving compliance with specific EMC standards, please refer to the relevant drive user guide.

Within the European Union, all machinery in which this product is used, must comply with the directives stated in the relevant drive user guide.

1.6 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

Standard squirrel cage induction motors are designed for single speed operation. If it is intended to use the capability of the drive to run a motor at speeds above its designed maximum, it is strongly recommended that the manufacturer is consulted first.

Low speeds may cause the motor to overheat because the cooling fan becomes less effective. 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 should not be relied upon.

It is essential that the correct value is entered in the motor rated current parameter Pr **00.046**, as this affects the thermal protection of the motor.

1.7 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.

1.8 Electrical installation

1.8.1 Electric shock risk

The voltages present in the following locations can cause severe electric shock and may be lethal:

- AC 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.

1.8.2 Stored 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.

2 Introduction

2.1 Products covered by this User Guide

This User Guide covers the SI-EtherCAT option module .Both the SI-Ethernet module and the onboard Ethernet interface offer the same functionality.

The SI-EtherCAT is an option module that provides EtherCAT connectivity and can be installed to the following drives:

- Unidrive M200 / M201 (sizes 2 to 9)
- Unidrive M300 (sizes 2 to 9)
- Unidrive M400 (sizes 2 to 9)
- Unidrive M600 (sizes 3 to 11)
- Unidrive M700 / M701 / M702 (sizes 3 to 11)

2.2 What is EtherCAT?

EtherCAT is an open high performance Ethernet-based fieldbus system that overcomes the system limitations of other Ethernet solutions. The Ethernet packet is no longer received, then interpreted and copied as process data at every connection; instead the Ethernet frame is processed on the fly. The development goal of EtherCAT was to apply Ethernet to automation applications that require short data update times (also called cycle times) with low communication jitter (for synchronization purposes) and low hardware costs. Typical application fields for EtherCAT are machine controls (e.g. semiconductor tools, metal forming, packaging, injection moulding, assembly systems, printing machines, robotics and many others).

2.3 About SI-EtherCAT

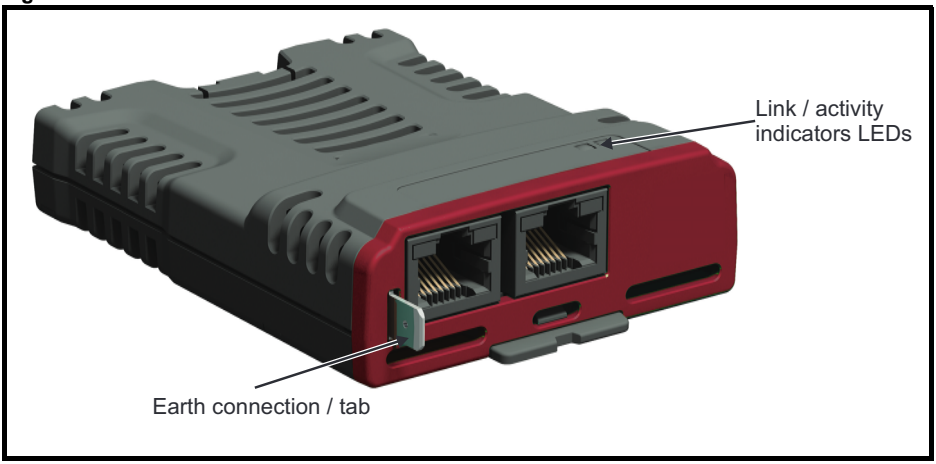
SI-EtherCAT is a option module that enables the Control Techniques Unidrive M range of variable speed drives to be connected to an EtherCAT network as a slave device. It can be used in a variety of applications, from those requiring accurate synchronization and precise motion control, to those where ease of use and open loop control are appropriate.

2.4 Features

- Standard RJ45 with support for shielded twisted pair, half-duplex / full-duplex and 10 Mbs / 100 Mbs connectivity
- Dual 100 Mbps EtherCAT interfaces for use in line topologies i.e. daisy chaining
- Supports the Unidrive M drives range
- Control loop synchronization
- Control cycle times down to 250 µs
- Configured Station Alias
- CANopen over EtherCAT (CoE) which includes:
    - Support of CANopen CiA402
    - Cyclic sync position mode
    - Interpolated position mode
    - Velocity mode
    - Homing mode
    - One transmit and one receive PDOs
    - SDO access to all profile objects and drive parameters
    - Cyclic sync velocity mode
    - Cyclic sync torque mode

2.5 Option module identification

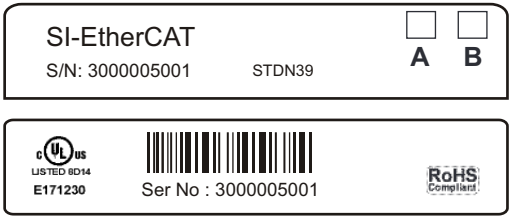
Figure 2-1 SI-EtherCAT



The SI-EtherCAT can be identified by:

- The label located on the underside of the option module.
- The color coding across the front of the SI-EtherCAT (brown-red).

Figure 2-2 SI-EtherCAT labels



2.5.1 Date code format

The date code is split into two sections: a letter followed by a number. The letter indicates the year, and the number indicates the week number (within the year) in which the option module was built. The letters start with A for 1991 (B for 1992, C for 1993 etc).

Example: A date code of W31 would correspond to week 31 of year 2013.

2.6 Product Conformance Certificate

SI-EtherCAT has been awarded full EtherCAT Conformance Certification by the EtherCAT Technology Group (ETG). A copy of the certificate is available on request from your supplier or local Control Techniques Drive Centre.

2.7 Conventions used in this guide

The configuration of the host drive and option module is done using menus and parameters. A menu is a logical collection of parameters that have similar functionality.

In the case of an option module, the option module set-up parameters in menu 0 will appear in drive menu 15, 16 or 17 depending on which slot the module is installed in. In the case of the onboard Ethernet interface, the set-up parameters in menu 0 will appear in drive menu 24.

The setting of the Option Slot Identifiers (Pr **11.056**) may change the slot numbering from those described above. The internal menus of the option module or onboard Ethernet interface will appear before menu 0 and after menu 41.

NOTE For M200, M300 and M400 drives, the option module set-up parameters will appear in menu 15.

The method used to determine the menu or parameter is as follows:

- Pr **S.mm.ppp** - Where **S** signifies the option module slot number and **mm.ppp** signifies the menu and parameter number respectively.
  If the option module slot number is not specified then the parameter reference will be a drive parameter.
- Pr **MM.ppp** - Where **MM** signifies the menu allocated to the option module setup menu and **ppp** signifies the parameter number within the set-up menu.
- Pr **mm.000** - Signifies parameter number 000 in any drive menu.

3 Mechanical installation

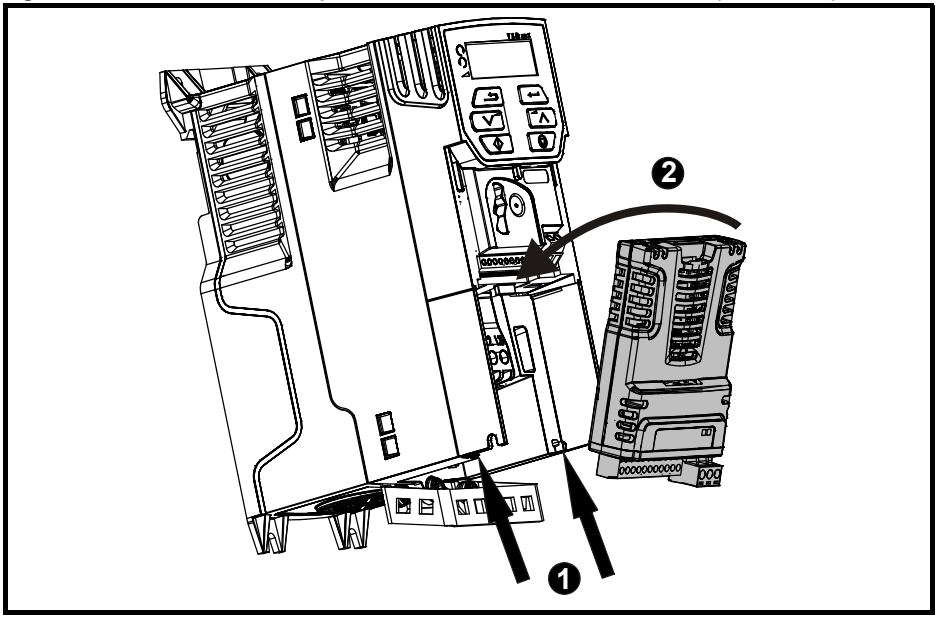
WARNING

Before installing or removing an option module in any drive, ensure the AC supply has been disconnected for at least 10 minutes and refer to Chapter 1 *Safety information* on page 5. If using a DC bus supply ensure this is fully discharged before working on any drive or option module.

3.1 General installation

The installation of an option module is illustrated in Figure 3-1.

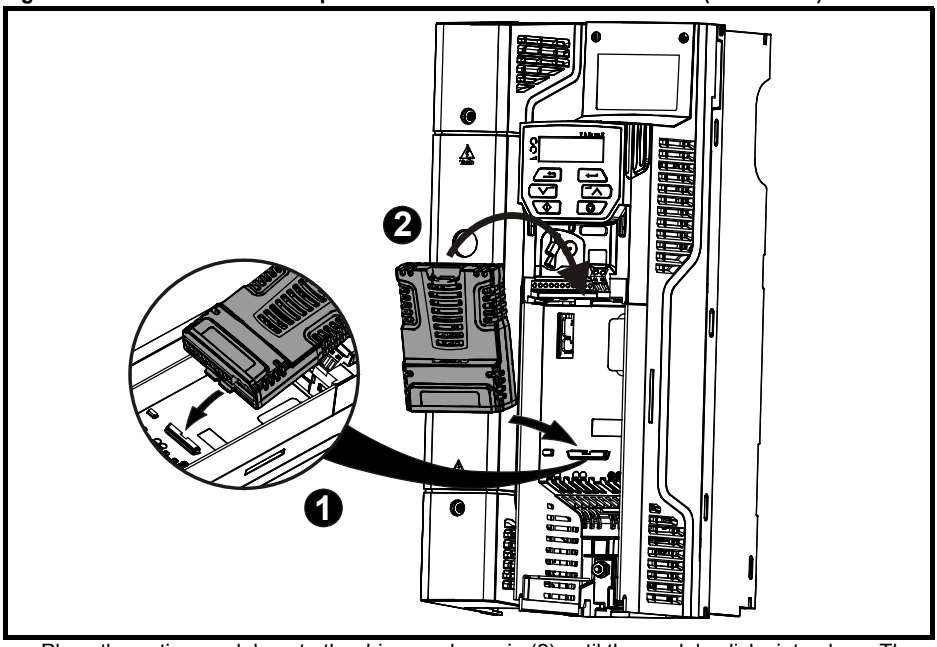
Figure 3-1 Installation of an SI option module on Unidrive M200 to M400 (sizes 2 to 4)



- With the option module tilted slightly backwards, align and locate the two holes in the rear of the option module onto the two tabs (1) on the drive.
- Place the option module onto the drive as shown in (2) until the module clicks into place. The terminal cover on the drive holds the option module in place, so this must be put back on.

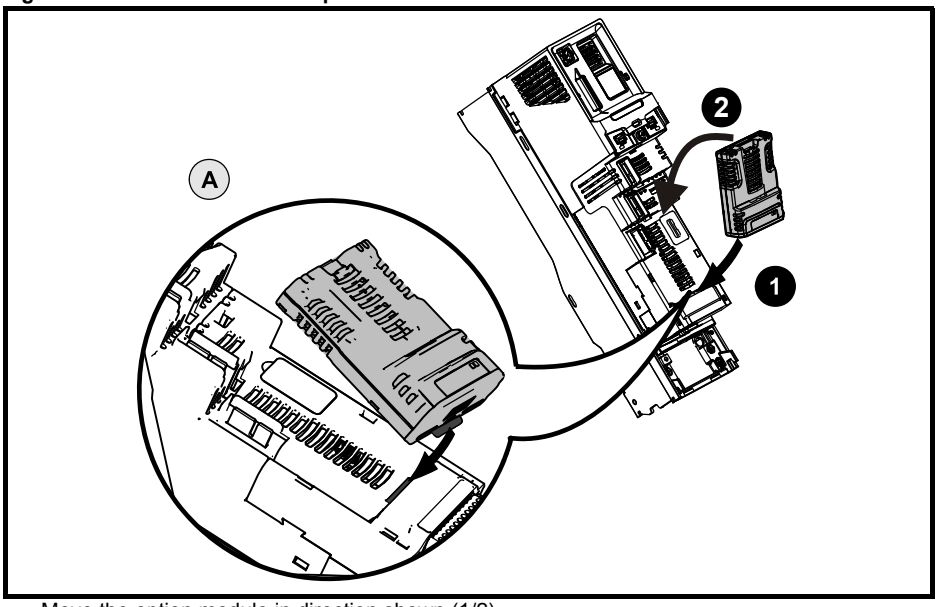
NOTE Option modules can only be installed on drives that have the option module slot functionality.

Figure 3-1 Installation of an SI option module on Unidrive M200 to M400 (sizes 5 to 8)



- Place the option module onto the drive as shown in (2) until the module clicks into place. The terminal cover on the drive holds the option module in place, so this must be put back on.

Figure 3-2 Installation of an SI option module on Unidrive M600 to M702



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

NOTE Option module slots must be used in the following order: Slot 3 (lower), Slot 2 (middle) and then Slot 1(upper).

4 Electrical installation

4.1 SI-EtherCAT module information

4.1.1 Bus media

The SI-EtherCAT option module incorporates two 100 BASE-TX RJ45 interfaces.

4.1.2 Cabling considerations

To ensure long-term reliability it is recommended that any cables used to connect a system together be tested using a suitable Ethernet cable tester, this is of particular importance when cables are constructed on site.

4.1.3 Cable

Cables should be shielded and as a minimum, meet TIA Cat 5e requirements.

NOTE Cabling issues are the single biggest cause of network downtime. Ensure cabling is correctly routed, wiring is correct, connectors are correctly installed and any switches or routers used are rated for industrial use. Office grade Ethernet equipment does not generally offer the same degree of noise immunity as equipment intended for industrial use.

4.1.4 Maximum network length

The main restriction imposed on Ethernet cabling is the length of a single segment of cable. The SI-EtherCAT module has two 100BASE-TX Ethernet ports, which support segment lengths of up to 100 m. This means that the maximum cable length which can be used between one SI-EtherCAT port and another 100BASE-TX port is 100 m however it is not recommended that the full 100 m cable length is used. The total network length is not restricted by the Ethernet standard but depends on the number of devices on the network and the transmission media (copper, fiber optic, etc.).

NOTE The EtherCAT system designer must consider the impact that the selected network structure will have on performance.

4.2 SI-EtherCAT terminal descriptions

The SI-EtherCAT module has two RJ45 Ethernet ports for the EtherCAT network.

Figure 4-1 SI-EtherCAT connections

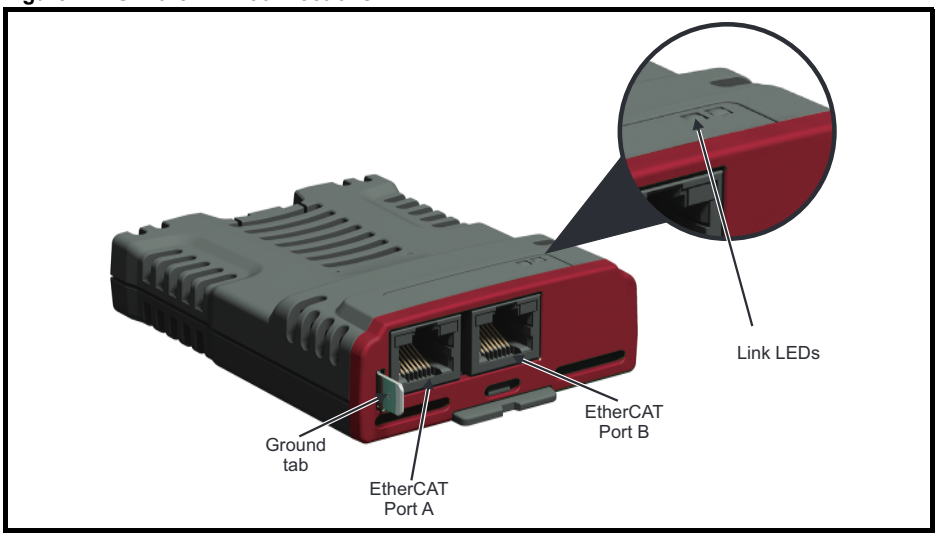


Table 4-1 EtherCAT terminal descriptions

Pin	A - IN	Pin	B - OUT
1	Transmit +	1	Transmit +
2	Transmit -	2	Transmit -
3	Receive +	3	Receive +
4	Not used	4	Not used
5	Not used	5	Not used
6	Receive -	6	Receive -
7	Not used	7	Not used
8	Not used	8	Not used

4.3 Module grounding and EMC

SI-EtherCAT is supplied with a grounding tab on the module that should be connected to the closest possible grounding point using the minimum length of cable. This will greatly improve the noise immunity of the module.

It is recommended that the Ethernet cable should be of the shielded type, and connectors should be shielded with a metal body. Tie-wrapping of the Ethernet cable's shield to the grounding bracket of the drive is necessary.

At least one EMC Ferrite inductor should be installed near to each communication port of the SI-EtherCAT module.

At least one EMC Ferrite inductor is necessary near the Master's (PC / PLC) EtherCAT Port. Proper grounding of the EtherCAT cable's shield near the Master (PC / PLC) is necessary.

Drive grounding brackets should be connected to each other by separate cables, and the cable length should be as small as possible.

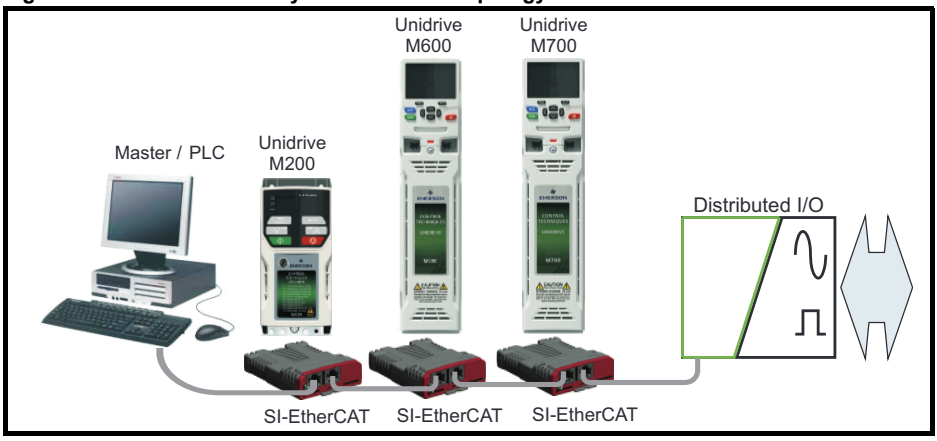
Please note EMC Ferrite inductors of the required specification are available from the following supplier:

Manufacturer:	WURTH ELEKTRONIK
Manufacturer Part No:	74271222
Order code:	1635620
Description:	Ferrite core, Split type

4.4 Network topology

Control Techniques recommend implementing daisy chaining on EtherCAT networks (see Figure 4-2). 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.

Figure 4-2 SI-EtherCAT daisy chain network topology



4.5 Minimum node-to-node cable length

There is no minimum length of cable recommended in the Ethernet standards. To avoid possible problems it is recommended that you allow sufficient cable length to ensure good bend radii on cables and avoid unnecessary strain on connectors.

5 Getting started

5.1 Quick start guide

This section is intended to provide a generic guide for setting up SI-EtherCAT with a master/ controller PLC. It will cover the basic steps required to get cyclic data communicating using the CANopen over EtherCAT (CoE) protocol on the SI-EtherCAT module.

Table 5-1 PDO test mappings

	RxPDO1	TxPDO1
Mapping 1	0x6040 (*controlword*) (16-bits)	0x6041 (*statusword*) (16-bits)
Mapping 2	0x6042 (*vl_target_velocity*) (16-bits)	0x6064 (*position_actual_value*) (32-bits)
Mapping 3	Pr **20.021** (32-bits)	N/A

NOTE It is strongly recommended that the latest firmware be used where possible to ensure that all features are supported.

Due to the large number of different masters that support CoE, details cannot be provided for a specific master. Generic support is available through your supplier or local Control Techniques Drive Centre. Before contacting your supplier or local Control Techniques Drive Centre for support please ensure you have read *section 10 Diagnostics* on page 94 of this manual and have checked that the SDO/PDO configurations are correct.

5.1.1 SI-EtherCAT XML file

Control Techniques provides EtherCAT device description files (in the form of .xml files). These files provide the master with information about the SI-EtherCAT module and drive configuration to aid with its configuration. These files can be downloaded from the Control Techniques CTSupport.com website or from your local Control Techniques Drive Centre or supplier. They should be placed in the directory specified by the master e.g. when using TwinCAT this could be C:\TwinCAT\Io\EtherCAT.

NOTE The master may have to be re-started for the file to be loaded.

5.1.2 Configuring the SI-EtherCAT module for cyclic communications

Unlike other Control Techniques fieldbus communication protocols, CoE does not require that any module parameters be changed in order to achieve communications. The baud rate of the network is fixed and the module is automatically allocated an address.

To check that the ethernet cable connected to the SI-EtherCAT module on the drive is connected correctly, look at the LED on the front of the SI-EtherCAT module relating to the connector being used, if this light is a solid green color then a link is established with the master, if this light if off then check the cabling and also check that the master has started communications.

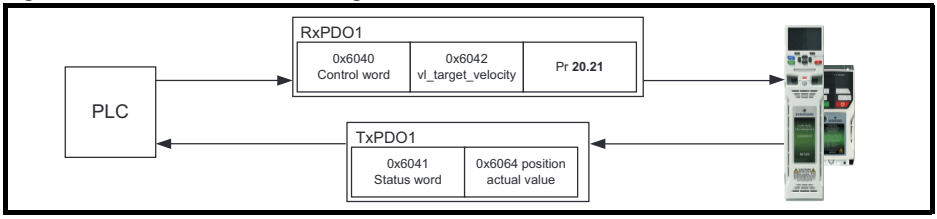
In the master, scan the network ensuring that the SI-EtherCAT module is connected correctly to the master. If the network is configured correctly the SI-EtherCAT node(s) should be visible in the PLC master.

Decide on the input / output data you wish to send cyclically (objects and/or parameters).

Cyclic data is implemented on CoE networks by using "Process Data Objects" or PDOs. Separate data objects are used for receiving (TxPDOs - from the slave to the master) and transmitting (RxPDOs - from the master to the slave) data.

These PDOs contain the cyclic data (objects and/or parameters), the RxPDOs available are 1, 2, 3, 5 and 6, the TxPDOs available are 1, 2, 3, 5 and 6 (for more information on these PDOs including default mappings please see section 6.3.2 *RxPDO mappings* on page 30 and section 6.3.3 *TxPDO mappings* on page 34).

Figure 5-1 SI-EtherCAT PDO configuration



RxPDO1 and TxPDO1 will need to be enabled in the master. Once enabled you will need to add mappings to the PDOs.

The format used when mapping objects to PDOs is as follows:

- Index: Object index number (0x0000)
- Sub-index: Object sub-index number (0x00)
- Size: Dependant on the size (in bytes) of the object to be mapped (range: 1-4)

The format used when mapping drive parameters to PDOs is as follows:

- Index: 0x2000 + (0x100 x S) + menu number
- Sub-index: 0x00 + parameter number
- Size: Dependant on the size (in bytes) of the object to be mapped (range: 1-4)

For example Pr **20.021** would be index 0x2014, sub-index 0x15 and the size would be 4 (the parameter is a 32-bit signed value).

NOTE The values are normally expressed in hexadecimal, so care must be taken to enter the correct parameter number.

For this example the following objects will need to be set in order to achieve the mappings of the parameters/objects in the PDOs.

Table 5-2 Cyclic data mapping configuration

RxPDO1:		TxPDO1:	
Object:	0x1600	Object:	0x1A00
Sub-index:	0x00	Sub-index:	0x00
Size:	1	Size:	1
Value:	3	Value:	2
Sub-index:	0x01	Sub-index:	0x01
Size:	4	Size:	4
Value:	0x60400010	Value:	0x60410010
Sub-index:	0x02	Sub-index:	0x02
Size:	4	Size:	4
Value:	0x60420010	Value:	0x60640020
Sub-index:	0x03	Not Used	
Size:	4		
Value:	0x20141520		

NOTE The format used to define the value of a mapped object is as follows:
Bit 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap).
Bit 8 to 15: Sub-index of the mapped object (if a gap, zero).
Bit 16 to 31: Index of the mapped object (if a gap, zero).

NOTE The maximum number of mappings in one PDO is twelve. There are no restrictions on the data length of these parameters (i.e. It is possible to map twelve, 32-bit parameters in one PDO). It is also possible to use a maximum of one RxPDOs and one TxPDOs.

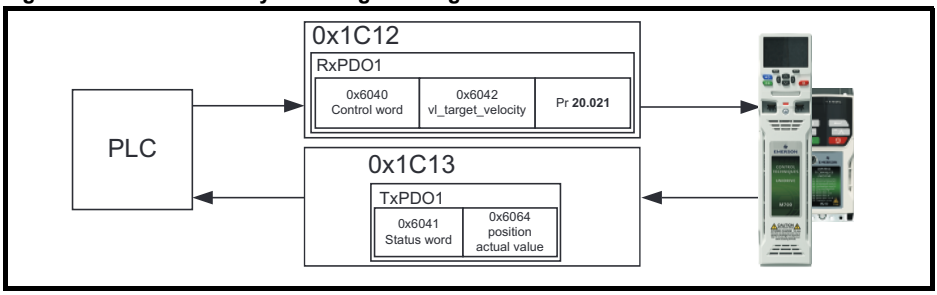
NOTE For M200, M300 and M400 the maximum update time achievable is 4 ms.

5.1.3 Configuring the sync managers

The sync manager is used to control the transmission of CANopen PDOs over the EtherCAT network.

The following objects 0x1C12 - sync manager 2 PDO assignment (RxPDO) and 0x1C13 - sync manager 3 PDO assignment (TxPDO) are required to assign PDOs to the synchronization task. For the purpose of the example assign one RxPDO to sync manager 2 and one TxPDOs to sync manager 3.

Figure 5-2 SI-EtherCAT sync manager configuration



Assigning RxPDO to the sync manager
To assign RxPDO1 to sync manager 2 PDO assignment set the values below to the following objects:

- Index: 0x1C12
- Sub index: 0x00
- Size: 1
- Value: 1

Setting object 0x1C12, sub-index 0 to a value of 1 (as above) indicates that one RxPDO will be assigned to the sync manager 2 assignment.

- Index: 0x1C12
- Sub index: 0x01
- Size: 2
- Value: 0x1600

Setting object 0x1C12, sub-index 1 to a value of 0x1600 (as above) maps RxPDO1 to the process data output sync.

Assigning TxPDO to the sync manager

To assign TxPDO1 to sync manager 3 PDO assignment set the values below to the following objects:

- Index: 0x1C13
- Sub index: 0x00
- Size: 1
- Value: 1

Setting object 0x1C13, sub-index 0 to a value of 1 (as above) indicates that one TxPDOs will be assigned to the sync manager 3 assignment.

- Index: 0x1C13
- Sub index: 0x01
- Size: 2
- Value: 0x1A00

Setting object 0x1C13, sub-index 1 to a value of 0x1A00 (as above) maps TxPDO1 to the process data input sync.

Download the configuration to the master.

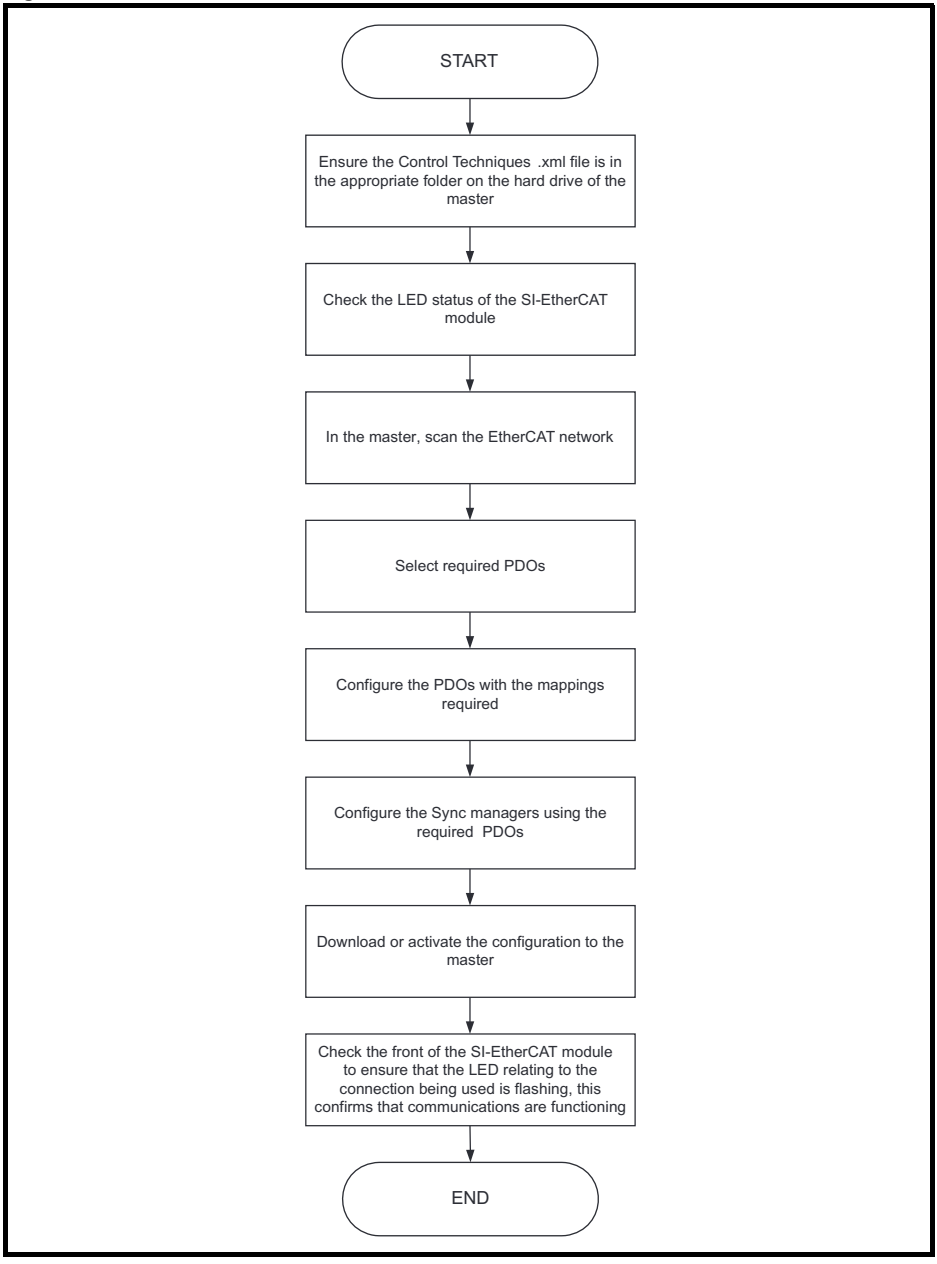
After downloading the configuration to the master the LED(s) on the front of the SI-EtherCAT should flash, depending on the port(s) connected.

Values written to parameters over RxPDOs should now be viewable using the drive's keypad so long as the master has put the slave into the operational state; also, parameter values changed using the drive keypad will be updated on the master.

5.2 Quick start flowchart

Figure 5-3 details the steps required to achieve cyclic communications on the EtherCAT network. This flowchart should be used as the starting point for all configurations.

Figure 5-3 Quick start flowchart



5.3 Supported objects

Table 5-3 lists the objects currently supported by SI-EtherCAT

Table 5-3 SI-EtherCAT Object Dictionary

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
1000	Device type	0	UDINT	RO	Y	Y	Y	Y	Y	Y
1001	Error register	0	USINT	RO	Y	Y	Y	Y	Y	Y
1018	Identity object (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Identity object (Vendor ID)	1	UDINT	RO	Y	Y	Y	Y	Y	Y
	Identity object (Product Code)	2	UDINT	RO	Y	Y	Y	Y	Y	Y
	Identity object (Software Version)	3	UDINT	RO	Y	Y	Y	Y	Y	Y
	(Reserved)	4	UDINT	RO	Y	Y	Y	Y	Y	Y
1600	Receive PDO mapping 1 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Receive PDO mapping 1 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1601	Receive PDO mapping 2 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Receive PDO mapping 2 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1602	Receive PDO mapping 3 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Receive PDO mapping 3 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1604	Receive PDO mapping 5 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Receive PDO mapping 5 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1605	Receive PDO mapping 6 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Receive PDO mapping 6 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1A00	Transmit PDO mapping 1 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Transmit PDO mapping 1 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1A01	Transmit PDO mapping 2 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Transmit PDO mapping 2 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
1A02	Transmit PDO mapping 3 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Transmit PDO mapping 3 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1A04	Transmit PDO mapping 5 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Transmit PDO mapping 5 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1A05	Transmit PDO mapping 6 (Number of objects)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	Transmit PDO mapping 6 (Mapped object *1 to si0*)	*1 to si0*	UDINT	RW	Y	Y	Y	Y	Y	Y
1C00	Sync manager communication type (Number of SM protocols)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM0 Usage)	1	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM1 Usage)	2	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM2 Usage)	3	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM3 Usage)	4	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM4 Usage)	5	USINT	RO	Y	Y	Y	Y	Y	Y
	Sync manager communication type (SM5 Usage)	6	USINT	RO	Y	Y	Y	Y	Y	Y
1C10	SM0 PDO assignment (Number of PDOs)	0	USINT	RO	Y	Y	Y	Y	Y	Y
1C11	SM1 PDO assignment (Number of PDOs)	0	USINT	RO	Y	Y	Y	Y	Y	Y
1C12	SM2 PDO assignment (Number of PDOs)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	SM2 PDO assignment (Assigned PDO index)	1	UINT	RW	Y	Y	Y	Y	Y	Y
1C13	SM3 PDO assignment (Number of PDOs)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	SM3 PDO assignment (Assigned PDO index)	1	UINT	RW	Y	Y	Y	Y	Y	Y
1C14	SM4 PDO assignment (Number of PDOs)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	SM4 PDO assignment (Assigned PDO index)	1	UINT	RW	Y	Y	Y	Y	Y	Y

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
1C15	SM5 PDO assignment (Number of PDOs)	0	USINT	RW	Y	Y	Y	Y	Y	Y
	SM5 PDO assignment (Assigned PDO index)	1	UINT	RW	Y	Y	Y	Y	Y	Y
2smm	Drive parameter access (s = slot 0x0 to 0xF, mm=menu 0x00 to 0xFF)	pp (pp=par 0x00 to 0xFF)	[var]	RW	Y	Y	Y	Y	Y	Y
3000	Position feedback encoder configuration	0	USINT	RW	Y	Y	Y	Y	Y	Y
3003	Homing source (Number of last sub-index)	0	USINT	RO	N	N	Y	N	N	N
	Homing source (Homing switch source)	1	USINT	RW	N	N	Y	N	N	N
	Homing source (Freeze/marker source)	2	USINT	RW	N	N	Y	N	N	N
3004	Additional position loop scaling (Number of last sub-index)	0	USINT	RO	N	Y	N	N	N	Y
	Additional position loop scaling (Numerator)	1	DINT	RW	N	Y	N	N	N	Y
	Additional position loop scaling (Denominator)	2	DINT	RW	N	Y	N	N	N	Y
3005	Cyclic data loss behaviour (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Cyclic data loss behaviour (Timeout (ms))	1	UINT	RW	Y	Y	Y	Y	Y	Y
	Cyclic data loss behaviour (Action)	2	USINT	RW	Y	Y	Y	Y	Y	Y
3006	Out cyclic data configuration (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Out cyclic data configuration (Copy to drive task)	1	USINT	RW	Y	Y	Y	Y	Y	Y
	Out cyclic data configuration (Copy from master task)	2	USINT	RW	Y	Y	Y	Y	Y	Y
3007	In cyclic data configuration (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	In cyclic data configuration (Copy from drive task)	1	USINT	RW	Y	Y	Y	Y	Y	Y
	In cyclic data configuration (Copy to master task)	2	USINT	RW	Y	Y	Y	Y	Y	Y
3008	Activate velocity mode redirection	0	USINT	RW	Y	N	N	Y	N	N
603F	Error code	0	UINT	RO	Y	Y	Y	Y	Y	Y
6040	Control word	0	UINT	WO	Y	Y	Y	Y	Y	Y

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
6041	Status word	0	UINT	RO	Y	Y	Y	Y	Y	Y
6042	vl_target_velocity	0	INT	RW	Y	N	N	N	N	N
6043	vl_velocity_demand	0	INT	RO	Y	N	N	N	N	N
6044	vl_velocity_actual_value	0	INT	RO	Y	N	N	N	N	N
6046	vl_velocity_min_max_ amount (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_velocity_min_max_ amount (Minimum velocity (rpm))	1	UDINT	RW	Y	N	N	N	N	N
	vl_velocity_min_max_ amount (Maximum velocity (rpm))	2	UDINT	RW	Y	N	N	N	N	N
6048	vl_velocity_acceleration (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_velocity_acceleration (Delta speed value (rpm))	1	UDINT	RW	Y	N	N	N	N	N
	vl_velocity_acceleration (Delta time value (s))	2	UINT	RW	Y	N	N	N	N	N
6049	vl_velocity_deceleration (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_velocity_deceleration (Delta speed value (rpm))	1	UDINT	RW	Y	N	N	N	N	N
	vl_velocity_deceleration (Delta time value (s))	2	UINT	RW	Y	N	N	N	N	N
604A	vl_velocity_quick_stop (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_velocity_ quick_stop (Delta speed value (rpm))	1	UDINT	RW	Y	N	N	N	N	N
	vl_velocity_ quick_stop (Delta time value (s))	2	UINT	RW	Y	N	N	N	N	N
604B	vl_setpoint_factor (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_setpoint_factor (Numerator)	1	INT	RW	Y	N	N	N	N	N
	vl_setpoint_factor (Denominator)	2	INT	RW	Y	N	N	N	N	N
604C	vl_dimension_factor (Number of last sub-index)	0	USINT	RO	Y	N	N	N	N	N
	vl_dimension_factor (Numerator)	1	INT	RW	Y	N	N	N	N	N
	vl_dimension_factor (Denominator)	2	INT	RW	Y	N	N	N	N	N

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
605A	Quick stop option code	0	UINT	RW	Y	Y	Y	Y	Y	Y
605B	Shutdown option code	0	UINT	RW	Y	Y	Y	Y	Y	Y
605C	Disable operation option code	0	UINT	RW	Y	Y	Y	Y	Y	Y
605E	Fault reaction option code	0	UINT	RW	Y	Y	Y	Y	Y	Y
6060	Modes of operation	0	USINT	RW	Y	Y	Y	Y	Y	Y
6061	Modes of operation display	0	USINT	RO	Y	Y	Y	Y	Y	Y
6062	Position demand value	0	DINT	RO	Y	Y	Y	Y	Y	Y
6064	Position actual value	0	DINT	RO	Y	Y	Y	Y	Y	Y
6065	Following error window	0	UDINT	RW	N	Y	N	N	N	Y
6067	Position window	0	UDINT	RW	N	Y	N	N	N	Y
606C	Velocity actual value	0	DINT	RO	Y	Y	Y	Y	Y	Y
6071	Target torque	0	INT	RW	N	N	N	N	Y	N
6073	Max current	0	UINT	RW	Y	Y	Y	Y	Y	Y
6075	Motor rated current	0	UDINT	RO	Y	Y	Y	Y	Y	Y
6077	Torque actual value	0	INT	RO	Y	Y	Y	Y	Y	Y
6078	Current actual value	0	INT	RO	Y	Y	Y	Y	Y	Y
607A	Target position	0	DINT	RW	N	N	N	N	N	Y
607C	Home offset	0	DINT	RW	N	N	Y	N	N	N
6080	Max motor speed	0	UDINT	RW	Y	Y	Y	Y	Y	Y
6084	Profile deceleration	0	UDINT	RW	N	Y	N	Y	Y	Y
6085	Quick stop deceleration	0	UDINT	RW	N	Y	N	N	N	Y
608F	Position encoder resolution (Number of last sub-index)	0	USINT	RO	N	Y	N	N	N	Y
	Position encoder resolution (Encoder increments)	1	UDINT	RO	N	Y	N	N	N	Y
	Position encoder resolution (Motor revolutions)	2	UDINT	RO	N	Y	N	N	N	Y
6091	Gear ratio (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Gear ratio (Motor revolutions)	1	UDINT	RW	Y	Y	Y	Y	Y	Y
	Gear ratio (Shaft revolutions)	2	UDINT	RW	Y	Y	Y	Y	Y	Y
6092	Feed constant (Number of last sub-index)	0	USINT	RO	Y	Y	Y	Y	Y	Y
	Feed constant (Feed value)	1	UDINT	RW	Y	Y	Y	Y	Y	Y
	Feed constant (Shaft revolutions)	2	UDINT	RW	Y	Y	Y	Y	Y	Y

Object Ref. (0x)	Description	Data Type		Access	Profile					
		Sub-index	Type		Velocity	Interpolated Position	Homing	Cyclic Sync Velocity	Cyclic Sync Torque	Cyclic Sync Position
6098	Homing method	0	USINT	RW	N	N	Y	N	N	N
6099	Homing speeds (Number of last sub-index)	0	USINT	RO	N	N	Y	N	N	N
	Homing speeds (Speed during switch search)	1	UDINT	RW	N	N	Y	N	N	N
	Homing speeds (Speed during zero point search)	2	UDINT	RW	N	N	Y	N	N	N
609A	Homing acceleration	0	UDINT	RW	N	N	Y	N	N	N
60B1	Velocity offset	0	DINT	RW	N	N	N	Y	N	N
60B2	Torque offset	0	INT	RW	N	N	N	Y	Y	Y
60C0	Interpolation sub-mode select	0	INT	RW	N	Y	N	Y	Y	Y
60C1	Interpolation data record (Number of last sub-index)	0	USINT	RO	N	Y	N	Y	Y	N
	Interpolation data record (Target position)	1	UDINT	RW	N	Y	N	Y	Y	N
60C2	Interpolation time period (Number of last sub-index)	0	USINT	RO	N	Y	N	Y	Y	Y
	Interpolation time period (Number of time periods)	1	USINT	RW	N	Y	N	Y	Y	Y
	Interpolation time period (Time period exponent)	2	SINT	RW	N	Y	N	Y	Y	Y
60F4	Following error actual value	0	DINT	RO	N	Y	N	N	N	Y
60FB	Position control parameter set (Number of last sub-index)	0	USINT	RO	N	Y	N	Y	Y	Y
	Position control parameter set (Proportional gain)	1	DINT	RO	N	Y	N	Y	Y	Y
	Position control parameter set (Speed feed forward gain)	2	DINT	RO	N	Y	N	Y	Y	Y
60FF	Target velocity	0	DINT	RW	N	N	N	Y	N	N
6502	Supported drive modes	0	UDINT	RO	Y	Y	Y	Y	Y	Y

6 Protocols

6.1 Process Data Objects (PDOs)

Cyclic data is implemented on EtherCAT networks by using "Process Data Objects" or PDOs. Separate data objects are used for transmitting (TxPDOs) and receiving (RxPDOs) data. PDO configuration objects are usually pre-configured in the EtherCAT master controller and downloaded to the SI-EtherCAT at network Initialization using SDOs.

6.2 Service Data Object (SDO) parameter access

The service data object (SDO) provides access to all objects in the EtherCAT object dictionary and the drive parameters are mapped into the object dictionary as 0x2XXX objects in the following way:

Index: 0x2000 + menu

Sub-index: parameter

For example Pr **20.021** would be index 0x2014 and the sub-index would be 0x15. The values are usually expressed in base 16 (hexadecimal), so care must be taken to enter the correct parameter number.

All other supported entries in the SI-EtherCAT object dictionary can also be accessed using SDOs. Refer to the master controller documentation for full details about implementing SDO transfers within the particular master controller.

Bit parameter mapping

When mapping to drive bit parameters, the parameter is stored in the drive as an 8-bit value, therefore for correct operation, the data type SINT (short integer) should be used for mapping to these parameters.

The following table shows the drive bit parameter value for a given value in the EtherCAT master.

EtherCAT Value		Parameter Value
Decimal	Hex (0x)	
-128 to 0	80 to 00	0 (Off)
1 to 127	01 to 7F	1 (On)

NOTE This is contrary to other option modules where any value other than zero will result in the parameter being set to a 1 (On).

NOTE Sub-index 0 for any menu will return the highest sub-index available for the object (i.e. the highest parameter number).

NOTE The following SDO services are supported:

- Initiate SDO Download (Write)
- Initiate SDO Upload (Read)
- Abort SDO Transfer (Error)

6.3 CANopen over EtherCAT (CoE)

The CoE protocol over EtherCAT uses a modified form of the CANopen object dictionary. This is specified in Table 6-1.

Table 6-1 CoE object dictionary

Index	Object dictionary area
0x0000 to 0x0FFF	Data type area
0x1000 to 0x1FFF	CoE communication area
0x2000 to 0x5FFF	Manufacturer specific area
0x6000 to 0x9FFF	Profile area
0xA000 to 0xFFFF	Reserved area

The object description format describes object related information such as size, range and descriptions and is detailed in Table 6-2.

Table 6-2 Object description format

<index>	**<object name>**		
Sub-index 0			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			

For entries having sub-indices

Table 6-3 Object description format with sub-indices

<index>	**<object name>**		
Sub-index 0			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			
Sub-index 1			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			
Sub-index …			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			
Sub-index n-1			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			
Sub-index n			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>		Type: <type>	
Description: <description>			

Definitions:

- <index>: A signed 16-bit number. This is the index of the object dictionary entry specified in four hexadecimal characters.

- <access>: A value describing how the object may be accessed (RW = read/write, RO = read-only and WO = write-only).
- <size>: The size of the object/sub-index in bytes.
- <unit>: The physical unit (e.g. ms, counts per second etc.).
- <type>: Data type:-

Data type	Size (bytes)	Range	Description
USINT	1	0 to 255	Unsigned short integer
SINT	1	-128 to 127	Signed short integer
UINT	2	0 to 65535	Unsigned integer
INT	2	-32768 to 32767	Signed integer
UDINT	4	0 to 2^{32}	Unsigned double integer
DINT	4	-2^{31} to $2^{31}-1$	Signed double integer

6.3.1 CoE communication area

The first set of objects specify general communication settings.

Table 6-4 Device type object

0x1000	**Device type**		
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	Dependent on drive type / mode (see description).	Type: UDINT	
Description:	The primary CoE functional profile is CiA402, so the value of this object is defined as follows: Bits 0 to 15 (Device Profile Number): 402 Bit 16 (Frequency Converter): x Bit 17 (Servo Drive): y Bit 18 (Stepper Motor): 0 Bit 24 (DC Drive - Control Techniques specific): 0 Bits 25-31 (Manufacturer specific): 0 This value will be dependent on the drive operating mode and / or type. On Unidrive M600 and above in the open-loop, RFC-A or Regen modes or on Unidrive M200 - M400, bit 16 will be set, while bit 17 will be clear. On Unidrive M600 and above in RFC-S mode, bit 17 will be set, while bit 16 will be clear.		

Table 6-5 Identity object

0x1018	Identity object		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	4	Type: USINT	
Description:	The number of the last sub-index in this object.		
Sub-index 1			
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	0x000000F9 (249)	Type: UDINT	
Description:	This contains the EtherCAT Technology Group vendor ID for Control Techniques (0x000000F9).		
Sub-index 2			
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	0x01mmvvtt	Type: UDINT	
Description:	Product code. This contains the drive product code. Byte0 (tt): Drive type (0 = Leroy Somer; 1 = Mentor MP; 2 = M600/M700; 3 = M100 to M400; 4 = MEV; 5 = Elevator ES) Byte1 (vv): Drive variant/derivative (derived from Pr **11.028**) Byte2 (mm): Drive mode (derived from Pr **11.084**) Byte3 (gg): Drive generation (0 = Unidrive SP; 1 = Unidrive M)		
Sub-index 3			
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	Derived from Pr **S.00.002**	Type: UDINT	
Description:	Module firmware version in the format *major.minor.version.build*		
Sub-index 4			
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	0	Type: UDINT	
Description:	A value of zero will be returned rather than the module serial number		

6.3.2 RxPDO mappings

Objects with indices from 0x1600 to 0x17FF specify receive PDO mappings. The mappings from CiA402 are included as standard (the PDO mappings will have the following default values).

Table 6-6 RxPDO mappings

PDO No.	Mapped object indices	Mapped default object names
1	0x6040	controlword
2	0x6040 0x6060	controlword modes_of_operation
3	0x6040 0x607A	controlword target_position
5	0x6040 0x6071	controlword target_torque
6	0x6040 0x6042	controlword vl_target_velocity

The RxPDO mapping objects are defined in the following tables. Each mapping object has the maximum number of sub-indices (each representing an object mapped to a PDO) defined in the XML configuration file (specified as “CF” in the following descriptions).

Table 6-7 RxPDO mapping 1

0x1600	Receive PDO mapping 1		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default: 1		Type: USINT	
Description: The number of mapped objects in the PDO			
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x60400010 - the CiA402 control word (0x6040)		Type: UDINT	
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

Table 6-8 RxPDO mapping 2

0x1601	Receive PDO mapping 2		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default: 2		Type: USINT	
Description: The number of mapped objects in this PDO.			
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x60400010 - the CiA402 control word (0x6040)		Type: UDINT	
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x60600008 - the CiA402 modes of operation object (0x6060)		Type: UDINT	
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

Table 6-9 RxPDO mapping 3

0x1602	Receive PDO mapping 3		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60400010 - the CiA402 control word (0x6040)	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x607A0020 - the CiA402 target position (0x607A).	Type: UDINT	
Description:	A mapping to an object with the following format: A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		

Table 6-10 RxPDO mapping 5

0x1604	Receive PDO mapping 5		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60400010 - the CiA402 control word (0x6040)	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60710010 - the CiA402 target torque (0x6071).	Type: UDINT	
Description:	A mapping to an object with the following format: A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		

Table 6-11 RxPDO mapping 6

0x1605	**Receive PDO mapping 6**		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60400010 - the CiA402 control word (0x6040)	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60420010 - the CiA402 vl target velocity (0x6042)	Type: UDINT	
Description:	A mapping to an object with the following format: A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		

Table 6-12 RxPDO mapping 8

0x1607	**Receive PDO mapping 8**		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	1	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x20062A10 - Drive control word (Pr **06.042**)	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap is required, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		

6.3.3 TxPDO mappings

Objects with the indices from 0x1A00 to 0x1BFF specify transmit PDO mappings. The following mappings from CiA402 are included as standard.

Table 6-13 TxPDO mappings

PDO number	Mapping object index	Mapping object name
1	0x6041	*statusword*
2	0x6041 0x6061	*statusword* *modes_of_operation_display*
3	0x6041 0x6064	*statusword* *position_actual_value*
5	0x6041 0x6077	*statusword* *torque_actual_value*
6	0x6041 0x6044	*statusword* *vl_velocity_actual_value*

The PDO mapping objects are defined below. Each mapping object has the maximum number of sub-indices (each representing an object mapped to a PDO) defined in the XML configuration file.

Table 6-14 TxPDO mapping 1

0x1A00	**Transmit PDO mapping 1**		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default: 1		Type: USINT	
Description: The number of mapped objects in the PDO			
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x60410010 - the CiA402 status word (0x6041)		Type: UDINT	
Description: A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.			

Table 6-15 TxPDO mapping 2

0x1A01	Transmit PDO mapping 2		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the CiA402 status word (0x6041)	Type: UDINT	
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60610008 - the CiA402 modes of operation display object (0x6061)	Type: UDINT	
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

Table 6-16 Tx PDO mapping 3

0x1A02	Transmit PDO mapping 3		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the CiA402 status word (0x6041)	Type: UDINT	
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60640020 - the CiA402 actual position (0x6064)	Type: UDINT	
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

Table 6-17 TxPDO mapping 5

0x1A04	Transmit PDO mapping 5		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the CiA402 status word (0x6041).	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60770010 - the CiA402 actual torque (0x6077)	Type: UDINT	
Description:	A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).		

Table 6-18 TxPDO mapping 6

0x1A05	Transmit PDO mapping 6		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of mapped objects in this PDO.		
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60410010 - the CiA402 status word (0x6041).	Type: UDINT	
Default:	0x60410010 - the CiA402 status word (0x6041)		
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		
Sub-index 2: 2nd mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60440010 - the CiA402 actual motor speed (0x6044).	Type: UDINT	
Description:	A mapping to an object with the following format: Bits 0 to 7: Length of the mapped object in bits, e.g. a 32-bit parameter would have a length of 32 or 0x20. Bits 8 to 15: Sub-index of the mapped object. Bits 16 to 31: Index of the mapped object.		

Table 6-19 TxPDO mapping 8

0x1A07	**Transmit PDO mapping 8**		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to 12	Size: 1 byte	Unit: N/A
Default: 1		Type: USINT	
Description: The number of mapped objects in this PDO.			
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x200A2810 - Drive status word (Pr **10.040**)		Type: UDINT	
Description: A mapping to an object with the following format: A mapping to an object. This will have the following format: Bits 0 to 7: Length of the mapped object in bits (if a gap is required, bit length of the gap). Bits 8 to 15: Sub-index of the mapped object (if a gap, zero). Bits 16 to 31: Index of the mapped object (if a gap, zero).			

6.3.4 Sync manager configuration

The sync managers are the EtherCAT means for setting access attributes for different areas of memory and triggering or notifying the application when the memory is accessed. The following objects specify how the sync managers (and thus corresponding memory areas) are utilized by the CoE protocol.

Table 6-20 Sync manager communication type object

0x1C00	**Sync manager communication type**		
Sub-index 0 - number of sync manager channels used			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 5		Type: USINT	
Description: The number of sync manager protocols used by the CoE protocol.			
Sub-index 1 - Usage of sync manager 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 1		Type: USINT	
Description: Sync manager 0 is used by CoE as the mailbox receive channel (master to slave).			
Sub-index 2 - Usage of sync manager 1			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 2		Type: USINT	
Description: Sync manager 1 is used by CoE as the mailbox send channel (slave to master).			
Sub-index 3 - Usage of sync manager 2			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 3		Type: USINT	
Description: Sync manager 2 is used by CoE as the process data output (RxPDOx - master to slave).			
Sub-index 4 - Usage of sync manager 3			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 4		Type: USINT	
Description: Sync manager 3 is used by CoE as the process data input (TxPDOs - slave to master).			
Sub-index 5 - Usage of sync manager 4			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 3		Type: USINT	
Description: Sync manager 4 is used by CoE as the process data output (RxPDOx - master to slave).			
Sub-index 6 - Usage of sync manager 5			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 4		Type: USINT	
Description: Sync manager 5 is used by CoE as the process data input (TxPDOs - slave to master).			

Table 6-21 Sync manager 0 PDO assignment object

0x1C10	**Sync manager 0 PDO assignment**		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 0		Type: USINT	
Description:	Number of assigned PDOs. The mailbox received sync manager can never have PDOs assigned to it.		

Table 6-22 Sync manager 1 PDO assignment object

0x1C11	Sync manager 1 PDO assignment		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description:	Number of assigned PDOs. The mailbox send sync manager can never have PDOs assigned to it.		

Table 6-23 Sync manager 2 PDO assignment object

0x1C12	Sync manager 2 PDO assignment		
Sub-index 0			
Access: RW	Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	1	Type: USINT	
Description:	The number of RxPDOs assigned to this sync manager (used for process data output).		
Sub-indices 1 to (sub-index 0)			
Access: RW	Range: 0x1600 to 0x17FF	Size: 2 bytes	Unit: N/A
Default:	0x1605	Type: UINT	
Description:	The object index of an RxPDO to assign to this sync manager. By default this is assigned to RxPDO mapping 6 (*vl_target_velocity* and *controlword*).		

Table 6-24 Sync manager 3 PDO assignment object

0x1C13	Sync manager 3 PDO assignment		
Sub-index 0			
Access: RW	Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	1	Type: USINT	
Description:	The number of TxPDOs assigned to this sync manager (used for process data input).		
Sub-indices 1 to (sub-index 0)			
Access: RW	Range: 0x1A00 to 0x1BFF	Size: 2 bytes	Unit: N/A
Default:	0x1A05	Type: UINT	
Description:	The object index of a TxPDO to assign to this sync manager. By default this is assigned to TxPDO mapping 6 (*vl_velocity_actual_value* and *statusword*).		

Table 6-25 Sync manager 4 PDO assignment object

0x1C14	Sync manager 4 PDO assignment		
Sub-index 0			
Access: RW	Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	1	Type: USINT	
Description:	The number of RxPDOs assigned to this sync manager (used for low priority process cyclic data).		
Sub-index 1 to (sub-index 0)			
Access: RW	Range: 0x1A00 to 0x1BFF	Size: 2 bytes	Unit: N/A
Default:	0	Type: UINT	
Description:	The object index of a RxPDO to assign to this sync manager.		

Table 6-26 Sync manager 5 PDO assignment object

0x1C15	Sync manager 5 PDO assignment		
Sub-index 0			
Access: RW	Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	1	Type: USINT	
Description:	The number of TxPDOs assigned to this sync manager (used for low priority process cyclic data).		
Sub-index 1 to (sub-index 0)			
Access: RW	Range: 0x1A00 to 0x1BFF	Size: 2 bytes	Unit: N/A
Default:	0	Type: UINT	
Description:	The object index of a TxPDO to assign to this sync manager.		

Sync managers 2 and 3 are used for high-priority deterministic process cyclic data.

Sync managers 4 and 5 are used for low-priority non-deterministic process cyclic data, they support:

- A maximum of 32 x 32-bit parameters allowed in each PDO when PDO6 is used (maximum of 12 x 32-bit parameters only in other PDOs).
- Slot parameter mapping (e.g. SI-Applications Plus menu 7x parameters)
- Note: when using slot parameter mapping, the data size must be 4 bytes (32 bits)
- Minimum cycle time of 2 ms.

6.3.5 Feedback encoder source

Table 6-27 Feedback encoder source

0x3000	Position Feedback Encoder Configuration		
Sub-index 0			
Access: RW	Range: 0 to 11	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description:	This specifies the source for position controller feedback, and the source for CiA402 position feedback objects, even when position control is not being performed. This will have a value as follows: 0 - The feedback source for the position controller will match the drive motor control feedback source (as specified in menu 3). 1 - Drive feedback source, P1 interface. 2 - Drive feedback source, P2 interface. 3 - Slot 1 position feedback module, P1 interface. 4 - Slot 1 position feedback module, P2 interface. 5 - Slot 2 position feedback module, P1 interface. 6 - Slot 2 position feedback module, P2 interface. 7 - Slot 3 position feedback module, P1 interface. 8 - Slot 3 position feedback module, P2 interface. 11 - Sensorless (the sensorless algorithm estimates position feedback). This value will be ignored on drives where no encoder input is present. This object will be read upon a transition from the EtherCAT Pre-operational state to the Safe-operational state.		

NOTE If the position feedback encoder configuration is changed then the change will only be made active upon a module reset or changing the mode of operation (0x6060), however, if the module is reset to activate the change then a "Sync Task Orun" trip may be seen.

NOTE The value of objects 0x3000 will be ignored on drives which do not support position feedback.

6.4 Additional position loop scaling

For applications where different feedback devices with different resolutions are required for the drive velocity and position loops, this object can be used to apply a scaling factor to the position loop output value.

Table 6-28 Additional position loop scaling

0x3004	**Additional position loop scaling**			
Sub-index 0				
Access: RO		Range: N/A	Size: 1 byte	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of the last sub-index in this object.			
Sub-index 1				
Access: RW		Range: -2^{31} to $+2^{31}-1$	Size: 4 bytes	Unit: N/A
Default:	1		Type: DINT	
Description:	The additional position loop output scaling numerator			
Sub-index 2				
Access: RW		Range: -2^{31} to $+2^{31}-1$	Size: 4 bytes	Unit: N/A
Default:	1		Type: DINT	
Description:	The additional position loop output scaling denominator			

6.5 Cyclic data loss behaviour

Table 6-29 Cyclic data loss behaviour

0x3005	**Cyclic data loss behaviour**		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of the last sub-index in this object.		
Sub-index 1			
Access: RW	Range: 0 to 65535	Size: 2 byte	Unit: ms
Default:	0	Type: UINT	
Description:	The maximum time, in ms, allowed between accesses to synchronous PDOs (read or writes). If no PDO access occurs for this period, the option will start cyclic data loss handling. If a value of zero is set, no cyclic data loss handling will occur. When used in modes that provide interpolation, thus having a mode-specific cycle time, the loss must be for the duration of (maximum time) cycle. The maximum time will be aligned to the start of a cycle. So for a position cycle time of 4 ms and a maximum time configuration of 6 ms, this would result in a loss detection of 2 cycles or 8 ms of PDO's.The time will always be rounded up to the next cycle. If the maximum time is configured to less than the cycle time then this will be rounded up to the cycle time. For a time of 0 ms the cyclic data loss detection will not trigger for any loss.		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description:	Cyclic Data Loss Action; the value will select an action as follows: 0: a trip will never occur; however, a cyclic data loss will still be handled by initiating a motor stop according to the Fault reaction option code and indicating a alarm as previously described. 1:The cyclic data loss trip will occur only after the motor has been stopped according to the Fault reaction option code; in so far as the motor stop can actually be detected, depending on the feedback actually in use, if any. 2: A trip will occur immediately on cyclic data loss (this implies that the motor will coast; no other motor stop will be initiated).		
Sub-index 3			
Access: RW	Range: 0 to 65535	Size: 1 byte	Unit: N/A
Default:	0	Type: UINT	
Description:	Cyclic loss counter Provides an indication of the number of PDO's lost. The counter is reset when the EtherCAT network is restarted.		

NOTE In the event of the cyclic data not being detected within the synchronisation cycle the drive will indicate a 'PDOs Lost' alarm.

7 Drive profile (CiA402) support

SI-EtherCAT supports the following modes of the CiA402 profile:

- Homing Mode
- Cyclic Synchronous Position Mode
- Interpolated Position Mode
- vl velocity mode
- Cyclic Synchronous Velocity Mode
- Cyclic Synchronous Torque Mode

7.1 0x6040 Controlword

This provides the primary method of controlling the behavior of the drive e.g. enabling, disabling, resetting, etc. Table 7-1 describes the format of the control word. The individual bits are used in combinations (see Table 7-2) to sequence the drive through the state machine described in Figure 7-1.

Table 7-1 Controlword

0x6040	**Controlword**															
Access: RW				Range: 0 to 65535				Size: Unsigned 16				Unit: N/A				
Default:			N/A					Type: UINT								
Description:			Provides the primary method of controlling the behavior of the drive.													
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Reserved				ila	r	oms	h	fr	oms		hos	eo	qs	ev	so	

LEGEND: ms = manufacturer-specific; r = reserved; oms = operation mode specific; h = halt; fr = fault reset; hos = homing operation start; eo = enable operation; qs = quick stop; ev = enable voltage; so = switch on

Table 7-2 Command coding

Command	**Bits of the controlword**				
	Bit 7	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Shutdown	0	X	1	1	0
Switch on	0	0	1	1	1
Switch on + enable operation	0	1	1	1	1
Disable voltage	0	X	X	0	X
Quick stop	0	X	0	1	X
Disable operation	0	0	1	1	1
Enable operation	0	1	1	1	1
Fault reset		X	X	X	X
NOTE: Automatic transition to Enable operation state after executing SWITCHED ON state functionality.					

7.2 0x6041 Statusword

This provides feedback about the current operating state of the drive. Table 7-4 describes the format of the status word and illustrates how the individual statusword bits are combined to represent the current state of the drive.

Table 7-3 Statusword

0x6041	Statusword		
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: N/A
Default: N/A		Type: UINT	
Description:	This provides feedback about the current operating state of the drive.		

Table 7-4 Statusword bit functions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms			ha	ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso

LEGEND: ms = manufacturer-specific; ha = homing attained; oms = operation mode specific; ila = internal limit active; tr = target reached; rm = remote; w = warning; sod = switch on disabled; qs = quick stop; ve = voltage enabled; f = fault; oe = operation enabled; so = switched on; rtso = ready to switch on

Table 7-5 State coding

Statusword	State
xxxx xxxx x0xx 0000b	Not ready to switch on
xxxx xxxx x1xx 0000b	Switch on disabled
xxxx xxxx x01x 0001b	Ready to switch on
xxxx xxxx x01x 0011b	Switched on
xxxx xxxx x01x 0111b	Operation enabled
xxxx xxxx x00x 0111b	Quick stop active
xxxx xxxx x0xx 1111b	Fault reaction active
xxxx xxxx x0xx 1000b	Fault

When using CoE to control the motor position, if the status word indicates a fault due to a drive trip, then to clear the fault, the fault reset command should be executed; if the drive is reset by the keypad then the status word will not be reset and will still indicate a fault condition

7.3 Common profile features

7.3.1 Sequencing control

These are the supported objects used to control the drive:

Table 7-6 Sequencing control supported objects

Index	Name
6040	Controlword
6041	Statusword
605B	shutdown_option_code
605C	disable_operation_option_code
605A	quick_stop_option_code
605E	fault_reaction_option_code
6060	modes_of_operation
6061	modes_of_operation_display
6080	max_motor_speed
6084	profile_deceleration
6085	quick_stop_deceleration
6502	supported_drive_modes

The behavior of the sequencing control is shown in Figure 7-1 *CoE state machine diagram* on page 46. This state machine indicates how the drive will be controlled. For clarity the Statusword is abbreviated to 'SW' in the diagram.

When in the 'QUICK STOP ACTIVE' state, the currently selected mode of operation indicates how a quick stop function should be handled. When the drive is stopped, and the Quick stop option code doesn't indicate that the state should remain at 'QUICK STOP ACTIVE', the state will move to 'SWITCH ON DISABLED'.

When in the 'OPERATION ENABLED' or 'QUICK STOP ACTIVE' states it is not possible to change the *mode_of_operation* object. This is to ensure that the motor is stopped before changing the operation mode. The mode_of_operation object will be read in all CiA402 states so that the operating mode can be changed at any time, which is necessary for homing: some axes (e.g. vertical axes) have to be homed and start ordinary positioning operation without the need to remove power from the motor, which, on a vertical axis, might allow a tool, etc, to fall and be damaged or cause damage; however, the state machine will not perform a mode change until the motor is at zero speed, as far as can be determined; the purpose of this requirement is to prevent motion discontinuities that might occur if the motor is being moved when the mode is changed.

The SI-EtherCAT master device must be in the operational state before the state machine can move from the 'SWITCH ON DISABLED' state to the 'READY TO SWITCH ON' state. If the master leaves the operational state while the state machine is in the 'SWITCH ON', 'OPERATION ENABLE' , 'QUICK STOP ACTIVE' or 'READY TO SWITCH ON' state then the option will transition to the 'SWITCH ON DISABLED' state. This implies that the drive will be inhibited and the motor will coast.

Figure 7-1 CoE state machine diagram

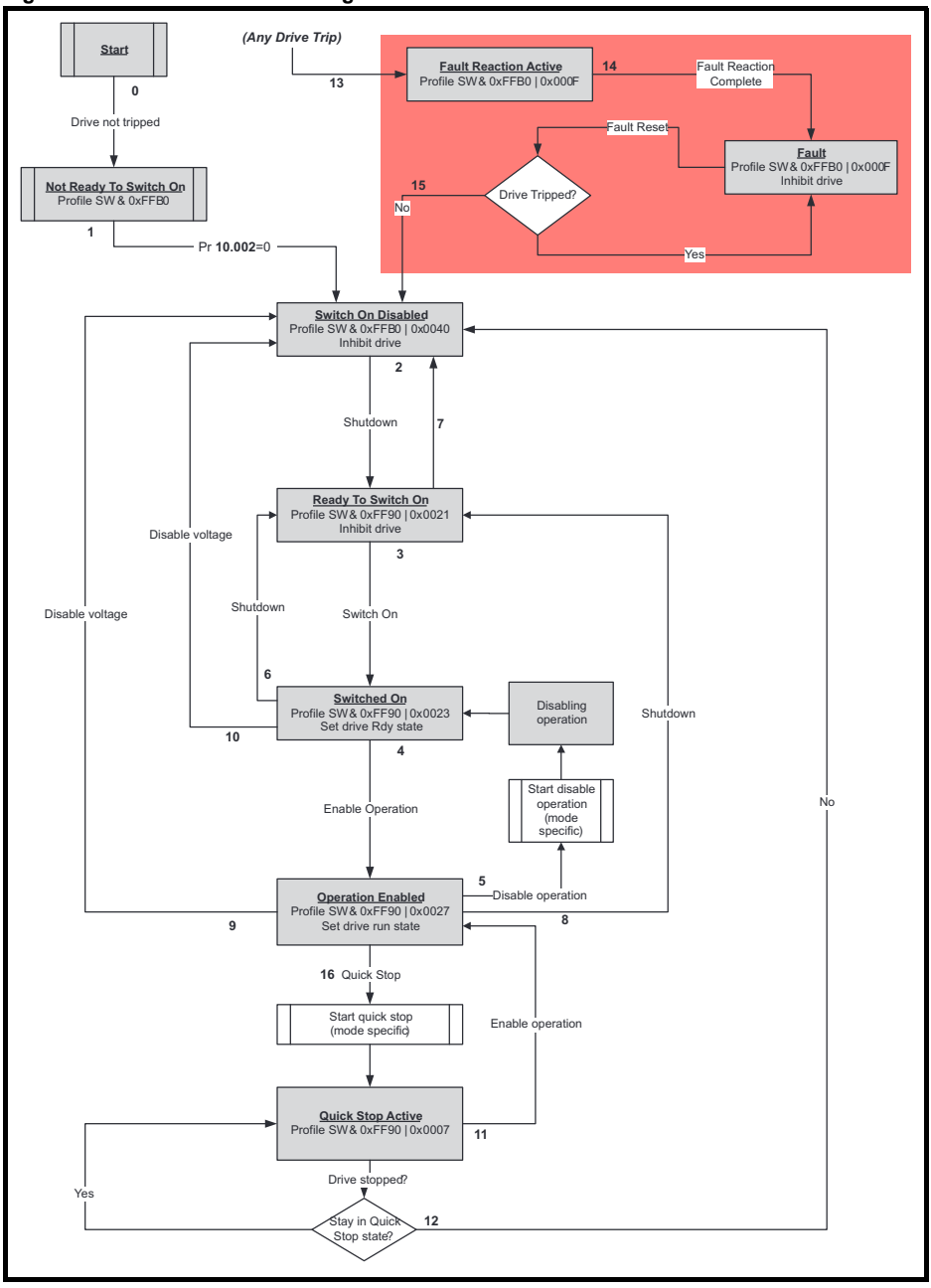


Table 7-7 CoE state machine transition and events

Transition	Event(s)	Action(s)
0	Automatic transition after power-on or reset application	Drive device self-test and/or self Initialization shall be performed
1	Automatic transition	Communication shall be activated
2	Shutdown command from control device or local signal	None
3	Switch on command received from control device or local signal	Power section shall be switched on if not already switched on
4	Enable operation command received from control device or local signal	Drive function shall be enabled and clear all internal set-points
5	Disable operation command received from control device or local signal	Drive function shall be disabled
6	Shutdown command received from control device or local signal	The high-power shall be switched off immediately, and the motor shall be free to rotate if not braked; additional action depends on the shutdown option code
7	Quick stop or disable voltage command from control device or local signal	None
8	Shutdown command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
9	Disable voltage command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
10	Disable voltage or quick stop command from control device or local signal	The high-power shall be switched off immediately if possible, and the motor shall be free to rotate if not braked
11	Quick stop command from control device or local signal	The quick stop function shall be started
12	Automatic transition when the quick stop function is completed and quick stop option code 1, 2, 3 or 4 disable voltage command received from control device (dependant on the quick stop option code)	The power section shall be switched off
13	Fault signal	The configure fault reaction function shall be executed
14	Automatic transition	The drive function shall be disabled; the high-power may be switched off
15	Fault reset command from control device or local signal	A reset of the fault condition is carried out, if no fault exists currently on the drive device; after leaving the Fault state, the Fault reset bit in the controlword shall be cleared by the control device
16	Enable operation command from control device, if the quick stop option code is 5, 6, 7 or 8	The drive function shall be enabled

7.3.2 0x605A Quick stop option code

This object indicates what action is performed when the quick stop function is executed. The slow down ramp is the deceleration value of the used mode of operations.

Table 7-8 Quick_stop_option_code

0x605A	Quick_stop_option_code		
Sub-index 0			
Access: RW	Range: 0 to 6	Size: Unsigned 16	Unit: N/A
Default: 2		Type: UINT	
Description:	Specifies what action is performed in the event of a quick stop function. See Table 7-7 *CoE state machine transition and events* on page 47 for more information.		

Table 7-9 Quick stop value definitions

Value	Definition
0	Disable drive function
1	Slow down on slow down ramp and transit into Switch on disabled
2	Slow down on quick stop ramp and transit into Switch on disabled
5	Slow down on slow down ramp and stay in Quick stop active
6	Slow down on quick stop ramp and stay in Quick stop active

7.3.3 0x605B Shutdown_option_code

This object is used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.

Table 7-10 Shutdown_option_code

0x605B	Shutdown_option_code		
Sub-index 0			
Access: RW	Range: 0 to 1	Size: Unsigned 16	Unit: N/A
Default: N/A		Type: UINT	
Description:	Used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.		

Table 7-11 Shutdown_option_code values

Value	Definition
0	Disable drive function (switch off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

7.3.4 0x605C Disable_operation_option_code

Disable drive function (switch off the drive power stage).

This object is used to control what action is performed if there is a transition from the ‘Operation Enabled’ state to the ‘Switched On’ state.

Table 7-12 Disabled_operation_option_code

0x605C	Disable_operation_option_code		
Sub-index 0			
Access: RW	Range: 0 to 1	Size: Unsigned 16	Unit: N/A
Default: N/A		Type: UINT	
Description:	This object is used to control what action is performed if there is a transition from the Operation Enabled state to the Switched On state.		

Table 7-13 Disable_operation_option_code values

Value	Definition
0	Disable drive function (switch off the drive power stage)
1	Slow down with slow down ramp; disable the drive function

7.3.5 0x605E Fault_reaction_option_code

This object is used to control what action is performed when a fault is detected (PDO loss). This object is ignored if the drive is tripped.

Table 7-14 Fault_reaction_option_code

0x605E	Fault_reaction_option_code		
Sub-index 0			
Access: RW	Range: 0 to 2	Size: Unsigned 16	Unit: N/A
Default:	N/A	Type: UINT	
Description:	This object is used to control what action is performed when a fault is detected.		

Table 7-15 Fault_reaction_option_code values

Value	Definition
0	Disable drive function, motor is free to rotate
1	Slow down on slow down ramp
2	Slow down on quick stop ramp

7.3.6 0x6060 Modes_of_operation

This object is used to request a change in the mode of operation.

Table 7-16 Modes_of_operation

0x6060	Modes_of_operation		
Sub-index 0			
Access: RW	Range: 0 to 8	Size: Unsigned 8	Unit: N/A
Default:	2	Type: USINT	
Description:	This object is used to request a change in the mode of operation.		

NOTE The default for this object is dependent on the drive operating mode. In Open-loop the default is 2. In RFC-s the default is 8.

Table 7-17 Modes_of_operation values

Value	Definition
0	No mode change
2	vl velocity mode
6	Homing mode
7	Interpolated Position mode
8	Cyclic Sync Position mode
9	Cyclic Sync Velocity mode
10	Cyclic Sync Torque mode

7.3.7 0x6061 Modes_of_operation_display

This read only object indicates the active mode of operation.

Table 7-18 Modes_of_operation_display

0x6061	Modes_of_operation_display		
Sub-index 0			
Access: RO	Range: 0 to 8	Size: Unsigned 8	Unit: N/A
Default:	N/A	Type: USINT	
Description:	Used to provide the active mode of operation.		

Table 7-19 Modes_of_operation_display values

Value	Definition
0	No mode change
2	vl velocity mode
6	Homing mode
7	Interpolated Position mode
8	Cyclic Sync Position mode
9	Cyclic Sync Velocity mode
10	Cyclic Sync Torque mode

7.3.8 0x6084 Profile deceleration

Table 7-20 Profile deceleration

0x6084	Profile deceleration		
Access: RW	Range:0 to 65536	Size: Unsigned 32	Unit: N/A
Default:	65536	Type: UDINT	
Description:	Provides the deceleration ramp for the positioning modes		

7.3.9 0x6085 Quick_stop_deceleration

This object is used to configure the deceleration rate used to stop the motor when the quick stop function is activated and the quick stop code object (0x605A) is set to 2 or 6. The quick stop deceleration is also used if the fault reaction code object (0x605E) is 2. The value is given in user-defined acceleration units.

Table 7-21 Quick_stop_deceleration

0x6085	Quick_stop_deceleration		
Sub-index 0			
Access: RW	Range:Range:0 to 65536	Size: Unsigned 32	Unit: N/A
Default:	65536	Type: UDINT	
Description:	Quick stop function for the positioning related modes.		

7.3.10 Profile units

The SI-EtherCAT implementation provides a means to convert profile units into position controller and drive units. All scaling values are standard profile objects. The following objects are supported:

Table 7-22 Supported profile units

Index	Name
0x608F	*position_encoder_resolution*
0x6091	*gear_ratio*
0x6092	*feed_constant*

For positions, the scaling control includes a feed constant, a gear ratio and an encoder revolution. These values are combined by the implementation into a simple scaling numerator and denominator. It is possible to change these values non-cyclically (i.e. using SDOs), in which case the scaling numerator and denominator and any position limit values are recalculated in the background. It is not, however, possible to change these values cyclically (i.e. by mapping PDOs to them).

For velocities, in addition to the position constants described above, these values are combined into a simple numerator and denominator to scale velocities to internal velocity units. This scaling also properly handles remainders (i.e. when used on a reference or feedback, accumulate the remainder and add it to subsequent velocity values, and when used with a limit, round up or down). It is possible to change these values non-cyclically (i.e. using SDOs), in which case the scaling numerator and denominator is recalculated in the background. It is also necessary to re-scale velocity limit values with the new factor. It is not possible to change these values cyclically (i.e. by mapping PDOs to them).

7.3.11 0x608F Position_encoder_resolution

This read only object indicates the configured encoder increments per number of motor revolutions. The information is read from the drive's encoder configuration.

Table 7-23 Position_encoder_resolution

0x608F	**Position_encoder_resolution**			
Sub-index 0				
Access: RO		Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		Type: USINT	
Description:				
Sub-index 1				
Access: RO		Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	1		Type: UDINT	
Description:	Encoder increments			
Sub-index 2				
Access: RO		Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	1		Type: UDINT	
Description:	Motor revolutions			

7.3.12 0x6091 Gear_ratio

This object is used to apply scaling. When configured, appropriate user units can be used to control the position of the shaft beyond a gearbox. The gear ratio is calculated using the following formula:

gear ratio = motor shaft revolutions / driving shaft revolutions

Table 7-24 Gear_ratio

0x6091	**Gear_ratio**		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2		Type: USINT	
Description:			
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1		Type: UDINT	
Description: Motor revolutions			
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1		Type: UDINT	
Description: Shaft revolutions			

7.3.13 0x6092 Feed_constant

This is used to configure a feed constant. This is the measurement distance per one revolution of the output shaft of the gearbox. The feed constant is calculated using the following formula:

feed constant = feed / driving shaft revolutions

Table 7-25 Feed_constant

0x6092	**Feed_constant**		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2		Type: USINT	
Description:			
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1		Type: UDINT	
Description: Feed			
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1		Type: UDINT	
Description: Shaft revolutions			

7.3.14 Basic position control

Basic position control is supported on the Unidrive M600 and above in RFC-A and RFC-S modes. The position control described here is used under the interpolated position mode of operation. Table 7-26 lists the objects that are supported:

Table 7-26 Basic position control supported objects

Index	Name
0x6062	*position_demand_value*
0x6065	*following_error_window*
0x6067	*position_window*
0x60F4	*following_error_actual_value*
0x60FB	*position_control_parameter_set*

7.3.15 0x6062 Position_demand_value

This read only object is used to provide the currently demanded position value. The value is given in user defined position units.

Table 7-27 Position_demand_value

0x6062	**Position_demand_value**		
Sub-index 0			
Access: RO	Range: 0 to 0xFFFFFFFF	Size: signed 32	Unit: N/A
Default:	N/A	Type: DINT	
Description:	Used to provide the currently demanded position value.		

7.3.16 0x6064 Position_actual_value

This read only object provides the actual value of the position feedback device. The value is given in internal units.

Table 7-28 Position_actual_value

0x6064	**Position_actual_value**		
Sub-index 0			
Access: RO	Range: 0 to 0xFFFFFFFF	Size: signed 32	Unit: N/A
Default:	N/A	Type: DINT	
Description:	This read only object provides the actual value of the position feedback device. The value is given in internal units.		

7.3.17 Following error window

This object can be used to indicate and configure the range of position values, symmetrical to the position demand value, outside of which a following error occurs. The value is given in user-defined position units.

Table 7-29 Following error window

0x6065	**Following error window**		
Sub-index 0			
Access: RW	Range: Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0xFFFFFFFF	Type: UDINT	
Description:	Permitted range of position values before a following error occurs.		

7.3.18 Position window

This object can be used to indicate and configure the symmetrical range of acceptable position values relative to the target position, within which the target position will be regarded as having been reached. The value is given in user-defined position units.

Table 7-30 Position window

0x6067	**Position window**		
Sub-index 0			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0xFFFFFFFF	Type: UDINT	
Description:	Permitted range of position values for target position to be regarded as reached.		

7.3.19 Motor rated current

This object indicates the configured motor rated current. The value is given in mA.

Table 7-31 Motor rated current

0x6075	**Motor rated current**		
Sub-index 0			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: mA
Default:	0xFFFFFFFF	Type: UDINT	
Description:	Motor rated current value derived from Pr **05.007**.		

7.3.20 0x6080 Max motor speed

Table 7-32 Max motor speed

0x6080	**Max motor speed**		
Sub-index 0			
Access: RO	Range: 0 to 0xFFFFFFFF	Unsigned 32	Unit: rpm
Default:	3000	Type: UDINT	
Description:	This object indicates the configured maximum allowed speed for the motor in either direction. It is used to protect the motor and changing the value of this object will also change Pr **1.06**. The value is given in rotations per minute (rpm).		

7.3.21 0x60F4 Following_error_actual_value

This read only object provides the actual value of the following error. The value is given in user-defined position units.

Table 7-33 Following_error actual_value

0x60F4	**Following_error actual_value**		
Sub-index 0			
Access: RO	Range: 0 to 0xFFFFFFFF	Size: signed 32	Unit: N/A
Default:	N/A	Type: DINT	
Description:	This read only object provides the actual value of the following error.		

7.3.22 0x60FB Position_control_parameter_set object

Table 7-34 Position_control_parameter_set object

0x60FB	Position_control_parameter_set		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of control loop parameters.		
Sub-index 1			
Access: RW	Range: 0 to 5000	Size: Unsigned 16	Unit: 0.01 rad/s/rad
Default:	2500	Type: DINT	
Description:	The position controller proportional gain.		
Sub-index 2			
Access: RW	Range: 0 to 2000	Size: Unsigned 16	Unit: 1 / 1000
Default:	1000 (i.e. a gain of 1)	Type: DINT	
Description:	The position controller speed feed forward gain.		

The AMC position controller kernel is used by the basic internal position control.

The *position_demand_value* object contains the value supplied by either the interpolated position mode or the profile position mode (in user units). It is updated every control loop cycle. This object can be mapped as cyclic data.

7.3.23 Supported drive modes

This object provides information on the supported drive modes.

Table 7-35 Supported drive modes

0x6502	Supported drive modes		
Sub-index 0			
Access: RO	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 992		Type: UDINT	

Description: Provides information on the supported drive modes as shown below.

31 16	15 11	10	9	8	7	6	5	4	3	2	1	0
ms	r	cstca	cst	csv	csp	ip	hm	r	tq	pv	vl	pp

Mnemonic	Description	Value
r	Reserved	0
ms	Manufacturer specific bits	0 = Function is not supported 1 = Function is supported
cstca	Cyclic sync torque mode with communication angle	0 = Mode is not supported 1 = Mode is supported
cst	Cyclic sync torque mode	
csv	Cyclic sync velocity mode	
csp	Cyclic sync position mode	
ip	Interpolated position mode	
hm	Homing mode	
tq	Torque profile mode	
pv	Profile velocity	
vl	Velocity mode	
pp	Profile position mode	

7.4 Interpolated position mode

Interpolated position mode operates on the Unidrive M600 in RFC-A and RFC-s modes. Table 7-36 lists the objects that are supported:

Table 7-36 Supported Interpolated position mode objects

Index	Name
0x60C0	*interpolation_submode_select*
0x60C1	*interpolation_data_record*
0x60C2	*interpolation_time_period*

NOTE When using one of the CiA402 positioning modes, Distributed Clocks must be enabled. Failure to do so may result in the SI-EtherCAT module going into the SAFE-OPERATIONAL state.

7.4.1 0x60C0 Interpolation_sub-mode_select

Table 7-37 0x60C0 Interpolation_sub-mode_select

0x60C0	Interpolation_sub-mode_select		
Sub-index 0			
Access: RW	Range: 0	Size: Signed 16	Unit: N/A
Default:	0 (Linear interpolation)		
Description:	Specifies the interpolation type. At present the only supported Interpolation Sub-Mode is 'Linear Interpolation'.	Type: INT	

7.4.2 0x60C1 Interpolation_data_record

This object is used to specify the target position. Linear interpolation is used to generate position demand values every 250 µs. The position is specified in user-defined position units. The value is written into sub-index 1.

Table 7-38 0x60C1 Interpolation_data_record

0x60C1	Interpolation_data_record		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	1	Type: USINT	
Description:	This object is used to specify the target position.		
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	N/A	Type: UDINT	
Description:	The set-point.		

7.4.3 0x60C2 Interpolation_time_period

Table 7-39 Interpolation_time_period

0x60C2	Interpolation_time_period		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of the last sub-index in this object.		
Sub-index 1			
Access: RW	Range: 0 to 255	Size: Unsigned 8	Unit: (sub-index 2)
Default:	250 (units are dependent on the value in sub-index 2)	Type: USINT	
Description:	The number of time units between interpolator re-starts. A time unit is defined by sub-index 2. The interpolator time period value is checked to ensure that it is valid. Valid values are 250 µs, 500 µs or any multiple of 1 ms. An attempt to write other values results in an SDO Abort code.		
Sub-index 2			
Access: RW	Range: -6 to 0	Size: Signed 8	Unit: N/A
Default:	-6 (a time unit of 1 µs)	Type: SINT	
Description:	This specifies the time unit for the interpolation time period. Sub-index 2 specifies the unit exponent. The time unit, therefore, is 10 (sub-index 2). The range of values allows for the shortest time unit to be 1 µs, and the longest to be 1 s.		

The implementation of interpolated position mode allows synchronous operation only, where a fixed, common interpolation interval is defined. The time specified must always be an integer multiple of the control loop cycle time. The time period index has a minimum value of -6 (i.e. the

smallest time unit will be microseconds), see Table 7-40 for more information.

Table 7-40 Interpolation time period units

Value in 0x60C2, sub-index 2	Description
0	1 second
-1	0.1 of a second
-2	0.01 of a second
-3	0.001 of a second
-4	0.0001 of a second
-5	0.00001 of a second
-6	0.000001 of a second

The time period is checked to ensure that it is an integer multiple of the control loop cycle time. Only linear interpolation is currently supported, this type inserts a delay of one interpolation time period.

The input buffer has a maximum size of 1 data record, and a data record contains one position in profile-defined units. The buffer is a FIFO buffer. On each interpolator time period, a value is read from this buffer. The correct number of data points for a specific interpolation mode are stored internally. When a new position command is loaded in, the oldest position command in the data set is discarded.

7.5 vl velocity mode

Velocity mode is supported on Unidrive M200 and above. It is not, however, supported in regen modes.

When the drive is in either of the RFC-A or RFC-S operating modes the scaled velocity is written to the drive internal speed shortcut. When the drive is in an open-loop operating mode the scaled velocity is written to the user preset reference parameter (Pr **01.021**). Table 7-41 lists the objects that are supported:

Table 7-41 vl velocity mode supported objects

Index	Name
0x3008	*Active velocity mode redirection*
0x6042	*vl_target_velocity*
0x6043	*vl_velocity_demand*
0x6044	*vl_velocity_actual_value*
0x6046	*vl_velocity_min_max_amount*
0x6048	*vl_velocity_accleration*
0x6049	*vl_velocity_deceleration*
0x604A	*vl_velocity_quick_stop*
0x604B	*vl_setpoint_factor*
0x604C	*vl_dimension_factor*

7.5.1 Activate velocity mode redirection

This object provides the facility to redirect the velocity mode reference from the normal velocity mode object (0x6402) to the cyclic sync velocity mode object (0x60FF).

Table 7-42 Activate velocity mode redirection

0x3008	Activate velocity mode redirection		
Sub-index 0			
Access: RW	Range: 0 to 1	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description:	Redirects the velocity mode reference from object 0x6042 to object 0x60FF. Normally object 0x60FF is the reference for csv mode and object 0x6042 is the reference for velocity mode. Activating this object means that object 0x60FF will be used as the reference for velocity mode. Units are RPM in the range -32768 to 32767. This object value change will take effect on a CiA402 transition from "Ready to switch on" to "Switched on".		

7.5.2 0x6042 vl_target_velocity

This object is used to set the required velocity of the system. It is multiplied by the *vl_dimension_factor* and the *vl_setpoint_factor*. The value is given in rpm, If the *vl_dimension_factor* has the value of 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7-43 vl_target_velocity

0x6042	vl_target_velocity		
Sub-index 0			
Access: RW	Range: -32768 to +32767	Size: Signed 16	Unit: rpm
Default:	0	Type: INT	
Description:	Used to set the required velocity of the system.		

7.5.3 0x6043 vl_velocity_demand

This read only object provides the instantaneous velocity demand generated by the drive ramp function. The value is given in rpm if the *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7-44 vl_velocity_demand

0x6043	vl_velocity_demand		
Sub-index 0			
Access: RO	Range: -32768 to +32767	Size: Signed 16	Unit: rpm
Default:	0	Type: INT	
Description:	Provides the instantaneous velocity demand generated by the drive ramp function.		

7.5.4 0x6044 vl_velocity_actual_value

This read only object provides the velocity at the motor spindle or load. In a closed loop system this is determined from the motor feedback device and in an open loop system it is a copy of *vl_velocity_demand*.

The value is given in rpm if the *vl_dimension_factor* has the value of 1, otherwise the value is in user units. Positive values indicate forward direction and negative values indicate reverse direction.

Table 7-45 velocity_actual_value

0x6044	**vl_velocity_actual_value**			
Sub-index 0				
Access: RO		Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	0		Type: INT	
Description:	Provides the velocity at the motor spindle or load.			

7.5.5 0x6046 vl_velocity_min_max_amount

This object is used to configure the minimum and maximum velocity.

The value is given in rpm if the *vl_dimension_factor* has the value of 1, otherwise the value is in user units.

Table 7-46 vl_velocity_min_max_amount

0x6046	**vl_velocity_min_max_amount**			
Sub-index 0				
Access: RO		Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of sub-indices in this object.			
Sub-index 1				
Access: RW		Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	0		Type: UDINT	
Description:	Used to configure the minimum velocity (both in the forward and reverse direction) that the system can operate at. Writing to this sub index will overwrite *vl_velocity_min* positive and *vl_velocity_min* negative.			
Sub-index 2				
Access: RW		Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	2147483647		Type: UDINT	
Description:	Used to configure the maximum velocity (both in the forward and reverse direction) that the system can operate at. Writing to this sub index will overwrite *vl_velocity_max* positive and *vl_velocity_max* negative.			

7.5.6 0x6048 vl_velocity_acceleration

This object is used to configure the delta speed and delta time of the slope of the acceleration ramp.

Example: To ramp to 1000 rpm in 5 s, possible values for delta speed and delta time are 10000 and 50 respectively.

vl_velocity_acceleration = delta speed / delta time

Table 7-47 0x6048 vl_velocity_acceleration

0x6048	**vl_velocity_acceleration**		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2		Type: USINT	
Description:	The number of sub-indices in this object.		
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default: 1000		Type: UDINT	
Description:	The value of delta speed is given in rpm if the *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default: 2		Type: UINT	
Description:	The value of delta time is given in seconds.		

7.5.7 0x6049 vl_velocity_deceleration

This object is used to configure the delta speed and delta time of the slope of the deceleration ramp.

Example: To decelerate by 800 rpm in 10 s, possible values for delta speed and delta time are 8000 and 100 respectively.

vl_velocity_deceleration = delta speed / delta time

Table 7-48 0x6049 vl_velocity_deceleration

0x6049	**vl_velocity_deceleration**		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2		Type: USINT	
Description:	The number of sub-indices in this object.		
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default: 1000		Type: UDINT	
Description:	The value of delta speed is given in rpm if the *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default: 2		Type: UINT	
Description:	The value of delta time is given in seconds.		

7.5.8 0x604A vl_velocity_quick_stop

This object is used to configure the delta speed and delta time of the slope of the deceleration ramp for quick stop.

Example: To decelerate by 800 rpm in 10 s, possible values for delta speed and delta time are 8000 and 100 respectively.

vl velocity deceleration = delta speed / delta time

Table 7-49 0x604A vl_velocity_quick_stop

0x604A	**vl_velocity_quick_stop**			
Sub-index 0				
Access: RO		Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of sub-indices in this object.			
Sub-index 1				
Access: RW		Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	1000		Type: UDINT	
Description:	The value of delta speed is given in rpm if the *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.			
Sub-index 2				
Access: RW		Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default:	2		Type: UINT	
Description:	The value of delta time is given in seconds.			

7.5.9 0x604B vl_setpoint_factor

This object is used to configure the numerator and denominator of the *vl_setpoint_factor.* The *vl_setpoint_factor* modifies the resolution or directing range of the specified setpoint. It does not influence the velocity limit function and the ramp function. A value of 0 must not be used.

Table 7-50 0x604B vl_setpoint_factor

0x604B	**vl_setpoint_factor**			
Sub-index 0				
Access: RO		Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of sub-indices in this object.			
Sub-index 1				
Access: RW		Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	1		Type: INT	
Description:	*vl_setpoint_factor* numerator (a value of 0 is not valid).			
Sub-index 2				
Access: RW		Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	1		Type: INT	
Description:	*vl_setpoint_factor* denominator (a value of 0 is not valid).			

7.5.10 0x604C vl_dimension_factor

This object is used to configure the numerator and denominator of the *vl_dimension_factor*. The *vl_dimension_factor* is used to scale the user units so that they can be used in a way that relates to the specific application.

Calculating the vl_dimension_factor:
Every user-specific velocity consists of a specific unit referred to as a specific unit of time (e.g. 1/s, bottles/min, m/s,...). The purpose of the *vl_dimension_factor* is to convert this specific unit to the revolutions/minute unit. A value of 0 must not be used.

Velocity [user-defined unit] / Dimension factor [rpm/user-defined unit] = Velocity [rpm]

Table 7-51 0x604C vl_dimension_factor

0x604C	**vl_dimension_factor**			
Sub-index 0				
Access: RO		Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of sub-indices in this object.			
Sub-index 1				
Access: RW		Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	1		Type: INT	
Description:	*vl_dimension_factor* numerator (a value of 0 is not valid).			
Sub-index 2				
Access: RW		Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	1		Type: INT	
Description:	*vl_dimension_factor* denominator (a value of 0 is not valid).			

The *vl_target_velocity* object is re-read every new profile cycle. It is scaled to appropriate units using the *vl_dimension_factor* and *vl_setpoint_factor* objects and then written to the drive preset reference 1 parameter (Pr **01.021**).

The object *vl_velocity_min_max* is handled every profile cycle. The *vl_target_velocity* is limited according to the values set in the object *vl_velocity_min_max*, which is read every profile cycle. The object *vl_velocity_min_max_amount* is mapped to *vl_velocity_min_max*.

The value of the *vl_velocity_demand* object is calculated in the background. The option reads the value of parameter Pr **02.001** (post ramp reference), scaled from RPM to user units using *vl_dimension_factor* and *vl_setpoint_factor*, and writes the value to the *vl_velocity_demand* object.

On a closed-loop drive, the speed feedback is calculated internally every profile cycle, scaled to the same units as *vl_target_velocity* and written to the *vl_velocity_actual_value* object. On an open-loop drive, the estimated motor speed is read from Pr **05.004** (motor RPM) in the background, scaled to the units of *vl_target_velocity* and written to the *vl_velocity_actual_value* object.

The *vl_velocity_acceleration* and *vl_velocity_deceleration* objects are handled in the background. They are read, scaled to drive acceleration units (depending on the drive operating mode), and written to the drive acceleration rate and deceleration rate presets. In addition, if the drive acceleration rate preset is changed, the *vl_velocity_acceleration* object is updated, and if the drive deceleration rate preset is changed (Pr **02.021**), the *vl_velocity_deceleration* object is updated.

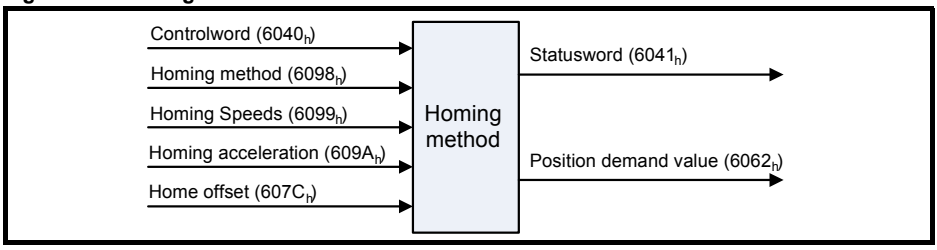
7.6 Homing mode

This section describes the method by which a drive seeks the home position (also called, the datum, reference point or zero point).

Figure 7-2 shows the defined input objects as well as the output objects. The user may specify the speeds, acceleration and the method of homing. There is a further object named home offset, which allows the user to displace zero in the user's coordinate system from the home position.

There is no output data except for those bits in the statusword, which return the status or result of the homing process and the demand to the position control loops.

Figure 7-2 Homing mode function



By choosing a homing method the following behavior is determined: The homing signal (home switch), the direction of actuation and where appropriate the position of the index pulse.

An encircled number in Figure 7-3 to Figure 7-8 indicates the code for selection of this homing position. The direction of movement is also indicated.

There are two sources of homing signal available: These are the home switch and the index pulse from an encoder.

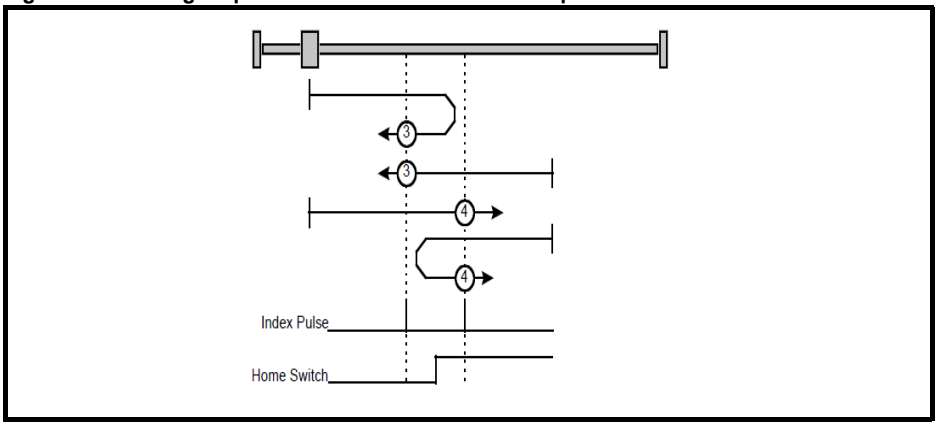
7.6.1 General homing definitions

Method 3 and 4: Homing on positive home switch and index pulse

Using these methods as shown in Figure 7-3 *Homing on positive home switch and index pulse* on page 64, the initial direction of movement shall be dependent on the state of the home switch.

The home position shall be at the index pulse either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

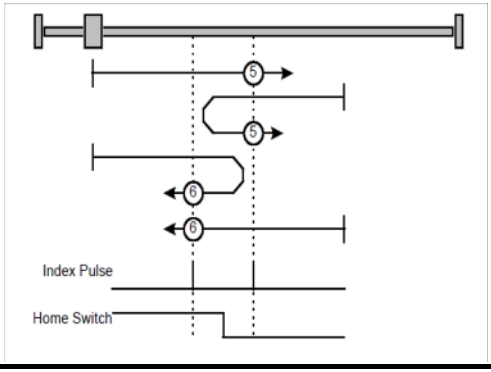
Figure 7-3 Homing on positive home switch and index pulse



Method 5 and 6: Homing on negative home switch and index pulse

Using these methods as shown in Figure 7-4 *Homing on negative home switch and index pulse* on page 65, the initial direction of movement shall be dependent on the state of the home switch. The home position shall be at the index pulse either to the left or the right of the point where the home switch changes state. If the initial position is sited so that the direction of movement shall reverse during homing, the point at which the reversal takes place is anywhere after a change of state of the home switch.

Figure 7-4 Homing on negative home switch and index pulse



Method 7 to 14: Homing on home switch and index pulse

These methods use a home switch, which is active over only a portion of the travel; in effect the switch has a 'momentary' action as the axis's position sweeps past the switch. Using the methods 7 to 10, the initial direction of movement shall be to the right, and using methods 11 to 14 the initial direction of movement shall be to the left except if the home switch is active at the start of the motion. In this case the initial direction of motion shall be dependent on the edge being sought. The home position shall be at the index pulse on either side of the rising or falling edges of the home switch, as shown in Figure 7-5 *Homing on home switch and index pulse - positive initial motion* on page 66 and Figure 7-6 *Homing on home switch and index pulse - negative initial motion* on page 66. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

Figure 7-5 Homing on home switch and index pulse - positive initial motion

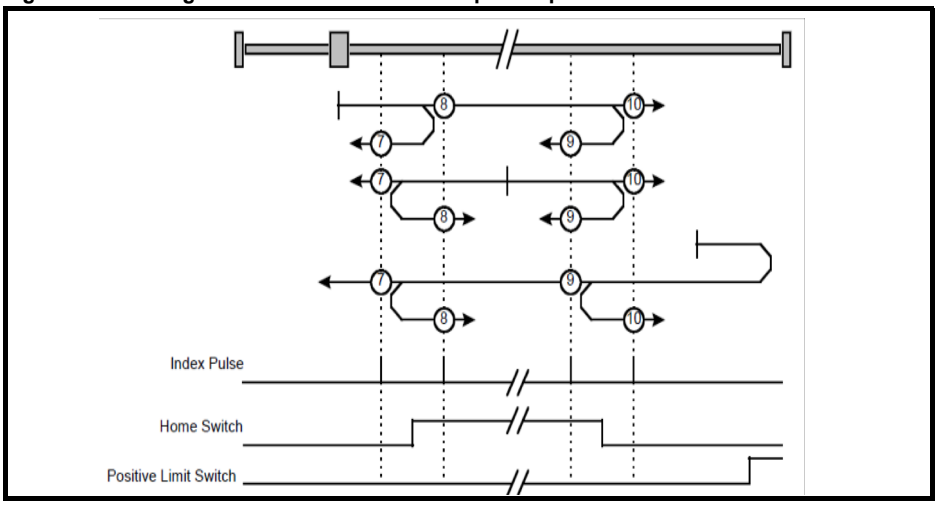
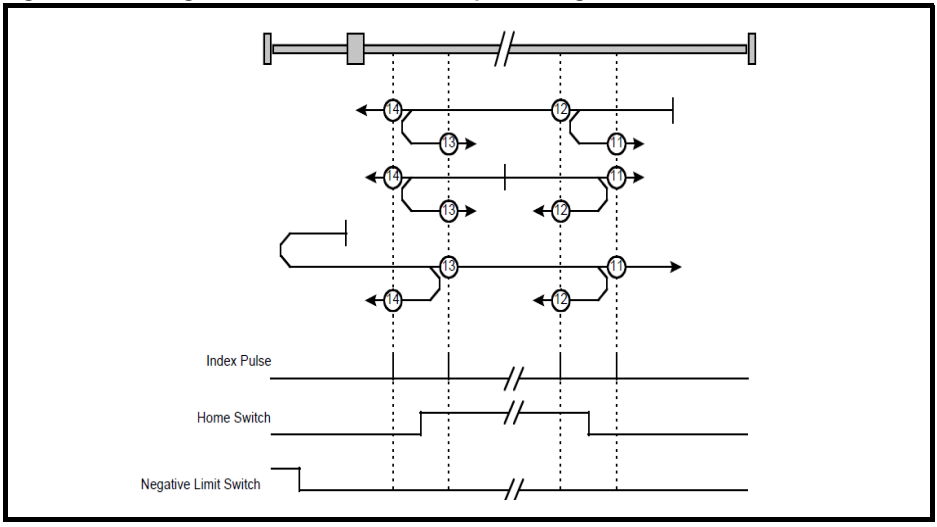


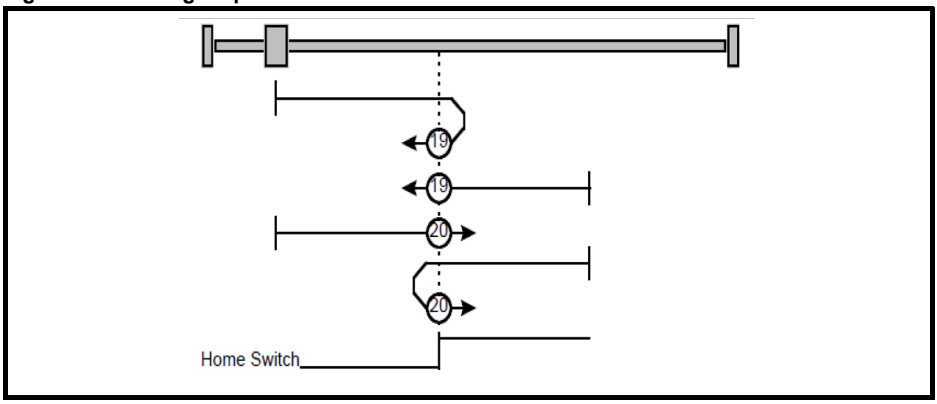
Figure 7-6 Homing on home switch and index pulse - negative initial motion



Method 15 and 16: Reserved
These methods are reserved.

Method 17 to 30: Homing without index pulse
These methods are similar to methods 3 to 14 except that the home position is not dependent on the index pulse but only dependent on the relevant home transitions. For example methods 19 and 20 are similar to methods 3 and 4 as shown in Figure 7-7 *Homing on positive home switch* on page 67.

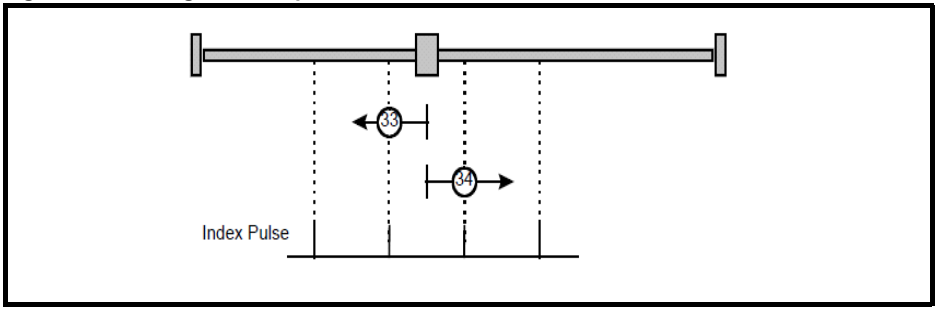
Figure 7-7 Homing on positive home switch



Method 31 and 32: Reserved
These methods are reserved.

Method 33 and 34: Homing on index pulse
Using these methods, the direction of homing is negative or positive respectively. The home position shall be at the index pulse found in the selected direction as shown in Figure 7-8 *Homing on index pulse* on page 67.

Figure 7-8 Homing on index pulse



Method 35: Homing on index pulse
In this method, the current position shall be taken to be the home position. This method does not require the drive device to be in operational enabled state.

Use of controlword and statusword
The homing mode uses some bits of the controlword and the statusword for mode-specific purposes. Table 7-52 *Definition of bits 4 and 8 of the controlword* on page 67 defines the values for bits 4 and 8 of the controlword.

Table 7-52 Definition of bits 4 and 8 of the controlword

Bit	Value	Definition
4	0	Do not start homing procedure.
	1	Start or continue homing procedure.
8	0	Enable bit 4.
	1	Stop Axis according to the configured Slow down or Quick stop ramp

Table 7-53 Definition of bits 10 and 12 of the statusword

Bit 12	Bit 10	Definition
0	0	Homing procedure is in progress.
0	1	Homing procedure is interrupted or not started.
1	0	Homing is attained, but target is not reached.
1	1	Homing procedure was completed successfully.
0	0	Homing error occurred, velocity is not 0.
0	1	Homing error occurred, velocity is 0.
1	X	Reserved.

7.6.2 Homing mode object definitions

0x3003 Homing source

This object indicates the configured source of the homing switch used during the homing procedure. Table 7-54 *Homing source* on page 68 specifies the object description.

Table 7-54 Homing source

0x3003	Homing source object		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description: The number of the last sub-index in this object.			
Sub-index 1			
Access: RW	Range: 1 to 6	Size: 1 byte	Unit: N/A
Default:	5	Type: USINT	
Description: The source of homing switch. This will specify the number of a drive digital input/output; the selected DIO also needs to be configured as an input. This value will be read when CiA402 homing operation mode is selected.			
Sub-index 2			
Access: RW	Range: 0 to 1	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description: Freeze or marker source for homing; this value will be read when CiA402 homing operation mode is selected. This will have a value as follows: 0 - Use the marker of the feedback source selected for position feedback (see object 0x3000) 1 - Use the F1 freeze of the selected feedback source (drive or numbered option module). 2 - Use the F2 freeze of the selected feedback source (drive or numbered option module).			

0x607C Home offset

This object indicates the configured difference between the zero position for the application and the machine home position (found during homing). During homing the machine home position is found and once the homing is completed, the zero position is offset from the home position by adding the home offset to the home position. All subsequent absolute moves shall be taken relative to this new zero position. This is illustrated in Figure 7-9 *Home offset definition* on page 69. The value of this object shall be given in user-defined position units. Negative values indicate the opposite direction.

Figure 7-9 Home offset definition

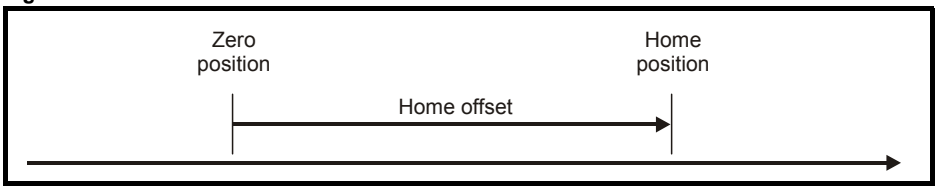


Table 7-55 Home offset

0x607C	Home offset		
Sub-index 0			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Signed 32	Unit: User-defined position units
Default: 0		Type: DINT	
Description: Homing offset value.			

0x6098 Homing method

This object indicates the configured homing method that shall be used. Table 7-56 *Homing method* on page 69 specifies the object description, and Table 7-57 *Homing method values* on page 69 specifies the value ranges for this object.

Table 7-56 Homing method

0x6098	Homing method		
Sub-index 0			
Access: RW	Range: 0 - 35	Size: Unsigned 8	Unit: N/A
Default: 0		Type: USINT	
Description: The homing method that shall be used.			

Table 7-57 Homing method values

Value	Definition
0	No homing method assigned
3	Method 3 shall be used
to	
34	Method 34 shall be used
35	Method 35 shall be used

0x6099 Homing speeds

This object indicates the configured speeds used during the homing procedure. The values shall be given in user-defined velocity units. Table 7-58 *Homing speeds* on page 70 specifies the object description.

Table 7-58 Homing speeds

0x6099	Homing speeds		
Sub-index 0			
Access: RO	Range: 2	Size: Signed 8	Unit: N/A
Default: 2		Type: USINT	
Description: The number of the last sub-index in this object.			
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 0		Type: UDINT	
Description: Speed during search for a switch.			
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 0		Type: UDINT	
Description: Speed during search for a zero.			

0x609A Homing acceleration

This object indicates the configured acceleration and deceleration to be used during the homing operation. The value shall be given in user-defined acceleration units. Table 7-59 *Homing acceleration* on page 70 specifies the object description.

Table 7-59 Homing acceleration

0x609A	Homing acceleration		
Sub-index 0			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: User-defined acceleration units
Default: 0		Type: UDINT	
Description:	Indicates the configured acceleration and deceleration to be used during homing operation.		

7.7 Cyclic sync position mode

Cyclic sync position mode is supported on the Unidrive M600 and above in RFC-A and RFC-S modes. It is not supported in open-loop or regen mode.

Table 7-60 Cyclic sync position mode

Index	Name
0x607A	target_position
0x60C0	Interpolation sub-mode select
0x60C2	interpolation_time_period

NOTE When using one of the CiA402 positioning modes, Distributed Clocks must be enabled. Failure to do so may result in the SI-EtherCAT module going into the SAFE-OPERATIONAL state.

Cyclic sync position mode provides linear interpolation which will always insert a delay of one position command. The time specified must always be an integer multiple of the control loop cycle time. The time period index has a minimum value of -6 (i.e. the smallest time unit will be microseconds). The time period is checked to ensure that it an integer multiple of the control loop cycle time.

A velocity feed forward will be calculated for the position controller. On each interpolator time period, a value is read from the target_position object. The correct number of data points for linear interpolation is stored internally. When a new target position is loaded in, the oldest position command in the data set will be discarded.

7.7.1 0x607A Target_position

This object indicates the commanded position that the drive should move to in cyclic sync position mode using the current settings of motion control parameters such as velocity, acceleration, deceleration, motion profile type etc. The value of this object is given in user-defined position units.

Table 7-61 Target position

0x607A	Target position			
Sub-index 0				
Access: RW		Range: 0 to 0xFFFFFFFF	Size: Signed 32	Unit: User-defined position units
Default:	N/A		Type: DINT	
Description:	Indicates the command positions that the drive should move to in cyclic sync position mode.			

Table 7-62 Interpolation sub-mode select

0x60C0	Interpolation sub-mode select			
Sub-index 0				
Access: RW		Range: 0 to 0	Size: 2 bytes	Unit: N/A
Default:	0 (Linear Interpolation)		Type: INT	
Description:	This will specify the interpolation type. The values have the following meanings: 0 = Linear Interpolation.			

Table 7-63 Interpolation time period

0x60C2	Interpolation time period			
Sub-index 0				
Access: RO		Range: N/A	Size: 1 byte	Unit: N/A
Default:	2		Type: USINT	
Description:	The number of the last sub-index in this object.			
Sub-index 1				
Access: RW		Range: 0 to 255	Size: 1 byte	Unit: (sub-index 2)
Default:	250		Type: USINT	
Description:	The number of time units between interpolator restarts. A time unit is defined by sub-index 2. The interpolator time period value will be checked to ensure that it is valid. Valid values are 250 µs, 500 µs or any multiple of 1 ms. Selecting other values will result in an error indication.			
Sub-index 2				
Access: RW		Range: -6 to 0	Size: 1 byte	Unit: N/A
Default:	-6 (a time unit of 1 µs)		Type: SINT	
Description:	This specifies the time unit for the interpolation time period. Sub-index 2 specifies the unit exponent. The time unit, therefore, is $10^{(\text{sub-index 2})}$. The range of values allows for the shortest time unit to be 1 µs, and the longest to be 1s.			

7.8 Cyclic Synchronous Velocity Mode

Cyclic Synchronous Velocity mode will be supported on Unidrive M600 and above in RFC-A and RFC-S operating modes.

On Unidrive M600 and above, this profile will operate on the control loop cycle time, using the drive's AMC speed reference (which is read by the drive every 250 µs, and the AMC will be configured to run in velocity mode).

The following objects will be supported:

Index	Name
606C	Velocity actual value
60B1	Velocity Offset
60C2	interpolation_time_period
60FF	target_velocity

The target_velocity object will be re-read every new profile cycle (as specified by the interpolation_time_period. This velocity demand will be scaled appropriately and written to the drive; interpolation will be used to generate additional intermediate values if the interpolation_time_period is greater than the interval at which the drive will read the hard speed reference parameter.

7.8.1 Velocity actual value

This object provides the facility to read the actual velocity feedback value.

Table 7-64 Velocity actual value

0x606C	**Velocity actual value**		
Sub-index 0			
Access: RO	Range: -2^{31} to $+2^{31}-1$	Size: 4 bytes	Unit: N/A
Default: 0		Type: DINT	
Description:	Indicates the actual velocity feedback value. Value is given per thousandths of RPM (e.g. A value of 100000 equates to 100.0 RPM as indicated in Pr **03.002**)		

7.8.2 Target velocity

This object is used to specify the target velocity value. The value is given in user-defined units.

Table 7-65 Target velocity

0x60FF	**Target velocity**		
Sub-index 0			
Access: RW	Range: -2^{31} to $+2^{31}-1$	Size: 4 bytes	Unit: N/A
Default: 0		Type: DINT	
Description:	Specifies the target velocity value per thousandths of RPM. (e.g. A value of 1000000 equates to a reference of 1000.0 RPM. In Pr **03.022**)		

7.8.3 Velocity offset

This object is used to specify the velocity offset value. The value is given in user-defined units.

Table 7-66 Velocity offset

0x60B1	Velocity offset		
Sub-index 0			
Access: RW	Range: -2^{31} to $+2^{31}-1$	Size: 4 bytes	Unit: N/A
Default: 0		Type: DINT	
Description:	Specifies the velocity offset value per thousandths of RPM. (e.g. A value of 1000000 equates to a reference of 1000.0 RPM. In Pr **03.022**). The target velocity value is added to the velocity offset value to give the final velocity reference value.		

7.9 Cyclic Synchronous Torque Mode

Cyclic Synchronous Torque Mode will be supported on Unidrive M600 and above.

On Unidrive M600 and above, this profile will operate on the control loop cycle time, using the drive's torque reference (which is read by the drive every 250 µs).

The following objects will be supported:

Index	Name
6071	target_torque
6073	max_current
6075	motor_rated_current
6077	torque_actual_value
6078	Current actual value
60B2	Torque Offset
60C2	Interpolation_time_period

The target_torque object will be re-read every new control loop cycle; this torque value will be limited by the max_current object (which is read in the background). This torque demand will be scaled appropriately and written to the drive *Torque Reference* (Pr **04.008**); interpolation will be used to generate additional intermediate values if the interpolation_time_period is greater than the interval at which the drive will read the torque reference parameter. The drive *Motor Rated Current* (Pr **05.007** or the second motor map equivalent) will be read in the background and written to the object motor_rated_current, which will be read-only.

7.9.1 Target torque

This object is used to specify the target torque value. The value is given in user-defined units.

Table 7-67 Target torque

0x6071	Target torque		
Sub-index 0			
Access: RW	Range: -32768 to 32767	Size: 2 bytes	Unit: N/A
Default: 0		Type: INT	
Description:	Specifies the target torque value. Value is in 0.1 % units. (e.g. A value of 1000 equates to 100.00 % in Pr **04.008**)		

7.9.2 Maximum current

This object is used to specify the maximum current value. The value is given in user-defined units.

Table 7-68 Maximum current

0x6073	Maximum current		
Sub-index 0			
Access: RW	Range: 0 to 65535	Size: 2 bytes	Unit: N/A
Default:	0	Type: UINT	
Description:	Specifies the maximum current value. Value is in 0.1 % units. (e.g. A value of 1000 equates to 100.0 % in Pr **04.007**) This value is also changed when Pr **04.007** is written to.		

7.9.3 Torque actual value

This object provides the actual instantaneous torque value. The value is given in user-defined units.

Table 7-69 Torque actual value

0x6077	Torque actual value		
Sub-index 0			
Access: RO	Range: -32768 to 32767	Size: 2 bytes	Unit: N/A
Default:	0	Type: INT	
Description:	Indicates the actual instantaneous torque value. Value is in 0.1 % units. (e.g. A value of 1000 equates to 100.0 % in Pr **04.003**) For open-loop drives, this value is taken from Pr **04.026**, on closed-loop drives this value is taken from Pr **04.003**.		

7.9.4 Current actual value

This object provides the actual instantaneous current value. The value is given in user-defined units.

Table 7-70 Current actual value

0x6078	Current actual value		
Sub-index 0			
Access: RO	Range: -32768 to 32767	Size: 2 bytes	Unit: N/A
Default:	0	Type: INT	
Description:	Indicates the actual instantaneous current value. Value is in 0.1 % units. (e.g. A value of 1000 equates to 100.0 % in Pr **04.004**)		

7.9.5 Torque offset

This object is used to specify the torque offset value. The value is given in user-defined units.

Table 7-71 Torque offset

0x60B2	Torque offset		
Sub-index 0			
Access: RW	Range: -32768 to 32767	Size: 2 bytes	Unit: N/A
Default:	0	Type: INT	
Description:	Specifies the torque offset value.		

7.10 Error Handling

The following objects will be provided to indicate an error condition:

Index	Name
1001	error_register
603F	error_code

Table 7-72 Error register

0x1001	Error register		
Sub-index 0			
Access: RO	Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	0	Type: USINT	
Description:	A non-zero value in this object indicates that an error has occurred. The bit(s) set indicate the type of error present. The following bits will be supported: 0: Generic error 1: Current 2: Voltage 3: Temperature When an error is indicated in this object, the particular error code will be contained in object 0x603F (Error code).		

Table 7-73 Error code

0x603F	Error code		
Sub-index 0			
Access: RO	Range: 0 toFFF	Size: 2 bytes	Unit: N/A
Default:	0	Type: UINT	
Description:	A non-zero value in this object indicates that an error has occurred. The value will be one of the codes described in the Error code table below.		

Table 7-74 Error code definitions

Error code	Meaning	Corresponding drive trip code (if available)
0x0000	Error reset / No error	0 – None
0xFFO1	Generic error	(Any trip code not elsewhere in table)
0x2300	Current, device output side	3 – OI ac
0x3130	Phase failure	32 – Phase Loss 98 - Out Phase Loss
0x2230	Short circuit/ground leakage (device internal)	5 – PSU 9 – PSU 24V 92 - Snubber OI
0x3210	DC link over-voltage	2 – Over Volts
0x3230	Load error	38 - Low Load
0x4310	Excess temperature drive	21 – OHt Inverter 22 – OHt Power 23 – OHt Control 27 – OHt dc bus 101 - OHt Brake
0x5112	"Supply low voltage" and "U2 = supply +24 V"	91 - User 24V
0x5200	Control device hardware	200 - Slot 1 Hardware Fault 203 - Slot 1 Not Fitted 204 - Slot 1 Different 205 - Slot 2 Hardware Fault 208 - Slot 2 Not Fitted 209 - Slot 2 Different 210 - Slot 3 Hardware Fault 213 - Slot 3 Not Fitted 214 - Slot 3 Different 250 - Slot 4 Hardware Fault 253 - Slot 4 Not Fitted 254 - Slot 4 Different 221 - Stored HF
0x5400	Power section	111 - Config P 220 - Power Data 223 - Rating Mismatch
0x5510	RAM	227 - Sub Array RAM Allocation
0x5530	Data storage (Non-volatile data memory)	31 – EEPROM Fail 36 – User Save 37 – Power Down Save
0x5430	Input stages	94 - Rectifier set up
0x5440	Contacts	226 - Soft Start
0x6010	Software reset (watchdog)	30 – Watchdog
0x6320	Parameter Error	199 - Destination 216 - Slot App Menu Crash 217 - App menu changed
0x7112	Brake chopper (over current brake chopper)	4 – OI Brake 19 – Brake R Too Hot
0x7113	Protective circuit break chopper	10 - Th Brake Res
0x7120	Motor	11 - Autotune 1 12 - Autotune 2 13 - Autotune 3 20 - Motor Too Hot

Error code	Meaning	Corresponding drive trip code (if available)
0x7122	Motor error or commutation malfunction	14 – Autotune 4 15 – Autotune 5 16 – Autotune 6 24 - Thermistor 25 - Th Short Circuit 33 - Resistance
0x7300	Sensor	17 - Autotune 7 162 to 163 – Encoder 12 to Encoder 13 176 – Name Plate 189 to 198 – Encoder 1 to Encoder 10 218 - Temp Feedback
0x7310	Speed	7 - Over speed
0x7500	Communication	90 - Power Comms 103 - Interconnect
0x7600	Data storage (external)	174 - Card Slot 175 – Card Product 177 – Card Boot 178 – Card Busy 179 – Card Data Exists 180 – Card Option 181 – Card Read Only 182 – Card Error 183 – Card No Data 184 – Card Full 185 – Card Access 186 – Card Rating 187 – Card Drive Mode 188 – Card Compare

8 Advanced features

8.1 Distributed clocks

SI-EtherCAT supports Distributed clocks. This is the scheme used by EtherCAT to accurately time synchronize slave devices. Position, speed and current control loops can all be synchronized.

When the option module is connected to a drive which can take a time synchronization signal (e.g. a Unidrive M600 or above), the EtherCAT Distributed Clocks facility can be used to provide this signal so the drive speed and current tasks are synchronized to the network. The position controller, and appropriate motion features will also be synchronized to the drive speed task.

NOTE In CoE interpolated position mode the position command provided by the master every interpolation cycle time is used to generate a position command for the drive every 250 µs.

8.1.1 Time synchronization support

When the option module is connected to a drive which can accept a time synchronisation signal (e.g. on Unidrive M600 and above), the EtherCAT distributed clocks facility can be used to provide this signal so that the drive tasks (including the motion, speed and current tasks) are synchronised to the network. On Unidrive M600 and above, the option synchronous task will also be synchronized to the drive OPT_SYNC signal; on Unidrive M200 to M400 it will be executed every 5 ms, asynchronous with the drive control loops (i.e. there is no synchronization).

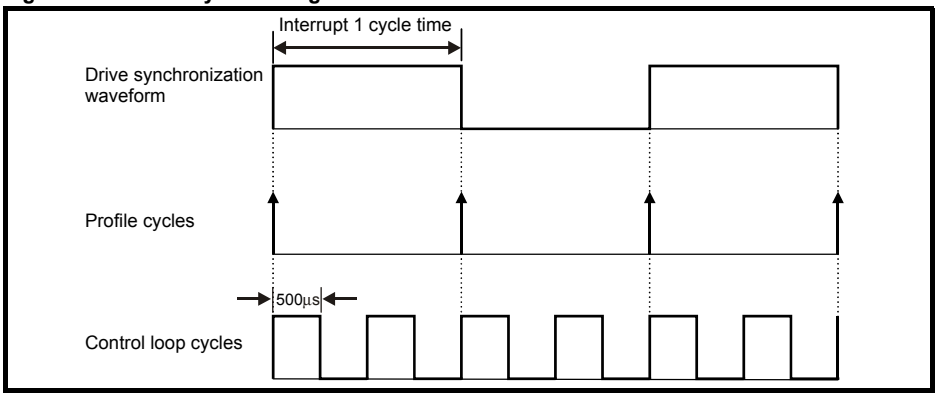
If possible, the option will provide a synchronization signal suitable for the longest interval drive cyclic task (this will also, of course, synchronize the higher rate tasks, if they are phase locked to the lowest rate task).

The drive motion and speed loops are executed every 250 µs on Unidrive M600 and above, which coincides with OPT_SYNC edges. This will be referred to as the control loop cycle. Synchronization must be enabled if the Cyclic Sync or Interpolated Position modes are used; an error will be indicated if this is not the case. These modes have an operating mode cycle time of the interpolation cycle time; other modes will have an operating mode cycle time matching the synchronous task (250 µs or 5 ms, depending on drive type)

Any operating mode cycle will be restarted every operating mode cycle time, in phase with the synchronisation events; if synchronization is enabled, the operating mode will not start execution until the first synchronization event occurs. If synchronization is lost, an error will be indicated, and the standard EtherCAT action for this event will occur.

Command and feedback values which are handled cyclically will be read at defined times in the cycle. Command values handled/used every cycle (operating mode or control loop) will be cached from the object dictionary in the task immediately before the drive critical update period. Any feedback values read during a cycle will be scaled as appropriate in that cycle, cached, and then written to the object dictionary in the task occurring immediately after the drive critical update period. Feedback values that change internally between control loop cycles (but whose objects are only updated every profile cycle) will be read from the last control loop cycle in the operating mode cycle. PDO data will be copied to and from the object dictionary (from and to the sync manager memory areas) in the drive critical update period at the beginning of every operating mode cycle. PDO data mapped to drive parameters (but not parameters accessed using Inter-Option Communications, or eCMP), will be written to those parameters in the critical update period at the beginning of every control loop cycle. This behaviour can be modified by the advanced cyclic data configuration objects.

Figure 8-1 Profile Cycle Timing



8.2 SI-EtherCAT protocol support

The following are supported:

- Four Sync Managers. Two are used for the Mailbox Protocol (non-cyclic data) and two are used for process data (cyclic data)
- Distributed Clocks
- CANopen over EtherCAT (CoE)

8.3 Advanced Cyclic Data Task Configuration

This configuration will allow the timing behaviour of the cyclic data handling to be modified; specifically, it will allow the tasks in which cyclic data is handled to be changed. The default configuration will be specified to reduce delays as much as possible, in case it is necessary to close control loops over the network.

On Unidrive M200 to Unidrive M400, the cyclic data tasks are asynchronous (i.e. there is no OPT_SYNC signal, or equivalent) to the drive tasks; there will be tasks corresponding to those described in the object descriptions, but they will not bear any relationship to the a drive critical update period which, from an option module point of view, does not exist. Arguably, these objects are of limited utility on these drives.

Table 8-1 Out cyclic data configuration

0x3006	Out cyclic data configuration		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of the last sub-index in this object.		
Sub-index 1			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: ms
Default:	0	Type: USINT	
Description:	High priority cyclic data task; selects the task in which high priority out (master to slave) cyclic data is copied from the intermediate buffer to the mapped objects, parameters, etc. 0 - Pre-Drive Critical update period. The default; this is the task that, on Unidrive M600 and above, starts execution 75 µs before the drive critical update period. This time may need to be modified after measuring actual task periods (hopefully it will be possible to start at a time closer to the critical update period). 1 - Drive Critical update period. Occurs for the first 70 µs following an edge of the OPT_SYNC signal. 2 - Post-Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period. 3 - Sync Manager task. This is the AL event task which occurs upon a sync manager access.		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	3	Type: USINT	
Description:	Intermediate buffer copy task. Selects the task in which the high priority out (master to slave) cyclic data is copied into the intermediate buffer from the EtherCAT sync manager space. 0 - Pre-Drive Critical update period. The task that, on Unidrive M600 and above, starts execution 75 µs before the drive critical update period. This time may need to be modified after measuring actual task periods (hopefully it will be possible to start at a time closer to the critical update period). 1 - Drive Critical update period. Occurs during the first 70 µs following an edge of the OPT_SYNC signal. 2 - Post-Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period. 3 - Sync Manager task. The default; it is the AL event task which occurs upon a sync manager access.		

Table 8-2 In cyclic data configuration

0x3007	In cyclic data configuration		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	The number of the last sub-index in this object.		
Sub-index 1			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: ms
Default:	2	Type: USINT	
Description:	High priority cyclic data task; selects the task in which high priority in (slave to master) cyclic data is copied to the intermediate buffer from the mapped objects, parameters, etc. 0 - Pre-Drive Critical update period. The default; this is the task that, on M600 and above, starts execution 75 µs before the drive critical update period. This time may need to be modified after measuring actual task periods (hopefully it will be possible to start at a time closer to the critical update period). 1 - Drive Critical update period. Occurs during the first 70 µs following an edge of the OPT_SYNC signal. 2 - Post Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period. 3 - Sync Manager task. The AL event task which occurs upon a sync manager access.		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	2	Type: USINT	
Description:	Intermediate buffer copy task. Selects the task in which the high priority in (slave to master) cyclic data is copied from the intermediate buffer into the sync manager space. 0 - Pre Drive Critical update period. The task that, on M600 and above, starts execution 75 µs before the drive critical update period. This time may need to be modified after measuring actual task periods (hopefully it will be possible to start at a time closer to the critical update period). 1 - Drive Critical update period. Occurs during the first 70 µs following an edge of the OPT_SYNC signal. 2 - Post Drive Critical update period. The default; it is the task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period. 3 - Sync Manager task. The AL event task which occurs upon a sync manager access.		

9 Parameter descriptions

It is intended that it is not necessary to use option module parameters for EtherCAT setup or control of a drive; parameters are mostly provided for status and information. This means that a user will configure the motor and feedback in the usual way, using parameters, install an EtherCAT option, and use CoE; objects to control the drive from that point onwards. Although, with objects which correspond to drive parameters, it should be possible to perform all drive/motor/feedback configuration using the EtherCAT interface.

In the following descriptions, S means the option module slot number.

9.1 Internal menus

SI-EtherCAT provides parameters for configuration and information, these parameters are grouped into menus as shown in Table 9-1.

Table 9-1 SI-EtherCAT internal menus

Menu	Name	Description
S.0	Setup	Provides module information such as firmware version and serial number
S.1	ECAT Status	Provides information on the EtherCAT network status
S.2	EoE Status	Provides information on the Ethernet over EtherCAT status and configuration
S.9	Resources	Provides information on the module task resources and PCB temperature

9.2 Parameter type codes

Table 9-2 lists the coding used for the parameter type in the subsequent parameter description tables.

Table 9-2 Parameter type codes

RW	Read / Write	RO	Read-only	Bit	Bit parameter	Txt	Text string	Date	Date parameter	Time	Time parameter
Chr	Character parameter	Bin	Binary parameter	IP	IP address	Mac	MAC address	Ver	Version number	SMP	Slot, menu, parameter
Num	Number parameter	DE	Destination	ND	No default value	RA	Rating dependant	NC	Non-copyable	PT	Protected
FI	Filtered	US	User save	PS	Power-down save	BU	Bit default or unipolar				

9.3 Single line parameter descriptions

Table 9-3 Menu 0 parameters (Set-up)

Parameter		Range	Default	Access	Size (Bits)
S.00.000	Parameter mm.00	0 to 65535		RW	16
S.00.001	Module ID	0 to 65535		RO	16
S.00.002	Firmware version	00.00.00.00 to 99.99.99.99		RO	32
S.00.003	Hardware version	0 to 65535		RO	16
S.00.004	Serial number LS	0 to 99999999		RO	32
S.00.005	Serial number MS	0 to 99999999		RO	32
S.00.006	Module status	-2 to 3		RO	8
S.00.007	Module reset	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.008	Module default	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.031	Slot indicator	1 to 8		RO	8
S.00.032	Slot menu number	0 to 255		RO	8
S.00.033	Disable drive control	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.034	Allow EEPROM Upgrade	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.035	Configured station alias	0 to 65535	0	RW	16
S.00.036	Sync OUT consistency enable	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.037	Sync OUT consistency parameter	0.00.000 to 9.99.999	0.00.000	RW	32
S.00.038	Sync IN consistency enable	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.039	Sync IN consistency parameter	0.00.000 to 9.99.999	0.00.000	RW	32
S.00.040	Non-sync OUT consistency enable	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.041	Non-sync OUT consistency parameter	0.00.000 to 9.99.999	0.00.000	RW	32
S.00.042	Non-sync IN consistency enable	0 (Off) to 1 (On)	0 (Off)	RW	1
S.00.043	Non-sync IN consistency parameter	0.00.000 to 9.99.999	0.00.000	RW	32

Table 9-4 Menu 1 parameters (EtherCAT Status)

Parameter		Range	Default	Access	Size (Bits)
S.01.000	Parameter mm.00	0 to 65535		RW	16
S.01.001	EtherCAT RUN indicator	0 (Unknown State) to 8 (Op)		RO	8
S.01.002	PDO Accesses per second	0 to 65535		RO	16
S.01.004	Mapped parameter xx.000	0 to 65535		RW	16

Table 9-5 Menu 2 parameters (Ethernet over EtherCAT Status)

Parameter		Range	Default	Access	Size (Bits)
S.02.000	Parameter mm.00	0 to 65535		RW	16
S.02.006	EoE IP Address	0 to 4294967295 (000.000.000.000 to 255.255.255.255)		RO	32
S.02.007	EoE Subnet mask	0 to 4294967295 (000.000.000.000 to 255.255.255.255)		RO	32
S.02.008	EoE Default gateway	0 to 4294967295 (000.000.000.000 to 255.255.255.255)		RO	32
S.02.011	EoE Virtual MAC Address	0 to $2^{48} - 1$ (0 to FFFFFFFFFFFF)		RO	64

Table 9-6 Menu 9 parameters (Resources)

Parameter		Range	Default	Access	Size (Bits)
S.09.000	Parameter mm.00	0 to 65535		RW	16
S.09.010	Pre-critical task % free	0 to 100		RO	8
S.09.011	Critical task % free	0 to 100		RO	8
S.09.012	Post-critical task % free	0 to 100		RO	8
S.09.020	Pre-critical task worst % free	0 to 100		RO	8
S.09.021	Critical task worst % free	0 to 100		RO	8
S.09.022	Post-critical task worst % free	0 to 100		RO	8
S.09.030	PCB Temperature	-128 to 127		RO	8

9.4 Full parameter descriptions

9.4.1 Menu 0 (Setup) - Corresponds to menu 15, 16 or 17

This menu will provide some common fieldbus option parameters used for basic housekeeping and information.

S.00.001	Module ID		
Minimum	0	Maximum	65535
Default	431	Units	
Type	16 Bit Volatile	Update Rate	Power-up write
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

The option module ID. SI-EtherCAT is 431.

S.00.002	Firmware version		
Minimum	0 (Display: 00.00.00.00)	Maximum	99999999 (Display: 99.99.99.99)
Default		Units	
Type	32 bit volatile	Update Rate	Power-up write
Display Format	Version number	Decimal Places	0
Coding	RO, Ver, ND, NC, PT, BU		

S.00.003	Hardware version		
Minimum	0	Maximum	655.35
Default	0	Units	
Type	16 bit volatile	Update Rate	Power-up write
Display Format	None	Decimal Places	2
Coding	RO, ND, NC, PT, BU		

Contains the module's hardware version information in the format xx.yy.

S.00.004	Serial Number LS		
Minimum	0	Maximum	99999999
Default	0	Units	
Type	32 bit volatile	Update Rate	Power-up write
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

The module serial number is available as a pair of 32-bit values where Serial Number LS (**S.00.004**) provides the least significant 8 decimal digits and Serial Number MS (**S.00.005**) provides the most significant 8 decimal digits. The reconstructed serial number is ((**S.00.005*** 100000000) + **S.00.004**). For example serial number "0001234567898765" would be stored as **S.00.005** = 12345, **S.00.004** = 67898765.

S.00.005	Serial Number MS		
Minimum	0	Maximum	99999999
Default	0	Units	
Type	32 bit volatile	Update Rate	Power-up write
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

See Serial Number LS (**S.00.004**).

S.00.006	Status		
Minimum	-2 (Display: Bootldr - Update)	Maximum	3 (Display: Error)
Default		Units	
Type	8 bit volatile	Update Rate	Background
Display Format	Text	Decimal Places	0
Coding	RO, Txt, ND, NC, PT		

Value	Text	Description
-2	Bootldr - Update	The bootloader is performing a flash update
-1	Bootldr - Idle	The bootloader is idle
0	Initializing	The firmware is currently Initializing.
1	OK	The firmware is initialised and no errors have been detected.
2	Config	A configuration error has been detected.
3	Error	An error has occurred preventing the firmware from running correctly.

S.00.007	Reset		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0	Units	
Type	1 bit volatile	Update Rate	Read every 200 ms Written to 0 on module initialization
Display Format	Bit	Decimal Places	0
Coding	RW, Bit, NC		

When set the module performs a warm reset. If a CiA402 profile is currently in control of the drive and motor, the motor will be brought to a stop, if possible (following configured deceleration ramps, etc), and the drive disabled before the reset is performed. When the reset has been performed and the module is performing its initialization routines the parameter will be cleared to zero. Note: The drive, and any other modules installed to the drive will not be affected by the reset.

S.00.008	Default		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0	Units	
Type	1 bit volatile	Update Rate	Read every 200 ms Written to 0 when save is complete
Display Format	Bit	Decimal Places	0
Coding	RW, Bit, NC		

If set to "ON" when the module is reset, this parameter will cause the option module to return to its "Out of Box configuration"; any settings stored on the module will be returned to their default values. This will include the CoE object dictionary, if it is saved. Following the default the module will set the parameter to "OFF" and the module will reset.

NOTE Take care using this parameter as any configuration information will be irretrievably lost

S.00.031	Slot Indicator		
Minimum	1	Maximum	8
Default		Units	
Type	8 bit volatile	Update Rate	Written on power-up
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

The parameter displays the number of the virtual option slot on the drive that the module is connected to. The values for the slots are 1 to 8, where the onboard slot is 4.

S.00.032	Slot Menu Number		
Minimum	0	Maximum	255
Default		Units	
Type	8 bit volatile	Update Rate	Written on power-up
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

The parameter displays the menu number of the option slot on the drive.

E.g. for Unidrive M the following mapping applies:

Slot 1 - Menu 15

Slot 2 - Menu 16

Slot 3 - Menu 17

Slot 4 - Menu 24

S.00.033	Disable drive control		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0	Units	
Type	1 bit User Save	Update Rate	Read in background
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

In normal operation, at various points in EtherCAT and CiA402 operation, a number of drive parameter values will be modified by the option module (to enable it to control the drive, other parameters implicitly written by the CiA402 profile, etc).
Setting this parameter to 1 will prevent the option module from writing to these parameters; user-mapped parameter writes will still occur, however.

S.00.034	Allow EEPROM Upgrade		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0	Units	
Type	1 bit User Save	Update Rate	Read in background
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

This allows the data in the EtherCAT configuration EEPROM to be upgraded, and it does this by preventing the EtherCAT ASIC from accessing the EEPROM, so that the processor can access it; this means that EtherCAT communications are disabled. This is achieved by setting this parameter to 'On' and performing an option reset (**S.00.007** = On); this parameter cannot be saved.

S.00.035	Configured Station Alias		
Minimum	0	Maximum	65535
Default	0	Units	
Type	16 bit User Save	Update Rate	Read on power up
Display Format	None	Decimal Places	0
Coding	RW, NC, PT, BU, US		

It is unnecessary for a user to set a station address manually in order to initiate EtherCAT communications; however, this parameter can be used to configure an EtherCAT Station Alias, which can be used to uniquely identify a particular slave. If this value is changed, it is necessary to reset the option for the new value to take effect (e.g. by saving parameters and performing a power cycle). If this value is left at the default value of zero, any value stored in the EtherCAT EEPROM will be used, and if a non-zero value is stored here, it will be used in place of the EEPROM value.

S.00.036	Sync OUT Consistency Enable		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0 (Display: Off)	Units	None
Type	1 bit User Save	Update Rate	EtherCAT state transition
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

S.00.037	Sync OUT Consistency Trigger Parameter		
Minimum	0 (Display: 0.00.000)	Maximum	1 (Display: 9.99.999)
Default	0 (Display: 0.00.000)	Units	None
Type	32 bit User Save	Update Rate	EtherCAT state transition
Display Format	SMP	Decimal Places	0
Coding	RW, DE		

The SI-EtherCAT module provides an output consistency feature for the synchronized cyclic data which ensures that the data in the output mappings is only updated when the mapped parameters are ready. This prevents data skew between parameters in the output mappings.

When the output consistency is enabled (**S.00.036** = On), the output consistency trigger parameter (**S.00.037**) is used to control the RxPDO data exchange, ensuring skew does not occur; a user program, for example, must check the trigger parameter is 1 before reading the mapped parameters, and it should clear the trigger parameter to 0 after all the mapped parameters have been read. The SI-EtherCAT module will check that the trigger parameter is 0 before writing to the RxPDO destinations and will set the trigger parameter to 1 after the RxPDO destinations have been written.

S.00.038	Sync IN Consistency Enable		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0 (Display: Off)	Units	None
Type	1 bit User Save	Update Rate	EtherCAT state transition
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

S.00.039	Sync IN Consistency Trigger Parameter		
Minimum	0 (Display: 0.00.000)	Maximum	1 (Display: 9.99.999)
Default	0 (Display: 0.00.000)	Units	None
Type	32 bit User Save	Update Rate	EtherCAT state transition
Display Format	SMP	Decimal Places	0
Coding	RW, DE		

The SI-EtherCAT module provides an input consistency feature for the synchronized cyclic data which ensures that the data in the input mappings is only updated when the mapped parameters are ready. This prevents data skew between parameters in the input mappings.

When the input consistency is enabled (**S.00.038** = On), the input consistency trigger parameter (**S.00.039**) is used to control the TxPDO data exchange, ensuring skew does not occur; a user program, for example, must check the trigger parameter is 0 before writing to the mapped parameters, and it should set the parameter to 1 after all the data has been written. The SI-EtherCAT module will check that the trigger parameter is 1 before reading the TxPDO sources and will set the trigger parameter to 0 after the TxPDO sources have been read.

S.00.040	Non-sync OUT Consistency Enable		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0 (Display: Off)	Units	None
Type	1 bit User Save	Update Rate	EtherCAT state transition
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

S.00.041	Non-sync OUT Consistency Trigger Parameter		
Minimum	0 (Display: 0.00.000)	Maximum	1 (Display: 9.99.999)
Default	0 (Display: 0.00.000)	Units	None
Type	32 bit User Save	Update Rate	EtherCAT state transition
Display Format	SMP	Decimal Places	0
Coding	RW, DE		

The SI-EtherCAT module provides an output consistency feature for the non-synchronized cyclic data which ensures that the data in the output mappings is only updated when the mapped parameters are ready. This prevents data skew between parameters in the output mappings.

When the output consistency is enabled (**S.00.040** = On), the output consistency trigger parameter (**S.00.041)** is used to control the RxPDO data exchange, ensuring skew does not occur; a user program, for example, must check the trigger parameter is 1 before reading the mapped parameters, and it should clear the trigger parameter to 0 after all the mapped parameters have been read. The SI-EtherCAT module will check that the trigger parameter is 0 before writing to the RxPDO destinations and will set the trigger parameter to 1 after the RxPDO destinations have been written.

S.00.042	Non-sync IN Consistency Enable		
Minimum	0 (Display: Off)	Maximum	1 (Display: On)
Default	0 (Display: Off)	Units	None
Type	1 bit User Save	Update Rate	EtherCAT state transition
Display Format	Bit	Decimal Places	0
Coding	RW, Bit		

S.00.043	Non-sync IN Consistency Trigger Parameter		
Minimum	0 (Display: 0.00.000)	Maximum	1 (Display: 9.99.999)
Default	0 (Display: 0.00.000)	Units	None
Type	32 bit User Save	Update Rate	EtherCAT state transition
Display Format	SMP	Decimal Places	0
Coding	RW, DE		

The SI-EtherCAT module provides an input consistency feature for the non-synchronized cyclic data which ensures that the data in the input mappings is only updated when the mapped parameters are ready. This prevents data skew between parameters in the input mappings.

When the input consistency is enabled (**S.00.042** = On), the input consistency trigger parameter (**S.00.043**) is used to control the TxPDO data exchange, ensuring skew does not occur; a user program, for example, must check the trigger parameter is 0 before writing to the mapped parameters, and it should set the parameter to 1 after all the data has been written. The SI-EtherCAT module will check that the trigger parameter is 1 before reading the TxPDO sources and will set the trigger parameter to 0 after the TxPDO sources have been read.

9.4.2 Menu 1 (EtherCAT Status)

This menu provides status information on the EtherCAT network.

S.01.001	EtherCAT RUN Indicator		
Minimum	0	Maximum	8
Default	0	Units	
Type	8 bit volatile	Update Rate	Background
Display Format	Text	Decimal Places	0
Coding	RO, Txt, ND, NC, PT, BU		

This parameter displays the EtherCAT Run state, as required by the EtherCAT Indicator and Marking Specification. It will contain one of the following values:

Value	Display String	Corresponding ESM State
1	"Init"	INIT
2	"PreOp"	PRE-OPERATIONAL
4	"SafeOp"	SAFE-OPERATIONAL
8	"Op"	OPERATIONAL

All other values will correspond to “Unknown State.

S.01.002	PDO Accesses per second		
Minimum	0	Maximum	65535
Default	0	Units	
Type	16 bit volatile	Update Rate	Written every second
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This will count the number of PDO accesses per second. For example, if there are two PDOs configured in Sync Manager 2, and two PDOs configured in Sync Manager 3, and both Sync Manager memory areas are written every 250 µs, this parameter will contain a value of approximately 16000 (the value may fluctuate slightly because it is not updated synchronously with the accesses).

S.01.004	Mapped Parameter xx.000		
Minimum	0	Maximum	65535
Default	0	Units	
Type	16 bit volatile	Update Rate	
Display Format	None	Decimal Places	0
Coding	RW, ND, NC, PT, BU		

This parameter is purely a mapping to Pr **mm.000** to allow Pr **mm.000** to be accessed using a CoE object (in the Control Techniques scheme, mapped CoE object indices correspond to menu numbers and sub-indices correspond to parameter numbers; since sub-index zero is already used for another CoE purpose, this cannot be used to access parameter zero of any menu).

9.4.3 Menu 2 (Ethernet over EtherCAT Status)

This menu provides information on the Ethernet over EtherCAT configuration.

S.02.006	EoE IP Address		
Minimum	0 (Display: 000.000.000.000)	Maximum	4294967295 (Display: 255.255.255.255)
Default	None	Units	
Type	32 bit volatile	Update Rate	On EtherCAT Initialization
Display Format	IP	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the EoE IP address of the SI-EtherCAT module assigned by the EtherCAT master.

S.02.007	EoE Subnet Mask		
Minimum	0 (Display: 000.000.000.000)	Maximum	4294967295 (Display: 255.255.255.255)
Default	None	Units	
Type	32 bit volatile	Update Rate	On EtherCAT Initialization
Display Format	IP	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the EoE Subnet mask of the SI-EtherCAT module assigned by the EtherCAT master.

S.02.008	EoE Default Gateway		
Minimum	0 (Display: 000.000.000.000)	Maximum	4294967295 (Display: 255.255.255.255)
Default	None	Units	
Type	32 bit volatile	Update Rate	On EtherCAT Initialization
Display Format	IP	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the EoE default gateway IP address of the SI-EtherCAT module assigned by the EtherCAT master.

S.02.011	EoE MAC Address		
Minimum	0 (Display: 000000000000)	Maximum	281474976710655 (Display: FFFFFFFFFFFF)
Default	None	Units	
Type	64 bit volatile	Update Rate	On EtherCAT Initialization
Display Format	Mac	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter displays the MAC address of the EoE virtual Ethernet interface as a 48 bit hexadecimal value.

9.4.4 Menu 9 (Resources)

This menu provides information on the SI-EtherCAT module resources.

S.09.010	Pre-critical task % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the current resource available for the pre-critical task. In the SI-EtherCAT option, this is the task executed 75 µs before the end of the 250 µs task executed synchronously with the drive control loops.

S.09.011	Critical task % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the current resource available for the critical task. In the SI-EtherCAT option, this is the task executed synchronously with the drive control loops every 250 µs.

S.09.012	Post-critical task % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the current resource available for the post-critical task. In the SI-EtherCAT option, this is the task executed 70 µs after start of the 250 µs task executed synchronously with the drive control loops.

S.09.020	Pre-critical task worst % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the worst case resource available for the pre-critical task.

S.09.021	Critical task worst % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the worst case resource available for the critical task.

S.09.022	Post-critical task worst % free		
Minimum	0	Maximum	100
Default	None	Units	%
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC, PT, BU		

This parameter shows the worst case resource available for the post-critical task.

S.09.030	SI-EtherCAT Module Temperature		
Minimum	-128	Maximum	127
Default	None	Units	°C
Type	8 bit volatile	Update Rate	Written in background
Display Format	None	Decimal Places	0
Coding	RO, ND, NC		

This parameter shows the SI-EtherCAT option module temperature in degrees Celsius.

10 Diagnostics

10.1 Module identification parameters

10.1.1 SI-EtherCAT module ID code

Table 10-1 SI-EtherCAT module ID code

SI-EtherCAT module ID code		
S.00.001	Default	431 (SI-EtherCAT)
	Range	0 to 65535
	Access	RO

The module ID code indicates the type of module installed in the slot. This is useful for checking the module is of the correct type.

10.1.2 SI-EtherCAT firmware version

Table 10-2 SI-EtherCAT firmware version - (major and minor)

SI-EtherCAT firmware version - (major and minor) (xx.yy)		
S.00.002	Default	N/A
	Range	0 to 65535
	Access	RO

10.2 SI-EtherCAT module temperature

Table 10-3 SI-EtherCAT module temperature

SI-EtherCAT module temperature		
S.09.030	Default	N/A
	Range	0 - 255
	Access	RO

This parameter shows the option module temperature reading in degrees Celsius.

10.3 Error handling

The following objects are provided to indicate an error condition

Table 10-4 Error handling objects

Index	Name
0x1001	Error_register
0x603F	Error_code

10.3.1 Error register

Table 10-5 Error register

0x1001	**Error register**		
Access: RO	Range: 0 to 255	Size: Unsigned 8	Unit: N/A
Default:	0		
Description:	A non-zero value in this object indicates that an error has occurred. The bit(s) set indicate the type of error present. The following bits are supported: 0: Generic error, 1: Current, 2: Voltage, 3: Temperature When an error is indicated in this object, the particular error code will be contained in object 0x603F (Error code).		

10.3.2 Error code

Table 10-6 Error code

0x603F	Error code		
Access: RO	Range: 0 to 0xFFFF	Size: 2 bytes	Unit: N/A
Default:	0		
Description:	A non-zero value in this object indicates that an error has occurred. The value will be one of the codes described in Table 10-7 below.		

Table 10-7 Error codes

Error code	Meaning	Corresponding drive trip Code (if available)
0x0000	Error reset / No error	0 – None
0xFFO1	Generic error	(Any trip code not elsewhere in table)
0x2300	Current, device output side	3 – OI ac
0x3130	Phase failure	32 – Phase Loss 98 - Out Phase Loss
0x2230	Short circuit/ground leakage (device internal)	5 – PSU 9 – PSU 24V 92 - Snubber OI
0x3210	DC link over-voltage	2 – Over Volts
0x3230	Load error	38 - Low Load
0x4310	Excess temperature drive	21 – OHt Inverter, 22 – OHt Power 23 – OHt Control, 27 – OHt dc bus 101 - OHt Brake
0x5112	"Supply low voltage" and "U2 = supply +24 V"	91 - User 24V
0x5200	Control device hardware	200 - Slot 1 Hardware Fault 203 - Slot 1 Not Fitted, 204 - Slot 1 Different 205 - Slot 2 Hardware Fault 208 - Slot 2 Not Fitted, 209 - Slot 2 Different 210 - Slot 3 Hardware Fault 213 - Slot 3 Not Fitted, 214 - Slot 3 Different 250 - Slot 4 Hardware Fault 253 - Slot 4 Not Fitted, 254 - Slot 4 Different 221 - Stored HF
0x5400	Power section	111 - Config P 220 - Power Data 223 - Rating Mismatch
0x5510	RAM	227 - Sub Array RAM Allocation
0x5530	Data Storage (Non-volatile data memory)	31 – EEPROM Fail 36 – User Save 37 – Power Down Save
0x5430	Input stages	94 - Rectifier set up
0x5440	Contacts	226 - Soft Start
0x6010	Software reset (watchdog)	30 – Watchdog
0x6320	Parameter Error	199 - Destination 216 - Slot App Menu Crash 217 - App menu changed

Error code	Meaning	Corresponding drive trip Code (if available)
0x7112	Brake Chopper (Over current brake chopper)	4 – OI Brake 19 – Brake R Too Hot
0x7113	Protective circuit break chopper	10 - Th Brake Res
0x7120	Motor	11 - Autotune 1, 12 - Autotune 2 13 - Autotune 3, 20 - Motor Too Hot
0x7122	Motor error or commutation malfunc.	14 – Autotune 4, 15 – Autotune 5 16 – Autotune 6, 24 - Thermistor 25 - Th Short Circuit, 33 - Resistance
0x7300	Sensor	17 - Autotune 7 162 to 163 – Encoder 12 to Encoder 13 176 – Name Plate 189 to 198 – Encoder 1 to Encoder 10 218 - Temp Feedback
0x7310	Speed	7 - Over speed
0x7500	Communication	90 - Power Comms 103 - Interconnect
0x7600	Data storage (external)	174 - Card Slot, 175 – Card Product 177 – Card Boot, 178 – Card Busy 179 – Card Data Exists, 180 – Card Option 181 – Card Read Only, 182 – Card Error 183 – Card No Data, 184 – Card Full 185 – Card Access, 186 – Card Rating 187 – Card Drive Mode, 188 – Card Compare

10.4 Drive trip display codes

Table shows the possible trip codes that will be displayed on the drive when a problem is detected with SI-EtherCAT or when SI-EtherCAT initiates a trip.

Table 10-8 Trip display codes

Value (Pr 10.070)	Display text	Description
100	Invalid Fdbk Src	An unknown or invalid feedback source has been configured
101	ECAT Init Error	An error occurred whilst initialising the EtherCAT communications
102	TO ECAT PDO	A PDO has not been written for longer than the specified timeout
103	Sync Task Orun	The synchronous task has overrun its allowed interval

10.5 Option module trips

Table 10-9 Option module trips

Value (Pr 10.070)	Display Text	Description
200	SW fault	Software Fault
201	BG Orun	Background task overrun
202	FW invalid	Invalid firmware for hardware version
203	Drv unknown	Unknown drive type
204	Drv unsupported	Unsupported drive type
205	Mode unknown	Unknown drive mode
206	Mode unsupported	Unsupported drive mode
207	FLASH corrupt	Corrupted non-volatile FLASH
208	Dbase init	Database initialisation error
209	FS init	File system initialisation error
210	Memory alloc	Memory allocation error
211	Filesystem	File system error
212	Configuration	Configuration file save error
213	OHt	Overheated
214	TO drv	The drive has not responded within the watchdog period
215	ECMP	eCMP communication failure
216	TO ECMP slot 1	eCMP communication to slot 1 timeout
217	TO ECMP slot 2	eCMP communication to slot 2 timeout
218	TO ECMP slot 3	eCMP communication to slot 3 timeout
219	TO ECMP slot 4	eCMP communication to slot 4 timeout
220	Reserved	Reserved
221	ERROR_MISSING_FACTORY_SETTINGS	Factory settings file is missing
222	ERROR_FUNCTIONAL_TEST	Functional test failed
223	ERROR_CONFIG_FILE_LOAD	Configuration file failed to load
224	ERROR_POWER_ON_TEST	Power on self test failed
225	ERROR_RUNTIME_CONFIG	Runtime configuration error

10.6 Updating SI-EtherCAT firmware

The latest SI-EtherCAT firmware is available from your local Control Techniques Drive Centre or supplier. To upload firmware to SI-EtherCAT a copy of Unidrive M Connect and a suitable communications lead for the option module's host drive is required.

10.7 Switching frequency

In applications where greater synchronization is required, it is suggested that the drive's automatic switching frequency option is switched off. If automatic frequency switching is required, then the network will continue to operate, however the synchronization jitter may increase for a short time when the switching frequency changes. To disable the drive's automatic switching frequency control, set the drive Pr **05.035** to Disabled (1).

10.8 Sync Task Orun trips

If SI-EtherCAT cannot complete the assigned tasks within its 250 µs Synchronous Task, a Sync Task Orun trip will be initiated; a Sync Task Orun trip indicates that the user is trying to accomplish too much within the Synchronous task. The user can influence the Synchronous Task by reducing the amount of cyclic data, or disabling drive control CiA402. To disable drive control set the Pr **S.00.033** to On (1), and perform an option reset via Pr **S.00.007**.

10.9 EtherCAT AL status codes

Table 10-10 shows the possible AL (Application Layer) status codes returned to the EtherCAT master controller during configuration or operational mode.

Table 10-10 Application Layer status codes

Code (0x)	Meaning	Description	Comment
0000	No error	No error	
0001	Unspecified error	No error code has been defined	Contact supplier
0002	No memory	Insufficient memory for operation	Contact supplier
0011	Invalid requested state changed	Requested state change is invalid	Follow the EtherCAT State Machine sequence to change state
0012	Unknown requested state change	Requested state change is unknown	Use only the EtherCAT State Machine state values
0013	Boot state not supported	Device does not support BOOT state	Contact supplier
0014	No valid firmware	Downloaded firmware application file is invalid	Download correct firmware application file
0015	Invalid mailbox configuration	Mailbox configuration differs from expected settings	Replace network description file with the correct file for device
0016	Invalid mailbox configuration	Slave device changed but network configuration is unchanged	Replace previous network description of old slave with the one of the new slave.
0017	Invalid Sync Manager configuration	PDO length, address or direction mismatch	Issue a re-calculation of the EtherCAT configuration.
0018	No valid inputs available	No valid inputs available on Slave device	Check slave input objects
0019	No valid outputs available	Slave device cannot receive valid output values	Check slave output objects
001A	Synchronization error	Too many RxPDO toggle errors have occurred	Check configuration
001B	Sync Manager watchdog	No process data received within specified timeout	Check process data configuration
001C	Invalid Sync Manager Types	Specified Sync Manager type is invalid	Use correct Sync Manager
001D	Invalid output configuration	Sync Manager for output process data is invalid	Use correct Sync Manager
001E	Invalid input configuration	Sync Manager for input process data is invalid	Use correct Sync Manager
001F	Invalid watchdog configuration	The watchdog configuration is invalid	Check watchdog setting
0020	Slave needs cold restart	Slave device requires a cold restart or power cycle	Restart the slave device

Code (0x)	Meaning	Description	Comment
0021	Slave needs INIT	Slave application requests INIT state	Re-initialise the slave device
0022	Slave needs PREOP	Slave application requests, PREOP state	Instruct slave device to enter PREOP state
0023	Slave needs SAFEOP	Slave application requests SAFEOP state	Instruct slave device to enter SAFEOP state
0024	Invalid input mapping	Invalid input mapping object	Check slave input mapping
0025	Invalid output mapping	Invalid output mapping object	Check slave output mapping
0026	Inconsistent settings	General settings mismatch	Check configuration settings
0027	Freerun not supported	Freerun not supported on slave	
0028	Synchronization not supported	Synchronization not supported on slave	
0029	Freerun needs 3 Buffer Mode	Sync Manager requires 3 Buffer Mode to run	
002A	Background Watchdog	Background task watchdog activated	
002B	No valid inputs and outputs	Slave device does not provide valid inputs and outputs	
002C	Fatal Sync error	The hardware synchronization signal has stopped	Set master to INIT and back to OP so that the DCs are initialized again.
002D	No Sync error	Hardware synchronization signal not detected	
0030	Invalid DC SYNC configuration	Distributed Clocks configuration is invalid	Check DC configuration
0031	Invalid DC Latch configuration	Distributed Clocks Latch configuration is invalid	Check DC configuration
0032	PLL error	Master not synchronized, at least one DC event received	Check wiring and synchronization settings
0033	DC Sync IO error	Multiple sync errors: At least one sync signal was received but the slave is no longer synchronized	Check network jitter Increase cycle time Use Distributed Clocks scheme
0034	DC Sync timeout error	Multiple sync errors: Excessive Sync Manager events missed	Check DC configuration
0035	DC invalid sync cycle time	DC sync cycle time is invalid	Check DC configuration
0036	DC Sync0 cycle time	DC Sync0 cycle time invalid for application	Check DC configuration
0037	DC Sync1 cycle time	DC Sync1 cycle time invalid for application	Check DC configuration

10.10 SDO abort codes

SDO messages use a request-response mechanism and the EtherCAT master will always expect a response from the slave device. If an error occurs with an SDO transfer SI-EtherCAT will return an SDO abort code to indicate the reason for the failure, the SDO abort codes are listed in Table 10-11.

Table 10-11 SDO abort codes

Abort code (in hex.)	Description
0x05030000	Toggle bit not alternated
0x05040000	SDO protocol timed out
0x05040001	Client/server command specifier not valid or unknown
0x05040002	Invalid block size (block mode only)
0x05040003	Invalid sequence number (block mode only)
0x05040004	CRC error (block mode only)
0x05040005	Out of memory
0x06010000	Unsupported access to an object
0x06010001	Attempt to read a write only object
0x06010002	Attempt to write a read only object
0x06020000	Object does not exist in the object dictionary
0x06040041	Object cannot be mapped to the PDO
0x06040042	The number and length of the objects to be mapped would exceed PDO length
0x06040043	General parameter incompatibility
0x06040047	General internal incompatibility in the device
0x06060000	Access failed due to a hardware error
0x06070010	Data type does not match, length of service parameter does not match
0x06070012	Data type does not match, length of service parameter too high
0x06070013	Data type does not match, length of service parameter too low
0x06090011	Sub-index does not exist
0x06090030	Value range of parameter exceeded (only for write access)
0x06090031	Value of parameter written too high
0x06090032	Value of parameter written too low
0x06090036	Maximum value is less than minimum value
0x08000000	General error
0x08000020	Data cannot be transferred or stored to the application
0x08000021	Data cannot be transferred or stored to the application because of local control
0x08000022	Data cannot be transferred or stored to the application because of the present device state
0x08000023	Object dictionary dynamic generation fails or no object dictionary is present

11 Glossary of terms

Address: This is the unique network identification given to a networked device to allow communication on a network. When a device sends or receives data the address is used to determine the source and the destination of the message.

Bit: A binary digit, this may have the value of 1 or 0.

Byte: A collection of eight binary digits that collectively store a value. This may be signed or unsigned.

Control word: A collection of binary digits that are used to control the drive. Features typically include directional controls, run controls and other similar functions.

Cyclic: Data that is transmitted at regular intervals over the network.

Data rate: Determines the communication speed of the network, the higher the value the more data can be sent across the network in the same time period.

Device: A piece of equipment connected to a network, this may be any type of equipment including repeaters, hubs, masters or slaves.

Double word: A 32-bit word, this may be signed or unsigned.

Grounding / Earthing: Describes the electrical safety or shielding connections for the module.

LED: Light emitting diode.

Long word: A 32-bit data word that may be signed or unsigned.

LSB: Least significant bit/byte.

MSB: Most significant bit/byte.

Node: A device on the network. This may be either a device such as a drive or part of the network such as a repeater.

Non cyclic data: Data that is requested or sent as required and not on a regular basis.

Octet: A collection of eight binary digits which form a byte.

PC: Personal computer.

PLC: Programmable logic controller.

Poll rate: The rate at which cyclic data is sent and received on the network.

Polled data: *See **Cyclic data**.*

Scan rate: See ***Poll rate***.

Shielding: A connection to provide additional immunity to noise used on a network cable.

Status word: A value that denotes the status of the drive. Each bit within the word will have a specific meaning.

Word: A collection of sixteen binary digits.

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