



User Guide

SI-EtherCAT

Part Number: 0478-0152-01

Issue Number: 1



www.controltechniques.com

General Information

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

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

Nevertheless, when the products eventually reach the end of their useful life, they must not be discarded but should instead be recycled by a specialist recycler of electronic equipment. Recyclers will find the products easy to dismantle into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, while other parts are secured with conventional fasteners. Virtually all parts of the product are suitable for recycling.

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

For current information on how this requirement applies in relation to specific Control Techniques products, please approach your usual contact in the first instance. Control Techniques position statement can be viewed at:

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Issue Number : 1

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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 Access

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

1.6 Fire protection

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

1.7 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.

Instructions for achieving compliance with specific EMC standards may be found in the relevant drive documentation.

Within the European Union, all machinery in which this product is used must comply with the following directives:

- 2006/42/EC: Safety of machinery.
- 2004/108/EC: Electromagnetic Compatibility.

1.8 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 **0.00.046**, as this affects the thermal protection of the motor.

1.9 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.

1.10 Electrical installation

1.10.1 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.

1.10.2 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 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).

2.2 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.

2.3 Features

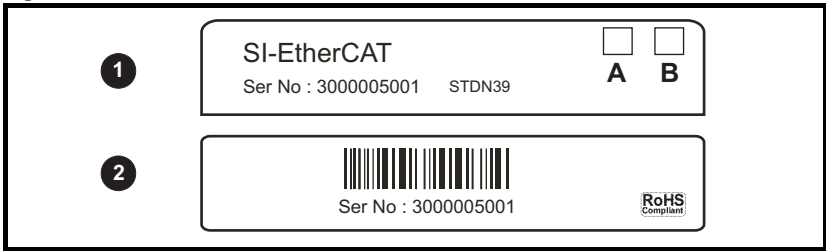
- Standard RJ45 with support for shielded twisted pair, half-duplex / full-duplex and 10 Mbs / 100 Mbs connectivity
- Dual 100 Mbps EtherCAT interfaces for use in line topologies i.e. daisy chaining
- Supports the Unidrive M drives range
- Control loop synchronization
- Control cycle times down to 250 μ s
- Configured Station Alias
- CANopen over EtherCAT (CoE) which includes:
 - Support of CANopen CiA402
 - Cyclic sync position mode
 - Interpolated position mode
 - Velocity mode
 - Profile torque 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

2.4 Option module identification

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 2-1 SI-EtherCAT labels



1. Topside module label
2. Underside module label.

2.4.1 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 go in alphabetical order, starting with A in 1990 (B in 1991, C in 1992 etc).

Example: A date code of V35 would correspond to week 35 of year 2012.

2.5 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.

2.6 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 of the option module's internal menus and parameters.

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

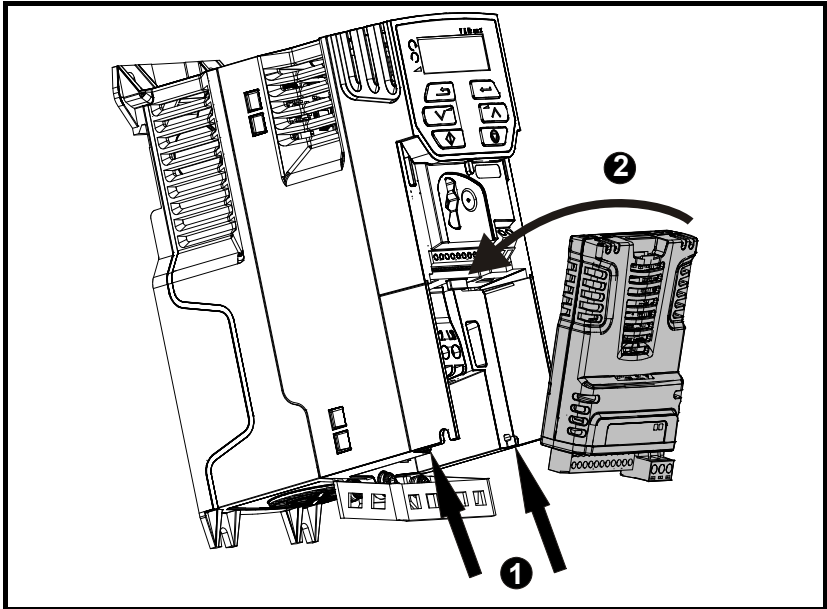


Before installing or removing a option module in any drive, ensure the AC supply has been disconnected for at least 10 minutes and refer to Chapter 1 *Safety information* on page 5. If using a DC bus supply ensure this is fully discharged before working on any drive or option module.

3.1 General installation

The installation of a 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)

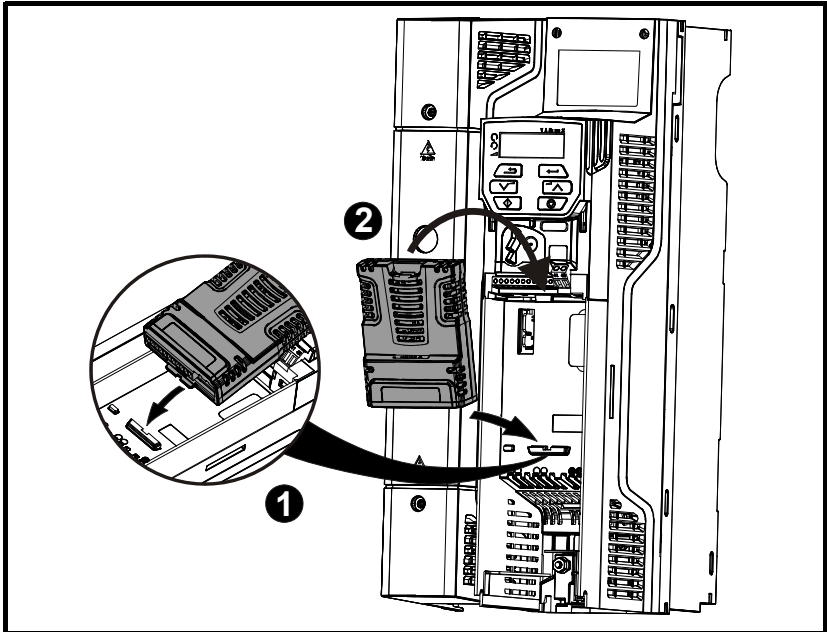


- With the option module tilted slightly backwards, align and locate the two holes in the rear of the option module onto the two tabs (1) on the drive.
- Place the option module onto the drive as shown in (2) until the module clicks into place. The terminal cover on the drive holds the option module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

NOTE

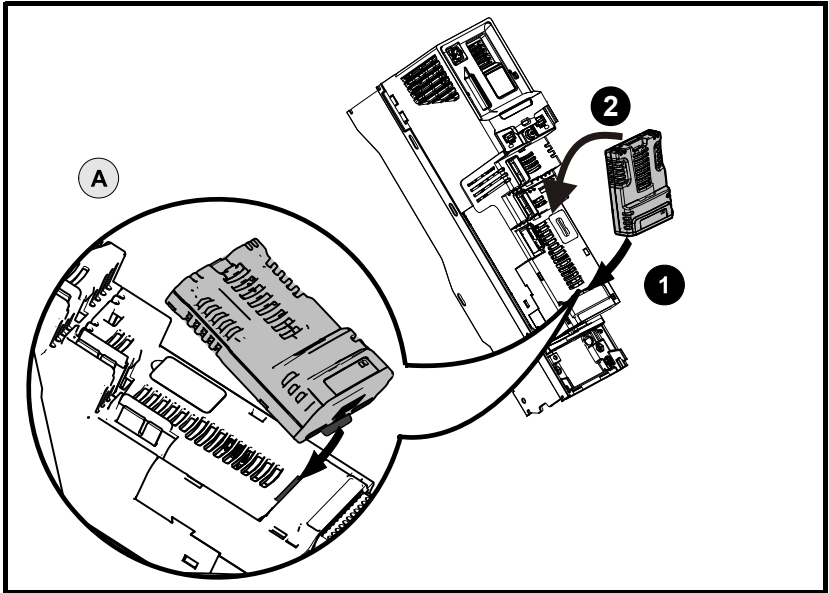
Option modules can only be installed on drives that have the option module slot functionality.

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 M810



- 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.

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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

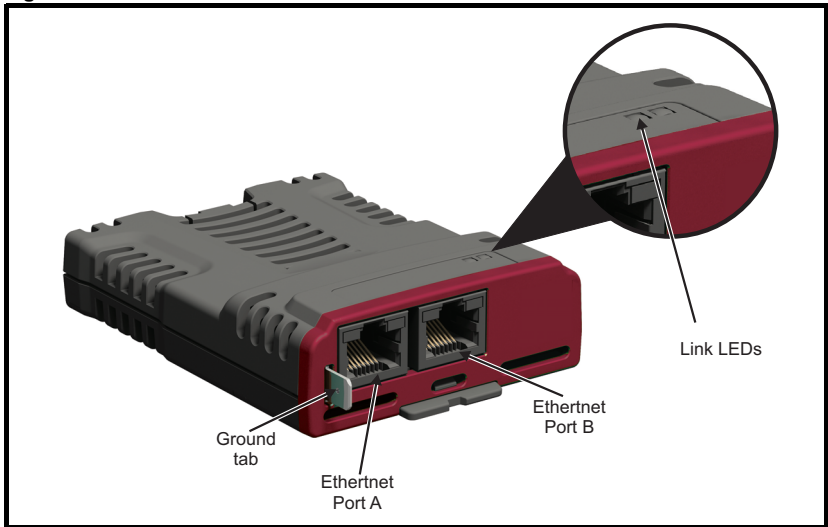


Table 4.1 EtherCAT terminal descriptions

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) Ethernet Port. Proper grounding of the Ethernet 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.

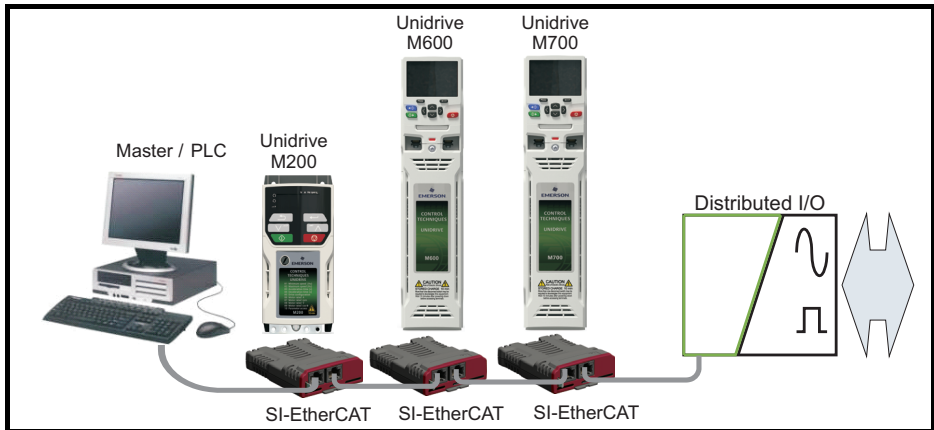
Please note EMC Ferrite inductors of the required specification are available from the following supplier:

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.

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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 (<i>controlword</i>) (16-bits)	0x6041 (<i>statusword</i>) (16-bits)
Mapping 2	0x6042 (<i>vl_target_velocity</i>) (16-bits)	0x6064 (<i>position_actual_value</i>) (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 72 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 is off then check the cabling and also check that the master has started communications.

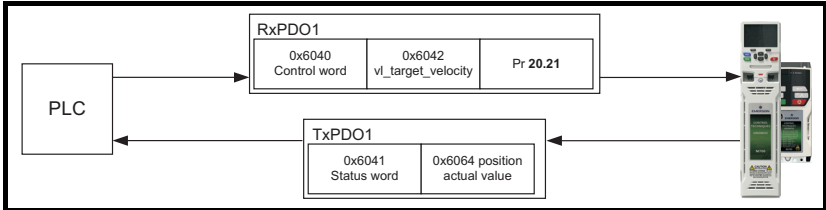
In the master, scan the network ensuring that the SI-EtherCAT module is connected correctly to the master. If the network is configured correctly the SI-EtherCAT node(s) should be visible in the PLC master.

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 24 and section 6.3.3 *TxPDO mappings* on page 27).

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 + 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.

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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).

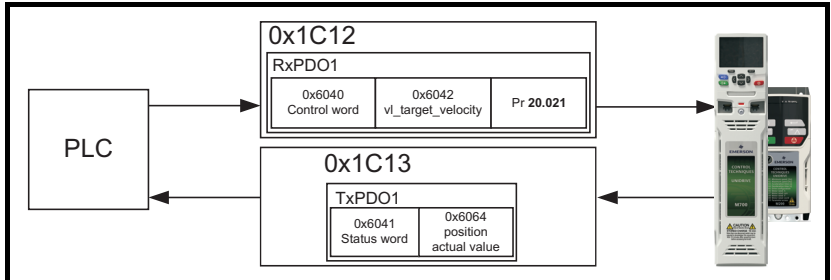
NOTE The maximum number of mappings in one PDO is twelve. There are no restrictions on the data length of these 2 parameters (i.e. It is possible to map five, 32-bit parameters in one PDO). It is also possible to use a maximum of one RxPDOs and one TxPDOs.

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.

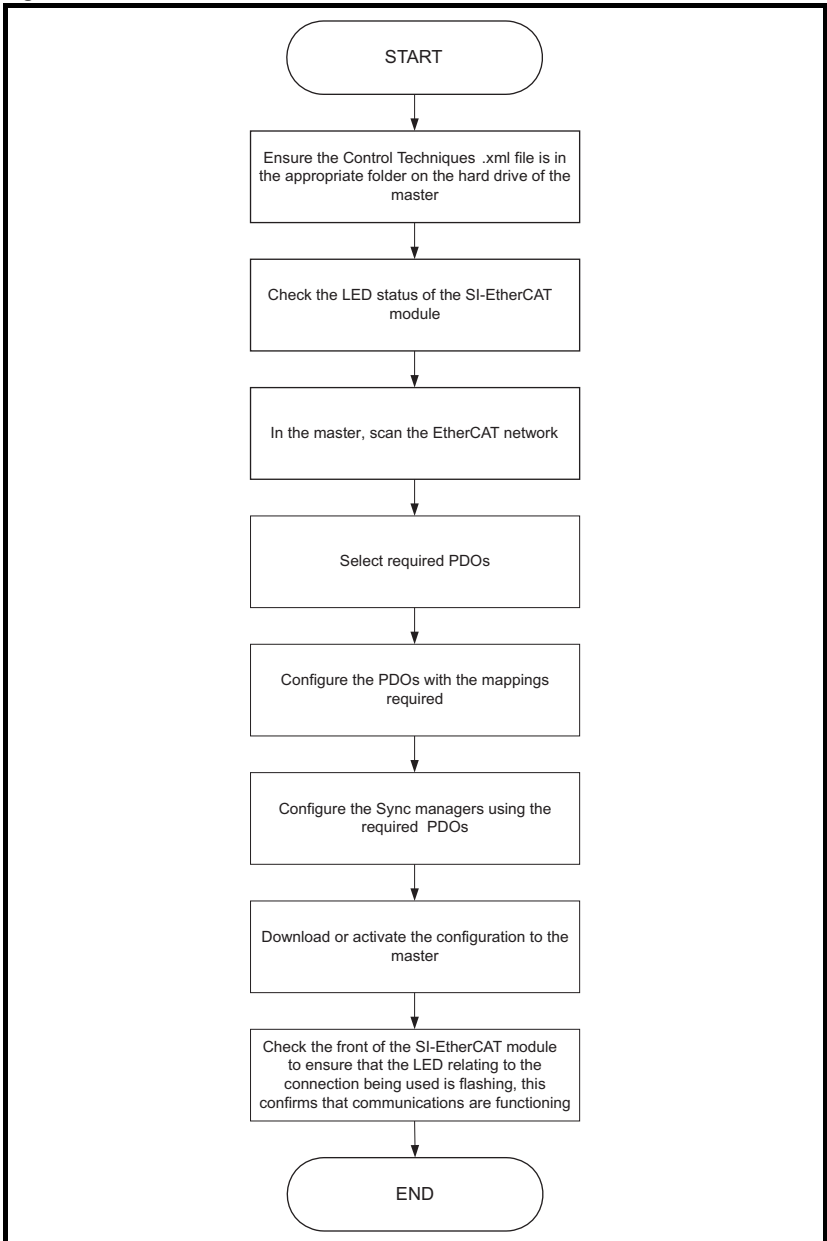
Values written to parameters over RxPDOs should now be viewable using the drive's keypad so long as the master has put the slave into the operational state; also, parameter values changed using the drive keypad will be updated on the master.

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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



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 (RxDPOs) 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.

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>	
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>			
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>			
Description: <description>			
Sub-index 1			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>			
Description: <description>			
...			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>			
Description: <description>			
Sub-index n-1			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>			
Description: <description>			
Sub-index n			
Access: <access>	Range: <range>	Size: <size>	Unit: <unit>
Default: <default>			
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.).

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).
Description:	<p>The primary CoE functional profile is CiA402, so the value of this object is defined as follows:</p> <p>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</p> <p>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.</p>

Table 6.5 Identity object

0x1018	Identity object
Sub-index 0	
Access: RO	Range: N/A Size: 1 byte Unit: N/A
Default:	4
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
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:	0x01mmvvt Byte 0: Drive Type (tt), Byte 1: Drive Variant/Derivative (vv), Byte 2: Drive Mode (mm), Byte 3: Generation (0x01)
Description:	This has the value of the option ID code.
Sub-index 3	
Access: RO	Range: N/A Size: 4 bytes Unit: N/A
Default:	Calculated from Pr S.00.002
Description:	This will contain the option module software version number; major in byte 3, minor in byte 2, sub version in byte 1, and the build number in byte 0.
Sub-index 4	
Access: RO	Range: N/A Size: 4 bytes Unit: N/A
Default:	0
Description:	This will contain zero, rather than the module or drive serial number

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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		
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)		
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			
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)			
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)			
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			
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)			
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).			
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).			

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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			
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)			
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).			
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			
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)			
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 vI target velocity (0x6042)			
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).			

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 6.12 TxPDO mappings

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

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 6.13 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			
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)			
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.			

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Table 6.14 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			
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)			
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)			
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 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			
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)			
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)			
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 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			
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).			
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)			
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 6.17 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			
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)			
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).			
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.			

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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 6.18 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			
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			
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			
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			
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			
Description: Sync manager 3 is used by CoE as the process data input (TxPDOs - slave to master).			

Table 6.19 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			
Description: Number of assigned PDOs. The mailbox received sync manager can never have PDOs assigned to it.			

Table 6.20 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			
Description: Number of assigned PDOs. The mailbox send sync manager can never have PDOs assigned to it.			

Table 6.21 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				
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				
Description: The object index of a RxPDO to assign to this sync manager. By default this is assigned to RxPDO mapping 6 (<i>v_target_velocity</i> and <i>controlword</i>).				

Table 6.22 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				
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				
Description: The object index of a TxPDO to assign to this sync manager. By default this is assigned to TxPDO mapping 6 (<i>v_velocity_actual_value</i> and <i>statusword</i>).				

6.3.5 Feedback encoder source

Table 6.23 Feedback encoder source

0x3000		Position Feedback Encoder Configuration		
Access: RW	Range: 0 to 11	Size: 1 byte	Unit: N/A	
Default: 0				
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: <ul style="list-style-type: none"> 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. 9 - Slot 4 position feedback module, P1 interface. 10 - Slot 4 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.				

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6.4 Cyclic data loss behaviour

Table 6.24 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		
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		
Description:	<p>The maximum time, in ms, allowed between accesses to PDOs (read or write). 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. An additional means of detection will be used in modes that provide interpolation, thus having a mode-specific cycle time (e.g. Interpolated Position Mode or Cyclic Sync Position, Velocity or Torque Mode); in these modes, the mode-specific cycle time (e.g. the interpolation cycle time) will be used instead, and the behaviour listed in sub-index 2 will be initiated if no data has arrived at the start of a new time period.</p>		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	0		
Description:	<p>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.</p> <p>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.</p> <p>2: a trip will occur immediately on cyclic data loss (this implies that the motor will coast; no other motor stop will be initiated).</p>		

7 Drive profile (CiA402) support

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

- Homing Mode
- Cyclic Synchronous Position Mode
- Interpolated Position Mode
- 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 .

Table 7.1 Controlword

0x6040		Controlword													
Access: RW		Range: 0 to 65535				Size: Unsigned 16				Unit: N/A					
Default:		N/A													
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				
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

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
605D	halt_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 . 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 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 ENABLED', '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.

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Figure 7-1 CoE state machine diagram

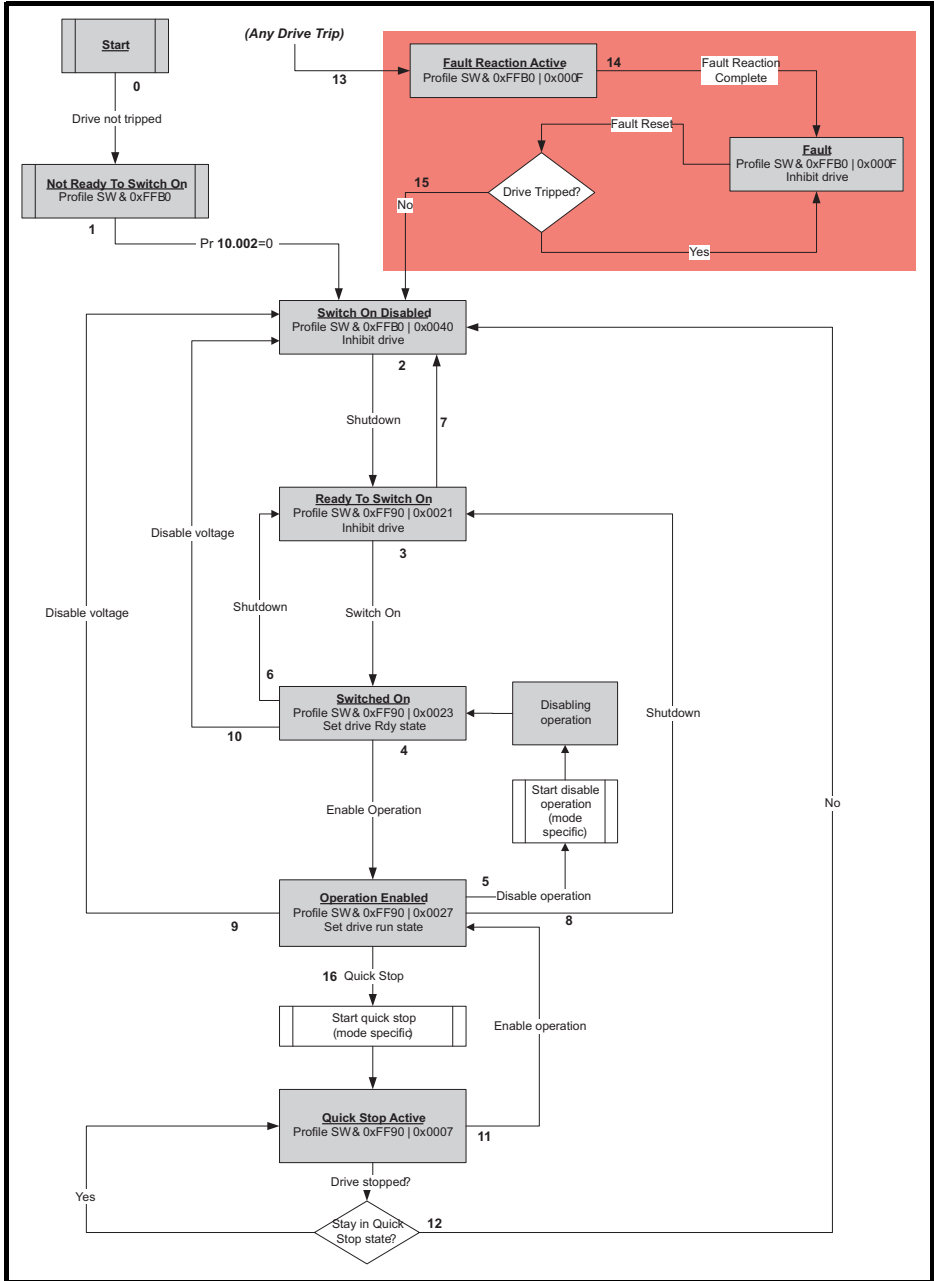


Table 7.7 CoE state machine transition and events

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

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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			
Access: RW	Range: 0 to 6	Size: Unsigned 16	Unit: N/A	
Default:	2			
Description:	Specifies what action is performed in the event of a quick stop function. See Table 7.7 <i>CoE state machine transition and events</i> on page 37 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			
Access: RW	Range: 0 to 1	Size: Unsigned 16	Unit: N/A	
Default:	N/A			
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			
Access: RW	Range: 0 to 1	Size: Unsigned 16	Unit: N/A	
Default:	N/A			
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. This object is ignored if the drive is tripped.

Table 7.14 Fault_reaction_option_code

0x605E	Fault_reaction_option_code		
Access: RW	Range: 0 to 2	Size: Unsigned 16	Unit: N/A
Default:	N/A		
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		
Access: RW	Range: 0 to 8	Size: Unsigned 8	Unit: N/A
Default:	2		
Description:	This object is used to request a change in the mode of operation.		

Table 7.17 Modes_of_operation values

Value	Definition
0	No mode change
2	vl velocity mode
4	Profile torque 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		
Access: RO	Range: 0 to 8	Size: Unsigned 8	Unit: N/A
Default:	N/A		
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
4	Profile torque mode
6	Homing mode
7	Interpolated position mode
8	Cyclic sync position mode

7.3.8 0x6084 Profile declaration

Table 7.20 Profile declaration

0x6084	Profile deceleration		
Access: RW	Range:0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	65536		
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:0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default:	2		
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	<i>position_encoder_resolution</i>
0x6091	<i>gear_ratio</i>
0x6092	<i>feed_constant</i>

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				
Description:				
Sub-index 1				
Access: RO	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A	
Default: 1				
Description: Encoder increments				
Sub-index 2				
Access: RO	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A	
Default: 1				
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:

$$\text{gear ratio} = \text{motor shaft revolutions} / \text{driving shaft revolutions}$$

Table 7.24 Gear_ratio

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

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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:

$$\text{feed constant} = \text{feed} / \text{driving shaft revolutions}$$

Table 7.25 Feed_constant

0x6092		Feed_constant	
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2			
Description:			
Sub-index 1			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1			
Description: Feed			
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 1			
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	<i>position_demand_value</i>
0x6065	<i>following_error_window</i>
0x6067	<i>position_window</i>
0x60F4	<i>following_error_actual_value</i>
0x60FB	<i>position_control_parameter_set</i>

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

7.3.17 0x6080 Max motor speed

Table 7.29 Max motor speed

0x6080	Max motor speed		
Sub-index 0			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	3000		
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).		

7.3.18 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 7.30 Following_error actual_value

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

7.3.19 0x60FB Position_control_parameter_set object

Table 7.31 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		
Description:	The number of control loop parameters.		
Sub-index 1			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: 0.01 rad/s/rad
Default:	2500		
Description:	The position controller proportional gain.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: 1 / 1000
Default:	1000 (i.e. a gain of 1)		
Description:	The position controller speed feed forward gain.		

The APC 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.

7.4 Interpolated position mode

Interpolated position mode operates on the Unidrive M600 in RFC-A and RFC-s modes. Table 7.32 lists the objects that are supported:

Table 7.32 Supported Interpolated position mode objects

Index	Name
0x60C0	<i>interpolation_submode_select</i>
0x60C1	<i>interpolation_data_record</i>
0x60C2	<i>interpolation_time_period</i>

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 7.33 0x60C0 Interpolation_sub-mode_select

0x60C0	Interpolation_sub-mode_select		
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'.		

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 μ s. The position is specified in user-defined position units. The value is written into sub-index 1.

Table 7.34 0x60C1 Interpolation_data_record

0x60C1	Interpolation_data_record		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	1		
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		
Description:	The set-point.		

7.4.3 0x60C2 Interpolation_time_period

Table 7.35 Interpolation_time_period

0x60C2		Interpolation_time_period	
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2			
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 dependant on the value in sub-index 2)			
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 μ s, 500 μ s or any multiple of 1ms. 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 μ s)			
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 μ s, 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 7.36 for more information.

Table 7.36 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.

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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 1.21). Table 7.37 lists the objects that are supported:

Table 7.37 vl velocity mode supported objects

Index	Name
0x6042	<i>vl_target_velocity</i>
0x6043	<i>vl_velocity_demand</i>
0x6044	<i>vl_velocity_actual_value</i>
0x6046	<i>vl_velocity_min_max_amount</i>
0x6048	<i>vl_velocity_acceleration</i>
0x6049	<i>vl_velocity_deceleration</i>
0x604A	<i>vl_velocity_quick_stop</i>
0x604B	<i>vl_setpoint_factor</i>
0x604C	<i>vl_dimension_factor</i>

7.5.1 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 7.38 vl_target_velocity

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

7.5.2 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 7.39 vl_velocity_demand

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

7.5.3 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 7.40 velocity_actual_value

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

7.5.4 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 7.41 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		
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		
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 <i>vl_velocity_min</i> positive and <i>vl_velocity_min</i> negative.		
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	2147483647		
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 <i>vl_velocity_max</i> positive and <i>vl_velocity_max</i> negative.		

7.5.5 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.

$$vl_velocity_acceleration = \text{delta speed} / \text{delta time}$$

Table 7.42 0x6048 vl_velocity_acceleration

0x6048		vl_velocity_acceleration	
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2			
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			
Description: The value of delta speed is given in rpm if the <i>vl_dimension_factor</i> and the <i>vl_setpoint_factor</i> 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			
Description: The value of delta time is given in seconds.			

7.5.6 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.

$$vl_velocity_deceleration = \text{delta speed} / \text{delta time}$$

Table 7.43 0x6049 vl_velocity_deceleration

0x6049		vl_velocity_deceleration	
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2			
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			
Description: The value of delta speed is given in rpm if the <i>vl_dimension_factor</i> and the <i>vl_setpoint_factor</i> 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			
Description: The value of delta time is given in seconds.			

7.5.7 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.

$$vl\ velocity\ deceleration = \text{delta speed} / \text{delta time}$$

Table 7.44 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				
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				
Description: The value of delta speed is given in rpm if the <i>vl_dimension_factor</i> and the <i>vl_setpoint_factor</i> 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				
Description: The value of delta time is given in seconds.				

7.5.8 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 7.45 0x604B vl_setpoint_factor

0x604B		vl_setpoint_factor		
Sub-index 0				
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A	
Default: 2				
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				
Description: <i>vl_setpoint_factor</i> 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				
Description: <i>vl_setpoint_factor</i> denominator (a value of 0 is not valid).				

7.5.9 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.

$$\text{Velocity [user-defined unit]} / \text{Dimension factor [rpm/user-defined unit]} = \text{Velocity [rpm]}$$

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Table 7.46 0x604C vl_dimension_factor

0x604C		vl_dimension_factor	
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default: 2			
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			
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			
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 read from the drive 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.

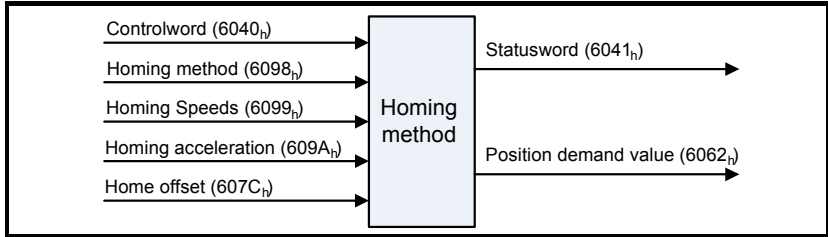
7.6 Homing mode

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.

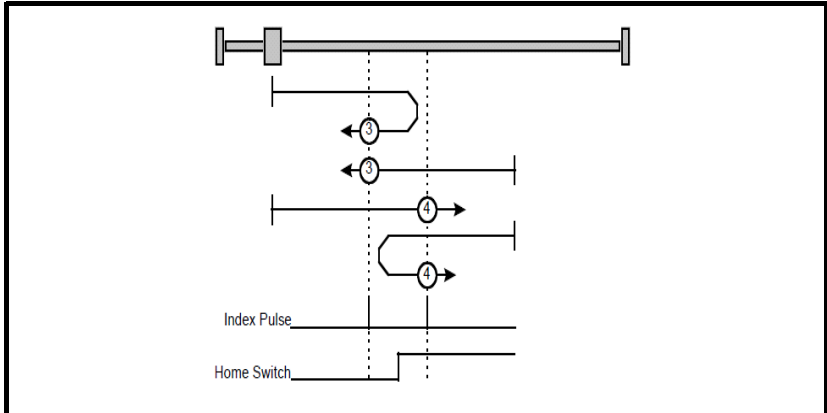
7.6.1 General homing definitions

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 52, 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.

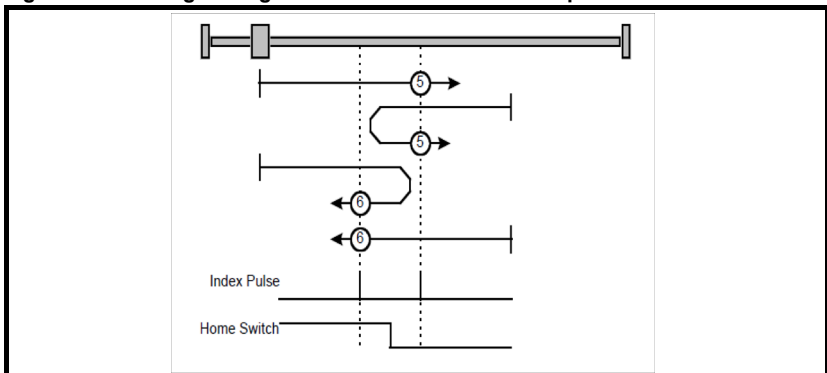
Figure 7-3 Homing on positive home switch and index pulse



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 52, 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 53 and Figure 7-6 *Homing on home switch and index pulse - negative initial motion* on page 53. 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

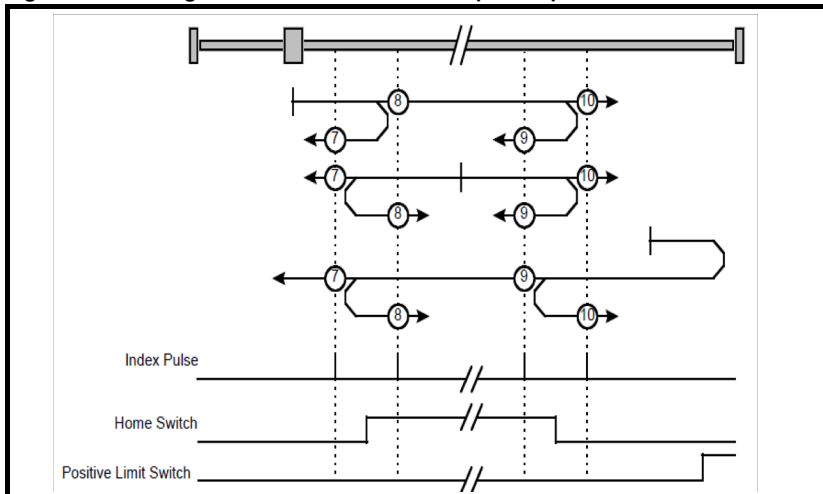
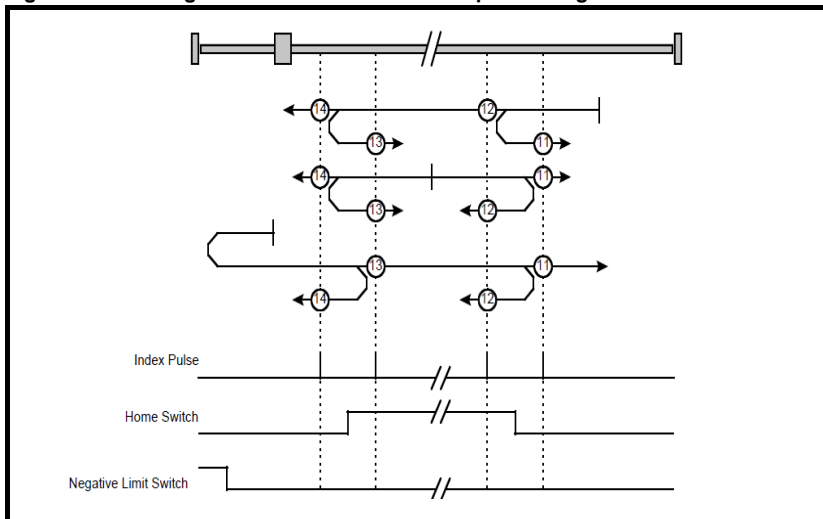


Figure 7-6 Homing on home switch and index pulse - negative initial motion



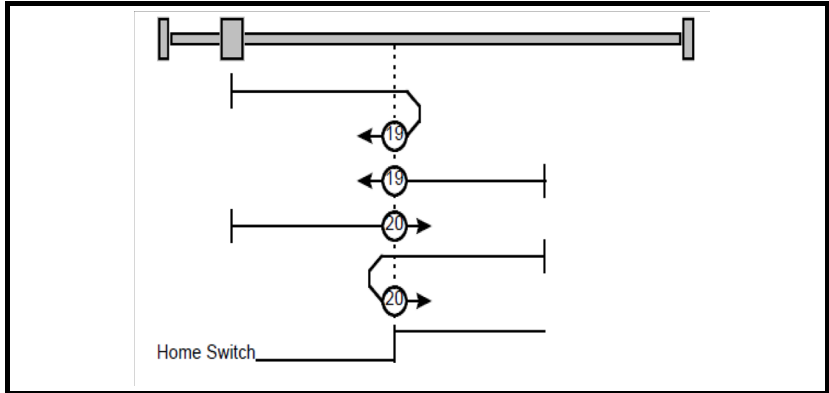
Method 15 and 16: Reserved

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 54.

Figure 7-7 Homing on positive home switch

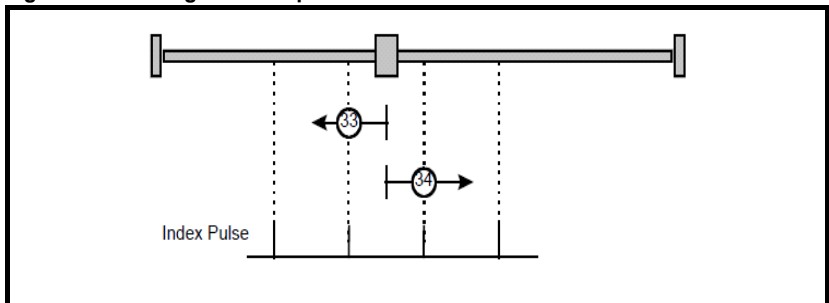
**Method 31 and 32: Reserved**

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 54.

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 7.47 *Definition of bits 4 and 8 of the controlword* on page 55 defines the values for bits 4 and 8 of the controlword.

Table 7.47 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 halt option code (0x605D).

Table 7.48 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 7.49 *Homing source* on page 55 specifies the object description.

Table 7.49 Homing source

0x3003	Homing source object		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 2			
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			
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			
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).			

The value of object 0x3001 will be ignored on drives which do not support position feedback.

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 56. 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 7.50 Home offset

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

0x6098 Homing method

This object indicates the configured homing method that shall be used. Table 7.51 *Homing method* on page 56 specifies the object description, and Table 7.52 *Homing method values* on page 56 specifies the value ranges for this object.

Table 7.51 Homing method

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

Table 7.52 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 7.53 *Homing speeds* on page 57 specifies the object description.

Table 7.53 Homing speeds

0x6099		Homing speeds	
Sub-index 0			
Access: RO	Range: 2	Size: Signed 8	Unit: N/A
Default: 2			
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			
Description: Speed during search for a switch.			
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: N/A
Default: 0			
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 7.54 *Homing acceleration* on page 57 specifies the object description.

Table 7.54 Homing acceleration

0x609A		Homing acceleration	
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: User-defined acceleration units
Default: 0			
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 7.55 Cyclic sync position mode

Index	Name
0x607A	target_position
0x60B1	velocity_offset
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 7.56 Target position

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

Table 7.57 Interpolation sub-mode select

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

Table 7.58 Interpolation time period

0x60C2		Interpolation time period		
Sub-index 0				
Access: RO		Range: N/A	Size: 1 byte	Unit: N/A
Default:	2			
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			
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 μ s, 500 μ s 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 μ s)			
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 μ s, 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 μ s, and the AMC will be configured to run in velocity mode).

The following objects will be supported:

Index	Name
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.

7.9 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 μ s).

The following objects will be supported:

Index	Name
6071	target_torque
6073	max_current
6075	motorRatedCurrent
6077	torqueActualValue
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 motorRatedCurrent, which will be read-only.

7.10 Error Handling

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

Index	Name
1001	error_register
603F	error_code

0x1001		Error register		
Access: RO		Range: 0 to 255	Size: 1 byte	Unit: N/A
Default:	0			
Description:	<p>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:</p> <ul style="list-style-type: none"> 0: Generic error 1: Current 2: Voltage 3: Temperature <p>When an error is indicated in this object, the particular error code will be contained in object 0x603F (Error code).</p>			

0x603F		Error code		
Access: RO		Range: 0 toFFF	Size: 2 bytes	Unit: N/A
Default:	0			
Description:	<p>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.</p>			

Error code	Meaning	Corresponding drive trip code (if available)
0x0000	Error reset / No error	0 – None
0xFF01	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

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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 μ s.

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 μ s 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 a operating mode cycle time matching the synchronous task (250 μ s or 5 ms, depending on drive type)

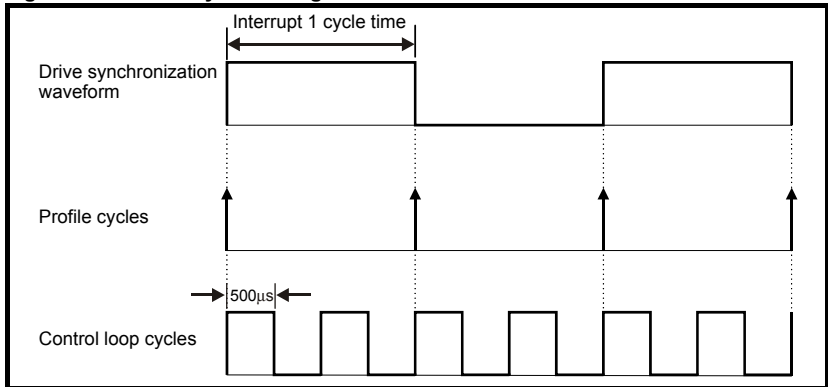
Any operating mode cycle will be restarted every operating mode cycle time, in phase with the synchronisation events; if synchronization is enabled, the operating mode will not start execution until the first synchronization event occurs. If synchronization is lost, an error will be indicated, and the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

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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.

0x3006	Out cyclic data configuration		
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2		
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		
Description:	<p>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.</p> <p>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).</p> <p>1 - Drive Critical update period. Occurs for the first 70 μs following an edge of the OPT_SYNC signal.</p> <p>2 - Post-Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period.</p> <p>3 - Sync Manager task. This is the AL event task which occurs upon a sync manager access.</p>		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	3		
Description:	<p>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.</p> <p>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).</p> <p>1 - Drive Critical update period. Occurs during the first 70 μs following an edge of the OPT_SYNC signal.</p> <p>2 - Post-Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period.</p> <p>3 - Sync Manager task. The default; it is the AL event task which occurs upon a sync manager access.</p>		

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0x3007		In cyclic data configuration	
Sub-index 0			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default: 2			
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			
Description:	<p>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.</p> <p>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).</p> <p>1 - Drive Critical update period. Occurs during the first 70 μs following an edge of the OPT_SYNC signal.</p> <p>2 - Post Drive Critical update period. The task that occurs immediately after the critical update period, up until the Pre Drive Critical Update Period.</p> <p>3 - Sync Manager task. The AL event task which occurs upon a sync manager access.</p>		
Sub-index 2			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default: 2			
Description:	<p>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.</p> <p>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).</p> <p>1 - Drive Critical update period. Occurs during the first 70 μs following an edge of the OPT_SYNC signal.</p> <p>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.</p> <p>3 - Sync Manager task. The AL event task which occurs upon a sync manager access.</p>		

9 Menus

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.

9.0.1 S.00.ppp (Corresponds to menu 15, 16, 17 or 24) - Customized drive setup / status menu

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	Maximum	999999 (Display 00.99.99.99)
Default		Units	
Type	32 bit volatile	Update Rate	Power-up write
Display Format	Version number	Decimal Places	0
Coding	RO, 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 $((\mathbf{S.00.005} * 100000000) + \mathbf{S.00.004})$. 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	Maximum	3
Default		Units	
Type	8 bit volatile	Update Rate	Background
Display Format	None	Decimal Places	0
Coding	RO, Txt, ND, NC, PT, BU		

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	Maximum	1
Default	0	Units	
Type	1 bit volatile	Update Rate	Read every 200 ms Written to 0 on module initialization
Display Format	None	Decimal Places	0
Coding	RW, 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	Maximum	1
Default	0	Units	
Type	1 bit volatile	Update Rate	Read every 200 ms Written to 0 when save is complete
Display Format	None	Decimal Places	0
Coding	RW, 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	0	Maximum	8
Default		Units	
Type	8 bit volatile	Update Rate	Written on power-up
Display Format	None	Decimal Places	0
Coding	RO, ND, 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, 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	Maximum	1
Default	0	Units	
Type	8 bit volatile	Update Rate	Read in background
Display Format	None	Decimal Places	0
Coding	RW, BU		

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	Maximum	1
Default	0	Units	
Type	1 bit volatile	Update Rate	Read in background
Display Format	None	Decimal Places	0
Coding	RW, BU		

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 used by setting this parameter and performing a option reset; the parameter cannot be saved.

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

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.

9.0.2 S.01.ppp - Status and configuration menu

S.01.001	EtherCAT RUN Indicator		
Minimum	0	Maximum	8
Default	0	Units	
Type	8 bit volatile	Update Rate	Background
Display Format	None	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

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 μ s, 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, NC, PT, BU		

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

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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
0xFF01	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

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Error code	Meaning	Corresponding drive trip Code (if available)
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 10.8 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

Trip	Description
Inalid Fdbk Scr	An unknown or invalid feedback source has been configured
ECAT Int Error	An error while initializing the EtherCAT communications
TO ECAT PDO	A PDO has not been written for longer than the specified time-out
Sync Task Orun	The synchronous task has overrun its allowed interval

10.5 Updating SI-EtherCAT firmware

The latest SI-EtherCAT firmware is available from your local Control Techniques Drive Centre or supplier, and can also be downloaded from www.ctsupport.com. 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.

10.6 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).

10.7 Sync Task Orun trips

If SI-EtherCAT can not 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 **S.00.007**.

10.8 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 10.9.

Table 10.9 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

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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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SCIGATE AUTOMATION (S) PTE LTD

No.1 Bukit Batok Street 22 #01-01 Singapore 659592

Tel: (65) 6561 0488

Fax: (65) 6562 0588

Email: sales@scigate.com.sg

Web: www.scigate.com.sg

Business Hours: Monday - Friday 8.30am - 6.15pm



0471-0152-01