



Getting Started

A guide for using a Control Techniques drive with a Beckhoff PLC over EtherCAT



Contents

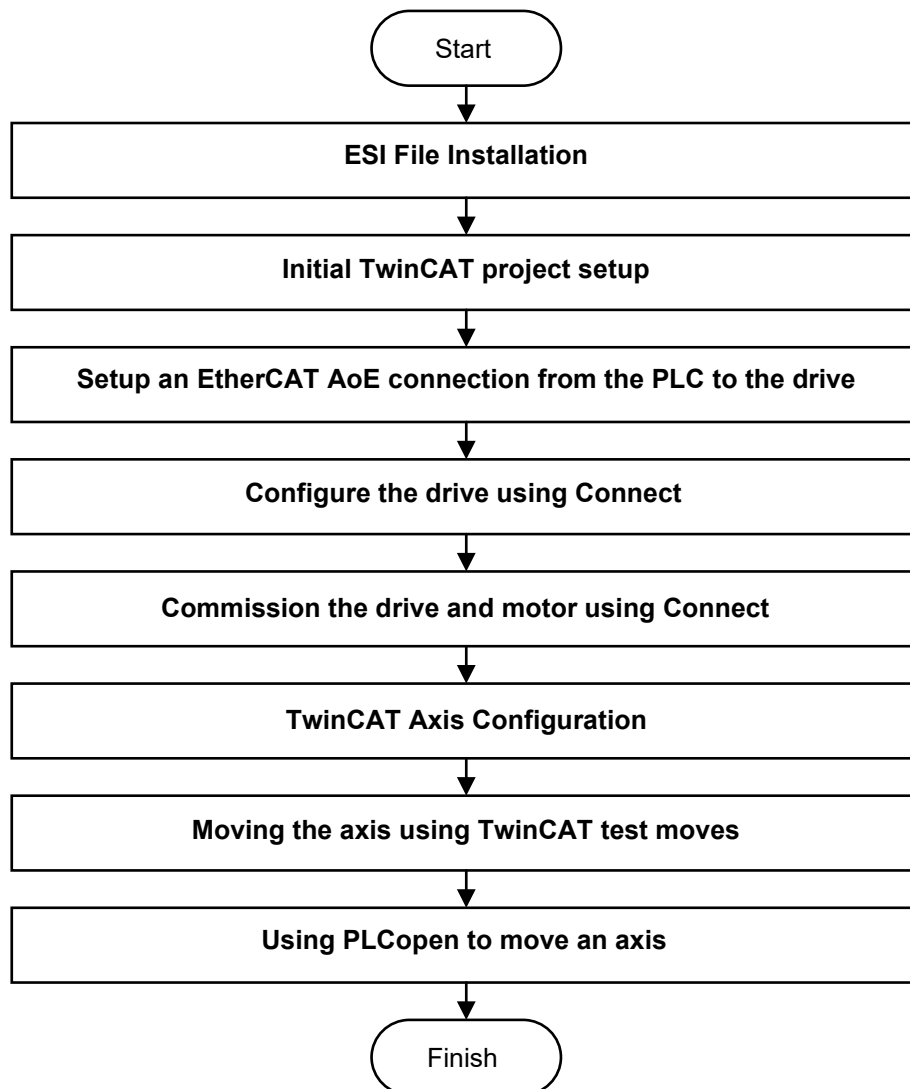
1	INTRODUCTION	4
2	ESI FILE INSTALLATION	5
3	INITIAL TWINCAT PROJECT SETUP	6
4	SETUP AN ETHERCAT AOE CONNECTION FROM THE PLC TO THE DRIVE	12
5	CONFIGURE THE DRIVE USING CONNECT	16
6	COMMISSION THE DRIVE AND MOTOR USING CONNECT	27
7	TWINCAT AXIS CONFIGURATION	44
8	MOVING THE AXIS USING TWINCAT TEST MOVES	49
9	USING PLCOPEN TO MOVE AN AXIS	52
10	HOW TO GUIDES	62
10.1	HOW TO HOME USING MC_HOME	62
10.2	HOW TO CONFIGURE PDO MAPPINGS	68
10.2.1	How to map touch probe PDOs	68
10.2.2	How to convert parameter numbers to CANopen object references	74
10.2.3	How pass data between drive parameters and variables using PDOs	78
10.2.4	How to map a drive encoder to an NC encoder axis	83
10.3	HOW TO VIEW CAN OBJECTS	89
10.3.1	MC_Power Disabled and Drive Disabled	90
10.3.2	MC_Power Disabled and Drive Enabled	90
10.3.3	MC_Power Enabled and Drive Enabled	90
10.4	HOW TO SETUP AXIS UNIT SCALING AND RESOLUTION	91
10.4.1	How to set the scaling using the startup list in TwinCAT	92
10.4.2	How to scale between NC axis speed and rpm	95
10.5	HOW TO UPGRADE ETHERCAT FIRMWARE	96
10.5.1	How to upgrade the EtherCAT interface firmware using Connect	96
10.5.2	How to use FoE to update the EtherCAT interface firmware	99
10.6	HOW TO SETUP A BECKHOFF IPC	108
10.7	HOW TO REMOVE “???” FROM LD DIAGRAM POU INPUTS AND OUTPUTS	113
10.8	HOW TO USE A STARTUP LIST IN TWINCAT	115
10.8.1	How to import a startup list .xml file from Connect into TwinCAT	115
10.8.2	How to add a single CAN object to the TwinCAT Startup List & Cyclic comms loss action	119
10.9	HOW TO SETUP AN ETHERCAT EoE CONNECTION	122
10.10	HOW AND WHEN TO TUNE THE POSITION LOOP	127
10.11	HOW AND WHEN TO USE INERTIA COMPENSATION	129
10.12	HOW TO SET UP A DUAL LOOP SYSTEM	131
11	ADDITIONAL INFORMATION	138
11.1	MECHANICAL BRAKE CONTROLLER LOGIC	138

11.1.1	RFC-S closed-loop permanent-magnet motor brake controller	138
11.1.2	RFC-A closed-loop induction motor brake controller	140
.....		142

1 Introduction

This document guides the user through the required steps, within Control Techniques Connect software and Beckhoff's TwinCAT IDE, to get a NC motion control axis working with a Control Techniques drive over EtherCAT.


The steps required to get the axis working are as follows:



The end result is a Control Techniques drive that can be used with the NC axis motion control function blocks included with TwinCAT.

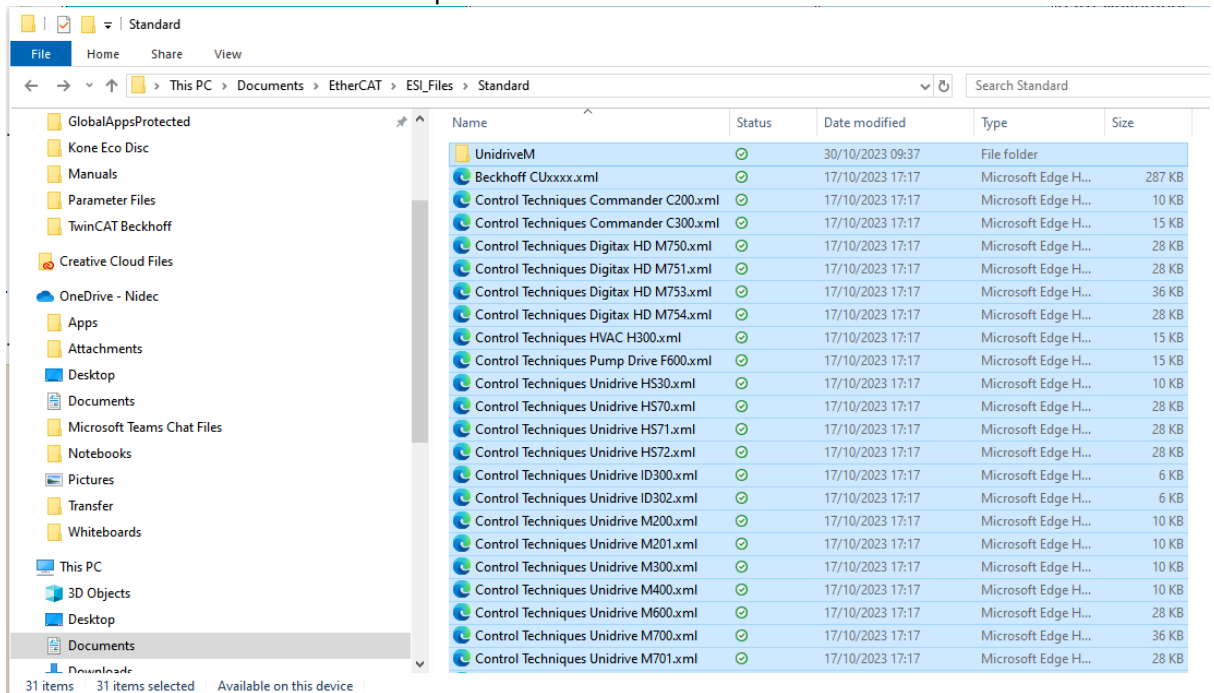
HINT: The ESI file **must** match the firmware of the EtherCAT module. Section **10.5 How to upgrade EtherCAT Firmware**.

HINT: The information in this manual is backed up by training videos on [YouTube](#).

 [Nidec Drives Support - YouTube](#)

2 ESI File Installation

1. Get the latest ESI files from the Control Techniques Section of the Nidec Drives [website](#) and extract the contents of the .zip file.
2. Make sure that TwinCAT is not running. Close the program if it is.
3. Extract the contents of the ESI file zip.



Copy the contents of the zip to "C:\TwinCAT\3.1\Config\Io\EtherCAT" or for newer installations of TwinCAT "C:\Program Files (x86)\Beckhoff\TwinCAT\3.1\Config\Io\EtherCAT"

4. When TwinCAT is next run, it will recognise Control Techniques drives after a "Scan".

HINT: The ESI file **must** match the firmware of the EtherCAT module. See section **10.5 How to upgrade EtherCAT Firmware**.

HINT: If the ESI files don't match the firmware in the EtherCAT option, after scanning the network and adding the EtherCAT master in the "I/O" section, the drives will appear as "Box 1", "Box 2" etc.

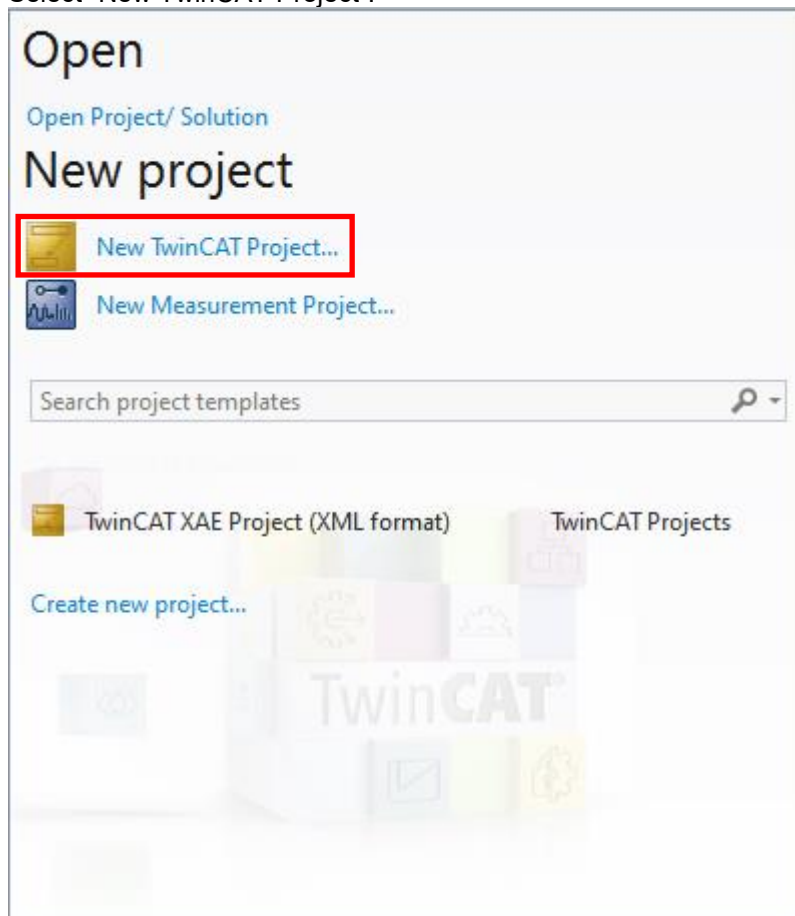
3 Initial TwinCAT project setup

This section shows the first steps required to get connected to a Beckhoff PLC/IPC.

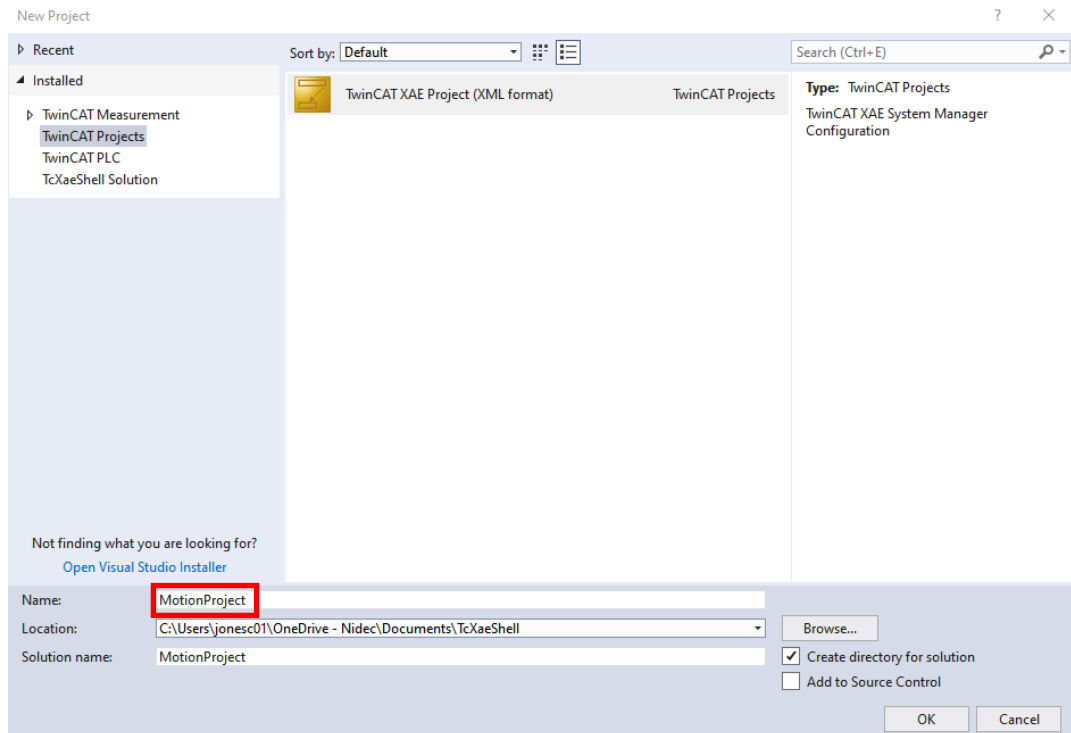
1. Start TwinCAT. For the purposes of these examples the TwinCAT XAE Shell will be used to run the TwinCAT IDE. This is available even if the PC doesn't have Visual Studio installed.



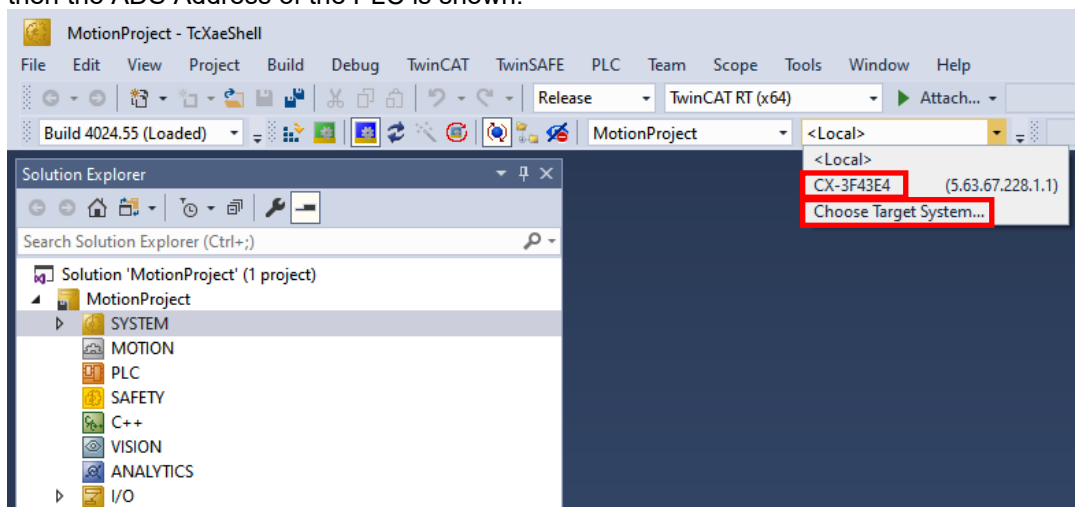
2. Select "New TwinCAT Project":



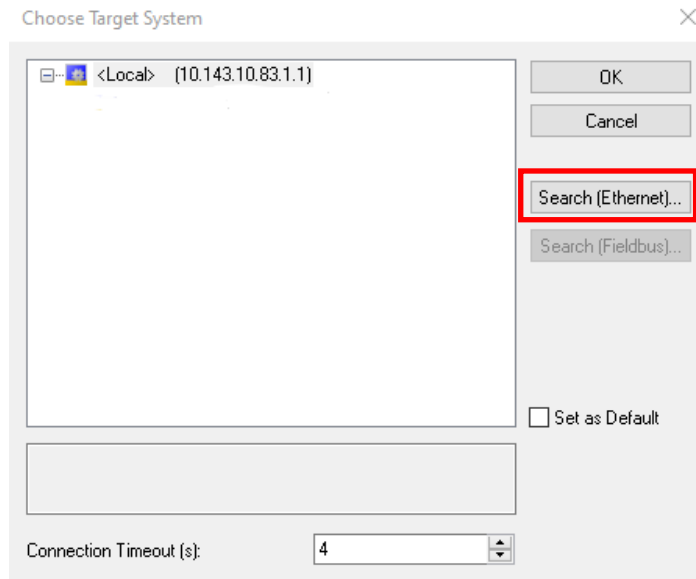
3. Give the project a sensible name e.g. “MotionProject” and then click “OK”.



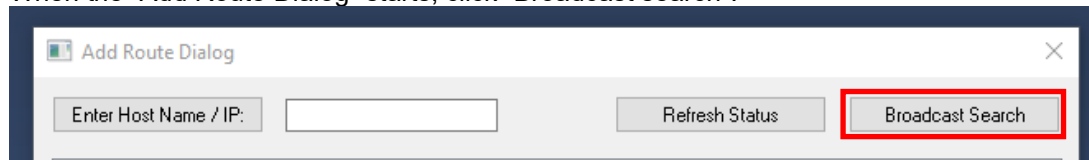
4. Select the target PLC. If your PLC has previously been connected to a TwinCAT project, then the ADS Address of the PLC is shown.



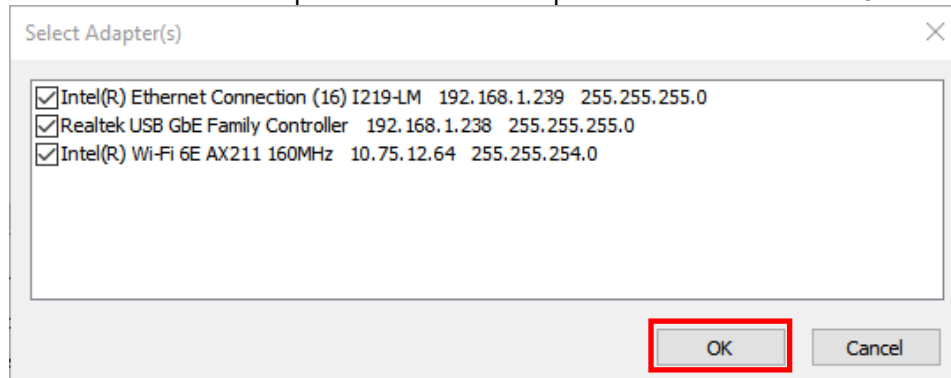
If the PLC hasn't previously been connected to a TwinCAT project, then select “Choose Target System...” and then “Search (Ethernet)” from the “Choose Target System” dialog.



5. When the “Add Route Dialog” starts, click “Broadcast search”.



and then select the adapter to search for compatible devices and click “OK”:



6. Select the PLC to connect to and then click “Add Route” and then “Close”.

Host Name	Connected	Address	AMS NetId	TwinCAT	OS Version	Fingerprint
CX-3F43E4	x	192.168.1.207	5.63.67.228.1.1	3.1.4024	Win CE (6.0)	479844A5153EE417577787572F28
CX-3F43E4	x	192.168.1.207	5.63.67.228.1.1	3.1.4024	Win CE (6.0)	479844A5153EE417577787572F28

Route Name (Target): CX-3F43E4

Route Name (Remote): GBNEWGRD1384

AmsNetId: 5.63.67.228.1.1

Virtual AmsNetId (NAT):

Transport Type: TCP_IP

Address Info: 192.168.1.207

☐ Host Name ☒ IP Address

Connection Timeout (s): 5

Max Fragment Size (kByte): 0

Target Route: ☐ Project ☒ Static ☐ Temporary

Remote Route: ☐ None / Server ☒ Static ☐ Temporary

☒ Advanced Settings ☐ Unidirectional

Add Route Close

HINT: If there is an Administrator password challenge the default password is “1”

Click “Yes” if the message below appears:

TcXaeShell

Active solution platform 'TwinCAT RT (x64)' differs from new target platform 'TwinCAT RT (x86)'!

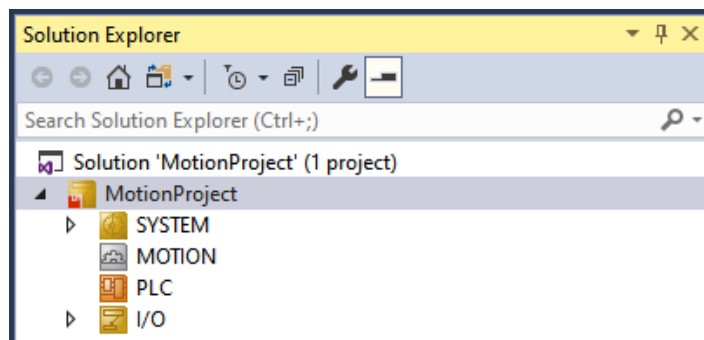
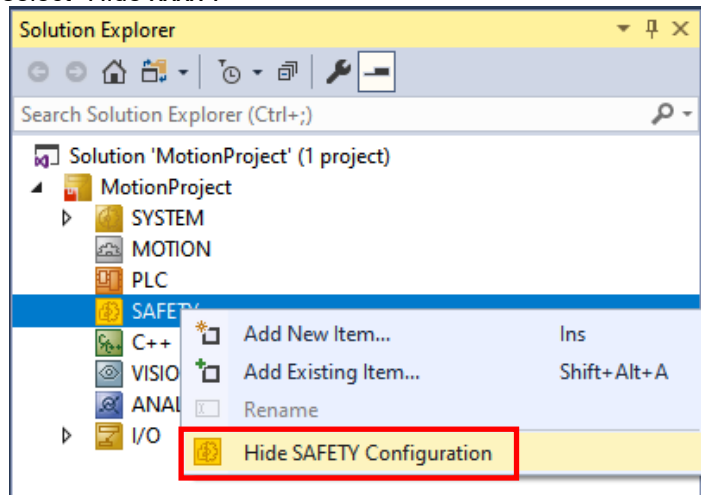
Change solution platform?

Yes No

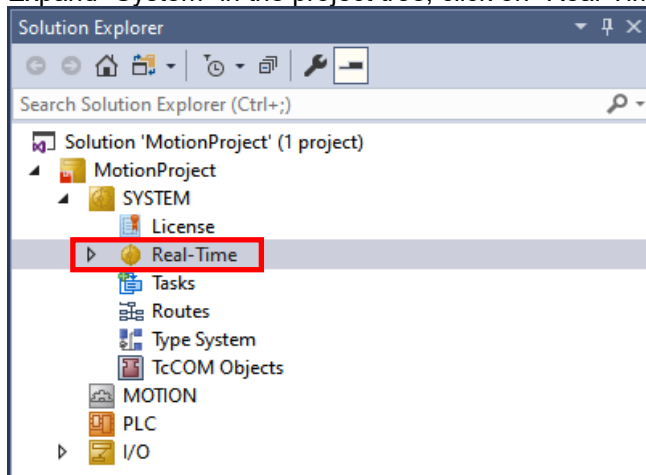
HINT: For brand new IPCs it is likely that the runtime hasn't been installed, and that the EtherCAT port hasn't been assigned. See section 10.6 How to setup a Beckhoff IPC

If this doesn't allow connection, Ping the IP address for the device or connect via Remote Desktop to ensure the connection to the PC is good. Then enter the IP address into the “Enter Host Name / IP:” and press enter.

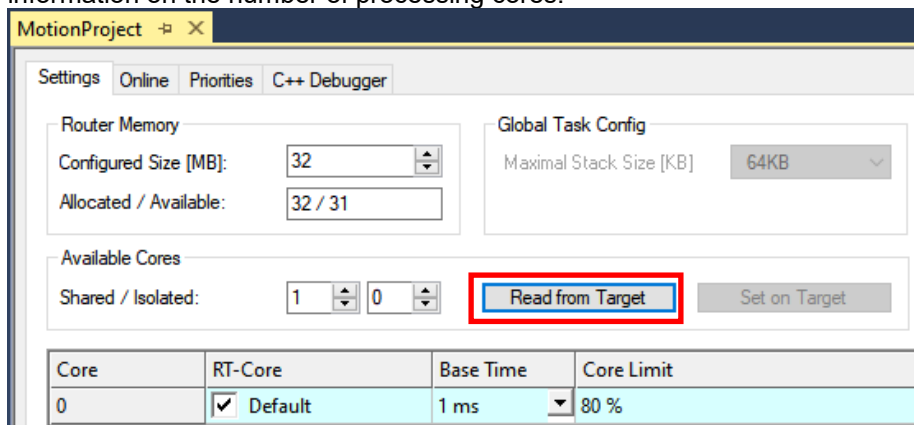
7. An optional step is to clean up any unrequired items from the project tree e.g. this example doesn't require Safety, C++, or Vision etc. To do this right click on the item and select "Hide xxxx".




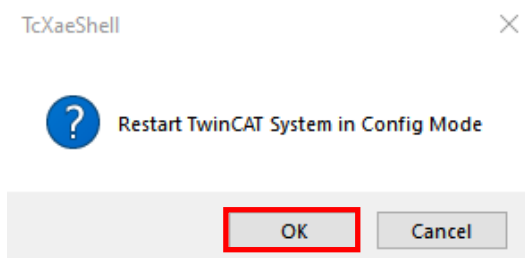
8. Expand “System” in the project tree, click on “Real-Time”:



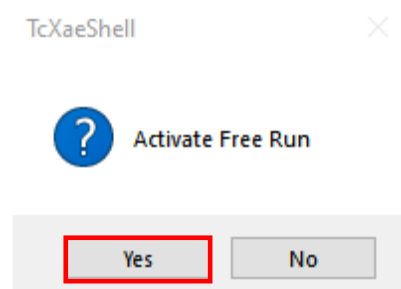
When the project settings tab appears, Select “Read from Target” to update the information on the number of processing cores.



9. Make sure the TwinCAT is in Config Mode by clicking on  in the tool bar and then click “OK” when prompted with the “Restart TwinCAT system in Config Mode” message:



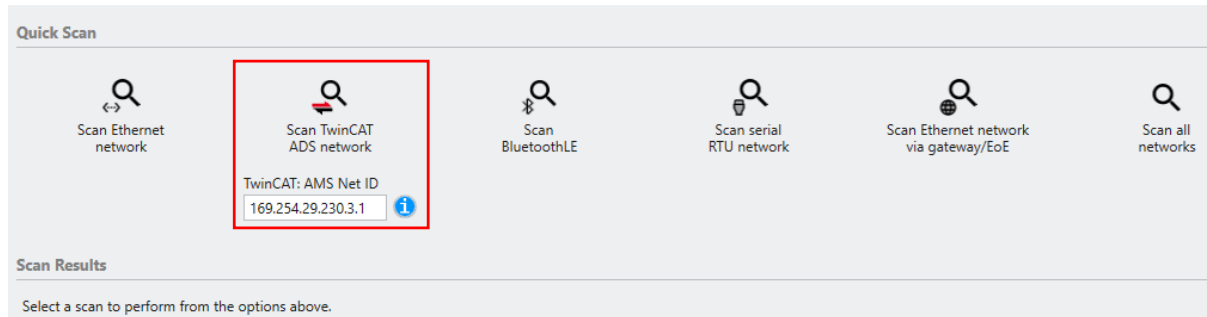
Failure to do this may result in the “Scan” feature being greyed out. Click “Yes” to the “Activate Free Run” pop-up.



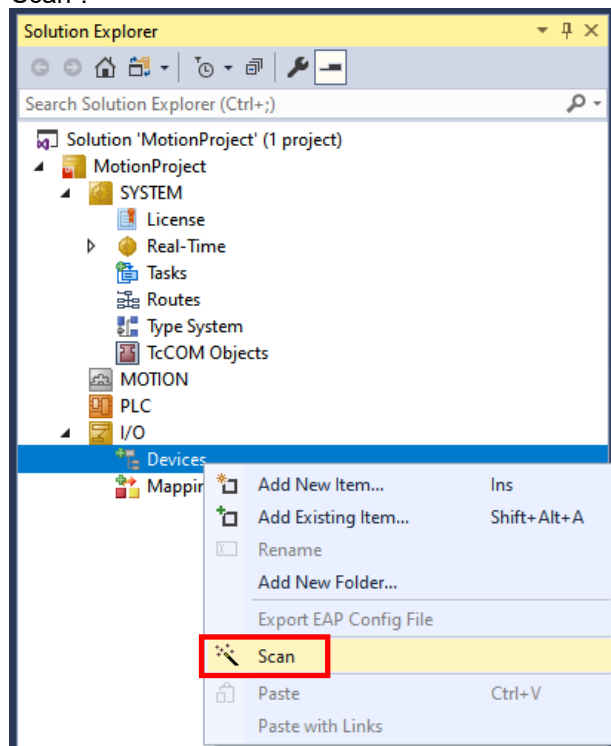
4 Setup an EtherCAT AoE connection from the PLC to the drive


An EtherCAT AoE (ADS over EtherCAT) connection allows communications between the drive(s) and the Connect PC tool in systems where the only communications connection to the drives is EtherCAT.

In the latest version of Connect it is possible to access the drive using the EtherCAT masters AMS network ID:



1. Expand the “I/O” category in the project tree, and then right click on “Devices” and select “Scan”:

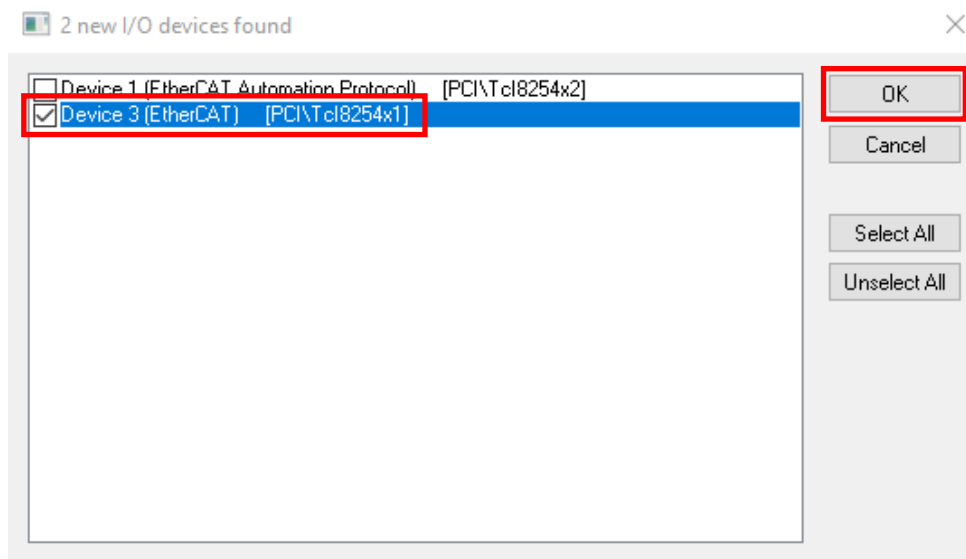


HINT: If “Scan” is greyed out, put TwinCAT in “Config” mode by pressing the following button .

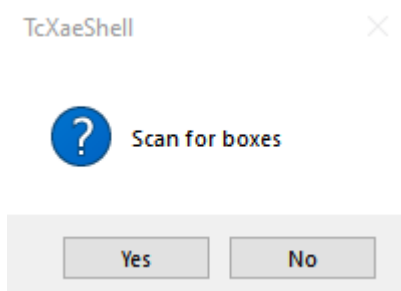
2. Click OK on the message below:



3. Select the “(EtherCAT)” device and then click “OK”.

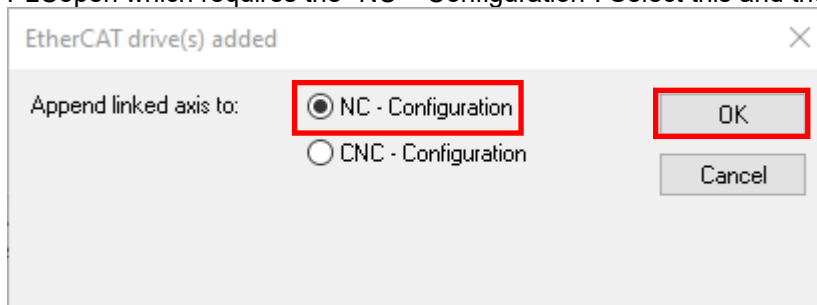


4. Make sure the Control Techniques drive has a suitable Ethernet cable connecting the drives EtherCAT port to the PLC’s EtherCAT port. To use the PLCopen functionality the drive must be either a Unidrive M or a Digitax HD.
5. Next, TwinCAT will prompt the user to scan the network for boxes. In this context, boxes means EtherCAT devices connected to the PLC’s EtherCAT port. Click “Yes” to accept this.

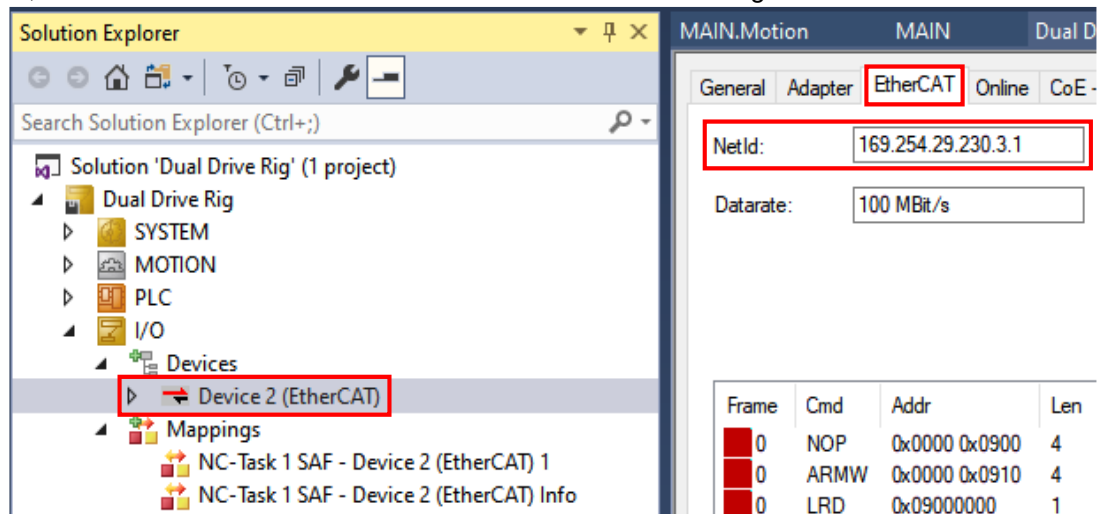


HINT: If there are any issues connecting to the target drives, the ESI files in TwinCAT may not match the firmware in the EtherCAT interface on the drive. The ESI file **must** match the firmware of the EtherCAT module. Section **10.5 How to upgrade EtherCAT Firmware** for details on how to update the firmware.

6. When the axis is found the “EtherCAT drive(s) added” dialog is shown. This guide is for PLCopen which requires the “NC – Configuration”. Select this and then click “OK”.

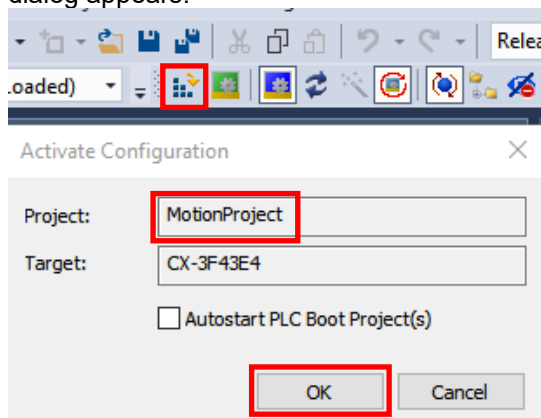


7. When the scan process is completed the PLC/IPC ADS address, (used by Connect), may be located. Double click on the EtherCAT network Master in the Solution Explorer, e.g. “Device 2”, and then select the “EtherCAT” tab. The AMS network ID is given next to “NetId:”.

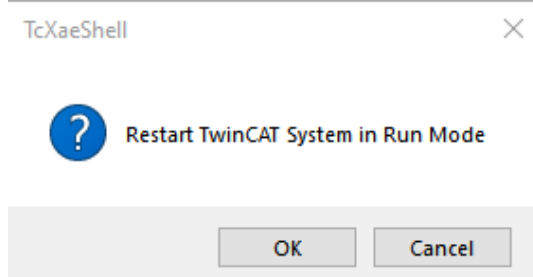


HINT: The EtherCAT port device number varies between different PLCs, depending on the network ports available. In general, the port required will be described as Device (n) (EtherCAT).

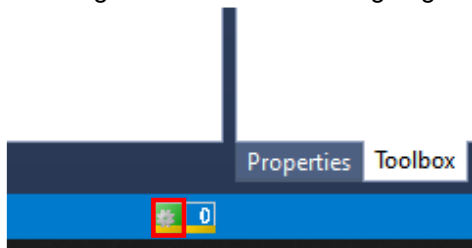
8. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



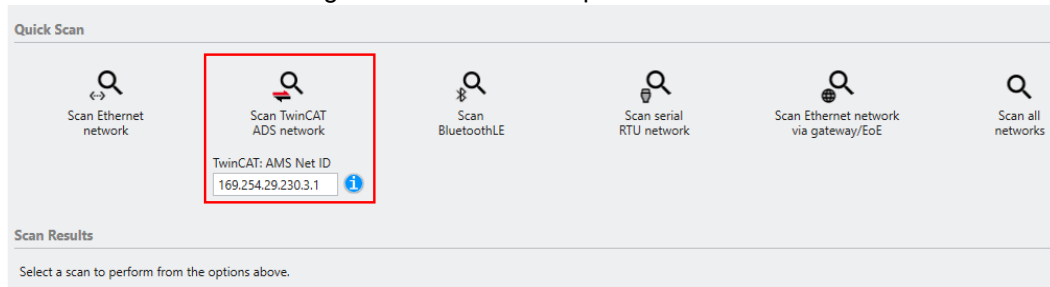
Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



9. If the system is operating properly the status icon in the bottom right corner of TwinCAT will show a green box with a rotating cog:



10. Communications will now be running and Connect will be able to search for the drive(s) on the EtherCAT network using the "NetId:" from step 7.



5 Configure the drive using Connect

Create a new Connect project to configure and commission the drive for the motion application:

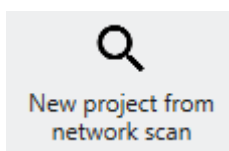
1. Open the Connect PC software by double clicking the “Connect” icon.



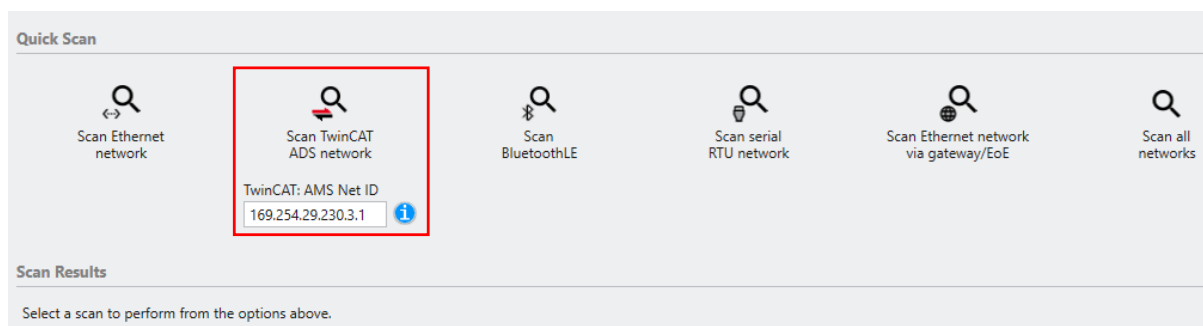
2. Ensure the version of Connect is a minimum V3.0.0. If an earlier version is installed please upgrade to V3.0.0; the software file may be obtained from your local Control Techniques Drive Centre / Distributor or Control Techniques [Support Suite](#).



3. When Connect opens select “New project from network scan”.





4. Select the communications type, such as ADS, to scan that network and locate the drives to be configured:



HINT: Section 4 Setup an EtherCAT AoE connection from the PLC to the drive shows where to get the EtherCAT AMS Net ID / ADS Network ID in TwinCAT.

5. When the scan completes all of the available nodes on the network will be found.

Scan Results

 New project with selected drives  Add selected drives to current project

Project 'My Project 4' will be created in 'C:\Users\jonesc01\OneDrive - Nidec\Documents\Control Techniques\Connect Cobalt'

Name:


Location:

Finished scanning for devices. (2 found.)



✓ Scanning TwinCAT ADS - 2 devices found

<input checked="" type="checkbox"/>	Address	Type	Name	Serial number
<input checked="" type="checkbox"/>	169.254.29.230.3.1:1001	Unidrive M700		123456789
<input checked="" type="checkbox"/>	169.254.29.230.3.1:1002	Unidrive M700		987654321

HINT: For this to be successful on an EtherCAT-based network, the Beckhoff TwinCAT PLC/IPC must be running, as indicated by a green "TC" LED on the PLC/IPC and the activated symbol highlighted in TwinCAT.



6. Give the project a meaningful name and then click "New project with selected drive".

 New project with selected drives  Add selected drives to current project

Project 'ADS TwinCAT' will be created in 'C:\Users\jonesc01\OneDrive - Nidec\Documents\Control Techniques\Connect Cobalt'

Name:

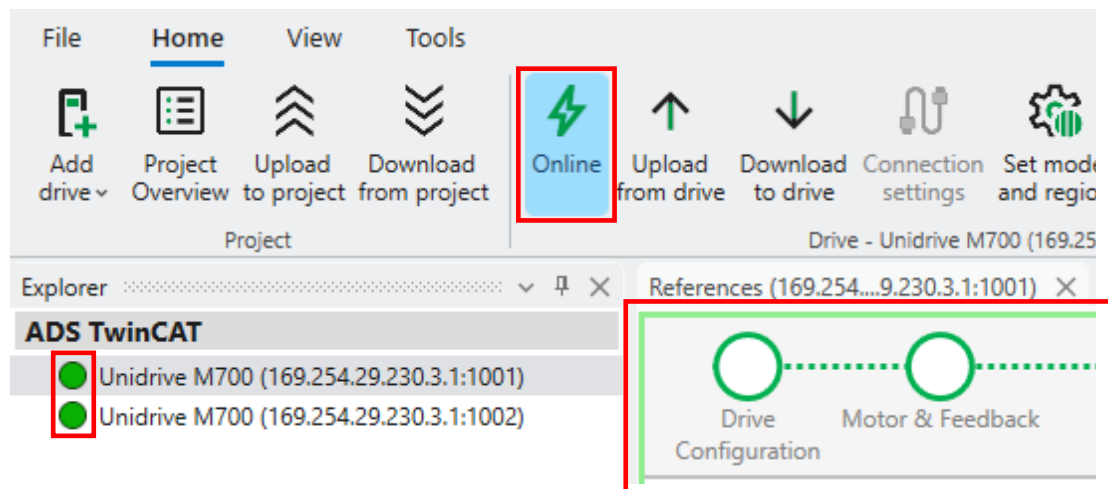
Location:

Finished scanning for devices. (2 found.)

✓ Scanning TwinCAT ADS - 2 devices found

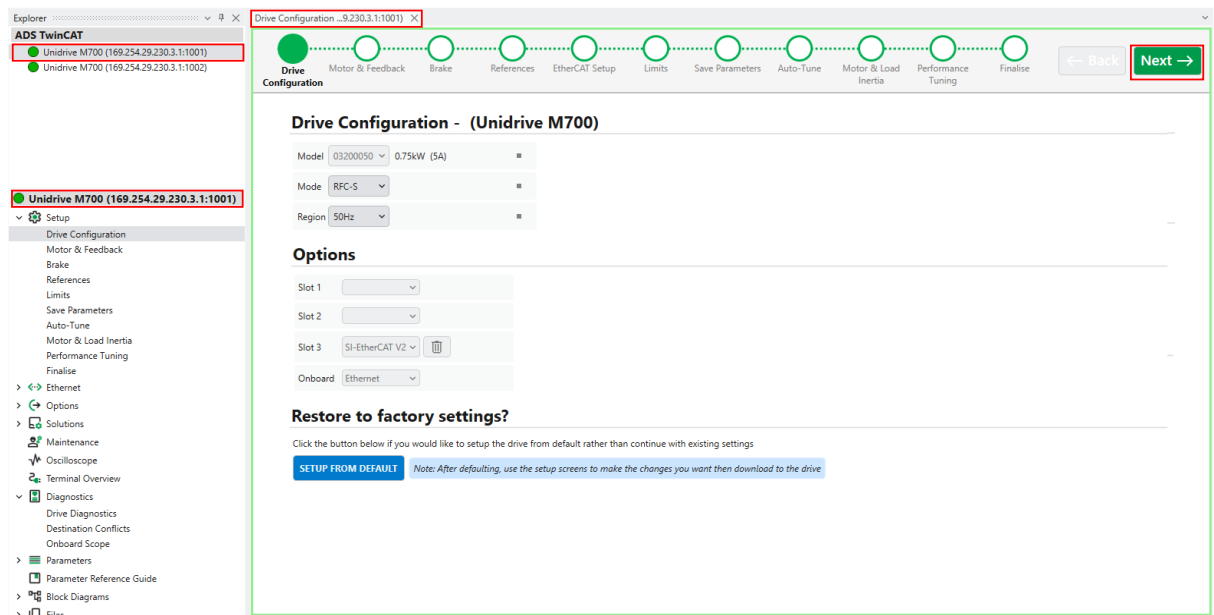
<input checked="" type="checkbox"/>	Address	Type	Name	Serial number
<input checked="" type="checkbox"/>	169.254.29.230.3.1:1001	Unidrive M700		123456789
<input checked="" type="checkbox"/>	169.254.29.230.3.1:1002	Unidrive M700		987654321

7. When the project opens, all drives on the network will be “Online” as indicated by the blue highlight on the “Online” button, the green dot next to each drive node in the Explorer tree, and the green border around the active tab page.



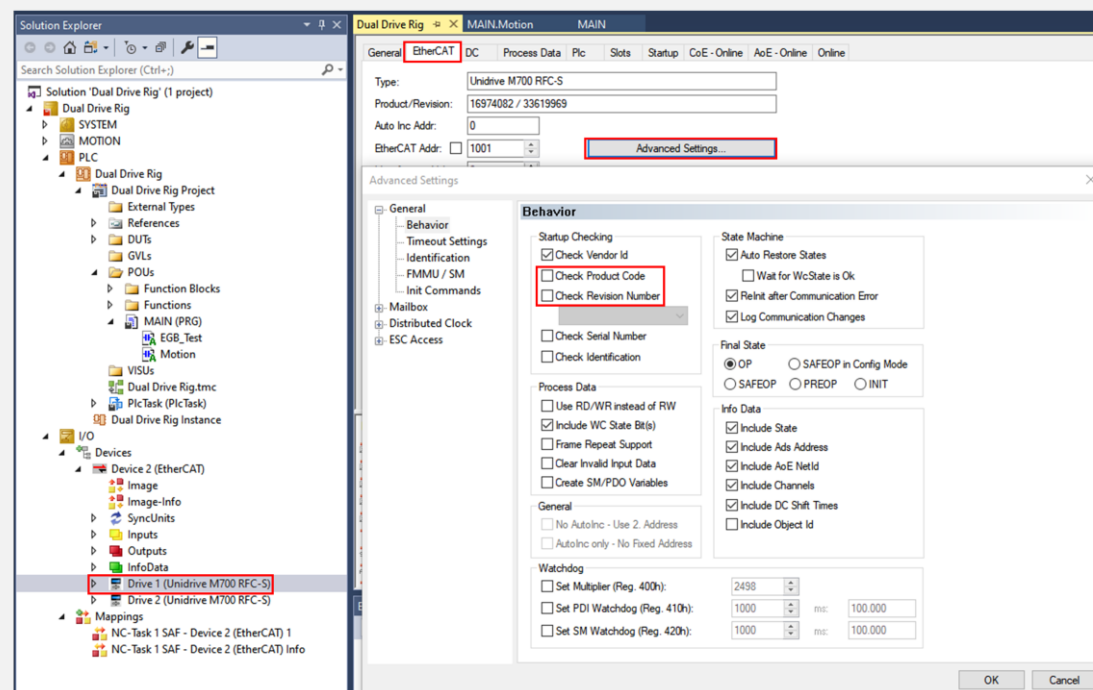
This means that any changes made take direct effect in the drive.

8. The first drive in the Explorer list is selected and has it's drive setup wizard opened.

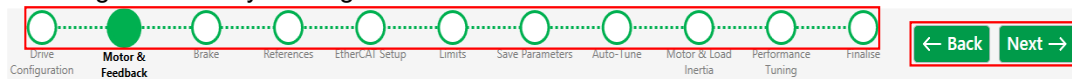


On this page the user can default the drive to remove any previous setup, change the operating mode to match the motor that has been connected to the drive, and select the region e.g. 50Hz or 60Hz.

HINT: Has comms been lost after changing the drive mode? This might be because the EtherCAT interface has V1 firmware installed which as a part of the start-up checks includes the drive mode. V2 firmware removes this issue. If the drive mode is changed the comms connection stops completely, in TwinCAT, change to “Config mode”, delete the EtherCAT drive nodes, and then right click on the network master and select “Scan” to add the nodes in their new mode, and then activate the configuration. Alternatively, uncheck the “Check Product Code” and “Check Revision Number”, and then activate the configuration. See also section **10.5 How to upgrade EtherCAT Firmware**.



The guided setup section is selected by either the “Next” and “Back” buttons, or by directly selecting a section by clicking on the circle section markers.



When finished, click “Next” move to the motor and feedback setup.

- Setup the motor and feedback device on the “Motor and Feedback” page. The required data for the motor and feedback device will be available on the motor name plate or the technical data sheet for the motor.

The screenshot shows the 'Motor & Feedback' page in the software interface. At the top, a progress bar indicates the current step is 'Motor & Feedback', with other steps like 'Drive Configuration', 'Brake', 'References', 'EtherCAT Setup', 'Limits', 'Save Parameters', 'Auto-Tune', 'Motor & Load Inertia', 'Performance Tuning', and 'Finalise' shown as completed or available. The page is divided into three main sections: 'Motor Search', 'Motor Setup', and 'Feedback selection'.

Motor Search: Includes a search bar with the placeholder 'Enter the motor model number or a custom motor name:' and buttons for 'Save', 'Export', 'Delete', and 'Import'.

Motor Setup: Contains several input fields for motor specifications:

- Motor Type: Permanent Magnet Servo
- Rated Current: 1.200 A
- Rated Voltage: 230 V
- Rated Speed: 3000.00 rpm
- Number Of Motor Poles: 6 Poles
- Volts Per 1000rpm: 98 V
- Torque Per Amp: 1.60 Nm/A

Feedback selection: Includes a 'Feedback Mode' dropdown set to 'Feedback device' and a 'Motor Control Feedback Select' dropdown set to 'P1 Drive'.

Feedback type: Includes a 'P1 Device Type' dropdown set to 'AB Servo' and radio buttons for 'Rotary' (selected) and 'Linear'. Below this are several input fields for feedback parameters:

- P1 Supply Voltage: 5V
- P1 Termination Select: 1
- P1 Rotary Lines Per Revolution: 4096
- P1 Rotary Turns Bits: 16

Thermistor Setup: Includes a 'Thermistor Connection' dropdown set to 'Drive P1', a 'Thermistor Fault Detection' dropdown set to 'Temperature', a 'P1 Thermistor Type' dropdown set to 'DIN44082', a 'P1 Thermistor Reset Threshold' input field set to 1800 Ω , and a 'P1 Thermistor Trip Threshold' input field set to 3330 Ω .

The user must configure the motor, feedback device and thermistor setup here.

Help is provided throughout Connect using small help trigger squares ■:

This screenshot shows a close-up of the 'Motor Setup' section. A red circle highlights a small help trigger square (■) next to the 'Rated Voltage' input field. A red arrow points from this square to a help popup window titled 'Rated voltage'.

Rated voltage

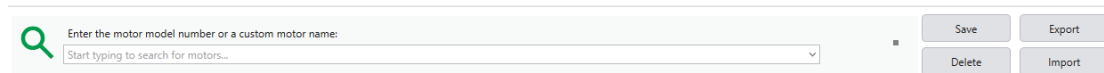
This is set to the motor name plate rated voltage in a.c. r.m.s volts (V). For induction motors the rated voltage changes dependent on whether the motor is wired in Star (Y), or Delta (Δ), configuration e.g. a common configuration is 400V in Star (Y) and 200V in Delta (Δ). For a servo motor, in most cases the drive default is fine as this parameter does not have an effect unless field weakening has been enabled.

This screenshot shows the 'Motor Search' page. A blue box at the top contains the text 'Motor & Feedback (16..9.230.3.1.1001)'. Below this is a progress bar with the 'Motor & Feedback' step highlighted. The 'Motor Search' section includes a search bar with the placeholder 'Please enter at least 3 characters of the motor nameplate to begin searching'. The search bar contains the text '067'. Below the search bar, a list of motor models is displayed, including 'CT Dynamics, 067EDA300XAFMA, 10 poles, 220V, 3000rpm, 1.5A, No Brake, Custom, Key, Heidenhain EC11118 EnDat 2.1 18-bit, DIN44082'.

HINT: Control Techniques Dynamics permanent-magnet servo motors and Leroy Somer induction motors and permanent-magnet process motors may be found using the motor search:

It is possible to save a motor and encoder configuration for later use; these are searchable too.

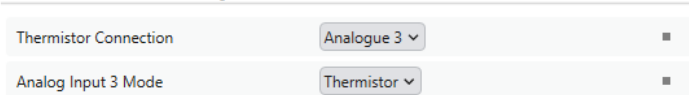
Motor Search



Motor Search interface showing a search bar with a magnifying glass icon, a dropdown menu with the placeholder text "Start typing to search for motors...", and four buttons: Save, Export, Delete, and Import.

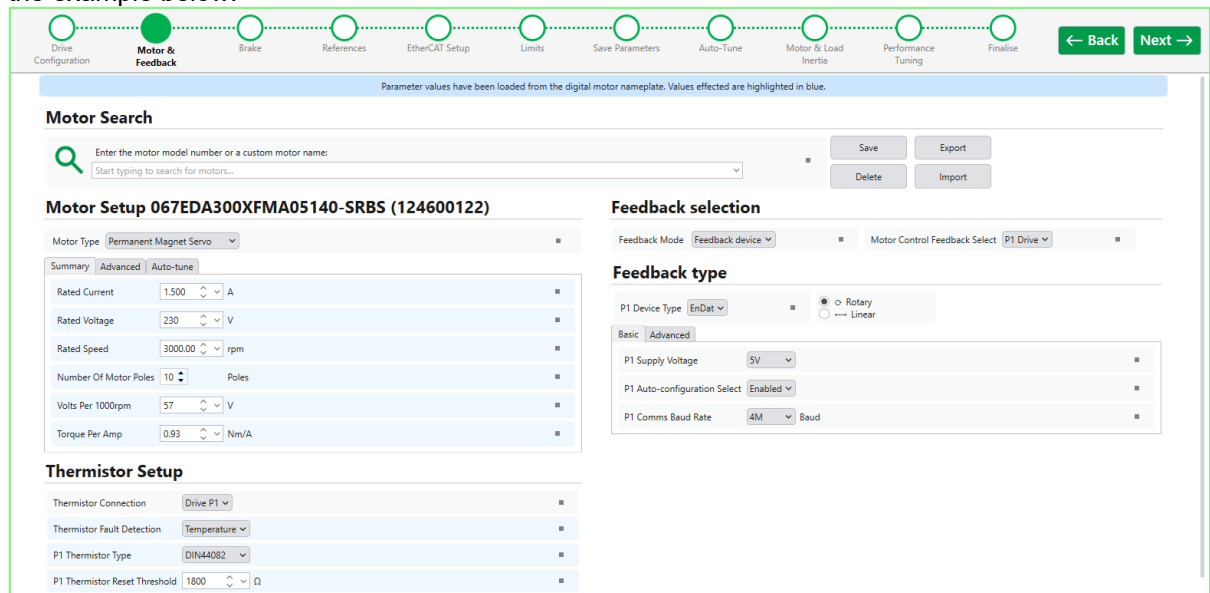
For induction motors, where the thermistor is not typically connected to the encoder interface D Type, and instead, is connected to a terminal on the drive (e.g. Analogue input 3), change the thermistor connection to Analogue 3.

Thermistor Setup



Thermistor Setup interface showing two dropdown menus: "Thermistor Connection" set to "Analogue 3" and "Analog Input 3 Mode" set to "Thermistor".

If the drive is either a Digitax HD or a Unidrive M with firmware $\geq V01.61.01.00$ and the motor is one from Control Techniques Dynamics that has an electronic nameplate loaded into the encoder, the motor and encoder data is setup automatically where the “Motor & Feedback” page looks like the example below:



Motor & Feedback setup page. The page is divided into several sections: Motor Search, Motor Setup, Feedback selection, and Thermistor Setup. The Motor Setup section is highlighted in light blue, indicating that the electronic nameplate has been loaded. The Motor Setup section shows the Motor Type as "Permanent Magnet Servo" and the Motor Model as "067EDA300XFMA05140-SRBS (124600122)". The Feedback selection section shows the Feedback Mode as "Feedback device" and the Motor Control Feedback Select as "P1 Drive". The Thermistor Setup section shows the Thermistor Connection as "Drive P1" and the Thermistor Fault Detection as "Temperature".

The light blue highlight shows that the electronic nameplate has been loaded. In addition, for EnDat 2.2, EnDat 3.0 and BiSS-C encoders the “Encoder type” fields are also configured automatically.

When finished, click “Next” to move to the brake setup.

10. The brake setup page allows braking resistor properties to be configured. The braking resistor is used to dissipate motor energy when slowing down. The settings provide protection for the braking resistor in addition to a thermal overload circuit which is typically provided with the resistor.

It can also be used to set up the drives mechanical brake controller. The mechanical brake controller releases and applies the mechanical brake automatically, making sure that the load is always controlled by either the motor or the mechanical brake. It is typically used in hoisting applications. For the majority of applications, assigning the “Brake Control: Brake Release” Output, setting the time for the brake to physically release the load in “Brake Control: Post-brake Release Delay”, and the time for the brake to physically apply and hold the load in “Brake Control: Brake Apply Delay” is sufficient.

Brake (169.254.29.230.3.1:1001) X

Drive Configuration Motor & Feedback **Brake** References EtherCAT Setup Limits Save Parameters Auto-Tune Motor & Load Inertia Performance Tuning Finalise ← Back Next →

Dynamic Braking Resistor

Is a dynamic braking resistor fitted? ☒

Braking Resistor Resistance 22.00 Ω

Braking Resistor Rated Power 0.050 kW

Braking Resistor Thermal Time Constant 3.300 s

The resistor must be connected between the BR terminal and +DC. It is recommended to fit a thermal protection device. The minimum braking resistance for this drive is 22 Ω . The brakes instantaneous power rating is 7.7 kW. The brakes continuous power rating is 1.5 kW.

Mechanical Brake Control

The mechanical brake controller is used in hoisting applications to ensure that the load is always being controlled by either the drive or the brake, when moving and stopping the load. The controller checks that the motor is producing torque to hold the load and compensates for the delay for the brake to physically release and apply.

Is a mechanical brake fitted? ☒

Terminal Invert Parameter

None ☐ Brake Control: Brake Release

None ☐ External Brake Released Indicator

Mechanical Brake Control Settings

Brake Control: Brake Apply Speed 5 rpm

Brake Control: Brake Delay 1.0 s

Brake Control: Post-brake Release Delay 1.0 s

Brake Control: Brake Apply Delay 1.0 s

For more information on the mechanical brake controller logic and timings see section **11.1 Mechanical brake controller logic**.

When finished, click “Next” to move to the reference setup.

11. The reference setup page for an EtherCAT motion control application, is where the maximum reference clamp is defined. Normally, the maximum reference clamp must be set to the motor rated speed, however, in some applications this is increased and may be adjusted from this page.

References (169.254...9.230.3.1:1001) X

Drive Configuration Motor & Feedback Brake **References** EtherCAT Setup Limits Save Parameters Auto-Tune Motor & Load Inertia Performance Tuning Finalise

← Back Next →

Reference Source

Select the reference to control the motor: Motion Control over Fieldbus

Reference source automatically set to Motion Control over Fieldbus due to presence of fieldbus option

Profile Setup

Maximum Reference Clamp: 3000.0 rpm

Minimum Reference Clamp: 0.0 rpm

The other motion profile properties are configured using the 3rd party controller and DS402 objects as detailed in the user manual for the fieldbus interface

When finished, click “Next” to move to the EtherCAT setup.

12. The EtherCAT Setup page allows the user to configure the stop behaviour from a digital input and from a loss of comms.

Easy Stop

Easy Stop allows the drive to be stopped using a pre-defined deceleration rate if a digital input is activated or if EtherCAT messages stop being received by the drive. The stop is handled so that any position following error is removed when the stop is activated.

Do you want to configure the Easy Stop behaviour?

Easy Stop Mode ☒

Easy Stop Deceleration Rate 0.200 s/1000rpm

Zero Speed Threshold 5 rpm

Network Loss Behaviour

If the EtherCAT network communications go down, configure the loss conditions for the easy stop to be performed.

Controlled Stop Network Loss Threshold 0

Stop on a Digital Input

If you would also like to perform an easy stop on a change of state of a digital input, specify the input below.

Terminal	Invert
None	<input type="checkbox"/>

When the “Easy Stop Mode” box is checked, the user can assign a digital input that will cause the axis to stop. The axis is permitted to run when 24V is applied to it, but if 24V is removed the axis will stop, using the “Easy Stop Deceleration Rate”.

The “Easy Stop Deceleration Rate” is also used when there is a loss of EtherCAT communications. The “Controlled Stop Network Loss Threshold” is a weighted threshold that increases by 3 for every missed message and decreases by 1 for every received message. In this way, occasional missed messages don’t affect the system, but a more permanent loss of messages such as a broken EtherCAT comms cable will stop the axis.

The “Zero speed threshold” is used by the CiA402 state machine, (the CANopen motion standard used to control the axis over EtherCAT communications), to verify that the axis has actually stopped before allowing further movement. The default value is suitable for most systems except those that have a noisy or low-resolution feedback device, in which case the value must be increased to account for the additional feedback noise.

When finished, click “Next” to move to the Limits setup.

13. The limits page allows the user to assign digital inputs to become hardware limit inputs. If the application doesn’t have hardware limits, leave the digital input assignments empty and move to the next step.

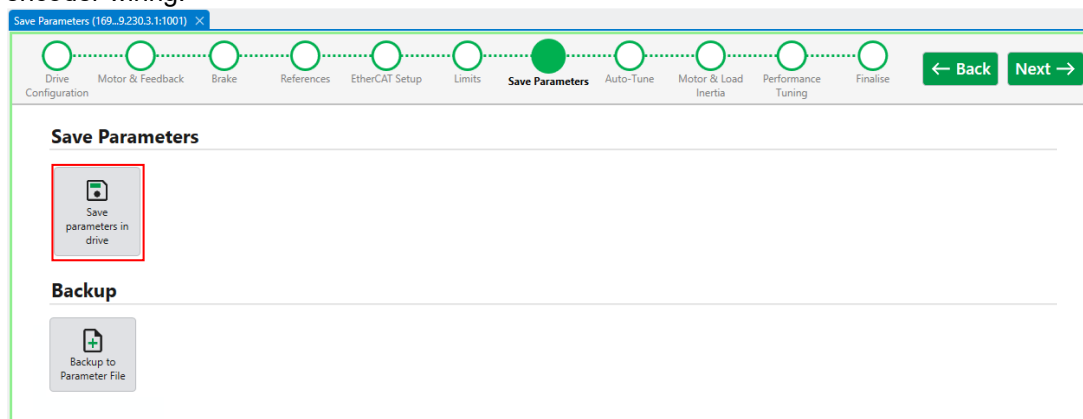
Hardware Travel Limit Configuration

Setup the 24V digital inputs used to trigger the positive and negative hardware limits. Note that when a limit is hit the axis will try to stop instantly with no profiling.

Terminal	Invert	Parameter
None	<input type="checkbox"/>	Forward Limit Switch
None	<input type="checkbox"/>	Reverse Limit Switch

When finished, click “Next” to move to the Save Parameters page.

14. The save parameters page allows the parameters configured so far to be saved. It is advised to do this prior to the commissioning activities since the power might have to be removed to correct a hardware issue as a result of a failed Autotune test, such as a reversed motor or encoder wiring.



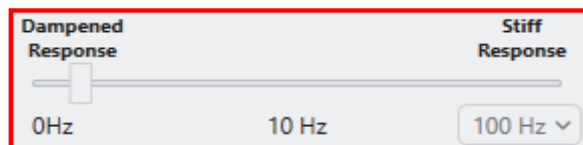
This completes the configuration section of the guided setup. The next section of the manual describes the commissioning of the drive and motor using the remaining steps in the guided setup.

6 Commission the drive and motor using Connect

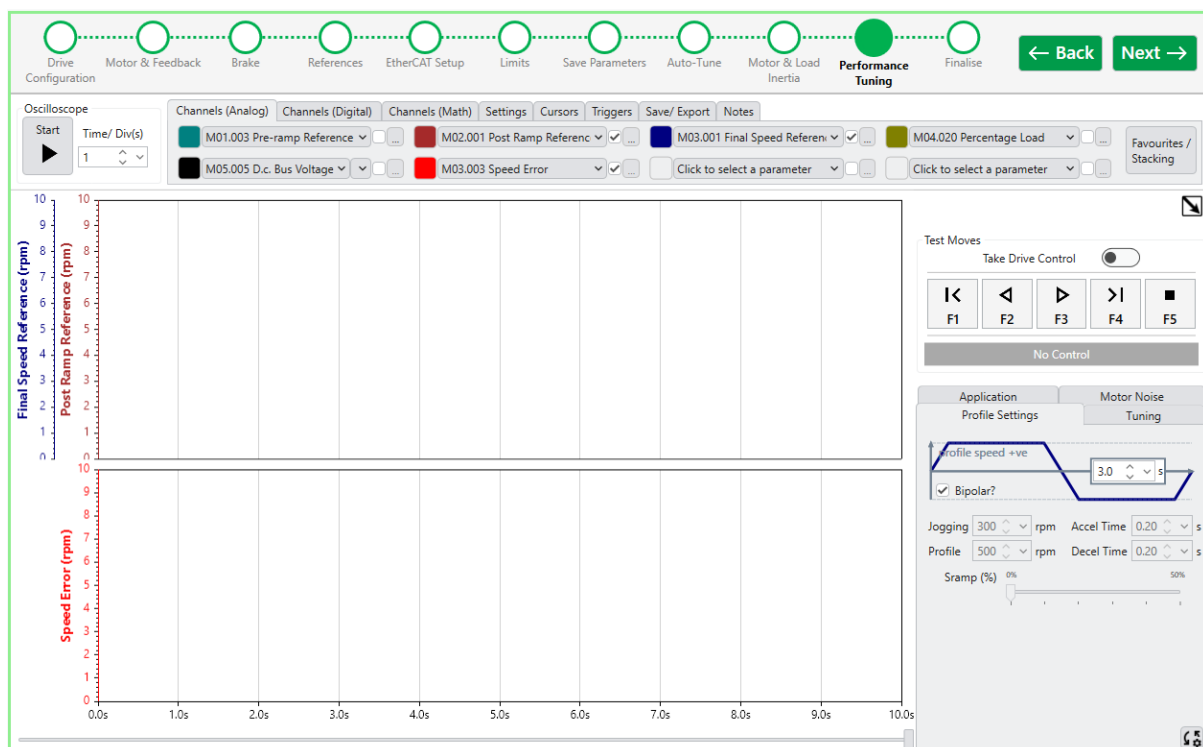
This section describes the process of commissioning the drive and motor in the application using the tools provided in the guided setup, which consist of:



- Auto-tune to measure the electrical properties of the motor such as resistance and inductance.
- An inertia-auto-tune to measure the inertia of the motor and load. Once this measurement is taken, tuning the axis is simplified to a single slider. It is **strongly** recommended to run this test.



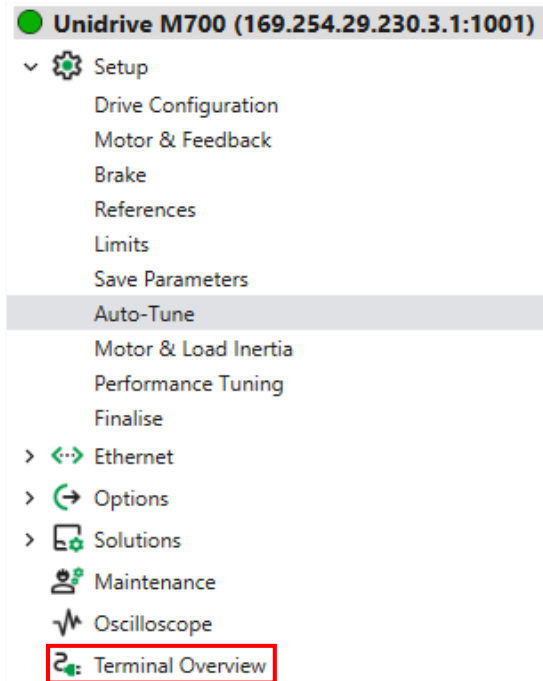
- Performance tuning and test moves. This page is a “one stop shop” with test move controls, motion profile setup, oscilloscope, and tuning controls on a single page ideal for site commissioning using a laptop.



- Finalising the application by saving the tuned parameters and creating a startup list allowing the PLC / IPC to configure the drive, each time the system powers up; this is helpful if the drive must be replaced.

Use the following steps to commission the motor and drive in the application.

1. Wire a switch or similar device to the drives STO input(s) where 24V is connected to the STO input(s) to enable the drive. The drive will not be able to run the motor until such a device is fitted. The terminals that supply 24V and host the STO input(s) are shown by the "Terminal Overview" in the device explorer.



Unidrive M700

Polarized connector: T1 - T11					
Terminal	Terminal Function	Invert	Mode	Mapped Parameter	State
T1	0V				
T2	24V Supply Input	<input type="checkbox"/>		M00.000 Parameter mm.000	
T3	0V				
T4	+10V Output				
T5/T6	Analog Input 1	<input type="checkbox"/>	Volt	M01.036 Analog Reference 1	
T7	Analog Input 2	<input type="checkbox"/>	Volt	M01.037 Analog Reference 2	
T8	Analog Input 3	<input type="checkbox"/>	Volt	M00.000 Parameter mm.000	
T9	Analog Output 1			M03.002 Speed Feedback	
T10	Analog Output 2			M04.002 Iq	
T11	0V				

Polarized connector: T21 - T31					
Terminal	Terminal Function	Invert	Mapped Parameter	State	
T21	0V				
T22	24V Supply Output	<input checked="" type="checkbox"/>	M00.000 Parameter mm.000		
T23	0V				
T24	Digital IO 01	<input type="checkbox"/>	M10.003 Zero Speed		
T25	Digital IO 02	<input type="checkbox"/>	M10.033 Drive Reset		
T26	Digital IO 03	<input type="checkbox"/>	M06.030 Run Forward		
T27	Digital Input 04	<input type="checkbox"/>	M06.032 Run Reverse		
T28	Digital Input 05	<input type="checkbox"/>	M01.041 Reference Select Flag 1		
T29	Digital Input 06	<input type="checkbox"/>	M06.031 Jog		
T30	0V				
T31	Drive Enable (24V STO)				

Polarized connector: T41 - T42					
Terminal	Terminal Function	Invert	Mapped Parameter	State	
T41/T42	Relay Output	<input type="checkbox"/>	M10.001 Drive Healthy		

SAFETY: Remove power from the drive before attempting to modify the drive or motor electrical connections.

2. Before attempting to run the Auto-tune ensure the STO switch is open i.e. 24V is not connected to the STO terminal(s).

3. The default setup for the auto-tune will be suitable for most applications. Additional controls are provided for expert users.

Making sure the motor is safe to move, run the Auto-tune by pressing “Start Autotune”

Auto-Tune (169.254.29.230:3.1-1001)

Drive Configuration Motor & Feedback Brake References EtherCAT Setup Limits Save Parameters **Auto-Tune** Motor & Load Inertia Performance Tuning Finalise

← Back Next →

Auto-Tune

An Auto-tune is used to sample the electrical properties of the motor to tune the drive operation.

WARNING! For safety reasons, even though an Auto-tune type says it is stationary, the motor should be treated as if motion may occur under full torque. Please take any appropriate safety measures in case the motor turns.

Auto-Tune Configuration

Select an Auto-tune type: Rotating Select the motion direction: ☒ Forwards ☐ Backwards

Auto-Tune Test

Start Auto-tune

The tool will advise you to apply 24V to the STO terminal to run the test.

Drive Configuration Motor & Feedback Brake References EtherCAT Setup Limits Save Parameters **Auto-Tune** Motor & Load Inertia Performance Tuning Finalise

← Back Next →

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An Auto-tune is used to sample the electrical properties of the motor to tune the drive operation.

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Auto-Tune Configuration

Select an Auto-tune type: Rotating Select the motion direction: ☒ Forwards ☐ Backwards

Auto-Tune Test

Stop Auto-tune

Auto-Tune
To start Auto-tune enable the drive by applying a 24V signal to the STO Terminal

The test takes approximately 30s to complete

Drive Configuration Motor & Feedback Brake References EtherCAT Setup Limits Save Parameters **Auto-Tune** Motor & Load Inertia Performance Tuning Finalise

← Back Next →

Auto-Tune

An Auto-tune is used to sample the electrical properties of the motor to tune the drive operation.

WARNING! For safety reasons, even though an Auto-tune type says it is stationary, the motor should be treated as if motion may occur under full torque. Please take any appropriate safety measures in case the motor turns.

Auto-Tune Configuration

Select an Auto-tune type: Rotating Select the motion direction: ☒ Forwards ☐ Backwards

Auto-Tune Test

Stop Auto-tune

Auto-Tune
Auto-tune in progress

When the test completes, the drive must be disabled by removing 24V from the STO input.

Drive Configuration

Motor & Feedback

Brake

References

EtherCAT Setup

Limits

Save Parameters

Auto-Tune

Motor & Load Inertia

Performance Tuning

Finalise

Back

Next

Auto-Tune

An Auto-tune is used to sample the electrical properties of the motor to tune the drive operation.

WARNING! For safety reasons, even though an Auto-tune type says it is stationary, the motor should be treated as if motion may occur under full torque. Please take any appropriate safety measures in case the motor turns.

Auto-Tune Configuration

Select an Auto-tune type: Rotating ■ Select the motion direction: ☒ Forwards ☐ Backwards ■

Auto-Tune Test

Stop Auto-tune

Auto-Tune
Complete Auto-tune by removing the 24V signal from STO terminal

The electrical property autotune is completed. Click next to move to the “Motor and load inertia” page.

Drive Configuration

Motor & Feedback

Brake

References

EtherCAT Setup

Limits

Save Parameters

Auto-Tune

Motor & Load Inertia

Performance Tuning

Finalise

Back

Next

Auto-Tune

An Auto-tune is used to sample the electrical properties of the motor to tune the drive operation.

WARNING! For safety reasons, even though an Auto-tune type says it is stationary, the motor should be treated as if motion may occur under full torque. Please take any appropriate safety measures in case the motor turns.

Auto-Tune Configuration

Select an Auto-tune type: Rotating ■ Select the motion direction: ☒ Forwards ☐ Backwards ■

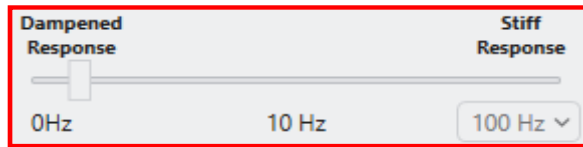
Auto-Tune Test

Start Auto-tune

Auto-Tune
Auto-tune completed successfully
(Parameters saved to drive)

Parameter	Caption	Categories	Value	Source / Destination
03.025	Position Feedback Phase Angle	Autotuned Parameters	218.3 °	
04.013	Current Controller Kp Gain	Autotuned Parameters	111	
04.014	Current Controller Ki Gain	Autotuned Parameters	1949	
05.016	Minimal Movement Phasing Test Angle		0.000 °	
05.017	Stator Resistance	Autotuned Parameters	3.932831 Ω	
05.024	Ld		9.595 mH	
05.059	Maximum Deadtime Compensation	Autotuned Parameters	0.750 µs	
05.060	Current At Maximum Deadtime Compensation	Autotuned Parameters	1.53 %	

4. The “Motor and load inertia” page configures a test to measure the motor and load inertia. This test is important as it allows the speed loop gains to be configured using a single control slider:



If the motor has a load connected, the default settings will be OK for most systems. Where there is no load i.e. a bare motor shaft it is recommended to increase the “Mechanical Load Test Level” to 5%. If the test fails to identify the inertia, increase the mechanical load test in steps of 5% up until 20% is reached.

Start the inertia test by clicking “Start Auto-tune”:

The tool will advise you to close the STO switch to apply 24V to the STO terminal and run the test.

When the test completes, remove 24V from the STO terminal.

Drive Configuration

Motor & Feedback

Brake

References

EtherCAT Setup

Limits

Save Parameters

Auto-Tune

Motor & Load Inertia

Performance Tuning

Finalise

← Back

Next →

Motor and Load Inertia

To get the best performance from the motor, the drive needs to know the motor and load inertia. This can either be entered manually or by performing an auto-tune on this tab.

Inertia setting method:

☐ Manual Entry
 ☒ Inertia Auto-tune

Inertia Auto-Tune Configuration

Select an Auto-tune type: Inertia 1: Oscillating
 Select the motion direction: ☒ Forwards ☐ Backwards
 Mechanical Load Test Level: 20 %

Inertia Auto-Tune Test

Stop Auto-tune

Inertia Auto-Tune
Complete Auto-tune by removing the 24V signal from STO terminal

The inertia test is complete. Click Next to move to the “Performance Tuning” page.

Drive Configuration

Motor & Feedback

Brake

References

EtherCAT Setup

Limits

Save Parameters

Auto-Tune

Motor & Load Inertia

Performance Tuning

Finalise

← Back

Next →

Motor and Load Inertia

To get the best performance from the motor, the drive needs to know the motor and load inertia. This can either be entered manually or by performing an auto-tune on this tab.

Inertia setting method:

☐ Manual Entry
 ☒ Inertia Auto-tune

Inertia Auto-Tune Configuration

Select an Auto-tune type: Inertia 1: Oscillating
 Select the motion direction: ☒ Forwards ☐ Backwards
 Mechanical Load Test Level: 20 %

Inertia Auto-Tune Test

Start Auto-tune

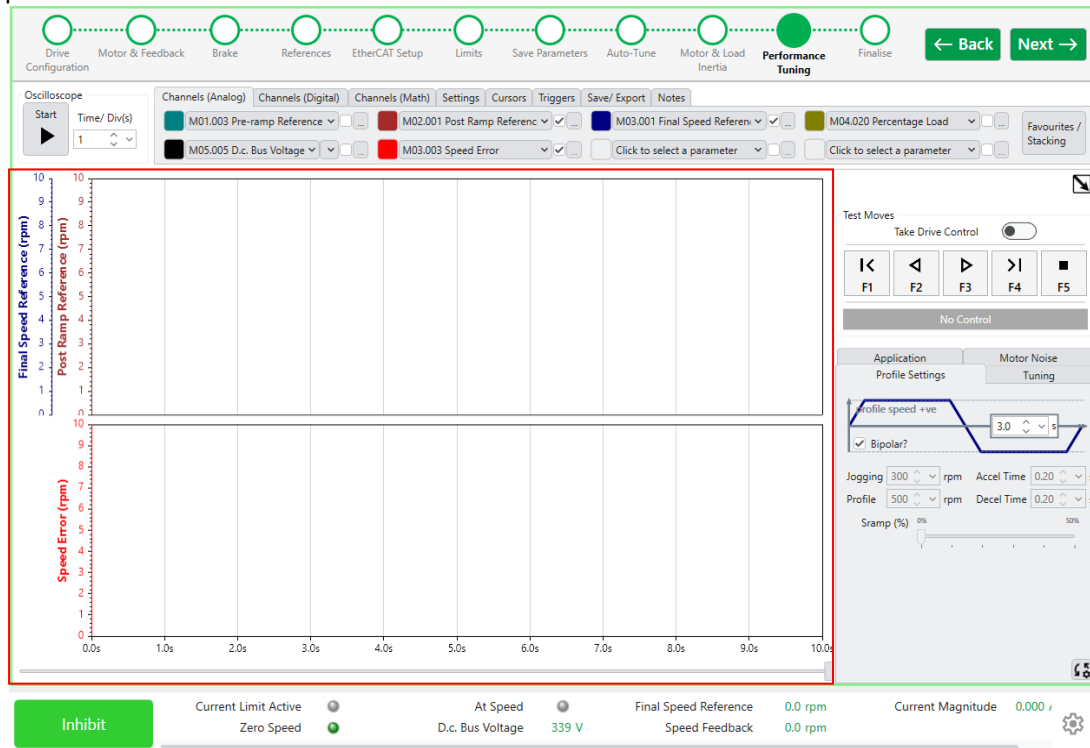
Inertia Auto-Tune
Auto-tune completed successfully
(Parameters saved to drive)

Auto-tuned values:

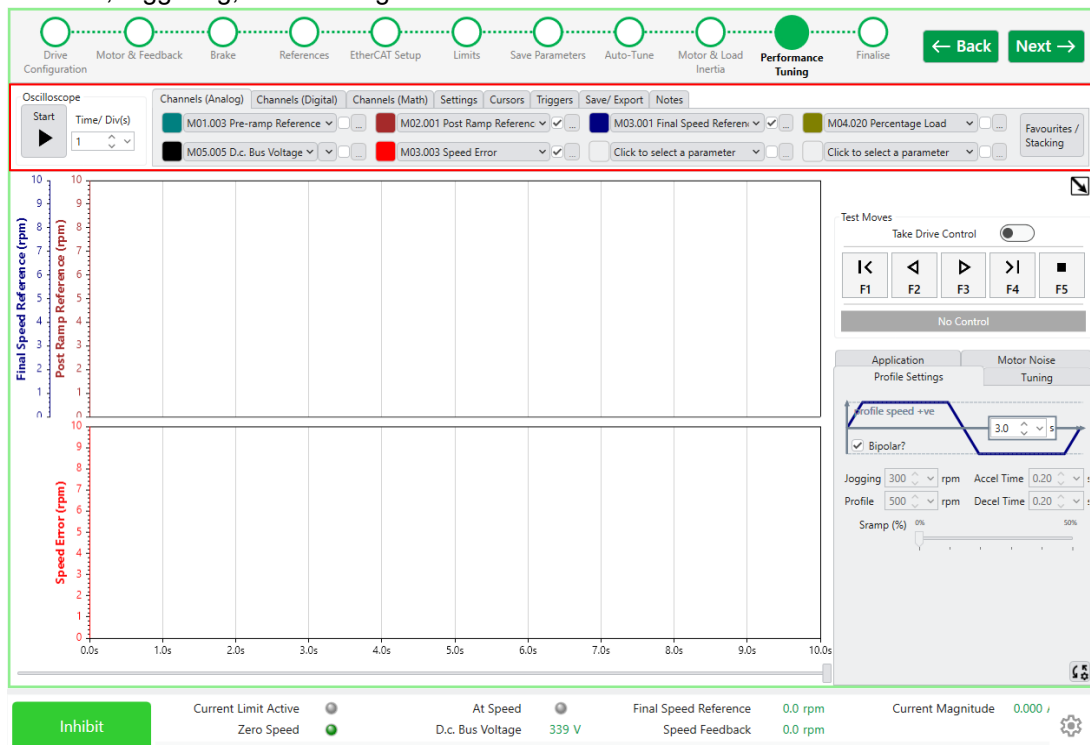
Parameter	Caption	Categories	Value	Source / Destination
03.018	Motor And Load Inertia	Autotuned Parameters	0.00017 kgm²	

- The “Performance Tuning” page provides a set of tools on a single page, optimised for laptop use, that are used to commission the drive and motor. The different sections of the tool are described below:

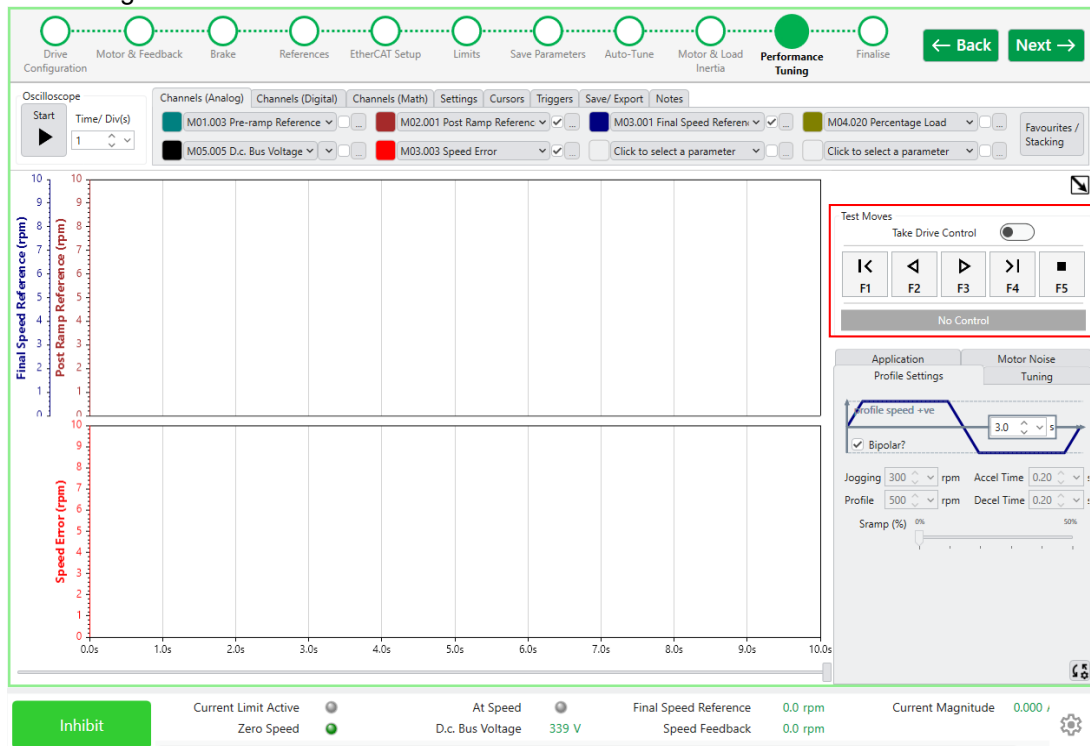
Oscilloscope – to show what is happening to the motor speed while jogging or tuning takes place:



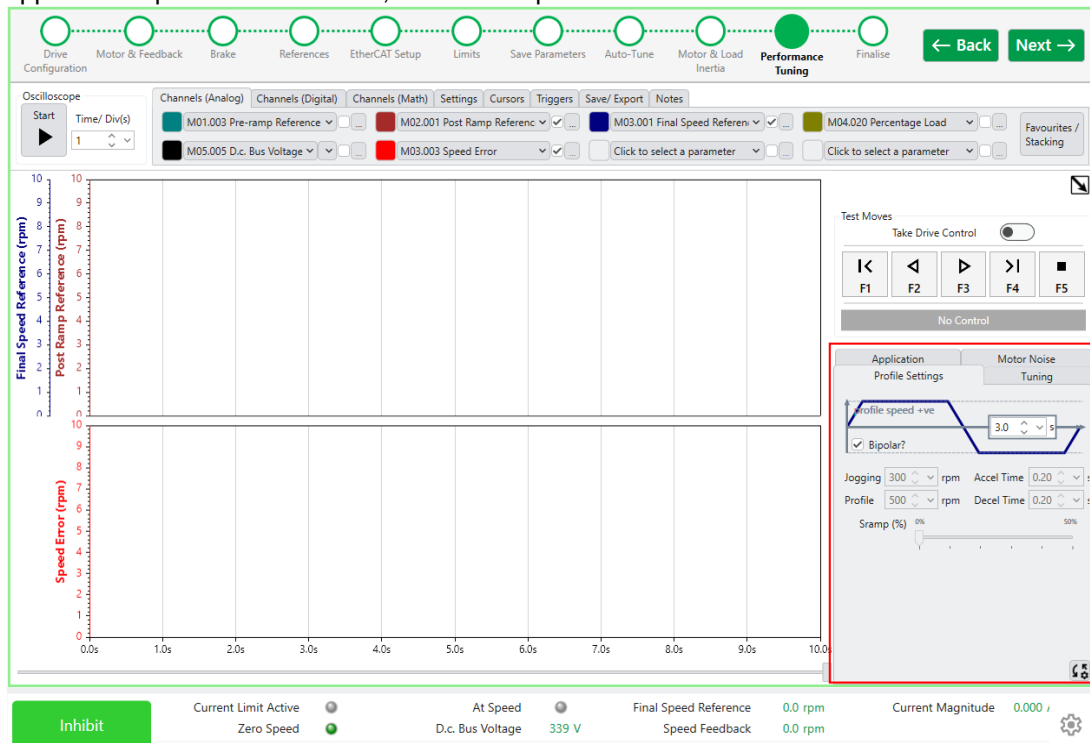
Oscilloscope controls – start and stop the trace, allow channels to be added / removed / modified, triggering, trace saving.



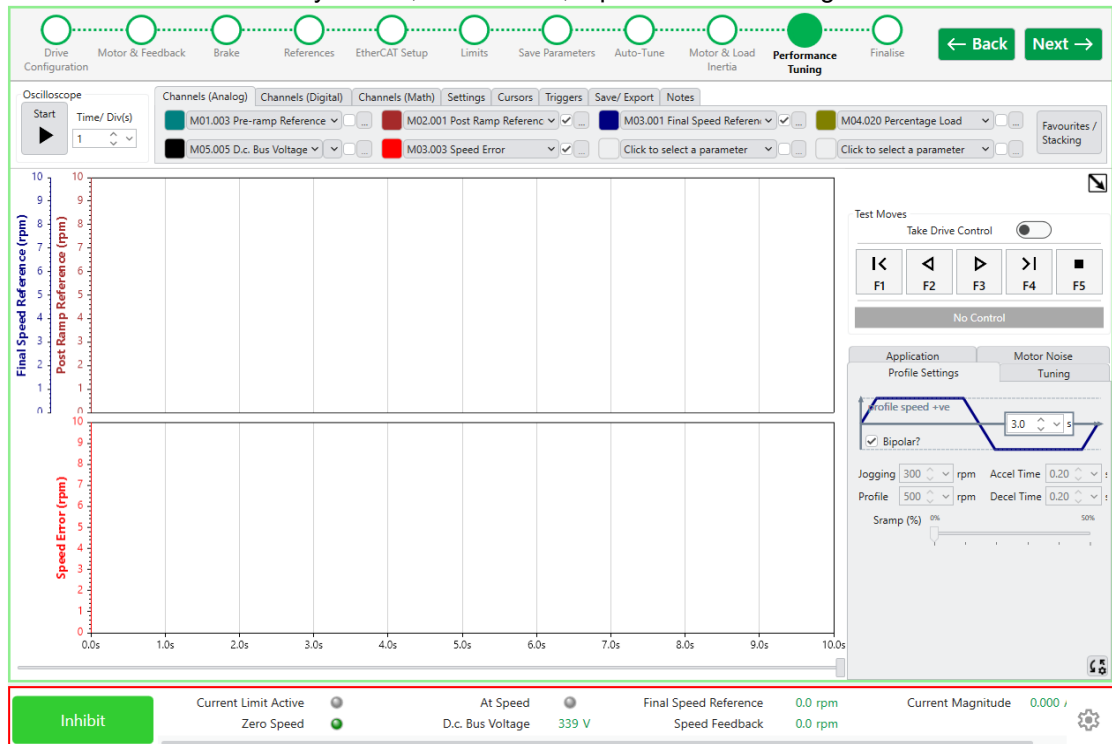
Test move commands – enable the test controls, jog forward / backwards, automatic running as a tuning reference.



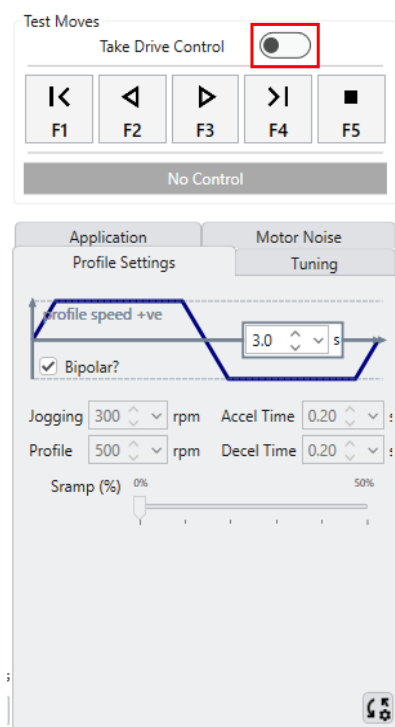
Commissioning tabs – configure the test move motion profile, speed and position loop tuning, application optimisation controls, and noise optimisation controls.



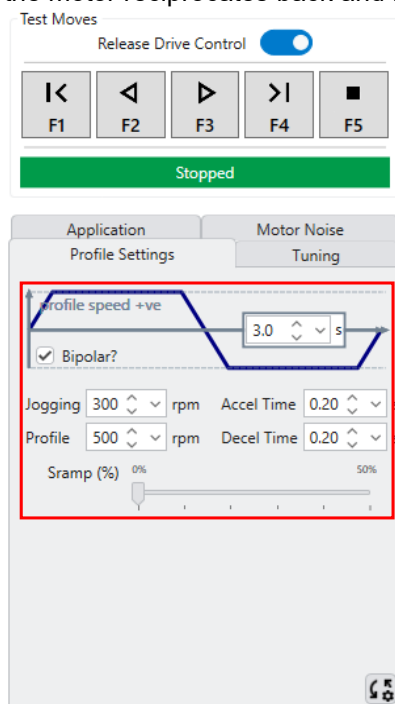
Status control – Shows key values, drive status, trip data and resetting.



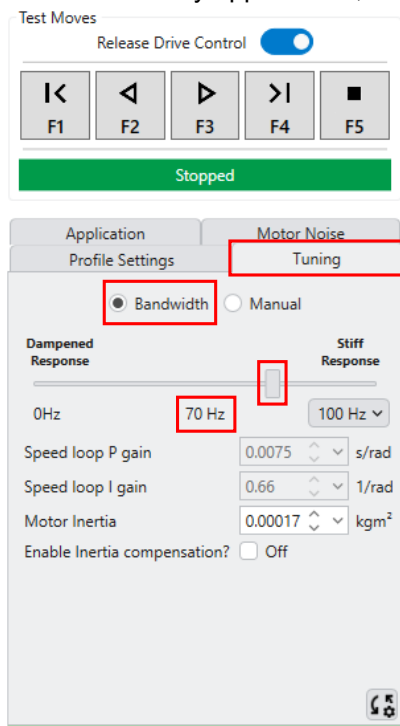
- Begin commissioning by jogging the axis (slowly) to determine if the motor direction is correct for the application. Ensure it is safe to move the motor. Click on “Take Drive Control” and then apply 24V to the STO input.



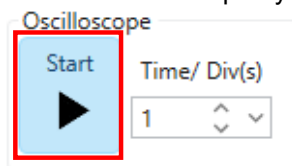
Configure the motion profile settings used when the test moves are running. This includes the jog speed, automatic running speed, acceleration and deceleration times, S ramp percentage, the overall profile time, and whether the automatic running is in one direction, or bipolar where the motor reciprocates back and forth.



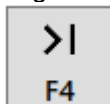
Select the Tuning tab, and then select “Bandwidth” mode. This will give moderate tuning suitable for many applications, with headroom to increase the gains further if required.



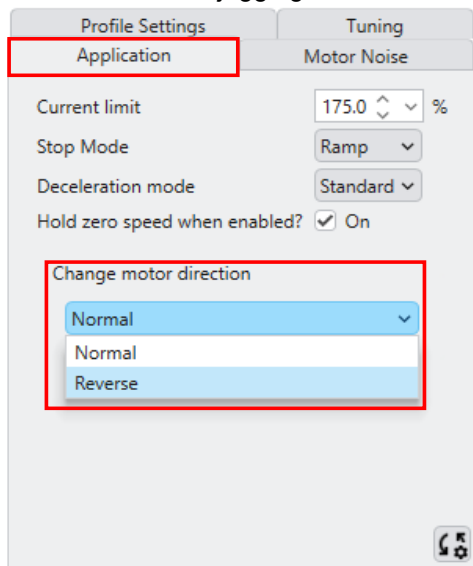
Start the oscilloscope by pressing the Oscilloscope start/stop button.



Jog the axis forward by pressing F4 or clicking on the Jog Forward button.



Verify that the movement is stable and that the forward direction of rotation is correct for the application. If the movement is unstable, modify the tuning slider until the desired performance is achieved. If the motor is turning the wrong way when jogging forward, remove 24V from the STO Input, select the Application tab, and then set the “Change Motor Direction” control to “Reverse”. Re-apply 24V to the STO terminal and verify that the motor direction is now correct when jogging forward.



7. If the application axis has hardware limit switches connected, test them by jogging into them gently and prove that the axis stops and that the switches have been connected to the correct terminals.

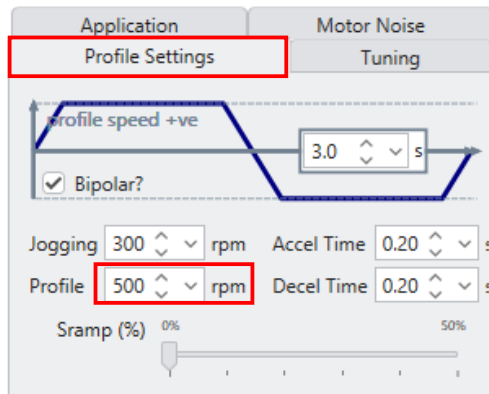
8. Verify the step response of the motor and load by enabling automatic running. Before tuning using these commands make sure that if the axis has physical limits that it is placed in the centre of these limits and that Bipolar mode is selected so that the axis moves back and forth. To stop the axis press F5 or click the stop button:



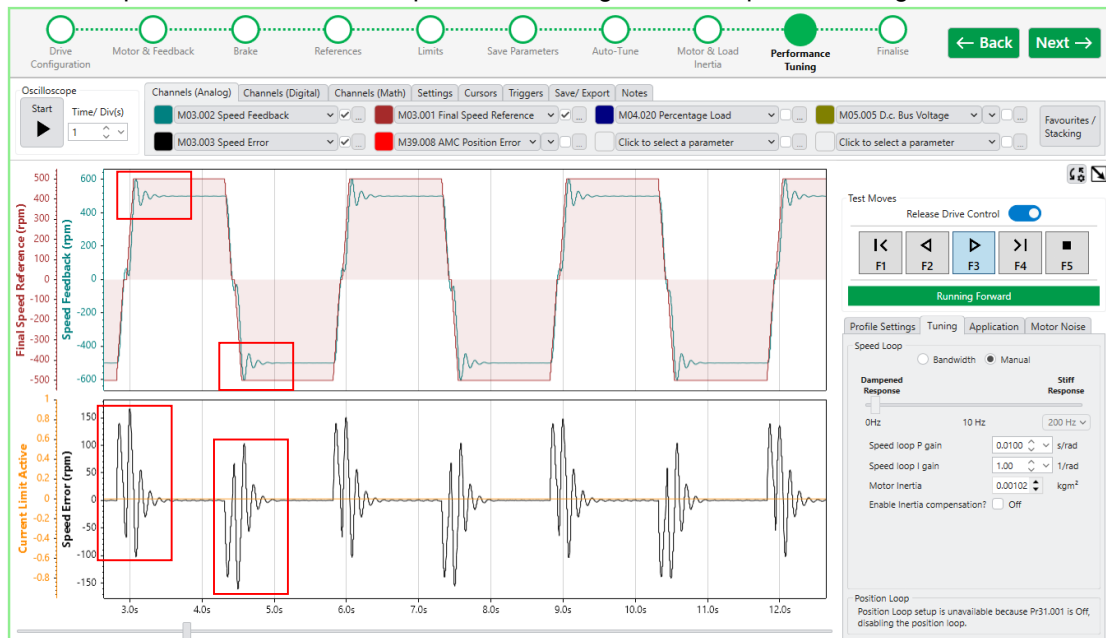
Select the initial direction of travel when automatic running using F2 (backwards) or F3 (Forwards) or by clicking the Run Forwards, Run Backwards buttons:



It is recommended to start with a slow Run speed and then gradually increase to make sure the axis doesn't move too far on the first try. The speed can be increased while running but bear in mind that the higher the speed, the further the axis will travel.

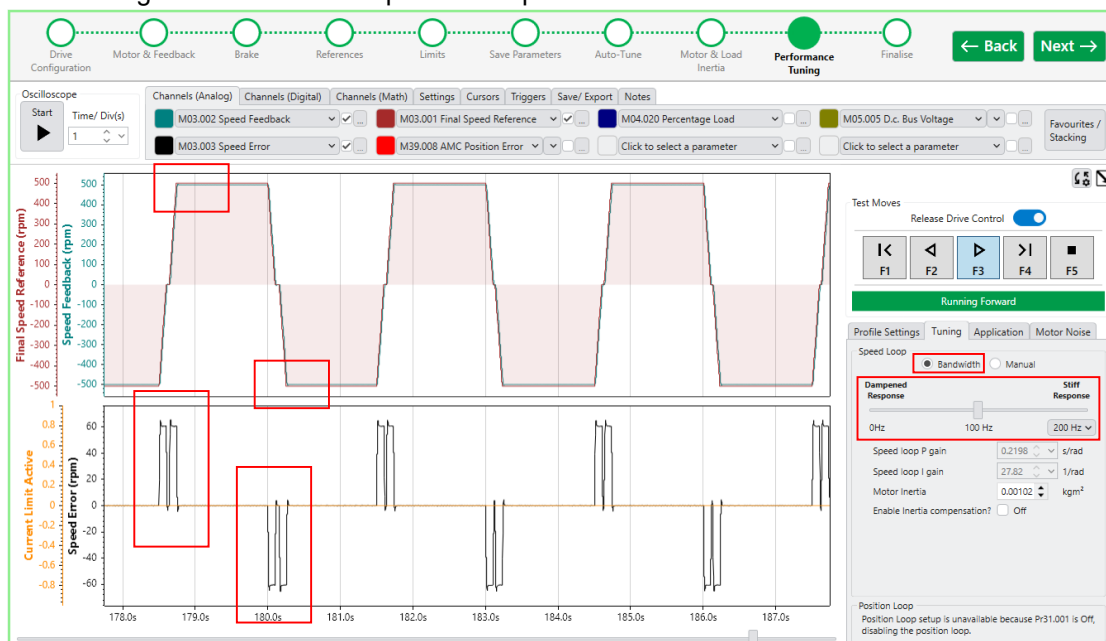


- Once the correct automatic run profile is running, the axis may be tuned further. Observe Final Speed Reference Pr3.001 and Speed Feedback Pr3.002 overlaid with each other, and the Speed Following Error Pr3.003 on a separate trace. Ensure there is no significant overshoot when stopping or when reaching the speed reference. If there is overshoot the gains can be increased. When doing this check that the drive isn't going into current limit by observing Pr10.009; this may be placed on the same trace as the speed following error. The example shows what the axis performance might look like prior to tuning:



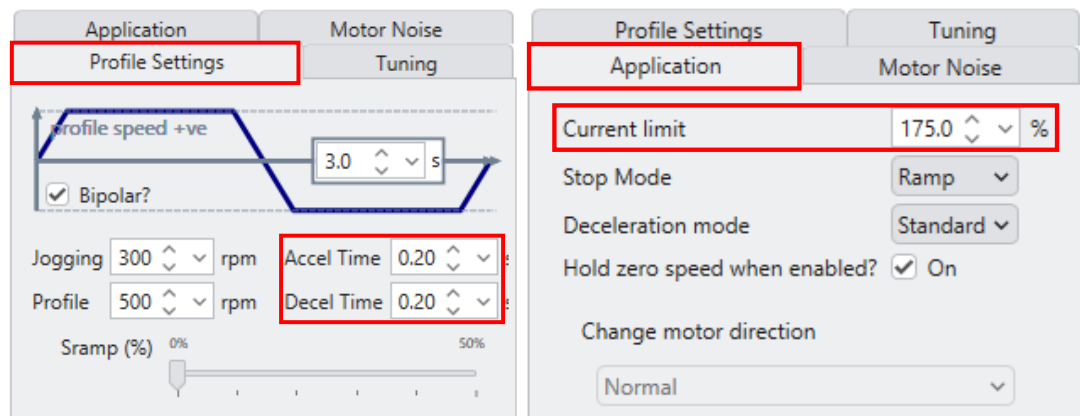
In the previous example trace it can be seen that there is significant speed overshoot caused by the load inertia and default gains. The speed following error shows oscillations when accelerating and decelerating. All of these artifacts can be tuned out easily using “Bandwidth” mode and adjusting the slider control to achieve the desired performance.

The example below shows an optimised result for the same application where Bandwidth mode tuning has been used to optimise the performance:

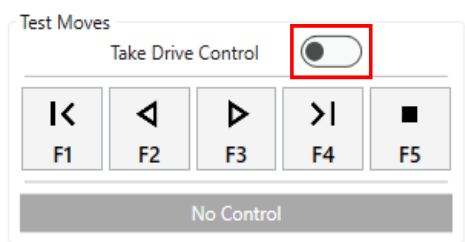


From the previous trace it can be seen that there is no significant speed overshoot, the speed following error isn't oscillating, and the drive isn't going into current limit.

If the drive is observed going into current limit, (Current Limit Active trace goes to 1), it is an indication that the drive is going into constant torque due to hitting the current limit. This can be resolved by increasing the current limits on the Application tab or by decreasing the acceleration and deceleration rate. It is further recommended to verify that the drive and motor combination have been sized correctly for the application in terms of their torque and current capability.



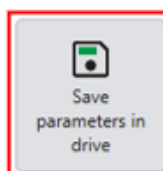
10. This stage of the tuning is complete. Further tuning may be required later to fully optimise the speed loop and position loop when the TwinCAT program provides the motion reference to the drive over EtherCAT PDO. Disable the drive by removing 24V from the STO input, and then disable the test move control by clicking on the "Release Drive Control". When drive control has been released it looks as shown below:



Click Next to move to the "Finalise" page.

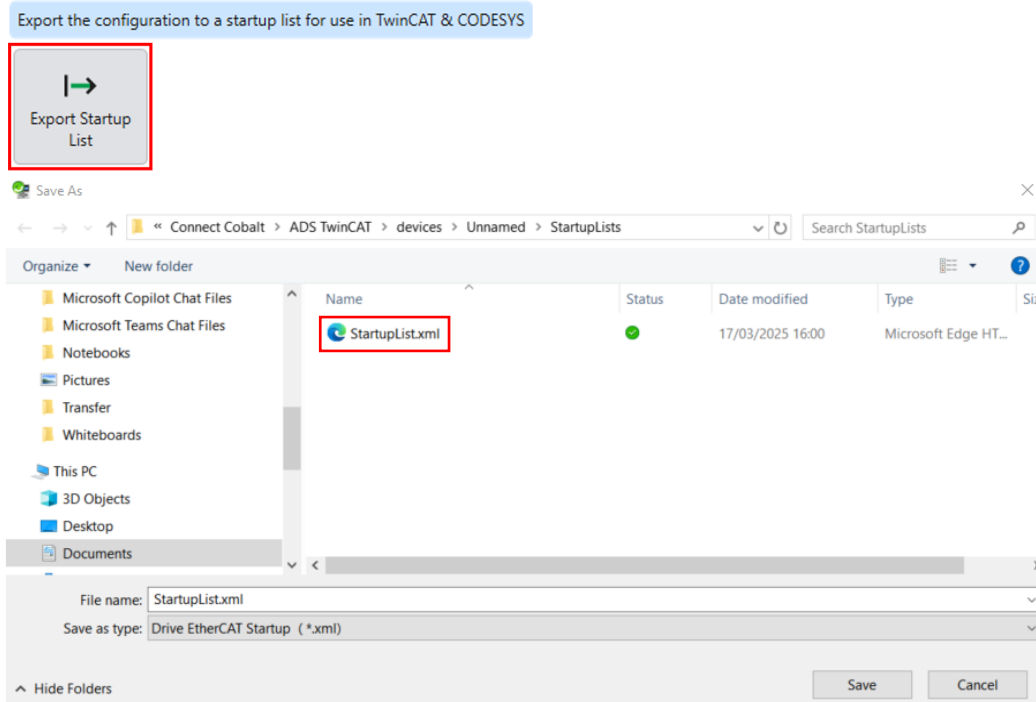
11. Save the tuned parameters in the drive by clicking the "Save Parameters" button:

Save Parameters



12. An EtherCAT startup list may be generated to preserve the configuration in the TwinCAT PLC/IPC. The startup list is in the form of a startup list.xml file that may be imported into TwinCAT. It is recommended to perform this when the application software has been written and the position loop has been tuned.

Export as Startup List



StartupList.xml is stored in the following location:

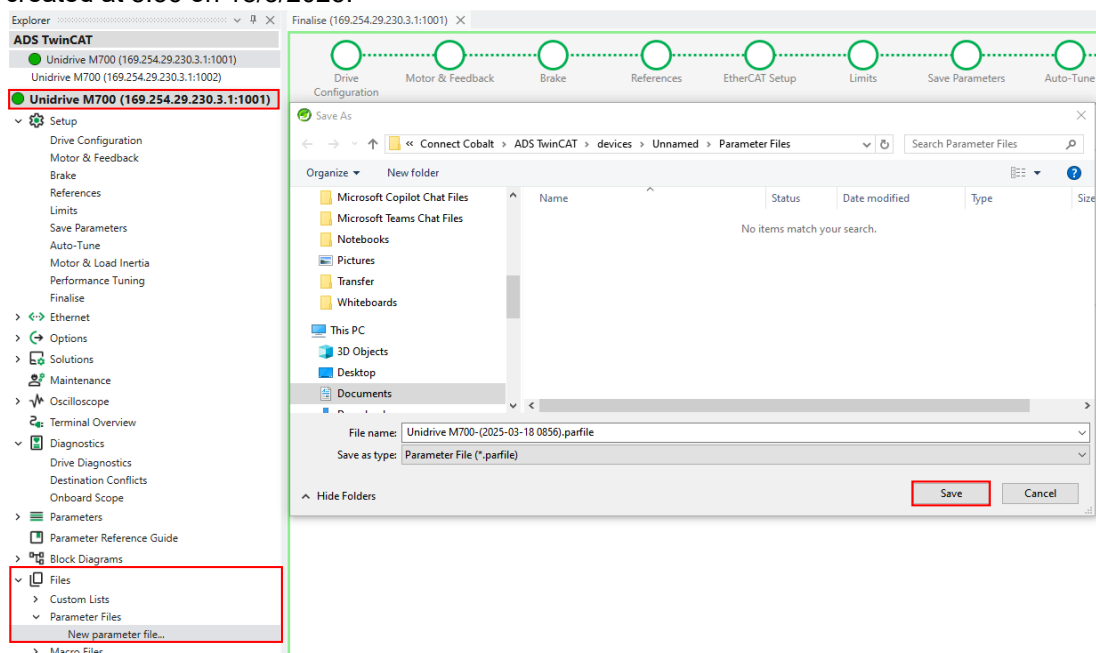
C:\Users\[USER NAME]\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists.

See section **10.8 How to use a startup list in TwinCAT.**

13. The startup list for an EtherCAT device is a helpful way to configure CiA402 CAN objects and drive parameters (addressed as CAN objects) when an EtherCAT node starts. There are a couple of standard ways in which this feature is used:

- To apply the parameters used to setup a drive axis from scratch. This will restore the original drive configuration in case the drive parameters have been altered.
- It can also be used to automatically configure a brand new drive (assuming the drive and EtherCAT option firmware match) in the event that a drive is replaced.

14. It is advised to make a parameter file once tuning has been completed by selecting “Files” > “Parameter Files” > “New parameter file...”. This file preserves the final setup of the drive, regardless of what happens to the Connect project later on, and forms a useful future reference of the configuration. Click “Save” to create the parameter file. The file is automatically time and date stamped, e.g. Unidrive M700-(2025-03-18 0856).parfile was created at 8:56 on 18/3/2025.



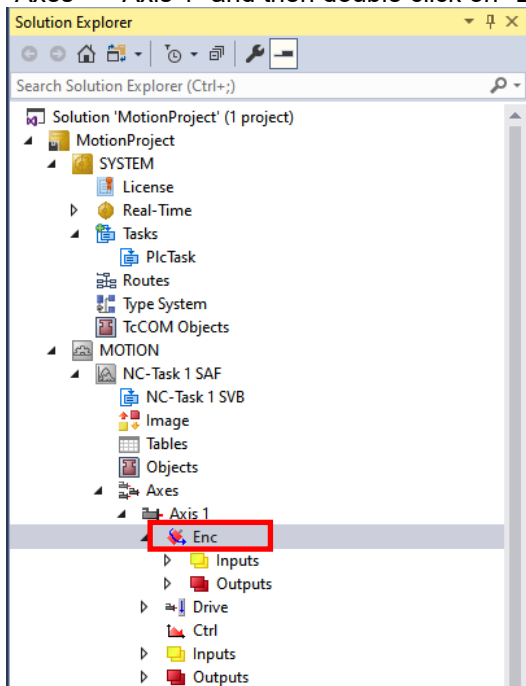
7 TwinCAT Axis Configuration

This section describes how to setup the basic properties of an axis including its unit scaling and monitoring. A detailed description of how scaling works is given in section **10.4 How to setup axis unit scaling**.

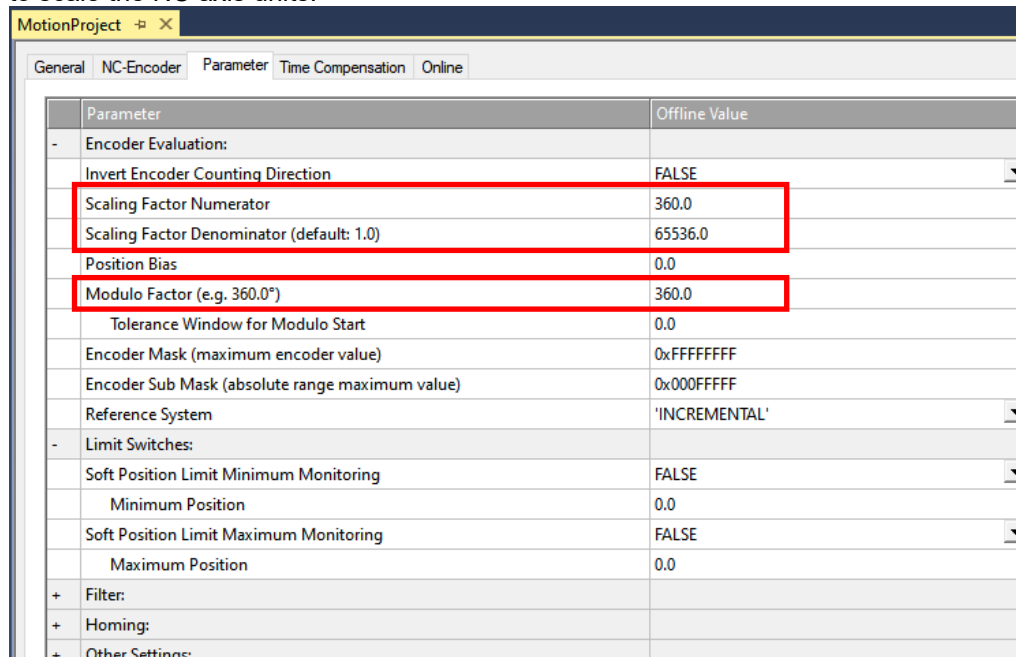
1. Put the IPC /PLC into configure mode by pressing the config mode button.



2. Set up the axis scaling. This can be found by selecting “MOTION” > “NC-Task 1 SAF” > “Axes” > “Axis 1” and then double click on “Enc”:

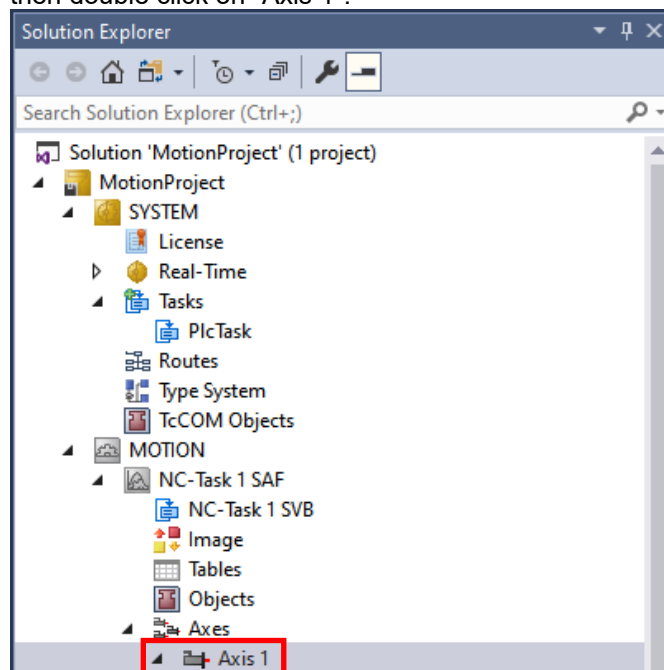


- The Encoder setup appears. Select the “Parameter” tab. “Scaling Factor Numerator” defines the number of Units represented by the number of encoder counts defined by “Scaling Factor Denominator”. See section **10.4 How to setup axis unit scaling** for more information on how to scale the NC axis units.



In the example above for 360° there are 65536 counts, so for 1 revolution in encoder counts we have 360°. Other configuration for things like software limits and DS402 Homing are on this tab if needed. The modulo factor only needs to be set if the axis is going to do some modulo positioning using MC_MoveModulo.

- Next choose the units that the axis uses. Select “Motion” > “NC-Task 1 SAF” > “Axes” and then double click on “Axis 1”:



- The axis setup appears. Select the “Settings” tab, and then change the unit type to something suitable e.g. “Degree”.

The screenshot shows the MotionProject software interface with the 'Settings' tab selected. The 'Unit' dropdown is highlighted with a red box and set to 'Degree'. Below it, the 'Display (Only)' section has checkboxes for 'Position' (mDegree, Modulo) and 'Velocity' (Degree/min). The 'Result' section shows units for Position (Degree), Velocity (Degree/s), Acceleration (Degree/s2), and Jerk (Degree/s3). The 'Axis Cycle Time / Access Divider' section shows a Divider of 1 and a Cycle Time (ms) of 2.000.

- Turn off the encoder following error limits as these tend to cause nuisance NC axis errors the first time the axis runs. Double click on the axis in the “Solution Explorer” tree, then select the “Parameter” tab. Scroll down to “Monitoring” and set “Position Lag Monitoring”, “Position Range Monitoring”, and “Target Position Monitoring” to FALSE. These checks can be reinstated later if required.

The screenshot shows the MotionProject software interface with the 'Parameter' tab selected. The 'Solution Explorer' tree on the left shows the project structure, with 'Axis 1' highlighted. The 'Parameter' table on the right lists various parameters and their values. The 'Monitoring' section is expanded, and the following parameters are highlighted with red boxes and set to FALSE:

Parameter	Offline Value
Position Lag Monitoring	FALSE
Position Range Monitoring	FALSE
Target Position Monitoring	FALSE

- Set the maximum dynamics. Typically the “Reference Velocity” and “Maximum Velocity” need to be set to the maximum reference that can be applied to the motor, as shown by Maximum Reference Clamp Pr1.006 or as configured on the “References” page in the Connect guided setup:

Use the formula provided in section **10.4 How to setup axis unit scaling** to convert the maximum reference speed in rpm into units/s. An example is given below:

An axis has a maximum speed of 3000rpm, and a scaling numerator of 360 units per revolution, the maximum speed in units per second is $3000 * 360 / 60 = 18000$.

Unless the application has a specific reason to limit the acceleration and deceleration maximum, the best option is to set the acceleration and deceleration to a high value such as $1E+20$, (100000000000000000000), so they don't cause nuisance NC axis errors when the axis is run for the first time.

Parameter	Offline Value
- Maximum Dynamics:	
Reference Velocity	18000.0
Maximum Velocity	18000.0
Maximum Acceleration	100000000000000000000.0
Maximum Deceleration	100000000000000000000.0
- Default Dynamics:	
Default Acceleration	1500.0
Default Deceleration	1500.0
Default Jerk	100000000000000000000.0

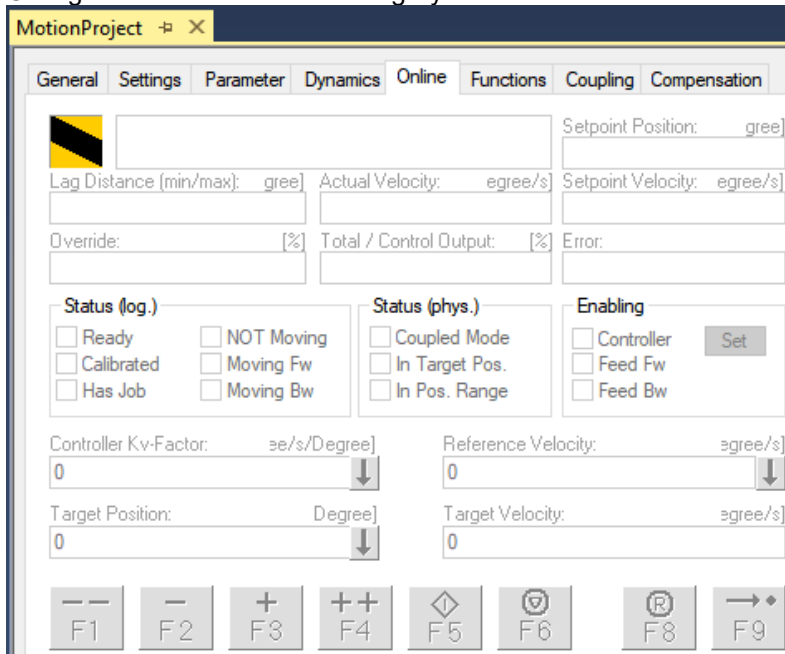
8. Configure the default dynamics for the axis. These are entirely dependent on the specific application. It can be helpful to set the default Jerk to $1E+20$, (100000000000000000000), which will invoke a linear acceleration profile if the jerk is left at 0 and will prevent nuisance NC axis errors.

The screenshot displays the Siemens NX software interface. On the left, the 'Solution Explorer' shows a project named 'Dual Drive Rig' with a tree structure including 'SYSTEM', 'MOTION', 'NC-Task 1 SVB', 'Image', 'Tables', 'Objects', and 'Axes'. 'Axis 1' is selected. On the right, the 'Dual Drive Rig' window is open, showing the 'Parameter' tab. A table lists parameters and their offline values:

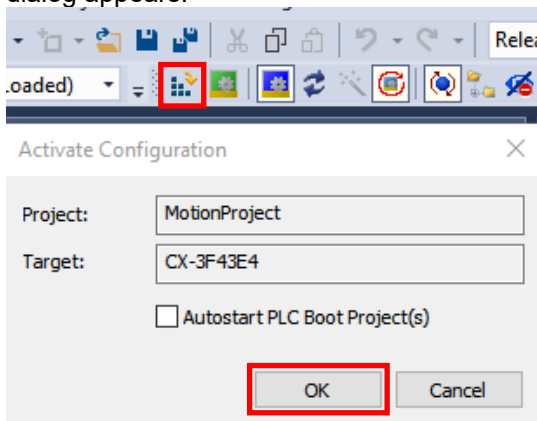
Parameter	Offline Value
- Maximum Dynamics:	
Reference Velocity	18000.0
Maximum Velocity	18000.0
Maximum Acceleration	100000000000000000000.0
Maximum Deceleration	100000000000000000000.0
- Default Dynamics:	
Default Acceleration	1500.0
Default Deceleration	1500.0
Default Jerk	100000000000000000000.0

8 Moving the axis using TwinCAT test moves

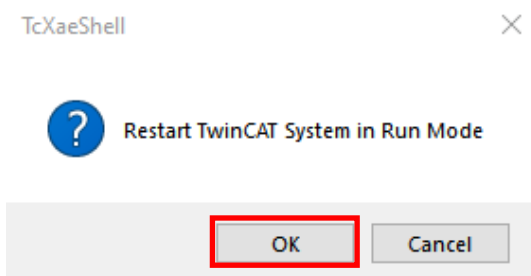
1. Click on the “Online” tab to reveal the test controls. At this point the system will be offline in Config mode so the controls are greyed out.



2. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



3. Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



- The “Online” tab test controls are now available. To run the drive the “Enabling” control must be configured. Press the “Set” button and when the “Set Enabling” dialog appears press the “All” button and set the override percentage to 100%. The axis will now move if for example F2 or F3 are pressed to jog the axis.

Setup EoE

General Settings Parameter Dynamics **Online** Functions Coupling Compensation

Position: **-638.3276** Setpoint Position: **-638.3281**

Lag Distance (min/max): **-0.0005 (-5.400, 5.493)** Actual Velocity: **0.0473** Setpoint Velocity: **0.0000**

Override: **100.0000 %** Total / Control Output: **0.00 / 0.00 %** Error: **0 (0x0)**

Status (log.) Status (phys.) Enabling

☒ Ready ☒ NOT Moving ☐ Coupled Mode ☒ Controller **Set**

☐ Calibrated ☐ Moving Fw ☐ In Target Pos. ☒ Feed Fw

☐ Has Job ☐ Moving Bw ☐ In Pos. Range ☒ Feed Bw

Controller Kv-Factor: **1** Reference Velocity: **2200**

Target Position: **0** Target Velocity: **2000**

F1 **F2** **F3** **F4** **F5** **F6** **F7** **F8**

Set Enabling

☒ Controller **OK**

☒ Feed Fw **Cancel**

☒ Feed Bw

Override [%]: **100** **All**

HINT: The motion profile setup is configured on the “Parameter” tab under “Manual Motion

General Settings **Parameter** Dynamics Online Functions Coupling Compensation

Parameter	Offline Value	Online Value
- Maximum Dynamics:		
Reference Velocity	2200.0	2200.0
Maximum Velocity	2000.0	2000.0
Maximum Acceleration	15000.0	15000.0
Maximum Deceleration	15000.0	15000.0
- Default Dynamics:		
Default Acceleration	1500.0	1500.0
Default Deceleration	1500.0	1500.0
Default Jerk	2250.0	2250.0
- Manual Motion and Homing:		
Homing Velocity (towards plc cam)	30.0	30.0
Homing Velocity (off plc cam)	30.0	30.0
Manual Velocity (Fast)	600.0	600.0
Manual Velocity (Slow)	100.0	100.0
Jog Increment (Forward)	5.0	5.0
Jog Increment (Backward)	5.0	5.0

5. The on screen buttons have the following function:



The following table provides an overview of all manual mode functions.

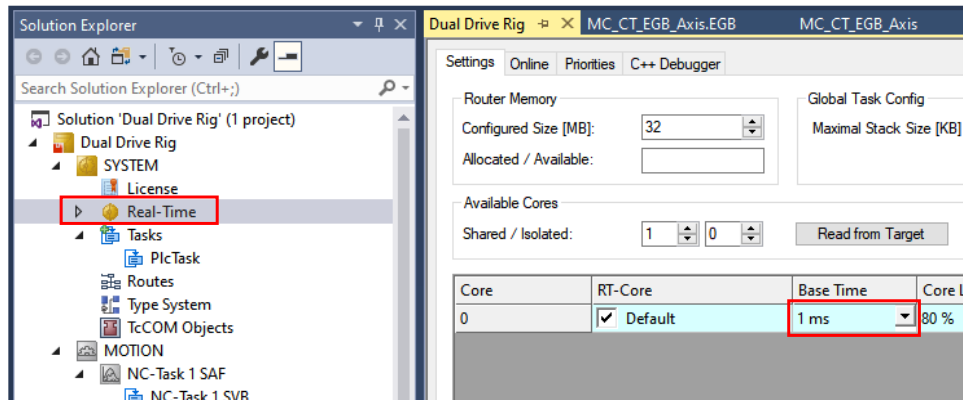
Function	Description
F1	Reverse travel with <i>Manual Velocity (Fast)</i>
F2	Reverse travel with <i>Manual Velocity (Slow)</i>
F3	Forward travel with <i>Manual Velocity (Slow)</i>
F4	Forward travel with <i>Manual Velocity (Fast)</i>
F5	Start a direct travel command <ul style="list-style-type: none"> • Enter the <i>Target Position</i> • Enter the <i>Target Velocity</i> • Start the travel command with F5
F6	Stop a direct travel command
F8	NC reset; the current motion command is aborted.
F9	Initiate homing (see TwinCAT documentation)

9 Using PLCopen to move an axis

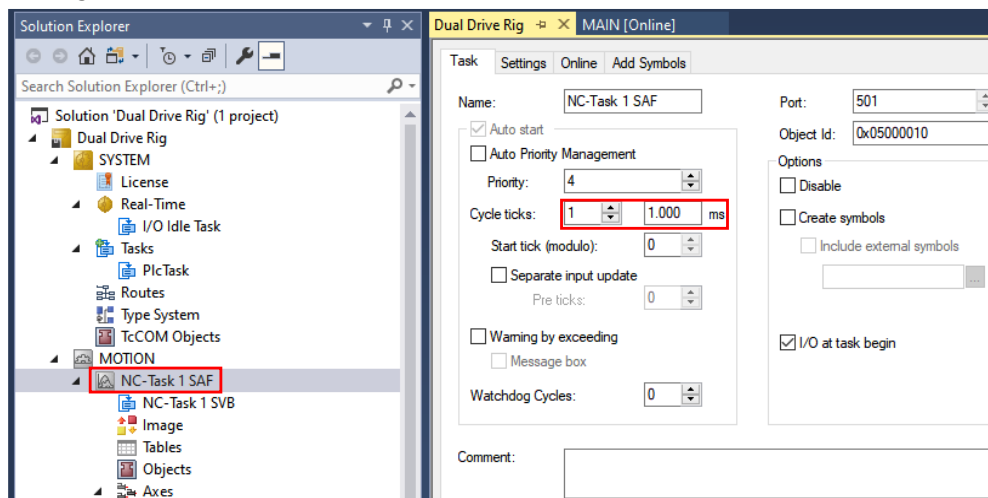
This section describes the basic steps needed to get PLCopen functionality running on a Beckhoff PLC. It is assumed that all the previous steps have been followed and the axis is proven to be working using the test moves control.

1. Before adding the motion it is worth reviewing the task and PDO update rates to see if they are suitable for the application. By default, the tasks are set to 10ms update which is relatively slow. Ideally, the PDO update, the NC Axis update rate and the PLC task should update at the same time e.g. all 1ms.

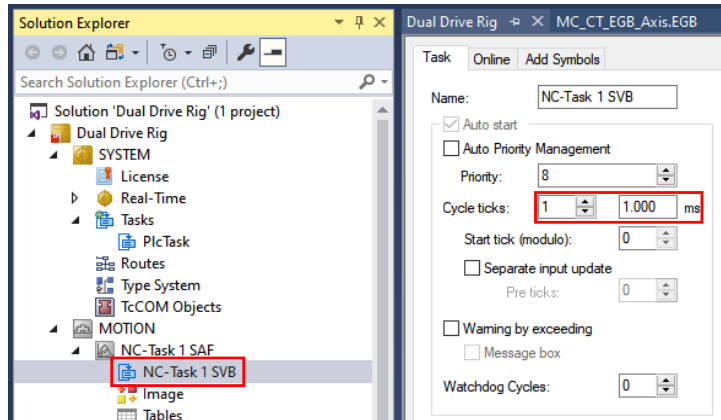
Set the Base time for real time tasks to 1ms:



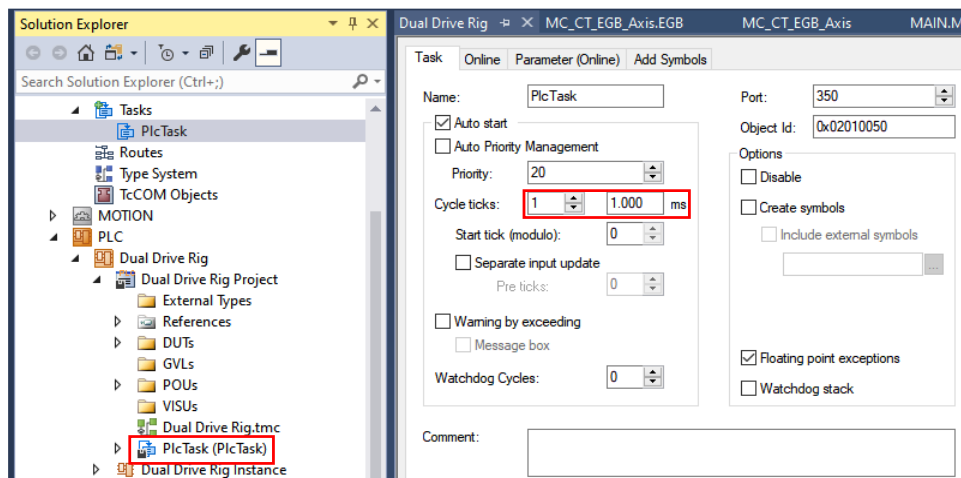
Set NC-Task 1 SAF to 1ms:



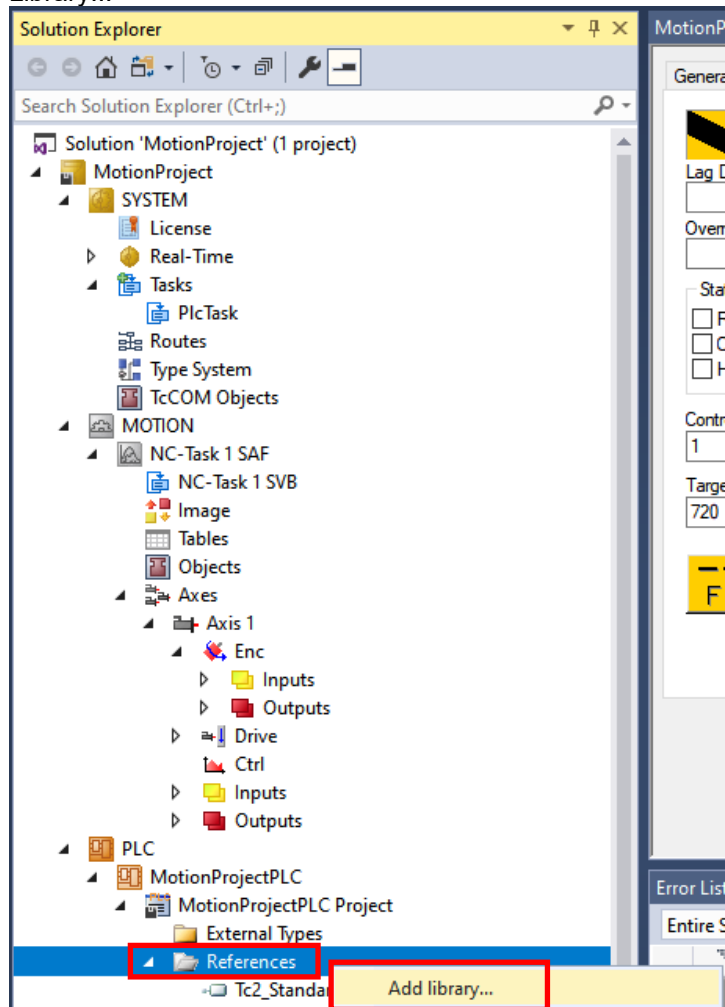
Set NC-Task 1SVB to 1ms:



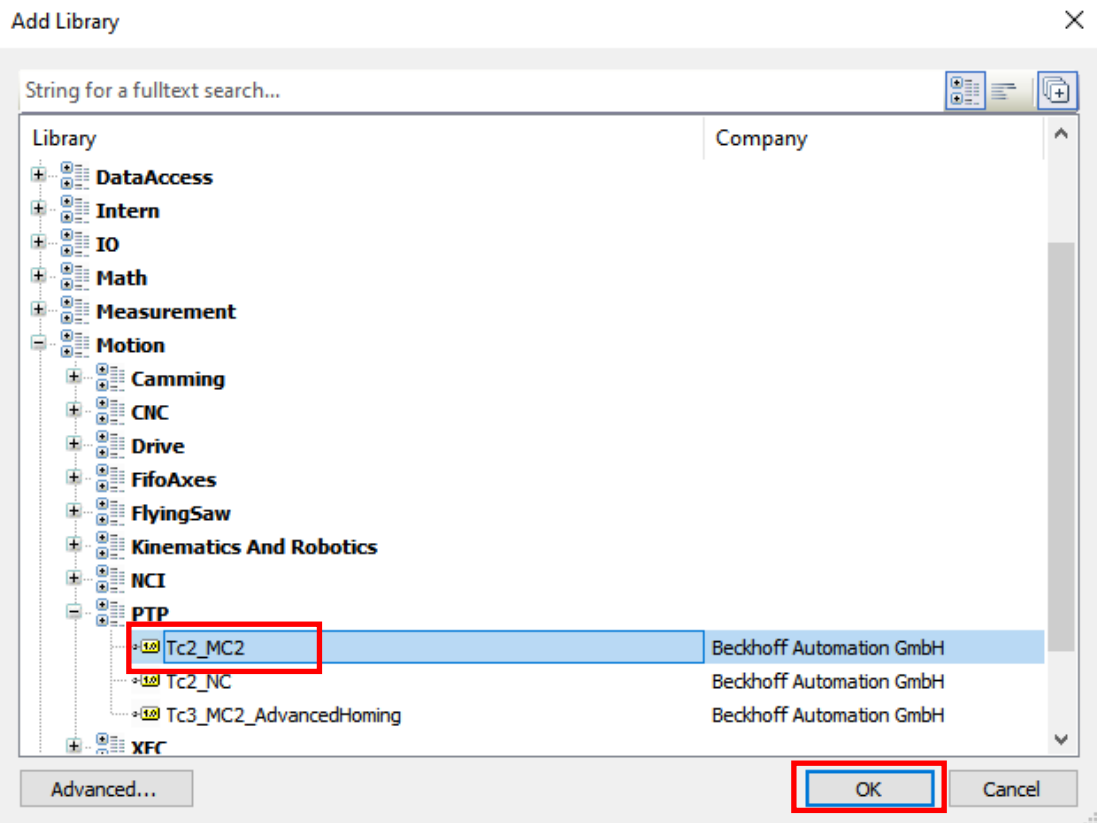
Set the task that the motion code is executed to 1ms:



2. We need to add the basic motion libraries required for point to point (PTP) motion. Select “PLC” > “[project name]” > “[project name] Project” > “References” then right click “Add Library...”

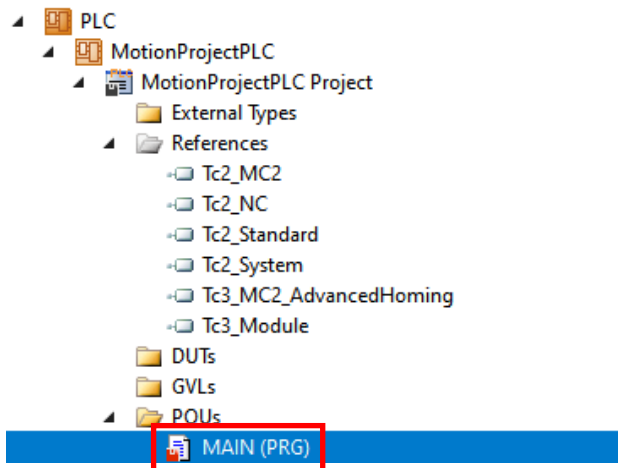


3. Select "Motion" > "PTP" and then highlight "Tc2_MC2" and then click "OK":

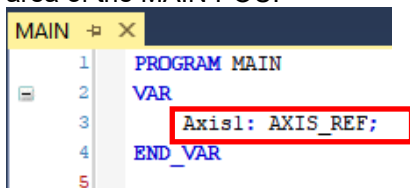


Repeat this process for the other libraries in the "PTP" category.

4. Select "PLC" > "{project name}" > "{project name} Project" > "POUs" and then double click on "MAIN".

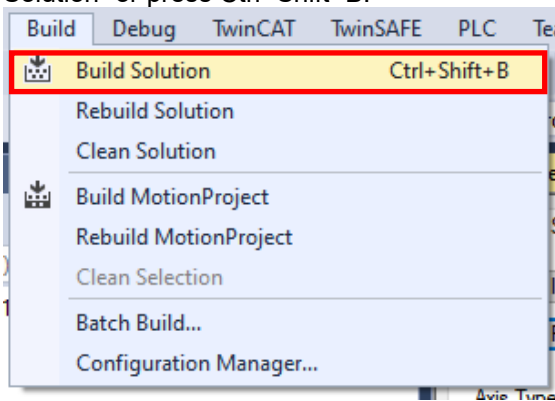


5. In the PLC part of the project add an AXIS_REF. This is the PLCOpen axis interface and is referred to in Beckhoff terminology as the "PLC Axis". Add the following into the declaration area of the MAIN POU.



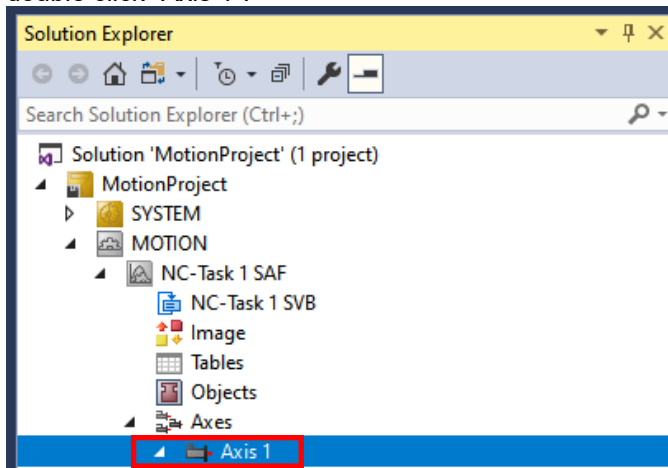
It is best to keep the naming of the axis similar to the project axis.

6. Build the project so the new AXIS_REF is known to the Project. Select “Build” > “Build Solution” or press Ctrl+Shift+B.

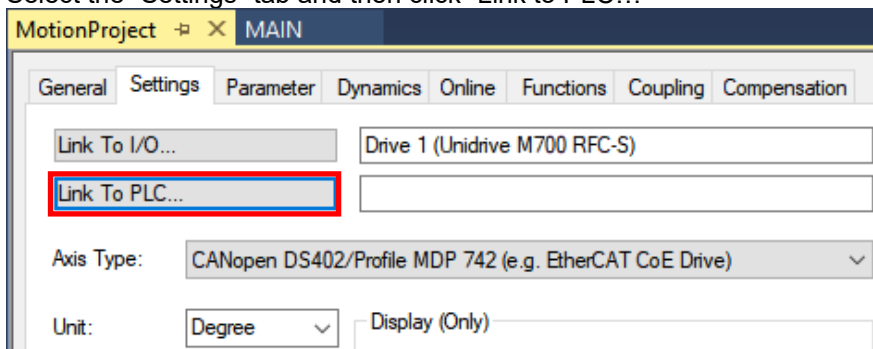


HINT: Failure to do this will result in the PLCopen axis not appearing in the list when linking the PLC Axis to the Motion Axis.

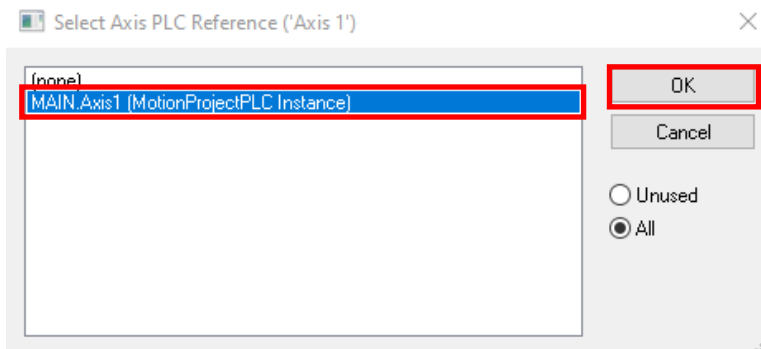
7. Link the PLC Axis to the Motion Axis. Select “Motion” > “NC-Task SAF” > “Axes” and then double click “Axis 1”:



8. Select the “Settings” tab and then click “Link to PLC...”



9. When the “Select Axis PLC Reference (‘Axis 1’)” dialog appears, select “MAIN.Axis1” and then click “OK”.



Now the axis is ready for normal PLCopen motion programming.

10. The next steps are the same whatever the platform e.g. Power the axis using MC_Power, Read the status using MC_ReadStatus, and jog using MC_Jog. To add this functionality the control blocks must be declared e.g.

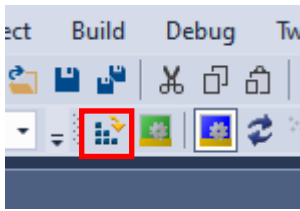
```
MotionProject  MAIN*  X
1  PROGRAM MAIN
2  VAR
3      Axis1: AXIS_REF;
4      Axis1Power: MC_Power;
5      Axis1Status: MC_ReadStatus;
6      Axis1Jog: MC_Jog;
7  END_VAR
```

Next, call the function blocks from the program area:

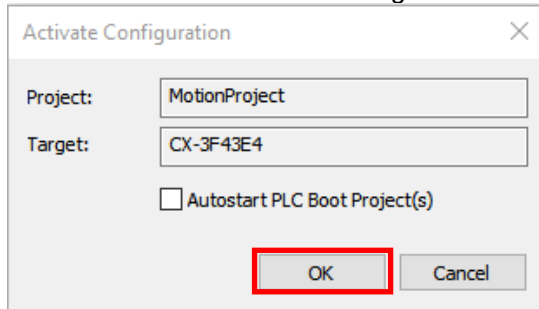
```
1  Axis1Power(Axis := Axis1);
2  Axis1Status(Axis := Axis1);
3  Axis1Jog(Axis := Axis1);
```

HINT: As a minimum the Axis must be linked to each PLCopen FB instance i.e. “Axis := Axis1”.

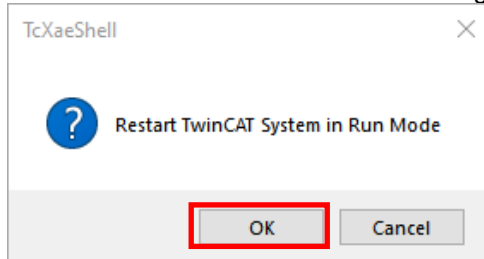
11. Press activate configuration to compile the software, and load it to the target, and set run mode:



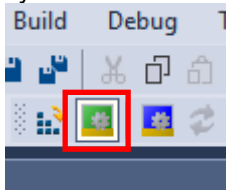
Click "OK" on the "Activate Configuration" dialog



Click "OK" on the restart TwinCAT dialog.

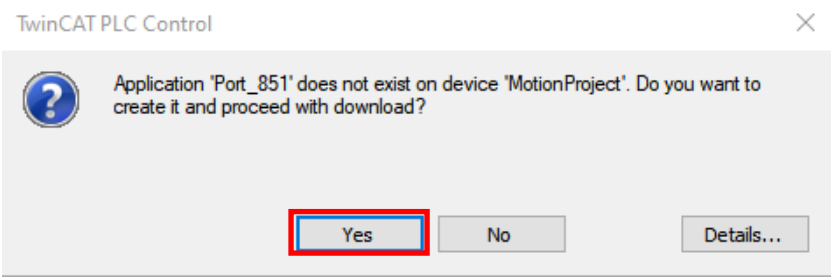


The PLC changes to run mode as shown by the box surrounding the green TwinCAT state symbol:



12. Click the login icon  to view the code while it runs:

Click “OK” to the “TwinCAT PLC Control” dialog.




The live values for each of the PLCopen function blocks may be seen:

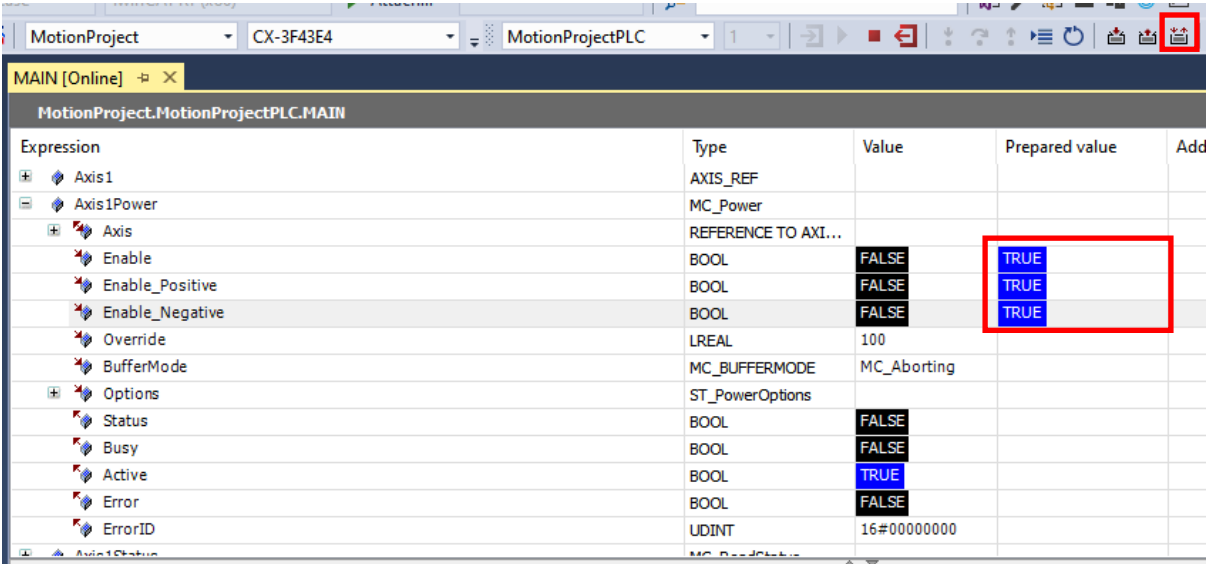
MAIN [Online] ▢ ×		
MotionProject.MotionProjectPLC.MAIN		
Expression	Type	Value
Axis1	AXIS_REF	
Axis1Power	MC_Power	
Axis	REFERENCE TO AXI...	
Enable	BOOL	FALSE
Enable_Positive	BOOL	FALSE
Enable_Negative	BOOL	FALSE
Override	LREAL	100
BufferMode	MC_BUFFERMODE	MC_Aborting
Options	ST_PowerOptions	
Status	BOOL	FALSE
Busy	BOOL	FALSE
Active	BOOL	FALSE
Error	BOOL	FALSE
ErrorID	UDINT	16#00000000
Axis1Status	MC_ReadStatus	
<pre>1 Axis1Power(Axis := Axis1); 2 Axis1Status(Axis := Axis1); 3 Axis1Jog(Axis := Axis1); RETURN</pre>		

13. Run the application (if it is not already running) by pressing the  button.

When the system is running the online tool bar looks like this:

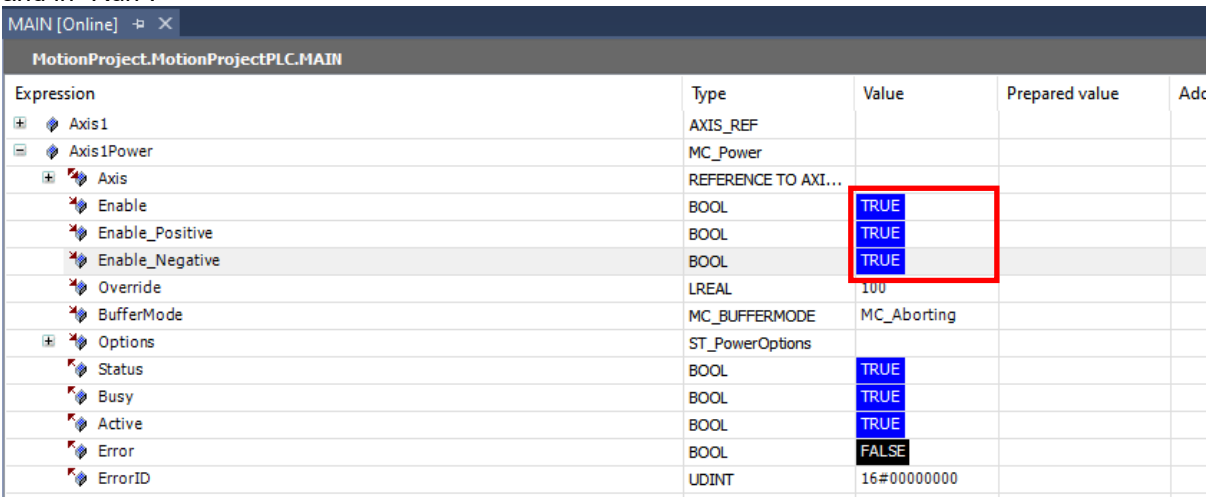


14. To power the axis, apply 24V to the drives STO / Enable input. Expand Axis1Power and then click in the prepare box to the right of the values of the Enable, Enable_Positive, and Enable_Negative inputs. Press the “Write Values” button  or Ctrl+F7 to set the prepared values.




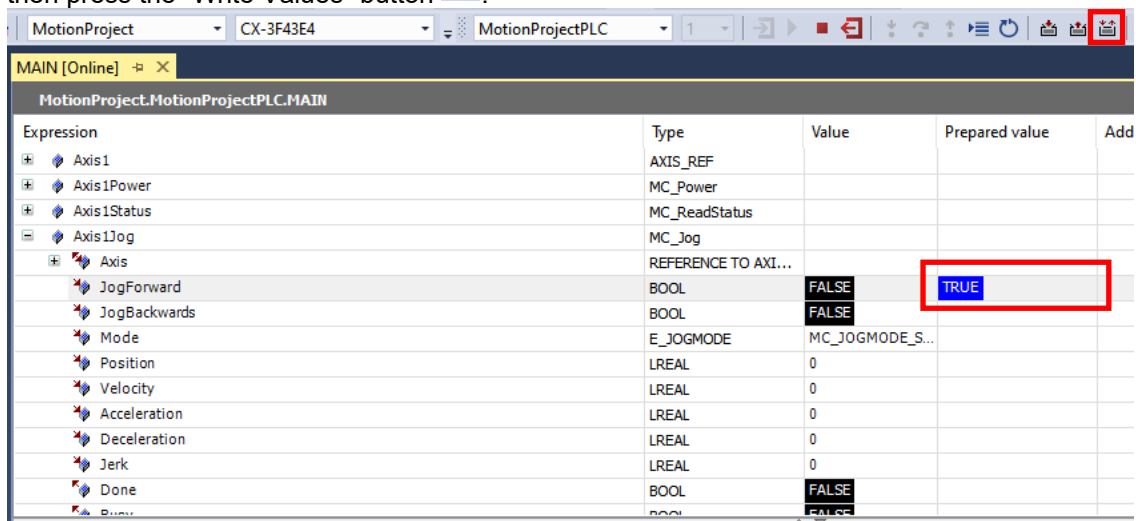
Expression	Type	Value	Prepared value	Add
Axis1	AXIS_REF			
Axis1Power	MC_Power			
Axis	REFERENCE TO AXI...			
Enable	BOOL	FALSE	TRUE	
Enable_Positive	BOOL	FALSE	TRUE	
Enable_Negative	BOOL	FALSE	TRUE	
Override	LREAL	100		
BufferMode	MC_BUFFERMODE	MC_Aborting		
Options	ST_PowerOptions			
Status	BOOL	FALSE		
Busy	BOOL	FALSE		
Active	BOOL	TRUE		
Error	BOOL	FALSE		
ErrorID	UDINT	16#00000000		
Axis1Status	MC_ReadStatus			

After the values have been applied the value changes as shown and the drive will be enabled and in “Run”:




Expression	Type	Value	Prepared value	Adc
Axis1	AXIS_REF			
Axis1Power	MC_Power			
Axis	REFERENCE TO AXI...			
Enable	BOOL	TRUE		
Enable_Positive	BOOL	TRUE		
Enable_Negative	BOOL	TRUE		
Override	LREAL	100		
BufferMode	MC_BUFFERMODE	MC_Aborting		
Options	ST_PowerOptions			
Status	BOOL	TRUE		
Busy	BOOL	TRUE		
Active	BOOL	TRUE		
Error	BOOL	FALSE		
ErrorID	UDINT	16#00000000		

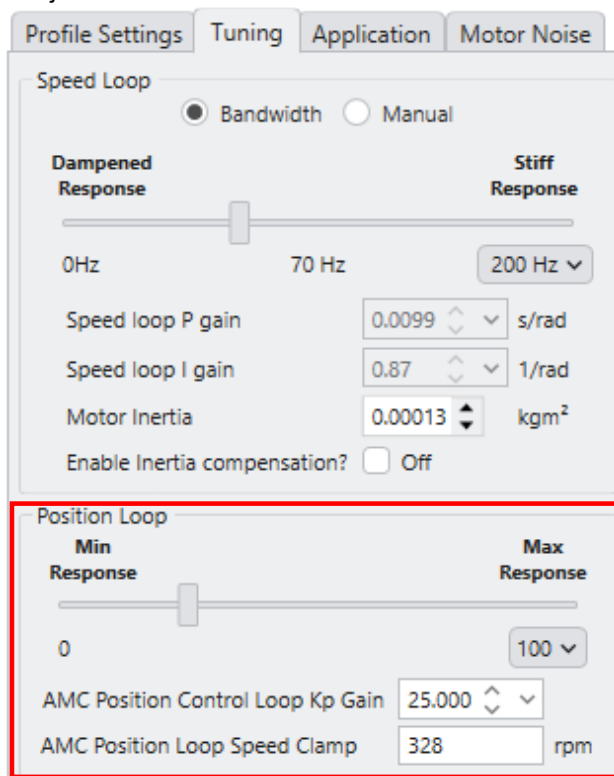
15. The axis may be Jogged by setting the JogForward or JogBackwards bits. If the inputs for Velocity, Acceleration, and Deceleration are left at 0, the default values configured in "Axis 1" > "Parameter" tab. Click in the "Prepared Value" box for JogForward to set it to TRUE and then press the "Write Values" button :



Expression	Type	Value	Prepared value	Add
Axis1	AXIS_REF			
Axis1Power	MC_Power			
Axis1Status	MC_ReadStatus			
Axis1Jog	MC_Jog			
Axis	REFERENCE TO AXI...			
JogForward	BOOL	FALSE	TRUE	
JogBackwards	BOOL	FALSE		
Mode	E_JOGMODE	MC_JOGMODE_S...		
Position	LREAL	0		
Velocity	LREAL	0		
Acceleration	LREAL	0		
Deceleration	LREAL	0		
Jerk	LREAL	0		
Done	BOOL	FALSE		
Run	BOOL	FALSE		

The axis will begin jogging. To stop the axis repeat this procedure but instead click the prepared value until FALSE is shown and then click "Write Values"  or Ctrl+F7.

16. When the complete motion system has been programmed, the position loop can be tuned using the worst case working motion profile e.g. one that has the highest acceleration rate and jerk. See section 10.10 How and when to tune the Position Loop.



Profile Settings | **Tuning** | Application | Motor Noise

Speed Loop

☒ Bandwidth ☐ Manual

Dampened Response **Stiff Response**

0Hz 70 Hz 200 Hz v

Speed loop P gain 0.0099 v s/rad

Speed loop I gain 0.87 v 1/rad

Motor Inertia 0.00013 v kgm²

Enable Inertia compensation? ☐ Off

Position Loop

Min Response **Max Response**

0 100 v

AMC Position Control Loop Kp Gain 25.000 v

AMC Position Loop Speed Clamp 328 rpm

10 How to guides

10.1 How to home using MC_Home

MC_Home is the standard homing function specified by the PLCopen standard. In TwinCAT like many other PLCopen IDEs, this triggers the homing functionality in DS402 to perform the homing function. The majority of the setup for this homing mechanism is actually defined by the “Axis 1” “Parameter” tab, and the “Enc” parameter tab.

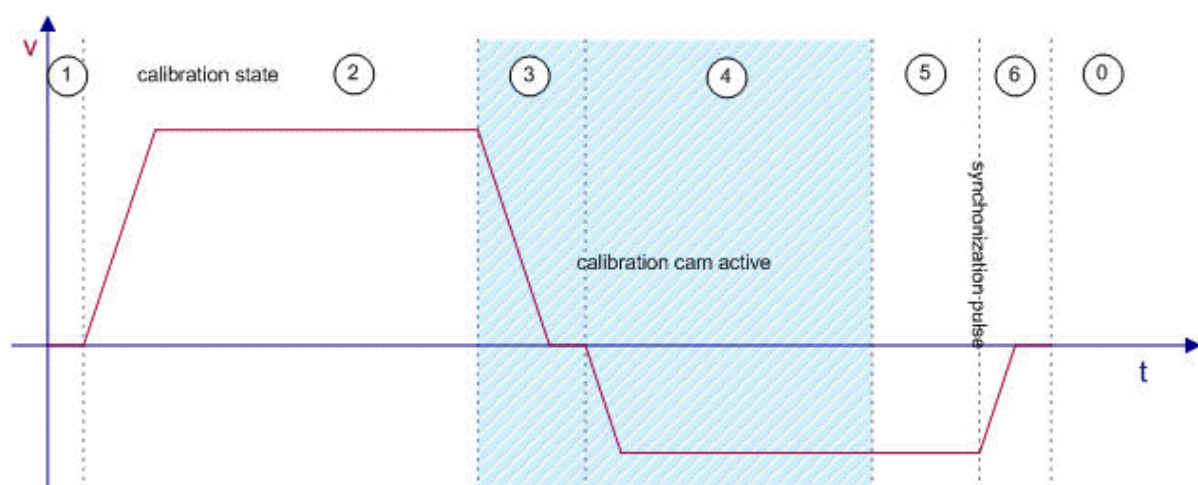
The screenshot shows the 'Parameter' tab for 'Axis 1' in the TwinCAT Parameter Explorer. The 'Manual Motion and Homing' section is highlighted with a red box. The parameters and their values are as follows:

Parameter	Offline Value
Maximum Dynamics:	
Reference Velocity	2200.0
Maximum Velocity	2000.0
Maximum Acceleration	15000.0
Maximum Deceleration	15000.0
Default Dynamics:	
Default Acceleration	1500.0
Default Deceleration	1500.0
Default Jerk	2250.0
Manual Motion and Homing:	
Homing Velocity (towards plc cam)	30.0
Homing Velocity (off plc cam)	30.0
Manual Velocity (Fast)	600.0
Manual Velocity (Slow)	100.0
Jog Increment (Forward)	5.0
Jog Increment (Backward)	5.0

The screenshot shows the 'Enc' parameter tab for 'Axis 1' in the TwinCAT Parameter Explorer. The 'Homing' section is highlighted with a red box. The parameters and their values are as follows:

Parameter	Offline Value
Limit Switches:	
Soft Position Limit Minimum Monitoring	FALSE
Minimum Position	0.0
Soft Position Limit Maximum Monitoring	FALSE
Maximum Position	0.0
Filter:	
Homing:	
Invert Direction for Homing Sensor Search	FALSE
Invert Direction for Sync Impuls Search	TRUE
Home Position (Calibration Value)	0.0
Reference Mode (Sync condition)	'Default'
Homing Sensor Source	'Default: PLC Cam (MC_Home)'


The default homing operation when using MC_Home is the classic homing profile shown below:

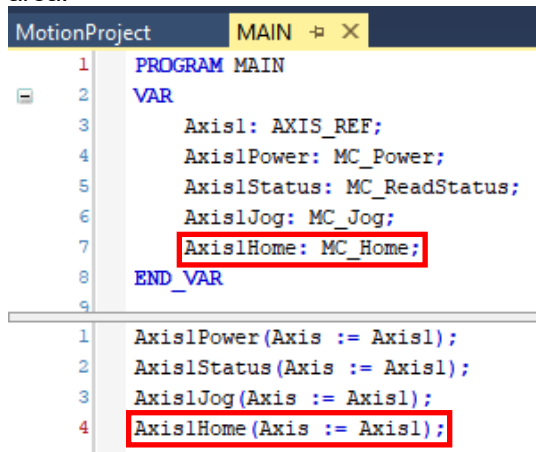


In the previous profile when homing is started:

- The axis will search forwards for a homing switch that has been routed to the MC_Home blocks bCalibrationCam (Home Switch) input.
- When the homing switch sets MC_Home. bCalibrationCam = TRUE, the motor will reverse direction looking for bCalibrationCam to change state to FALSE.
- When MC_Home. bCalibrationCam = FALSE, the position is reset to MC_Home.Position.
- The axis slows down and stops, and MC_Home.Done is set to TRUE.

To test the behaviour, use the following steps:

1. Set Configuration Mode by pressing  and then click OK to all the following dialogs.
2. Declare an instance of MC_Home called Axis1Home and then reference it in the program area:

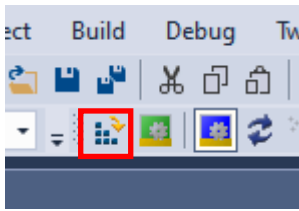


The screenshot shows the MotionProject software interface. The top bar indicates the project is in 'MAIN' mode. The left sidebar shows a tree view with 'MotionProject' and 'MAIN'. The main area displays the program code for 'MAIN'. The code is as follows:

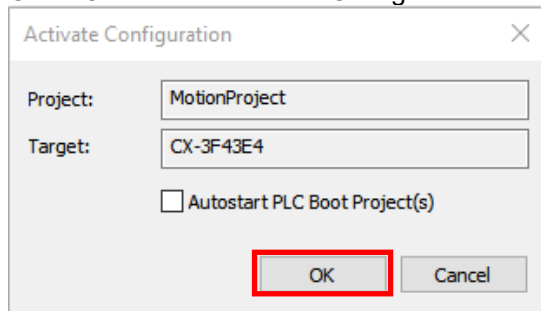
```
1 PROGRAM MAIN
2 VAR
3     Axis1: AXIS_REF;
4     Axis1Power: MC_Power;
5     Axis1Status: MC_ReadStatus;
6     Axis1Jog: MC_Jog;
7     Axis1Home: MC_Home;
8 END_VAR
9
10 Axis1Power(Axis := Axis1);
11 Axis1Status(Axis := Axis1);
12 Axis1Jog(Axis := Axis1);
13 Axis1Home(Axis := Axis1);
```

The lines 7 and 13 are highlighted with red boxes, indicating the declaration and reference of the Axis1Home instance.

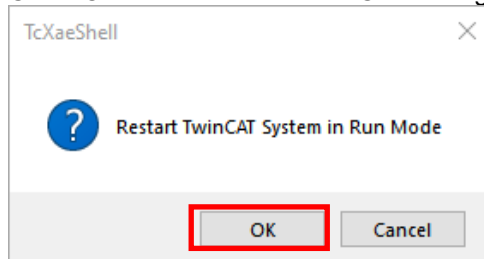
3. Press activate configuration to compile the software, and load it to the target, and set run mode:



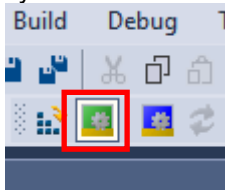
Click "OK" on the "Activate Configuration" dialog



Click "OK" on the restart TwinCAT dialog.

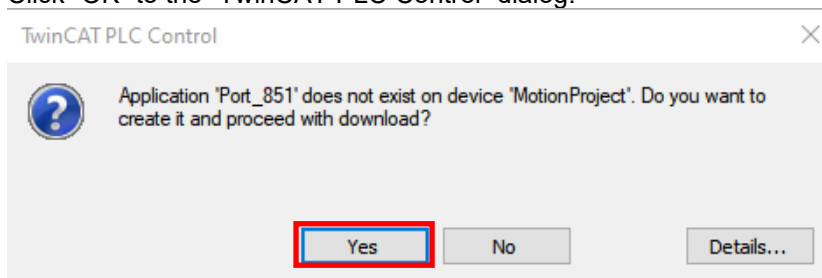



The PLC changes to run mode as shown by the box surrounding the green TwinCAT state symbol:



4. Click the login icon  to view the code while it runs:


Click "OK" to the "TwinCAT PLC Control" dialog.

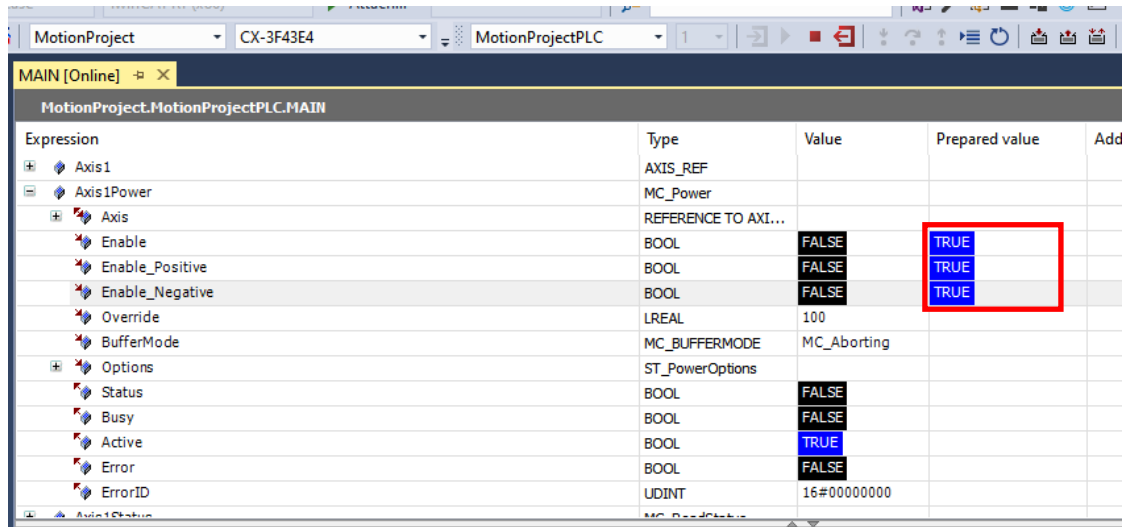


- Run the application (if it is not already running) by pressing the  button.

When the system is running the online tool bar looks like this:

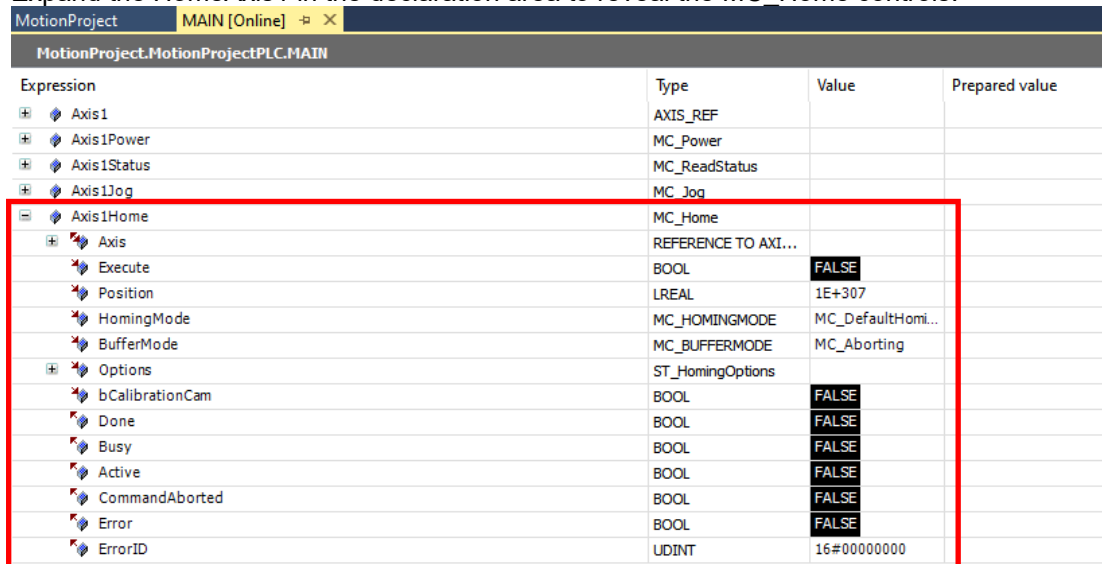


- To power the axis, apply 24V to the drives STO / Enable input. Expand Axis1Power and then click in the prepare box to the right of the values of the Enable, Enable_Positive, and Enable_Negative inputs. Press the “Write Values” button  or Ctrl+F7 to set the prepared values.
























Expression	Type	Value	Prepared value	Add
Axis1	AXIS_REF			
Axis1Power	MC_Power			
Axis	REFERENCE TO AXI...			
Enable	BOOL	FALSE	TRUE	
Enable_Positive	BOOL	FALSE	TRUE	
Enable_Negative	BOOL	FALSE	TRUE	
Override	LREAL	100		
BufferMode	MC_BUFFERMODE	MC_Aborting		
Options	ST_PowerOptions			
Status	BOOL	FALSE		
Busy	BOOL	FALSE		
Active	BOOL	TRUE		
Error	BOOL	FALSE		
ErrorID	UDINT	16#00000000		


- Expand the HomeAxis1 in the declaration area to reveal the MC_Home controls:
























Expression	Type	Value	Prepared value
Axis1	AXIS_REF		
Axis1Power	MC_Power		
Axis1Status	MC_ReadStatus		
Axis1Jog	MC_Jog		
Axis1Home	MC_Home		
Execute	BOOL	FALSE	
Position	LREAL	1E+307	
HomingMode	MC_HOMINGMODE	MC_DefaultHomi...	
BufferMode	MC_BUFFERMODE	MC_Aborting	
Options	ST_HomingOptions		
bCalibrationCam	BOOL	FALSE	
Done	BOOL	FALSE	
Busy	BOOL	FALSE	
Active	BOOL	FALSE	
CommandAborted	BOOL	FALSE	
Error	BOOL	FALSE	
ErrorID	UDINT	16#00000000	





















8. Start the homing process by setting Axis1Home.Execute = TRUE by clicking the prepared value box until it says true and then press the Write Value button :

MotionProject MAIN [Online]  			
MotionProject.MotionProjectPLC.MAIN			
Expression	Type	Value	Prepared value
 Axis1	AXIS_REF		
 Axis1Power	MC_Power		
 Axis1Status	MC_ReadStatus		
 Axis1Jog	MC_Jog		
 Axis1Home	MC_Home		
 Axis	REFERENCE TO AXI...		
 Execute	BOOL	FALSE	TRUE
 Position	LREAL	1E+307	
 HomingMode	MC_HOMINGMODE	MC_DefaultHomi...	
 BufferMode	MC_BUFFERMODE	MC_Aborting	
 Options	ST_HomingOptions		
 bCalibrationCam	BOOL	FALSE	
 Done	BOOL	FALSE	
 Busy	BOOL	FALSE	
 Active	BOOL	FALSE	
 CommandAborted	BOOL	FALSE	
 Error	BOOL	FALSE	
 ErrorID	UDINT	16#00000000	





















9. The axis runs forward. To simulate hitting the homing switch, set Axis1Home.bCalibrationCam to TRUE by clicking the prepared value box until it says TRUE and then press the Write Value button :

MotionProject MAIN [Online]  			
MotionProject.MotionProjectPLC.MAIN			
Expression	Type	Value	Prepared value
 Axis1	AXIS_REF		
 Axis1Power	MC_Power		
 Axis1Status	MC_ReadStatus		
 Axis1Jog	MC_Jog		
 Axis1Home	MC_Home		
 Axis	REFERENCE TO AXI...		
 Execute	BOOL	TRUE	
 Position	LREAL	1E+307	
 HomingMode	MC_HOMINGMODE	MC_DefaultHomi...	
 BufferMode	MC_BUFFERMODE	MC_Aborting	
 Options	ST_HomingOptions		
 bCalibrationCam	BOOL	FALSE	TRUE
 Done	BOOL	FALSE	
 Busy	BOOL	TRUE	
 Active	BOOL	TRUE	
 CommandAborted	BOOL	FALSE	
 Error	BOOL	FALSE	
 ErrorID	UDINT	16#00000000	

10. The Axis runs backwards looking for the falling edge of Axis1Home. bCalibrationCam. To simulate releasing the homing switch, set Axis1Home. bCalibrationCam to FALSE by clicking the prepared value box until it says FALSE and then press the Write Value button :

MotionProject MAIN [Online]  			
MotionProject.MotionProjectPLC.MAIN			
Expression	Type	Value	Prepared value
 Axis1	AXIS_REF		
 Axis1Power	MC_Power		
 Axis1Status	MC_ReadStatus		
 Axis1Jog	MC_Jog		
 Axis1Home	MC_Home		
 Axis	REFERENCE TO AXI...		
 Execute	BOOL	TRUE	
 Position	LREAL	1E+307	
 HomingMode	MC_HOMINGMODE	MC_DefaultHomi...	
 BufferMode	MC_BUFFERMODE	MC_Aborting	
 Options	ST_HomingOptions		
 bCalibrationCam	BOOL	TRUE	FALSE
 Done	BOOL	FALSE	
 Busy	BOOL	TRUE	
 Active	BOOL	TRUE	
 CommandAborted	BOOL	FALSE	
 Error	BOOL	FALSE	
 ErrorID	UDINT	16#00000000	

11. The position is reset, the axis stops, and Axis1Home is set to TRUE indicating that the homing sequence has completed.

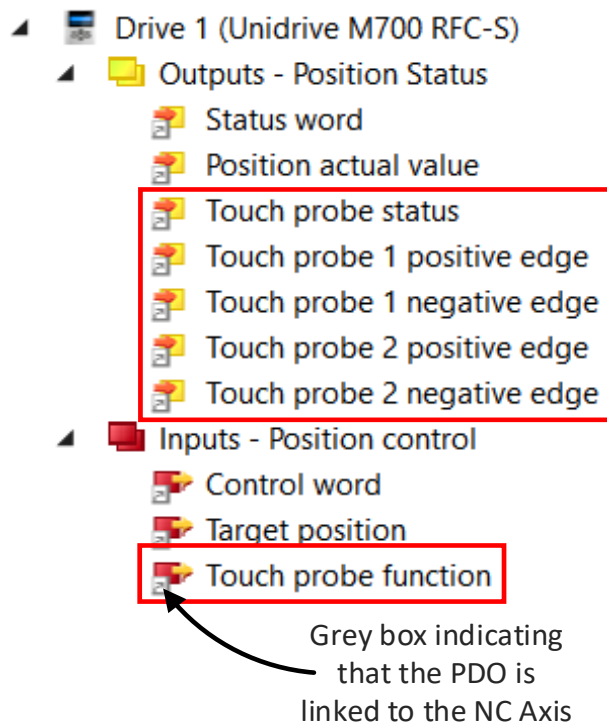
MotionProject MAIN [Online]  			
MotionProject.MotionProjectPLC.MAIN			
Expression	Type	Value	Prepared value
 Axis1	AXIS_REF		
 Axis1Power	MC_Power		
 Axis1Status	MC_ReadStatus		
 Axis1Jog	MC_Jog		
 Axis1Home	MC_Home		
 Axis	REFERENCE TO AXI...		
 Execute	BOOL	TRUE	
 Position	LREAL	1E+307	
 HomingMode	MC_HOMINGMODE	MC_DefaultHomi...	
 BufferMode	MC_BUFFERMODE	MC_Aborting	
 Options	ST_HomingOptions		
 bCalibrationCam	BOOL	FALSE	
 Done	BOOL	TRUE	
 Busy	BOOL	FALSE	
 Active	BOOL	FALSE	
 CommandAborted	BOOL	FALSE	
 Error	BOOL	FALSE	
 ErrorID	UDINT	16#00000000	

For further information on MC_Home Setup see the Beckhoff Information System
<https://infosys.beckhoff.com/>



10.2 How to configure PDO mappings

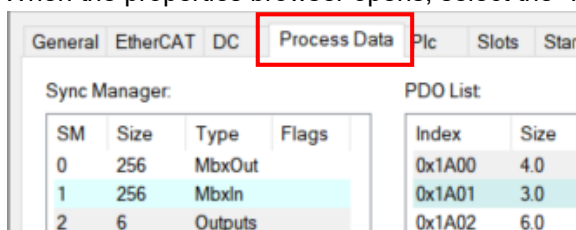
10.2.1 How to map touch probe PDOs

Using the default ESI PDO mappings, the Touch probe functionality is not mapped, and will result in MC_TouchProbe giving an error ID of 0x701 (1793). When Touch Probe 1 and 2 are mapped correctly it looks like this in the project tree:



To resolve this, the following steps show how to map the data in:

1. Put TwinCAT in Config mode by clicking on the  button.
2. Locate the drive to add the links to under "I/O" in the solution explorer. Double click on the Drive name e.g. Drive 1:

3. When the properties browser opens, select the "Process Data" tab:



- To set the PDO List find “Inputs - Position Control” box, and click on it to highlight the selection:

PDO List

Index	Size	Name	Flags	SM	SU
0x1A04	4.0	Outputs - Torque Status			0
0x1A05	0.0	Outputs - Large Mapping Set			0
0x1600	4.0	Inputs - Velocity Control			0
0x1601	3.0	Inputs - Control and Mode of Op			0
0x1602	6.0	Inputs - Position Control		2	0
0x1604	4.0	Inputs - Torque Control			0
0x1605	0.0	Inputs - Large Mapping Set			0

- Right click in the “PDO Content” box, and right click, then select “Add New Item...”:

PDO Content (0x1602):

Index	Size	Offs	Name	Type
0x6040:00	2.0	0.0	Control word	UINT
0x607A:00	4.0	2.0	Target position	DINT
	6.0			

Predefined PDO

Ctrl+Shift+A
 Del

- When the “Pdo Entry dialog” appears, scroll through the “From Dictionary:” options and look for 0x60B8 or Touch Probe Function. Click on this entry when it has been located. The details of the mapping will be automatically added. Click “OK” when finished.

Edit Pdo Entry

Name:

Index (h/d):

Sub Index (h/d):

Data Type:

Bit Length:

From Dictionary:

0x6040 - Controlword
 0x6042 - vl target velocity
 0x6046:01 - vl velocity min amount
 0x6046:02 - vl velocity max amount
 0x6048:01 - delta speed
 0x6048:02 - delta time
 0x6049:01 - delta speed
 0x6049:02 - delta time
 0x604A:01 - delta speed
 0x604A:02 - delta time
 0x604B:01 - vl set-point factor numerator
 0x604B:02 - vl set-point factor denominator
 0x604C:01 - vl dimension factor numerator
 0x604C:02 - vl dimension factor denominator

- This process is repeated for the outputs. Select the PDO list item marked Outputs – Position Status

PDO List

Index	Size	Name	Flags	SM	SU
0x1A00	4.0	Outputs - Velocity status			0
0x1A01	3.0	Outputs - Status and Mode of Op			0
0x1A02	6.0	Outputs - Position Status		3	0
0x1A04	4.0	Outputs - Torque status			0
0x1A05	0.0	Outputs - Large Mapping Set			0
0x1600	4.0	Inputs - Velocity control			0
0x1601	3.0	Inputs - Control and Mode of Op			0
0x1602	8.0	Inputs - Position control		2	0

Then add a new item:

PDO Content (0x1A02):

Index	Size	Offs	Name	Type	Default (hex)
0x6041:00	2.0	0.0	Status word	UINT	
0x6064:00	4.0	2.0	Position actual value	DINT	
0x6064:04	4.0	6.0	Position actual value	DINT	

Then Select 0x60B9 – Touch Probe Status, and click OK when completed:

Edit Pdo Entry

Name: OK

Index (h/d): Cancel

Sub Index (h/d):

Data Type:

Bit Length:

From Dictionary:

- 0x603F - Error code
- 0x6041 - Statusword
- 0x6043 - v1 velocity demand
- 0x6044 - v1 velocity actual value
- 0x6061 - Modes of operation display
- 0x6062 - Position demand value
- 0x6064 - Position actual value
- 0x606B - Velocity demand value
- 0x606C - Velocity actual value
- 0x6077 - Torque actual value
- 0x6078 - Current actual value
- 0x60B9 - Touch probe status
- 0x60BA - Touch probe 1 positive edge
- 0x60BB - Touch probe 1 negative edge

8. If only 1 touch probe is required just map the edge type required using the previous method. By default positive edge is selected by the touch probe instance.

Edit Pdo Entry

Name: Touch probe 1 positive edge

Index (h/d): 0x60BA 24762

Sub Index: 0x0 0

Data Type: DINT

Bit Length: 32

From Dictionary:

- 0x603F - Error code
- 0x6041 - Statusword
- 0x6043 - vl velocity demand
- 0x6044 - vl velocity actual value
- 0x6061 - Modes of operation display
- 0x6062 - Position demand value
- 0x6064 - Position actual value
- 0x606B - Velocity demand value
- 0x606C - Velocity actual value
- 0x6077 - Torque actual value
- 0x6078 - Current actual value
- 0x60B9 - Touch probe status
- 0x60BA - Touch probe 1 positive edge
- 0x60BD - Touch probe 1 negative edge

9. It is possible to include all 4 edges if required for Touch probe 1 (negative and positive) and Touch probe 2 (negative and positive):

Edit Pdo Entry

Name: Touch probe 1 positive edge

Index (h/d): 0x60BA 24762

Sub Index: 0x0 0

Data Type: DINT

Bit Length: 32

From Dictionary:

- 0x606B - Velocity demand value
- 0x606C - Velocity actual value
- 0x6077 - Torque actual value
- 0x6078 - Current actual value
- 0x60B9 - Touch probe status
- 0x60BA - Touch probe 1 positive edge
- 0x60BB - Touch probe 1 negative edge
- 0x60BC - Touch probe 2 positive edge
- 0x60BD - Touch probe 2 negative edge
- 0x60F4 - Following error actual value
- 0x60FA - Control effort
- 0x60FB:01 - P Gain
- 0x60FB:02 - Vff Gain

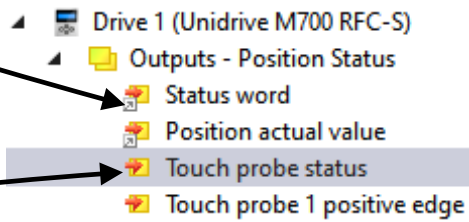
For simplicity, this example continues assuming Touch probe 1 is used with a rising edge only.

HINT: A minimum of firmware V01.61.00.00 drive firmware and EtherCAT firmware V01.12.00.24 with the associated ESI files are required to use this functionality.

10. When the PDO mappings are added they need a further step to link them to the axis.

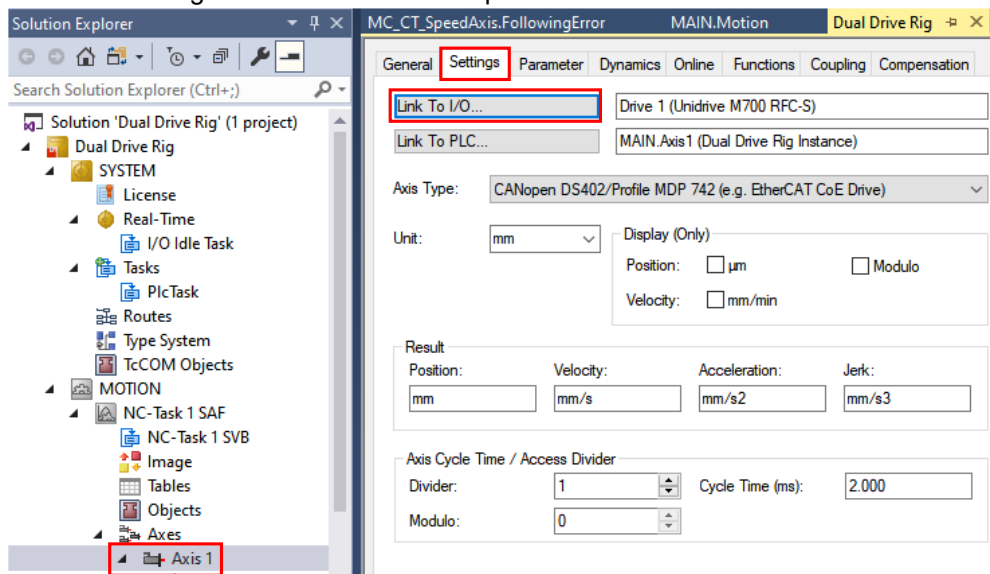
Grey box indicating
that the PDO is
linked to the NC Axis

The new PDOs don't
have the grey box and
are not linked yet

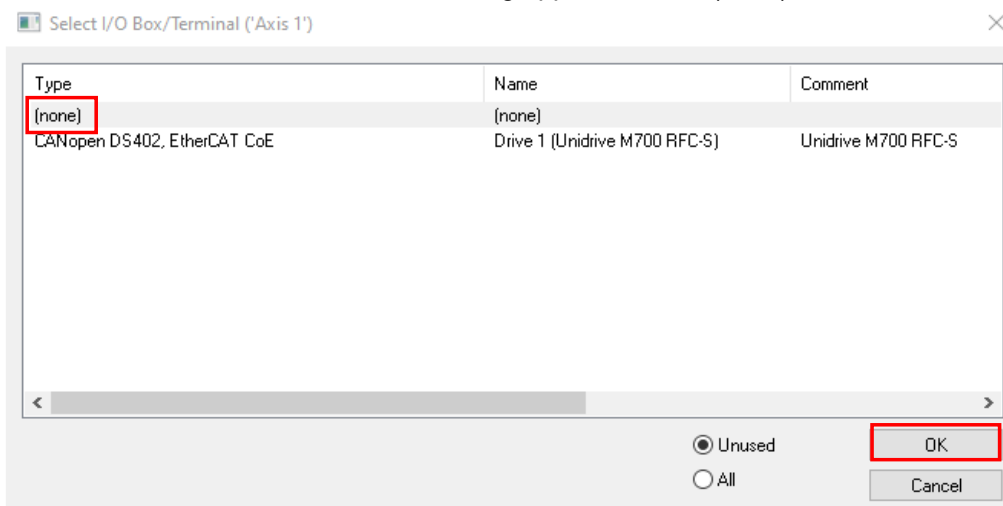


HINT: In the latest versions of TwinCAT the axis linking process happens automatically.

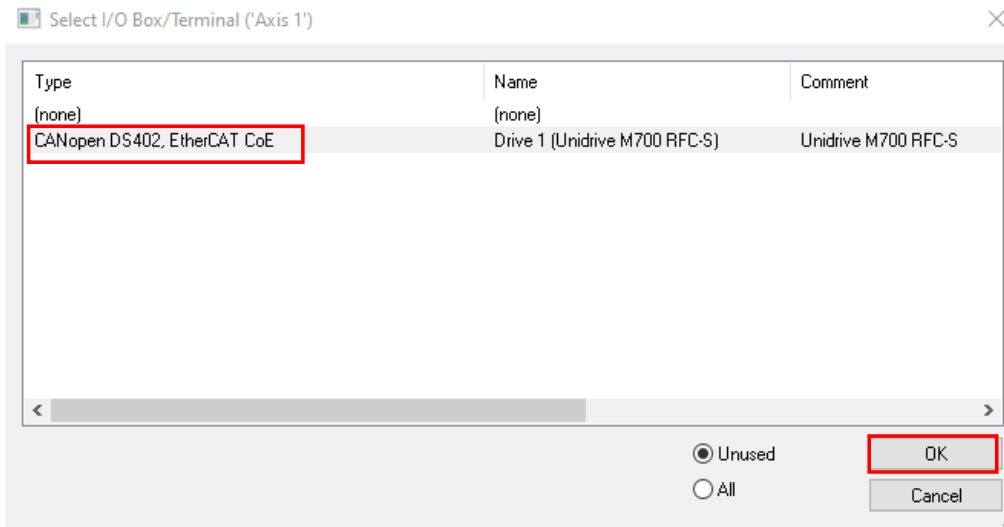
11. To link the new Touch Probe PDOs, double click on the axis associated with the drive and select the settings tab. When the tab is open click on "Link to I/O...":



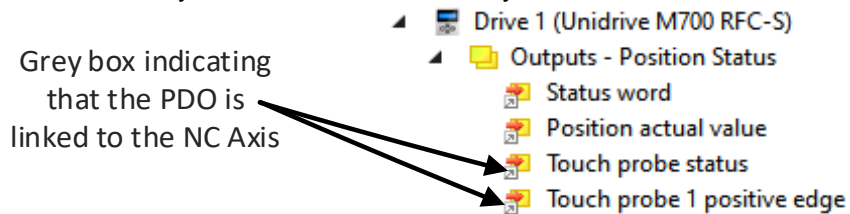
12. When the "Select I/O Box / Terminal" dialog appears, select (none) and then click "OK":





13. Click “Link to I/O...” on the Settings tab a second time, and when the “Select I/O Box / Terminal” dialog appears, choose the drive that is associated with the axis and click “OK”:



14. The TwinCAT system will then automatically connect the Axis to the drive PDO mapping:



15. Save the changes by pressing  and activate the configuration by pressing . Touch probe can now be used without errors using MC_TouchProbe and TRIGGER_REF.

10.2.2 How to convert parameter numbers to CANopen object references

Parameters are converted to CANopen style object reference using the following formula:

$$\text{Index} = 0x2000 + 0x100 * \text{Slot Number} + \text{Menu number (converted to hexadecimal)}$$
$$\text{Subindex} = \text{Parameter number}$$

E.g. Drive parameter Pr3.017 is referenced as Index = 2003, Subindex = 17

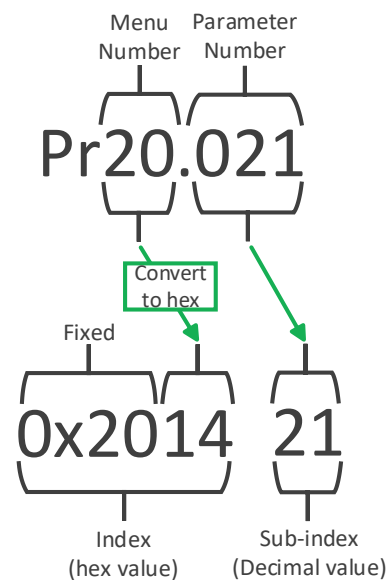
HINT: The slot number is 0 for standard drive parameters such as Pr3.017.

10.2.2.1 Short drive parameter references

Pr20.021 → Index 0x2014 Sub-index 21

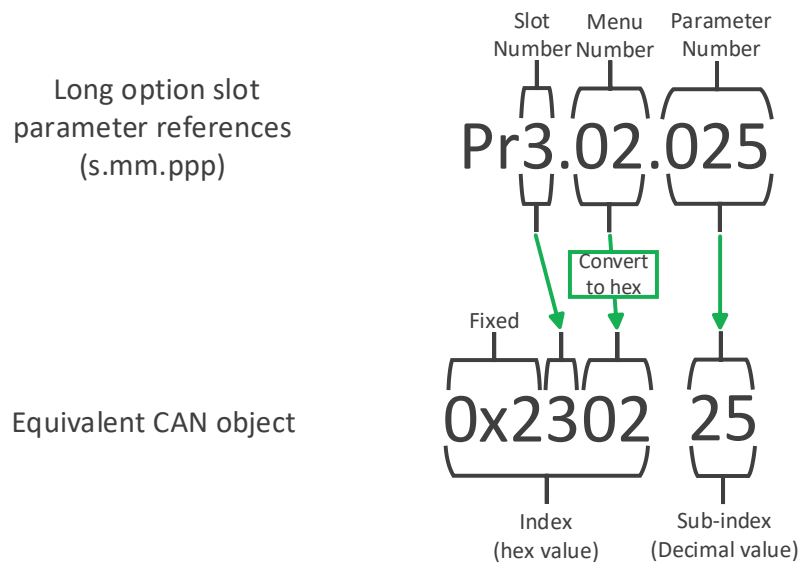
Short drive parameter
references (mm.ppp)

Equivalent CAN object



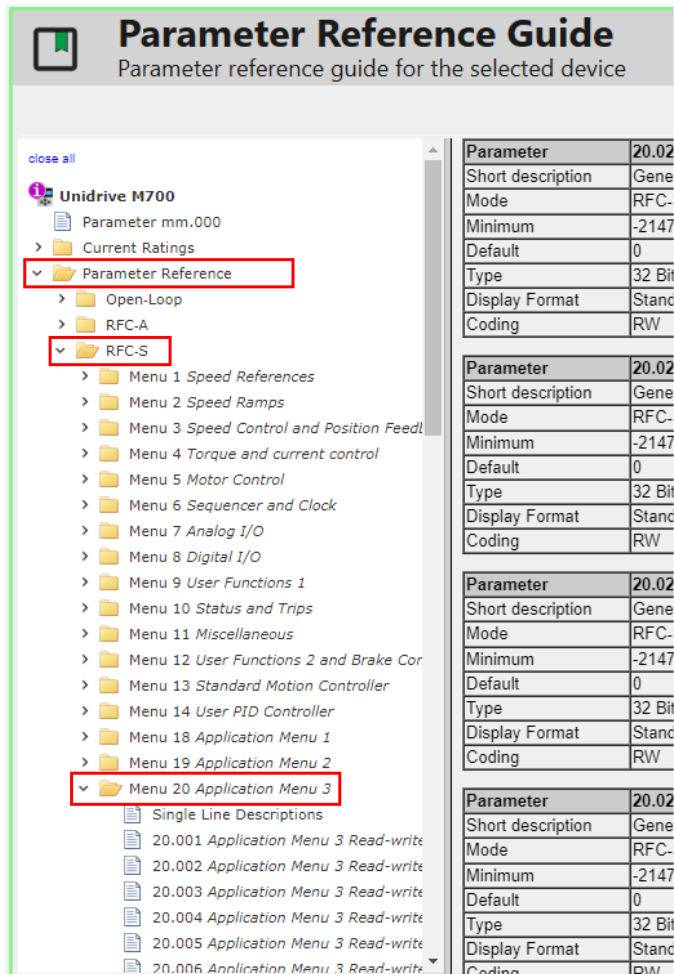
10.2.2.2 Long option parameter references

Pr3.02.025 → Index 0x2302 Sub-index 25



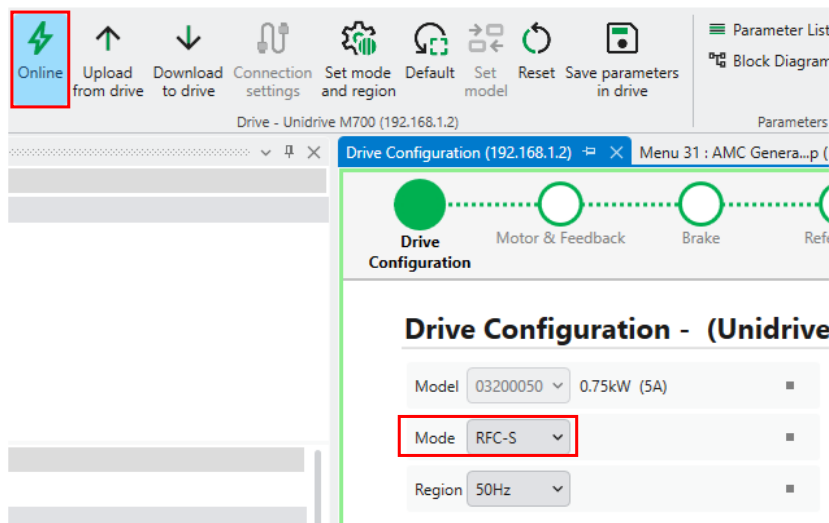
10.2.2.3 How to find the parameter data type

The data type can be found by looking at the parameter reference guide in Connect. Click “Parameter Reference Guide” in the Device tree and then expand “Parameter Reference”, then expand the drive mode e.g. Open-Loop, RFC-A or RFC-S, then select the menu number for the target parameter for the PDO e.g. Menu 20.



Parameter	20.02
Short description	Gene
Mode	RFC-
Minimum	-2147
Default	0
Type	32 Bit
Display Format	Stand
Coding	RW

If you are unsure of the mode that the drive is in double click on “Setup” > “Drive Configuration” and the current mode will be shown when the drive is “Online”.



Drive - Unidrive M700 (192.168.1.2)

Drive Configuration (192.168.1.2) Menu 31 : AMC Genera...p (

Drive Configuration - (Unidrive

Model 03200050 0.75kW (5A)

Mode RFC-S

Region 50Hz

Select the parameter to get the data type for:

How to videos

Unidrive M700 (169.254.29.230.3.1:1001)

Unidrive M700 (169.254.29.230.3.1:1001)

- Setup
 - Drive Configuration
 - Motor & Feedback
 - Brake
 - References
 - Limits
 - Save Parameters
 - Auto-Tune
 - Motor & Load Inertia
 - Performance Tuning
 - Finalise
- Ethernet
- Options
- Solutions
- Maintenance
 - Oscilloscope
 - Terminal Overview
- Diagnostics
- Parameters
 - Parameter Reference Guide

Parameter Reference Guide

Parameter reference guide for the selected device

- Menu 12 User Functions 2 and Brake Cor
- Menu 13 Standard Motion Controller
- Menu 14 User PID Controller
- Menu 18 Application Menu 1
- Menu 19 Application Menu 2
- Menu 20 Application Menu 3
 - Single Line Descriptions
 - 20.001 Application Menu 3 Read-writ
 - 20.002 Application Menu 3 Read-writ
 - 20.003 Application Menu 3 Read-writ
 - 20.004 Application Menu 3 Read-writ
 - 20.005 Application Menu 3 Read-writ
 - 20.006 Application Menu 3 Read-writ
 - 20.007 Application Menu 3 Read-writ
 - 20.008 Application Menu 3 Read-writ
 - 20.009 Application Menu 3 Read-writ
 - 20.010 Application Menu 3 Read-writ
 - 20.011 Application Menu 3 Read-writ
 - 20.012 Application Menu 3 Read-writ
 - 20.013 Application Menu 3 Read-writ
 - 20.014 Application Menu 3 Read-writ
 - 20.015 Application Menu 3 Read-writ
 - 20.016 Application Menu 3 Read-writ
 - 20.017 Application Menu 3 Read-writ
 - 20.018 Application Menu 3 Read-writ
 - 20.019 Application Menu 3 Read-writ
 - 20.020 Application Menu 3 Read-writ
 - 20.021 Application Menu 3 Read-writ
 - 20.022 Application Menu 3 Read-writ

Parameter	20.021 Application Menu 3 Read-write Long Integer 21			
Short description	General read-write long integer application parameter			
Mode	RFC-S			
Minimum	-2147483648	Maximum	2147483647	
Default	0	Units		
Type	32 Bit Volatile	Update Rate	N/A	
Display Format	Standard	Decimal Places	0	
Coding	RW			

Parameter	20.022 Application Menu 3 Read-write Long Integer 22			
Short description	General read-write long integer application parameter			
Mode	RFC-S			
Minimum	-2147483648	Maximum	2147483647	
Default	0	Units		
Type	32 Bit Volatile	Update Rate	N/A	
Display Format	Standard	Decimal Places	0	
Coding	RW			

Parameter	20.023 Application Menu 3 Read-write Long Integer 23			
Short description	General read-write long integer application parameter			
Mode	RFC-S			
Minimum	-2147483648	Maximum	2147483647	
Default	0	Units		
Type	32 Bit Volatile	Update Rate	N/A	
Display Format	Standard	Decimal Places	0	
Coding	RW			

Parameter	20.024 Application Menu 3 Read-write Long Integer 24			
Short description	General read-write long integer application parameter			
Mode	RFC-S			
Minimum	-2147483648	Maximum	2147483647	

The parameter reference guide gives a number of bits and a minimum and maximum which may be used to find the IEC data type e.g. DINT. The table below show how to convert to IEC data type used by TwinCAT:

Bits from parameter reference guide	Signed range	IEC data type
1	N/A	BOOL
8	No	USINT
8	Yes	SINT
16	No	UINT
16	Yes	INT
32	No	UDINT
32	Yes	DINT

E.g. Pr20.021 is a 32bit value and the range is -2147483648 to 2147483647 which shows that the value is signed, therefore the IEC data type used in TwinCAT is DINT.

Bits from parameter reference guide Pr20.021	Signed range	IEC data type
32	Yes	DINT

10.2.3 How pass data between drive parameters and variables using PDOs

This section shows how to map data from a PLC program variable to a drive parameter via PDO mapping, and from a drive parameter to a PLC program variable via PDO mapping. The following instructions show how to map to and from Menu 20 parameters in the drive, however the same philosophy can be applied to any parameter.

1. For the purposes of this example the PDO mappings will interact with variables in a GVL (Global Variable List) making the data available to any POU. Right click on the GVL folder and select “Add” > “Global Variable List”. Name the list and then in declaration area of the GVL add the following:

```
GVL* ×
1 {attribute 'qualified_only'}
2 VAR_GLOBAL
3   FromDriveToPLC AT %I* :DINT; // Mapped to I register with system memory allocation so it appears in the mapping list for drive Outputs
4   FromPLC_ToDrive AT %Q* :DINT; // Mapped to Q registers with system memory allocation so it appears in the mapping list for drive Inputs
5 END_VAR
```

HINT: The variables in the list have been allocated to the I and Q memory areas. This is a key step that allows the variables to be “seen” in the in the PDO linking list. Take care to use the correct memory area where I registers are for data going from the drive to the PLC, and Q registers are for data going from the PLC to the drive.

HINT: The “*” used in the memory allocation e.g. %I* allows the TwinCAT system to select which area of the registers should be used. This is recommended.

2. When the GVL is created build the application by pressing Ctrl+Shift+b. This will make the GVL elements available in later steps. Failure to do this will mean that the variables such as FromDriveToPLC will not appear in the data mapping selector.
3. In the “Solution Explorer” tree, double click on the drive node to exchange PDO data with to open the drive properties. Next click on the “Process Data” tab, then select the 0x1A02 index from the PDO list, then right click in the PDO Content box and select “Add New Item...”

The screenshot shows the TwinCAT software interface. On the left is the 'Solution Explorer' showing a project named 'Dual Drive Rig'. The 'Process Data' tab is selected. The 'PDO List' table shows the following data:

Index	Size	Name	Flags	SM	SU
0x1A00	4.0	Outputs - Velocity status			0
0x1A01	3.0	Outputs - Status and Mode of Op			0
0x1A02	16.0	Outputs - Position Status		3	0
0x1A04	4.0	Outputs - Torque status			0
0x1A05	0.0	Outputs - Large Mapping Set			0
0x1600	4.0	Inputs - Velocity control			0
0x1601	3.0	Inputs - Control and Mode of Op			0
0x1602	8.0	Inputs - Position control		2	0

The 'PDO Content (0x1602)' table shows the following data:

Index	Size	Offs	Name	Type	Default (he
0x6040.00	2.0	0.0	Control word	UINT	
0x607A.00	4.0	2.0	Target position	DINT	
0x60B8.00	2.0	6.0	Touch probe function	UINT	
8.0					

At the bottom right of the PDO Content table, there is a button labeled 'Add New Item...' with the keyboard shortcut 'Ctrl+Shift+A'.

4. How to convert parameter numbers to CANopen object references Using the information in section **10.2.2 How to convert parameter numbers to CANopen object references**, add the reference for the parameter to receive data from. For this example Pr20.030 will be used. Click “OK” when the parameter reference has been added.

Edit Pdo Entry ✕

Name:	M20P30		OK	Cancel
Index (h/d):	0x2014	8212		
Sub Index	0x1E	30		
Data Type:	DINT			
Bit Length:	32			

From Dictionary:

- 0x603F - Error code
- 0x6041 - Statusword
- 0x6043 - vl velocity demand
- 0x6044 - vl velocity actual value
- 0x6061 - Modes of operation display
- 0x6062 - Position demand value
- 0x6064 - Position actual value
- 0x606B - Velocity demand value
- 0x606C - Velocity actual value
- 0x6077 - Torque actual value
- 0x6078 - Current actual value
- 0x60B9 - Touch probe status
- 0x60BA - Touch probe 1 positive edge
- 0x60BB - Touch probe 1 negative edge

5. Select “0x1602” in the PDO list, then right click in the PDO Content box and select “Add New Item...”. Using the information in section **10.2.2 How to convert parameter numbers to CANopen object references**, add the reference for the parameter to send data to. For this example Pr20.031 will be used. Click “OK” when the parameter reference has been added.

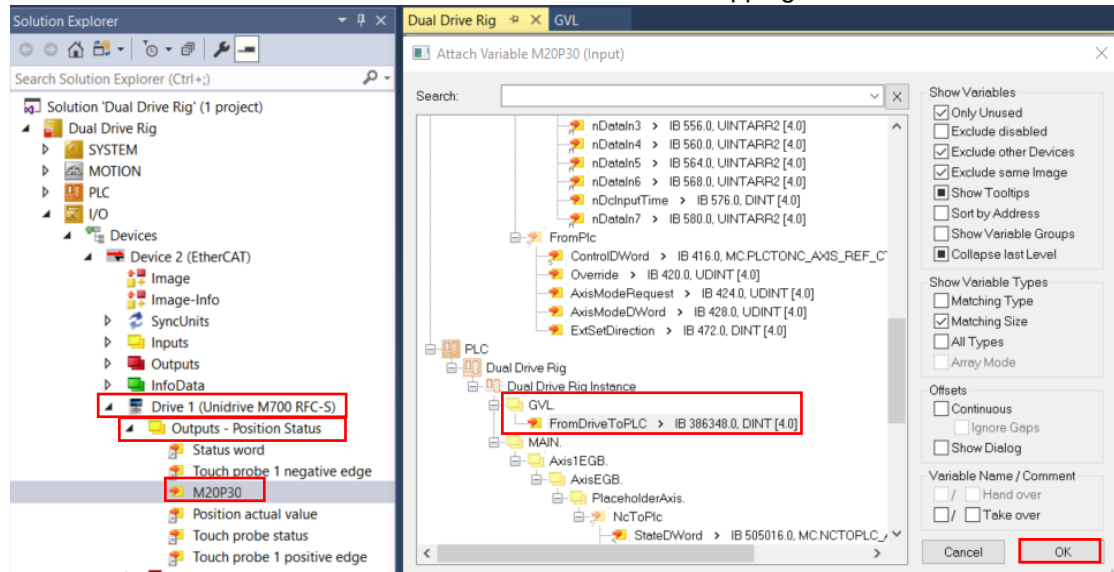
Edit Pdo Entry ✕

Name:	M20P31		OK	Cancel
Index (h/d):	0x2014	8212		
Sub Index	0x1F	31		
Data Type:	DINT			
Bit Length:	32			

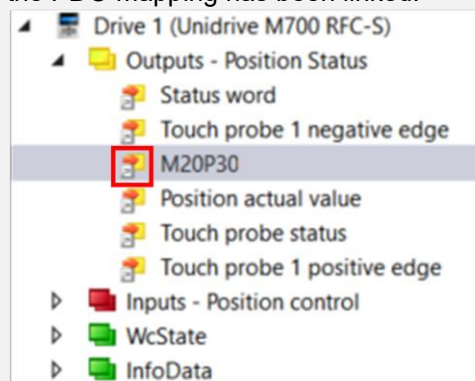
From Dictionary:

- 0x6040 - Controlword
- 0x6042 - vl target velocity
- 0x6046:01 - vl velocity min amount
- 0x6046:02 - vl velocity max amount
- 0x6048:01 - delta speed
- 0x6048:02 - delta time
- 0x6049:01 - delta speed
- 0x6049:02 - delta time
- 0x604A:01 - delta speed
- 0x604A:02 - delta time
- 0x604B:01 - vl set-point factor numerator
- 0x604B:02 - vl set-point factor denominator
- 0x604C:01 - vl dimension factor numerator
- 0x604C:02 - vl dimension factor denominator

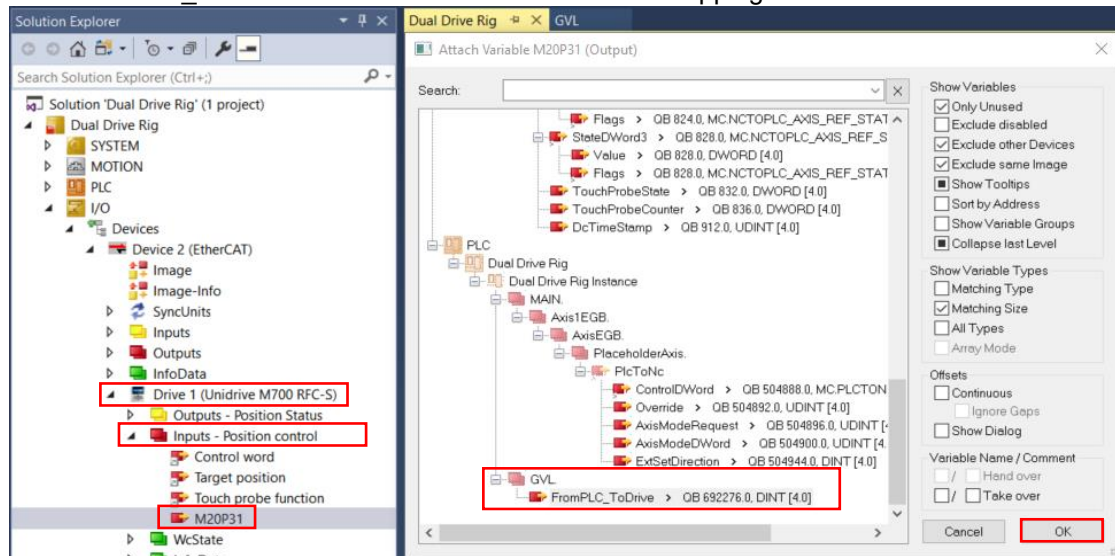
- Map the Output PDO “M20.P30” to “GVL.FromDriveToPLC”. Expand the tree under the drive to reveal the Output mappings, then double click on the mapping to link. When the “Attach Variable” dialog opens, scroll down the list until “GVL.FromDriveToPLC” is seen. Click on “GVL.FromDriveToPLC” and then click “OK” to link the mapping to the variable.



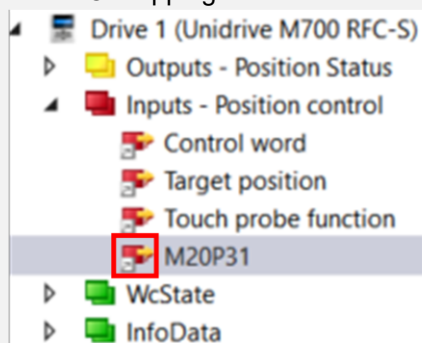
HINT: The link icon is now visible, (small grey box with an arrow inside), indicating that the PDO mapping has been linked.



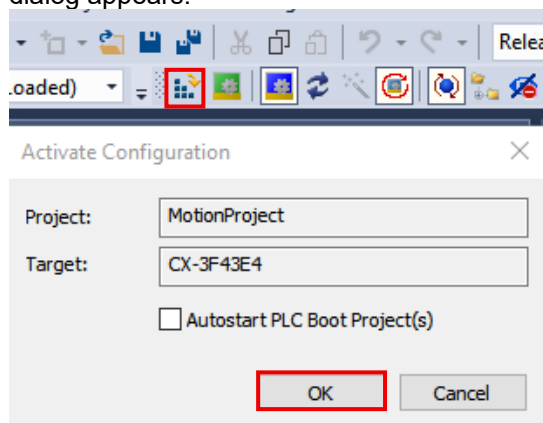
- Map the Input PDO “M20.P31” to “GVL.FromPLC_ToDrive”. Expand the tree under the drive to reveal the Input mappings, then double click on the mapping to link. When the attach variable dialog opens, scroll down the list until “ GVL.FromPLC_ToDrive” is seen. Click on “ GVL.FromPLC_ToDrive” and then click “OK” to link the mapping to the variable.




HINT: The link icon is now visible, (small grey box with an arrow inside), indicating that the PDO mapping has been linked.



8. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



9. Click the login icon  to view the code while it runs:

10. Run the application (if it is not already running) by pressing the  button.

11. Double click on the GVL in “Solution Explorer”. Values set in Pr20.030 in the drive are now passed to “GVL.FromDriveToPLC” and values set in “GVL.FromPLC_ToDrive” are passed to Pr20.031.

Expression	Type	Value	Prepared value	Address	Comment
FromDriveToPLC	DINT	111		%I*	Mapped to I registers with system memory allocation so it appears in the mapping
FromPLC_ToDrive	DINT	222		%Q*	Mapped to Q registers with system memory allocation so it appears in the mapping

Parameter	Caption	Categories	Value
20.026	Application Menu 3 Read-write Long Integer 26		0
20.027	Application Menu 3 Read-write Long Integer 27		0
20.028	Application Menu 3 Read-write Long Integer 28		0
20.029	Application Menu 3 Read-write Long Integer 29		0
20.030	Application Menu 3 Read-write Long Integer 30		111
20.031	Application Menu 3 Read-write Long Integer 31		222

In the previous example it can be seen that a value of “111” was passed from Pr20.030 to GVL.FromDriveToPLC, and that a value of “222” was passed from GVL.FromPLC_ToDrive to Pr20.031. The screen shot shows the GVL values from TwinCAT and the drive parameter values in Connect.

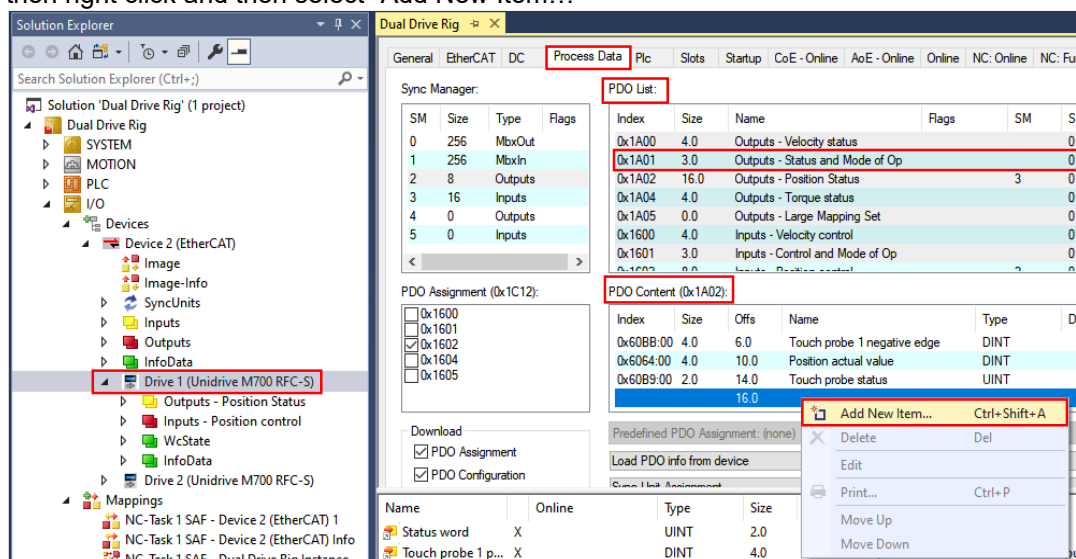
10.2.4 How to map a drive encoder to an NC encoder axis

It is possible to map a drive encoder e.g. a line encoder connected to the drive P2 interface or an SI-Universal Encoder module so that could be used as a master position reference for MC_GearIn or MC_CamIn. The following steps show how to configure the mapping and setup the Encoder axis.

1. It is assumed that the encoder to map to has already been connected to a spare encoder port on the drive e.g. Drive P2 interface on the D-type encoder port, or an encoder module such as an SI-Universal Encoder fitted in one of the drive option slots. Find the Normalised Position parameter. The table below shows the parameters for each possible encoder port and the equivalent Index and Subindex to use in the TwinCAT Process Data mapping:

Encoder port	Parameter	Index	Subindex	Data Type
Drive P1	Pr3.058	0x2003	0x3A (58)	DINT (32Bit)
Drive P2	Pr3.158	0x2003	0x9E (158)	DINT (32Bit)
Slot 1 P1	Pr15.058	0x200F	0x3A (58)	DINT (32Bit)
Slot 1 P2	Pr26.058	0x201A	0x3A (58)	DINT (32Bit)
Slot 2 P1	Pr16.058	0x2010	0x3A (58)	DINT (32Bit)
Slot 2 P2	Pr27.058	0x201B	0x3A (58)	DINT (32Bit)
Slot 3 P1	Pr17.058	0x2011	0x3A (58)	DINT (32Bit)
Slot 3 P2	Pr28.058	0x201C	0x3A (58)	DINT (32Bit)

2. Ensure that the encoder is working by moving the encoder and at the same time check that the position in the relevant encoder interface parameter, as detailed in the previous table, is changing with the movement.
3. In TwinCAT, double click on the EtherCAT slave drive to add the encoder PDO mapping to. When the properties for the slave drive open, select the "Process Data" tab, and then in the "PDO List" select object "0x1A02". In the "PDO content" box scroll to the bottom of the list and then right click and then select "Add New Item..."



- When the “Edit PDO Entry” dialog opens, enter the Name, Index, Subindex and Data Type as listed in the previous table. For this example, Slot 2 P1 is the location of the second encoder and the mapping has been named “Line Encoder”. Click “OK” when finished.

Edit Pdo Entry

Name: Line Encoder

Index (h/d): 0x2010 8208

Sub Index: 0x3A 58

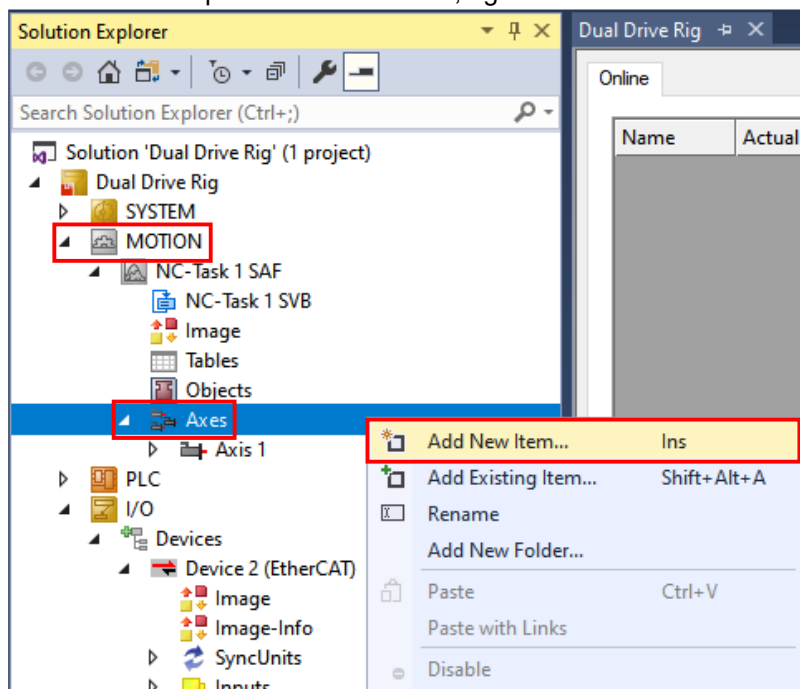
Data Type: DINT

Bit Length: 32


From Dictionary:

- 0x603F - Error code
- 0x6041 - Statusword
- 0x6043 - vl velocity demand
- 0x6044 - vl velocity actual value
- 0x6061 - Modes of operation display
- 0x6062 - Position demand value
- 0x6064 - Position actual value
- 0x606B - Velocity demand value
- 0x606C - Velocity actual value
- 0x6077 - Torque actual value
- 0x6078 - Current actual value
- 0x60B9 - Touch probe status
- 0x60BA - Touch probe 1 positive edge
- 0x60BB - Touch probe 1 positive edge

- In the solution explorer under “Motion”, right click on “Axes” and select “Add New Item...”.



- When the “Insert NC Axis” dialog opens, change the type to “Encoder Axis”. Click “OK” when finished.



Insert NC Axis

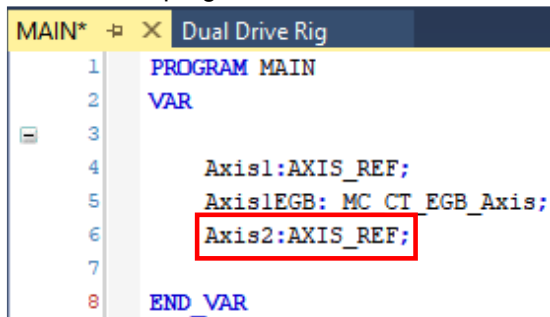
Name: Multiple:

Type:

Parameter:

Comment:

- In the motion program POU add an instance of AXIS_REF for the Encoder Axis.

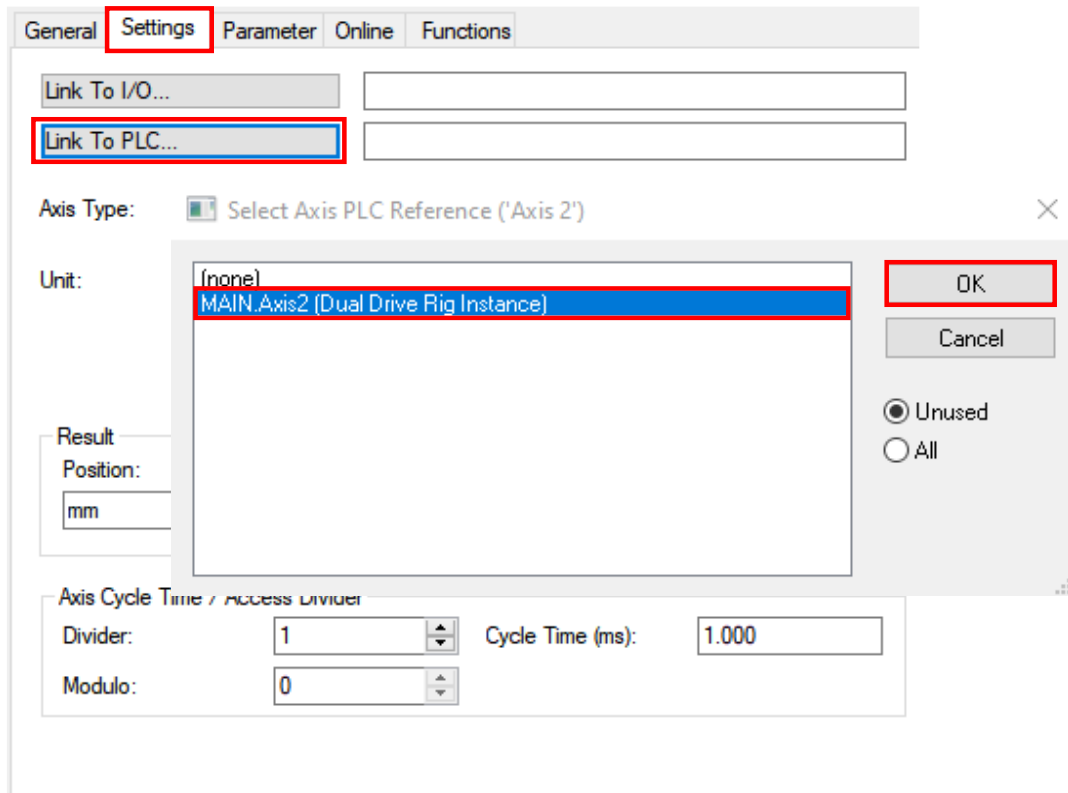


```

1  PROGRAM MAIN
2  VAR
3
4      Axis1:AXIS_REF;
5      Axis1EGB: MC CT_EGB_Axis;
6      Axis2:AXIS_REF;
7
8  END_VAR

```

- In the Solution Explorer tree, double click on the encoder axis, (Axis 2), when the properties for the axis open, select the “Settings” tab. Click “Link To PLC”, and then select the new instance of AXIS_REF, e.g. “Axis2”.



General **Settings** Parameter Online Functions

Link To I/O...

Link To PLC...

Axis Type:

Unit:

Result Position:

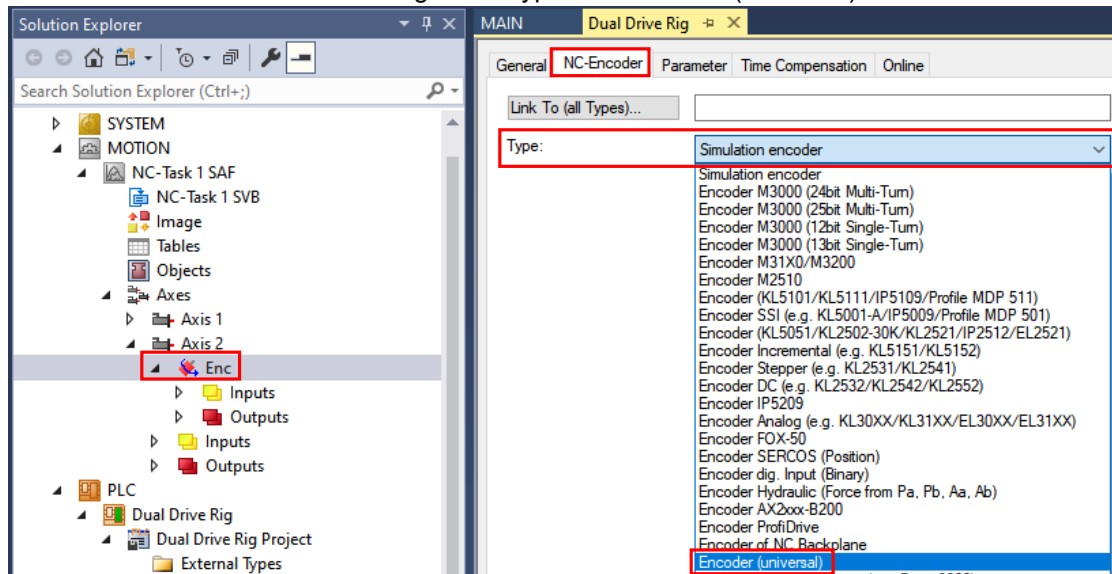
Axis Cycle Time / Access Divider

Divider: Cycle Time (ms):

Modulo:

☒ Unused ☐ All

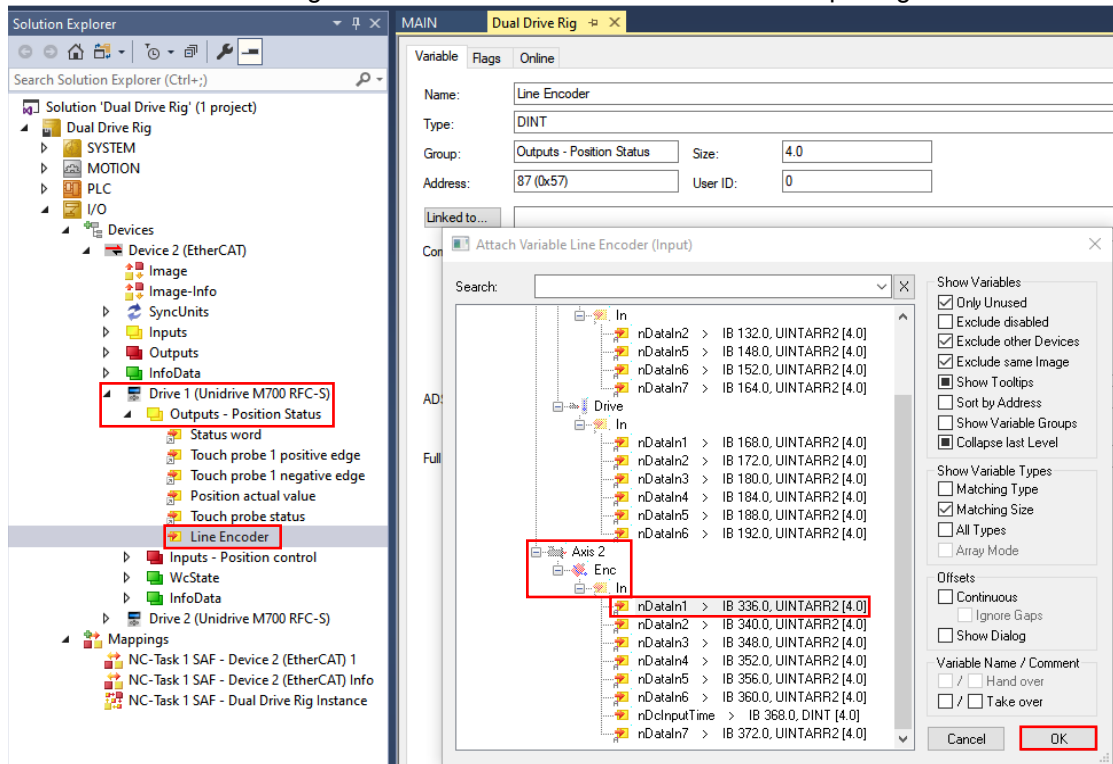
9. Expand the encoder axis and double click on “Enc”, when the properties for the encoder open select the “NC-Encoder” tab. Change the “Type:” to “Encoder (universal)”



10. Select the “Parameter” tab and then set the “Scaling Factor Numerator” to the number of units per revolution of the encoder, e.g.1000. Set the “Scaling Factor Denominator” to the number of encoder counts per revolution – by default this is 65536.

General NC-Encoder Parameter Time Compensation Online	
Parameter	Offline Value
- Encoder Evaluation:	
Invert Encoder Counting Direction	FALSE
Scaling Factor Numerator	1000.0
Scaling Factor Denominator (default: 1.0)	65536.0

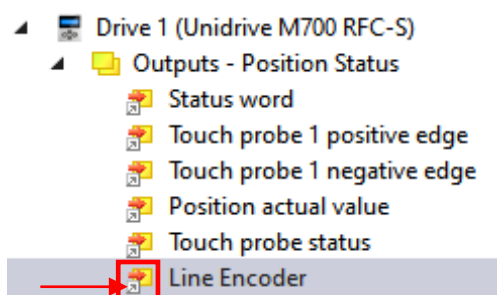
11. Expand the tree for the drive that the encoder is connected to, then open “Outputs”, and double click on the name given to the encoder PDO link created in step 4 e.g. “Line Encoder”.




When the “Attach Variable Line Encoder (Input)” dialog opens scroll down to the axis associated with the encoder, e.g. Axis 2 and select “Axis 2” > “Enc” > “In” > “nDataIn1” and then click “OK”.

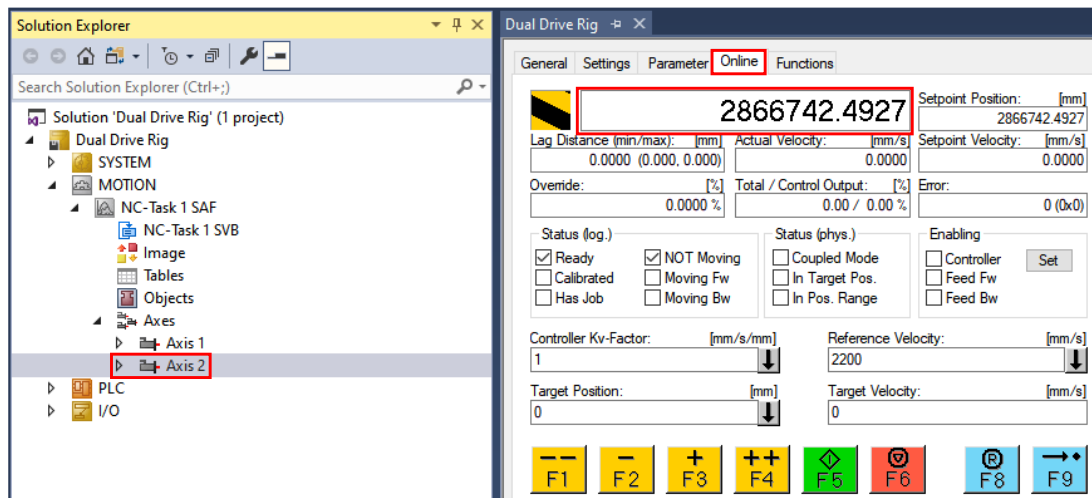
HINT: “nDataIn1” is always where the encoder data is mapped to, regardless of the axis number.

The PDO for the encoder is now linked to the encoder axis as indicated by the small grey box with an arrow in it:



12. Apply the new settings to the project by clicking the “Activate configuration button” . Click “OK” to any following message boxes.

13. Verify the encoder is working by double clicking on the encoder axis e.g. Axis 2, and when the properties for the axis open, select the online tab to view the position. This will change as the encoder is moved.

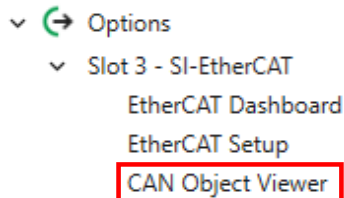


14. The encoder reference can now be used as the master for an MC_GearIn or MC_CamIn by using the axis name e.g. Axis2.

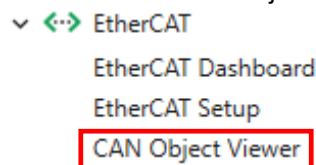
10.3 How to view CAN objects

Connect has a powerful diagnostic aid to help the user view CANopen object live called the CAN Object Viewer. This helps the user to diagnose setup and operational issues with the CiA402 system layer upon which EtherCAT and NC axes run. If the TwinCAT network isn't starting, or a drive axis isn't running when it should, this tool can help the user understand what is going on.

The tool is found in the Drive explorer tree under "Options" > "Slot[n]" > "CAN Object Viewer" where [n] is the drive slot in which the SI-EtherCAT interface is located.



For Dedicated EtherCAT Drives Such as Digitax HD M753 it is found in the drive explorer tree under "EtherCAT" > "CAN Object Viewer".



The image below shows an example of the CAN Object Viewer during use:

EtherCAT CAN Object Viewer
[Open ESI Folder](#)

Control Techniques Unidrive M700
#x02010001

Operation
Cyclic Sync Position

Op

PDO access
1000 /sec

FSOE messages
0 /sec

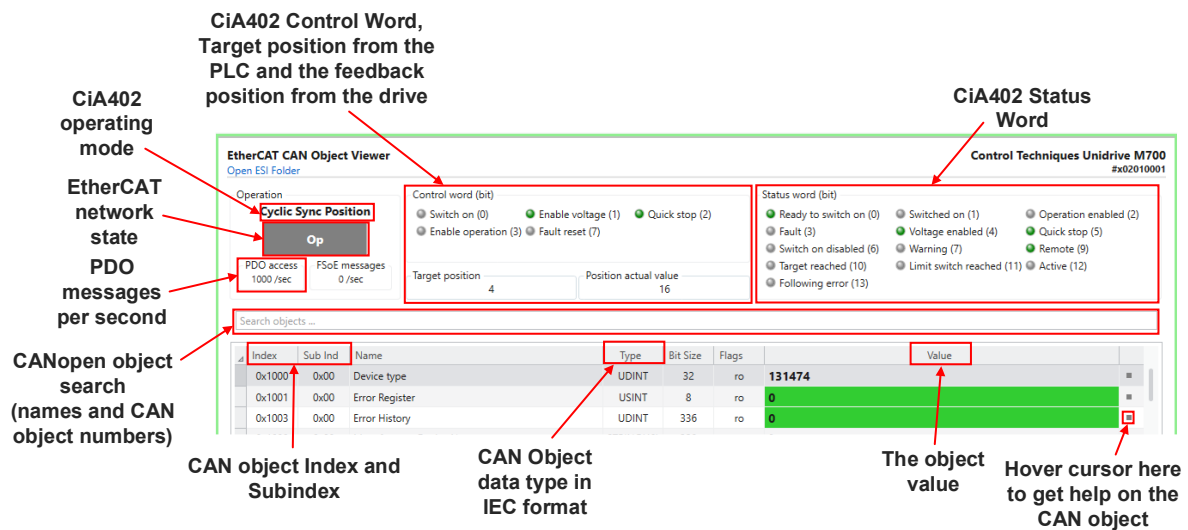
Control word (bit)
☐ Switch on (0) ☒ Enable voltage (1) ☒ Quick stop (2)
☐ Enable operation (3) ☐ Fault reset (7)

Status word (bit)
☒ Ready to switch on (0) ☐ Switched on (1) ☐ Operation enabled (2)
☐ Fault (3) ☒ Voltage enabled (4) ☐ Quick stop (5)
☐ Switch on disabled (6) ☐ Warning (7) ☐ Remote (9)
☐ Target reached (10) ☐ Limit switch reached (11) ☐ Active (12)
☐ Following error (13)

Target position: 4 Position actual value: 16

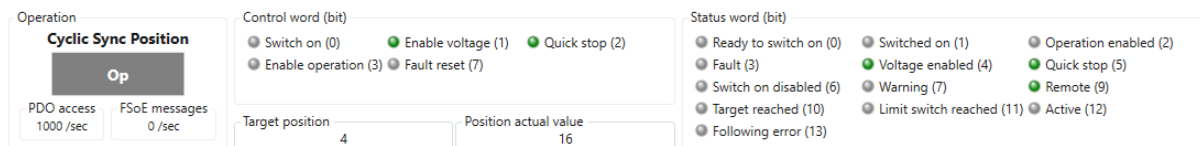
Index	Sub Ind	Name	Type	Bit Size	Flags	Value
0x1000	0x00	Device type	UDINT	32	ro	131474
0x1001	0x00	Error Register	USINT	8	ro	0
0x1003	0x00	Error History	UDINT	336	ro	0
0x1008	0x00	Manufacturer Device Name	STRING(40)	320	ro	0
0x1009	0x00	Manufacturer Hardware Version	STRING(40)	320	ro	0
0x100A	0x00	Manufacturer Software Version	STRING(40)	320	ro	0
0x1018	0x00	Identity Object	DT1018	144	ro	4
	0x01	Vendor ID	UDINT	32	ro	249
	0x02	Product Code	UDINT	32	ro	16974082
	0x03	Revision Number	UDINT	32	ro	0x2010001
	0x04	Serial Number	UDINT	32	ro	123456789
0x10F1	0x00	Error Settings	DT10F1	64		2
	0x01	Local Error Reaction	UDINT	32		2
	0x02	Sync Error Counter Limit	UINT	16		0
0x1600	0x00	Inputs - Velocity control	DT1600	400	rw	2
	0x01	Controlword	UDINT	32	rw	110
	0x02	SubIndex 002	UDINT	32	rw	1614938128
0x1601	0x00	Inputs - Control and Mode of Op	DT1600	400	rw	2
	0x01	Control word	UDINT	32	rw	110
	0x02	Modes of operation	UDINT	32	rw	Cyclic Sync Position

The following image highlights some of the useful features and information available within this tool.



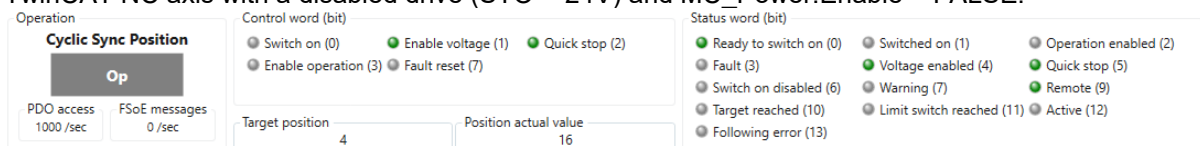
10.3.1 MC_Power Disabled and Drive Disabled

This screenshot acts a guide to understand the expected CiA402 Status and Control word for a TwinCAT NC axis with a disabled drive (STO = 0V) and MC_Power.Enable = FALSE.



10.3.2 MC_Power Disabled and Drive Enabled

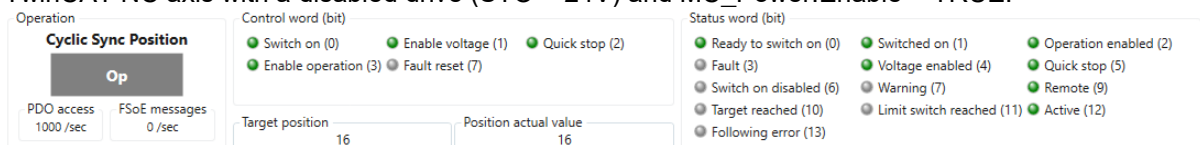
This screenshot acts a guide to understand the expected CiA402 Status and Control word for a TwinCAT NC axis with a disabled drive (STO = 24V) and MC_Power.Enable = FALSE.



HINT: "Ready to switch on (0)" is now active.

10.3.3 MC_Power Enabled and Drive Enabled

This screenshot acts a guide to understand the expected CiA402 Status and Control word for a TwinCAT NC axis with a disabled drive (STO = 24V) and MC_Power.Enable = TRUE.



HINT: "Switch on (0)", "Enable operation (3)", "Switched on (1)", "Operation enabled (2)", and "Active (12)" are now active.

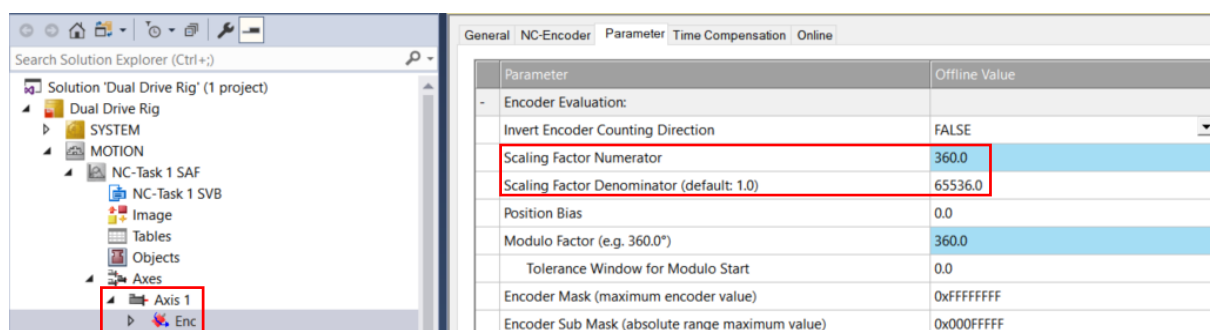
10.4 How to setup axis unit scaling and resolution

Unit scaling in most motion control systems, including a TwinCAT NC axis, requires the user to specify how many feedback counts there are for a given distance, where feedback in counts is converted into application units such as degrees or mm. Normally this is represented as a numerator and denominator where:

- The numerator is a number of distance units.
- The denominator is the number of position feedback counts from the position feedback device that equals the numerator value.

There are number of different ways to set up the position feedback scaling but the easiest is based around rotating the motor by 1 revolution and indicating how many feedback counts (as seen by the drive) there will be per revolution and how many application units will be moved in 1 revolution.

By default, the number of feedback counts per revolution is set to 65536. If the applications units are degrees and there is no output gearbox, the unit scaling ratio would be set to a numerator of 360, and a denominator of 65536. In TwinCAT it looks like this:



If we add a 4:1 reduction gearbox, the number of rotations at the output of the gearbox is reduced by the gearbox ratio so in this example the scaling numerator is $360 * 1 / 4 = 90$.

In the drive, the resolution in feedback counts is given by $2^{(32-Pr3.057)}$. By default, P1 Normalisation Turns Pr3.057 = 16 so the number of feedback counts per revolution is $2^{(32-16)} = 65536$. Provided the feedback encoder has a resolution greater than 16bit, the resolution of the axis can be increased by modifying P1 Normalisation Turns Pr3.057, where a reduction in the number of turns bits adds more feedback counts per revolution. See the table below:

Pr3.057 Turns bits	Counts per revolution	Bits per revolution	Turns bits as hex
16	65536	16	0x10
15	131072	17	0x0F
14	262144	18	0x0E
13	524288	19	0x0D
12	1048576	20	0x0C
11	2097152	21	0x0B
10	4194304	22	0x0A
9	8388608	23	0x09
8	16777216	24	0x08
7	33554432	25	0x07
6	67108864	26	0x06
5	134217728	27	0x05
4	268435456	28	0x04

HINT: The total resolution is always 32bit, where the sum of the turns bits and bits per revolution always adds up to 32bits.

The two main ways to setup Pr3.057 are by configuring the value in Connect and saving it, or by setting Pr3.057 in the startup list in TwinCAT directly, or by exporting the startup list from Connect once the system / application is fully commissioned.

10.4.1 How to set the scaling using the startup list in TwinCAT

The resolution is configured by default in Pr3.057. See the previous table for the number that the turns bits should be set, (Hex value), to for a particular number of counts per revolution.

For setup in the startup list the following data is needed:

Parameter	Index (hex)	Subindex (dec)	Comment
Pr3.057	2003	57	Turns bits

Use the following steps to configure a startup list entry for a drive parameter directly:

1. Double click on the drive to modify the startup list for, from the properties select the “Startup” tab, and then click “new”.

The screenshot shows the TwinCAT software interface. On the left, the 'Solution Explorer' displays a project tree with 'Update firmware using FoE' selected. Under 'I/O' > 'Devices', 'Device 2 (EtherCAT)' is expanded, and 'Drive 1 (Unidrive M700)' is highlighted. On the right, the 'Update firmware using FoE' window is open, with the 'Startup' tab selected. The 'Startup' tab contains a table of startup list entries. The table has columns: Transition, Protocol, Index, Data, and Comment. The entries are as follows:

Transition	Protocol	Index	Data	Comment
<PS>	CoE	0x1A00 C 0	02 00 10 00 41 60 10 00 4...	download pdo 0x1A00 entr...
<PS>	CoE	0x1A01 C 0	02 00 10 00 41 60 08 00 6...	download pdo 0x1A01 entr...
<PS>	CoE	0x1A02 C 0	02 00 10 00 41 60 20 00 6...	download pdo 0x1A02 entr...
<PS>	CoE	0x1A04 C 0	02 00 10 00 41 60 10 00 7...	download pdo 0x1A04 entr...
<PS>	CoE	0x1A05 C 0	00 00	download pdo 0x1A05 entr...
<PS>	CoE	0x1600 C 0	02 00 10 00 40 60 10 00 4...	download pdo 0x1600 entr...
<PS>	CoE	0x1601 C 0	02 00 10 00 40 60 08 00 6...	download pdo 0x1601 entr...
<PS>	CoE	0x1602 C 0	02 00 10 00 40 60 20 00 7...	download pdo 0x1602 entr...
<PS>	CoE	0x1604 C 0	02 00 10 00 40 60 10 00 7...	download pdo 0x1604 entr...
<PS>	CoE	0x1605 C 0	00 00	download pdo 0x1605 entr...
<PS>	CoE	0x1C12 C 0	01 00 02 16	download pdo 0x1C12 index
<PS>	CoE	0x1C13 C 0	01 00 02 1A	download pdo 0x1C13 index
<PS>	CoE	0x1C14 C 0	00 00	download pdo 0x1C14 index
<PS>	CoE	0x1C15 C 0	00 00	download pdo 0x1C15 index
<P, PS>	AoE	1/3	A9 FE 1D E6 03 02	AoE Init Cmd (download N...
<P, PS>	CoE	0xF030 C 0	00 00	download slot cfg
<P, PS>	CoE	0x6060:00	8	eee init

At the bottom of the 'Startup' tab, there are 'Move Up', 'Move Down', and 'New...' buttons. The 'New...' button is highlighted with a red box. Below the 'Startup' tab, there is a table of device parameters:

Name	Online	Type	Size	> Addr...	In/Out	User ID	Linked to
Status word	X	UINT	2.0	71.0	Input	0	nState1, nStat
Position actual v...	X	DINT	4.0	73.0	Input	0	nDataIn1, In .
WcState	X	BIT	0.1	1522.3	Input	0	nState4, nStat
InputToggle	X	BIT	0.1	1524.3	Input	0	nState4, nStat
State	8	UINT	2.0	1548.0	Input	0	
AdsAddr	169.254.29.230.3.1...	AMSADDR	8.0	1550.0	Input	0	
AoeNetId	169.254.29.230.3.2	AMSNETID	6.0	1558.0	Input	0	

- When the “Edit CANopen Startup Entry” dialog opens, populate it as shown below and check the “Complete Access” checkbox to allow the Sub-Index to be configured:

Edit CANopen Startup Entry ✕

Transition

☐ I → P

☒ P → S ☐ S → P

☐ S → O ☐ O → S

Index (hex):

Sub-Index (dec):

☐ Validate ☒ Complete Access

OK

Cancel

Data (hexbin): Hex Edit...

Validate Mask:

Comment: Edit Entry...

Index	Name	Flags	Value
1003:0	Error History		> 0 <
1003:01	SubIndex 001	RO	0x00000000 (0)
1003:02	SubIndex 002	RO	0x00000000 (0)
1003:03	SubIndex 003	RO	0x00000000 (0)
1003:04	SubIndex 004	RO	0x00000000 (0)
1003:05	SubIndex 005	RO	0x00000000 (0)
1003:06	SubIndex 006	RO	0x00000000 (0)
1003:07	SubIndex 007	RO	0x00000000 (0)
1003:08	SubIndex 008	RO	0x00000000 (0)
1003:09	SubIndex 009	RO	0x00000000 (0)
1003:0A	SubIndex 010	RO	0x00000000 (0)
10F1:0	Error Settings		> 2 <
1C32:0	Sync Manager 2 parameters		> 32 <

- Uncheck the “Complete Access” checkbox and then click “OK”.

Edit CANopen Startup Entry ✕

Transition

☐ I → P

☒ P → S ☐ S → P

☐ S → O ☐ O → S

Index (hex):

Sub-Index (dec):

☐ Validate ☐ Complete Access

OK

Cancel


Data (hexbin): Hex Edit...


Validate Mask:

Comment: Edit Entry...


Index	Name	Flags	Value
1003:0	Error History		> 0 <
1003:01	SubIndex 001	RO	0x00000000 (0)
1003:02	SubIndex 002	RO	0x00000000 (0)
1003:03	SubIndex 003	RO	0x00000000 (0)
1003:04	SubIndex 004	RO	0x00000000 (0)
1003:05	SubIndex 005	RO	0x00000000 (0)
1003:06	SubIndex 006	RO	0x00000000 (0)
1003:07	SubIndex 007	RO	0x00000000 (0)
1003:08	SubIndex 008	RO	0x00000000 (0)
1003:09	SubIndex 009	RO	0x00000000 (0)
1003:0A	SubIndex 010	RO	0x00000000 (0)
10F1:0	Error Settings		> 2 <
1C32:0	Sync Manager 2 parameters		> 32 <

- The new entry in the Startup list looks like this:

 PS CoE 0x2003:39 0x10 (16) Turns bits

- Click the Activate Configuration button to apply the startup list. 
- Click OK on the “Restart TwinCAT System in Run Mode” dialog.

TcXaeShell ✕

 **Restart TwinCAT System in Run Mode**

OK Cancel

- After a few seconds the system will reset, and the new setting will be applied in the drive.

10.4.2 How to scale between NC axis speed and rpm

To convert an NC axis speed in units/s into rpm use the following formula:

$$\text{Drive speed in rpm} = \text{Speed(Units per s)} * 60 / \text{Scale Numerator}$$

E.g. The axis is running at 1000°/s with a scaling numerator of 360 per rev. The resulting speed in rpm observed in Pr3.002 is $1000 * 60 / 360 = 166.6\text{rpm}$

To convert the speed seen at the drive, in rpm, into NC axis speed in units/s use the following formula:

$$\text{NC axis speed} = \text{Speed(rpm)} * \text{Scale Numerator} / 60$$

E.g. The axis is running at 1000rpm with a scaling numerator of 1234 mm per rev. The resulting speed in rpm observed in the NC axis ActVelo parameter is $1000 * 1234 / 60 = 20566.6\text{rpm}$

10.5 How to upgrade EtherCAT Firmware


There are 2 main ways to update the firmware and they are each used in different situations.

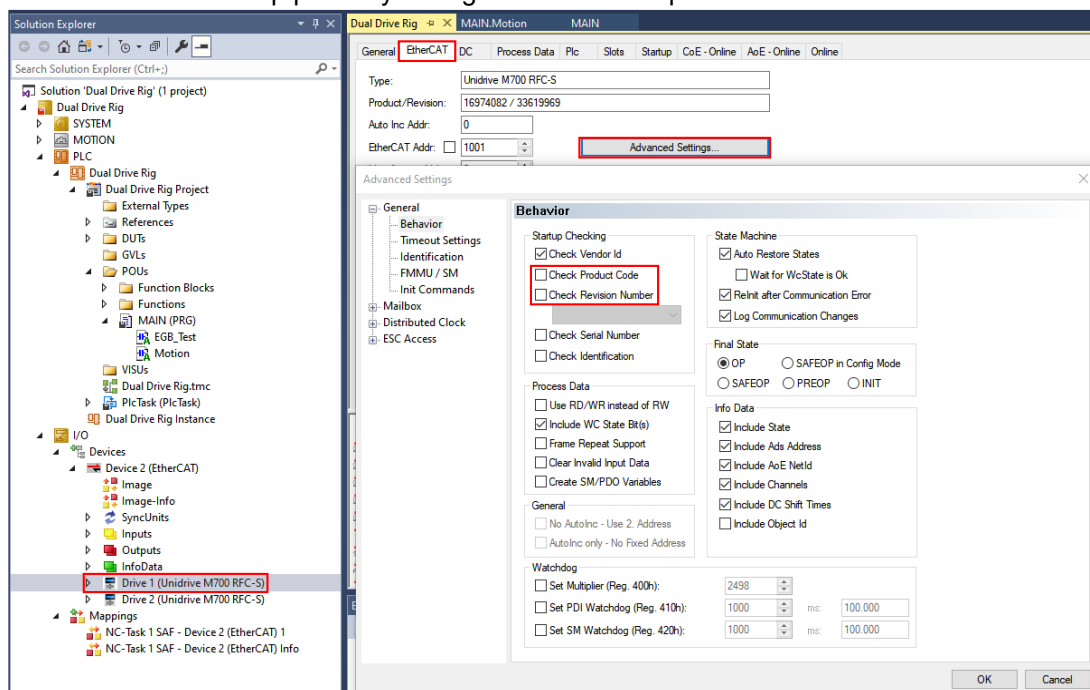
The most common way as described in section **10.5.1 How to upgrade the EtherCAT interface** firmware using Connect shows how to update the firmware using Connect which is used when there is an existing, working connection to the drive, either by ADS or AoE or serial / ethernet communications.

The second method is for situations where communications is by EtherCAT and it hasn't been possible to establish an ADS or AOE connection. In this scenario it is recommended to use FoE in TwinCAT to update the firmware. This is described in section **10.5.2 How to use FoE to update the EtherCAT interface firmware**.

10.5.1 How to upgrade the EtherCAT interface firmware using Connect

When setting up an EtherCAT network it is important to make sure the ESI file and firmware match each other to prevent issues when starting the EtherCAT network. The following steps assume that there is a working EtherCAT connection already – if a connection can't be established, use the steps in section **10.5.2 How to use FoE to update the EtherCAT interface firmware**.

1. Before updating using the EtherCAT interface using Connect, in the TwinCAT project, uncheck the “Check Product Code” and “Check Revision Number” check boxes in the EtherCAT drive properties, and then activate the configuration . This is so that the changes to the product code that will happen when the firmware is updated don't cause ADS / AoE communications to stop part way through the firmware update.

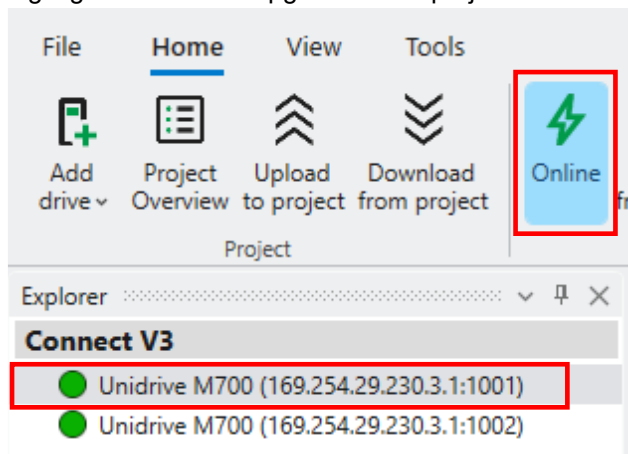


2. Install and open the “Connect” PC tool.
3. Establish a connection between the PC being used for Connect and the Control Techniques drive, this connection can be achieved via Ethernet, EoE, ADS, or serial communications.

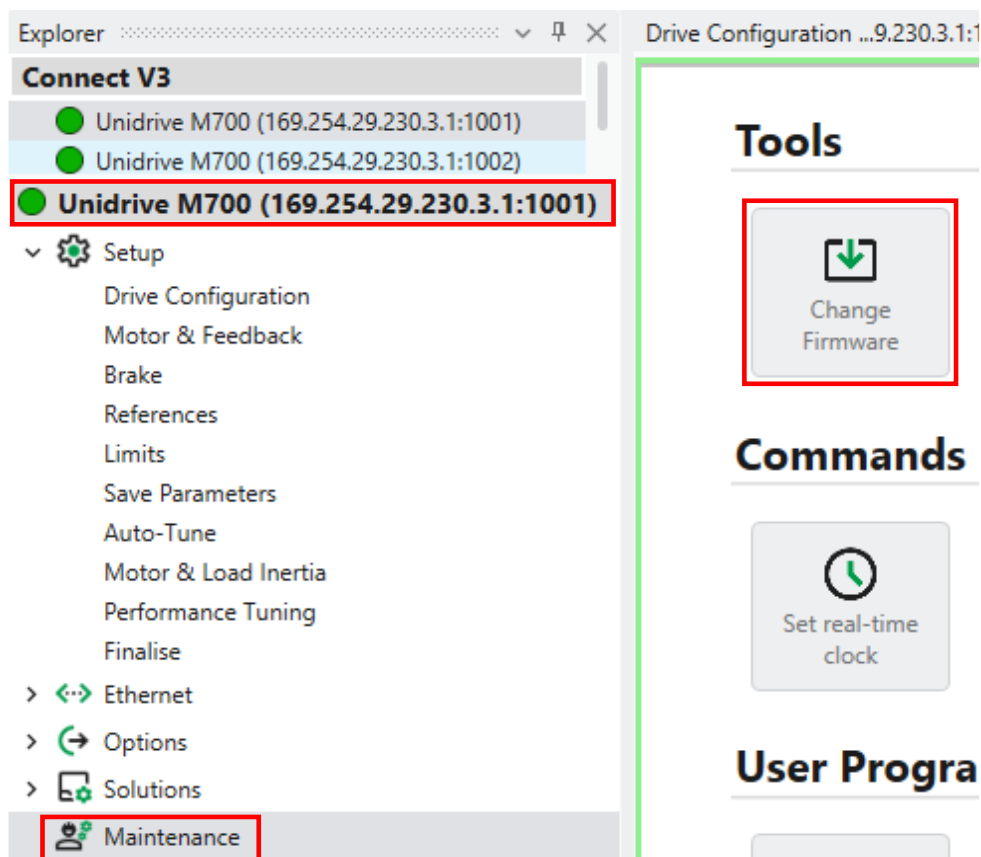
HINT: Ethernet and Serial communications may be used directly with the drive, but any EtherCAT-based communications require an EtherCAT network Master to be configured before the drive can be communicated with such as a PLC or IPC.

See sections **3** and **4** for details on how to establish the connection over an EtherCAT network using a Beckhoff TwinCAT PLC / IPC, and AoE / ADS communications as described in section **4 Setup an EtherCAT AoE connection from the PLC to the drive**, is the easiest to work with. The remaining firmware upgrade steps shown using ADS.

4. Highlight the drive to upgrade in the project tree and then click “Online”.

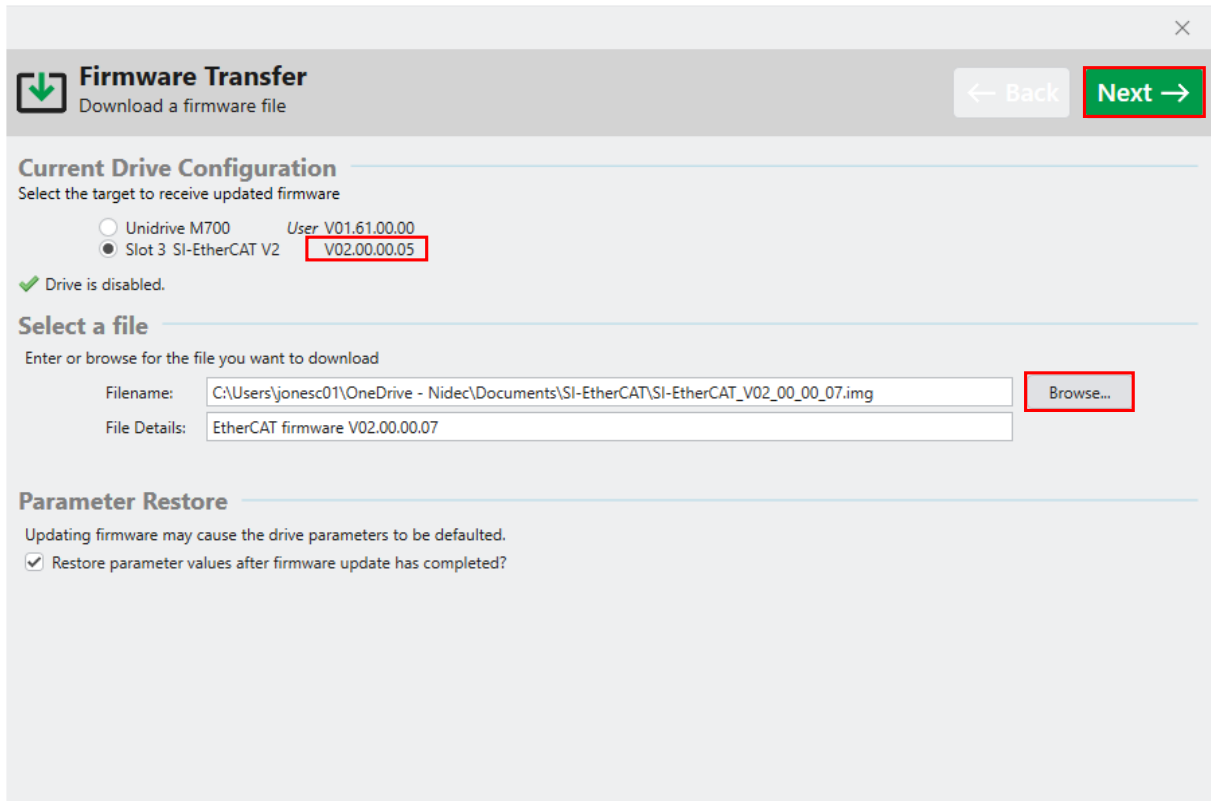


5. From the drive explorer tree double click on “Maintenance” and then “Change Firmware”:



- The “Firmware Transfer” tool will open. This tool displays the current firmware present in the drive and any connected option modules.

To perform a firmware upgrade, select the slot that the SI-EtherCAT module is installed in and click the “Browse...” button to locate the SI-EtherCAT firmware:

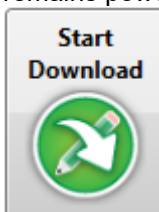


The screenshot shows the 'Firmware Transfer' window. At the top, there's a title bar with a green download icon and the text 'Firmware Transfer' and 'Download a firmware file'. On the right, there are 'Back' and 'Next' buttons. The main content area is divided into three sections: 'Current Drive Configuration', 'Select a file', and 'Parameter Restore'. In 'Current Drive Configuration', 'Slot 3 SI-EtherCAT V2' is selected, and its firmware version 'V02.00.00.05' is highlighted with a red box. A green checkmark indicates 'Drive is disabled.'. In 'Select a file', the 'Filename' field contains 'C:\Users\jonesc01\OneDrive - Nidec\Documents\SI-EtherCAT\SI-EtherCAT_V02_00_00_07.img' and the 'File Details' field contains 'EtherCAT firmware V02.00.00.07'. A red box highlights the 'Browse...' button. In 'Parameter Restore', there's a checkbox labeled 'Restore parameter values after firmware update has completed?' which is checked.

Make sure that the drive is disabled and that any application software modules e.g. MCi210 or SI-Applications Plus have their programs stopped.

Click  to continue.

- Click “Start Download” to begin the transfer of the firmware. Please ensure that the drive remains powered up and the communications stay intact until the process has completed.



- Power down the PLC/IPC and drives, then re-apply power to re-establish the network.

HINT: Downgrading the firmware using Connect over ADS may not fully work since the ESI file used in the PLC / IPC will no longer match the target after the firmware has been transferred to the EtherCAT module and the EtherCAT master will stop ADS

10.5.2 How to use FoE to update the EtherCAT interface firmware

In situations where it hasn't been possible to establish communications to the drive and only EtherCAT communications are available, instead of using Connect over ADS / AoE, it is possible to load the firmware directly using TwinCAT provided the EtherCAT interface firmware is greater than V01.08.00.14.

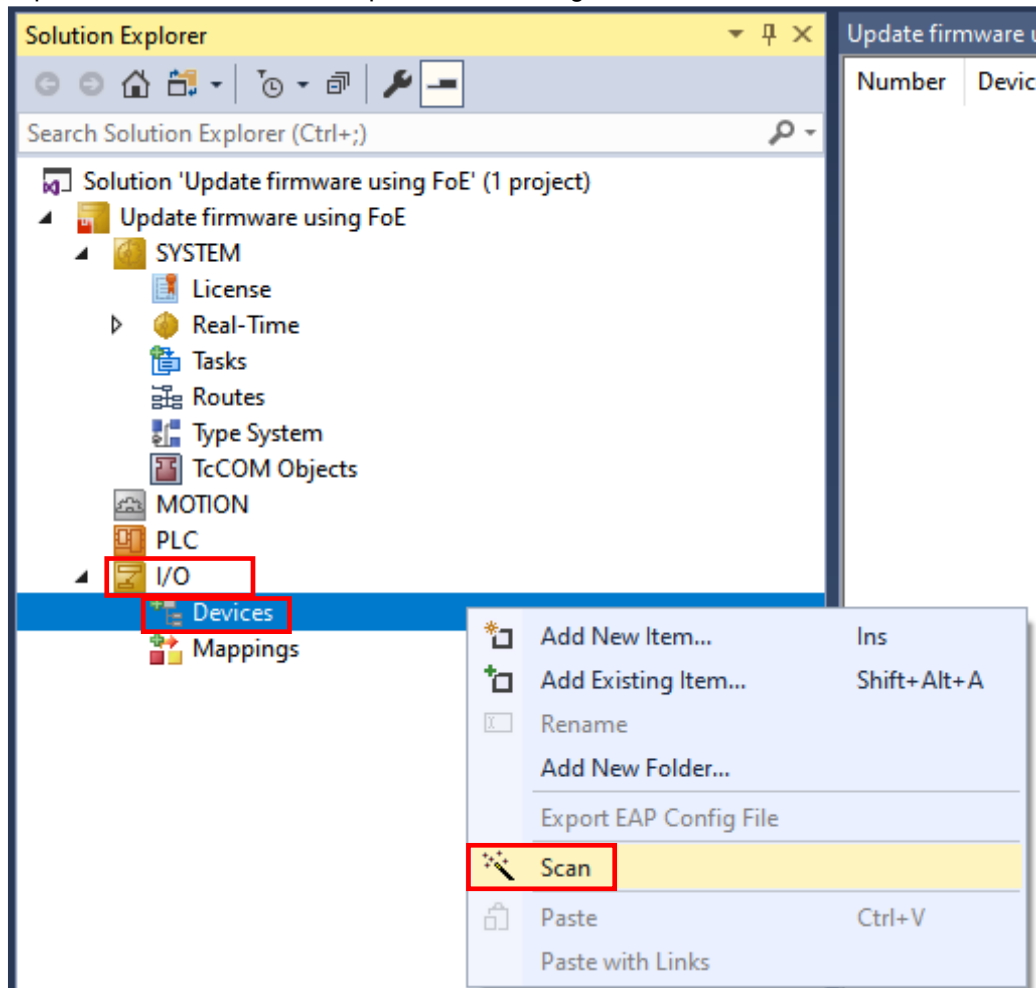
For firmware older than V01.08.00.14 an alternative connection must be made to the drive using Control Techniques RS485 adapter, or using Ethernet and an SI-Ethernet / Factory Fitted Ethernet option, or a KI-Keypad Plus.

This situation might occur if the EDS files installed in TwinCAT don't match the firmware in the module. Before using this method, make sure that the EDS files in TwinCAT match the firmware that will be loaded in the following steps.

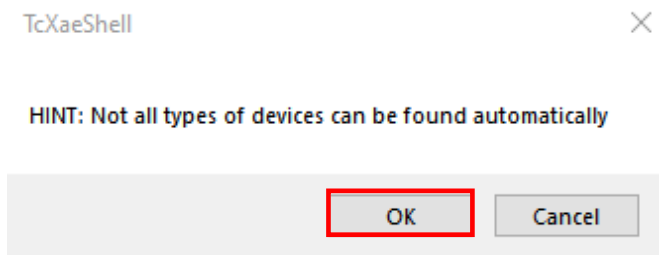
It is assumed that the steps in section **3 Initial TwinCAT project setup** have been followed to create a project before using these steps.

For a brand new project it is **strongly** recommended to update to EtherCAT interface V2 firmware and ESI files. Use the following steps to update the firmware:

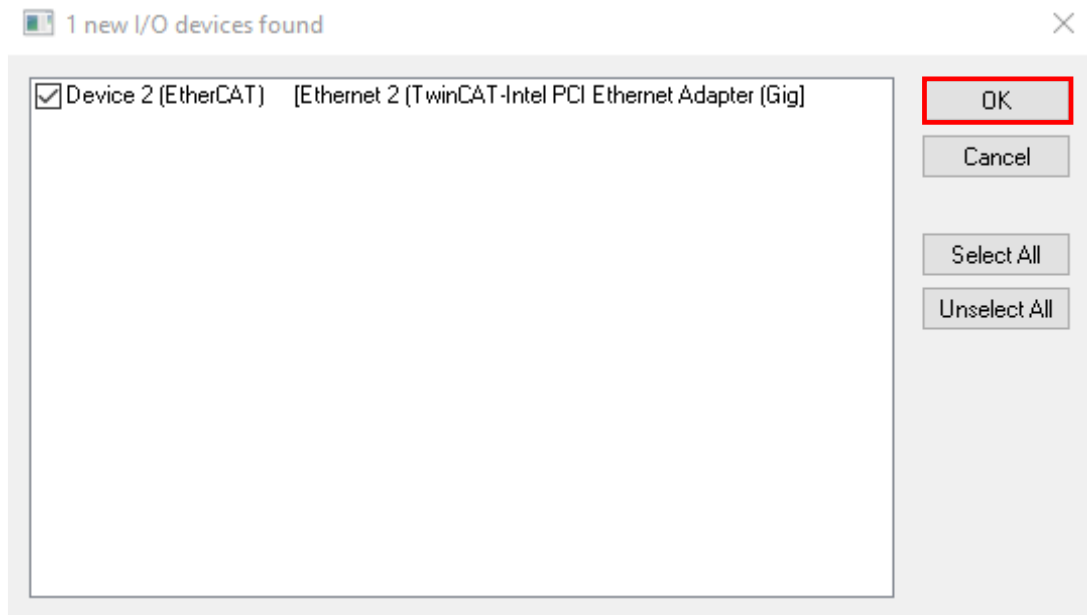
1. Expand "I/O" in the Solution Explorer and then right click on "Devices" and then select "Scan":



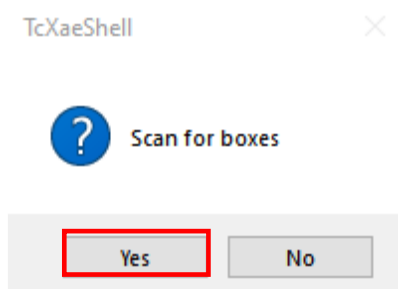
- Click “OK” to the “HINT: Not all types of devices can be found automatically” pop-up.



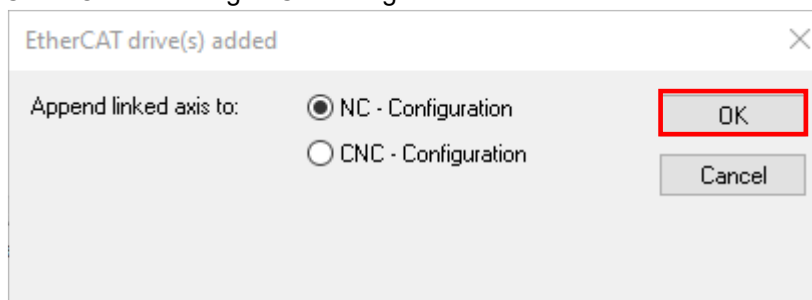
- After the device search finishes, select the EtherCAT interface and then select “OK”.



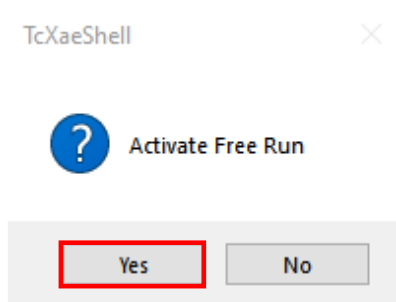
- Select “Yes” when the “Scan for boxes?” pop-up appears:



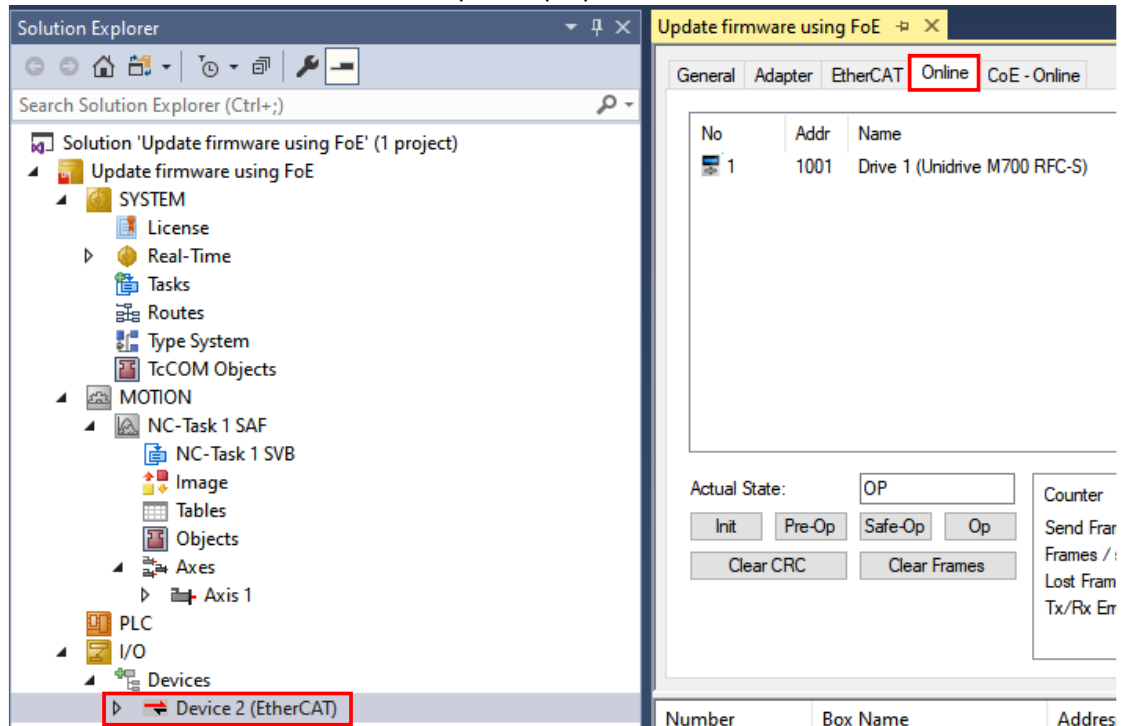
- Click “OK” to adding “NC – configuration”.



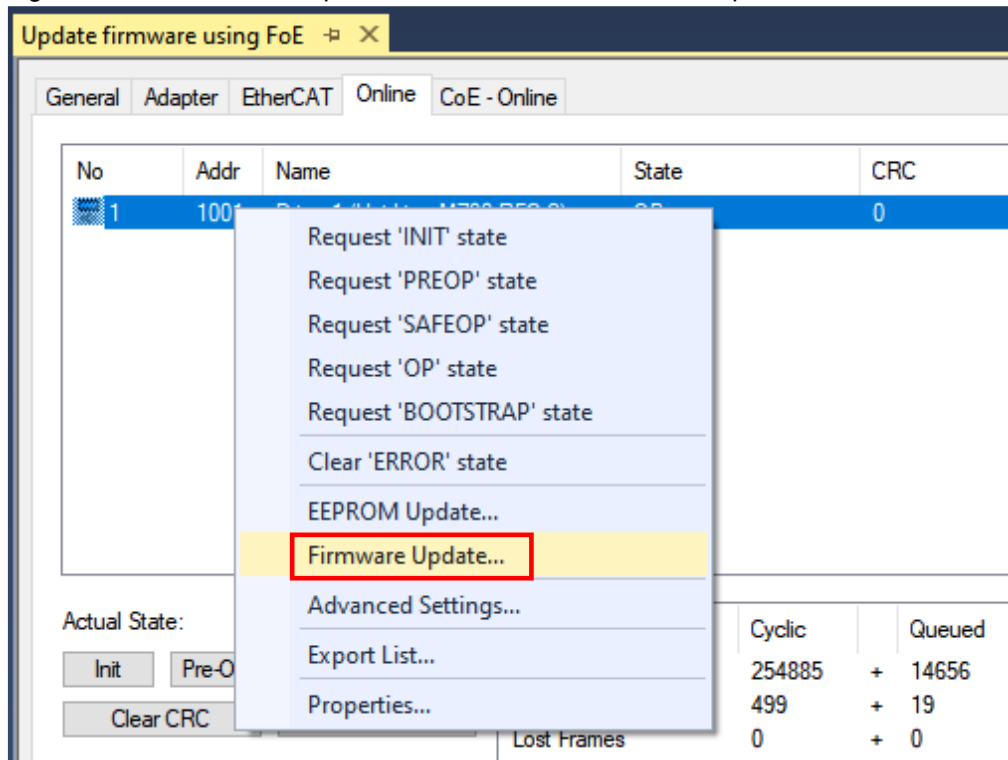
6. Click “Yes” on the “Activate Free Run” pop-up.



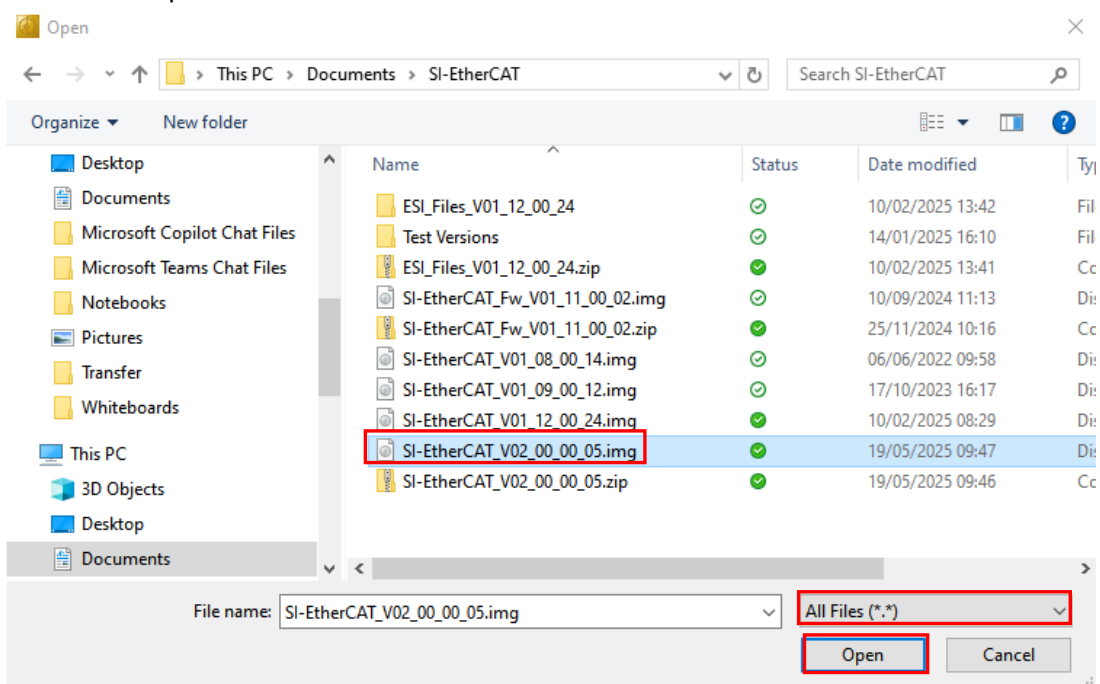
7. Double click the EtherCAT master to open its properties and then select the “Online” tab:



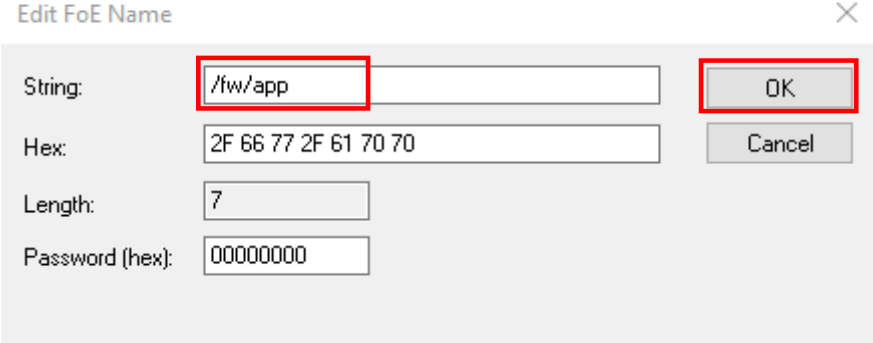
8. Right click on the drive to update and then select “Firmware Update...”



9. The file explorer opens. Set the file type to “All Files (*.*)”, then select the firmware file, and then select “Open”.



10. When the “Edit FoE Name” pop-up appears change “String:” to the correct file path for the firmware image file which is “/fw/app”, and then select “OK”.



Edit FoE Name

String: /fw/app

Hex: 2F 66 77 2F 61 70 70

Length: 7

Password (hex): 00000000

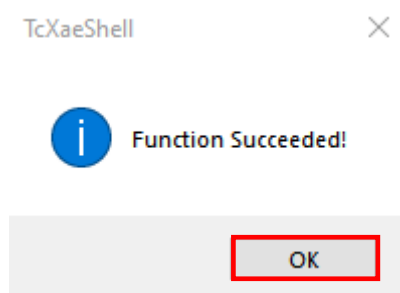
OK

Cancel

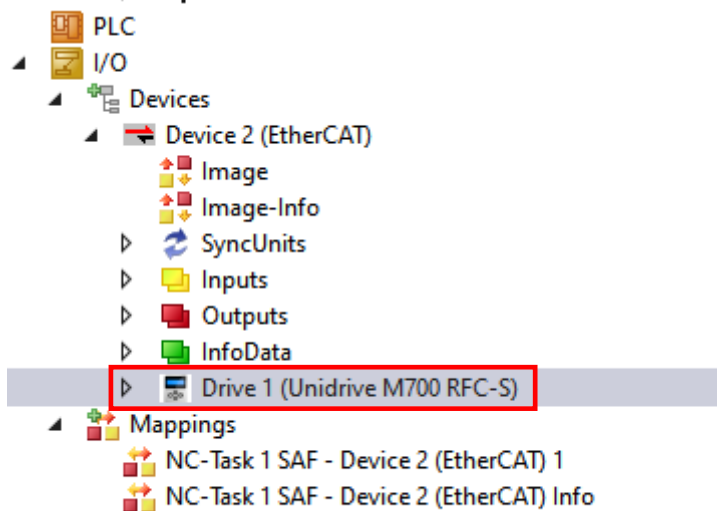
11. The file download runs. Wait until it finishes.



12. When the download completes the “Function Succeeded!” message appears. Click “OK”.



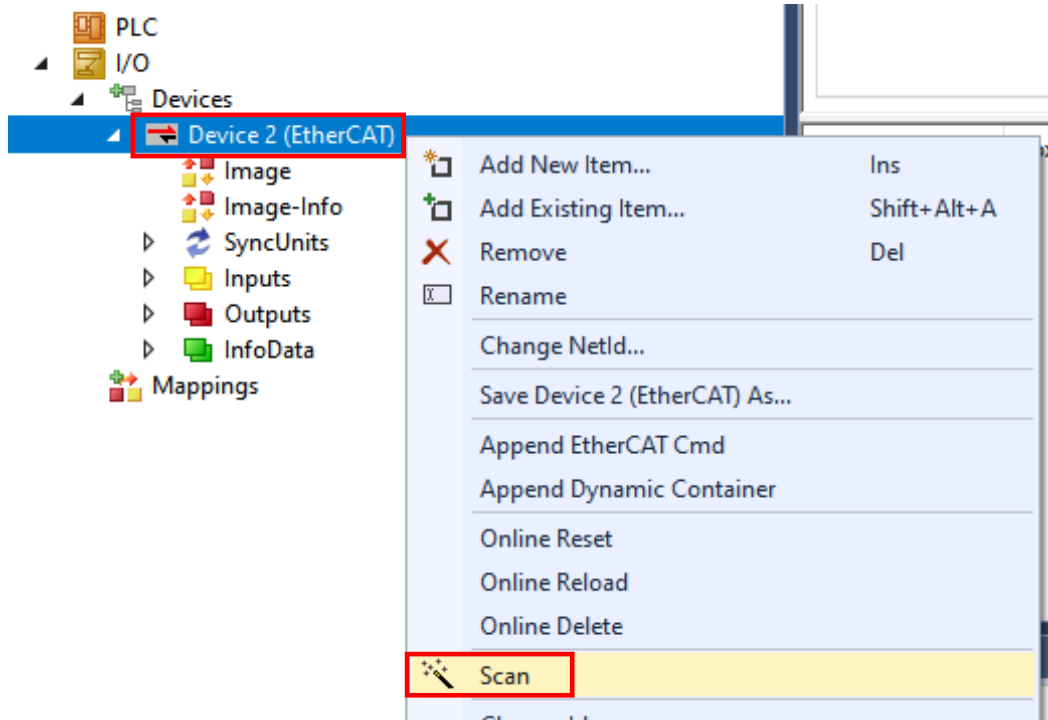
13. Delete the drive that has been updated in the Solution Explorer tree.



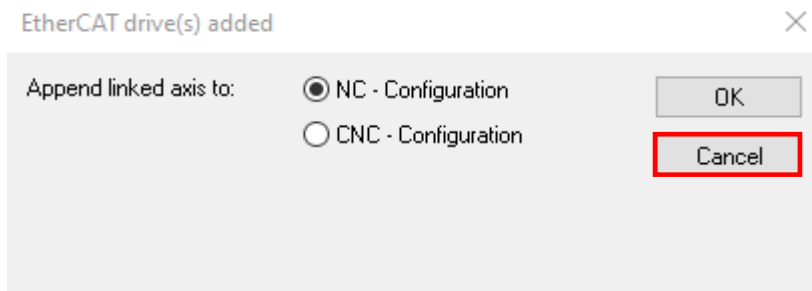
Click “OK” to the following message:



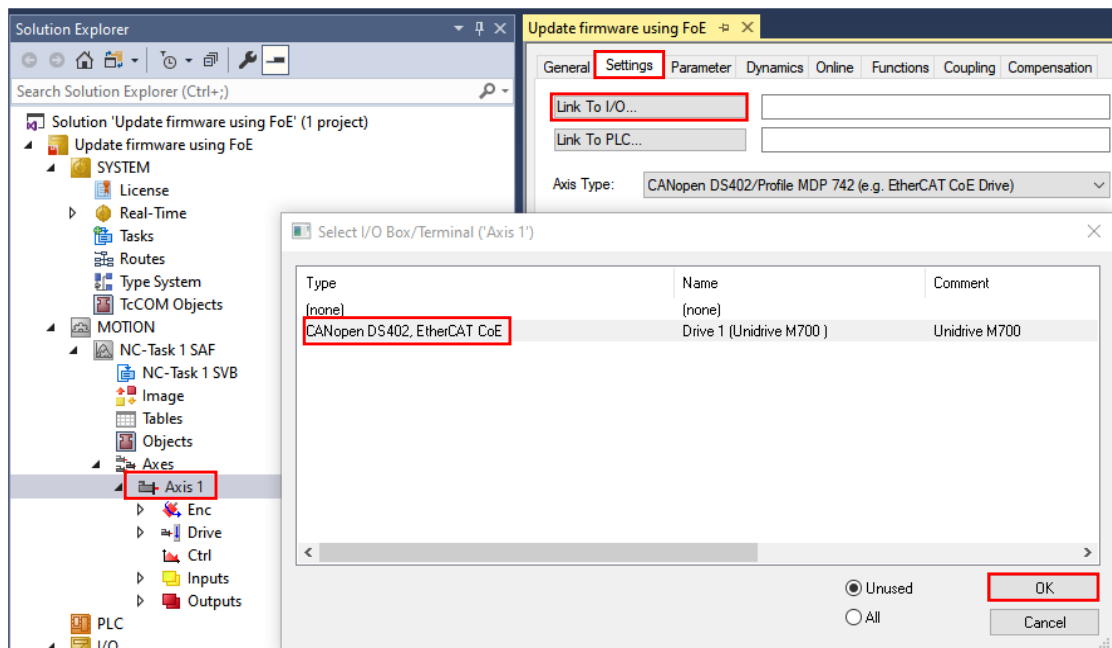
14. Right click on the EtherCAT master in the solution explorer tree and then select “Scan”.



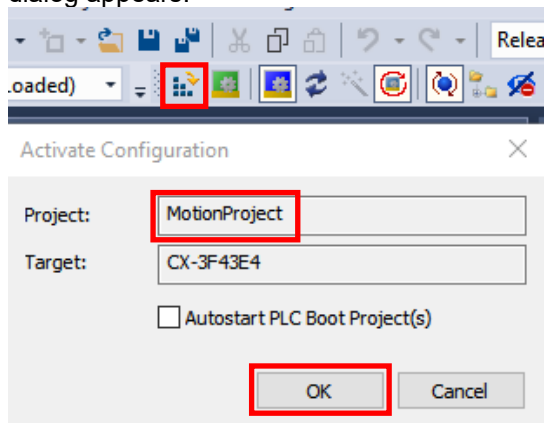
15. When the “EtherCAT drive(s) added” dialog appears select “Cancel” so that another NC axis isn’t added to the project.



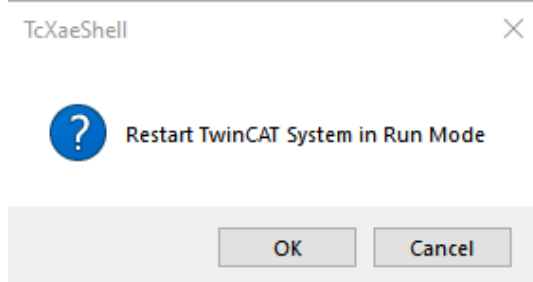
16. Link the NC that was created for the drive axis originally, back to the drive EtherCAT comms by double clicking on the axis e.g. Axis 1 to open it properties and select the “Settings” tab. Click on “Link To I/O...”, select the Drive from the list to link to the axis, e.g. Drive 1, and then select “OK”.



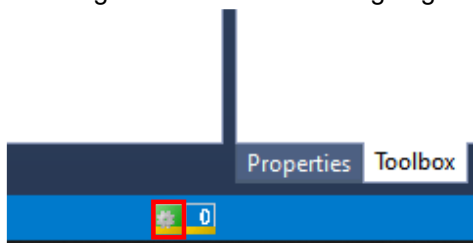
17. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



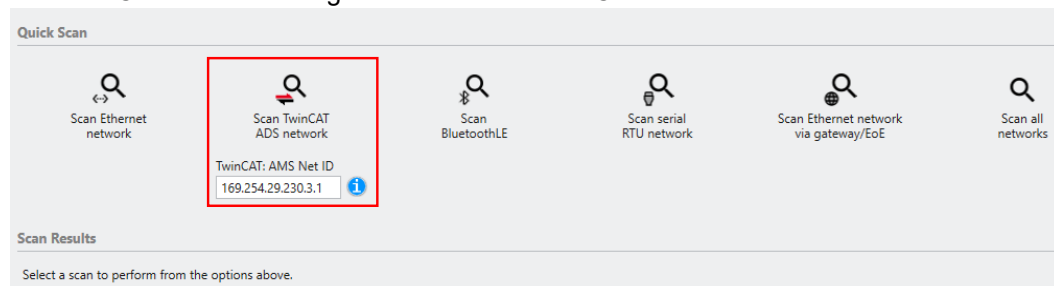
Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



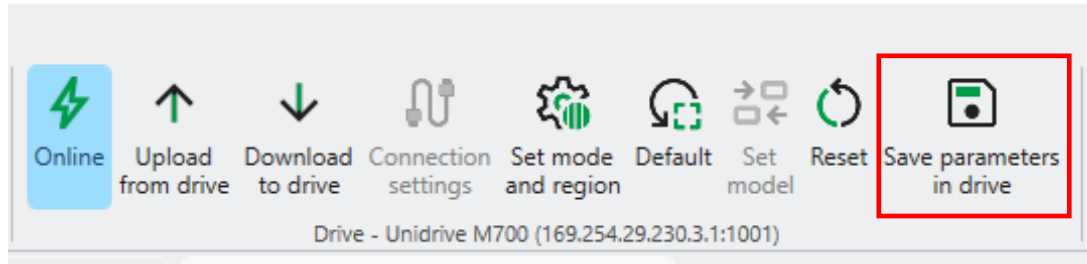
18. If the system is operating properly the status Icon in the bottom right corner of TwinCAT will show a green box with a rotating cog:



19. Communications will now be running and Connect will be able to search for the drive(s) on the EtherCAT network using the “NetId:”. If the In Connect Scan the network to find the drive.



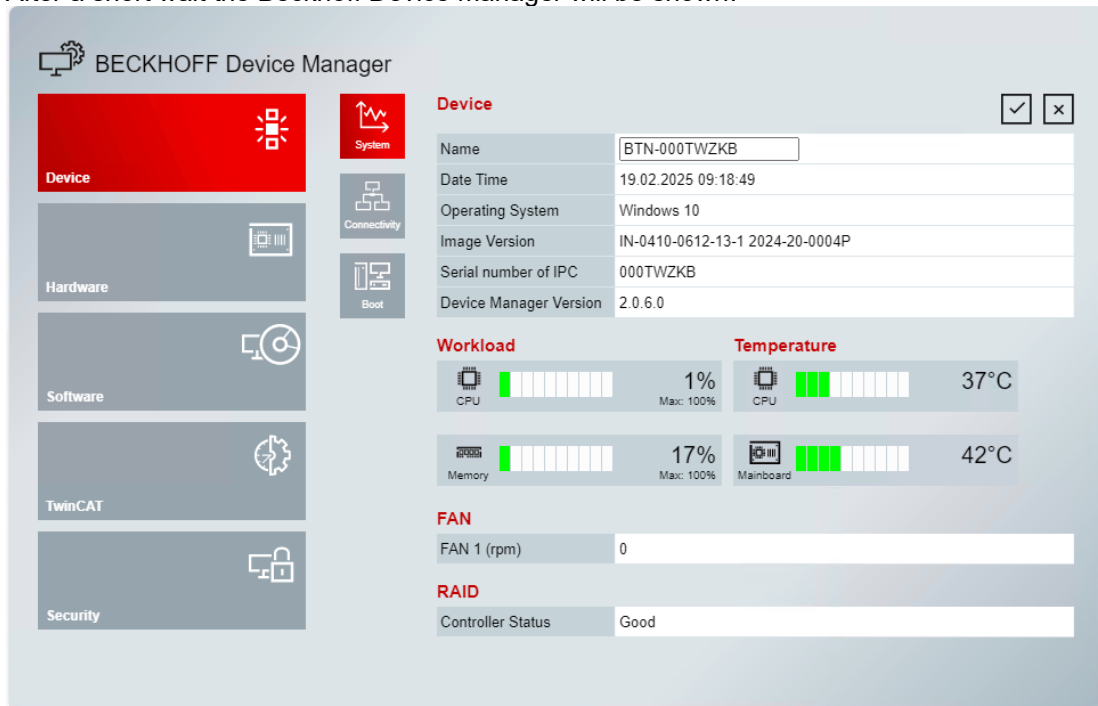
20. If the EtherCAT firmware has been upgraded from V1 to V2 a save is required to acknowledge the update. Start a project as described in section **5 Configure the drive using Connect** and once the project is open, select the drive to save and then click “Save parameters in drive” to complete the process.



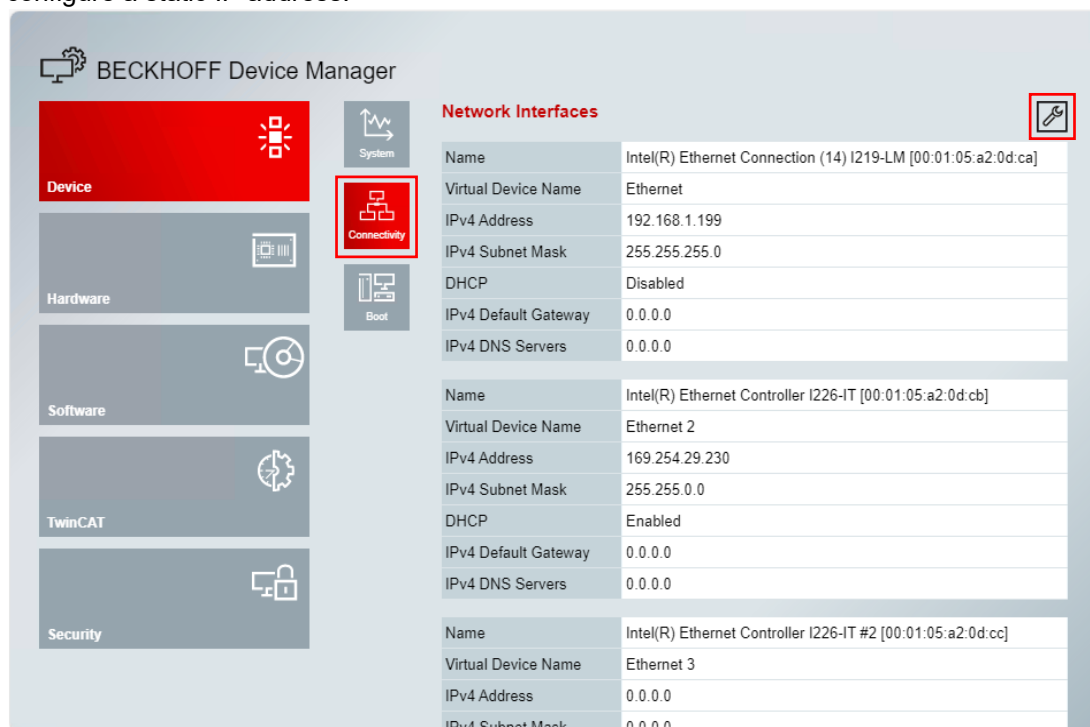
10.6 How to setup a Beckhoff IPC

IPCs from Beckhoff such as the C6025 are not supplied with the TwinCAT runtime or any EtherCAT port setup. The following steps can be used to turn a Beckhoff IPC into a TwinCAT controller.

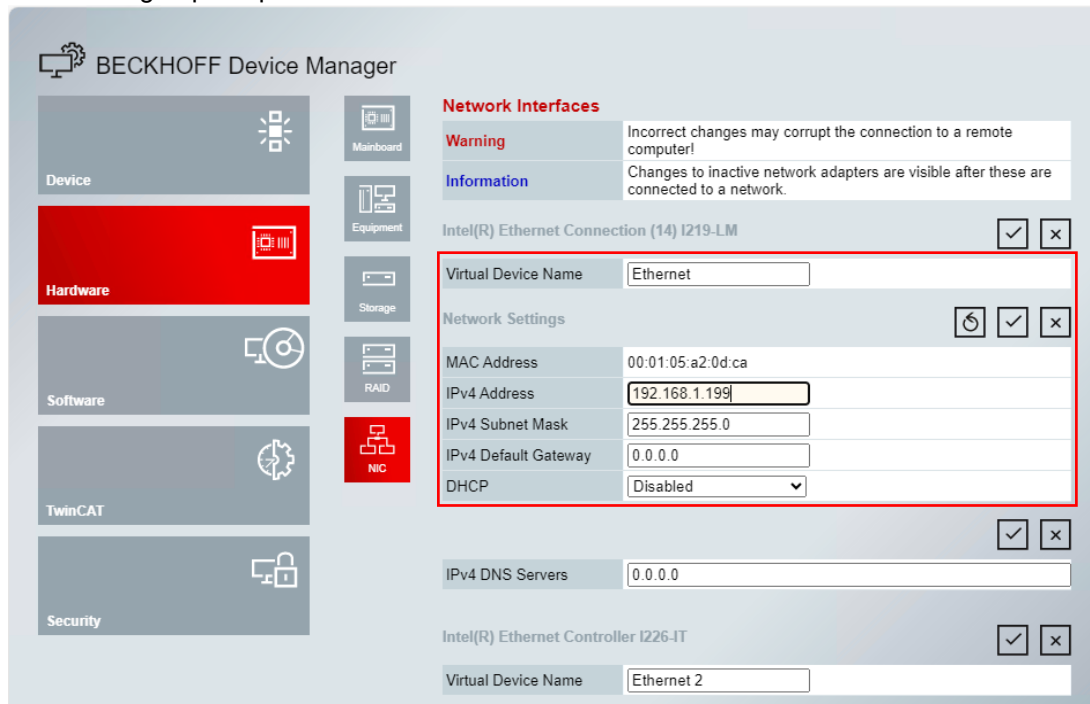
1. Apply 24V to the IPC. Follow the user guide for the IPC for the details on the power connector wiring.
2. Plug a monitor, keyboard and mouse into the IPC.
3. After a short wait the Beckhoff Device manager will be shown:



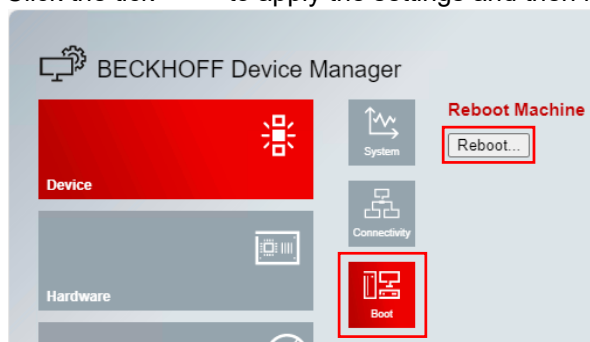
4. Select Connectivity and then click the spanner icon on the top right of the Device Manager to configure a static IP address:



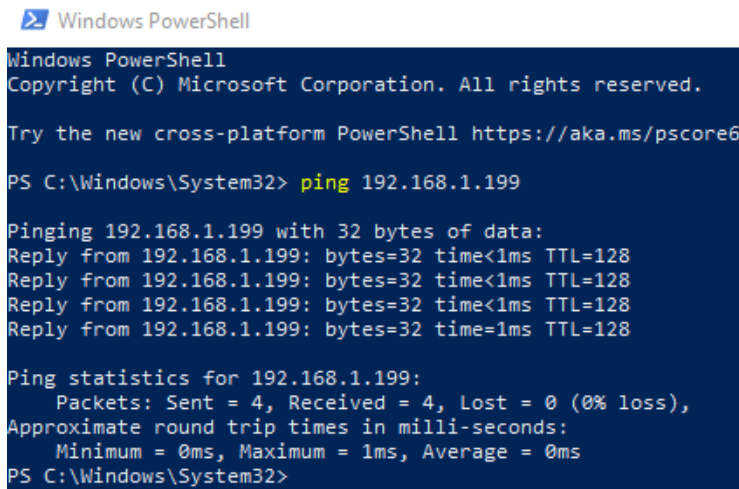
5. Choose an ethernet port that will become the Ethernet connection to your PC. There is normally 1 port that is slower than the others, this is the best port to use for the PC connection since the high-speed ports should be used for EtherCAT real time communication.



6. Click the tick ☒ to apply the settings and then reboot.



- Using the command prompt or Powershell, ping the new IP address to make sure it is operational. When the command prompt is shown type “ping ” followed by the IP address assigned e.g. “ping 192.168.1.199”. The screen shot below shows a successful ping:



```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

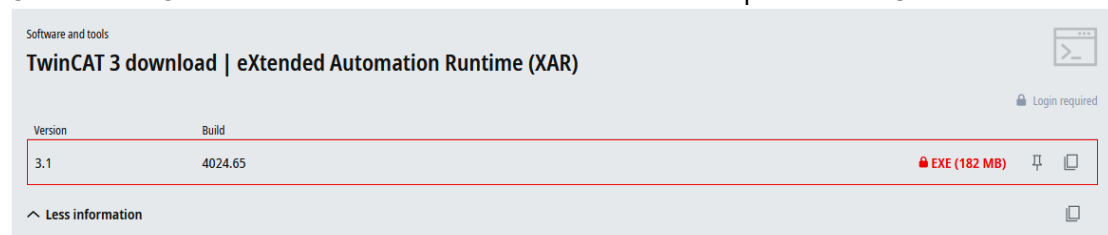
Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Windows\System32> ping 192.168.1.199

Pinging 192.168.1.199 with 32 bytes of data:
Reply from 192.168.1.199: bytes=32 time<1ms TTL=128
Reply from 192.168.1.199: bytes=32 time<1ms TTL=128
Reply from 192.168.1.199: bytes=32 time<1ms TTL=128
Reply from 192.168.1.199: bytes=32 time=1ms TTL=128

Ping statistics for 192.168.1.199:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 1ms, Average = 0ms
PS C:\Windows\System32>
```

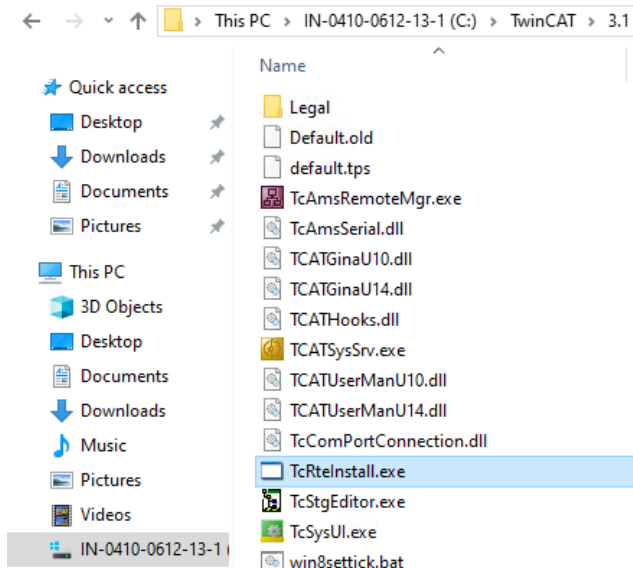
- From this point onwards, the Beckhoff Device Manager can be accessed using a web browser e.g. type in “https://192.168.1.199/config”.
- Get the TwinCAT XAR runtime from the Beckhoff website and put it onto a USB stick:



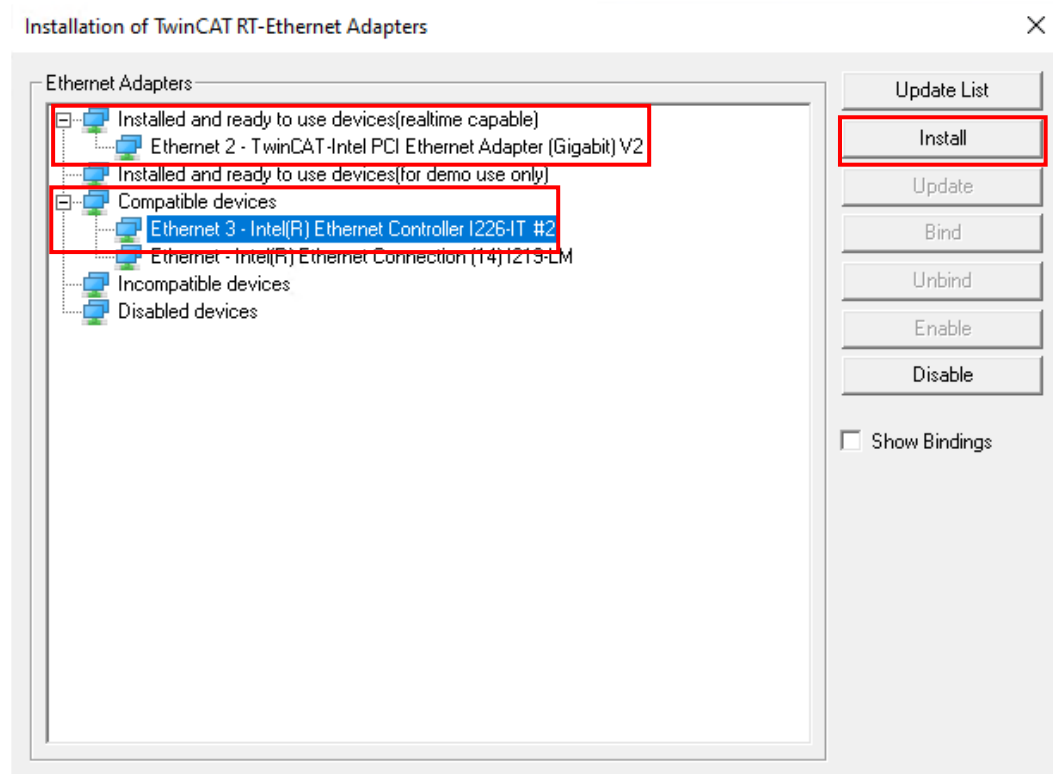
Put the USB stick with the runtime on it into one of the IPCs USB ports.

- Using file explorer on the IPC locate the USB stick, copy the files from the USB to the IPCs documents folder, and then double click on the installer file to start the installation. When the installation completes the IPC must be rebooted.
- When the IPC boots up the “TC” LED will now be lit up blue.

12. Access the IPC file system using File Explorer and navigate to C:/TwinCAT/3.1/System. In this folder there is a file called "TcRtelInstall.exe". Double click on this to assign the EtherCAT network port on the IPC.

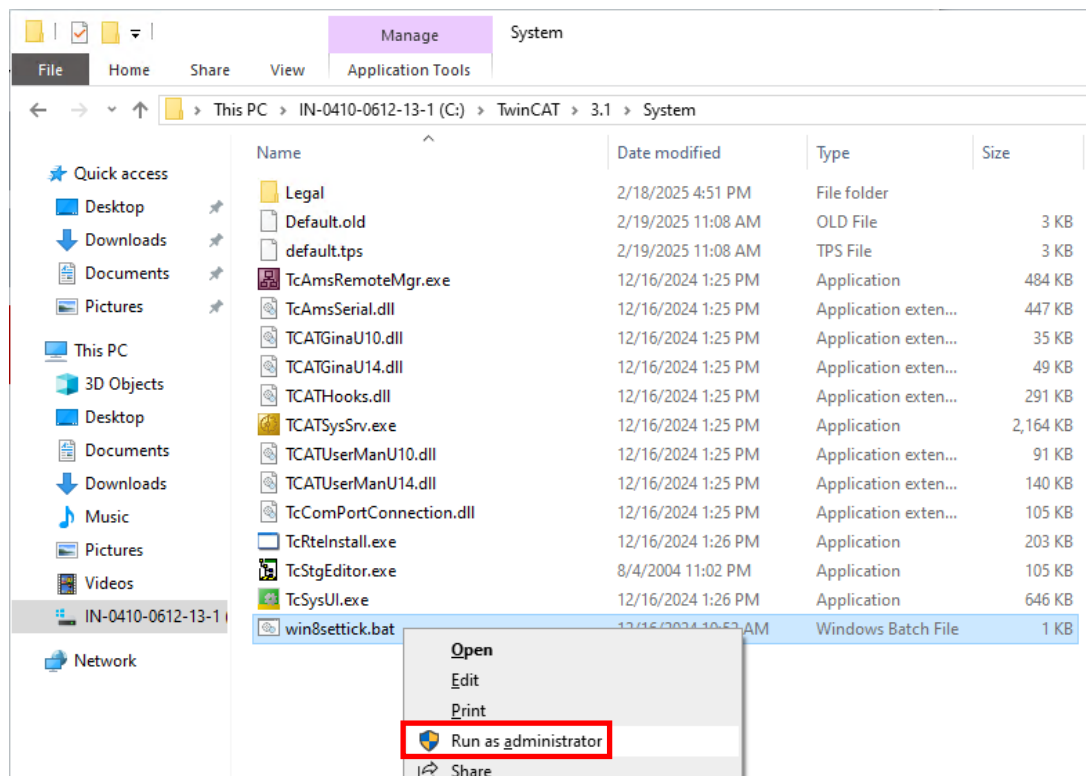


13. When the installer opens, click on the port to become the EtherCAT network port in the "Compatible Devices" list and then click "Install". When the process is completed the newly installed port will appear in the "Installed and ready to use devices (realtime capable)" list.

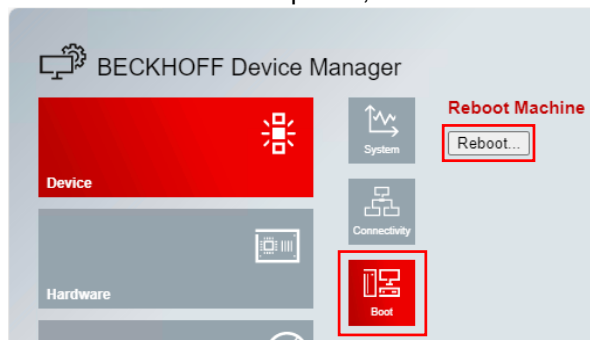


Close the installer when finished

14. In the same folder location, C:/TwinCAT/3.1/System, run win8settick.bat as an Administrator, (right click on the file select “Run as Administrator...”).



15. When the batch file completes, reboot the IPC.

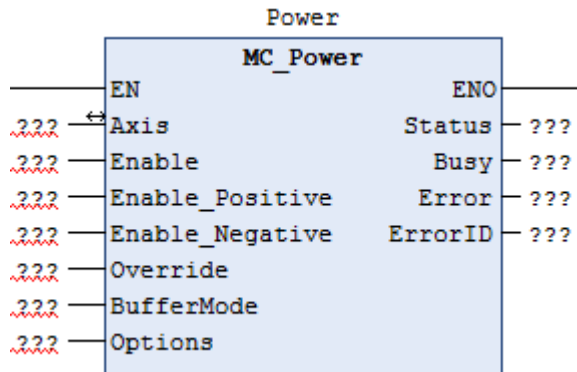


16. The IPC can now be used with TwinCAT.

10.7 How to Remove “???” from LD diagram POU inputs and outputs

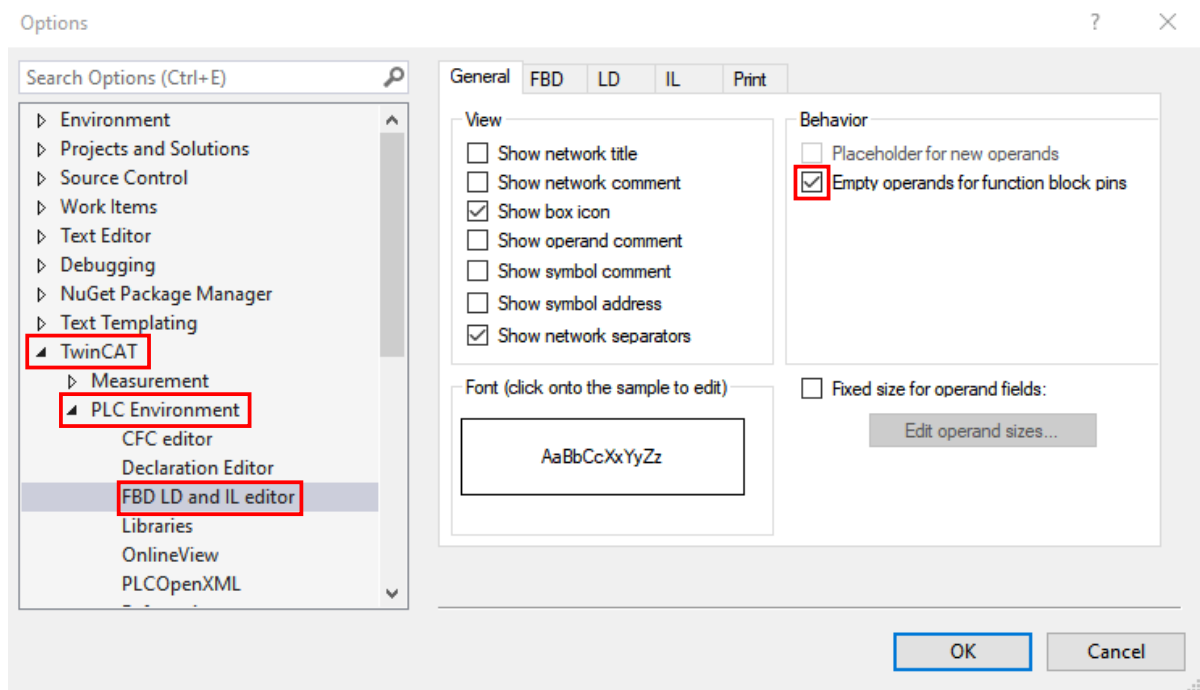
LD diagram language can be a nice way to explore the functionality of the NC axis PLCOpen function blocks. Each input and output can be seen side by side, any enumerated values selected, and all output values may be seen.

However, the default environment behaviour when using the LD language can be cumbersome when inserting function blocks to a ladder rung. All of the POU Inputs and Outputs have “???” next to them which must be deleted or overwritten before the program can be compiled which is time consuming.

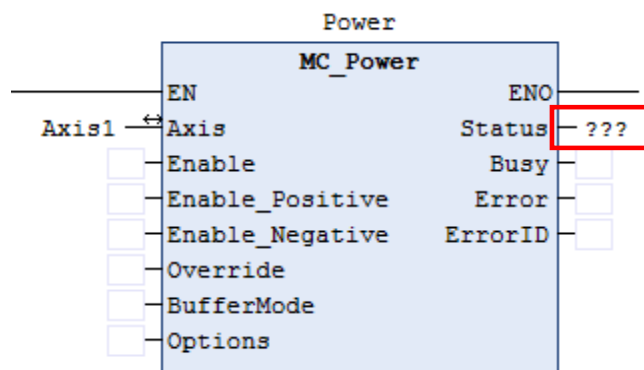


The “???” at the POU’s I/O is optional. The following steps show how to turn this off:

- Go to “Tools” > “Options”
- Go to “TwinCAT” > “PLC Environment” > “FB LD and IL editor”.
- Check the “Empty operands for function block pins”



After making this change, when new POUs are inserted to a rung, only the first output has “???” which is much easier to delete:



10.8 How to use a startup list in TwinCAT

The startup list for an EtherCAT device is a helpful way to configure CiA402 CAN objects and drive parameters (addressed as CAN objects) when an EtherCAT node starts. There are a couple of standard ways in which this feature is used:

1. To apply the parameters used to setup a drive axis from scratch. This will restore the original drive configuration in case the drive parameters have been altered. It can also be used to automatically configure a brand new drive (assuming the drive and EtherCAT option firmware match) in the event that a drive is replaced.
2. To configure CiA402 CAN objects that define how the system operates such as the behaviour of the drive when comms are lost via object 0x3005.

The following sections detail how to use TwinCAT in these scenarios.

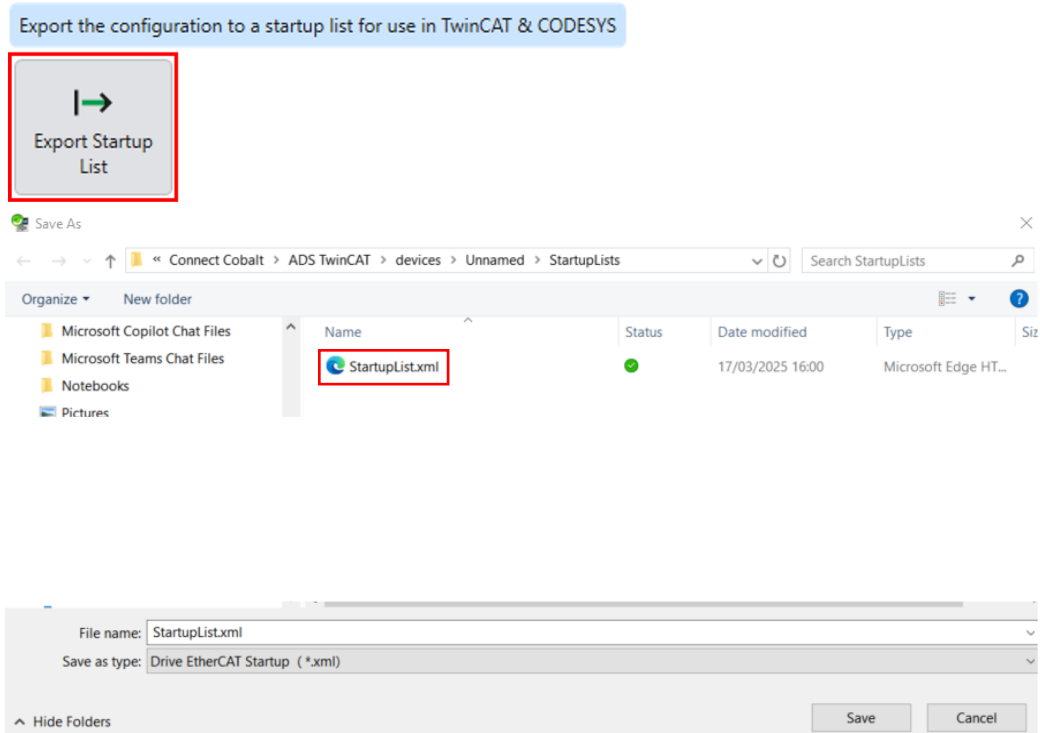
10.8.1 How to import a startup list .xml file from Connect into TwinCAT

A startup list .xml file can be generated by Control Techniques Connect after the axis has been commissioned. A startup list generated by Control Techniques Connect software holds all of the changes made to the drive in a format that TwinCAT can import, so that every time the drive is powered up, its settings are restored. This can be helpful if a drive has to be replaced, since the previous setup is restored including things like motor map, encoder type, tuning values etc.

The following steps show how to import the file into TwinCAT:

1. An EtherCAT startup list may be generated to preserve the configuration in the TwinCAT PLC/IPC. The startup list is in the form of an startup list .xml file that may be imported into TwinCAT. The export start-up list button can be found on the “Finalize” step in the guided setup.

Export as Startup List



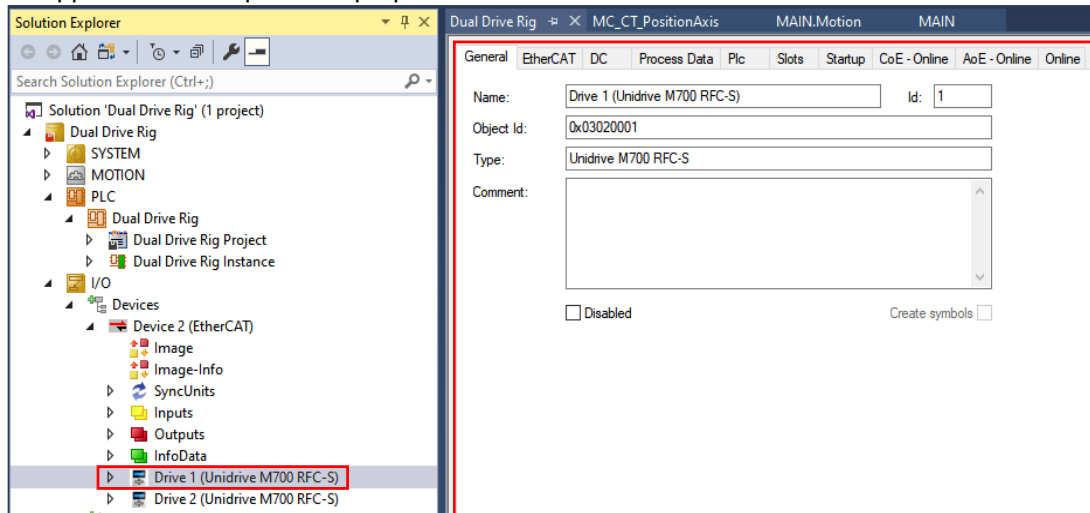
StartupList.xml is stored in the following location:

C:\Users\[USER NAME]\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists.

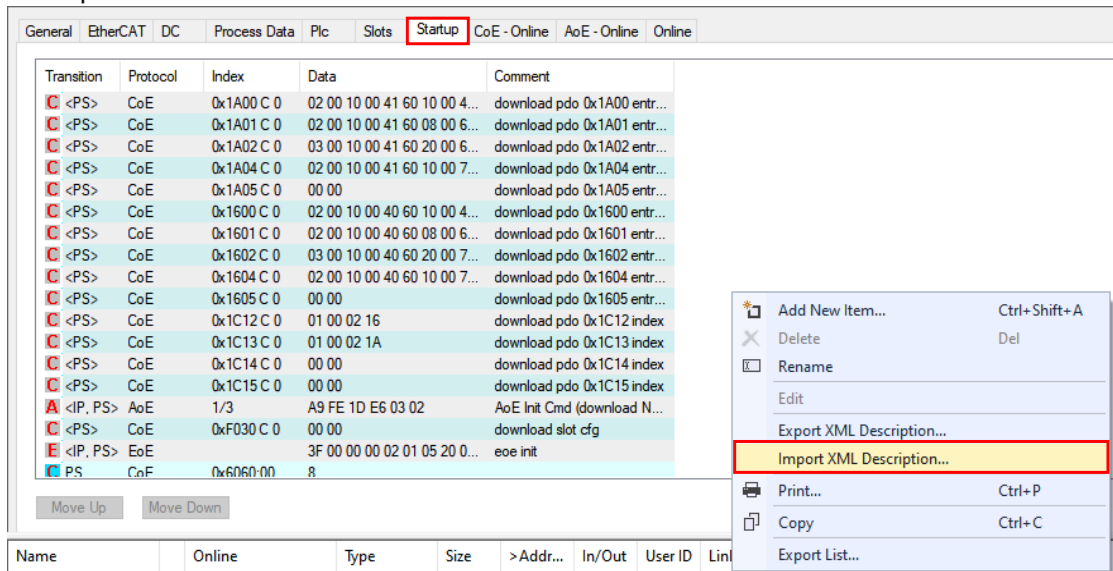
- Open the TwinCAT project.
- Make sure config mode is selected as indicated by the blue config button being highlighted. Click the blue Config button if it is not highlighted.



- Double click on the drive node in the Solution explorer pane, that the startup list .xml file will be applied to. This opens the properties for the drive node.



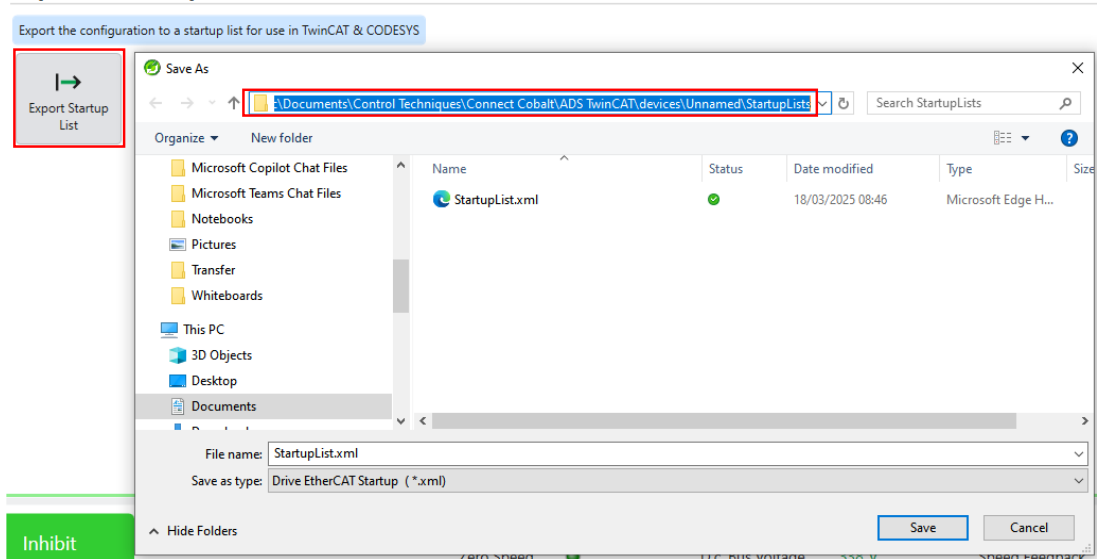
- Select the Startup tab. Right click anywhere on the startup tab, and select "Import XML Description..."



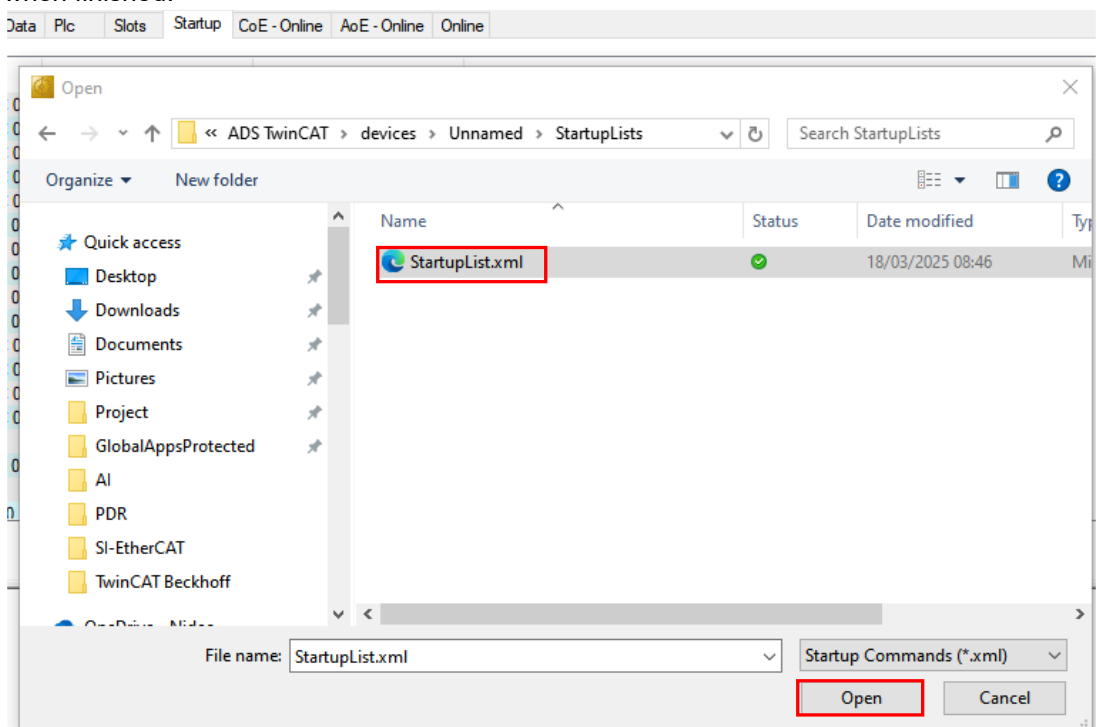
6. Navigate to the location of the startup list generated by Connect. The general form for the path to the .xml file is "C:\Users\[USER NAME]\OneDrive\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists"

Alternatively the path for the .xml file can be copied by opening the original Connect project, go to "Setup" > "Finalise" page and then click on "Export Startup List" and then copy the path from the explorer window.

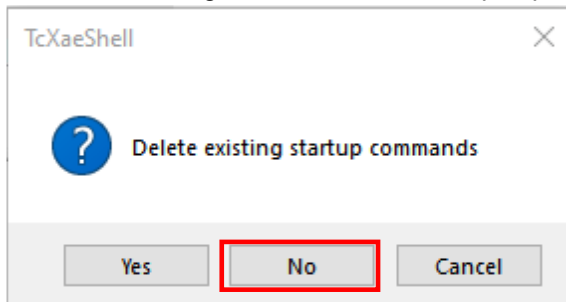
Export as Startup List



Paste the path from Connect into the TwinCAT import .XML window path and click "Open" when finished.



7. A pop up will ask if the original start up list should be deleted? Select “No” which instead of deleting the original start up list and replacing it with the one from Connect, it will append / add to the existing list with the extra setup imported from Connect.



8. Apply the startup list by clicking the “Activate Configuration” button, and click “OK” or “Yes” on any following pop-up messages:



10.8.2 How to add a single CAN object to the TwinCAT Startup List & Cyclic comms loss action

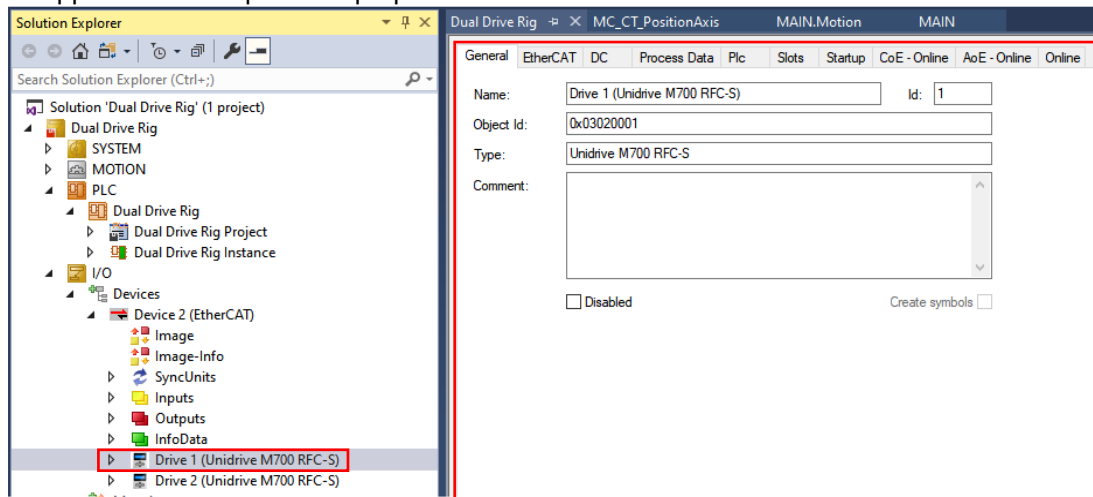
This section describes how to add single CAN objects to the startup list. The object may be ones specified by the CiA402 standard, custom ones as specified in the SI-EtherCAT manual e.g. 0x3005 Cyclic data loss behaviour, or drive parameters arranged in CAN object format - see section 10.2.2 **How to convert parameter numbers to CANopen object references.**

Use the following steps to add ESI specified CANopen objects to the startup list in TwinCAT:

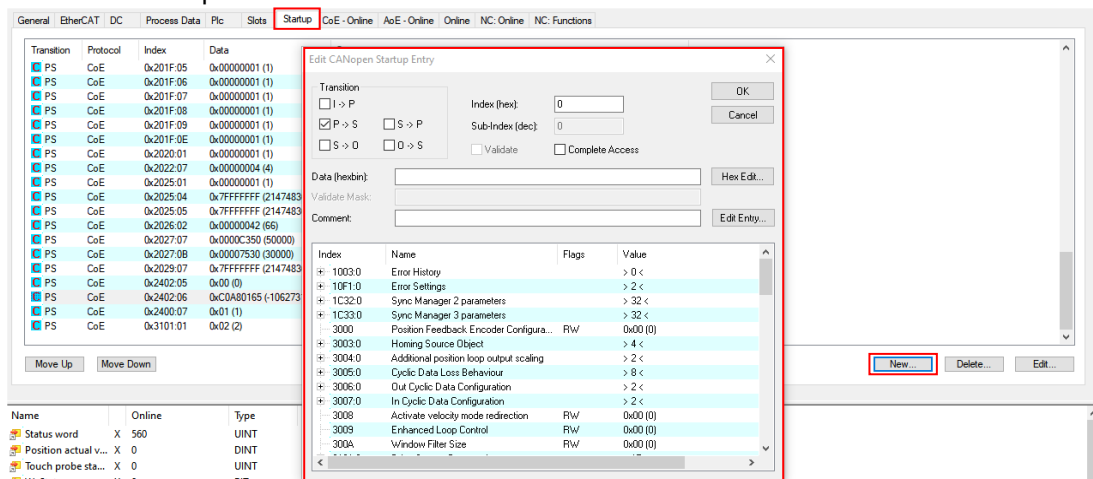
1. Open the TwinCAT project.
2. Make sure config mode is selected as indicated by the blue config button being highlighted. Click the blue Config button if it is not highlighted. Click "OK" on any following pop-up messages.



3. Double click on the drive node in the Solution explorer pane, that the startup list .xml file will be applied to. This opens the properties for the drive node.



4. Select the Startup tab. Then click on "New":



- Select the CANopen object index and subindex to edit from the list. In this example Index 3005 subindex 2 is selected.

Edit CANopen Startup Entry

Transition:
☐ I -> P
☒ P -> S ☐ S -> P
☐ S -> O ☐ O -> S
☐ Validate ☐ Complete Access

Index (hex): 3005
 Sub-Index (dec): 2

Data (hexbin): 02 Hex Edit...
 Validate Mask:
 Comment: Cyclic data loss action Edit Entry...

Index	Name	Flags	Value
1C33:0	Sync Manager 3 parameters		> 32 <
3000	Position Feedback Encoder Configura...	R/W	0x00 (0)
3003:0	Homing Source Object		> 4 <
3004:0	Additional position loop output scaling		> 2 <
3005:0	Cyclic Data Loss Behaviour		> 8 <
3005:01	Time out	R/W	0x0000 (0)
3005:02	Cyclic data loss action	R/W	0x02 (2)
3005:03	CI402 Cyclic Data Missed counter	R/W	0x0000 (0)
3005:04	Re-arm time	R/W	0x000A (10)
3005:05	Max Weighted Internal SM event miss...	R/W	0x0000 (0)
3005:06	Reserved	R/W	0x0000 (0)
3005:07	Max PDO loss duration	R/W	0x0000 (0)
3005:08	Too many PDO counter	R/W	0x0000 (0)

- Double click on the subindex to open the “Set Value Dialog”. Enter the value as either a decimal or hex value. When finished click “OK” in the “Set Value Dialog” and the “Edit CANopen Startup Entry” dialog.

Edit CANopen Startup Entry

Transition:
☐ I -> P
☒ P -> S ☐ S -> P
☐ S -> O ☐ O -> S
☐ Validate ☐ Complete Access

Index (hex): 3005
 Sub-Index (dec): 2




















Data (hexbin): 02 Hex Edit...
 Validate Mask:
 Comment: Cyclic data loss action Edit Entry...

Index	Name	Flags	Value
1C33:0	Sync Manager 3 parameters		> 32 <
3000	Position Feedback Encoder Configura...	R/W	0x00 (0)
3003:0	Homing Source Object		> 4 <
3004:0	Additional position loop output scaling		> 2 <
3005:0	Cyclic Data Loss Behaviour		> 8 <
3005:01	Time out	R/W	0x0000 (0)
3005:02	Cyclic data loss action	R/W	0x02 (2)
3005:03	CI402 Cyclic Data Missed counter	R/W	0x0000 (0)
3005:04	Re-arm time	R/W	0x000A (10)
3005:05	Max Weighted Internal SM event miss...	R/W	0x0000 (0)
3005:06	Reserved	R/W	0x0000 (0)
3005:07	Max PDO loss duration	R/W	0x0000 (0)
3005:08	Too many PDO counter	R/W	0x0000 (0)

Set Value Dialog

Dec: 2 OK
 Hex: 0x02 Cancel
 Float:
 Bool: 0 1 Hex Edit...
 Binary: 02 1
 Bit Size: ☐ 1 ☒ 8 ☐ 16 ☐ 32 ☐ 64 ☐ ?
 New... Delete... Edit...

7. The new entry is added to the startup list.

General	EtherCAT	DC	Process Data	Plc	Slots	Startup	CoE - Online	AoE - Online	Online	NC: Online	NC
Transition	Protocol	Index	Data	Comment							
 PS	CoE	0x201F:06	0x00000001 (1)	Connect Auto-generated: 00.31.006 = 1							
 PS	CoE	0x201F:07	0x00000001 (1)	Connect Auto-generated: 00.31.007 = 1							
 PS	CoE	0x201F:08	0x00000001 (1)	Connect Auto-generated: 00.31.008 = 1							
 PS	CoE	0x201F:09	0x00000001 (1)	Connect Auto-generated: 00.31.009 = 1							
 PS	CoE	0x201F:0E	0x00000001 (1)	Connect Auto-generated: 00.31.014 = 1							
 PS	CoE	0x2020:01	0x00000001 (1)	Connect Auto-generated: 00.32.001 = 1							
 PS	CoE	0x2022:07	0x00000004 (4)	Connect Auto-generated: 00.34.007 = 4							
 PS	CoE	0x2025:01	0x00000001 (1)	Connect Auto-generated: 00.37.001 = 1							
 PS	CoE	0x2025:04	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.37.004 = 2147483647							
 PS	CoE	0x2025:05	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.37.005 = 2147483647							
 PS	CoE	0x2026:02	0x00000042 (66)	Connect Auto-generated: 00.38.002 = 0.066							
 PS	CoE	0x2027:07	0x0000C350 (50000)	Connect Auto-generated: 00.39.007 = 50.000							
 PS	CoE	0x2027:0B	0x00007530 (30000)	Connect Auto-generated: 00.39.011 = 3000.0							
 PS	CoE	0x2029:07	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.41.007 = 2147483647							
 PS	CoE	0x2402:05	0x00 (0)	Connect Auto-generated: 04.2.005 = 0							
 PS	CoE	0x2402:06	0xC0A80165 (-1062731419)	Connect Auto-generated: 04.2.006 = 192.168.1.101							
 PS	CoE	0x2400:07	0x01 (1)	Connect Auto-generated: Reset Option in Slot 4							
 PS	CoE	0x3101:01	0x02 (2)	Connect Auto-generated: End Startup List							
 PS	CoE	0x3005:02	0x02 (2)	Cyclic data loss action							

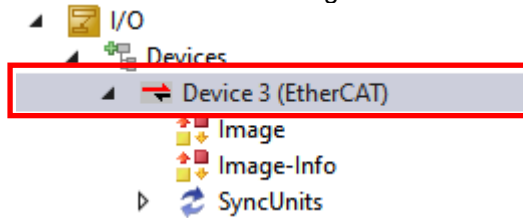
8. Apply the startup list by clicking the “Activate Configuration” button. Click “OK” on any following pop-up messages.



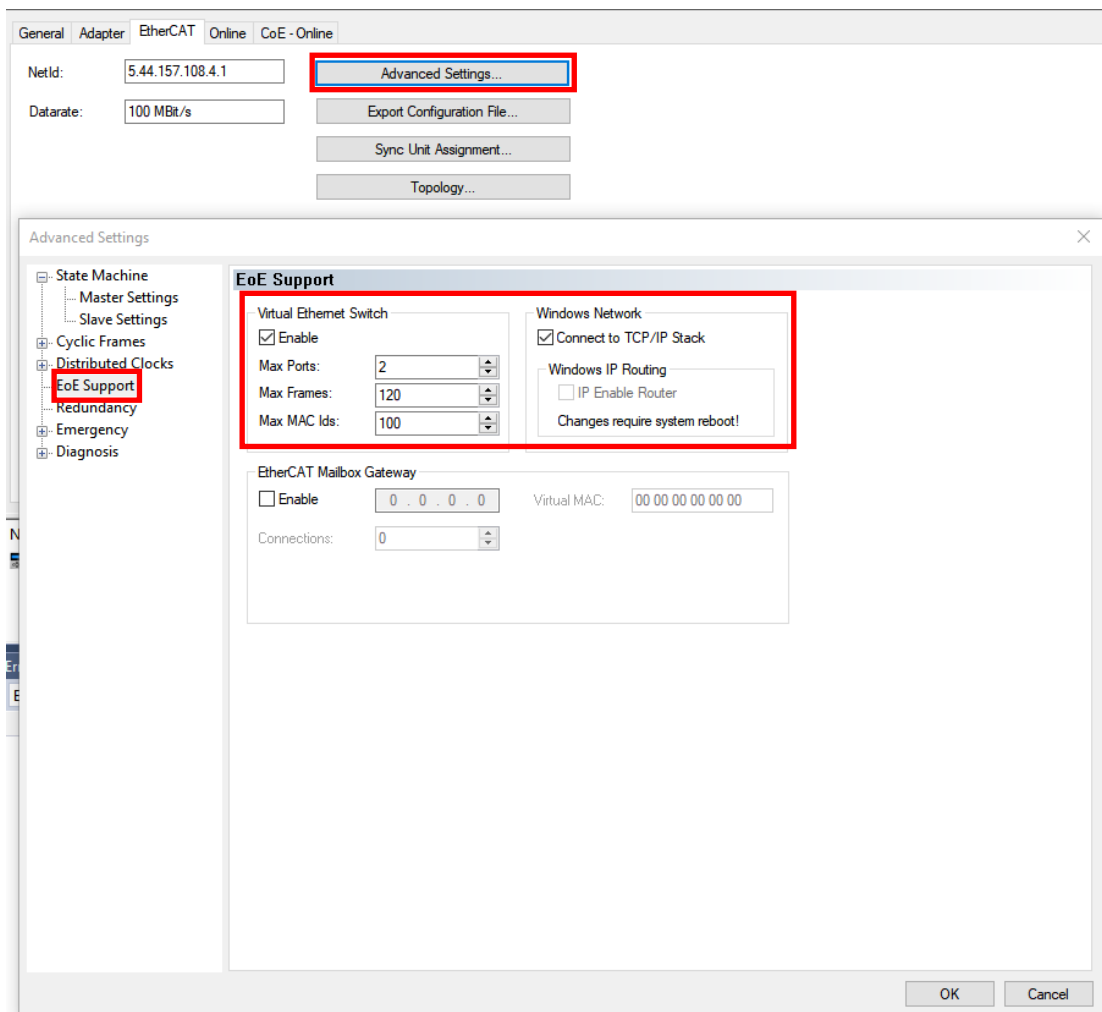
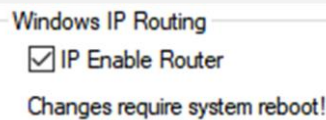
10.9 How to setup an EtherCAT EoE connection

This section details how to establish an EoE (Ethernet Over EtherCAT) connection after the controller and axis has been added to the project as shown by section 3 Initial TwinCAT project setup.

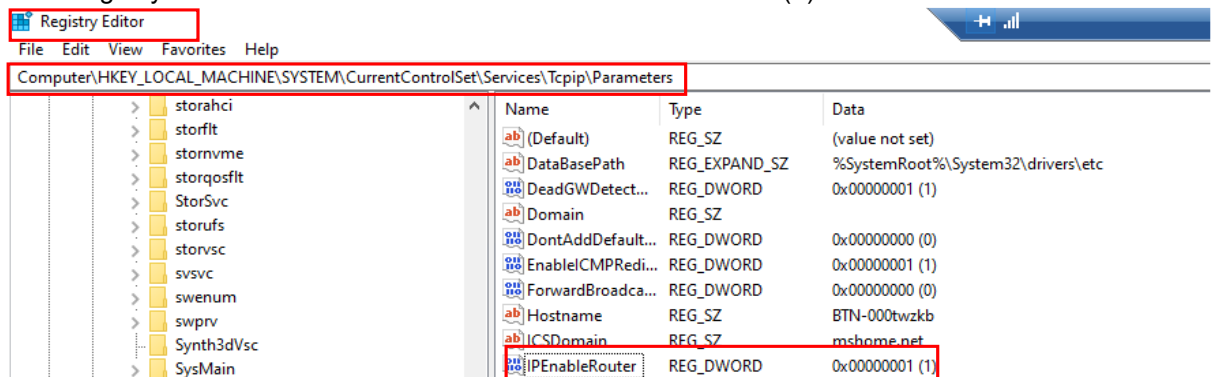
1. Double click on the EtherCAT Device under "I/O" > "Devices", then select the EtherCAT tab, and then "Advanced Settings..."



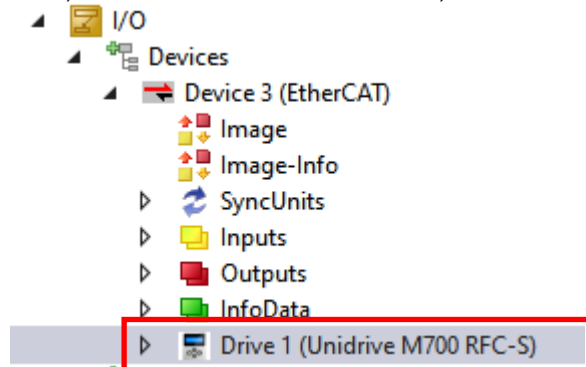
HINT: For IPCs and PLCs, the "Windows IP Routing" checkbox must be checked to allow the IPC to act as a router for the EoE messages.



In the registry for the IPC this sets IPEnableRouter to 0x00000001(1)

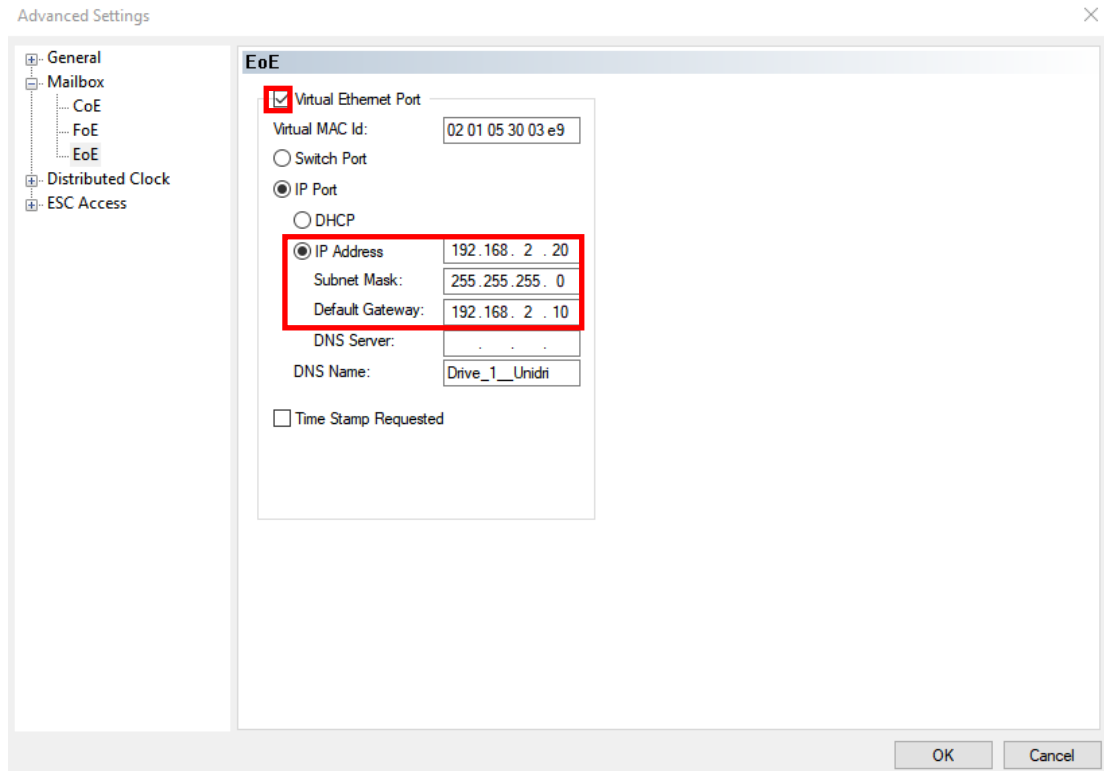


- Next, click on the drive to connect to, "I/O" > "Devices" > "Device (n)" > "Drive(n)":




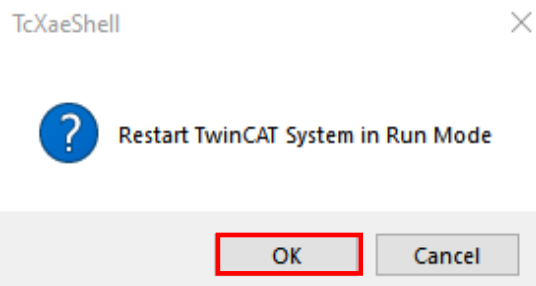
When the device information opens, select the "EtherCAT" tab and then "Advanced Settings..."

- When the “Advanced Settings” tab opens select “Mailbox” > “EoE”:

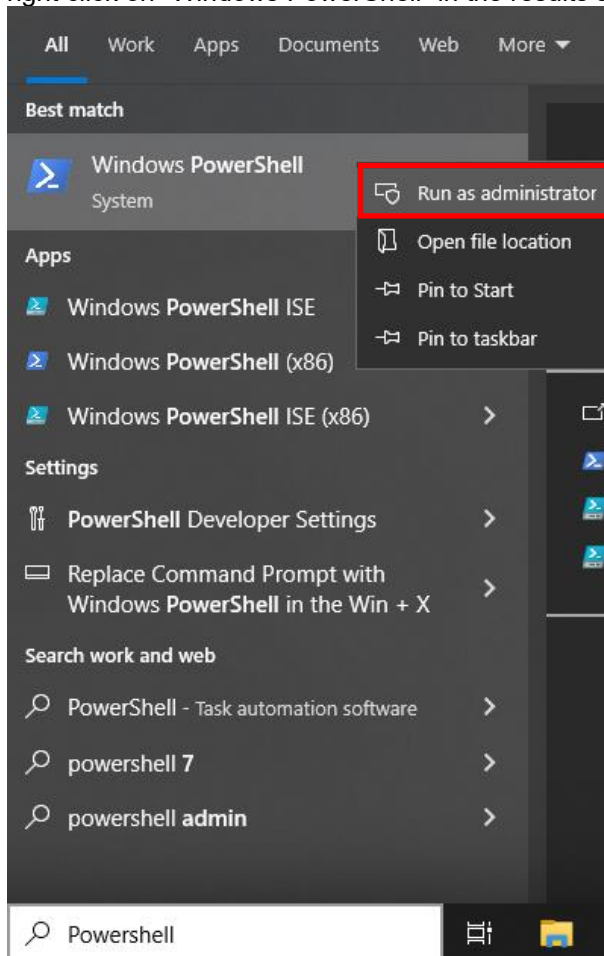


Check the “Virtual Ethernet Port” box, then set the “IP Port” and “IP Address” radio buttons. The “IP Address” is set to the IP address that you would like the drive to have, which must not clash with the PLC’s EtherCAT port IP address, e.g. 192.168.2.20. The subnet mask is set to 255.255.255.0. the Default gateway is set to the IP Address of the port that connects the drive to the PLC e.g. 192.168.2.10. Click “OK” when completed.

- Download the configuration to the PLC by clicking on Activate Configuration .
- Click OK on the “Restart TwinCAT System in Run Mode” dialog.



6. Create a persistent route in the PC to allow access to the EtherCAT Slave drive. Open the command prompt as an administrator by typing in “powershell” in the windows search, then right click on “Windows PowerShell” in the results and select “Run as administrator”.



7. Add the persistent route using the “route” command:

```
Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Windows\system32> route -p add 192.168.2.0 mask 255.255.255.0 192.168.1.10
```

In this example:

- “route -p add” gives a permanent route that will persist even when the power is cycled on the PC.
- “192.168.2.0” allows routing to any IP address in the range of 192.168.2.1 to 192.168.2.255. This is the PLC EtherCAT port address range.
- Subnet mask is “255.255.255.0”
- The gateway is set to the IP address of the Ethernet port on the PLC, used to connect to the PC, in this example the IP address of the PLC's Ethernet port is 192.168.1.10.

8. Use Route print to check the route is now listed:

```
Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\Windows\system32> route -p add 192.168.2.0 mask 255.255.255.0 192.168.1.10
OK!
PS C:\Windows\system32> route print

=====
Persistent Routes:
  Network Address      Netmask  Gateway Address  Metric
      192.168.2.0      255.255.255.0    192.168.1.10      1
=====
```

9. Test the route to the drive using ping, e.g. ping 192.168.2.20:

```
PS C:\Windows\system32> ping 192.168.2.20

Pinging 192.168.2.20 with 32 bytes of data:
Reply from 192.168.2.20: bytes=32 time=28ms TTL=63
Reply from 192.168.2.20: bytes=32 time=15ms TTL=63
Reply from 192.168.2.20: bytes=32 time=13ms TTL=63
Reply from 192.168.2.20: bytes=32 time=16ms TTL=63

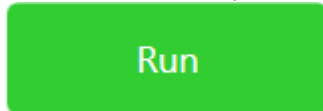
Ping statistics for 192.168.2.20:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 13ms, Maximum = 28ms, Average = 18ms
PS C:\Windows\system32>
```

10. PC tools such as Connect may now be used with the drive using the EoE IP Address e.g. 192.168.2.20.

10.10 How and when to tune the Position Loop

The axis position loop in the drive is activated once the NC axis is powered on, where:

- The drive is enabled by applying 24V to the STO terminal.
- The drive is healthy i.e. no trips.
- MC_Power has been used, successfully, to power on the axis.
- If a keypad is fitted, the display indicates “Run”.
- If Connect is online, the status in the bottom left shows “Run”.

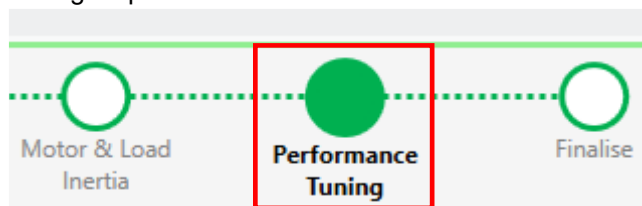


The position loop should be tuned when the application software is written, and the machine is running with the worst-case production motion profile, i.e. the most dynamic motion profile coupled with the highest load that will be experienced by the system while running.

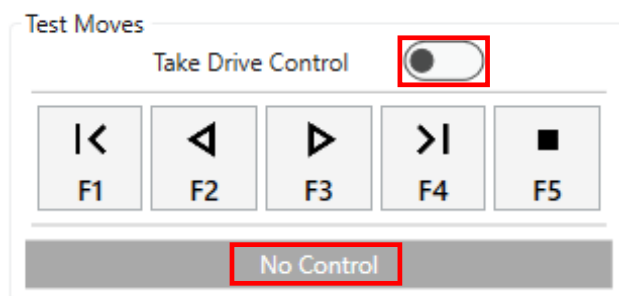
In many cases the default position loop p gain of 25.00 will give reasonable performance, but in cases where there are tight tolerances, the position loop performance can be increased to suit the requirement.

Before attempting to tune the position loop the speed loop must be tuned first as described in section **6 Commission the drive and motor using Connect**.

With the machine running its worst-case motion profile, open Connect and go to the Performance Tuning step



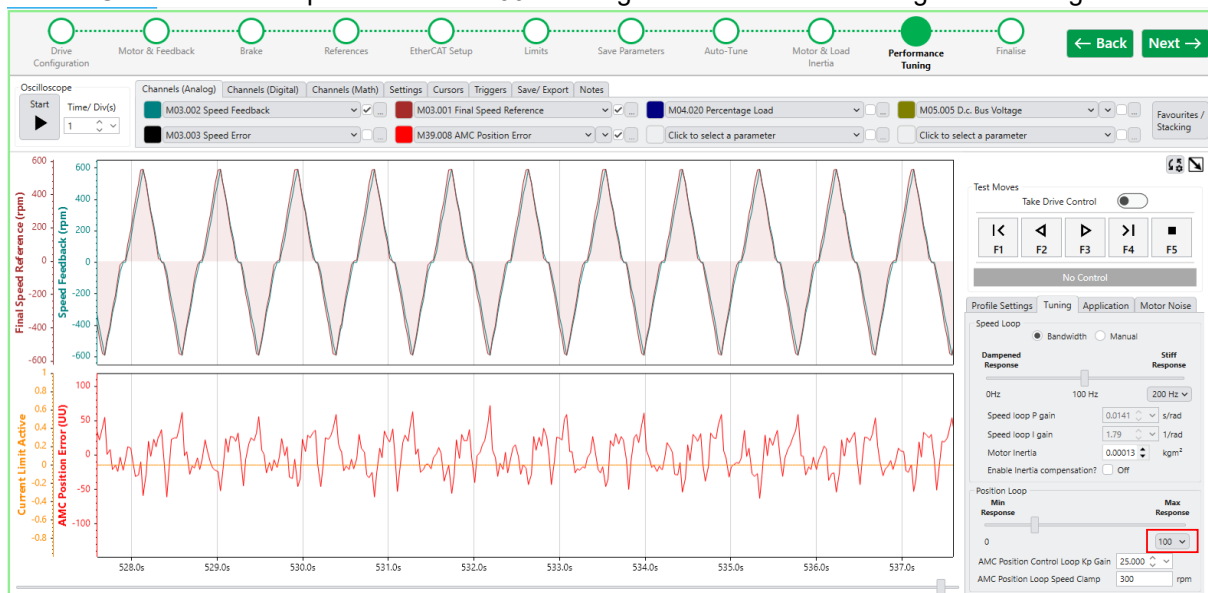
Don't enable the test move control. The test moves status must say “No Control” to leave the application software in control of the drive and therefore the drive position loop active, ready for tuning.



Move the position loop p gain slider to optimise the tuning and observe the red AMC Position Loop Error trace. Move the slider to the right to increase the position loop gain and increase the response. The smaller the peak values the better the tuning is.



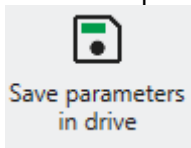
If the P Gain needs to be pushed above 100 the range can be increased using the following control:



Care must be taken when increasing the gain as it is possible to increase the gain until the system stability limit is reached and the axis motor will make additional noise or worst case oscillate. Small steps are recommended when tuning.

If the tuning has reached the best possible position error and axis noise compromise, it is possible to reduce the error further by adding Jerk to the motion profile if one has not already been used. Even very high Jerk values can make a big difference to the peak position following error values when beginning and ending acceleration or deceleration.

When the optimal value has been reached save the parameters in the drive.



10.11 How and when to use inertia compensation

Inertia compensation, as the name suggests should only be used when there is significant load inertia and / or large acceleration rates. If the inertia is low or the acceleration rates are also low then this feature will not benefit the performance of the axis and is best not used.

Inertia compensation engages a Torque Feedforward term in the drive which, assuming the motor and load inertia has been measured correctly, applies a torque reference to the drive in proportion to the motion profile acceleration output and the inertia value. This helps reduce speed loop following error during acceleration and deceleration, at the cost of slightly increased motor noise.

Before using this feature the speed and position loops must be tuned first as described in sections **6 Commission the drive and motor using Connect** and **10.10 How and when to tune the Position Loop**.

To use the inertia compensation check the Enable inertia compensation checkbox on the Performance Tuning step of the guided setup.

The screenshot shows the 'Performance Tuning' step of a guided setup. It has four tabs: 'Profile Settings', 'Tuning', 'Application', and 'Motor Noise'. The 'Tuning' tab is active. Under the 'Speed Loop' section, there are two radio buttons: 'Bandwidth' (selected) and 'Manual'. Below these are two sliders: 'Dampened Response' (ranging from 0 Hz to 100 Hz) and 'Stiff Response' (ranging from 100 Hz to 200 Hz). The '200 Hz' value is selected for the Stiff Response. Below the sliders are three input fields: 'Speed loop P gain' (0.0141 s/rad), 'Speed loop I gain' (1.79 1/rad), and 'Motor Inertia' (0.00013 kgm²). At the bottom of the Speed Loop section, the 'Enable Inertia compensation?' checkbox is checked and highlighted with a red box. Below the Speed Loop section is the 'Position Loop' section, which has a 'Min Response' slider (0 to 100) and a 'Max Response' dropdown (100). Below these are two input fields: 'AMC Position Control Loop Kp Gain' (100.000) and 'AMC Position Loop Speed Clamp' (300 rpm).

If motor noise induced by the inertia compensation term must be reduced, or the amount of inertia compensation must be increased to further improve the following error, select manual speed loop tuning to disconnect the inertia value from the speed loop gain setting. Then decrease the inertia value to reduce motor noise or increase the inertia to increase the output of the inertia compensation.

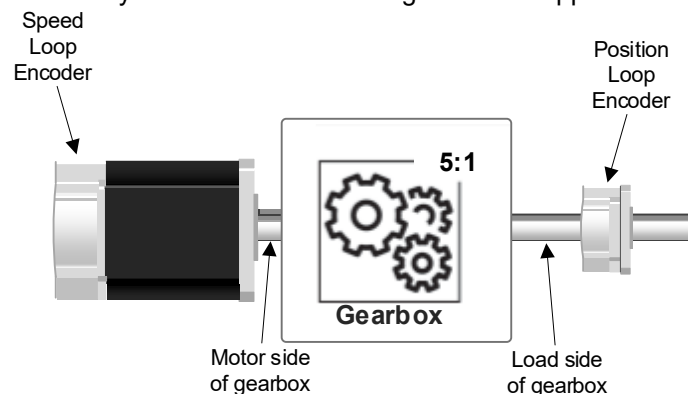
Before modifying the “Motor Inertia” make a note of the original value so it can be restored later if required.

The screenshot shows the 'Motor Noise' tab in a software configuration window. Under the 'Speed Loop' section, the 'Manual' radio button is selected and highlighted with a red box. Below this, there is a slider for 'Dampened Response' (0 Hz to 100 Hz) and a dropdown for 'Stiff Response' (200 Hz). The 'Speed loop P gain' is set to 0.0141 s/rad, and the 'Speed loop I gain' is set to 1.79 1/rad. The 'Motor Inertia' is set to 0.00032 kgm² and is highlighted with a red box. The 'Enable Inertia compensation?' checkbox is checked and labeled 'On'. The 'Position Loop' section below shows a 'Min Response' slider (0 to 100) and a 'Max Response' dropdown (100). The 'AMC Position Control Loop Kp Gain' is set to 100.000, and the 'AMC Position Loop Speed Clamp' is set to 300 rpm.

HINT: If the Inertia has been modified to tune the output of the Inertia Compensation feature, and Bandwidth mode tuning is later required, the inertia must be restored to its original value before selecting bandwidth mode, otherwise the speed loop gains may be calculated incorrectly.

10.12 How to set up a dual loop system

This section describes how to configure a dual loop system where the position loop is closed using an encoder attached directly to the load side of the gearbox as opposed to the motor side.



This type of system compensates for any backlash or torsional effects in the gearbox, resulting in a greater level of positioning accuracy at the load.

For this example, it is assumed that the motor encoder is connected the drives P1 interface, whilst the position feedback encoder will be connected to the drives P2 interface. Therefore, we need to configure the following CANopen over EtherCAT (CoE) objects:

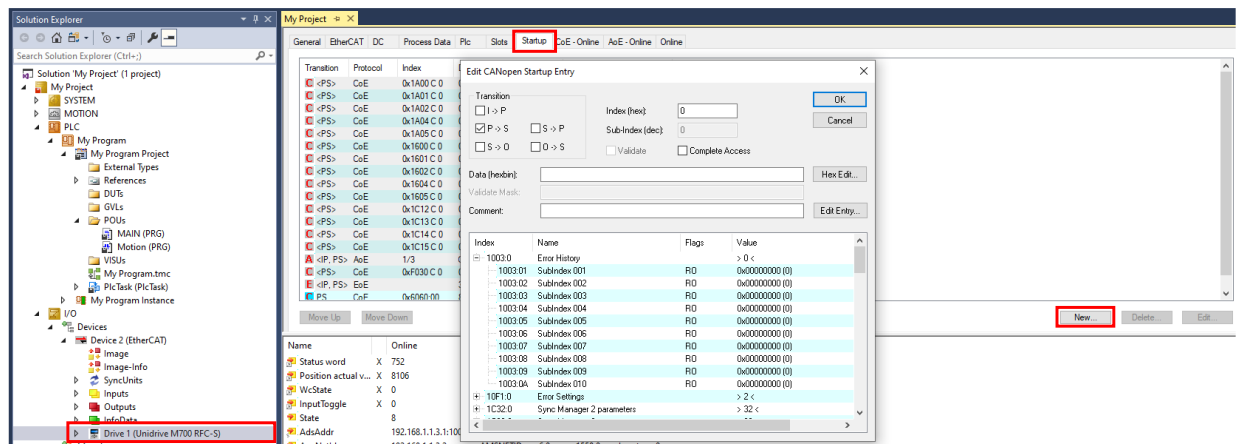
- Index: 0x3000, Sub Index: 0 – Position Feedback Encoder Configuration.
- Index: 0x3004, Sub Index: 1 – Additional Position Loop Output Scaling Numerator.
- Index: 0x3004, Sub Index: 2 – Additional Position Loop Output Scaling Denominator.

The following steps will describe how to cause the configuration of these CoE objects to happen when the PLC / IPC / Controller is first powered on.

1. Follow the relevant steps outlined in section **7 TwinCAT Axis Configuration** to configure a TwinCAT project, an EtherCAT network configured with a single Control Techniques drive.
2. Ensure config mode is selected as indicated by the blue config button being highlighted. Click the blue Config button if it is not highlighted.

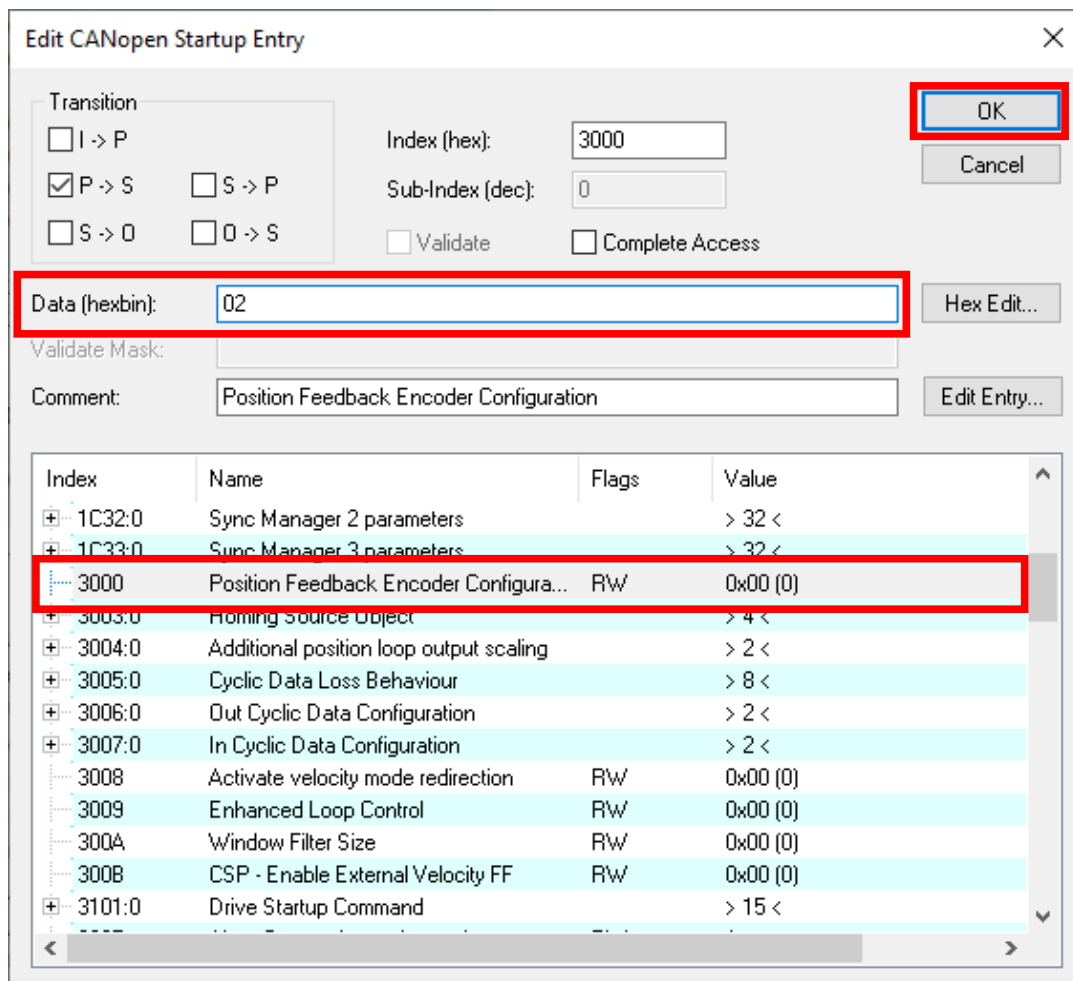


- From the project tree, double click on "Drive1" and select the "Startup" tab followed by the "New..." button:



- The "Edit CANopen Startup Entry" dialog will be displayed.

From the list of available mappings, select "3000 Position Feedback Encoder Configuration", enter "02" into the Data field and click "OK".



HINT: The value of 2 corresponds to the drives P2 Interface which is being used as the position interface in this example. Other interfaces can be selected using the values in the list below.

This list is an extract from Section 6.3.5 Feedback encoder source taken from the SI-EtherCAT User Guide.

6.3.5 Feedback encoder source

Table 6-36 Feedback encoder source

0x3000 Position Feedback Encoder Configuration			
Access: RW	Range: 0 to 11	Size: 1 byte	Unit: N/A
Default: 0	Type: Unsigned Integer / USINT		
PDO Mappable: No	Update Rate: On change of CiA402 profile		
Description:	This specifies the source for position controller feedback, and the source for CiA402 position feedback objects.		

The source will have a value as follows:


















0 – The feedback source for the position controller will match the drive motor control feedback source (see below for details).

- 1 – Drive feedback source, P1 interface.
- 2 – Drive feedback source, P2 interface.
- 3 – Slot 1 position feedback module, P1 interface.
- 4 – Slot 1 position feedback module, P2 interface.
- 5 – Slot 2 position feedback module, P1 interface.
- 6 – Slot 2 position feedback module, P2 interface.
- 7 – Slot 3 position feedback module, P1 interface.
- 8 – Slot 3 position feedback module, P2 interface.
- 11 – Sensorless (the sensorless algorithm estimates position feedback).

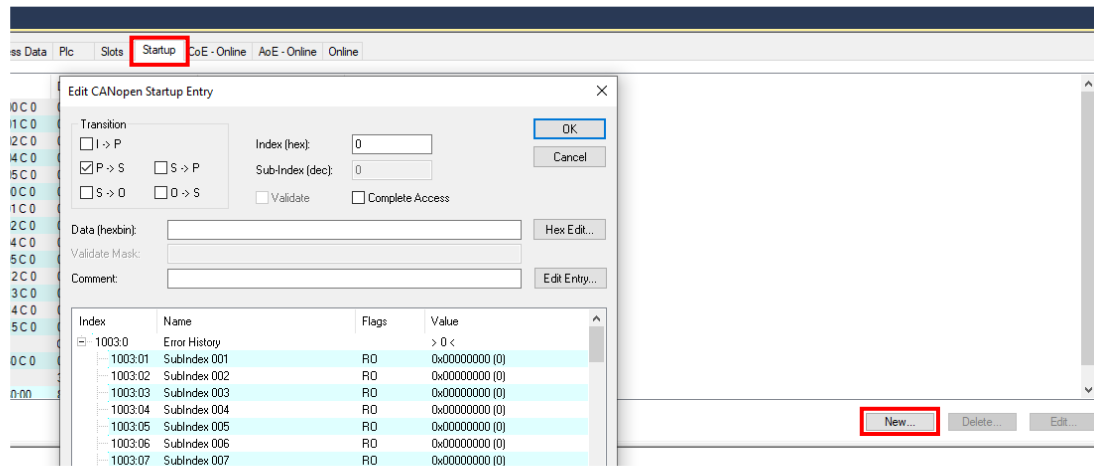
This value will be ignored on drives where no encoder input is present.

This object will be read upon a transition from the EtherCAT Pre-operational state to the Safe operational state.

5. The new entry will now appear in the “Startup Parameters” list.

My Project				
My Project CAT DC Process Data Plc Slots Startup CoE - Online AoE - Online Online				
Transition	Protocol	Index	Data	Comment
 <PS>	CoE	0x1A02 C 0	02 00 10 00 41 60 20 00 6...	download pdo 0x1A02 entries
 <PS>	CoE	0x1A04 C 0	02 00 10 00 41 60 10 00 7...	download pdo 0x1A04 entries
 <PS>	CoE	0x1A05 C 0	00 00	download pdo 0x1A05 entries
 <PS>	CoE	0x1600 C 0	02 00 10 00 40 60 10 00 4...	download pdo 0x1600 entries
 <PS>	CoE	0x1601 C 0	02 00 10 00 40 60 08 00 6...	download pdo 0x1601 entries
 <PS>	CoE	0x1602 C 0	03 00 10 00 40 60 20 00 7...	download pdo 0x1602 entries
 <PS>	CoE	0x1604 C 0	02 00 10 00 40 60 10 00 7...	download pdo 0x1604 entries
 <PS>	CoE	0x1605 C 0	00 00	download pdo 0x1605 entries
 <PS>	CoE	0x1C12 C 0	01 00 02 16	download pdo 0x1C12 index
 <PS>	CoE	0x1C13 C 0	01 00 02 1A	download pdo 0x1C13 index
 <PS>	CoE	0x1C14 C 0	00 00	download pdo 0x1C14 index
 <PS>	CoE	0x1C15 C 0	00 00	download pdo 0x1C15 index
 <IP, PS>	AoE	1/3	C0 A8 01 01 03 02	AoE Init Cmd (download NetId)
 <PS>	CoE	0xF030 C 0	00 00	download slot cfg
 <IP, PS>	EoE		3F 00 00 00 02 01 05 20 0...	ee init
 PS	CoE	0x6060:00	8	
 PS	CoE	0x3000:00	0x02 (2)	Position Feedback Encoder Configuration

6. From the “Startup” view, select the “New...” button.



7. The “Edit CANopen Startup Entry” dialog will be displayed.

From the list of available mappings, select “3004 Scaling Numerator”.

The value of the numerator will represent the number of motor revolutions required to achieve the distance of the denominator.

For example, if a motor is coupled to a 5:1 gearbox and no other gearing is used in the system, the value of 5 should be entered into the numerator “Value” field.

Enter the numerator into the value field and click “OK”.

Transition:
☐ I -> P
☒ P -> S
☐ S -> O
☐ S -> P
☐ O -> S

Index (hex): 3004
Sub-Index (dec): 1
☐ Validate
☐ Complete Access

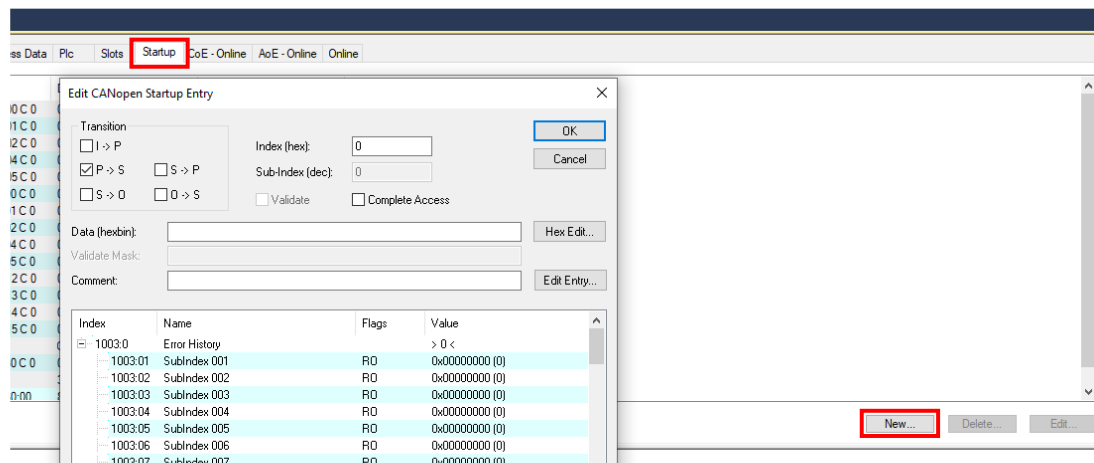
Data (hexbin): 05 00 00 00
Hex Edit...

Validate Mask:
Comment: Scaling Numerator
Edit Entry...

Index	Name	Flags	Value
3003:0	Homing Source Object		> 4 <
3004:0	Additional position loop output scaling		> 2 <
3004:01	Scaling Numerator	RW	0x00000001 (1)
3004:02	Scaling Denominator	RW	0x00000001 (1)
3005:0	Cyclic Data Loss Behaviour		> 8 <
3006:0	Out Cyclic Data Configuration		> 2 <
3007:0	In Cyclic Data Configuration		> 2 <
3008	Activate velocity mode redirection	RW	0x00 (0)
3009	Enhanced Loop Control	RW	0x00 (0)
300A	Window Filter Size	RW	0x00 (0)
300B	CSP - Enable External Velocity FF	RW	0x00 (0)
3101:0	Drive Startup Command		> 15 <
6007	Abort Connection option code	RW	1

HINT: The values specified in the “Data (hexbin)” are in the hex format, e.g. hex 14 = decimal 20 etc.

8. From the “Startup Parameters” view, select the “New...” button.



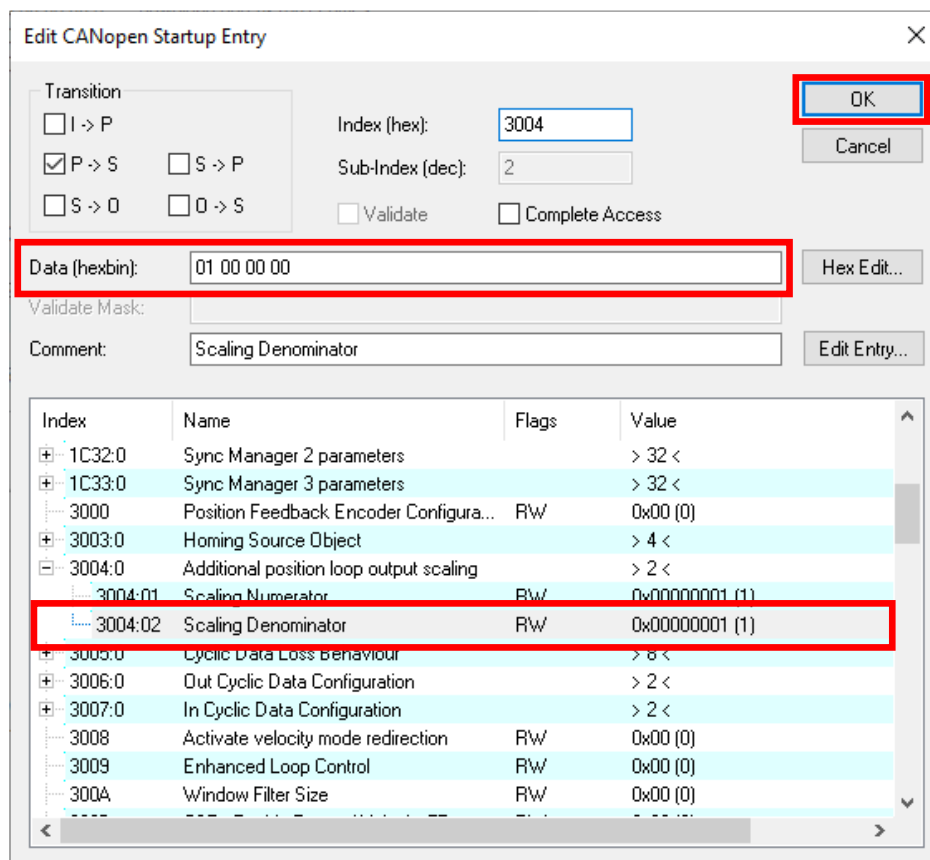
9. The “Edit CANopen Startup Entry” dialog will be displayed.

From the list of available mappings, select “3004 Scaling Denominator”.

The value of the denominator will represent the revolutions achieved per number of motor revolutions as specified by the numerator.

For example, if a motor is coupled to a 5:1 gearbox and no other gearing is used in the system, the value of 1 should be entered into the denominator “Value” field.

Enter the numerator into the value field and click “OK”.



10. The Scaling Numerator, Scaling Denominator and Position Feedback Encoder Configuration mappings will now be present in the "Startup" list which means their values will be written to the specified CoE objects on startup of the PLC / IPC / Controller. A drive configured in this way will use the P2 interface for position control for any NC axis associated with this drive.

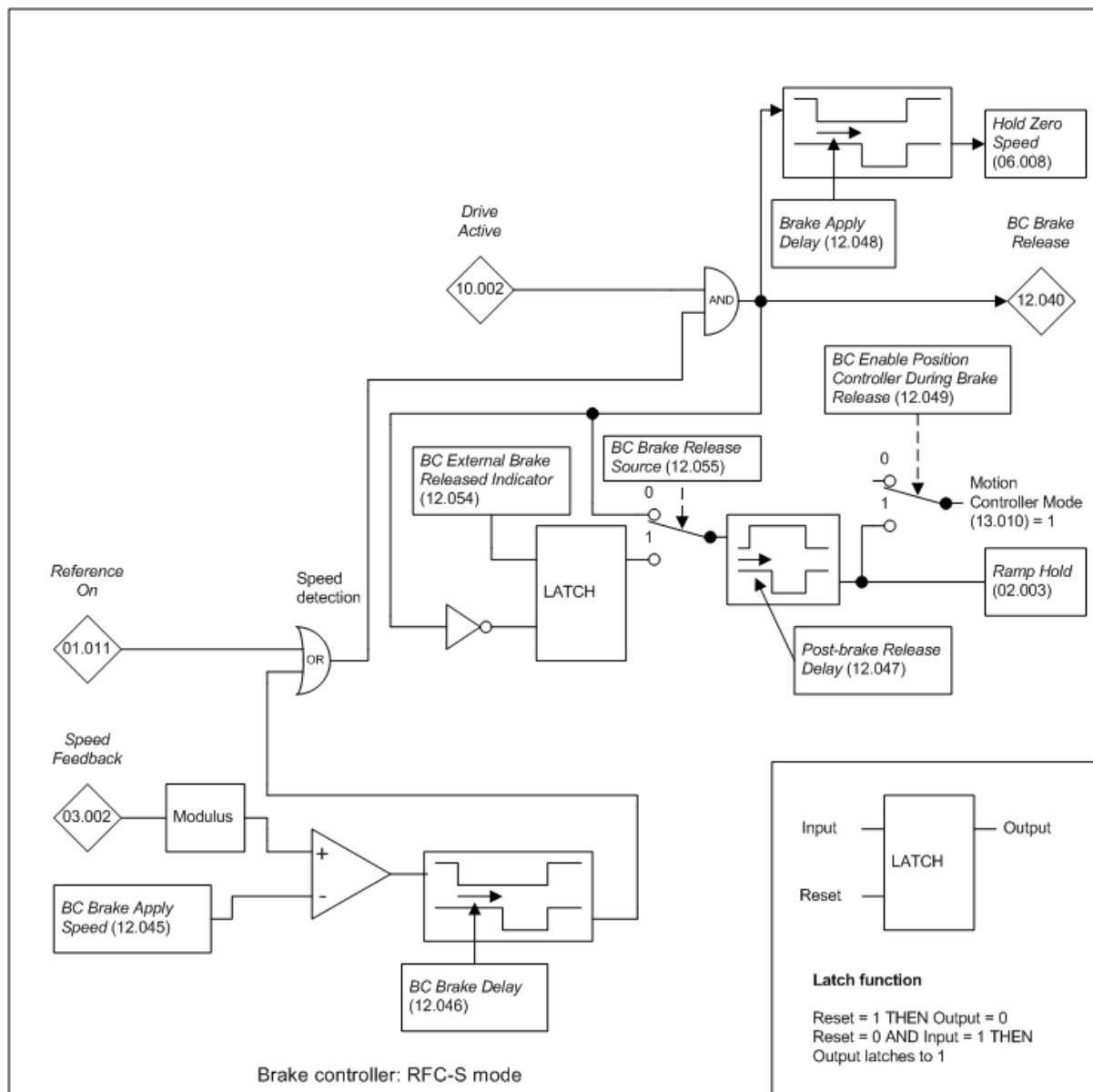
My Project - X				
General EtherCAT DC Process Data Plc Slots Startup CoE - Online AoE - Online Online				
Transition	Protocol	Index	Data	Comment
C <PS>	CoE	0x1A05 C 0	00 00	download pdo 0x1A05 entries
C <PS>	CoE	0x1600 C 0	02 00 10 00 40 60 10 00 4...	download pdo 0x1600 entries
C <PS>	CoE	0x1601 C 0	02 00 10 00 40 60 08 00 6...	download pdo 0x1601 entries
C <PS>	CoE	0x1602 C 0	03 00 10 00 40 60 20 00 7...	download pdo 0x1602 entries
C <PS>	CoE	0x1604 C 0	02 00 10 00 40 60 10 00 7...	download pdo 0x1604 entries
C <PS>	CoE	0x1605 C 0	00 00	download pdo 0x1605 entries
C <PS>	CoE	0x1C12 C 0	01 00 02 16	download pdo 0x1C12 index
C <PS>	CoE	0x1C13 C 0	01 00 02 1A	download pdo 0x1C13 index
C <PS>	CoE	0x1C14 C 0	00 00	download pdo 0x1C14 index
C <PS>	CoE	0x1C15 C 0	00 00	download pdo 0x1C15 index
A <IP, PS>	AoE	1/3	C0 A8 01 01 03 02	AoE Init Cmd (download NetId)
C <PS>	CoE	0xF030 C 0	00 00	download slot cfg
E <IP, PS>	CoE		3F 00 00 00 02 01 05 20 0...	coe init
C PS	CoE	0x6060:00	8	
C PS	CoE	0x3000:00	0x02 (2)	Position Feedback Encoder Configuration
C PS	CoE	0x3004:01	0x00000005 (5)	Scaling Numerator
C PS	CoE	0x3004:02	0x00000001 (1)	Scaling Denominator

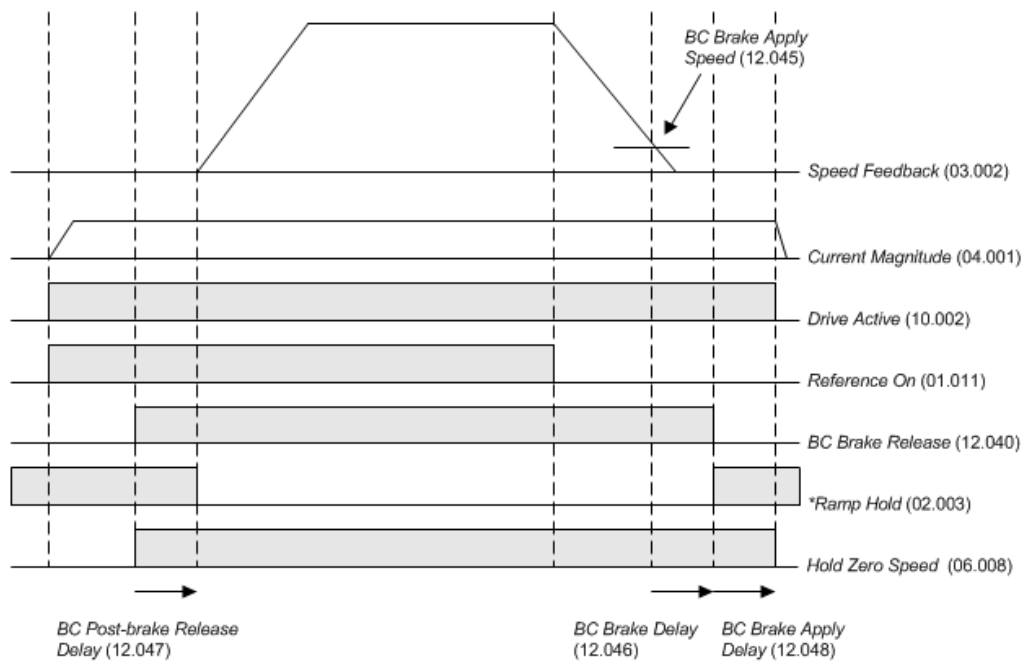
11 Additional information

11.1 Mechanical brake controller logic

11.1.1 RFC-S closed-loop permanent-magnet motor brake controller

This section indicates the logic and timing diagrams for the brake controller in RFC-S mode for closed-loop permanent-magnet motors to help illustrate the functionality and timing.



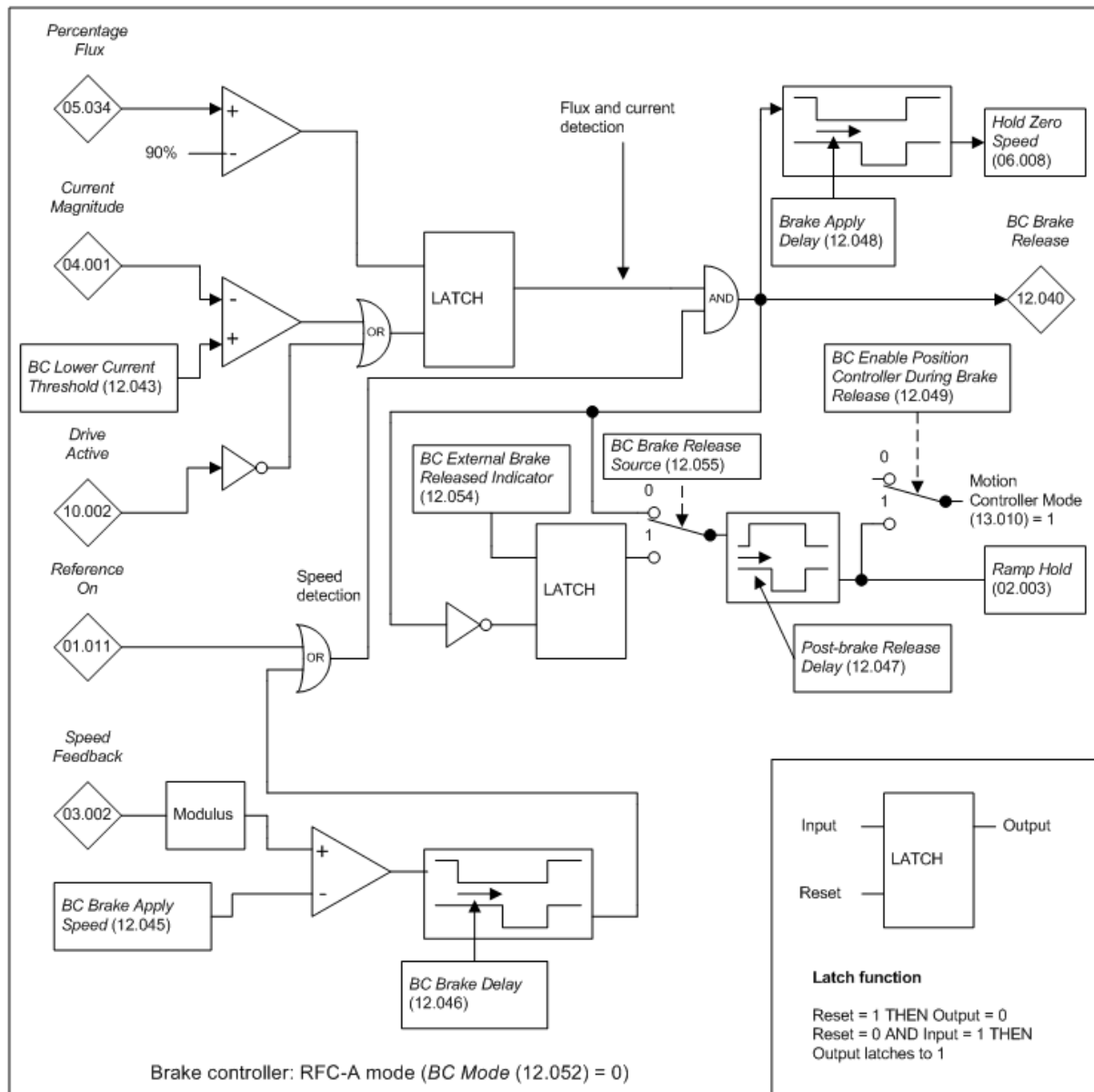


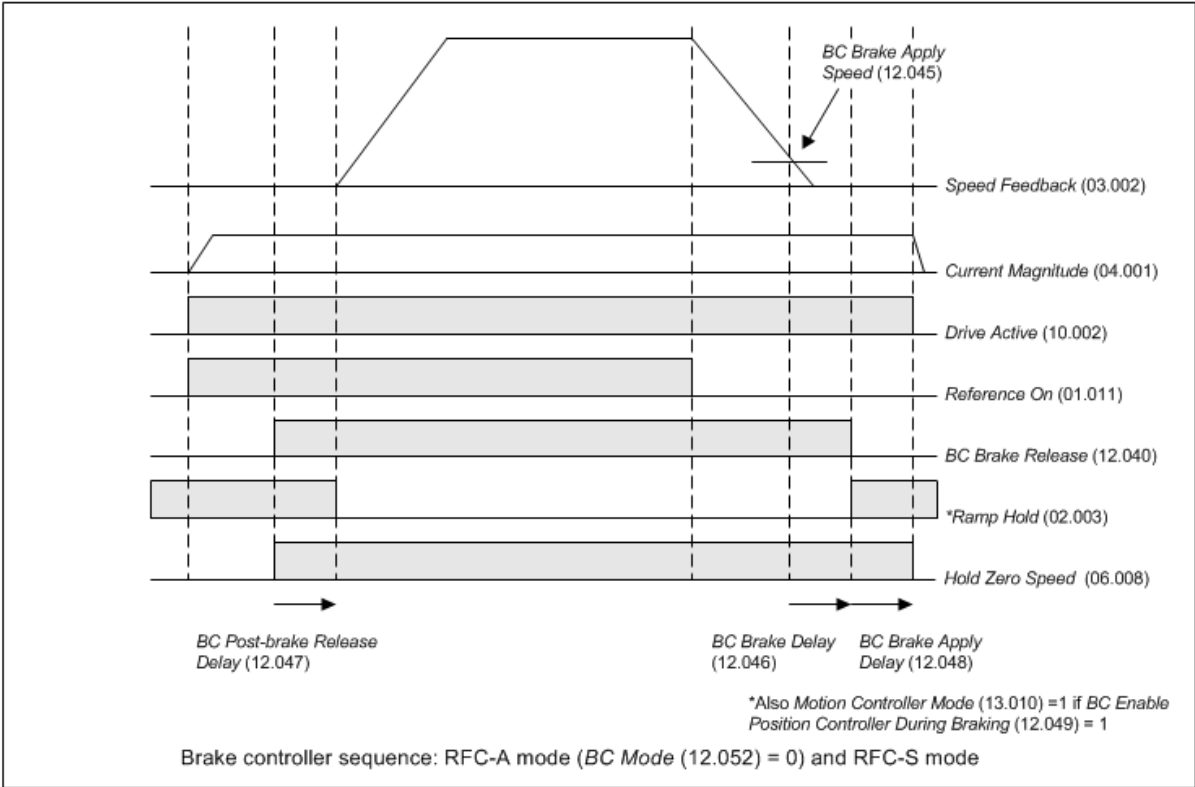
*Also Motion Controller Mode (13.010) = 1 if BC Enable Position Controller During Braking (12.049) = 1

Brake controller sequence: RFC-A mode (BC Mode (12.052) = 0) and RFC-S mode

11.1.2 RFC-A closed-loop induction motor brake controller

This section indicates the logic and timing diagrams for the brake controller in RFC-A mode for closed-loop induction motors to help illustrate the functionality and timing.







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