SM-EtherCAT

User Guide

Unidrive SP

Affinity

Digitax ST

Commander SK

Mentor MP

EPA ®
®M

Distributor for:

Nidec

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Original Instructions

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

Documentation

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

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

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1 Safety information

1.1 Warnings, cautions and notes

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

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

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

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

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

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

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

1.3 Responsibility

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

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

1.4 Compliance with regulations

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

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

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

2006/42/EC Safety of machinery.

2014/30/EU: Electromagnetic Compatibility.

1.5 Electrical hazards

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

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

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

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

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

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

1.6 Stored electrical charge

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

1.7 Mechanical hazards

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

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

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

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

1.8 Access to equipment

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

1.9 Environmental limits

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

1.10 Hazardous environments

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

1.11 Motor

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

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

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

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

1.12 Mechanical brake control

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

1.13 Adjusting parameters

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

1.14 Electromagnetic compatibility (EMC)

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

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2 Introduction

2.1 Features

- Standard RJ45 with support for shielded twisted pair, half-duplex / full-duplex and 10Mbs / 100Mbs connectivity
- Dual 100Mbps EtherCAT interfaces for use in line topologies i.e. daisy chaining
- Supports the Unidrive SP drives range, Mentor MP, Affinity, Digitax ST and Commander SK
- Control loop synchronization
- Control cycle times down to 250μs
- Configured Station Alias
- CANopen over EtherCAT (CoE) which includes:
    - Support of CANopen DSP-402 (Device Profile for Drives and Motion)
    - Cyclic sync position mode
    - Interpolated position mode
    - Velocity mode
    - Profile torque mode
    - Homing mode
    - Two transmit and two receive PDOs
    - SDO access to all profile objects and drive parameters
    - Two digital inputs available for use in homing mode
- EoE (Ethernet over EtherCAT)

2.2 Introduction to SM-EtherCAT

SM-EtherCAT is a Solutions Module that enables the Control Techniques 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 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).

2.4 Solution module identification

The SM-EtherCAT can be identified by:

1. The label located on the underside of the Solutions Module.
2. The color coding across the front of the SM-EtherCAT (brown-red).

Figure 2-1 SM-EtherCAT label
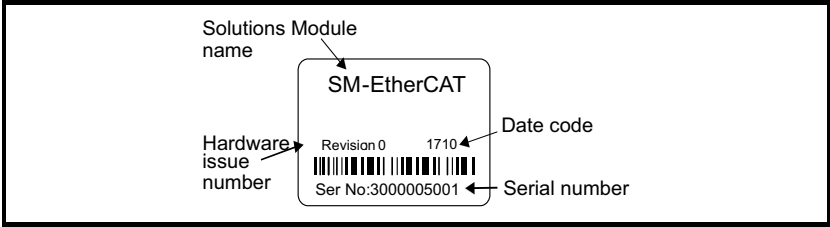
2.4.1 Date code format

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

Example:

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

2.5 Product Conformance Certificate

SM-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 Solutions Module is done using menus and parameters. A menu is a logical collection of parameters that have similar functionality.

In the case of a Solutions Module, the parameters will appear in one of three menus 15, 16 or 17 depending on the drive type and slot the module is installed into as shown in Table 2.1 *Drive menu availability* below. The menu is denoted by the number before the decimal point.

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

- Pr **xx.00**   - signifies any menu and parameter number 00.
- Pr **MM.xx**   - where **MM** signifies the menu allocated to the solutions module (as shown in Table 2.1 *Drive menu availability*) and **xx** signifies the parameter number.

Table 2.1 Drive menu availability

Drive Type	Slot 1 15.xx	Slot 2 16.xx	Slot 3 17.xx
Unidrive SP	Yes	Yes	Yes
Affinity	Yes	Yes	No
Mentor MP	Yes	Yes	Yes
Commander SK	Yes	No	No
Digitax ST	Yes	Yes	No

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NOTE All references in this manual to SM-Applications/Plus should also extend to SM-Applications Lite/Lite V2. The exceptions to this are references to SM-Applications/Plus input/output, CTSync or the EIA (RS) -485 port, as these are not supported on SM-Applications Lite/Lite V2. For full details of the differences see the SM-*Applications Modules and Motion Processors User Guide*.

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

3 Mechanical installation

3.1 General installation

The installation of a Solutions Module is illustrated in Figure 3-1.

Figure 3-1 Installing a Solutions Module
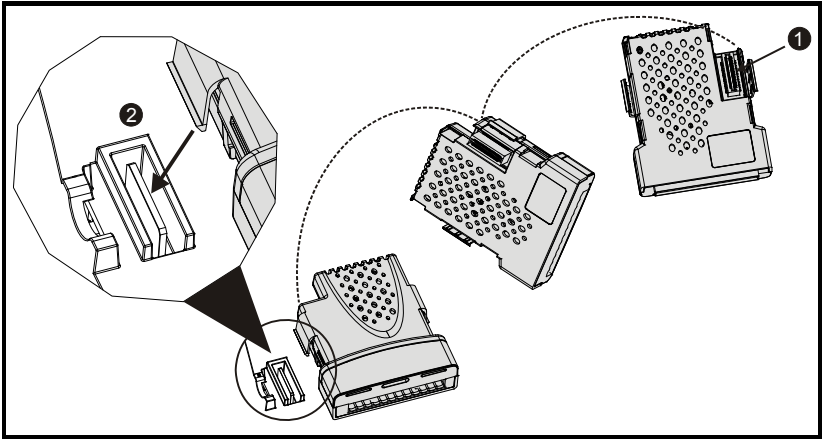
The Solutions Module connector is located on the underside of the module (1). Push this into the Solutions Module slot located on the drive until it clicks into place (2). Note that some drives require a protective tab to be removed from the Solutions Module slot. For further information, refer to the appropriate drive manual.

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4   Electrical installation

4.1   SM-EtherCAT module information

4.1.1   Bus media

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

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

4.2   SM-EtherCAT terminal descriptions

The SM-EtherCAT module has two RJ45 Ethernet ports for the EtherCAT network. There are also two digital inputs available for use in Homing Mode.

Figure 4-1 EtherCAT connection
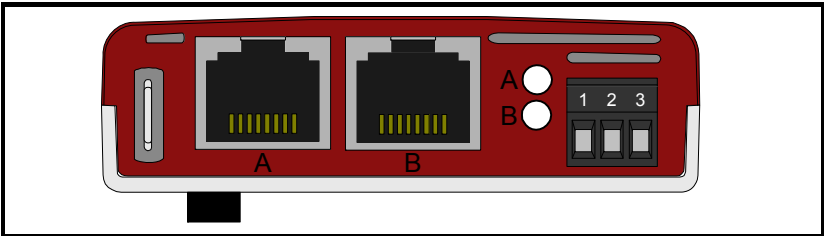
Table 4.1 EtherCAT terminal descriptions

Pin	A - IN	Pin	B - OUT	Digital Inputs	Function
1	Transmit +	1	Transmit +	1	0V Common
2	Transmit -	2	Transmit -	2	Digital input 0
3	Receive +	3	Receive +	3	Digital input 1
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

SM-EtherCAT is supplied with a grounding tag 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.

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 SM-EtherCAT daisy chain network topology
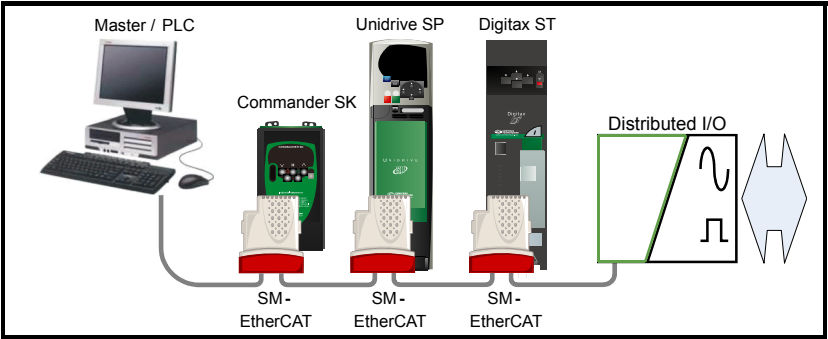
4.5   Minimum node-to-node cable length

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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5.1   Quick start guide

This section is intended to provide a generic guide for setting up SM-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 SM-EtherCAT module.

5.1.1   SM-EtherCAT version compatibility

Table 5.1 SM-EtherCAT version compatibility

Drive type	Drive firmware	SM-EtherCAT firmware
Unidrive SP	V01.08.00 or later	V01.00.00 or later
Affinity	V01.02.00 or later	V01.00.00 or later
Digitax ST	V01.02.00 or later	V01.00.00 or later
Commander SK	V01.06.00 or later	V01.00.00 or later
Mentor MP	V01.00.00 or later	V01.02.00 or later

For the purpose of the example this section will follow the steps required to set up cyclic communications using one RxPDO and two TxPDOs. These PDOs will consist of the mappings shown in Table 5.2:

Table 5.2 PDO test mappings

	RxPDO1	TxPDO1	TxPDO6
Mapping 1	0x6040 (*controlword*) (16-bits)	0x6041 (*statusword*) (16-bits)	Pr **18.22** (16-bits)
Mapping 2	0x6042 (*vl_target_velocity*) (16-bits)	0x6064 (*position_actual_value*) (32-bits)	Pr **20.21** (32-bits)
Mapping 3	Pr **20.21** (32-bits)	N/A	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 9 Diagnostics* on page 75 of this manual and have checked that the SDO/PDO configurations are correct.

5.1.2   SM-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 SM-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.

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

In the master, scan the network ensuring that the SM-EtherCAT module is connected correctly to the master. If the network is configured correctly the SM-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, 6 and 22, the TxPDOs available are 1, 2, 3, 6 and 22 (for more information on these PDOs including default mappings please see section 6.3.2 *RxPDO mappings* on page 25 and section 6.3.3 *TxPDO mappings* on page 28).

Figure 5-1 SM-EtherCAT PDO configuration
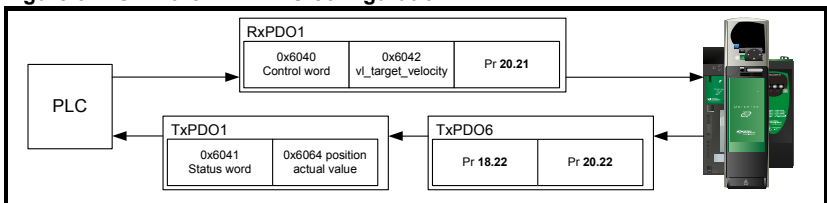
RxPDO1, TxPDO1 and TxPDO6 will need to be enabled in the master. Once enabled you will need to add mappings to the PDOs.

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 **20.21** 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.

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

Table 5.3 Cyclic data mapping configuration

RxPDO1:		TxPDO1:		TxPDO6:	
Object:	0x1600	Object:	0x1A00	Object:	0x1A05
Sub-index:	0x00	Sub-index:	0x00	Sub-index:	0x00
Size:	1	Size:	1	Size:	1
Value:	3	Value:	2	Value:	2
Sub-index:	0x01	Sub-index:	0x01	Sub-index:	0x01
Size:	4	Size:	4	Size:	4
Value:	0x60400010	Value:	0x60410010	Value:	0x20121610
Sub-index:	0x02	Sub-index:	0x02	Sub-index:	0x02
Size:	4	Size:	4	Size:	4
Value:	0x60420010	Value:	0x60640020	Value:	0x20141620
Sub-index:	0x03	Not Used		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 five. There are no restrictions on the data length of these 5 parameters (i.e. It is possible to map five, 32-bit parameters in one PDO). It is also possible to use a maximum of two RxPDOs and two TxPDOs.

5.1.4   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 two TxPDOs to sync manager 3.

Figure 5-2 SM-EtherCAT sync manager configuration
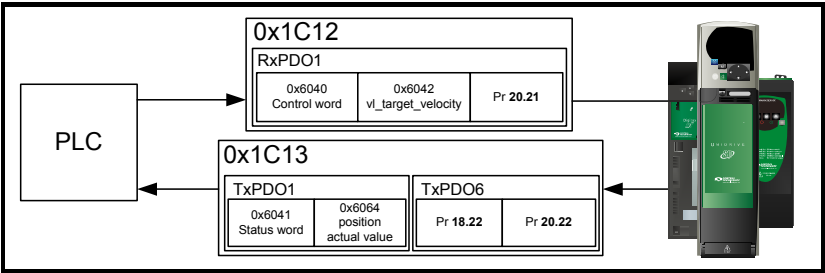
Assigning RxPDO to the sync manager

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: 2

Setting object 0x1C13, sub-index 0 to a value of 2 (as above) indicates that two TxPDOs will be assigned to the sync manager 3 assignment.

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

- Index: 0x1C13
- Sub index: 0x02
- Size: 2
- Value: 0x1A05

Setting object 0x1C13, sub-index 1 to a value of 0x1A00 and sub-index 2 to a value of 0x1A05 (as above) maps TxPDO1 and TxPDO6 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 SM-EtherCAT should flash, depending on the port(s) connected.

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

5.2 Quick start flowchart

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

Figure 5-3 Quick start flowchart

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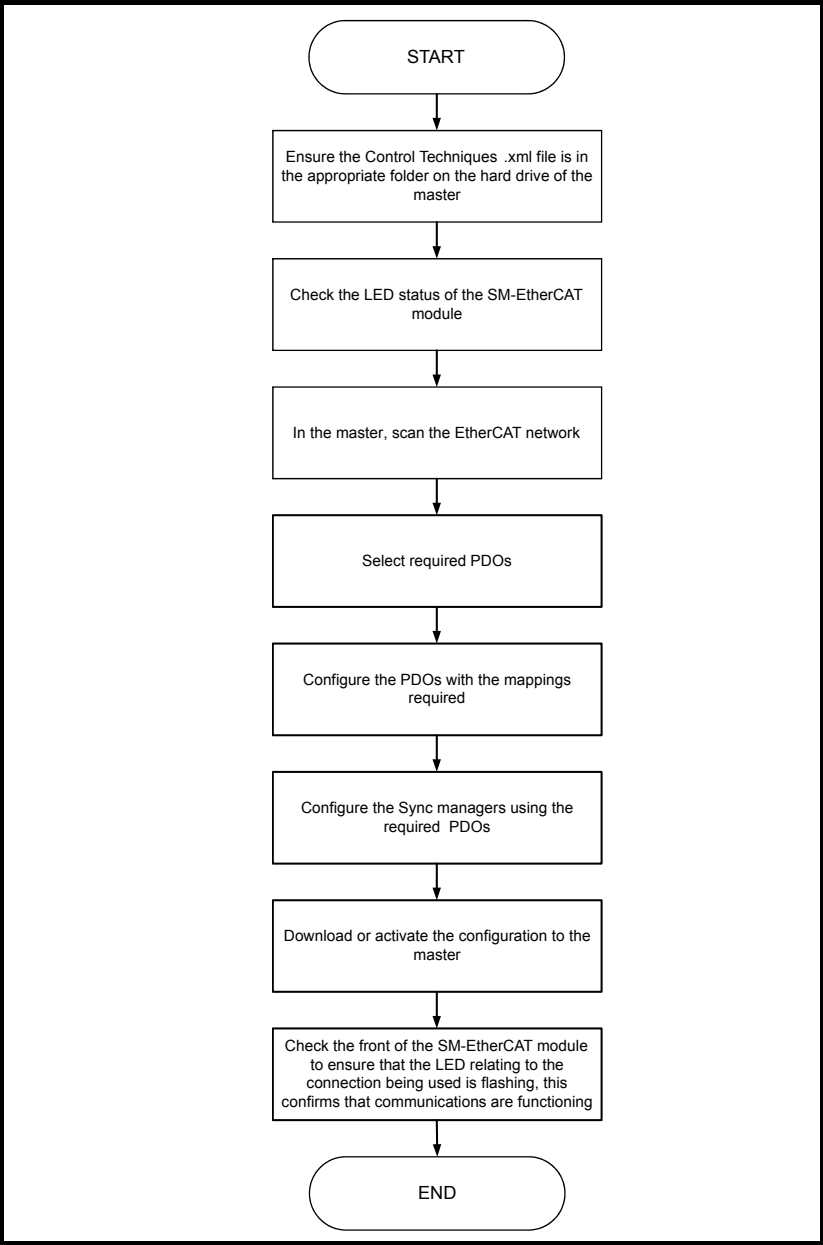
5.3 Saving parameters to the drive

On the Unidrive SP, Affinity, Digitax ST and Commander SK to avoid loss of the configured settings when the drive is powered down it is necessary to write 1000 to Pr **MM.00** followed by pressing the reset button to perform a drive save. On Mentor MP Pr **MM.00** needs to be set to a value of 'SAVE' followed by pressing the reset button.

To store drive parameters:

- Set Pr **MM.00** to 1000 (Mentor MP, Pr **MM.00**=SAVE).
- Press the red RESET button.

The drive will store all parameters (except Menu 20) but the operation of the SM-EtherCAT will not be affected. Changes made to the SM-EtherCAT configuration parameters will not take effect until the SM-EtherCAT is reset.

NOTE Unidrive-SP, Mentor MP, Affinity and Digitax ST: Menu 20 applications parameters may be saved if an Applications Module is installed, menu 20 is stored in the Applications Module's memory. See the relevant Applications Module documentation for more information. If the drive is running on backup supply only, Pr **MM.00** must be set to 1001 to perform a save.

NOTE This saves only drive and module parameters and not SM-EtherCAT related objects.

5.4 SM-EtherCAT Node address

Table 5.4 SM-EtherCAT Node address

SM-EtherCAT Node address		
Pr **MM.03**	Default	0
	Range	0 to 65535
	Access	RW

It is not necessary for a user to set a node address manually in order to initiate EtherCAT communications; however, this parameter can be used to configure an EtherCAT Station Alias. When changed, this value will be stored in the option non-volatile storage upon a transition from the INIT state to the PRE-OPERATIONAL state; this change will also cause an AL Status Code to be set to indicate that the option needs to be reset. It will be possible to read the value at the 16-bit word address 0x0004 of the SII (Slave Information Interface) data, and in EtherCAT register 0x0012 (a 16-bit word).

5.5 SM-EtherCAT RUN

Table 5.5 SM-EtherCAT RUN

SM-EtherCAT RUN		
Pr **MM.04**	Default	1
	Range	1 to 8
	Access	RW

This parameter displays the SM-EtherCAT RUN state as required by the EtherCAT indicator and Marking Specification. It will contain one of the values in Table 5.6.

Table 5.6 EtherCAT State Machine State

Value	ESM State
1	INIT
2	PRE-OPERATIONAL
4	SAFE-OPERATIONAL
8	OPERATIONAL

Although this parameter has the read/write attribute, it will be forced to the state value continuously to prevent it being written by another entity.

5.6   Re-initializing the SM-EtherCAT

Table 5.7 SM-EtherCAT re-initialize

SM-EtherCAT re-initialize		
Pr MM.32	Default	0 (OFF)
	Range	0 (OFF) to 1 (ON)
	Access	RW

Changes to the SM-EtherCAT configuration in menu 15, 16 or 17 parameters on Unidrive SP and Mentor MP, menu 15 or 16 on Affinity and Digitax ST or menu 15 on Commander SK will not take effect until the SM-EtherCAT has been re-initialized.

To re-initialize SM-EtherCAT:

1.   Set Pr **MM.32** to ON.
2.   When the sequence has been completed, Pr **MM.32** will be reset to OFF.
3.   The SM-EtherCAT will re-initialize using the updated configuration.

NOTE   The above sequence does NOT store the SM-EtherCAT configuration parameters in the drive or the SM-EtherCAT's internal FLASH memory. This parameter will change back to OFF immediately and as such the change may not be visible on the display.

5.7   Re-initialize all Solutions Modules

To re-initialize all Solutions Modules installed on a drive:

1.   Set Pr **MM.00** to 1070 (see note below).
2.   Press the red RESET button on the drive. Another parameter (e.g. Pr **01.00**) must be used.

NOTE   This sequence does NOT store the SM-EtherCAT configuration parameters in the drive or the SM-EtherCAT FLASH memory.

NOTE   On Commander SK drives, Pr **00.00** is not available.

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6 Protocols

6.1 Process Data Objects (PDOs)

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

6.1.1 PDO Priority

If 2 PDOs are mapped in a sync manager then the second PDO will always be considered to be low priority (and, as such, should not be used for deterministic process data).

Mappings to slow parameters (such as SM-Applications PLC parameters, etc) should always be placed in the second PDO. When there is more than one PDO mapping in a Sync Manager, placing a slow parameter in the first PDO will trigger an SDO abort code. If only one PDO is mapped to a sync manager, then placing a slow parameter in that PDO will make it low priority (so slow parameter accesses should not be placed in PDOs where deterministic data access is required).

It is possible to map any drive parameters in PDOs.

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 **20.21** 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 SM-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). Pr **MM.00** in any drive can only be accessed as Pr **61. 01** (0x203D, sub-index changes to 1).

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>			

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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:	0x00030192		
Description:	The primary CoE functional profile is DSP-402, the value of the object is defined as follows: Bits 0 to 15 (Device profile number): 402 (0x192) Bit 16 (Frequency converter): x Bit 17 (Servo drive): y Bit 18 (Stepper motor): 0 Bit 24 (DC drive - manufacturer specific : z Bits 25 to 31 (Manufacturer specific): 0 This value will depend on the drive operating mode and/or type. On a Unidrive SP in open-loop or closed-loop mode or a Mentor MP in closed-loop mode, bit 16 will be set, while bits 17 and 24 will be cleared. On a Unidrive SP in Servo mode or a Digitax ST, bit 17 will be set, while bits 16 and 24 will be cleared.		

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:	See Pr **MM.01**		
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:	High word: Pr **MM.02** Low word: Pr **MM.51**		
Description:	Contains the option module software version number (the major and minor version parameter placed in the high word of this object, and the sub-version parameter (Pr **MM.51**) is the low word).		
Sub-index 4			
Access: RO	Range: N/A	Size: 4 bytes	Unit: N/A
Default:	See Pr **MM.35**		
Description:	Contains the option hardware serial number.		

6.3.2 RxPDO mappings

Objects with indices from 0x1600 to 0x17FF specify receive PDO mappings. The mappings from DSP-402 are included as standard (the PDO mappings will have the following default values).

Table 6.6 RxPDO mappings

PDO number	Mapping object index	Mapping object name
1	0x6040	*controlword*
2	0x6040 0x6060	*controlword* *modes of operation*
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).

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Table 6.7 RxPDO mapping 1

0x1600	Receive PDO mapping 1		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default:	1		
Description:	The number of mapped objects in thie PDO		
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0x60400010 - the DSP-402 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 (CF)	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 DSP-402 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 DSP-402 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 6

0x1605	Receive PDO mapping 6		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	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 DSP-402 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 DSP-402 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 6.10 RxPDO mapping 22

0x1615	Receive PDO mapping 22		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default:	0		
Description:	The number of mapped objects in thie PDO		
Sub-indices 1 to 255: 1st to 255th mapped objects in this PDO.			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0		
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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6.3.3 TxPDO mappings

Objects with the indices from 0x1A00 to 0x1BFF specify transmit PDO mappings. The following mappings from DSP-402 are included as standard.

Table 6.11 TxPDO mappings

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

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

Table 6.12 TxPDO mapping 1

0x1A00	Transmit PDO mapping 1		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default: 1			
Description: The number of mapped objects in thie PDO			
Sub-index 1: 1st mapped object			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default: 0x60410010 - the DSP-402 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.		

Table 6.13 TxPDO mapping 2

0x1A01	Transmit PDO mapping 2		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	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 DSP-402 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 DSP-402 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 6.14 Tx PDO mapping 3

0x1A02	Transmit PDO mapping 3		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	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 DSP-402 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 DSP-402 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.		

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Table 6.15 TxPDO mapping 6

0x1A05	Transmit PDO mapping 6		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	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 DSP-402 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 DSP-402 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.		

Table 6.16 TxPDO mapping 22

0x1A15	Transmit PDO mapping 22		
Sub-index 0: Number of mapped objects			
Access: RW	Range: 0 to (CF)	Size: 1 byte	Unit: N/A
Default:	0		
Description:	The number of mapped objects in thie PDO		
Sub-indices 1 to 255: 1st to 255th mapped objects in this PDO.			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: 4 bytes	Unit: N/A
Default:	0		
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 6.17 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:	4		
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 6.18 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 6.19 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 6.20 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 (*vl_target_velocity* and *controlword*).		

Table 6.21 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 (*vl_velocity_actual_value* and *statusword*).		

6.3.5   Feedback encoder source

Table 6.22 Feedback encoder source

0x2802	Feedback encoder source		
Sub-index 0			
Access: RW	Range: 0 to 3	Size: 1 byte	Unit: N/A
Default:	0		
Description:	This object specifies the source position for position controller feedback.		

0 = Use drive as the feedback source
1 = Use the encoder module in slot 1 as the encoder source
2 = Use the encoder module in slot 2 as the encoder source
3 = Use the encoder module in slot 3 as the encoder source

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6.4 Ethernet over EtherCAT (EoE)

This protocol allows standard Ethernet messages and protocols to be tunnelled through the EtherCAT network. This provides users with the possibility of connecting to the Control Techniques PC Tools (SyPT Pro, SyPTLite, CTSoft, CTScope and Winflasher) along the same connection currently being used for SM-EtherCAT communications.

| NOTE | For help configuring this protocol with the Control Techniques PC Tools, please refer to Knowledge Base document *COMMS046* on CTSupport titled *Connecting to the Control Techniques' PC Tools using the SM-EtherCAT module and EoE (Ethernet over EtherCAT)*. |

6.4.1 EoE IP address

The SM-EtherCAT EoE IP address is defined in the EtherCAT Master and is displayed in the module parameters as shown in Figure 6-1.

Figure 6-1 EoE IP address format

SM-EtherCAT EoE IP address	W$_{ip}$	X$_{ip}$	Y$_{ip}$	Z$_{ip}$
	Pr **MM.10**	Pr **MM.11**	Pr **MM.12**	Pr **MM.13**
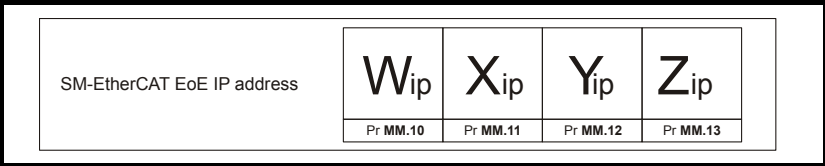
Table 6.23 EoE - IP address W$_{ip}$

EoE - IP address W$_{ip}$		
Pr **MM.10**	Default	0
	Range	0 to 255
	Access	RW

This is the most significant octet of the SM-EtherCAT EoE IP address.

Table 6.24 EoE - IP address X$_{ip}$

EoE - IP address X$_{ip}$		
Pr **MM.11**	Default	0
	Range	0 to 255
	Access	RW

This is the second most significant octet of the SM-EtherCAT EoE IP address.

Table 6.25 EoE - IP address Y$_{ip}$

EoE - IP address Y$_{ip}$		
Pr **MM.12**	Default	0
	Range	0 to 255
	Access	RW

This is the third most significant octet of the SM-EtherCAT EoE IP address.

Table 6.26 EoE - IP address Z_{ip}

EoE - IP address Z_{ip}		
Pr **MM.13**	Default	0
	Range	0 to 255
	Access	RW

This is the least significant octet of the SM-EtherCAT EoE IP address.

6.4.2 EoE Subnet mask

The SM-EtherCAT EoE Subnet mask is defined in the EtherCAT Master and is displayed in the module parameters as shown in Figure 6-2.

Figure 6-2 EoE Subnet mask format
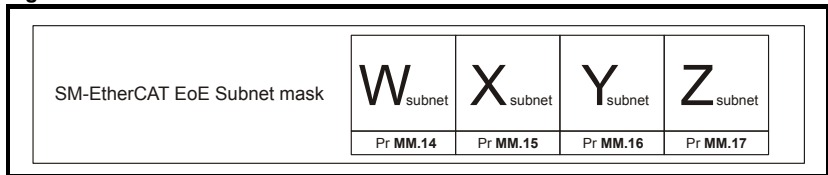
Table 6.27 EoE - Subnet mask W_{subnet}

EoE - Subnet Mask W_{subnet}		
Pr **MM.14**	Default	0
	Range	0 to 255
	Access	RW

This is the most significant octet of the SM-EtherCAT EoE Subnet mask.

Table 6.28 EoE - Subnet mask X_{subnet}

EoE - Subnet Mask X_{subnet}		
Pr **MM.15**	Default	0
	Range	0 to 255
	Access	RW

This is the second most significant octet of the SM-EtherCAT EoE Subnet mask.

Table 6.29 EoE - Subnet mask Y_{subnet}

EoE - Subnet Mask Y_{subnet}		
Pr **MM.16**	Default	0
	Range	0 to 255
	Access	RW

This is the third most significant octet of the SM-EtherCAT EoE Subnet mask.

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Table 6.30 EoE - Subnet mask Z$_{subnet}$

EoE - Subnet Mask Z$_{subnet}$		
Pr **MM.17**	Default	0
	Range	0 to 255
	Access	RW

This is the least significant octet of the SM-EtherCAT EoE Subnet mask.

6.4.3 EoE Default gateway

The SM-EtherCAT EoE Default gateway is defined in the EtherCAT Master and is displayed in the module parameters as shown in Figure 6-3.

Figure 6-3 EoE Default gateway

| SM-EtherCAT EoE Default gateway	W$_{gateway}$	X$_{gateway}$	Y$_{gateway}$	Z$_{gateway}$
	Pr **MM.18**	Pr **MM.19**	Pr **MM.20**	Pr **MM.21**

NOTE	The default gateway is a routing device that allows a host to reach other devices that are not on the same subnet. The default gateway must be on the same subnet as the host that is trying to use it.

Table 6.31 EoE - Default gateway W$_{gateway}$

EoE - Default gateway W$_{gateway}$		
Pr **MM.18**	Default	0
	Range	0 to 255
	Access	RW

This is the most significant octet of the SM-EtherCAT EoE Default gateway.

Table 6.32 Default gateway X$_{gateway}$

EoE - Default gateway X$_{gateway}$		
Pr **MM.19**	Default	0
	Range	0 to 255
	Access	RW

This is the second most significant octet of the SM-EtherCAT EoE Default gateway.

Table 6.33 Default gateway Y$_{gateway}$

EoE - Default gateway Y$_{gateway}$		
Pr **MM.20**	Default	0
	Range	0 to 255
	Access	RW

This is the third most significant octet of the SM-EtherCAT EoE Default gateway.

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Table 6.34 Default gateway Z$_{gateway}$

EoE - Default gateway Z$_{gateway}$		
Pr **MM.21**	Default	0
	Range	0 to 255
	Access	RW

This is the least significant octet of the SM-EtherCAT EoE Default gateway.

NOTE Although parameters Pr **MM.10** - Pr **MM.21** have RW access, changing them via the parameters will have no affect to the EoE settings. The EoE configuration for the SM-EtherCAT module can only be done with an EtherCAT master which supports the EoE protocol (e.g. TwinCAT). The settings for Pr **MM.10** - Pr **MM.21** will need to be set by the Master and these parameters are for display purposes only.

6.4.4   SM-EtherCAT reduce serial interface priority

Table 6.35 Reduce Drive serial interface priority

Reduce Drive serial interface priority		
Pr **MM.37**	Default	OFF
	Range	OFF - ON
	Access	RW

It is not possible for the both the Drive and the SM-EtherCAT module to support all of the available serial communication protocols simultaneously. This means that the user must decide if they wish the drive to provide the primary communication interface via its serial RJ45 connector, or the SM-EtherCAT module. In the default state the primary interface will be provided by the drive.

Pr **MM.37** = OFF (default):

It will not be possible to forward on messages that are intended for either the drive or another option module. The SM-EtherCAT module will be able to handle two types of messages:

1. Those that access Drive parameters
2. Those that access SM-Applications parameters.

Pr **MM.37** = ON:

The SM-EtherCAT module will request that the drive permits it to become the primary communication interface. If the drive is able to transfer control then the following restrictions will be imposed:

1. The drives serial interface will only be able to handle messages that are 32 bytes or less. A Remote LCD keypad would continue to work, although SM-Application parameters would not be visible. If a message is received that is too long for the drive to handle, no reply will be sent.
2. Any LCD keypad fitted (not remotely mounted) to the drive will stop working.

NOTE Pr **MM.37** must be set to ON to achieve EoE communications.

NOTE Pr **MM.37** only needs to be considered when used with a Unidrive SP, Digitax ST, Mentor MP of Affinity. It has no use when used with a Commander SK.

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7 Drive profile (DSP-402) support

SM-EtherCAT supports the following modes of the DSP-402 profile:

- Cyclic sync position mode
- Interpolated position mode
- vl velocity mode
- Profile torque mode
- Homing mode

7.1 0x6040 Controlword

This provides the primary method of controlling the behavior of the drive e.g. enabling, disabling, resetting, etc. Table 7.1 describes the format of the control word. The individual bits are used in combinations (see Table 7.2) to sequence the drive through the state machine described in Figure 7-1.

Table 7.1 Controlword

0x6040			Controlword												
Access: RW				Range: 0 to 65535				Size: Unsigned 16				Unit: N/A			
Default:		N/A													
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
0x6040	*controlword*
0x6041	*statusword*
0x605B	*shutdown_option_code*
0x605C	*disable_operation_option_code*
0x605A	*quick_stop_option_code*
0x605D	*halt_option_code*
0x605E	*fault_reaction_option_code*
0x6060	*modes_of_operation*
0x6061	*modes_of_operation_display*
0x6085	*quick_stop_deceleration*

The behavior of the sequencing control is shown in Figure 7-1 *CoE state machine diagram* . 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 SM-EtherCAT master device must be in the operational state before the state machine can move from the 'SWITCH ON DISABLED' state to the 'READY TO SWITCH ON' state. If the master leaves the operational state while the state machine is in the 'SWITCH ON', 'OPERATION ENABLE' , 'QUICK STOP ACTIVE' or 'READY TO SWITCH ON' state then the option will transition to the 'SWITCH ON DISABLED' state. This implies that the drive will be inhibited and the motor will coast.

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Figure 7-1 CoE state machine diagram
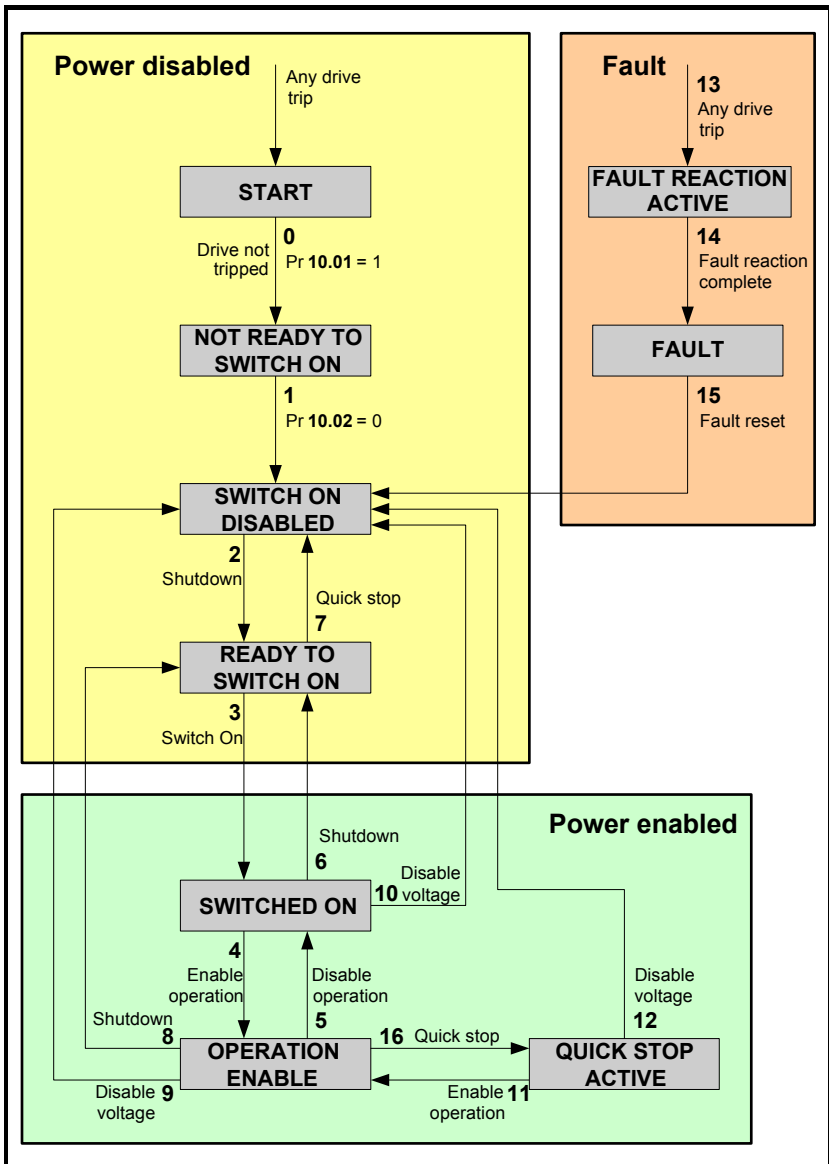
NOTE On the Digitax ST, Unidrive SP, Affinity and Mentor MP with the default drive parameters the 'Switched on' state will correspond to a drive status of 'STOP'. If the STOP state is not acceptable for any SM-EtherCAT applications that do not use the menu 12 brake controller, Pr **6.08** will have to be set to OFF. With Pr **6.08** set to OFF the 'Switched on' state will now correspond to a drive status of 'Rdy'.

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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When the SM-EtherCAT module transitions from the EtherCAT Safe-operational state to the EtherCAT Operational state, a number of drive parameters are set to allow the CoE profiles to control the drive and motor. These parameters are set in the following order:

- Pr **6.42** to 0
- Pr **6.43** to On (1)
- Pr **3.22** to 0 (where present)
- Pr **3.23** to On (1) (where present)
- Pr **3.13** to OFF (0) (In open-loop operating modes)
- Pr **2.10** to 1
- Pr **2.20** to 1
- Pr **2.02** to On (1)
- Pr **1.04** to 0
- Pr **1.21** to 0
- Pr **1.38** to 0
- Pr **1.08** to OFF (0)
- Pr **1.10** to On (1)
- Pr **1.09** to OFF (0)
- Pr **1.15** to 1
- Pr **1.14** to 3

These values are set once and not continuously forced. They are not reset when leaving the Operational state. In addition, the option starts to write parameters implicitly mapped by the CoE profiles, when moving to the Operational state.

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 *CoE state machine transition and events* on page 41 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

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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

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 deceleration

Table 7.20 Profile deceleration

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

Table 7.22 Supported profile units

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

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

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

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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:

gear ratio = motor shaft revolutions / driving shaft revolutions

Table 7.24 Gear_ratio

0x6091	Gear_ratio		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		
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:

feed constant = feed / driving shaft revolutions

Table 7.25 Feed_constant

0x6092	Feed_constant		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	2		
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 SP in servo mode, closed-loop vector mode and RFC mode. It works on the Digitax ST and Mentor MP but is not supported in open-loop or regen mode on any of the drives. It is also not available on Commander SK or Affinity. The position control described here is used under the interpolated position mode of operation. Table 7.26 lists the objects that are supported:

Table 7.26 Basic position control supported objects

Index	Name
0x6062	*position_demand_value*
0x6064	*position_actual_value*
0x6065	*following_error_window*
0x6067	*position_window*
0x6080	*max motor speed*
0x60F4	*following_error_actual_value*
0x60FB	*position_control_parameter_set*

7.3.15 0x6062 Position_demand_value

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

Table 7.27 Position_demand_value

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

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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.		

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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 SP in servo mode, closed-loop vector mode and RFC mode. This mode also operates on the Digitax ST and Mentor MP. Table 7.32 lists the objects that are supported:

Table 7.32 Supported Interpolated position mode objects

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

NOTE When using one of the DSP-402 positioning modes, Distributed Clocks must be enabled. Failure to do so may result in the SM-EtherCAT module going into the SAFE-OPERATIONAL state (Pr **MM.04** = 4).

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 250µs. 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 250µs, 500µs 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 1µs)			
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 1µs, and the longest to be 1s.			

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 SP, Digitax ST, Affinity, Mentor MP and Commander SK. It is not, however, supported in regen modes.

When the drive is in either of the closed-loop or servo 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	*vl_target_velocity*
0x6043	*vl_velocity_demand*
0x6044	*vl_velocity_actual_value*
0x6046	*vl_velocity_min_max_amount*
0x6047	*vl_velocity_min_max*
0x6048	*vl_velocity_accleration*
0x6049	*vl_velocity_deceleration*
0x604A	*vl_velocity_quick_stop*
0x604B	*vl_setpoint_factor*
0x604C	*vl_dimension_factor*

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 *vl_velocity_min* positive and *vl_velocity_min* negative.		
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	2147483647		
Description:	Used to configure the maximum velocity (both in the forward and reverse direction) that the system can operate at. Writing to this sub index will overwrite *vl_velocity_max* positive and *vl_velocity_max* negative.		

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7.5.5   0x6047 vl_velocity_min_max

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 7.42 0x6047 vl_velocity_min_max

0x6047	vl_velocity_min_max		
Sub-index 0			
Access: RO	Range: N/A	Size: Unsigned 8	Unit: N/A
Default:	4		
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 positive velocity at which the system can operate.		
Sub-index 2			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	2147483647		
Description:	Used to configure the maximum positive velocity at which the system can operate.		
Sub-index 3			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	0		
Description:	Used to configure the minimum negative velocity at which the system can operate.		
Sub-index 4			
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: rpm
Default:	2147483647		
Description:	Used to configure the maximum negative velocity at which the system can operate.		

7.5.6   0x6048 vl_velocity_acceleration

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

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

vl_velocity_acceleration = delta speed / delta time

Table 7.43 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 *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default:	2		
Description:	The value of delta time is given in seconds.		

7.5.7 0x6049 vl_velocity_deceleration

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

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

vl_velocity_deceleration = delta speed / delta time

Table 7.44 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 *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default:	2		
Description:	The value of delta time is given in seconds.		

7.5.8 0x604A vl_velocity_quick_stop

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

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

vl velocity deceleration = delta speed / delta time

Table 7.45 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 *vl_dimension_factor* and the *vl_setpoint_factor* have the value 1, otherwise the value is in user units.		
Sub-index 2			
Access: RW	Range: 0 to 65535	Size: Unsigned 16	Unit: s
Default:	2		
Description:	The value of delta time is given in seconds.		

7.5.9 0x604B vl_setpoint_factor

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

Table 7.46 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:	*vl_setpoint_factor* numerator (a value of 0 is not valid).		
Sub-index 2			
Access: RW	Range: -32768 to +32767	Size: Signed 16	Unit: N/A
Default:	1		
Description:	*vl_setpoint_factor* denominator (a value of 0 is not valid).		

7.5.10 0x604C vl_dimension_factor

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

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

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

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Table 7.47 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 **1.21**).

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 **2.01** (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 **5.04** (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 **2.21**), the *vl_velocity_deceleration* object is updated.

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7.6 Profile torque mode

The profile torque mode is supported on Unidrive SP, Digitax ST, Affinity, Mentor MP and Commander SK. It is possible to use this profile in regen mode on the Unidrive SP. On the Unidrive SP and Digitax ST in closed-loop or servo mode, this mode operates on the profile cycle time, using the drives internal torque shortcut (which is read by the drive every 250µs). On the Commander SK, Unidrive SP and Affinity in open-loop mode, the torque reference is written to the drive user torque parameter, which is handled every 4ms. When using profile torque mode object 0x604A *vl_velocity_quick_stop* will be used in the event of a quick stop (also for quick stop option codes 2 and 6 the 0x6049 *vl_velocity_deceleration* object will be used). Table 7.48 shows the objects that are supported:

Table 7.48 Profile torque mode supported objects

Index	Name
0x6071	*Target_torque*
0x6075	*Motor_rated_current*
0x6078	*Current_actual_value*
0x6087	*Torque_slope*

7.6.1 0x6071 Target_torque

This object indicates the configured input value for the torque controller in profile torque mode. The value of this object is given per thousand of rated torque.

Table 7.49 0x6071 Target_torque

0x6071	Target_torque		
Access: RW	Range: -32768 to +32767	Size: Signed 16	Unit: 0.1% of rated torque
Default:	0		
Description:	Indicates the configured input value for the torque controller in profile torque mode.		

7.6.2 0x6075 Motor_rated_current

This object indicates the configured motor rated current. It is taken from the motor's name-plate. Depending on the motor and drive technology this current is DC, peak or rms (root-mean-square) current. All relative current data refers to this value. The value of this object is given in mA.

Table 7.50 0x6075 Motor_rated_current

0x6075	Motor_rated_current		
Access: RO	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: mA
Default:	0		
Description:	Indicates the configured motor rated current (Pr **5.07**).		

7.6.3   0x6078 Current_actual_value

This object provides the actual value of the current. It shall correspond to the current in the motor. The value of this object is given per thousand of rated current.

Table 7.51 0x6078 Current_actual_value

0x6078	Current_actual_value		
Access: RO	Range: -32768 to +32767	Size: Signed 16	Unit: 0.1% of rated current
Default:	0		
Description:	Provides the actual value of the current.		

7.6.4   0x6087 Torque_slope

This object indicates the configured rate of change of torque. The value of this object is given in units of per thousand of rated torque per second.

Table 7.52 Torque_slope

| 0x6087	Torque_slope		
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Unsigned 32	Unit: 0.1% of rated torque per second
Default:	0		
Description:	Indicates the configured rate of change of torque.		

7.7   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
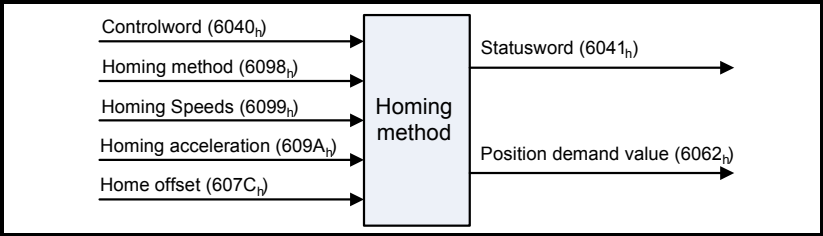
By choosing a homing method the following behavior is determined: The homing signal (positive limit switch, negative limit switch, home switch), the direction of actuation and where appropriate the position of the index pulse.

An encircled number in Figures 7-3 to 7-10 indicates the code for selection of this homing position. The direction of movement is also indicated.

There are four sources of homing signal available: These are the negative and positive limit switches, the home switch and the index pulse from an encoder.

In the diagrams of homing sequences in Figure 7-3, the encoder count increases as the axis's position moves to the right, in other words the left is the minimum position and the right is the maximum position.

There are two digital inputs on the front of the SM-EtherCAT module that can be used in Homing Mode, more information is given in the following section.

7.7.1 General homing definitions

Method 1: Homing on negative limit switch and index pulse

Using this method as shown in Figure 7-3 *Homing on negative limit switch and index pulse* on page 59, the initial direction of movement shall be leftward if the negative limit switch is inactive (here: low). The home position shall be at the first index pulse to the right of the position where the negative limit switch becomes inactive.

Figure 7-3 Homing on negative limit switch and index pulse
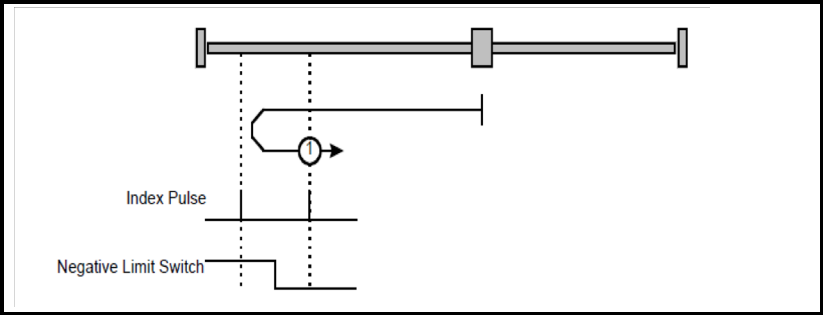
Method 2: Homing on positive limit switch and index pulse

Using this method as shown in Figure 7-4 *Homing on positive limit switch and index pulse* on page 59, the initial direction of movement shall be rightward if the positive limit switch is inactive (here: low). The position of home shall be at the first index pulse to the left of the position where the positive limit switch becomes inactive.

Figure 7-4 Homing on positive limit switch and index pulse

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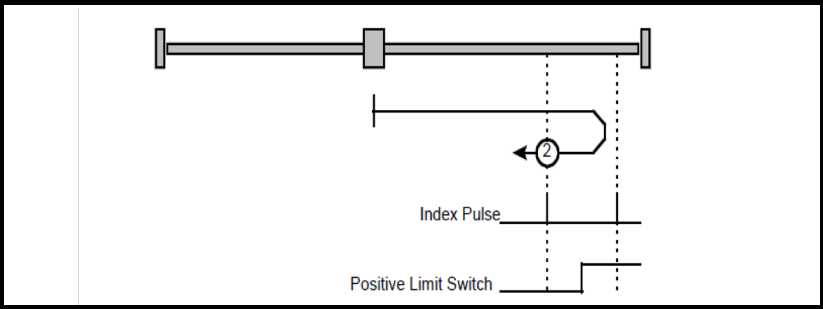
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Method 3 and 4: Homing on positive home switch and index pulse

Using these methods as shown in Figure 7-5 *Homing on positive home switch and index pulse* on page 60, 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.
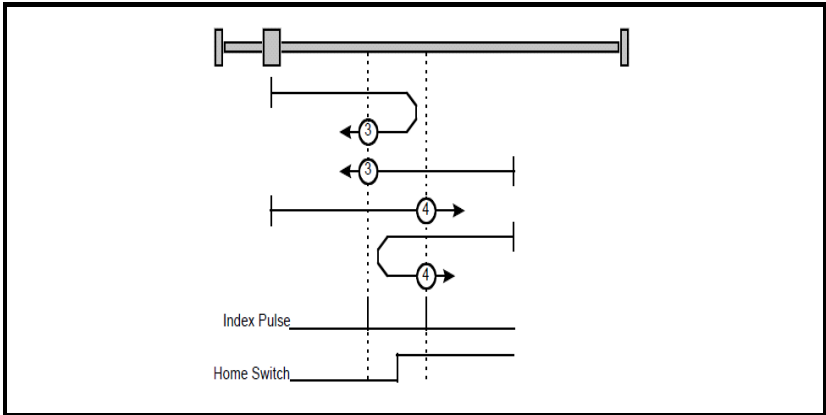
Figure 7-5 Homing on positive home switch and index pulse

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

Using these methods as shown in Figure 7-6 *Homing on negative home switch and index pulse* on page 60, 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.
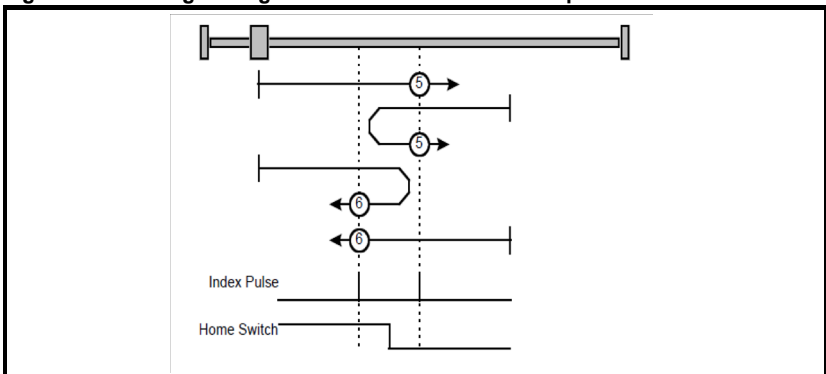
Figure 7-6 Homing on negative home switch and index pulse

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 7-7 *Homing on home switch and index pulse - positive initial motion* on page 61 and Figure 7-8 *Homing on home switch and index pulse - negative initial motion* on page 62. If the initial direction of movement leads away from the home switch, the drive shall reverse on encountering the relevant limit switch.

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

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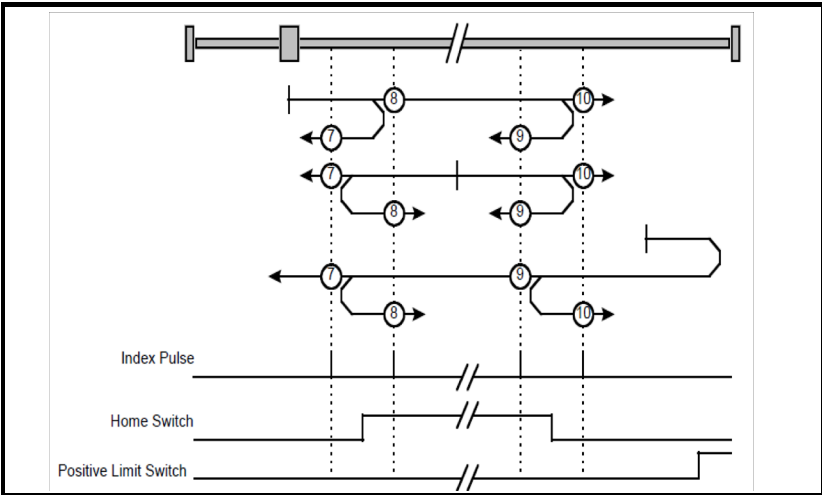
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Figure 7-8 Homing on home switch and index pulse - negative initial motion
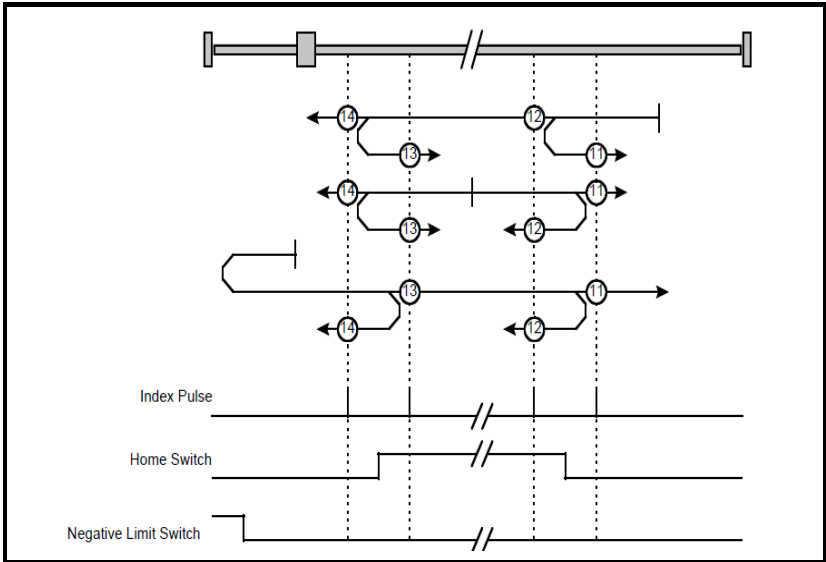
Method 15 and 16: Reserved

These methods are reserved.

Method 17 to 30: Homing without index pulse

These methods are similar to methods 1 to 14 except that the home position is not dependent on the index pulse but only dependent on the relevant home or limit switch transitions. For example methods 19 and 20 are similar to methods 3 and 4 as shown in Figure 7-9 *Homing on positive home switch* on page 62.

Figure 7-9 Homing on positive home switch
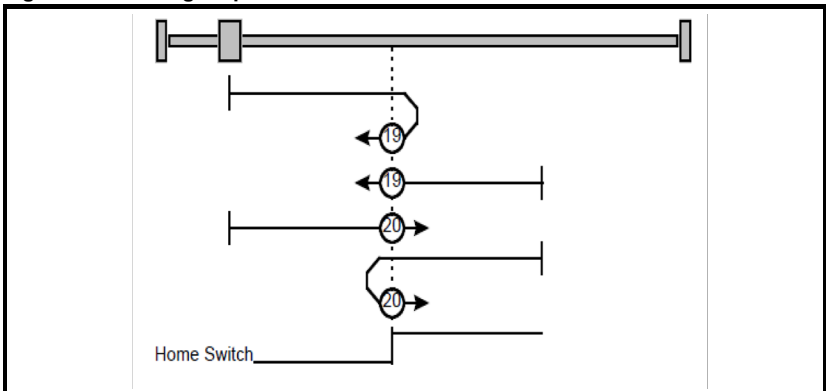
Method 31 and 32: Reserved

These methods are reserved.

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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 7-10.

Figure 7-10 Homing on index pulse
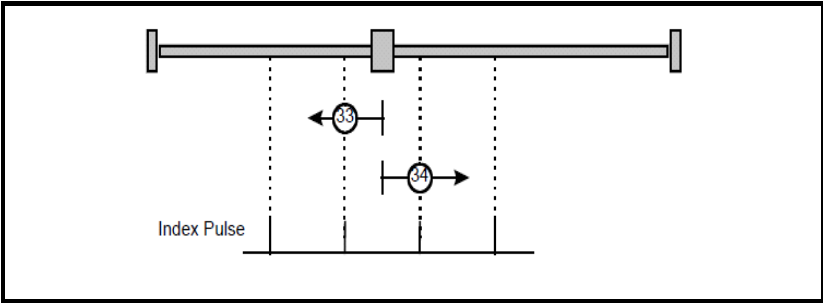
Method 35: Homing on index pulse

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 7.53 *Definition of bits 4 and 8 of the controlword* on page 63 defines the values for bits 4 and 8 of the controlword.

Table 7.53 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 7.54 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.

7.7.2 Homing mode object definitions

0x2803 Homing source

This object indicates the configured source of the homing switch used during the homing procedure. Table 7.55 *Homing source* on page 64 specifies the object description.

Table 7.55 Homing source

0x2803	Homing source		
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: 1 to 8	Size: Unsigned 8	Unit: N/A
Default: 5			

Description: The source of the homing switch. This will specify a digital input as follows:
        1 to 6 - The number of a drive digital input
        7 to 8 - SM-EtherCAT option module digital input 0 or 1			

Sub-index 2			
Access: RW	Range: 0 to 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Use the feedback source freeze for homing. This will cause the freeze from the selected feedback device to be used instead of the index (marker) pulse when it is required during homing.			

0x2804 Freeze object

This object is used to configure the freeze function that can be used within the Homing mode profile. Table 7.56 *Freeze object* on page 64 specifies the object description.

Table 7.56 Freeze object

0x2804	Freeze object		
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 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Route the option freeze onto the drive. Setting a value of 1 here will route the option digital input 0 onto the drive freeze line.			
Sub-index 2			
Access: RW	Range: 0 to 1	Size: Unsigned 8	Unit: N/A
Default: 0			
Description: Option to drive freeze invert. Setting a value of 1 will invert the freeze signal routed onto the drive from the option input 0 (if 0x2804, sub-index 1 is set to 1). This value will be read only on a transition from 0 to 1 in sub-index 1.			

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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 7-11 *Home offset definition* on page 65. The value of this object shall be given in user-defined position units. Negative values indicate the opposite direction.

Figure 7-11 Home offset definition
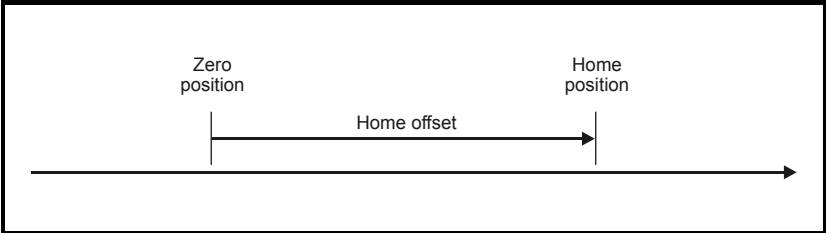
Table 7.57 Home offset

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 7.58 *Homing method* on page 65 specifies the object description, and Table 7.59 *Homing method values* on page 65 specifies the value ranges for this object.

Table 7.58 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 7.59 Homing method values

Value	Definition
0	No homing method assigned
1	Method 1 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 7.60 *Homing speeds* on page 66 specifies the object description.

Table 7.60 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 7.61 *Homing acceleration* on page 66 specifies the object description.

Table 7.61 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.		

7.8   Cyclic sync position mode

Cyclic sync position mode is supported on the Unidrive SP in servo mode, closed-loop vector mode and RFC mode. It is also supported on the Digitax ST Servo and Mentor MP drives. It is not supported on a Unidrive SP in open-loop or regen mode. It is also not supported on a Commander SK or an Affinity.

Table 7.62 Cyclic sync position mode

Index	Name
0x6077	torque_actual_value
0x607A	target_position
0x60B1	velocity_offset
0x60C2	interpolation_time_period

NOTE	When using one of the DSP-402 positioning modes, Distributed Clocks must be enabled. Failure to do so may result in the SM-EtherCAT module going into the SAFE-OPERATIONAL state (Pr **MM.04** = 4).

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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.

7.8.1 0x6077 Torque_actual_value

This object provides the actual value of the torque. It shall correspond to the instantaneous torque in the motor. The value is given per thousand of rated torque.

Table 7.63 Torque actual value

0x6077	Torque actual value		
Access: RO	Range: -32768 to +32767	Size: Signed 16	Unit: 0.1% of rated torque
Default:	0		
Description:	Provides the actual value of the torque.		

7.8.2 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 7.64 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.		

7.8.3 0x60B1 Velocity offset

This object provides the offset for the velocity value. The offset is given in user defined velocity units. In cyclic synchronous position mode this object contains the input value for velocity feed forward.

Table 7.65 Velocity offset

0x60B1	Velocity offset		
Access: RW	Range: 0 to 0xFFFFFFFF	Size: Signed 32	Unit: User-defined velocity units
Default:	0		
Description:	Provides the offset for the velocity value.		

8 Advanced features

8.1 Distributed Clocks

SM-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 SP or Digitax ST), 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 250µs.

8.1.1 Time synchronization support

When the option module is connected to a drive which can take a time synchronization signal (e.g. a Unidrive SP or Digitax ST), 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.

The time between edges of the drive synchronization square wave (referred to as the drive synchronization interval) will be an integer multiple of 250µs (up to a maximum value of 15ms).

The position controller will be executed at the interval defined in the Distributed Clock settings, if Distributed Clocks is disabled the controller will execute each 250µs. When the profile torque or velocity control mode is used with Distributed Clocks enabled, a new profile cycle will be started every sync interval in the control loop cycle starting at the sync signal edge as shown in Figure 8-1. This will be referred to as a profile cycle. When Distributed Clocks are not enabled, a new profile cycle will be started every 250µs.

Figure 8-1 Profile Cycle Timing

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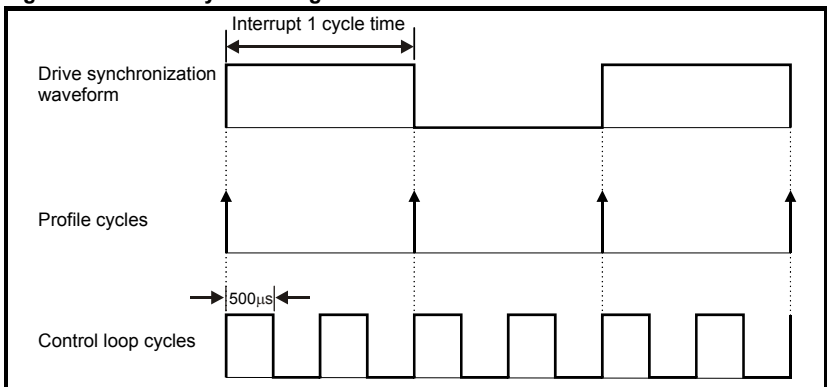
It is expected that most systems will have the interpolation cycle time equal to the drive synchronization interval. An interpolation cycle is referred to as a profile cycle. The interoperation between a profile cycle when interpolation position mode is being used and the drive synchronization interval is described as follows:

1. Interpolation cycle time = drive synchronization interval. In this case, each new interpolation cycle will be synchronized to the drive synchronization interval. Interpolation will be performed in each of the subsequent control loop cycles until the next sync signal edge.

Command and feedback values which are handled cyclically will be read at defined times in the cycle. Command values handled/used every cycle (profile or control loop) will be cached from the object dictionary in the 90μs period at the beginning of that cycle.

Any feedback values read during a cycle will be scaled as appropriate in that cycle, cached, and then written during the 90μs period at the beginning of the next cycle. 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 profile cycle.

PDO data will be copied to and from the object dictionary (from and to the sync manager memory areas) in the 90μs period at the beginning of every profile cycle. PDO data mapped to drive parameters (but not SM-Applications PLC parameters or other parameters accessed using Inter-Option Communications), will be written to those parameters in the 90μs period at the beginning of every control loop cycle.

8.2   SM-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)
- Ethernet over EtherCAT (EoE)
- CMP protocol through Modbus RTU (only on the Unidrive SP, Digitax ST, Mentor MP and Affinity)

8.3   Menu 61 - General Module Setup

8.3.1   Parameter 1.00 shortcut

Table 8.1 Parameter 1.00 shortcut

Parameter 1.00 shortcut		
Pr **61.01**	Default	0
	Range	0 to 32767
	Access	RW

This Parameter can be used as a shortcut to Pr **1.00** as DSP-402 objects do not permit access to parameter zero.

8.3.2 Drive synchronization control

Table 8.2 Drive synchronization control

Drive synchronization control		
Pr **61.03**	Default	1
	Range	0 to 2
	Access	RW

Table 8.3 synchronization control values

Value	Description
0	Independent. Module should not try to become synchronization master to the drive.
1	Master with sync. Module should try to become synchronization master to the drive only when fieldbus specific synchronization has been achieved.
2	Master always. Module should always try to become synchronization master to the drive.

8.3.3 Inter-option module synchronization control

Table 8.4 Inter-option module synchronization control

Inter-option module synchronization control		
Pr **61.04**	Default	1
	Range	0 to 2
	Access	RW

Table 8.5 Inter-option module synchronization control values

Value	Description
0	Independent. Module should not try to become synchronization master to other modules.
1	Master with sync. Module should try to become synchronization master to other modules only when fieldbus specific synchronization has been achieved.
2	Master always. Module should always try to become synchronization master to other modules.

8.3.4 Inter-option clock synchronization control

Table 8.6 Inter-option clock synchronization control

Inter-option clock synchronization control		
Pr **61.05**	Default	0
	Range	0 to 2
	Access	RW

This parameter provides control of the inter-option module clock synchronization mechanism.

Table 8.7 Inter-option clock synchronization control values

Value	Description
0	Independent. Module should not try to be come synchronization master to clocks in other modules.
1	Master. Module should try to become synchronization master to clocks in other modules.
2	Slave. Module should become a synchronization slave to clocks in another module.

8.3.5 Option slot indicator

Table 8.8 Option slot indicator

Option slot indicator		
Pr **61.07**	Default	0
	Range	0 to 3
	Access	RO

The parameter displays the number of the option slot on the drive that the SM-EtherCAT module is connected to. The values for the slots are 1, 2 and 3.

8.3.6 Option hardware issue

Table 8.9 Option hardware issue

Option hardware issue		
Pr **61.40**	Default	0
	Range	0 to 255
	Access	RO

The parameter displays the hardware revision number of the module.

8.3.7 500ms Task % free

Table 8.10 500ms Task % free

500ms Task % free		
Pr **61.42**	Default	0
	Range	0 to 100
	Access	RO

This parameter indicates what percentage of the 500ms system task is unused and still available.

8.3.8 External memory % free

Table 8.11 External memory % free.

External memory % free		
Pr **61.43**	Default	0
	Range	0 to 100
	Access	RO

This parameter indicates what percentage of the external memory is unused and still available.

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8.3.9 Internal memory % free

Table 8.12 Internal memory % free

Internal memory % free		
Pr **61.44**	Default	0
	Range	0 to 100
	Access	RO

This parameter indicates what percentage of the internal memory is unused and still available.

8.3.10 Option module error sub-code

Table 8.13 Option module error sub-code

Option module error sub-code		
Pr **61.49**	Default	0
	Range	0 to 255
	Access	RO

This parameter provides more detailed information of the cause of the current SM-EtherCAT slot error.

8.3.11 Bootloader software version

Table 8.14 Bootloader software version

Bootloader software version (XX.YY)		
Pr **61.50**	Default	0
	Range	0 to 9999
	Access	RO

8.3.12 Bootloader software sub-version

Table 8.15 Bootloader software sub-version

Bootloader software subversion (ZZ)		
Pr **61.51**	Default	0
	Range	0 to 99
	Access	RO

These parameters provide the XX.YY and ZZ parts of the bootloader firmware version number while the main application is running.

8.4 Advanced cyclic data configuration

This configuration will allow the behavior of the cyclic data handling to be modified; specifically, it will allow the tasks in which cyclic data is handled to be changed.

Table 8.16 Out cyclic data configuration

0x2820	Out cyclic data configuration			
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 2	**Size**: Unsigned 8	**Unit**: ms	
Default: 0				
Description: High priority cyclic data task; selects the task in which high priority out (master to slave) cyclic data is copied between the intermediate buffer and the mapped objects, parameters, etc. 0 – Critical task (**default**). This is the first 90μs of the critical task. 1 – Critical+90 task. This is the task that commences 90μs after the critical task start, and finishes before the next critical task. 2 – Sync Manager task. This is the AL event task which occurs upon a sync manager access.				
Sub-index 2				
Access: RW	**Range**: 0 to 2	**Size**: Unsigned 8	**Unit**: N/A	
Default: 2				
Description: Intermediate buffer copy task. Selects the task in which the high priority out (master to slave) cyclic data is copied into the intermediate buffer. 0 – Critical task. This is the first 90μs of the critical task. 1 – Critical+90 task. This is the task that commences 90μs after the critical task start, and finishes before the next critical task. 2 – Sync Manager task (**default**). This is the AL event task which occurs upon a sync manager access.				

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Table 8.17 In cyclic data configuration

0x2821	In cyclic data configuration						
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 2	Size:	Unsigned 8	Unit:	ms
Default:	1						
Description:	High priority cyclic data task; selects the task in which high priority in (slave to master) cyclic data is copied between the intermediate buffer and the mapped objects, parameters, etc. 0 – Critical task. This is the default task. This is the first 90µs of the critical task. 1_Critical+90 task (**Default**). This is the task that commences 90µs after the critical task start, and finishes before the next critical task. 2 – Sync Manager task (default). This is the AL event task which occurs upon a sync manager access.						
Sub-index 2							
Access:	RW	Range:	0 to 2	Size:	Unsigned 8	Unit:	N/A
Default:	1						
Description:	Intermediate buffer copy task. Selects the task in which the high priority in (slave to master) cyclic data is copied into the intermediate buffer. 0 – Critical task. This is the first 90µs of the critical task. 1_Critical+90 task (**Default**). This is the task that commences 90µs after the critical task start, and finishes before the next critical task. 2 – Sync Manager task (default). This is the AL event task which occurs upon a sync manager access.						

8.5   Internal shortcuts

Internal shortcuts are provided for very fast operation. It is not possible to read the values non-cyclically; they can only be accessed at certain parts of the cycle in order to read and write correct values.

Table 8.18 Internal position feedback shortcut

0x2830	Internal position feedback shortcut					
Sub-index 0						
Access:	RO	Range:	-2^{31} to $+2^{31}$-1	Size:	Signed 32	Unit:	Counts
Default:	0					
Description:	This value is the *drive* feedback source. It consists of the coarse position in the most significant 16 bits and the fine position in the least significant 16 bits. It will then have a number of turns bits shifted into the most significant bits ("pushing" as many fine position bits as required out). This should not be read in the first 90µs after the RMINT edge, because data skew may result.					

Table 8.19 Internal torque shortcut

0x2831	Internal torque shortcut					
Sub-index 0						
Access:	RW	Range:	N/A	Size:	Signed 16	Unit:	0.01% rated torque
Default:	0					
Description:	This represents the drive internal torque shortcut, scaled to 0.01% units.					

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9 Diagnostics

9.1 Module identification parameters

The basic menu parameters can be accessed through the slot menu in the drive, Pr **MM.PP,** where **MM** is the menu for SM-EtherCAT in the host drive. The basic menu parameters may also be accessed using menu 60, i.e. Pr **60.PP**.

9.1.1 SM-EtherCAT module ID code

Table 9.1 SM-EtherCAT module ID code

SM-EtherCAT module ID code		
Pr **MM.01**	Default	421 (SM-EtherCAT)
	Range	-
	Access	RO

The module ID code indicates the type of module installed in the slot corresponding to menu **MM**. This is useful for checking the module is of the correct type.

9.1.2 SM-EtherCAT firmware version

Table 9.2 SM-EtherCAT firmware version - (major and minor)

SM-EtherCAT firmware version - (major and minor) (xx.yy)		
Pr **MM.02**	Default	N/A
	Range	00.00 to 99.99
	Access	RO

Table 9.3 SM-EtherCAT firmware version - (subversion)

SM-EtherCAT firmware version (subversion) (zz)		
Pr **MM.51**	Default	N/A
	Range	0 to 99
	Access	RO

Unidrive SP (Sizes 1 to 6) / Unidrive SPM / Mentor MP
The software version of the Solutions Modules can be identified by looking at Pr **15.02** or Pr **16.02** or Pr **17.02** and Pr **15.51** or Pr **16.51** or Pr **17.51**.

Menu 15,16 or 17 is Solutions Module slot dependent with menu 17 being the lowest position nearest the control terminal connections.

The software version takes the form of xx.yy.zz, where Pr **15.02** or Pr **16.02** or Pr **17.02** displays xx.yy and Pr **15.51** or Pr **16.51** or Pr **17.51** displays zz (e.g. for software version 01.01.00 on a module in the middle Solutions Module slot, Pr **16.02** will display 1.01 and Pr **16.51** will display 0).

Unidrive SP (Size 0) / Digitax ST / Unidrive ES / Affinity
The software version of the Solutions Modules can be identified by looking at Pr **15.02** or Pr **16.02** and Pr **15.51** or Pr **16.51**.

Menu 15 or 16 is Solutions Module slot dependent with menu 15 (Unidrive SP size 0 and Digitax ST) or menu 16 (Unidrive ES and Affinity) being the position nearest the control terminal connections.

The software version takes the form of xx.yy.zz, where Pr **15.02** or Pr **16.02** displays xx.yy and Pr **15.51** or Pr **16.51** displays zz (e.g. for software version 01.01.00 on a module in the middle Solutions Module slot (Unidrive ES and Affinity) or for Unidrive SP size 0 and Digitax ST, the Solutions Module slot nearest the incoming supply terminals, Pr **16.02** will display 1.01 and Pr **16.51** will display 0).

Commander SK (Sizes B to D and 2 to 6)
The software version of the Solutions Module can be identified by looking at Pr **15.02** and Pr **15.51**. The software version takes the form of xx.yy.zz, where Pr **15.02** displays xx.yy and Pr **15.51** displays zz (e.g. for software version 01.01.00 Pr **15.02** will display 1.01 and Pr **15.51** will display 0).

The full version of the SM-EtherCAT firmware can be assembled by combining the major version (xx.yy) and the minor version (zz) as follows: xx.yy.zz.

9.2   Network configuration objects

9.2.1   SM-EtherCAT network loss trip

Table 9.4 Network loss behavior object

0x2813	Network loss behavior		
Sub-index 0:			
Access: RO	Range: N/A	Size: 1 byte	Unit: N/A
Default:	2		
Description:	The number of sub-indices in this object.		
Sub-index 1: Maximum time interval			
Access: RW	Range: 0 to 65535	Size: 2 bytes	Unit: ms
Default:	0 (by default the network loss behavior is disabled).		
Description:	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 network loss handling. If a value of zero is set, no network loss handling will occur.		
Sub-index 2: Trip type			
Access: RW	Range: 0 to 2	Size: 1 byte	Unit: N/A
Default:	0		
Description:	Network loss trip type. If this value is set to 0, a network loss trip will never occur; however, a network loss will still be handled by stopping the drive and indicating a warning as previously described. If this value is set to 1, the network loss trip will occur only after the motor has been stopped according to the Fault reaction option code. If the value is set to 2, the network loss trip will occur immediately on network loss (this implies that the motor will coast).		

SM-EtherCAT resets an internal timer when a valid message is received from the EtherCAT network. The network loss trip is triggered when no new messages are received before the timer times out. The SM-EtherCAT will trip the drive and the SM-EtherCAT error code parameter (Pr **MM.50**) will show 120.

After power-up or reset the network loss trip is not armed until one of the following events occur:

- SYNC message is received
- RxPDO is received

Once the trip has been armed, a minimum of one of the above messages must be received or transmitted in each time period set in sub-index 2 of the Network loss behavior object (0x2813).

9.3 Diagnostic parameters

Table 9.5 SM-EtherCAT operating status

SM-EtherCAT operating status		
Pr **MM.06**	Default	N/A
	Range	-9999 to 9999
	Access	RO

9.3.1 Running states

Table 9.6 Diagnostic information - running states

Pr **MM.06**	Meaning	Description
0	Link established	A link has been established but no frames are being transmitted or received.
>0	Handled messages per second	The number of cyclic PDO messages that the active EtherCAT is handling per second.

Table 9.7 Diagnostic information - application

Pr **MM.06**	Meaning	Description
-99	Application started	The main application has been launched.
-70	Initializing file system	The file system is initializing.
-50	Initializing databases	The databases are initializing.
-30	Initializing fieldbus	The fieldbus is initializing.
-25	Starting fieldbus	The fieldbus is starting.
-1	Initialization complete	The option module has initialized correctly but no network communication is taking place. i.e. no EtherCAT frames have been transmitted or received.

Table 9.8 Diagnostic information - bootloader

Pr **MM.06**	Meaning	Description
-199	Boot loader start	The bootloader is starting up.
-180	Initializing memory	The memory manager is being initialized.
-150	Initializing file system	The file system handler is being initialized.
-149	Format file system	The file system is being formatted.
-148	Verify file system	The file system is being verified.
-130	Check boot mode	The required boot mode is being checked.
-110	Loading application	The requested application image is being copied from the file system to memory.
-101	Launching application	The application is being launched.
-100	Default mode	The bootloader has finished but no application was launched.

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9.4   Drive trip display codes

If the SM-EtherCAT detects an error during operation, it will force a trip on the drive. However, the trip code displayed on the drive will only indicate which slot initiated the trip. The exact reason for the trip will be indicated in the SM-EtherCAT error code parameter, Pr **MM.50**.

Table 9.9 shows the possible trip codes that will be displayed on the drive when a problem is detected with SM-EtherCAT or when SM-EtherCAT initiates a trip.

Table 9.9 Drive trip display codes

Trip Code	Fault	Description
SLX.HF/ SL.HF	Hardware fault	The drive has detected that a Solutions Module is present, but is unable to communicate with it. If this occurs, please contact your supplier or local Control Techniques Drive Centre.
SLX.Er/ SL.Er	Error	Error trip generated by SM-EtherCAT
SLX.nF/ SL.nF	Not installed	This trip will occur if a drive slot is configured for an option module, but no module is installed in the slot.
SLX.dF/ SL.dF	Different module installed	The slot configuration parameters stored in the drive are not valid SM-EtherCAT configuration parameters. This trip will also occur when an SM-EtherCAT is installed to a previously un-used slot.

9.5   SM-EtherCAT module temperature

Table 9.10 SM-EtherCAT module temperature

SM-EtherCAT module temperature		
Pr **MM.44**	Default	N/A
	Range	0 - 255
	Access	RO

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

9.6   SM-EtherCAT serial number

Table 9.11 SM-EtherCAT serial number

SM-EtherCAT serial number		
Pr **MM.35**	Default	N/A
	Range	0 - 16777215
	Access	RO

The serial number is loaded into the SM-EtherCAT during manufacture and cannot be changed. It contains the last eight digits of the 10-digit serial number of the label.

9.7   SM-EtherCAT error codes

Table 9.12 SM-EtherCAT error codes

SM-EtherCAT error codes		
Pr **MM.50**	Default	N/A
	Range	0 to 255
	Access	RO

If an error is detected during operation the module will force a trip on the drive and update the error code parameter (Pr **MM.50**). Table 9.13 shows the SM-EtherCAT error codes.

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Table 9.13 SM-EtherCAT error codes

Error code	Fault
1	No fieldbus mode has been selected
2	Critical task over-run
3	Invalid feedback source
4	Unknown drive type
5	Unsupported drive type
10	Invalid or missing application
62	Database Initialization error
63	File system Initialization error
64	Error initializing fieldbus stack
74	The option module has overheated
75	The drive is not responding
76	The Modbus connection has timed out
80	Inter-option communication failure
81	Inter-option communication to slot 1 timeout
82	Inter-option communication to slot 2 timeout
83	Inter-option communication to slot 3 timeout
84	Memory allocation error
85	File system error
86	Configuration file error
98	The option module background task has not been completed
99	Software fault
120	Network loss trip

9.8 Error handling

The following objects are provided to indicate an error condition

Table 9.14 Error handling objects

Index	Name
0x1001	Error_register
0x603F	Error_code

9.8.1 Error register

Table 9.15 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).			

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9.8.2 Error code

Table 9.16 Error code

0x603F	Error code		
Access: RO		Range: 0 to 0xFFFF	Size: Unsigned 16	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 9.17 Error codes below.		

Table 9.17 Error codes

Error Code	Meaning	Corresponding Drive Trip Code
0x0000	Error reset / No error	0 – No trip
0x1000	Generic error	(Any trip code not elsewhere in table)
0x2200	Internal current	109 - OIdC.P 189 – O.cL (SK Only)
0x2300	Current, device output side	3 – OI.AC 20 – It.AC 104 - OIAC.P
0x3000	Voltage	8 – PS.10V
0x3130	Phase failure	32 – PH 107 – PH.P
0x3200	Voltage inside the device	1 – UU 2 – OU 5 – PS 9 – PS.24V 108 – PS.P
0x3210	dc bus over-voltage	106 - OV.P
0x4200	Temperature device	21 – O.ht1 22 – O.ht2 23 – O.CtL 27 – O.ht3 102 – Oht4.P 105 – Oht2.P
0x5000	Device hardware	200 – SL1.HF 201 – SL1.t0 202 – SL1.Er 203 – SL1.nF 204 – SL1.dF 205 – SL2.HF 206 – SL2.t0 207 – SL2.Er 208 – SL2.nF 209 – SL2.dF 210 – SL3.HF 211 – SL3.t0 212 – SL3.Er 213 – SL3.nF 214 – SL3.dF 215 – SL.rtd 217 – HF17 218 – HF18 219 – HF19 220-232 – HF20-HF32
0x5530	Data Storage (Non-volatile data memory)	31 – EEF 36 – SAVE.Er 37 – PSAVE.Er

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0x6200	Device Software (User Software)	10 – t010 32 – t038 40 to 89 – t040 to t089 90 to 99 – UP --- / t090 to t099 101 – t101 112 to 160 – t112 to t160 168 to 174 – t168 to t174 216 – t216
0x6320	Parameter Error	199 - dESt
0x7112	Brake Chopper (Over current brake chopper)	4 – OI.br 19 – It.br 103 – OIbr.P
0x7200	Measurement Circuit	33 – rS
0x7300	Sensor	14 – tunE4 15 – tunE5 16 – tunE6 161 to 167 – Enc11 to Enc17 176 – EnP.Er 189 – Enc1 (SP Only) 190 to 198 – Enc2 to Enc10
0x7510	Communication (Serial Interface 1)	30 – SCL
0x7600	Additional Modules (Data storage)	175 – C.Prod 177 – C.boot 178 – c.bUSY 179 – C.Chg 180 – C.OPtn 181 – C.RdO 182 – C.Err 183 – C.dAt 184 – C.FULL 185 – C.Acc 186 – C.rtg 187 – C.TyP 188 – C.cPr
0x9000	External Error	6 – Et

9.9 Critical task % free

Table 9.18 SM-EtherCAT critical task % free

SM-EtherCAT critical task % free		
Pr **MM.46**	Default	N/A
	Range	0 to 100
	Access	RO

Table 9.19 Worst case critical task % free

SM-EtherCAT worst case critical task % free		
Pr **MM.47**	Default	N/A
	Range	0 to 100
	Access	RO

Parameters Pr **MM.46** and Pr **MM.47** indicate how much of the cycle time allocated to the critical task is remaining and available for other module tasks.

9.10   SDO abort codes

SDO messages use a request-response mechanism and the EtherCAT master will always expect a response from the slave device. If an error occurs with an SDO transfer SM-EtherCAT will return an SDO abort code to indicate the reason for the failure, the SDO abort codes are listed in Table 9.20.

Table 9.20 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

9.11   FLASH file system % free

Table 9.21 SM-EtherCAT FLASH file system % free

SM-EtherCAT FLASH file system % free		
Pr **MM.48**	Default	N/A
	Range	0 to 100
	Access	RO

Indicates what percentage of the flash based file system is unused and still available.

9.12 Updating SM-EtherCAT firmware

The SM-EtherCAT firmware is available from your local Control Techniques Drive Centre or supplier and can also be downloaded from CTSupport.com. To upload firmware to the SM-EtherCAT module the use of Winflasher is required, this application is also available from your local Control Techniques Drive Centre or supplier.

NOTE It is important that the filename of the SM-EtherCAT firmware application file is not altered, doing so may result in problems with the firmware upload process.

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

NOTE The minimum Winflasher firmware version with SM-EtherCAT support is V03.07.00.

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10 Quick reference

Table 10.1 and Table 10.3 list of all the SM-EtherCAT set-up objects and parameters that are required to configure the module.

Table 10.1 SM-EtherCAT objects reference

Object	Name	Description	Cross reference
0x1000	Device type	Specifies the device profile being used (DSP-402).	Section 6.3.1 on page 24
0x1018	Identity object	Contains SM-EtherCAT specific identity information.	Section 6.3.1 on page 24
0x1600	Receive PDO mapping 1	Contains the mapping information for receive PDO mapping 1.	Section 6.3.2 on page 25
0x1601	Receive PDO mapping 2	Contains the mapping information for receive PDO mapping 2.	Section 6.3.2 on page 25
0x1605	Receive PDO mapping 6	Contains the mapping information for receive PDO mapping 6.	Section 6.3.2 on page 25
0x1615	Receive PDO mapping 22	Contains the mapping information for receive PDO mapping 22.	Section 6.3.2 on page 25
0x1A00	Transmit PDO mapping 1	Contains the mapping information for transmit PDO mapping 1.	Section 6.3.3 on page 28
0x1A01	Transmit PDO mapping 2	Contains the mapping information for transmit PDO mapping 2.	Section 6.3.3 on page 28
0x1A02	Transmit PDO mapping 3	Contains the mapping information for transmit PDO mapping 3.	Section 6.3.3 on page 28
0x1A05	Transmit PDO mapping 6	Contains the mapping information for transmit PDO mapping 6.	Section 6.3.3 on page 28
0x1A15	Transmit PDO mapping 22	Contains the mapping information for transmit PDO mapping 22.	Section 6.3.3 on page 28
0x1C00	Sync manager communication type	This read-only object provides sync manager usage details.	Section 6.3.4 on page 31
0x1C10	Sync manager 0 PDO assignment	This read-only object contains information relating to the non-cyclic receive mailbox.	Section 6.3.4 on page 31
0x1C11	Sync manager 1 PDO assignment	This read-only object contains information relating to the non-cyclic send mailbox.	Section 6.3.4 on page 31
0x1C12	Sync manager 2 PDO assignment	Contains the currently in use receive PDOs.	Section 6.3.4 on page 31
0x1C13	Sync manager 3 PDO assignment	Contains the currently in use transmit PDOs.	Section 6.3.4 on page 31
0x2802	Feedback encoder source	Specifies the source position for position controller feedback.	Section 6.3.5 on page 32
0x2803	Homing source	Indicates the configured source of the homing switch used during the homing procedure.	Section 7.7.2 on page 64
0x2804	Freeze object	Used to configure the freeze function that can be used within the Homing mode profile.	Section 7.7.2 on page 64
0x2813	Network loss behavior object	Used to configure the network loss trip behavior (watchdog).	Section 9.2.1 on page 76
0x2820	Out cyclic data configuration	The number of the last sub-index in this object	Section 8.4 on page 73
0x2821	In cyclic data configuration	The number of the last sub-index in this object	Section 8.18 on page 74

Object	Name	Description	Cross reference
0x2830	Internal position feedback shortcut	This value is the *drive* feedback source. It consists of the coarse position in the most significant 16 bits and the fine position in the least significant 16 bits. It will then have a number of turns bits shifted into the most significant bits ("pushing" as many fine position bits as required out). This should not be read in the first 90μs after the RMINT edge, because data skew may result.	Section 8.18 on page 74
0x2831	Internal torque shortcut	This represents the drive internal torque shortcut scaled to 0.01% units.	Section 8.19 on page 74
0x603F	Error code	Indicates the current drive error code.	Section 9.8.2 on page 80
0x6040	Controlword	Provides the primary method of controlling the behavior of the drive.	Section 7.1 on page 37
0x6041	Statusword	This provides feedback about the current operating state of the drive.	Section 7.2 on page 38
0x6042	vl_target_velocity	Used to set the required velocity of the system.	Section 7.5.1 on page 51
0x6043	vl_velocity demand	Provides the instantaneous velocity demand generated by the drive ramp function.	Section 7.5.2 on page 51
0x6044	vl_velocity_actual value	Provides the velocity at the motor spindle or load.	Section 7.5.3 on page 52
0x6046	vl_velocity_min max_amount	This object is used to configure the minimum and maximum velocity.	Section 7.5.4 on page 52
0x6047	vl_velocity_min max	This object is used to configure the minimum and maximum velocity.	Section 7.5.5 on page 53
0x6048	vl_velocity acceleration	This object is used to configure the delta speed and delta time of the slope of the acceleration ramp.	Section 7.5.6 on page 53
0x6049	vl_velocity deceleration	This object is used to configure the delta speed and delta time of the slope of the deceleration ramp.	Section 7.5.7 on page 54
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.	Section 7.5.8 on page 54
0x604B	vl_setpoint factor	This object is used to configure the numerator and denominator of the vl_setpoint_factor.	Section 7.5.9 on page 55
0x604C	vl_dimension_ factor	This object is used to configure the numerator and denominator of the vl_dimension_factor.	Section 7.5.10 on page 55
0x605A	Quick_stop option_code	Specifies what action is performed in the event of a quick stop function	Section 7.3.2 on page 42
0x605B	Shutdown_option code	Used to control what action is performed if there is a transition from the Operation Enabled state to the Ready To Switch On state.	Section 7.3.3 on page 43
0x605C	Disable operation_optionc ode	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.	Section 7.3.4 on page 43
0x605E	Fault_reaction option_code	This object is used to control what action is performed when a fault is detected.	Section 7.3.5 on page 43
0x6060	Modes_of operation	This object is used to request a change in the mode of operation.	Section 7.3.6 on page 44
0x6061	Modes of operation display	This read only object is used to provide the active mode of operation.	Section 7.3.7 on page 44

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Object	Name	Description	Cross reference
0x6062	Position_demand value	Used to provide the currently demanded position value.	Section 7.3.15 on page 47
0x6064	Position_actual value	This read only object provides the actual value of the position feedback device.	Section 7.3.16 on page 48
0x6071	Target_torque	This object indicates the configured input value for the torque controller in profile torque mode.	Section 7.6.1 on page 57
0x6075	Motor_rated_curr ent	This object indicates the motor rated current.	Section 7.6.2 on page 57
0x6077	Torque_actual_val ue	This object provides the actual torque value	Section 7.8.1 on page 67
0x6078	Current_actual_va lue	This object provides the actual value of the current.	Section 7.6.3 on page 58
0x607A	Target_position	Indicates the command positions that the drive should move to in cyclic sync position mode.	Section 7.8.2 on page 67
0x607C	Home offset	this object indicates the configured difference between the zero position for the application and the machine home position (found during homing).	Section 7.57 on page 65
0x6080	Max motor speed	This object indicated the configured maximum allowed speed for the motor in either direction.	Section 7.29 on page 48
0x6084	Profile deceleration	Provides the deceleration ramp for the positioning modes	Section 7.3.8 on page 44
0x6085	Quick_stop deceleration	This object is used to configure the deceleration rate used to stop the motor when the quickstop function is activated and the quick stop code object (0x605A) is set to 2 or 6.	Section 7.3.8 on page 44
0x608F	Position_encoder resolution	This read only object indicates the configured encoder increments per number of motor revolutions.	Section 7.3.11 on page 46
0x6091	Gear_ratio	This object is used to apply scaling.	Section 7.3.12 on page 46
0x6092	Feed_constant	This is used to configure a feed constant.	Section 7.3.13 on page 47
0x6098	Homing Method	This object indicates the configured homing method that shall be used.	Section 7.58 on page 65
0x6099	Homing speeds	This object indicated the configured speeds used during the homing procedure.	Section 7.60 on page 66
0x609A	Homing acceleration	Indicates the configured acceleration and deceleration to be used during homing operation.	Section 7.61 on page 66
0x60B1	Velocity_offset	This object provides the value of the velocity offset.	Section 7.8.3 on page 67
0x60F4	Following_error actual_value	This read only object provides the actual value of the following error.	Section 7.3.18 on page 48
0x60FB	Position_control parameter_set object	Used to configure the positional control gains.	Section 7.3.19 on page 48
0x60C0	Interpolation sub-mode_select	Specifies the interpolation type.	Section 7.4.1 on page 49
0x60C1	Interpolation data_record	This object is used to specify the target position.	Section 7.4.2 on page 49
0x60C2	Interpolation time_period	The number of time units between interpolator re-starts.	Section 7.36 on page 50

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Table 10.2 Virtual parameter reference

Parameter	Default	Description	Cross reference
Pr **61.01**	0	Parameter 1.00 shortcut	Section 8.3.1 on page 69
Pr **61.03**	1	Drive synchronization control	Section 8.3.2 on page 70
Pr **61.04**	1	Inter-option module synchronization control	Section 8.3.3 on page 70
Pr **61.05**	0	Inter-option clock synchronization control	Section 8.3.4 on page 70
Pr **61.07**	0	Option slot indicator	Section 8.3.5 on page 71
Pr **61.40**	0	Option hardware issue	Section 8.3.6 on page 71
Pr **61.42**	0	500mS Task % free	Section 8.3.7 on page 71
Pr **61.43**	0	External memory % free	Section 8.3.8 on page 71
Pr **61.44**	0	Internal memory % free	Section 8.3.9 on page 72
Pr **61.49**	0	Option module error sub-code	Section 8.3.10 on page 72
Pr **61.50**	0	Bootloader software version - major and minor (XX.YY)	Section 8.3.11 on page 72
Pr **61.51**	0	Bootloader software version -subversion (ZZ)	Section 8.3.12 on page 72

Table 10.3 SM-EtherCAT parameter reference

Object	Description	Default	Range	Cross reference
Pr **MM.01**	SM-EtherCAT module ID code	421	- - - -	Section 9.1.1 on page 75
Pr **MM.02**	SM-EtherCAT firmware - major and minor version	N/A	00.00 to 99.99	Section 9.1.2 on page 75
Pr **MM.03**	Node address	0	0 to 65535	Section 5.4 on page 20
Pr **MM.04**	EtherCAT RUN	1	1 to 8	Section 5.5 on page 20
Pr **MM.06**	SM-EtherCAT operating status	N/A	-9999 to 9999	Section 9.3 on page 77
Pr **MM.10**	EoE - IP address W_{ip}			Section 6.23 on page 33
Pr **MM.11**	EoE - IP address X_{ip}			Section 6.24 on page 33
Pr **MM.12**	EoE - IP address Y_{ip}			Section 6.25 on page 33
Pr **MM.13**	EoE - IP address Z_{ip}			Section 6.26 on page 34
Pr **MM.14**	EoE - Subnet mask W_{subnet}			Section 6.27 on page 34
Pr **MM.15**	EoE - Subnet mask X_{subnet}	0	0 to 255	Section 6.28 on page 34
Pr **MM.16**	EoE - Subnet mask Y_{subnet}			Section 6.29 on page 34
Pr **MM.17**	EoE - Subnet mask Z_{subnet}			Section 6.30 on page 35
Pr **MM.18**	EoE - Default gateway $W_{gateway}$			Section 6.31 on page 35
Pr **MM.19**	EoE - Default gateway $X_{gateway}$			Section 6.32 on page 35
Pr **MM.20**	EoE - Default gateway $Y_{gateway}$			Section 6.33 on page 35
Pr **MM.21**	EoE - Default gateway $Z_{gateway}$			Section 6.34 on page 36
Pr **MM.32**	SM-EtherCAT re-initialize	0 (OFF)	0 (OFF) to 1 (ON)	Section 5.5 on page 20
Pr **MM.35**	SM-EtherCAT serial number	N/A	0 to 16777215	Section 9.6 on page 78
Pr **MM.37**	Reduce Drive serial interface priority	OFF	OFF - ON	Section 6.35 on page 36
Pr **MM.44**	SM-EtherCAT module temperature	N/A	0 to 255	Section 9.5 on page 78
Pr **MM.46**	Critical task % free	N/A	0 to 100	Section 9.14 on page 79
Pr **MM.47**	Worst case critical task % free	N/A	0 to 100	Section 9.19 on page 81
Pr **MM.48**	Flash file system % free	N/A	0 to 100	Section 9.11 on page 82
Pr **MM.50**	SM-EtherCAT error code	N/A	0 to 255	Section 9.7 on page 78
Pr **MM.51**	SM-EtherCAT firmware - subversion	N/A	0 to 99	Section 9.1.2 on page 75

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.

Earthing / Grounding: 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*.

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

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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