MYOSTAT MOTION CONTROL INC.

CM1-E User Guide

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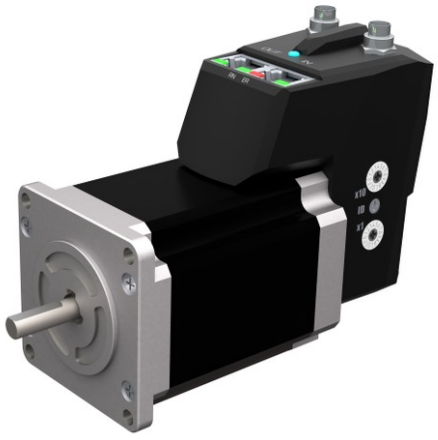


This is an uncontrolled document

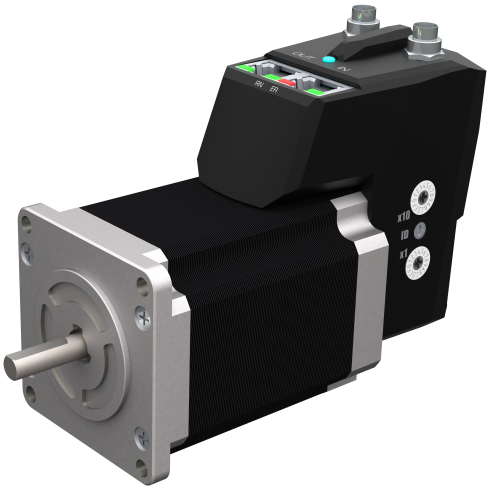
EtherCAT®

1 Table of Contents

2 CM1-E DESIGN REFERENCES

The intelligence and efficiency of the Cool Muscle servos, combined with an EtherCAT interface and separate power for control and drive.

Cool Muscle CM1_E Ethernet servos implement the CiA402 drive profile with CSP, CSV, PV, PP, and HM modes.



2.1 USER GUIDE

Use the search bar or links on the left to find the content you are looking for. Alternatively download a pdf copy of the user guide.

2.2 TECHNICAL SPECIFICATIONS

2.3 DATASHEETS

- CM1-E-17X30D.PDF
- CM1-E-23XX0D.PDF

2.4 CAD FILES

2.4.1 3D Models

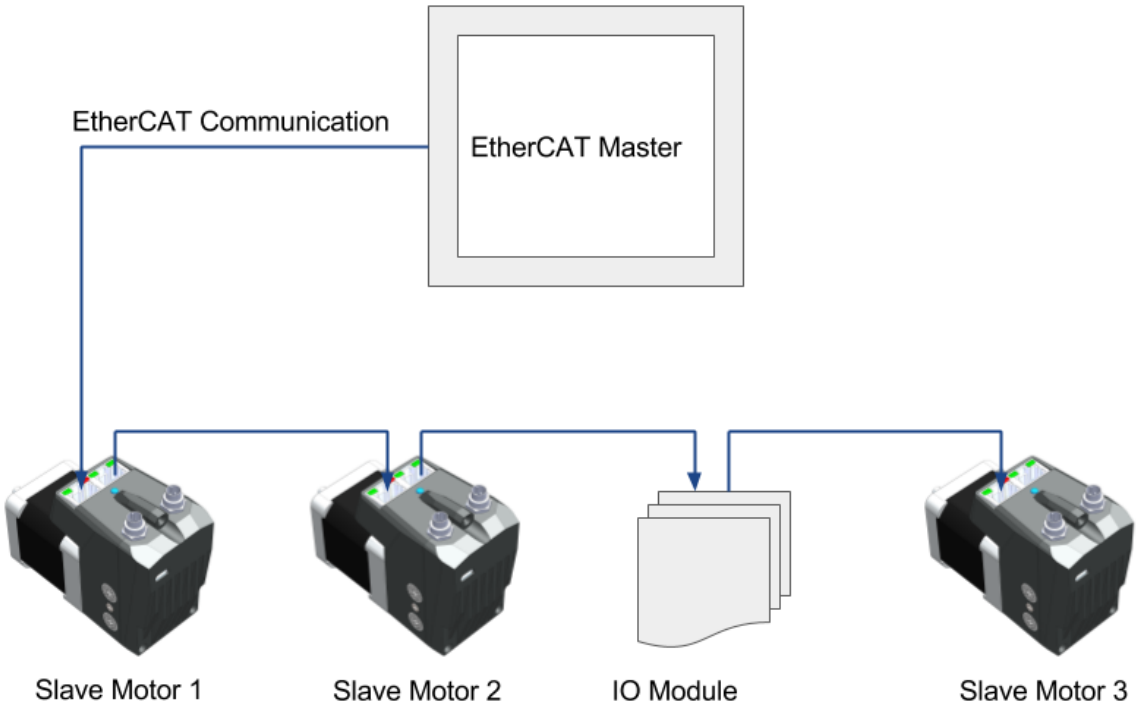
- CM1-E-17L30D MCAD
- CM1-E-17S30D MCAD
- CM1-E-23S30D MCAD
- CM1-E-23L20D MCAD

3 Introduction

3.1 Overview

EtherCAT®[(1)] is a high speed, real time communication protocol that has the ability to update many devices in the microsecond range. This makes it ideal for multi-axis synchronised control or in systems where a master is coordinating a large variety of devices such as sensors, motion axes, distributed IO, etc.

The following network diagram shows a typical EtherCAT network including an EtherCAT master, 3 Cool Muscle slave devices and an additional IO module.



1 Figure: EtherCAT Network Topology

3.2 Cool Muscle Motors

The following CM1 motors are available with integrated EtherCAT communication. Use the Cool Muscle EtherCAT Bridge for all other models

Part Number	Input Voltage	Peak Torque	Peak Current	Peak Speed
CM1-E-17S30D	24V ± 10%	0.117 Nm (11.61 oz.in)	1.0A	3000 rpm
CM1-E-17L30D	24V ± 10%	0.54 Nm (76.4 oz.in)	1.8A	3000 rpm
CM1-E-23S30D	24V ± 10%	0.46 Nm (65.14 oz.in)	5.1A	3000 rpm
CM1-E-23L20D	24V ± 10%	1.24 Nm (175.6 oz.in)	3.4A	2000 rpm

1 Table: Integrated EtherCAT Cool Muscle motors

If the drive and control power are separated all motors will draw a maximum of 125mA on the 24V control power.

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(1) EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

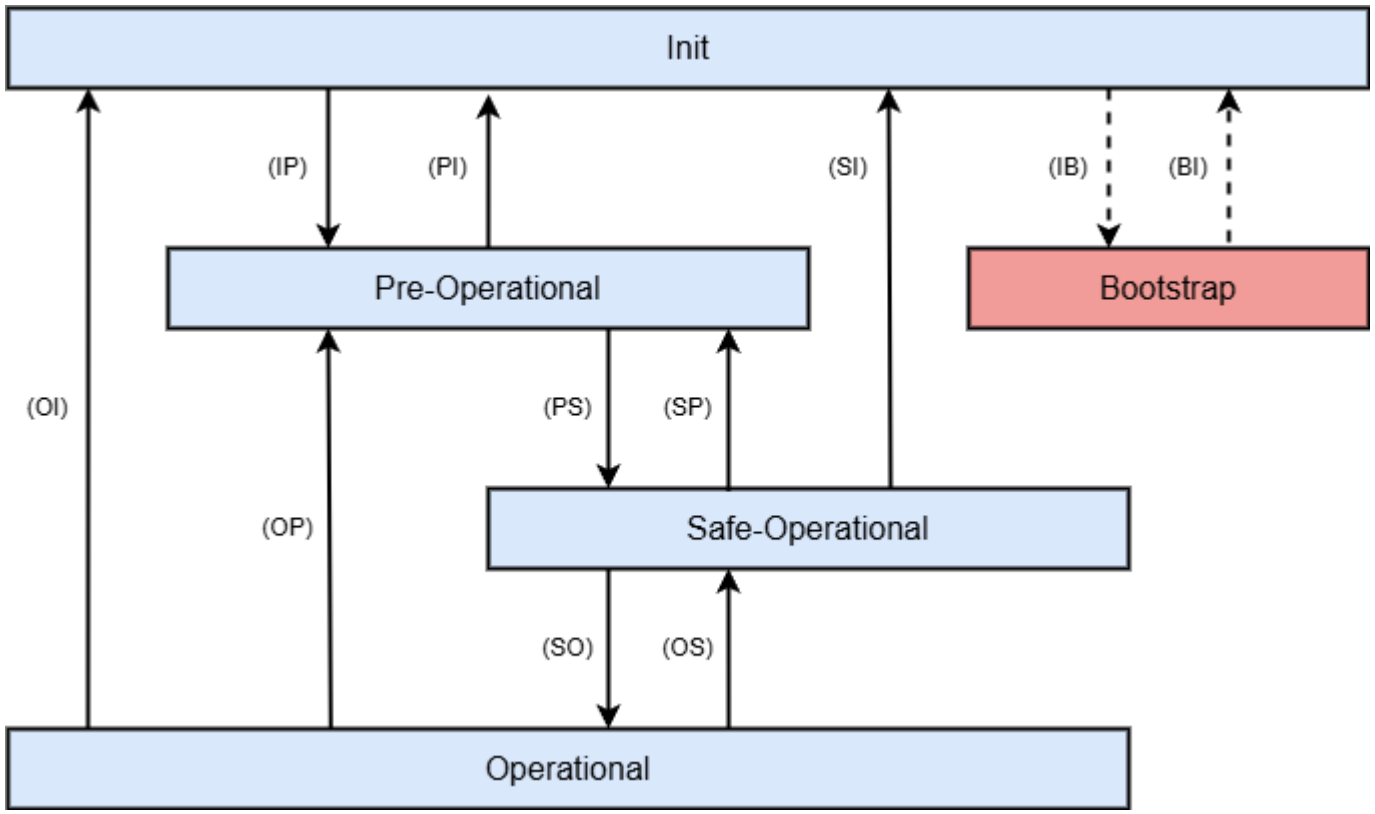
4 EtherCAT Overview

4.1 EtherCAT State Machine

The EtherCAT State Machine (ESM) is required on all EtherCAT devices. The ESM in general

- defines 5 communication states of the slave device
    - Init, Pre-Operational, Safe-Operational, Operational
    - Bootstrap is an optional state for firmware upload
- specifies initialization and error handling of the slave device
- identifies the current communication relationship between the master and slave device
    - requested and current state are accessed through the AL Control and AL Status registers

The ESM states can be transitioned as shown



Init State

- No communication to the application layer is allowed
- master only has communication to the data link registers (slave device eeprom, addressing, etc)

Pre-Operational State

- Mailbox (SDO) communication to the application layer is available
- No Process Data (PDO) communication.
- PDO register mapping should be completed. Transition to Safe-Operation will configure mapping.

Safe-Operational State

- Mailbox (SDO) communication to the application layer is available
- Slave output (tx) Process Data (PDO) communication is evaluated

Operational State

- All communication is commenced and valid

Bootstrap State

- The bootstrap state is used when updating EtherCAT firmware.

4.2 Explicit Device ID

4.2.1 General Description

The use of EtherCAT Device identification is to identify an EtherCAT slave explicitly. This is necessary for the following use cases:

- Hot Connect applications
  Within some applications it might be useful to connect or disconnect parts of the network. In this case the master must have the possibility to identify which part of the network is available.
- Prevention against cable swapping
  If at least two identical devices are used in one application it might be necessary to prevent the mix-up of these devices by cable swapping. Example Scenario: Within a machining center there might be two identical drives to work in X and Y direction. To avoid that the drives receive wrong process data, for example after a device replacement, an explicit identification of the devices can be used.

The Device Identification value can be used optionally for unique addressing.

4.2.2 Rotary Selectors

The CM1-E uses 2 rotary selectors on the side of the motor to set the ID. These use hexadecimal values to set the range from 0-255. The values are set as follows

	x10	**x1**
Description	Most significant 4 bits	Least significant 4 bits
Example value	B_h	5_h
Combined value	$B5_h$ (181_d)	

4.2.3 ID Range Usage

The following ID range is permissible

ID	**Usage**
0x00 (0)	No ID is set and Explicit Device ID is not used

ID	Usage
0x01-0xFE (1-254)	Explicit Device ID has been set
0xFF (255)	Reserved • Value cannot be used and will be read as 0 by the master

4.2.4 Configured Station Alias

For backwards compatibility with certain master controllers the Configured Station Alias Register 0x0012 may be used. The following conditions exist:

Explicit Device ID Value	Configured Station Alias Value	Usage
0	0	No identification used or expected
>0	0	Explicit Device ID is used
0	>0	Configured Station Alias is used
>0	>0	Internal error generated

4.3 PDO Timing

The CM1-E slave will accept a number of PDO rates. The rate is auto-detected and no additional setup is required on the slave.

Accepted rates are

1. 1000µs (1ms)
2. 500µs
3. 250µs
4. 200µs

The detected rate can be read in object 0xFE00:1.

4.4 PDO Mappings

The Cool Muscle EtherCAT slave has a few static PDO mapping options. It does not use dynamic mapping.

- The RxPDO is the PDO received by the motor/slave device
- The TxPDO is the PDO transmitted by the motor/slave device

Position units are in encoder counts (pulses). There are 50,000 encoder counts per revolution.

The following mappings are available.

4.4.1 Dynamic Switching of mode

This mapping is useful as a generic mapping. The master can run in any of the available modes as well as switch dynamically between them. The PDO also offers a lot of feedback information for diagnostics.

RxPDO - 0x1600

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6040	Controlword	-	UINT16	All	The Controlword is used to control the state of the mode of operation.
0x60FE	Digital outputs	-	UINT16	All	Set the state of the digital outputs
0x607A	Target position	units	INT32	CSP, PP	Set the target position of the motor
0x60FF	Target speed	units/s	INT32	CSV	Set the target speed of the motor.
0x6060	Modes of operation	-	INT8	All	Set the required mode of operation

TxPDO - 0x1A00

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6041	Statusword	-	UINT16	All	The Statusword describes the current state of the mode of operation.
0x603F	Error Code	-	UINT16	All	The actual error code currently active.
0x6064	Position Actual Value	units	INT32	All	The value of the motor's actual position
0x606C	Speed Actual Value	units/s	INT32	All	The value of the motor's actual speed
0x6077	Torque Actual Value	0.1% rated torque	INT16	All	The value of the motor's actual peak torque
0x60FD	Digital Inputs	-	UINT16	All	Digital inputs status
0x2301	Temperature	°c	INT16	All	The actual motor temperature in °c.
0x6079	DC Voltage	0.1VDC	INT16	All	The actual DC 24V DC bus voltage

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6061	Modes of operation display	-	INT8	All	The mode of operation currently running.

4.4.2 CSP Mode

This mapping is useful when a minimum amount of data wants to be transferred using CSP mode.

RxPDO - 0x1601

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6040	Controlword	-	UINT16	All	The Controlword is used to control the state of the mode of operation.
0x60FE	Digital outputs	-	UINT16	All	Set the state of the digital outputs
0x607A	Target position	units	INT32	CSP, PP	Set the target position of the motor

TxPDO - 0x1A01

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6041	Statusword	-	UINT16	All	The Statusword describes the current state of the mode of operation.
0x603F	Error Code	-	UINT16	All	The actual error code currently active.
0x6064	Position Actual Value	units	INT32	All	The value of the motor's actual position
0x6077	Torque Actual Value	0.1% rated torque	INT16	All	The value of the motor's actual peak torque
0x606C	Speed Actual Value	units/s	INT32	All	The value of the motor's actual speed
0x60FD	Digital Inputs	-	UINT16	All	Digital inputs status

4.4.3 CSV Mode

This mapping is useful when a minimum amount of data wants to be transferred using CSP mode.

RxPDO - 0x1602

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6040	Controlword	-	UINT16	All	The Controlword is used to control the state of the mode of operation.
0x60FE	Digital outputs	-	UINT16	All	Set the state of the digital outputs
0x60FF	Target speed	units/s	INT32	CSV	Set the target speed of the motor.

TxPDO - 0x1A02

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6041	Statusword	-	UINT16	All	The Statusword describes the current state of the mode of operation.
0x603F	Error Code	-	UINT16	All	The actual error code currently active.
0x6064	Position Actual Value	units	INT32	All	The value of the motor's actual position
0x6077	Torque Actual Value	0.1% rated torque	INT16	All	The value of the motor's actual peak torque
0x606C	Speed Actual Value	units/s	INT32	All	The value of the motor's actual speed
0x60FD	Digital Inputs	-	UINT16	All	Digital inputs status

4.4.4 Profile Mode

This mapping is useful when profile position or profile velocity mode is used.

RxPDO - 0x1603

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6040	Controlword	-	UINT16	All	The Controlword is used to control the state of the mode of operation.
0x60FE	Digital outputs	-	UINT16	All	Set the state of the digital outputs
0x607A	Target position	units	INT32	CSP, PP	Set the target position of the motor
0x60FF	Target speed	units/s	INT32	CSV, PV	Set the target speed of the motor.
0x6081	Profile velocity	-	UINT32	PP	Set the required mode of operation
0x6083	Profile acceleration		UINT32	PP, PV	

TxPDO - 0x1A03

Object	Name	Units	Data Type	Applicable Modes of Operation	Description
0x6041	Statusword	-	UINT16	All	The Statusword describes the current state of the mode of operation.
0x603F	Error Code	-	UINT16	All	The actual error code currently active.
0x6064	Position Actual Value	units	INT32	All	The value of the motor's actual position
0x606C	Speed Actual Value	units/s	INT32	All	The value of the motor's actual speed
0x6077	Torque Actual Value	0.1% rated torque	INT16	All	The value of the motor's actual peak torque
0x60FD	Digital Inputs	-	UINT16	All	Digital inputs status
0x2301	Temperature	°c	INT16	All	The actual motor temperature in °c.
0x6079	DC Voltage	0.1VDC	INT16	All	The actual DC 24V DC bus voltage

5 Wiring and LED Information

5.1 Overview

The following diagram shows an overview of all connectors and LEDs.

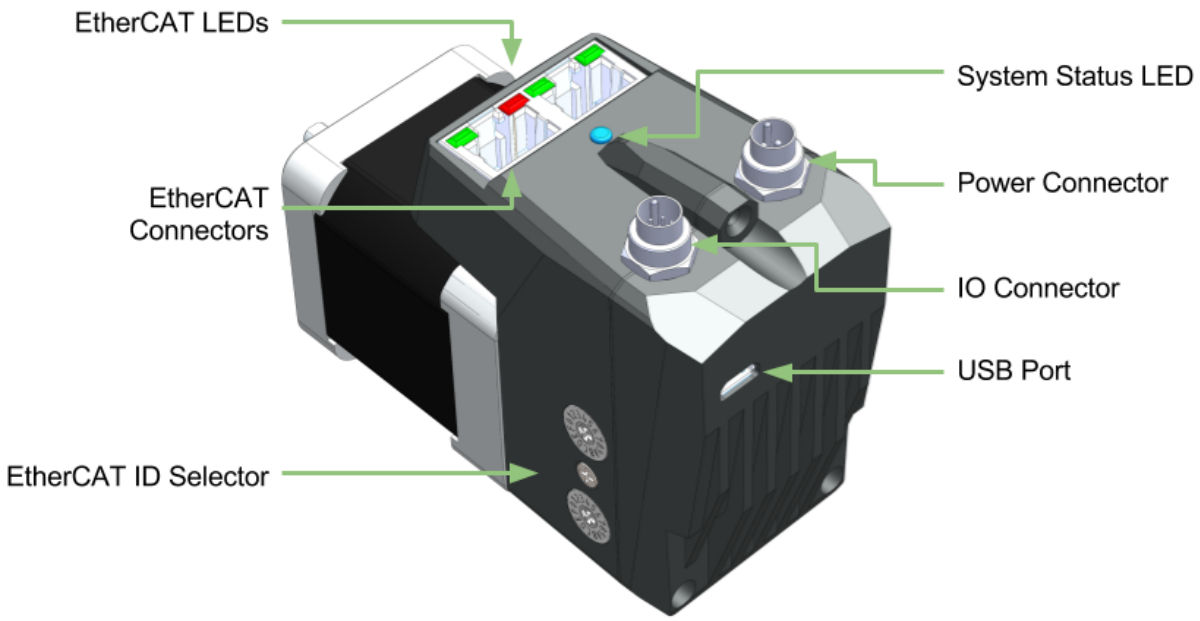
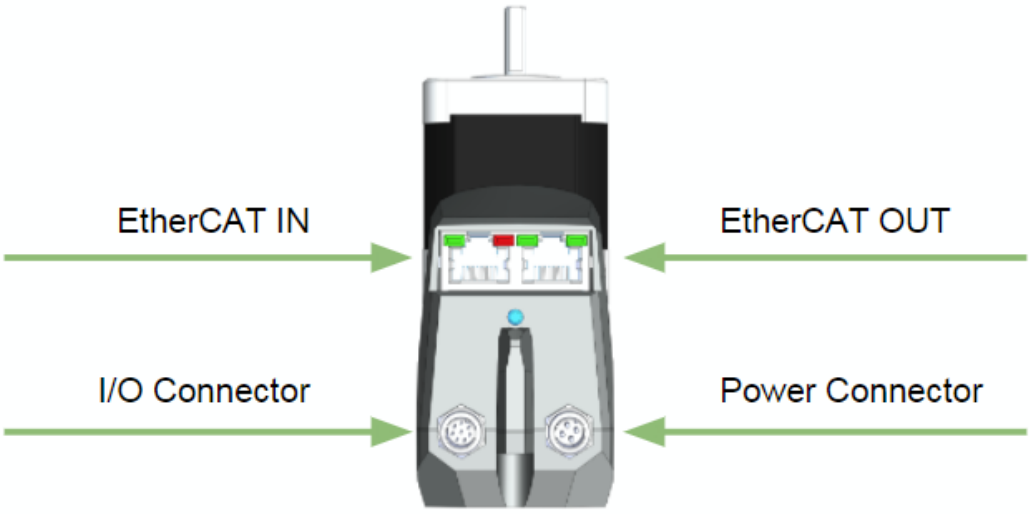


Figure: Overview of Connections and status LEDs

5.2 Motor Connections

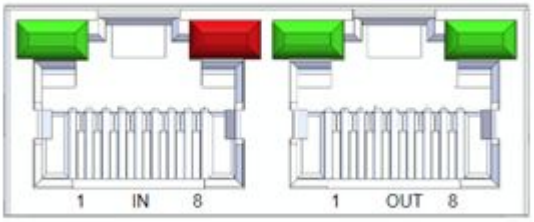


5.2.1 EtherCAT Connectors

The EtherCAT ports use standard Ethernet RJ45 CAT5e, M8-A or M8-D connectors depending on the motor variant. They are labeled IN and OUT as per the EtherCAT standard.

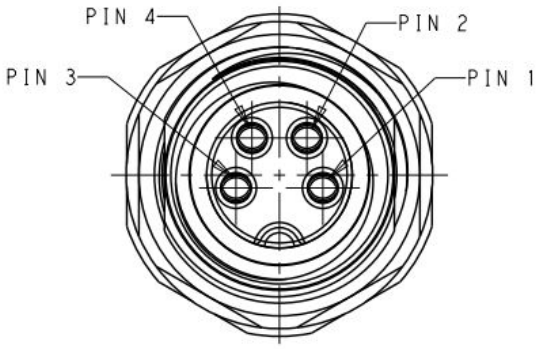
Connector Options

- RJ45



2 Amphenol - RJHSE538B0

- M8-A Female



3 TE Connectivity - T4041017041-000

Pinout

	RJ45[(1)]	M8-A
Tx+	1	1
Rx+	3	2
Rx-	6	3
Tx-	2	4

(1) Pins 4,5,7 and 8 are connected to GND.

Example Cables

All ethernet cables are standard pinouts and are available from a variety of online suppliers or cable houses. Here are a few example cables from the Phoenix Contact NBC series

Image	Part Number	Description	Digikey Link
	1407353	M8-A male to RJ45 Phoenix Contact - 1407353	Digikey - 1407353

Image	Part Number	Description	Digikey Link
	1407349	M8-A male to M8A male Phoenix Contact - 1407349	Digikey - 1407349
	1227562	RJ45 to RJ45 Phoenix Contact - 1227562	Digikey - 1227562

5.2.2 Power Connector

The power connector supplies 24V to the EtherCAT slave and the motor separately. These two can be tied together so both are off the same power supply.

The power connector is an M9 circular connector from Binder. The relevant parts numbers are

Connector	Part Number	Supplier
Motor connector	09 0081 20 04	Binder
Female cable side mating connector	99 0080 102 04	Binder
4m power cable	CM1M9-4F-4000	Myostat

- The CM1M9-4F-4000 is 24AWG with conductor resistance of 97.5Ω/km
    - The HF version with EXT-3D cable has a resistance of 91.1Ω/km

Pin #	Description	Voltage	Current
1 - yellow	EtherCAT + Motor Control Power	24V ±10%	125mA max
2 - white	0V	-	
3 - grey	0V	-	
4 - orange	Motor Drive Power	24V ±10%	See individual motor ratings

*Colors indicated are for the standard **CM1M9-4F-4000** power cable.*

- NOTE: There is no reverse polarity protection. Ensure the 24V power is connected correctly before powering the unit.
- Maintaining EtherCAT power and switching off motor drive power will
  - retain motor position
  - remove any ability for the motor to be driven (as power to the motor drive has been removed).

5.2.3 I/O Connector

- Connecting a digital input to GND will produce a logical high on the device.
- All digital inputs can be monitored by the EtherCAT master.
- Inputs 2 and 3 are also connected to the motor controller. This allows them to function as inputs for embedded home routines as well as any standard CML programming when in CML mode
- The analog input is referenced by the motor and available in CML mode
- Output 1 is controller by the EtherCAT slave controller. It is switched on and off by the EtherCAT master
- Output 2 can be programmed as a standard motor output and cannot be controller directly by the EtherCAT master.

Connector	Part Number	Supplier
Motor connector	09 0481 22 08	Binder
Female cable side mating connector	99 0480 102 08	Binder
4m I/O cable	CM1M9-8F-4000	Myostat

Pin #	Name	EtherCAT Function	Motor Function	Specifications			
Digital Inputs - Sourcing (supply 0V to trigger)				**Parameter**	**Min**	**Max**	**Unit**
1 - orange	IN1	Digital input 1	-	Voltage Range	0	36	V
2 - brown	IN2	Digital input 2	Digital input 2	Input ON level	0	1.4	V
3 - green	IN3	Digital input 3	Digital input 3	Input OFF level	1.4	36	V
4 - yellow	IN4	Digital input 4	-	Continuous Current	-	30	mA
				Peak Current	-	0.5	A
				Pulse Width	-	1	ms
Analog Input (0-5V)				**Parameter**	**Min**	**Max**	**Unit**

Pin #	Name	EtherCAT Function	Motor Function	Specifications			
5 - purple	A-IN5	-	Analog input 4	Voltage Range	0	5	V
				Resolution	10 bit		
Digital Outputs - Sinking (output supplies 0V when asserted)				**Parameter**	**Min**	**Max**	**Unit**
6 - blue 7 - black	OUT1 OUT2	Digital output 1 -	- Output 2	Voltage Range	0	-	V
				Continuous Current	-	1	A
				Inductive Load Peak Rev Current	-	0.2	A
				Inductive Load Peak Rev Voltage	-	70	V
Signal Ground (0V)				**Parameter**	**Min**	**Max**	**Unit**
8 - red	0V	0V	0V	Voltage Range	0	0	V

- *Colors indicated are for the standard **CM1M9-8F-4000** I/O cable.*
- *For custom cable length pin-out and colors see CM1M9-8F.PDF*

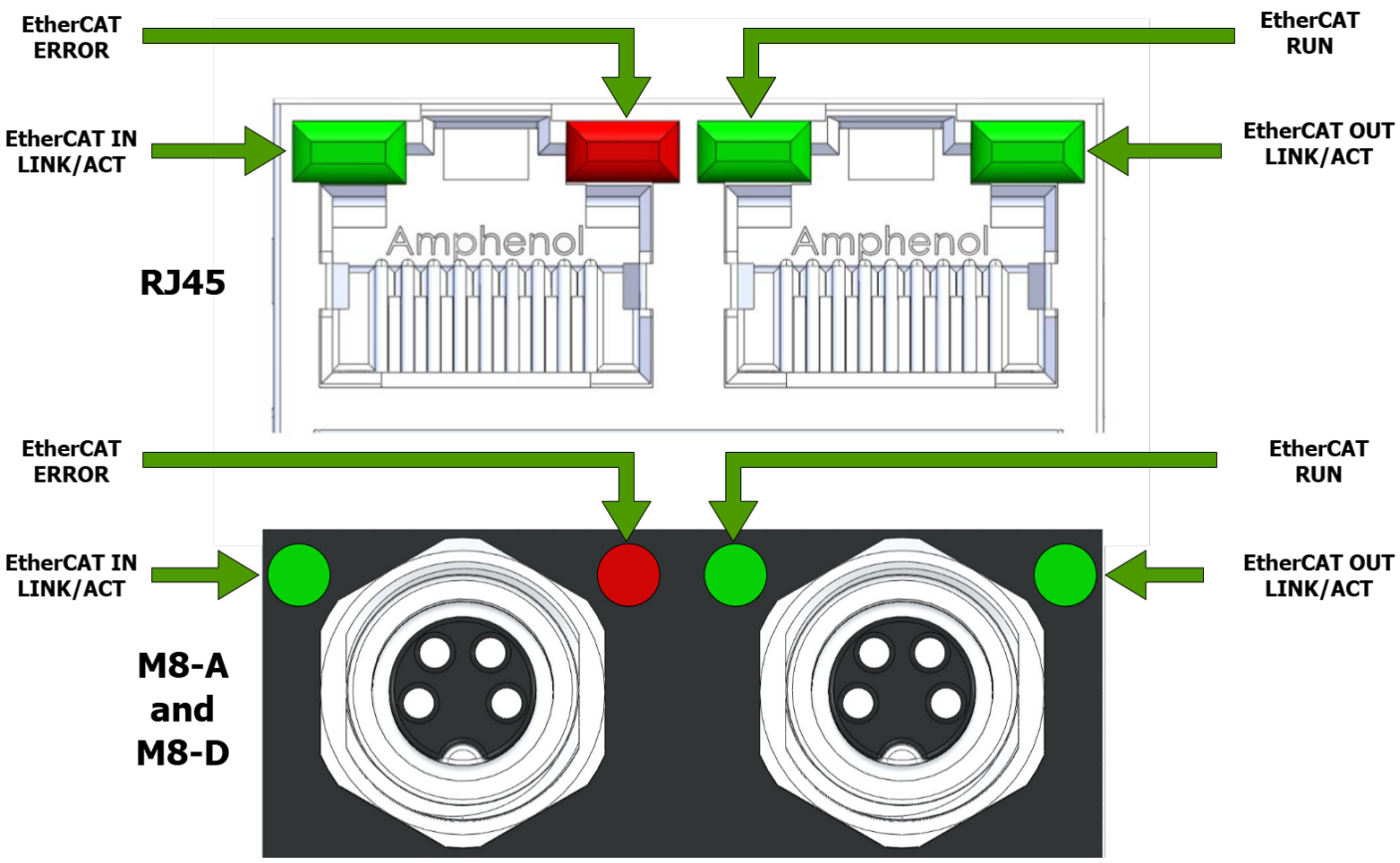
5.2.4 USB Connection

The USB connector is a standard micro USB and is used to update the EtherCAT firmware. When it is plugged into a computer it will create a virtual serial port.

5.3 LEDs

5.3.1 EtherCAT Status LEDs

An EtherCAT slave device is required to have LEDs indicating different states.



Link/Activity Indicator

There is a Link/Activity LED for both the IN and OUT EtherCAT ports. The table below describes the indicator conditions and their associated states

Link	Activity	Condition	Link/Activity Code
Yes	No	Port Open	On
Yes	Yes	Port Open	Flickering
No	N/A	Port Closed	Off

Run Indicator

The Run indicator shows the state of the EtherCAT State Machine. The indicator states are described in the table below.

Indicator State	Slave State	Description
Off	Initialisation	The device is in state "Init"

Indicator State	Slave State	Description
Blinking	Pre-Operational	The device is in state "Pre-Operational"
Single Flash	Safe-Operational	The device is in state "Safe-Operational"
On	Operational	The device is in state "Operational"
Flickering	Init or Bootstrap	The device is booting and has not yet entered the "Init" state or, the device is in state "Bootstrap. Firmware download is in progress.

Error Indicator

The Error indicator shall show device and EtherCAT errors. Errors are as defined in the table below.

Error State	Error Name	Description	Example
On	Application controller failure	A critial communication or application error has occured	• Over torque error • Motor communication error
Double flash	Process Data Watchdog timeout/ EtherCAT watchdog timeout	An application watchdog timeout has occured	Sync Manager watchdog timeout
Single flash	Local Error	Slave device application has changed the EtherCAT state autonomously, due to local error.	Device has changed from Op to safe-op due to EtherCAT error
Blinking	Invalid Configuration	General Configuration error	
Flickering	Booting Error	Init state reached but boot error detected	Application boot error
Off	No Error	Device is in working condition	

5.3.2 System and Motor Status LED

The system status LED provides feedback to the user on overall system status. The following states exist

LED Colour	Description
Red	Motor Error Solid: • 24V motor drive power not present

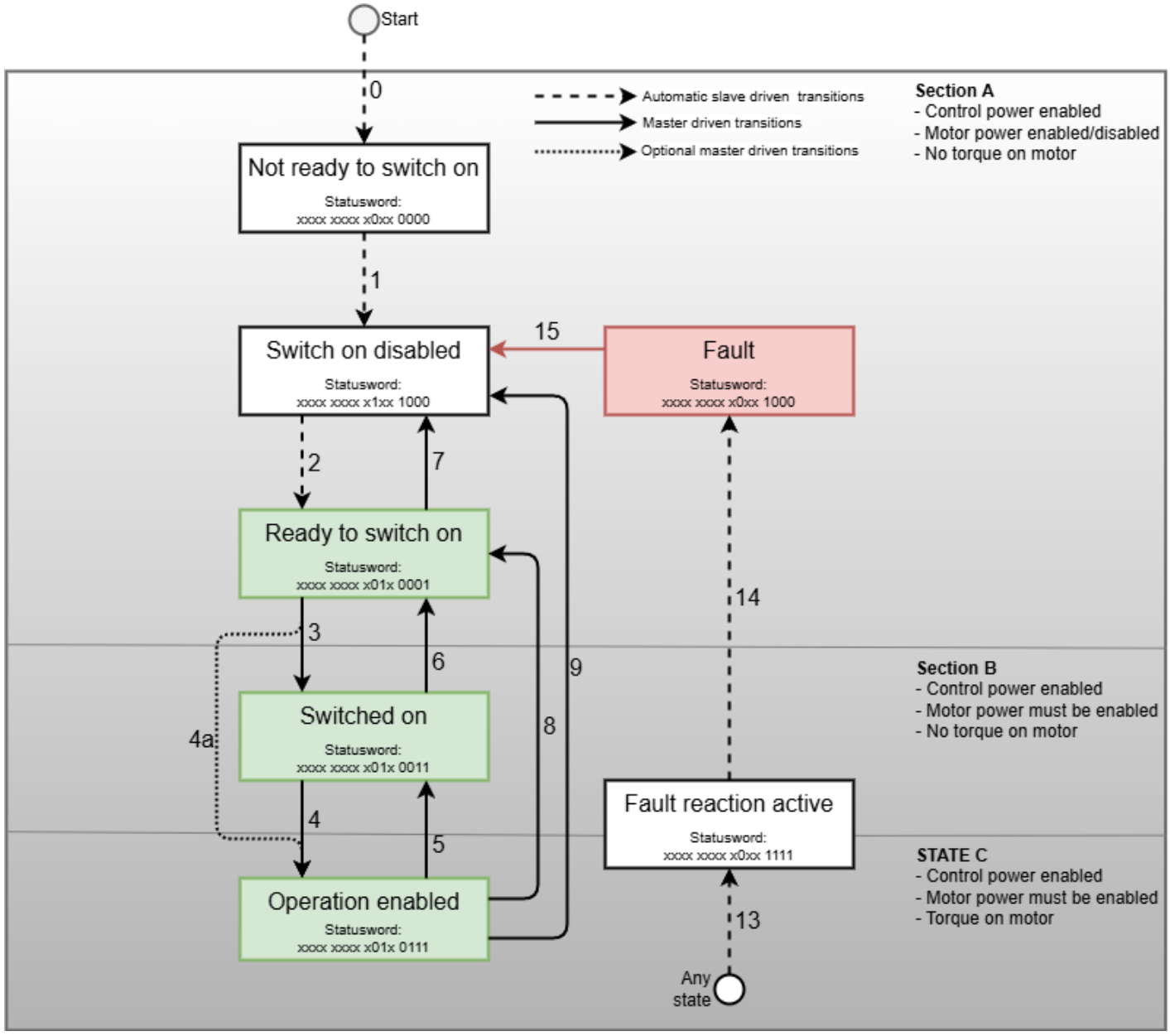
LED Colour	Description
	Blinking • Motor communication error Flashing: • 1 - Position error • 2 - Over speed error • 4 - Over torque error
Green	Solid - CiA402 Mode

6 CiA 402 - Drives and Motion Control Device Profile

6.1 Controlling the Power Drive System

6.1.1 State Machine

The drive state machine is controlled by the Controlword (0x6040) and the status is viewed by the Statusword (0x6041). The state machine can be operated as shown below



There are a few things to note when using the state machine

- When the mode of operation is set to any CiA402 mode the state machine automatically transitions to "Ready to switch on".
- When the transitioning out of "Fault" the state machine automatically transitions to "Ready to switch on".
- Section A
    - no torque is present on the motor in Section A regardless of if motor power is present
- Section B
    - motor power must be present to transition to "Switched on".
    - If motor power is switched off or not present a fault will occur.
    - no torque is present on the motor in Section B.
- Section C
    - If motor power is switched off or not present a fault will occur.
    - Torque is present on the motor in Section C.
    - It is possible for the master to transition straight to "Operation enabled".
- See the Controlword description for additional information on state transitions 1-15.

6.1.2 Controlword (0x6040)

The Controlword is used to transition between and set the required states in the state machine.

The Controlword bits are defined as follows:

Bit	Name	Abbreviation
0	Switch on	SO
1	Enable voltage	EV
2	Quick stop	QS
3	Enable operation	EO
4-6	Operation mode specific	OMS
7	Fault reset	F
8	Halt	H
9	Operation mode specific	OMS
10	Reserved	R
11-15	Manufacturer specific	MS

- The drive does not support the Quick stop bit and shall be ignored if set to 0.

The following bits are required when transitioning between states:

Transition		Value (h)	BITS						
			0 (SO)	1 (EV)	2 (QS)	3 (EO)	4-6 (OMS)	7 (F)	8-15
15	**Fault → Ready to switch on**	**0x86**	0	1	1	0	xxx	1	xxxxxxxx
8/9/0	**Non fault → Ready to switch on**	**0x06**	0	1	1	0	xxx	0	xxxxxxxx
3/5	**→ Switched on[(1)]**	**0x07**	1	1	1	0	xxx	0	xxxxxxxx
4/4a	**→ Operation enabled**	**0x0F/0x1F**	1	1	1	1	xxx	0	xxxxxxxx

[(1)] The switched on state is often bypassed by the master.

6.1.3 Statusword (0x6041)

The statusword has the following defined bits

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

Definitions

- ms = manufacture specific
- 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

FSA States

The Statusword indicates the current state of the drive state machine. The following table outlines the Statusword bits and the represented state

State	Statusword Bits	Functional Meaning
Not ready to switch on	xxxx xxxx x0xx 0000	No CiA mode of operation selected

State	Statusword Bits	Functional Meaning
Switch on disabled[1]	xxxx xxxx x100 0000	No motor torque - drive disabled
Ready to switch on	xxxx xxxx x01x 0001	No motor torque - drive disabled
Switched on	xxxx xxxx x01x 0011	No motor toque - drive disabled
Operation Enabled	xxxx xxxx x01x 0111	Motor has torque - drive enabled
Fault reaction active[1]	xxxx xxxx x0xx 1111	Motor is losing torque - drive disabling
Fault	xxxx xxxx x0xx 1000	No motor torque - drive disabled
Quick stop active[2]	xxxx xxxx x00x 0111	Not implemented

[1] these states are automatically transitioned through
[2] quick stop active is not currently implemented

Voltage Enabled - Bit4

The CM1-E has separate control and motor power. The 24V motor power status can be read through bit 4 on the statusword.

- bit4=1 - 24V motor drive power is detected.
- bit4=0 - motor drive power is not detected.

The voltage DC value is also available on object 0x6079 (DC link voltage).

6.2 Modes of Operation

CiA402 defines modes of operation. This allows the user to use the drive in a mode that is most suited to the application.

Modes of operation object list

Index	Name	Function
0x6060	Modes of operation	Write the required mode of operation
0x6061	Modes of operation display	Read the current mode of operation set on the drive

The following modes of operation are available on the drive

Mode of operation	Abbreviation	0x6060 value
Profile Position mode	PP mode	1
Profile Velocity mode	PV mode	3

Mode of operation	Abbreviation	0x6060 value
Homing Mode	HM mode	6
Cyclic Synchronous Position mode	CSP mode	8
Cyclic Synchronous Velocity mode	CSV mode	9

6.2.1 Switching between modes

The drive is designed for dynamic switching between modes of operation. The "Modes of operation" and "Modes of operation display" are available in the RxPDO and TxPDO respectively. This allows the user to switch modes of operation without changing the ESM out of Operational. It is recommended the motor is put into a safe known state before switching modes. The master should send PDO data to the current mode of operation and the desired mode while switching modes. This should be continued until the "Modes of operation display" indicates the new mode has been set.

6.2.2 Profile Position Mode

Profile position mode provides an effective way to run the motor in position mode with very little overhead on the Ethercat master. The EtherCAT master sets the required acceleration, velocity and position before issuing the run command/bit. Single set-point is implemented which means the master can change the target position, speed and acceleration at any point by updating the values and issuing a new run bit. If the drive is required to continuously update position it is recommended that CSP mode is used instead. The Profile mode PDO mapping or the Dynamic Switching of Modes PDO mapping should be selected to effectively run Profile Position mode. See PDO Mappings for more information.

The following objects are used in Profile Position mode

Object	Name	Value	Unit	Description	PDO Mapped
0x6040	Controlword	-	-	See Controlword for general usage.	Yes
0x6041	Statusword	-	-	See Statusword for general usage.	Yes
0x6060	Modes of operation	1	-	Sets the mode to Profile Position mode	Yes
0x607A	Target Position	-2^{32} to $+2^{31}$	pulses	Sets the target position.	Yes
0x6081	Profile velocity	See Peak Speeds	pulses/s	Sets the target velocity of the profile.	Yes
0x6083	Profile acceleration(1)	0 - 32767	pulses/s^2	Sets the profile acceleration. The deceleration uses the same value.	Yes

[1] The acceleration used internally in the drive has a unit of 1000 pulses/s2. As such the value is 0x6083 is rounded to the nearest 1000. If the value is less than 1000 the value of 1000 used.

Use of Controlword and Statusword

The Controlword and Statusword use some additional mode specific bits in Profile Position mode.

Controlword

The following tables show the controlword usage.

15-10	9	8	7	6	5	4	3-0
See Controlword	Change on set-point	Halt	See Controlword	abs/rel	Change set immediately	New set-point	See Controlword

Bit	Name	Value	Definition
4	New set-point	0 → 1	Next positioning shall be started immediately.
5	Change set immediately	1 - N/A	Bit 5 will always be considered a 1 and will be ignored. Change set immediately is always executed
6	abs/rel	N/A	Absolute positioning is always executed. This bit shall be ignored
8	Halt	0	Positioning shall be executed or continued
		1	The axis shall be stopped using the deceleration value in 0x6083
9	Change on set-point	N/A	Single set point mode is always executed. Bit9 is ignored.

Statusword

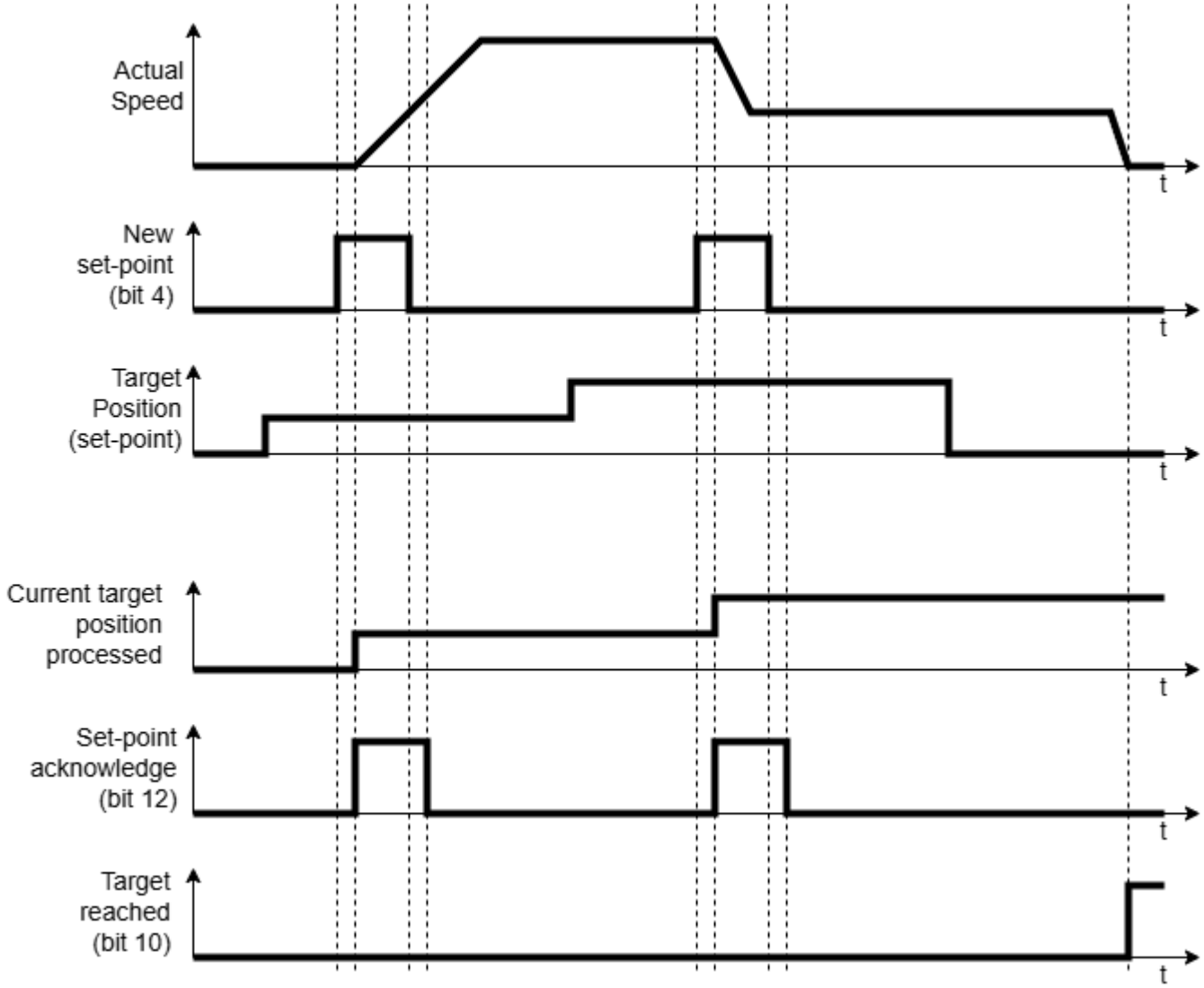
The following tables show the statusword usage.

15	14	13	12	11	10	9-0
See Statusword		Following Error	Set-point acknowledge	See Statusword	Target reached	See Statusword

Bit	Value	Definition
10	0	Halt (Bit 8 in controlword) = 0: Target position not reached Halt (Bit 8 in controlword) = 1: Axis decelerating

Bit	Value	Definition
	1	Halt (Bit 8 in controlword) = 0: Target position reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	0	Waiting for new setpoint
	1	Set point has been processed.
13	0	No following error. The drive is able to follow the commanded trajectory
	1	Following error. The drive cannot follow the commanded trajectory.

Single set-point handshaking procedure



Use of acceleration and deceleration value

The deceleration value is always set to the acceleration value.

The acceleration used internally in the drive has a unit of 1000 pulses/s2. As such the value is 0x6083 is rounded to the nearest 1000. If the value is less than 1000 the value of 1000 used.

6.2.3 Profile Velocity Mode

Profile Velocity mode provides an effective way to run the motor in velocity mode with very little overhead on the Ethercat master. The EtherCAT master sets the required acceleration, deceleration and then issues the target velocity. The drive will ramp up to the target velocity.

The following objects are used in Velocity Profile mode

Object	Name	Value	Unit	Description	PDO Mapped
0x6040	Controlword	-	-	See Controlword for general usage.	Yes
0x6041	Statusword	-	-	See Statusword for general usage.	Yes
0x6060	Modes of operation	3	-	Sets the mode to Profile Velocity mode	Yes
0x60FF	Target speed	See Peak Speeds	pulses/s	Sets the target speed	Yes
0x6083	Profile Acceleration	0-32767	Kpulses/s^2	Profile Acceleration	No
0x6084	Profile Deceleration	0-32767	Kpulses/s^2	Profile Deceleration	No

Use of Controlword and Statusword

The Controlword and Statusword use some additional mode specific bits in Profile velocity mode.

The Controlword Bit8 is used a s a Halt bit.

Bit	Value	Definition
8	0	The motion shall be executed or continued
	1	The axis shall be stopped using the deceleration value in 0x6084

The Statusword implements 2 additional bits to indicate if the target velocity is reached and/or is the current velocity is 0.

Bit	Value	Definition
10	0	Halt (Bit 8 in controlword) = 0: Target not reached Halt (Bit 8 in controlword) = 1: Axis decelerating
	1	Halt (Bit 8 in controlword) = 0: Target reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	0	Speed is not equal to 0
	1	Speed is equal to 0

Use of acceleration and deceleration value

The deceleration value is only used when the target velocity is set to 0 or the halt bit is set. For all other changes in velocity the acceleration value is used.

6.2.4 Homing Mode

Homing mode can be used to utilize the drives embedded homing routines. These routines allow accurate homing to be achieved without the delays communicating to the controller. The standard Cool Muscle home routines are accessible through the homing modes object. Homing mode does not require any specialized PDO mappings and can be used with any of the standard mappings. See EtherCAT Overview for more information.

The following objects are used in Homing mode

Object	Name	Value	Unit	Description	PDO Mapped
0x6040	Controlword	-	-	See Controlword for general usage.	Yes
0x6041	Statusword	-	-	See Statusword for general usage.	Yes
0x6060	Modes of operation	6	-	Sets the mode to Homing mode	Yes
0x607C	Home Offset	-3276700 to +3276700	encoder pulses (50 000 per motor revolution)	Once a home sensor or hardstop has been achieved the motor will move the distance of the offset. The final position will be set to 0. This value is written to an internal motor register which has a resolution of 100 pulses. As such the value written into 0x607C will be rounded to the nearest 100 internally.	No
0x6098	Homing Method	0 to -6	-	• 0: No home routine selected • -1: Hardstop CW • -2: Hardstop CCW • -3: Input 2 sensor CW • -4: Input 2 sensor CCW • -5: Input 3 sensor CW • -6: Input 3 sensor CCW See Homing Methods for additional information	No
0x6099:01	Homing Speed	1000 - 500000	pulses/s	The homing speed is written to an internal register which has a unit of 100 pulses/s. The value written into 0x6099 will be rounded to the closest 100.	No
0x609A	Homing Acceleration	1000-5000000	pulse/s^2	The homing acceleration is written to an internal register which has a unit of 1000	No

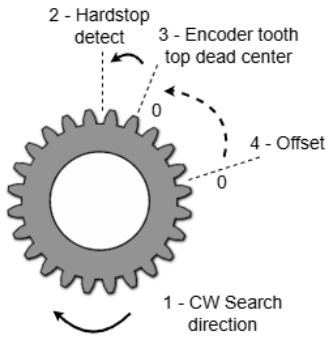
Object	Name	Value	Unit	Description	PDO Mapped
				pulses/s. The value written into 0x609A will be rounded to the closest 1000.	
0x60F6:1B	Homing Torque	10-100	% rated torque	Set the torque during the home routine. 1. When homing to a hardstop this value will indicate the limit at which the hardstop is reached 2. When homing to a switch this value will limit the torque during the home routine.	No

Homing Methods

Two distinct methods are available when executing a home routine.

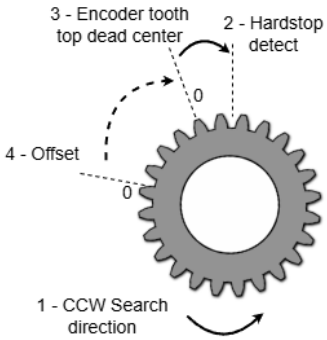
1. Hardstop detect - the motor moves towards a hardstop. When the hardstop is reached the driver reads the position of the magnetic encoder. It then moves back 2 teeth of the encoder gear to set the absolute position. Moving back the two teeth allows for high repeatability as fatigue and variance in the hardstop detect can be accounted for automatically.
2. Sensor detect - the motor moves towards a home sensor. When the sensor is triggered the driver interrupt captures the motor position. The motor decelerates and moves back to the captured position.
    a. If the sensor is detect when the home routine is first initiated the motor will move off the sensor first in the opposite direction to the defined origin search direction.

Hardstop CW - 0x6098=-1



1. Motor runs CW towards a hardstop.
2. The driver monitors the motor current and detects when a hardstop has been reached.
3. Motor backs up CCW to the 2nd previous encoder tooth (improved repeatability) and sets the position to 0.
4. If an offset is set the motor moves the offset distance
    a. Care should be taken not to set a +ve offset as this will move the load into the hardstop
5. Sets the final position to 0.

Hardstop CCW - 0x6098=-2

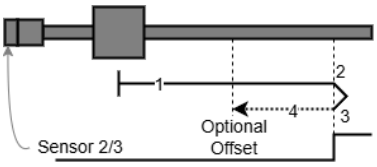


1. Motor runs CCW towards a hardstop.
2. The driver monitors the motor current and detects when a hardstop has been reached.
3. Motor backs CW up to the 2nd previous encoder tooth (improved repeatability) and sets the position to 0.
4. If an offset is set the motor moves the offset distance.
    a. Care should be taken not to set a -ve offset as this will drive the load into the hardstop
5. Sets the final position to 0.

Sensor CW - 0x6098=-3 or -5

INPUT2 - 0x6098=-3

INPUT3 - 0x6098=-5



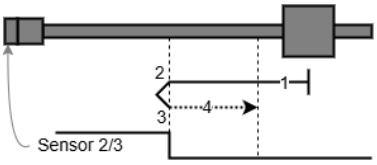
- Diagram shown with motor connected to linear actuator.
    - CW rotation moves the load left to right
- Sensor is connected directly on IN2 or IN3

1. Motor runs CW waiting for sensor input
2. Sensor rising edge triggers the input, motor captures encoder position, decelerates and reverses direction
3. Motor stops on captured position and sets position to 0
4. If an offset is defined the motor continues to the defined offset and sets the final target position to 0.
    a. Offset could be +ve or -ve. The above diagram shows a -ve offset

Sensor CCW - 0x6098=-4 or -6

INPUT2 - 0x6098=-4

INPUT3 - 0x6098=-6



- Diagram shown with motor connected to linear actuator.
    - CCW rotation moves the load right to left

1. Motor runs CCW waiting for sensor input
2. Sensor rising edge triggers the input, motor captures encoder position, decelerates and reverses direction
3. Motor stops on captured position and sets position to 0
4. If an offset is defined the motor continues to the defined offset and sets the final target position to 0.
    a. Offset could be +ve or -ve. The above diagram shows a +ve offset.

- Sensor is connected directly on IN2 or IN3

Use of Controlword and Statusword

The Controlword and Statusword use some additional mode specific bits in Homing mode.

Controlword

The following tables show the controlword usage.

15-9	8	7	6-5	4	3-0
See Controlword	Halt	See Controlword	reserved (0)	Homing operation Start	See Controlword

Bit	Name	Value	Definition
4	Homing operation start	0 → 1	Start or continue homing procedure
8	Halt	0	Enable bit 4
		1	The axis shall be stopped using the deceleration value in 0x609A

Statusword

The following tables show the statusword usage.

15-14	13	12	11	10	9-0
See Statusword	Homing Error	Homing attained	See Statusword	Target reached	See Statusword

General Definitions

Bit	Value	Definition
10	0	Homing procedure is in progress
	1	The motor has reached its target position or is currently disabled via the controlword
12	0	Homing not attained. • This value will by default start at 0. • This value will be reset to 0 when a new home routine is started.
	1	Homing attained

Bit	Value	Definition
		• This value will be set to 1 when a home has been achieved. I.e. a hardstop has been hit or a sensor has been triggered • This value will be reset to 0 when a new home routine is started • This value will be reset to 0 if there is a home routine error or the home routine is aborted before the motor reaches target position
13	0	No home routine error
	1	Home routine error

Bit Sequence

Bit 13	Bit 12	Bit 10	Description
0	0	0	Homing procedure in progress
0	0	1	Homing procedure is interrupted or not started • motor could be enabled or disabled depending on controlword
0	1	0	Homing is attained, but target is not reached • Hardstop - hardstop has been detected. Offset not completed • Sensor - sensor has been detected. Offset not completed
0	1	1	Homing procedure is completed successfully. Current position is set to 0. • Hardstop - hardstop has been detected. Offset completed • Sensor - sensor has been detected. Offset completed
1	0	0	Homing error occurred, velocity is not 0
1	0	1	Homing error occurred, velocity is 0 Occurs if any motor error occurs.
1	1	1	An error exists but a home routine has been completed.

6.2.5 Cyclic Synchronous Position Mode

Cyclic synchronous position mode is set by setting the Modes of operation to 8. CSP mode is designed to allow the master controller full control of the position target. The 0x6064 position target shall be updated every PDO cycle. Failure to update the position target at the defined PDO interval will result in noisy and poor motion.

The following objects are used in CSP mode

Object	Value	Unit	Description	PDO Mapped
0x6040	-	-	See Controlword	Yes

Object	Value	Unit	Description	PDO Mapped
0x6041	-	-	See Statusword	Yes
0x607A	-2^{32} to $+2^{31}$	pulses	Target position	Yes
0x6064	-2^{32} to $+2^{31}$	pulses	Position actual value	Yes
0x6060	8	-	CSP mode set	Yes

- Additional PDO objects are available. See PDO Mappings.

Use of Controlword and Statusword

No additional Controlword and Statusword bits are implemented.

6.2.6 Cyclic Synchronous Velocity Mode

Cyclic synchronous velocity mode is set by setting the Modes of operation to 9. CSV mode is designed to allow the master controller full control of the instantaneous velocity target. The 0x60FF velocity target shall be updated every PDO cycle. Failure to update the position velocity at the defined PDO time interval will result in noisy and poor motion.

The following objects are used in CSP mode

Object	Value	Unit	Description	PDO Mapped
0x6040	-	-	See Controlword	Yes
0x6041	-	-	See Statusword	Yes
0x60FF	See Peak Speeds	pulses/ms	Target velocity	Yes
0x606C	See Peak Speeds	pulses/ms	Velocity actual value	Yes
0x6060	9	-	CSV mode set	Yes

- Additional PDO objects are available. See PDO Mappings.

Motor maximum speeds

Part number	Max Speed RPM	Max 0x606C (Target velocity)
CM1-E-17S30D	3000 rpm	-2,500,000 to +2,500,000
CM1-E-17L30D	3000 rpm	-2,500,000 to +2,500,000
CM1-E-23S30D	3000 rpm	-2,500,000 to +2,500,000
CM1-E-23L20D	2000 rpm	-1,666,667 to +1,666,667

Use of Controlword and Statusword

No additional Controlword and Statusword bits are implemented.

6.3 Motor Peak Speeds

The four supported motors have differing peak speeds. See the table below for each motors maximum speed

Model Number	RPM	Pulses/s	Pulses/ms
CM1-E-17S30D	3000rpm	2500000	2500
CM1-E-17L30D	3000rpm	2500000	2500
CM1-E-23S30D	3000rpm	2500000	2500
CM1-E-23L20D	2000rpm	1666666	1666

7 Object Dictionary

7.1 Communication Objects

7.1.1 0x1000: Device Type

Provides information on the device type.

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Device Type	0x00-0xFFFFFFFFh	0x00040192	UDINT	ro	No

Explanation of set value

Bits	Name	Description
0-15	Device Profile Number	402 (0x192): Drive Profile
16-23	Type	04: Step motor
24-31	Mode	0: Manufacturer specific

7.1.2 0x1001: Error Register

Indicates the error type that occurs in the slave device. The generic error bit is set on all errors. Specific error codes can be found in object 0x603F: Error Code

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Error Register	0x00-0xFF	0x00	USINT	ro	No

Definition of bits:

Bit	Error Description
0	Generic
1	Current
2	Voltage
3	Temperature
4	Communication Error
5	Device profile specific

Bit	Error Description
6	N/A
7	Manufacturer specific

7.1.3 0x1008: Manufacturer Device Name

Indicates the manufacturers device name

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Manufacturers Device Name	-	"CM1-E"	STRING	ro	No

7.1.4 0x1009: Manufacturer Hardware Version

Indicates the EtherCAT hardware version.

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Manufacturer Hardware Version	-	"MYO28-02A"	STRING	ro	No

7.1.5 0x100A: Manufacturer Software Version

Indicates the version of the EtherCAT firmware

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Manufacturer Software Version	-	"1.0.0"	STRING	ro	No

7.1.6 0x1018: Identity Object

Indicates general device information

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Number of Entries	0x01-0x04	0x04	USINT	ro	No
0x01	Vendor ID	0x00-0xFFFFFFFF	0x00004441	UDINT	ro	No
0x02	Product Code	0x00-0xFFFFFFFF	0x44412002	UDINT	ro	No
0x03	Revision Number	0x00-0xFFFFFFFF	0x20020001	UDINT	ro	No

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x04	Serial Number	0x00-0xFFFFFFFF	0x00000000	UDINT	ro	No

7.2 PDO Mapping Objects

7.2.1 0x1600: Receive PDO mapping parameter - Dynamic switching of modes

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x07	ro	No
0x01	Controlword mapping	0x60400010	ro	No
0x02	Target position mapping	0x607A0020	ro	No
0x03	Target velocity mapping	0x60FF0020	ro	No
0x04	Digital outputs mapping	0x60FE0010	ro	No
0x05	Mode of operation mapping	0x60600008	ro	No

7.2.2 0x1601: Receive PDO mapping parameter - CSP mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x04	ro	No
0x01	Controlword mapping	0x60400010	ro	No
0x02	Target position mapping	0x607A0020	ro	No
0x03	Digital outputs mapping	0x60FE0010	ro	No

7.2.3 0x1602: Receive PDO mapping parameter - CSV mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x04	ro	No
0x01	Controlword mapping	0x60400010	ro	No
0x02	Target velocity mapping	0x60FF0020	ro	No

Sub-index	Description	Value	Access	PDO Mapping
0x03	Digital outputs mapping	0x60FE0010	ro	No

7.2.4 0x1603: Receive PDO mapping parameter - Profile mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x06	ro	No
0x01	Controlword mapping	0x60400010	ro	No
0x03	Target Position mapping	0x607A0020	ro	No
0x04	Target Velocity mapping	0x60FF0020	ro	No
0x05	Profile Velocity mapping	0x60810020	ro	No
0x06	Profile Acceleration mapping	0x60830020	ro	No
0x07	Mode of operation mapping	0x60600008	ro	No

7.2.5 0x1A00: Transmit PDO mapping parameter - Dynamic switching of modes

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x0B	ro	No
0x01	Statusword mapping	0x60410010	ro	No
0x02	Position actual value mapping	0x60640020	ro	No
0x03	Velocity actual value mapping	0x606C0020	ro	No
0x04	Torque actual value mapping	0x60770020	ro	No
0x05	Digital input mapping	0x60FD0010	ro	No
0x06	Error code mapping	0x603F0010	ro	No
0x07	Temperature-C mapping	0x23010010	ro	No
0x08	DC voltage mapping	0x60790010	ro	No
0x09	Modes of operation display mapping	0x60610008	ro	No

7.2.6 0x1A01: Transmit PDO mapping parameter - CSP mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x07	ro	No
0x01	Statusword mapping	0x60410010	ro	No
0x02	Position actual value mapping	0x60640020	ro	No
0x03	Velocity actual value mapping	0x606C0020	ro	No
0x04	Torque actual value mapping	0x60770020	ro	No
0x05	Digital input mapping	0x60FD0010	ro	No
0x06	Error code mapping	0x603F0010	ro	No

7.2.7 0x1A02: Transmit PDO mapping parameter - CSV mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x07	ro	No
0x01	Statusword mapping	0x60410010	ro	No
0x02	Position actual value mapping	0x60640020	ro	No
0x03	Velocity actual value mapping	0x606C0020	ro	No
0x04	Torque actual value mapping	0x60770020	ro	No
0x05	Digital input mapping	0x60FD0010	ro	No
0x06	Error code mapping	0x603F0010	ro	No

7.2.8 0x1A03: Transmit PDO mapping parameter - Profile mode

Sub-index	Description	Value	Access	PDO Mapping
0x00	Number of entries	0x0B	ro	No

Sub-index	Description	Value	Access	PDO Mapping
0x01	Statusword mapping	0x60410010	ro	No
0x02	Position actual value mapping	0x60640020	ro	No
0x03	Velocity actual value mapping	0x606C0020	ro	No
0x04	Torque actual value mapping	0x60770020	ro	No
0x05	Digital input mapping	0x60FD0010	ro	No
0x06	Error code mapping	0x603F0010	ro	No
0x07	Temperature-C mapping	0x23010010	ro	No
0x08	DC voltage mapping	0x60790010	ro	No
0x09	Mode of operation display mapping	0x60610008	ro	No

7.3 CiA402 Drive Profile Objects

7.3.1 0x603F: Error Code

Indicates specific error code when an error occurs.

Sub-index	Description	Range	Default	Type	Access	PDO Mapping
0x00	Error Code	0x0000-0xFFFF	0x0000	UINT	ro	No

The following table outlines the error and the relevant objects that are set.

0x603F Error Code	0x1001 Error Register	0x6041 Fault (Bit 3)	Description
0x0000	0x00	0	No error
0x2310	0x03	1	Continuous over current error (torque overload)
0x4310	0x09	1	Drive over temperature
0x4502	0x00	0	No mode selected (0x6060=0) [1]
0x7310	0x81	1	Over speed error

0x7320	0x81	1	Position Error overflow
0x7500	0x11	1	Motor communication error
0x7510	0x11	1	Motor drive to EtherCAT slave communication error
0x8611	0x00	0	Motor not currently following commanded position [1,2]
0xFF01	0x00	0	Motor disabled by command[1]
0xFF04	0x81	1	Emergency stop active
0xFF05	0x11	0/1[3]	24V drive power not present

1. Not an error state
2. The motor is not following because for example the FSM state is not in Operation Enabled.
3. If the FSM is in Operation Enabled the loss of 24V power will generate a fault on the statusword otherwise the fault bit will not show an error.

7.3.2 0x6040: Controlword

Sub-index	Description	Type	Access	PDO Mapping
0x00	Used to control the drive's state machine	UINT	rw	Yes

For more information on the Controlword usage see the chapter CiA 402 - Drives and Motion Control Device Profile

7.3.3 0x6041: Statusword

Sub-index	Description	Type	Access	PDO Mapping
0x00	Displays the status of the drive's state machine	UINT	ro	Yes

For more information on the Statusword usage see the chapter CiA 402 - Drives and Motion Control Device Profile

7.3.4 0x6060: Modes of operation

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the desired mode of operation	SINT	rw	Yes

Value	Mode of Operation
0	No mode selected
3	Profile Velocity (PV) Mode
6	Homing Mode (HM)
8	Cyclic Synchronois Position (CSP) Mode
9	Cyclic Synchronous Velocity (CSV) Mode

7.3.5 0x6061: Modes of operation display

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the mode of operation currently set on the drive	SINT	ro	Yes

Value	Mode of Operation
0	No mode selected
3	Profile Velocity (PV) Mode
8	Cyclic Synchronois Position (CSP) Mode
9	Cyclic Synchronous Velocity (CSV) Mode

7.3.6 0x6064: Position actual value

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the actual position of the motor. • Unit - pulses (50,000 pulses/revolution)	DINT	ro	Yes

7.3.7 0x606C: Speed actual value

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the actual speed of the motor.	DINT	ro	Yes

Sub-index	Description	Type	Access	PDO Mapping
	• Unit - pulses/millisecond (50,000 pulses/revolution)			

7.3.8 0x6072: Peak torque

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the peak torque of the motor. • Unit - 0.1% of rated torque	UINT	ro	Yes

7.3.9 0x6073: Motor max current

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the max current of the motor. • Unit - 0.1% of rated current	UINT	ro	No

7.3.10 0x6075: Motor rated current

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the rated current of the motor. • Unit - mA	UDINT	ro	No

7.3.11 0x6076: Motor rated torque

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the rated torque of the motor. • Unit - mNm	UDINT	ro	Yes

7.3.12 0x6077: Torque actual value

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the actual torque of the motor. • Unit - 0.1% of rated torque	INT	ro	Yes

7.3.13 0x6079: DC link circuit voltage

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the actual value of the 24V DC bus. • Unit - 0.1V	DINT	ro	Yes

7.3.14 0x607A: Target position

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the target position of the motor. • Unit - pulses (50,000 pulses/ revolution) • Used in CSP and CML modes	DINT	rw	Yes

7.3.15 0x607C: Home offset

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the offset after a home switch/ hardstop has been found. • Unit - pulses (50,000 pulses/ revolution) • Internally will be rounded to the closest 100. • Used in homing mode	DINT	rw	No

7.3.16 0x6081: Profile velocity

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the target velocity in profile position mode • Unit - pulses/s (50,000 pulses/ revolution) • Used in profile position mode	UDINT	rw	Yes

7.3.17 0x6083: Profile acceleration

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the profile acceleration. • Unit - pulses/s^2 (50,000 pulses/ revolution) • Used in profile position and profile velocity modes	UDINT	rw	Yes

7.3.18 0x6084: Profile deceleration

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the profile deceleration in profile velocity mode. • Unit - pulses/s^2 (50,000 pulses/ revolution) • Used in profile velocity mode	UDINT	rw	No

7.3.19 0x6098: Homing method

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the method of the home routine. • 0: No home routine selected • -1: Hardstop CW • -2: Hardstop CCW • -3: Input 2 sensor CW • -4: Input 2 sensor CCW • -5: Input 3 sensor CW • -6: Input 3 sensor CCW	SINT	rw	No

7.3.20 0x6099: Homing speeds

Sub-index	Description	Type	Access	PDO Mapping
0x00	Highest sub-index supported	SINT	rw	No
0x01	Speed during search for switch or hardstop • The homing speed is written to an internal register which has a unit of 100 pulses/s.	UDINT	rw	No

Sub-index	Description	Type	Access	PDO Mapping
	The value written into 0x6099:01 will be rounded to the closest 100. • Used in homing mode			
0x02	N/A Speed during search for 0 uses the same speed as search for switch/hardstop	UDINT	rw	No

7.3.21 0x609A: Homing acceleration

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the homing acceleration in homing mode. • Unit - pulses/s^2 (50,000 pulses/ revolution) • The homing acceleration is written to an internal register which has a unit of 1000 pulses/s. The value written into 0x609A will be rounded to the closest 1000. • Used in homing mode	UDINT	rw	No

7.3.22 0x60F6: K Parameter Settings

Sub-index	Description	Type	Access	PDO Mapping
0x00	Highest sub-index supported = 0x51 (81_d)	USINT	rw	No
0x51 ... 0x51	K parameter settings. • See standard Cool Muscle documentation for details • Typically these parameters do not need to be modified as the current profile mode changes them directly as required.	UINT	rw	No

7.3.23 0x60FB: H Parameter Settings (Tuning Parameters)

Sub-index	Description	Type	Access	PDO Mapping
0x00	Number of entries	UINT	ro	No

Sub-index	Description	Type	Access	PDO Mapping
0x01	H0	INT	rw	No
0x02	H1	INT	rw	No
0x03	H2	INT	rw	No
0x04	H3	INT	rw	No
0x05	H4	INT	rw	No
0x06	H5	INT	rw	No
0x07	H6	INT	rw	No
0x08	H7	INT	rw	No
0x09	H8	INT	rw	No

- The H parameters are stored in non-volatile memory in the drive. The value will be retained on power down and do not need to be reloaded after a power cycle.
- Information on the H infinity parameters can be found in the RT3 user manual - Motor Tuning.

7.3.24 0x60FD: Digital inputs

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the status of the inputs	UINT	ro	Yes

Bit	7	6	5	4	3	2	1	0
INPUT	-	-	-	-	4	3	2	1

7.3.25 0x60FE: Digital outputs

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the digital output	UINT	rw	Yes

Bit	7	6	5	4	3	2	1	0
OUTPUT	-	-	-	-	-	-	-	OUT1

- Output 1 is driven by 0x60FD
- Output 2 is driven by the motor driver depending on the K34 value. See K Parameters for additional information. Example
    - Set K34=20 for alarm output
    - Set K34=10 for inposition signal output.

7.3.26 0x60FF: Target velocity

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the target velocity of the motor. • Unit - pulses/ms (50,000 pulses/ revolution) • Used in CSV, PV and CML modes	DINT	rw	Yes

7.3.27 0x6502: Supported drive modes

Sub-index	Description	Type	Access	PDO Mapping
0x00	Shows support drive modes Value = 0x1A5 *Bit0 = 1: PP mode* Bit1 = 0: VL mode *Bit2 = 1: PV mode* Bit3 = 0: TQ mode Bit4 = 0: reserved *Bit5 = 1: HM mode* Bit6 = 0: IP mode *Bit7 = 1: CSP mode* *Bit8 = 1: CSV mode* Bit9 = 0: CST mode	UDINT	ro	No

7.4 Manufacturer Specific Objects

7.4.1 0x2201: 32bit User Variables

This object contains 4 volatile variables. Variable1 in addition has BIT15 and BIT14 mapped to the manufacturer specific bits, B15 and B14, on the Statusword (0x6041).

An example of usage would be if the application requires a custom home routine. These bit could be set as a flag to indicate the home routine has been completed. Due to the volatile nature of the variables if a reset occurs on the drive the flag bit would be reset.

Sub-index	Description	Type	Access	PDO Mapping
0x00	Number of entries	UINT	ro	No
0x01	Variable1	DINT	rw	BIT15 and B14 are mapped to the Statusword 0x6041 BIT15 and B14.
0x02	Variable2	DINT	rw	No
0x03	Variable3	DINT	rw	No
0x04	Variable4	DINT	rw	No

7.4.2 0x2301: Drive temperature

Sub-index	Description	Type	Access	PDO Mapping
0x00	Read the drive temperature • Unit - degrees C	INT	ro	Yes

7.4.3 0xFE00: PDO Timing

The PDO time is autodetected by the slave. The detected time can be read in 0xFE00.

Only PDO rates of 200µs, 250µs, 500µs and 1000µs (1ms) are accepted by the CM1-E.

Sub-index	Description	Type	Access	PDO Mapping
0x00	Number of entries	UINT	ro	No
0x01	PDO Time in µs	UINT	ro	No
0x02	N/A	UINT	ro	No
0x03	N/A	UINT	ro	No
0x04	N/A	UINT	ro	No

7.4.4 0xFF00: Status LED brightness

Sub-index	Description	Type	Access	PDO Mapping
0x00	Set the brightness of the system and motor status LED.This is a non-volatile object that is stored in memory.	SINT	rw	No

Sub-index	Description	Type	Access	PDO Mapping
	• Range [0,16] • 0 - OFF • 1 - minimum brightness (default) • 16 - maximum brightness			

7.4.5 0xFF01: Status LED Override

Sub-index	Description	Type	Access	PDO Mapping
0x00	Override the status LED colour and flash. This allows the user to use the status LED to indicate custom operations such as identify a motor in a large axes application.	UDINT	rw	No

Byte Description

	Byte3	Byte2	Byte1	Byte0
Description	Red LED on/off	Green LED on/off	Blue LED on/off	Override on/off Bit 0 - override on/off Bit 1 - flash on/off
Values	0x00 - Red OFF 0x01 - Red ON	0x00 - Green OFF 0x01 - Green ON	0x00 - Blue OFF 0x01 - Blue ON	0x00 - No override 0x01 - Override with solid colour defined in bytes 3-1 0x03 - Override with flash colour defined in bytes 3-1

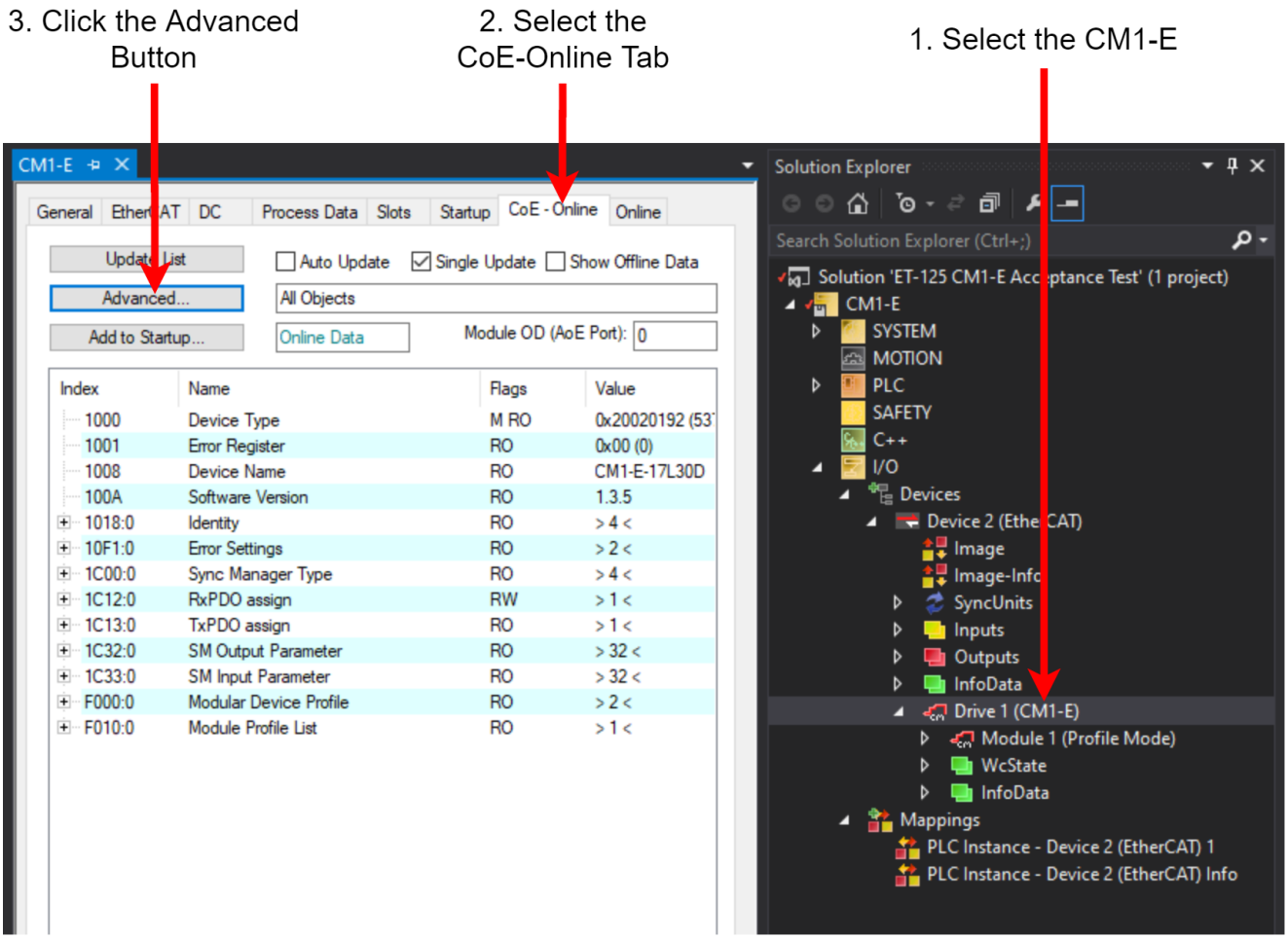
Example Values

- 0xFF01 = 0x01010101 - LED will turn solid white
- 0xFF01 = 0x01000003 - LED will flash red

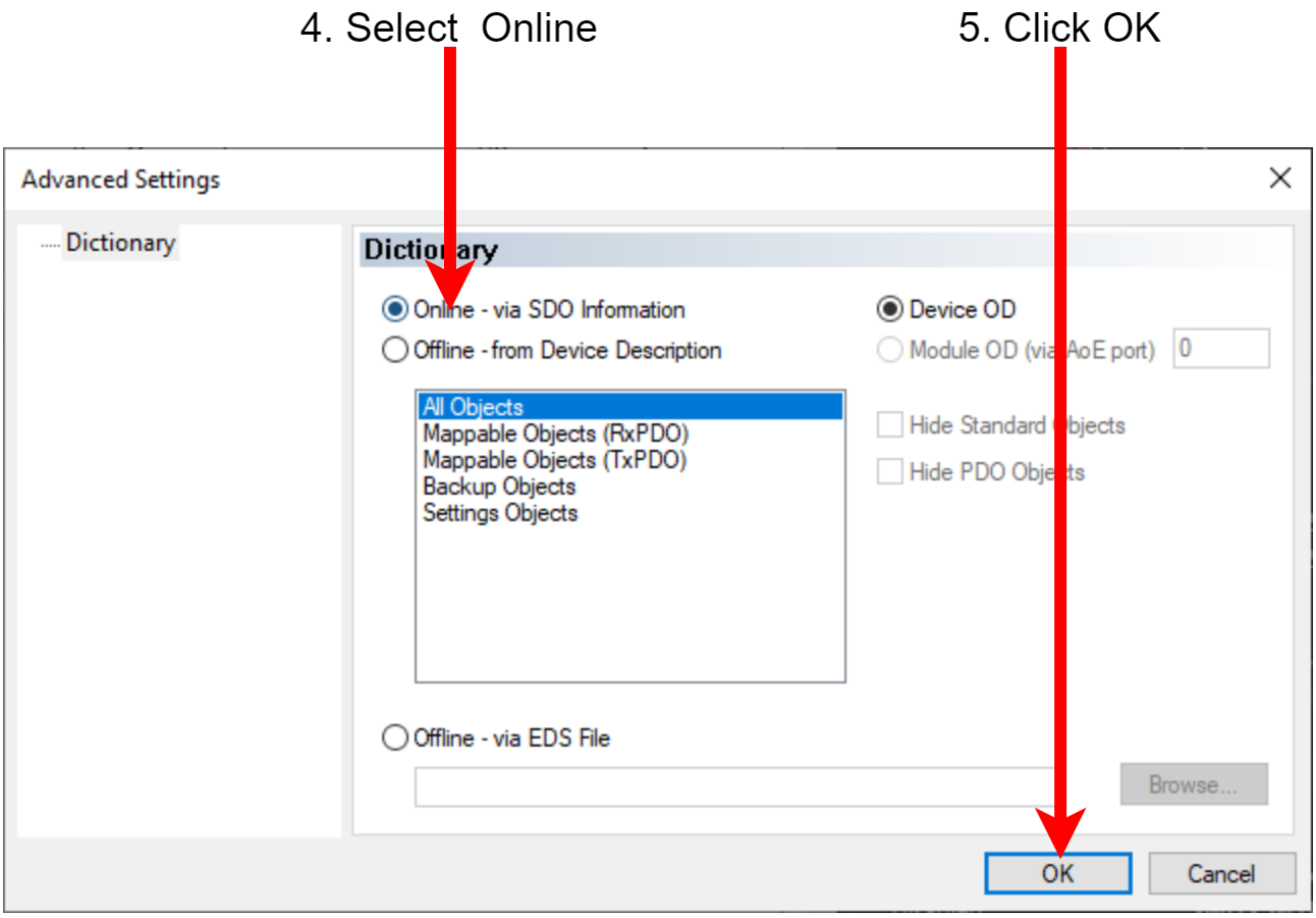
7.5 Accessing the Objects in TwinCAT3

The following instructions show how to read/write the objects in TwinCAT3 through the online object dictionary. It assumes a CM1-E drive has already been added.

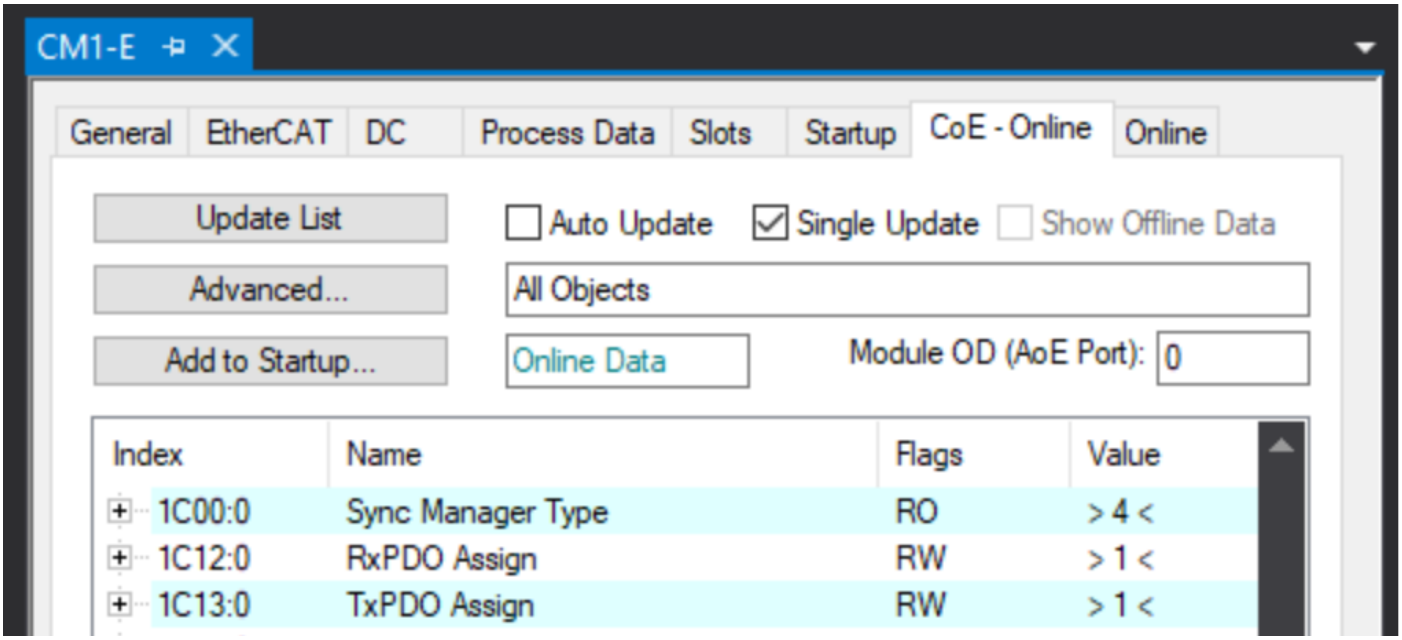
1. In the Solution Explorer select the CM1-E drive
2. Select the CoE-Online tab. Only the objects listed in the EDS are currently listed.
3. Click the Advanced button to enable reading all objects.

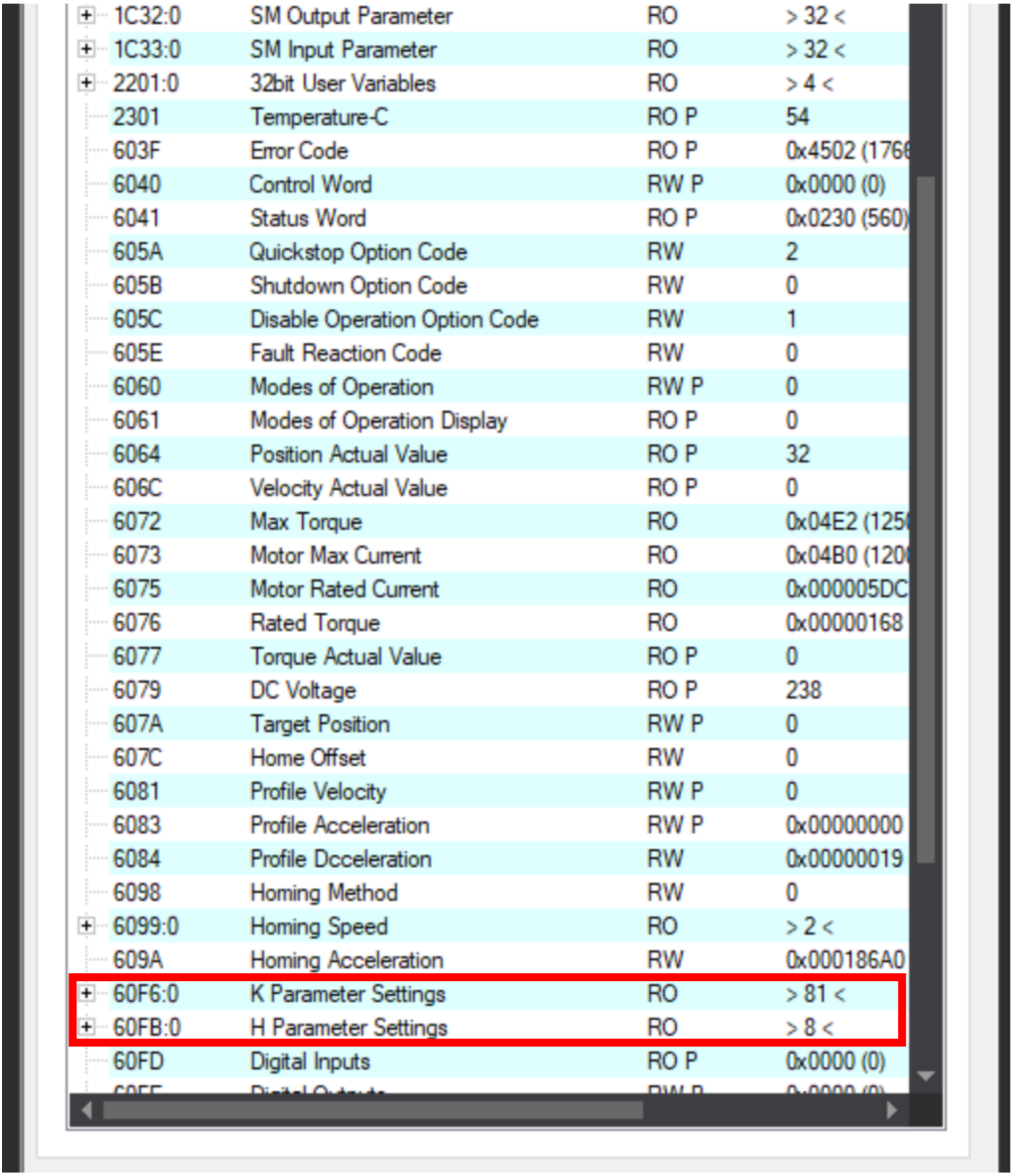


4. Select the Online radio button
5. Click OK



The full object dictionary is now available. The K and H parameters are shown below in red. Expand the list to see all the parameters.





1C32:0	SM Output Parameter	RO	> 32 <
1C33:0	SM Input Parameter	RO	> 32 <
2201:0	32bit User Variables	RO	> 4 <
2301	Temperature-C	RO P	54
603F	Error Code	RO P	0x4502 (176
6040	Control Word	RW P	0x0000 (0)
6041	Status Word	RO P	0x0230 (560)
605A	Quickstop Option Code	RW	2
605B	Shutdown Option Code	RW	0
605C	Disable Operation Option Code	RW	1
605E	Fault Reaction Code	RW	0
6060	Modes of Operation	RW P	0
6061	Modes of Operation Display	RO P	0
6064	Position Actual Value	RO P	32
606C	Velocity Actual Value	RO P	0
6072	Max Torque	RO	0x04E2 (125
6073	Motor Max Current	RO	0x04B0 (120
6075	Motor Rated Current	RO	0x000005DC
6076	Rated Torque	RO	0x00000168
6077	Torque Actual Value	RO P	0
6079	DC Voltage	RO P	238
607A	Target Position	RW P	0
607C	Home Offset	RW	0
6081	Profile Velocity	RW P	0
6083	Profile Acceleration	RW P	0x00000000
6084	Profile Dcceleration	RW	0x00000019
6098	Homing Method	RW	0
6099:0	Homing Speed	RO	> 2 <
609A	Homing Acceleration	RW	0x000186A0
60F6:0	K Parameter Settings	RO	> 81 <
60FB:0	H Parameter Settings	RO	> 8 <
60FD	Digital Inputs	RO P	0x0000 (0)

8 CM1-E Certifications

8.1 CE Declaration

- CM1-E / CM1-T CE Declaration of Conformity
- CM1M9 CE Declaration of Conformity

9 Data Sheets and MCAD

9.1 MCAD 3D Models

For additional 3D formats please contact Myostat support (support@myostat.ca).

CM1-E-17L30 MCAD

CM1-E-17S30 MCAD

CM1-E-23L20 MCAD

CM1-E-23S30 MCAD

9.2 Datasheets

9.2.1 CM1-E-17

CM1-E-17X30D rev 1.3.pdf

9.2.2 CM1-E-23

CM1-E-23XX0D rev 1.2.pdf

10 XML File and Firmware Updates

10.1 Version Information

Version #	Update Information	XML
V1.3.5	Revision #: 0x20020103 (No XML update. Revision number is not changed) 1. Bug Fixes a. Statusword error bit not asserted on 0x7510 error The statusword error bit was only not asserted if there was a communication problem to the drive on power up. Changes i. Clearing the fault on a power up fault will reset the MCU in an attempt to initiate communication. If the fault reset bit remains active and the fault occurs again a reset will occur again. This process will repeat itself. ii. Clearing the fault if it occurs during regular runtime will not reset the MCU. Alternate methods are attempted in this case that do not require a reset. b. Motion not occuring in CSV, CSP or Profile Velocity though the drive indicates it is. Changes i. EtherCAT slave switches modes and has additional checks before sending data to the drive	Myostat_CM1-E (V1.3.0)_MDP.xml Myostat_CM1-E (V1.3.0)_FLAT.xml
V1.3.4	Revision #: 0x20020103 (No XML update. Revision number is not changed) 1. Feature updates a. Object 0x2201 added. Object is 4 volatile 32 bit registers that can be used as variables. Variable 1 BIT15 and BIT14 are mapped to the Statusword (0x6041). This allows the bits to be used as flags. For example a homing complete flag.	Myostat_CM1-E (V1.3.0).xml
V1.3.3	Revision #: 0x20020103 (No XML update. Revision number is not changed) 1. Feature updates a. Target velocity in CSV mode is now in count/s. Previously it was counts/ms b. Velocity Actual Value is now in counts/s. Previously was in counts/ms	Myostat_CM1-E (V1.3.0).xml
V1.3.2	Revision #: 0x20020103 (No XML update. Revision number is not changed) 1. Feature updates a. PDO communication rate now includes multiple periods. i. Specifically 200us, 250us, 500us and 1ms. ii. No setting is required on the slave/drive which autodetects the rate. 2. Bug fixes a. OUT LED indicator fixed.	Myostat_CM1-E (V1.3.0).xml

Version #	Update Information	XML
V1.3.0	Revision #: 0x20020103 1. Feature Updates a. SM and PDI watchdog implemented. The motor will disable if a watchdog timeout is encountered b. *Mode of Operation* and *Mode of Operation Display* have been added to the Profile Mode RxPDO and TxPDO respectively. c. Statusword BIT12 is implemented for CSV and CSP mode. BIT12 indicates if the drive is following the commanded position. d. EEPROM data is included in the update and will load automatically. e. Revision # is updated with each release. The matching XML is required. This allows for multiple version on the same network. 2. Bug fixes a. Halt bit on Homing Mode would not halt the motor when switching modes at the same time. b. Speed for HM and PP mode is now correctly returned. It was 1/4 or the actual value. 3. General improvements on task handling and timing.	Myostat_CM1-E (V1.3.0).xml
V1.2.0	1. Feature Updates a. F/W update through FoE in Bootstrap. b. Object 0xFF01 - Status LED override 2. Bug Fixes a. SDO objects now available in all ESM states. In previous versions the entire dictionary was not available until the slave had transitioned into OP at least one.	Please contact support
V1.1.3	1. Added support for Explicit Device ID 2. Improved SDO data transfer	
V1.1.2	1. Improved USB communication for a. Changing H gain parameters b. Running the motor in CML mode c. Updating firmware	

For information on how to update the CM1-E firmware please contact Myostat support

- Support Portal
- support@myostat.ca
- +1 905 836-4441

11 EtherCAT Master Examples

11.1 TwinCAT

This project uses a PLC visual to run the motor in a number of modes using the standard axis and motion libraries. It is configured to run from a C6017 PLC. This can be changed in the project to a different PLC or local device. The project is archived as .tnzip and can be imported through File → Open → Open Solution from archive

TC CM1-E Demo.tnzip

11.2 Trio Motion Technology

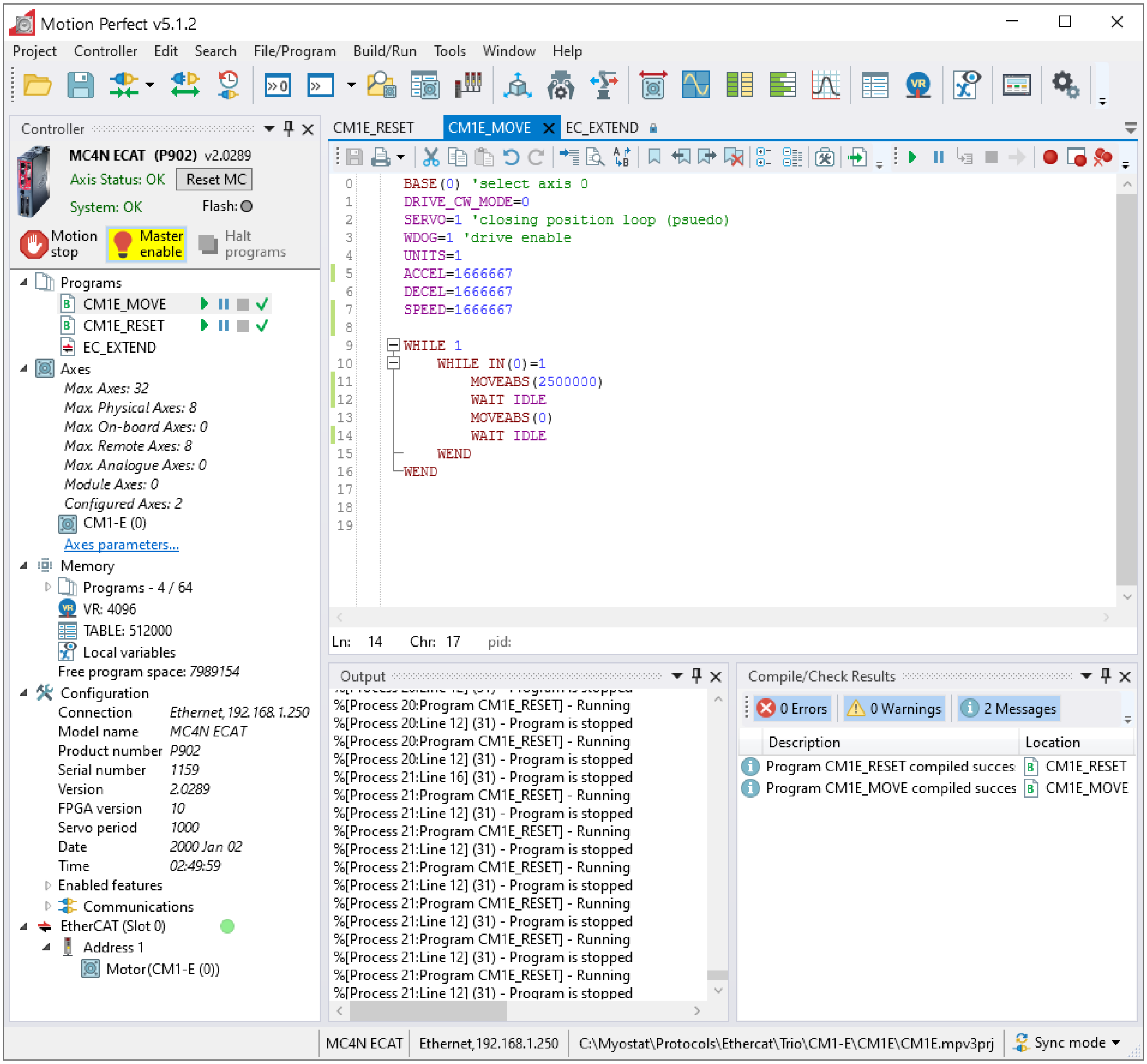
Trio Motion Technology have a series of EtherCAT master controllers. The following example use the MC4N-ECAT to control the CM1-E.

The CM1-E utilizes the EC_EXTEND.txt file to add the CM1-E as a slave device. The sample EC_EXTEND can be found in the example project.

CM1-E Motion Perfect Example .zip

11.2.1 Motion Perfect Sample

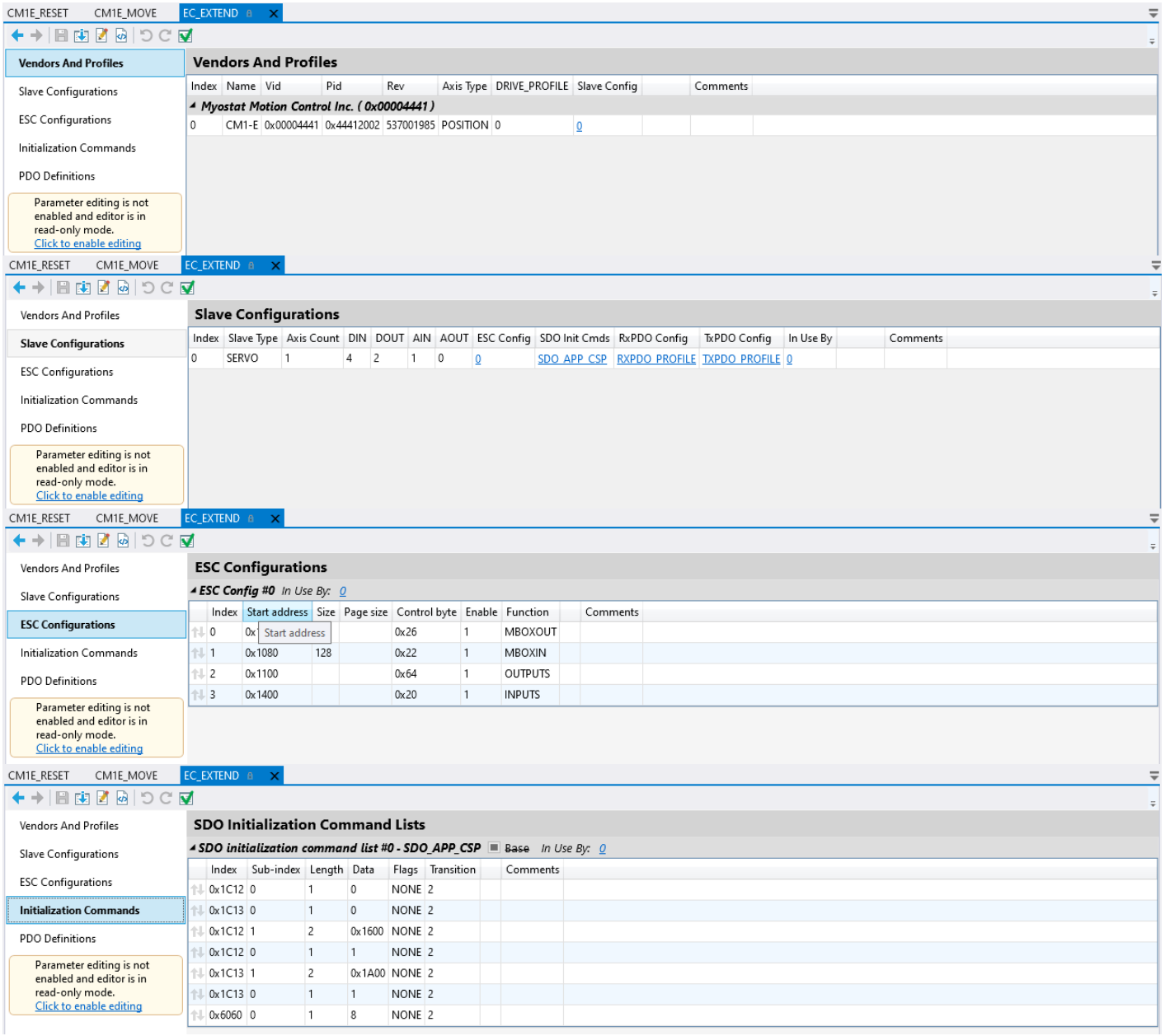
The project sample includes the EC_EXTEND, a move program and a reset from error program.

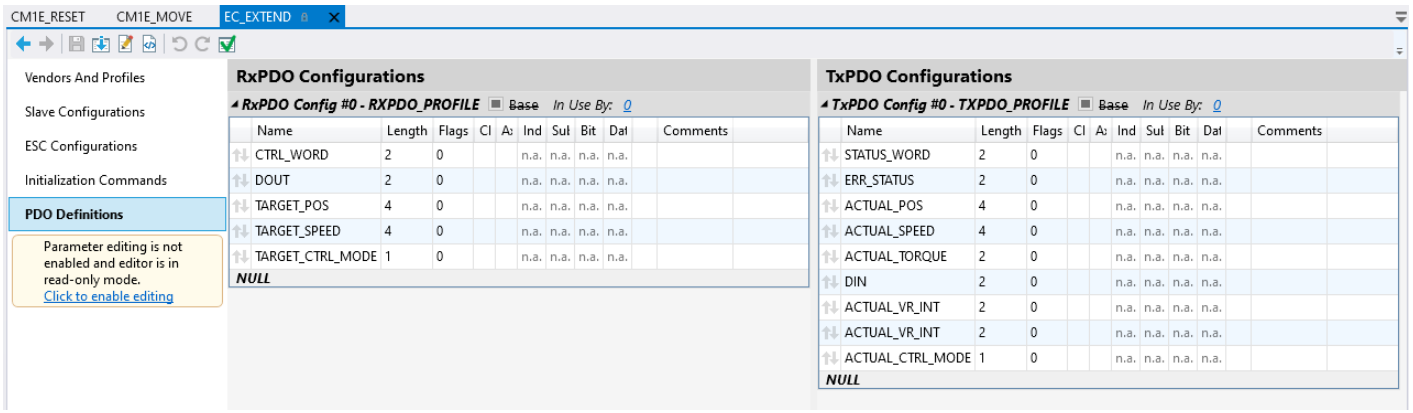


EC_EXTEND

The EC_EXTEND.txt can be used or can be setup as per the following images. The easiest method for is to import the CM1-E xml and then do a few small modifications to the PDO Definitions to match the images below.

The xml can be found here Myostat_CM1-E (V1.3.0).xml


CM1E_RESET
CM1E_MOVE
EC_EXTEND
Vendors And Profiles
Slave Configurations
ESC Configurations
Initialization Commands
PDO Definitions
Parameter editing is not enabled and editor is in read-only mode.
Click to enable editing
Vendors And Profiles
Index Name Vid Pid Rev Axis Type DRIVE_PROFILE Slave Config Comments
Myostat Motion Control Inc. (0x00004441)
0 CM1-E 0x00004441 0x44412002 537001985 POSITION 0 0
Slave Configurations
Index Slave Type Axis Count DIN DOUT AIN AOUT ESC Config SDO Init Cmds RxPDO Config TxPDO Config In Use By Comments
0 SERVO 1 4 2 1 0 0 SDO_APP_CSP RXPDO_PROFILE TXPDO_PROFILE 0
ESC Configurations
ESC Config #0 In Use By: 0
Index Start address Size Page size Control byte Enable Function Comments
0 0x Start address 0x26 1 MBOXOUT
1 0x1080 128 0x22 1 MBOXIN
2 0x1100 0x64 1 OUTPUTS
3 0x1400 0x20 1 INPUTS
SDO Initialization Command Lists
SDO initialization command list #0 - SDO_APP_CSP Base In Use By: 0
Index Sub-index Length Data Flags Transition Comments
0x1C12 0 1 0 NONE 2
0x1C13 0 1 0 NONE 2
0x1C12 1 2 0x1600 NONE 2
0x1C12 0 1 1 NONE 2
0x1C13 1 2 0x1A00 NONE 2
0x1C13 0 1 1 NONE 2
0x6060 0 1 8 NONE 2


CM1E_RESET
CM1E_MOVE
EC_EXTEND
Vendors And Profiles
Slave Configurations
ESC Configurations
Initialization Commands
PDO Definitions
Parameter editing is not enabled and editor is in read-only mode.
Click to enable editing
RxPDO Configurations
RxPDO Config #0 - RXPDO_PROFILE
Base
In Use By: 0
Name Length Flags Comments
CTRL_WORD 2 0
DOUT 2 0
TARGET_POS 4 0
TARGET_SPEED 4 0
TARGET_CTRL_MODE 1 0
NULL
TxPDO Configurations
TxPDO Config #0 - TXPDO_PROFILE
Base
In Use By: 0
Name Length Flags Comments
STATUS_WORD 2 0
ERR_STATUS 2 0
ACTUAL_POS 4 0
ACTUAL_SPEED 4 0
ACTUAL_TORQUE 2 0
DIN 2 0
ACTUAL_VR_INT 2 0
ACTUAL_VR_INT 2 0
ACTUAL_CTRL_MODE 1 0
NULL