Getting Started

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

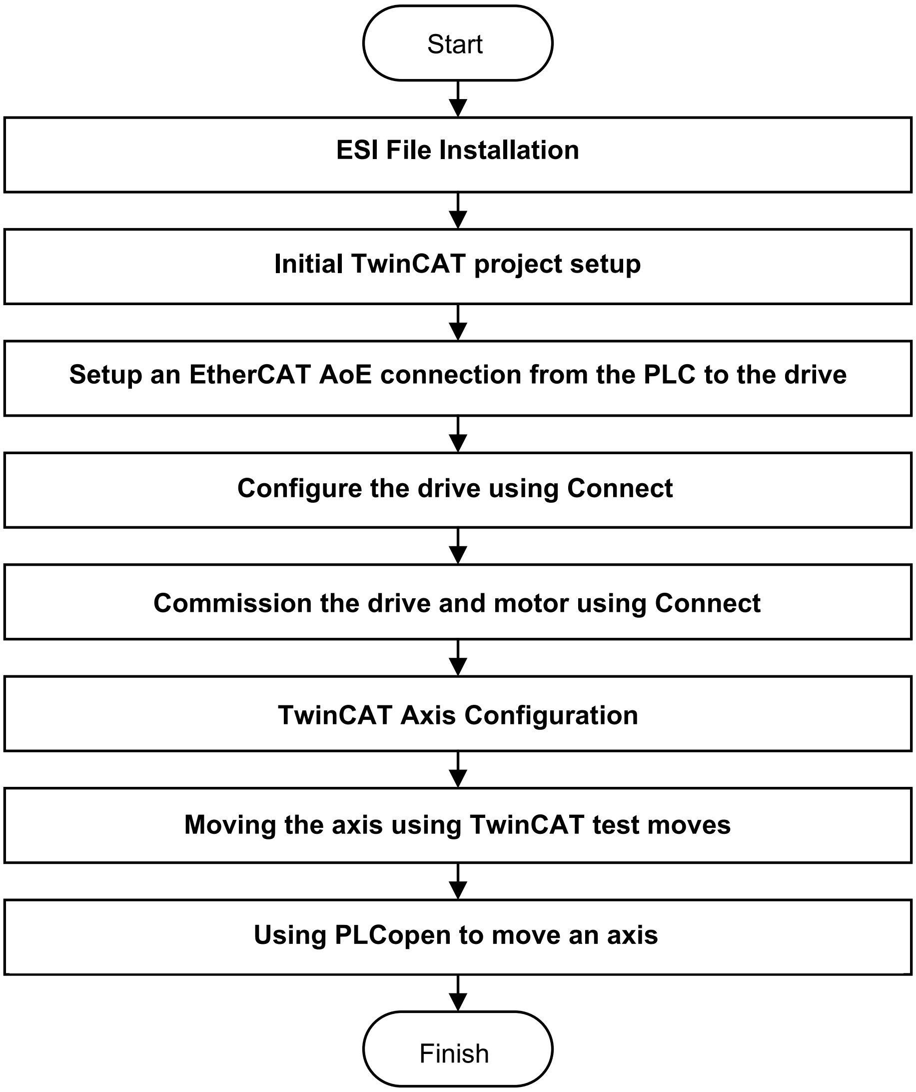
Issue 7

Contents

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**.

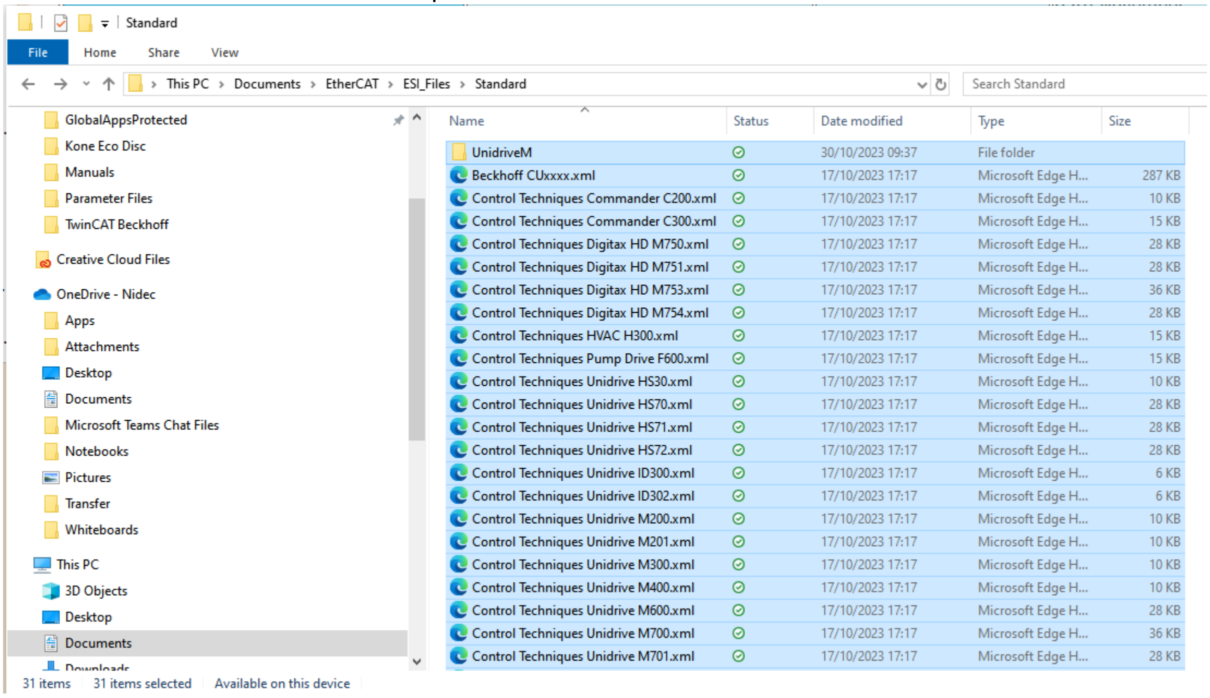
> **HINT:** The information in this manual is backed up by training videos on YouTube.
>
> Nidec Drives Support - YouTube

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.

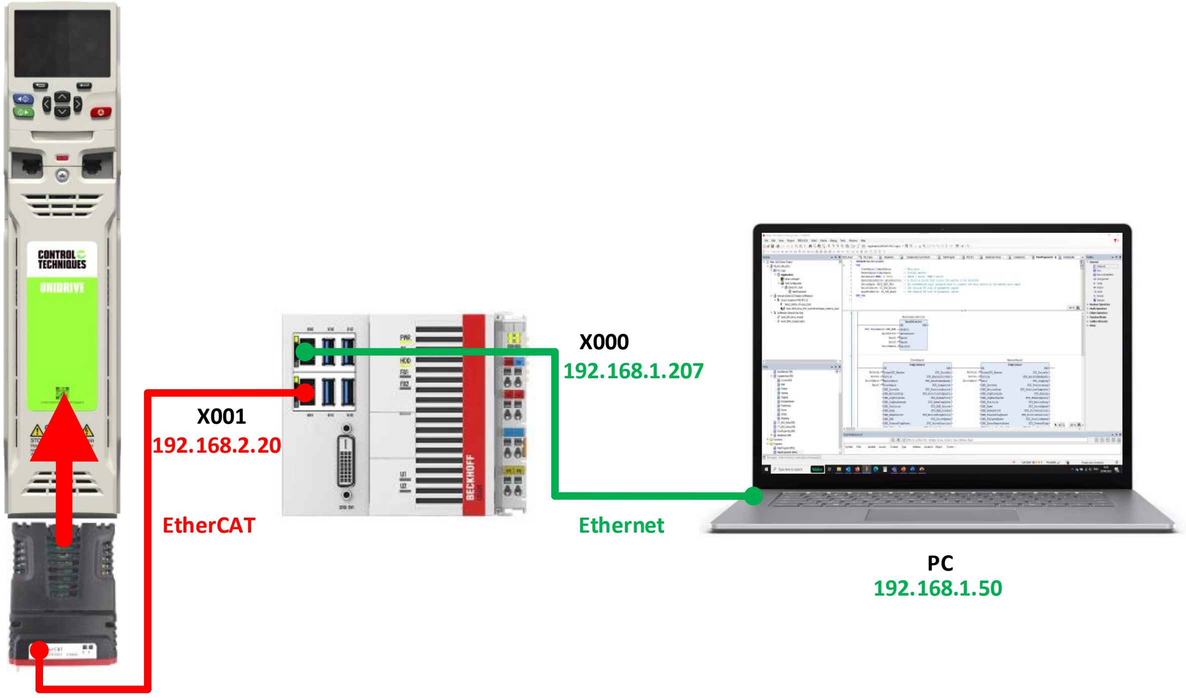
3 Initial TwinCAT project setup

To allow Connect to communicate to the slave drives in the EtherCAT network, an AoE (ADS over EtherCAT) connection must be configured.

Before continuing, an Ethernet cable should be connected between the Ethernet port of the programming PC and the Ethernet port of the PLC / IPC / Controller (X000 in the diagram below).

A second Ethernet cable should be connected between the EtherCAT port of the PLC / IPC / Controller (X001 in the diagram below) and the EtherCAT post of the Control Techniques Drive / SI-EtherCAT module in use.

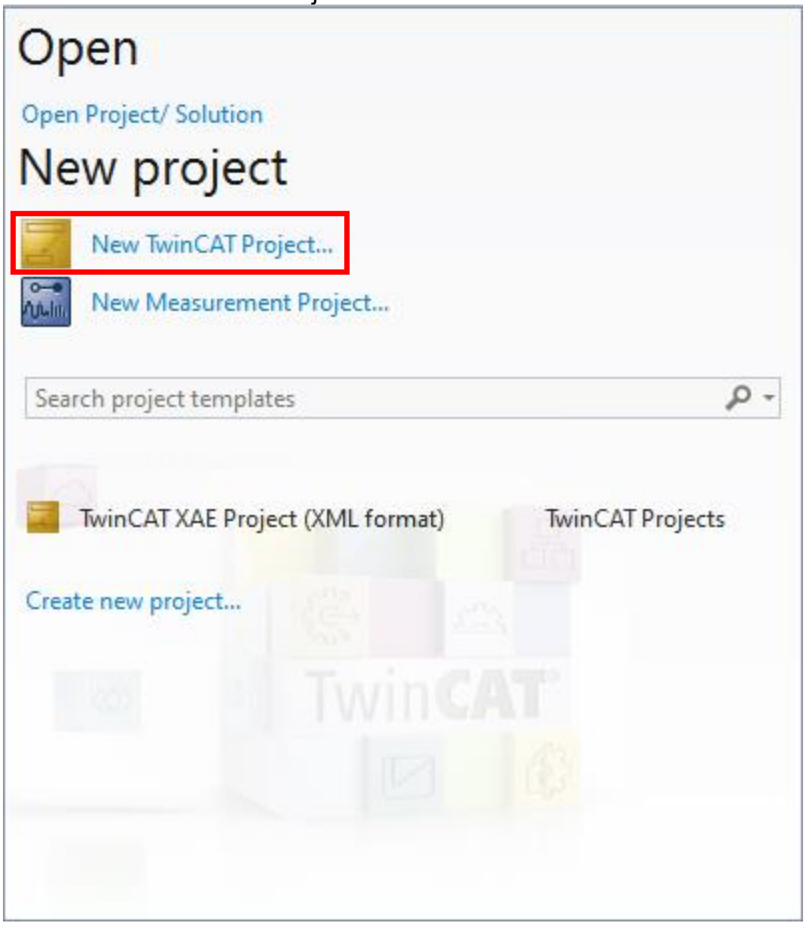
It is assumed that the Ethernet addresses of the programming PC and PLC / IPC / Controller are in the same range e.g.192.168.1.x.



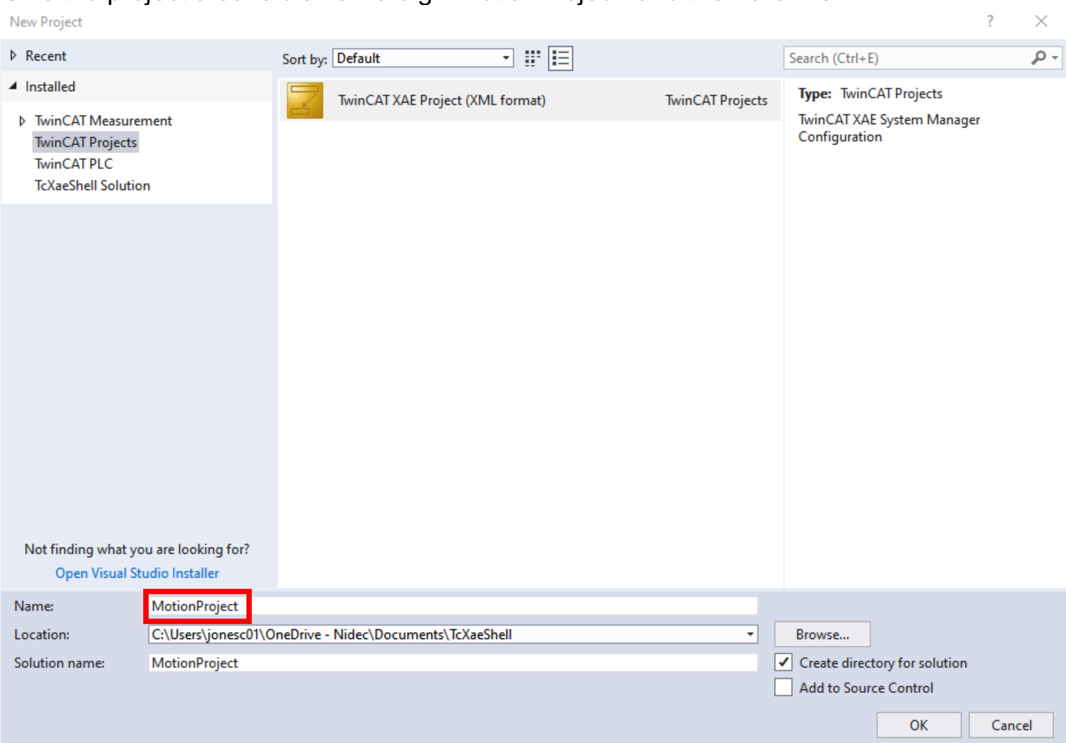
This section shows the first steps required to get connected to a Beckhoff PLC/IPC.

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.

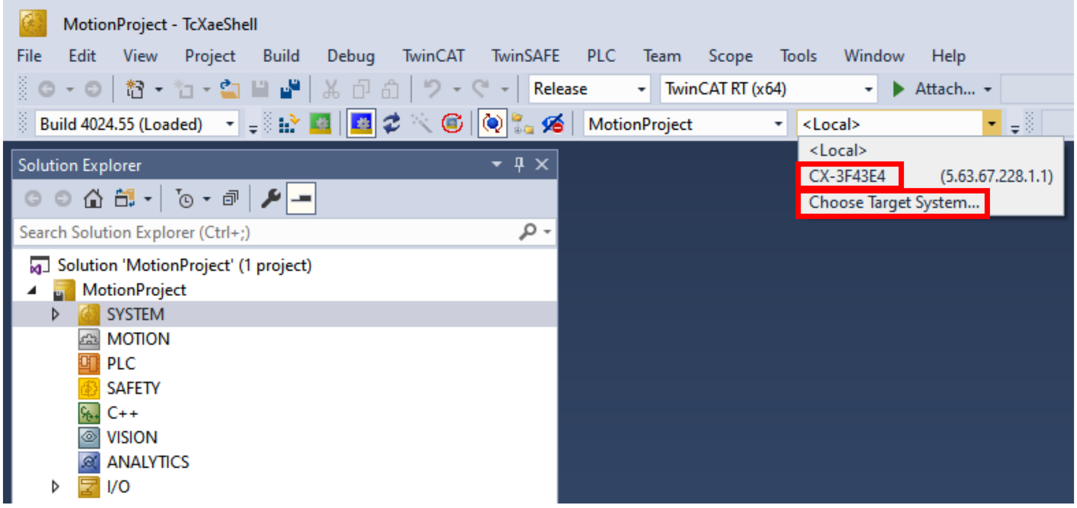
2. Select “New TwinCAT Project”:



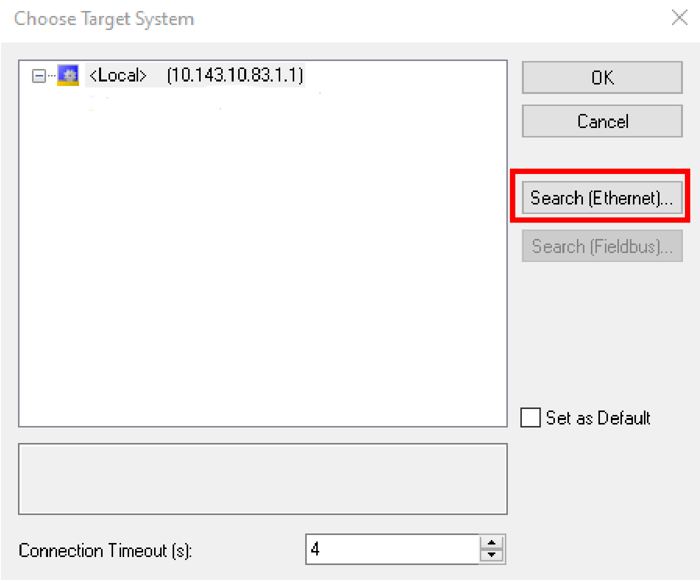
3. Give the project a sensible name e.g. “MotionProject” and then click “OK”.



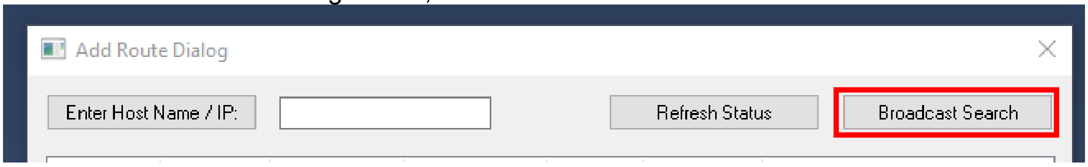
4. Select the target PLC. If your PLC has previously been connected to a TwinCAT project, then the ADS Address of the PLC is shown.



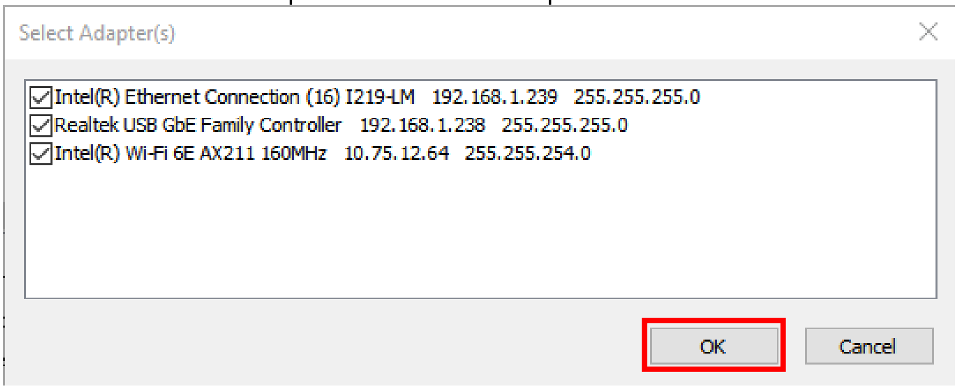
If the PLC hasn't previously been connected to a TwinCAT project, then select "Choose Target System…" and then "Search (Ethernet)" from the "Choose Target System" dialog.



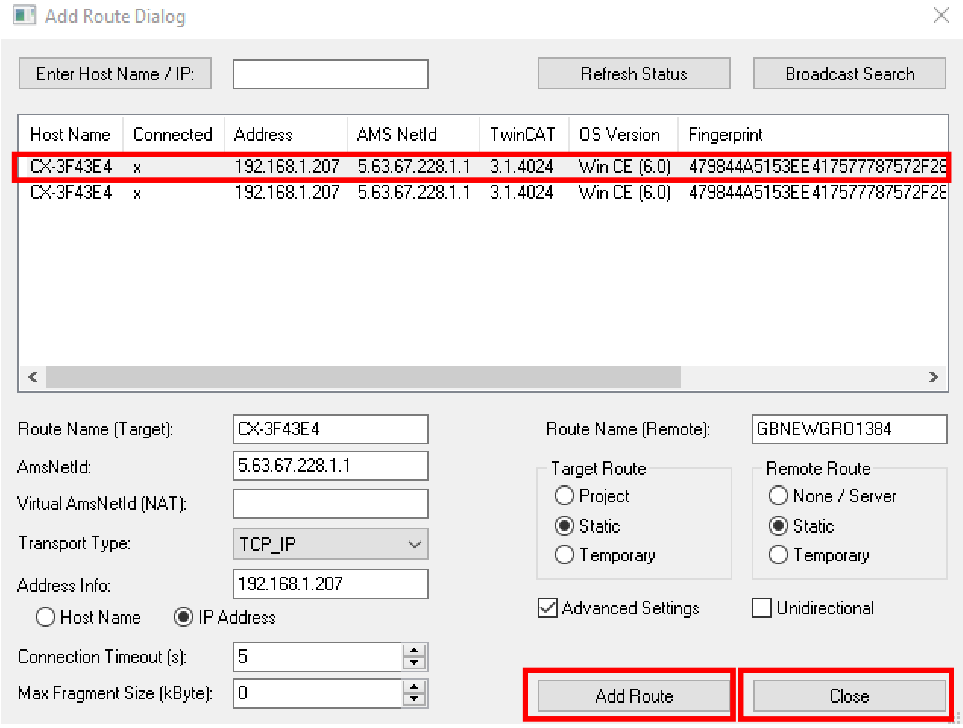
5. When the “Add Route Dialog” starts, click “Broadcast search”.



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



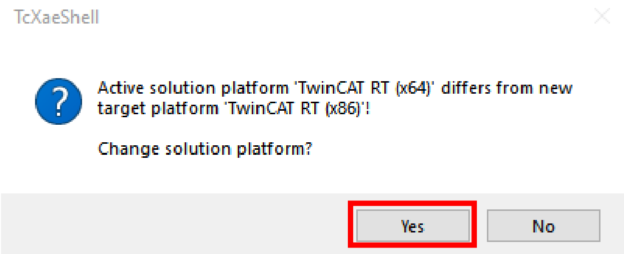
6. Select the PLC to connect to and then click “Add Route” and then “Close”.



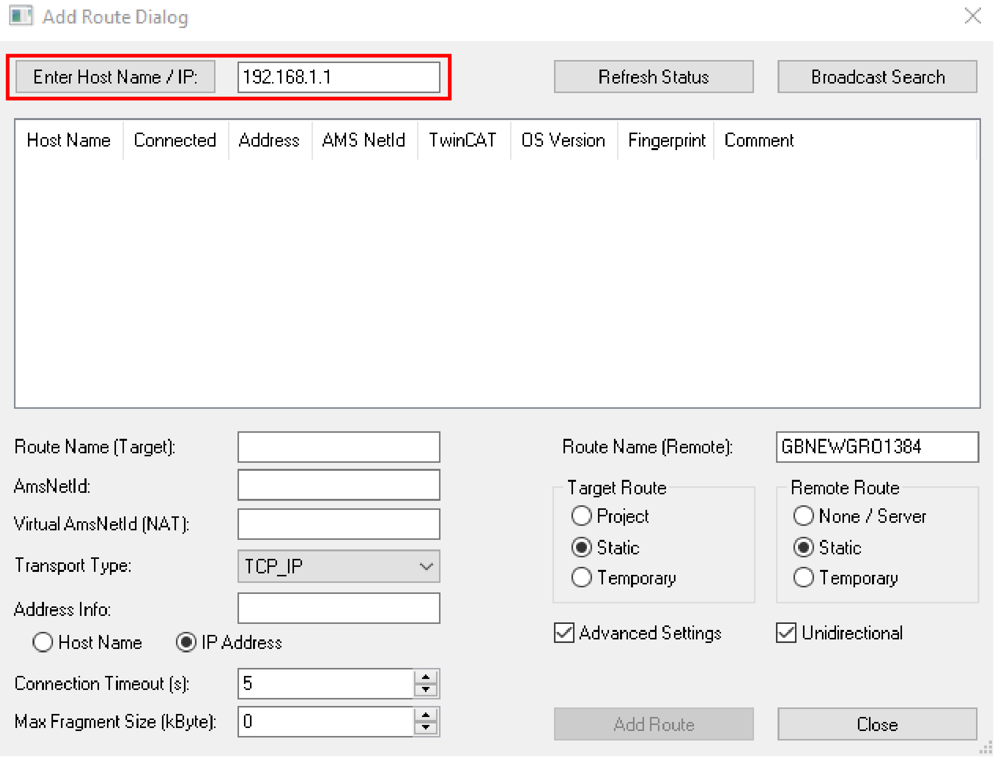
HINT: If there is an Administrator password challenge the default password is “1”

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**

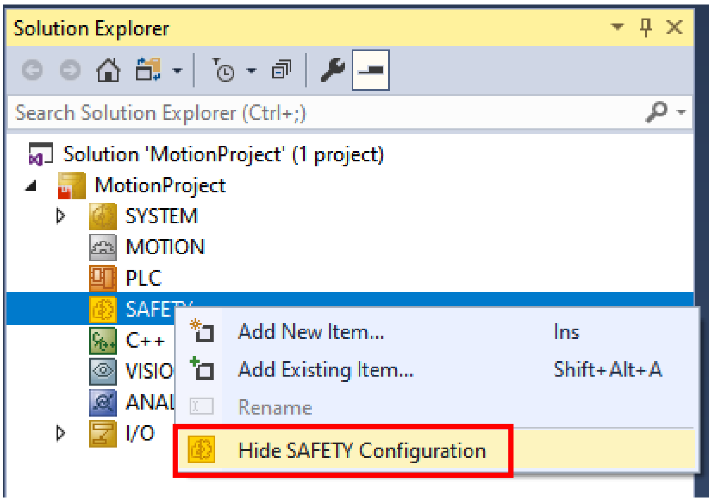
Click “Yes” if the message below appears:

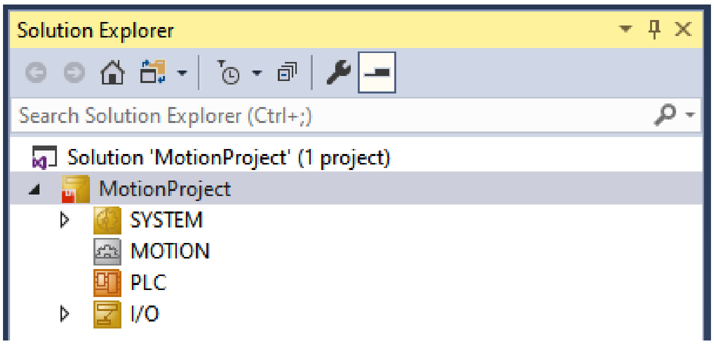


If this doesn't allow connection, Ping the IP address for the device or connect via Remote Desktop to ensure the connection to the PC is good. Then enter the IP address into the "Enter Host Name / IP:" and press enter.

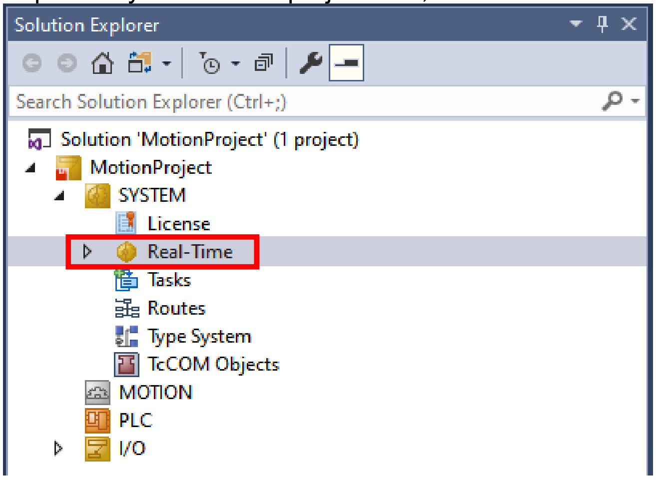


7. An optional step is to clean up any unrequired items from the project tree e.g. this example doesn't require Safety, C++, or Vision etc. To do this right click on the item and select "Hide xxxx".

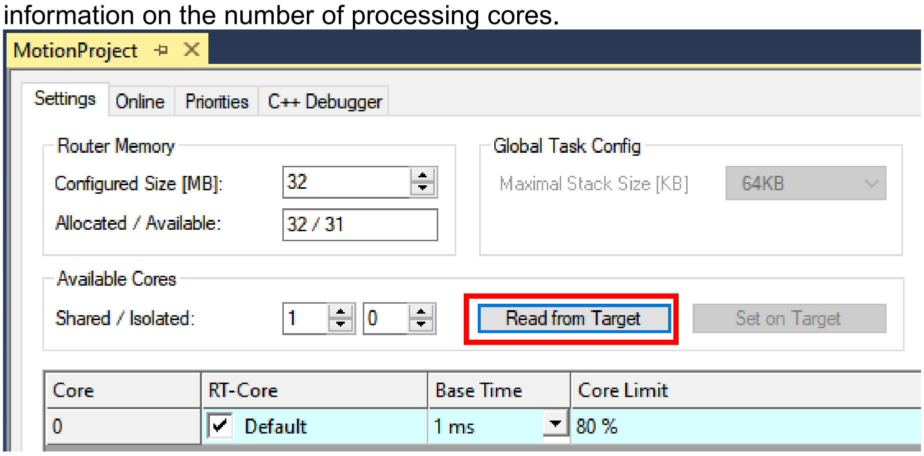


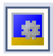


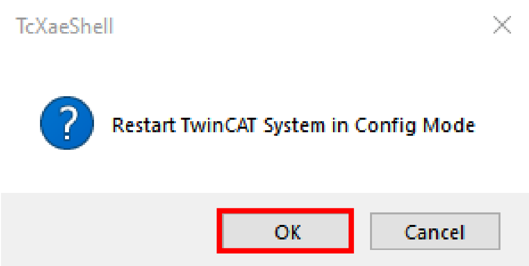
8. Expand “System” in the project tree, click on “Real-Time”:



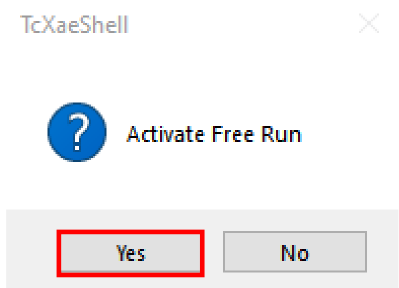
When the project settings tab appears, Select “Read from Target” to update the information on the number of processing cores.



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:



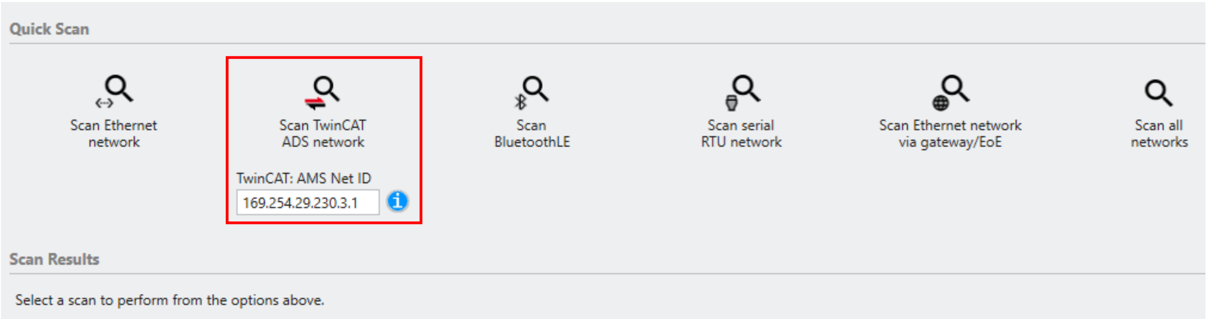
Failure to do this may result in the “Scan” feature being greyed out. Click “Yes” to the “Activate Free Run” pop-up.



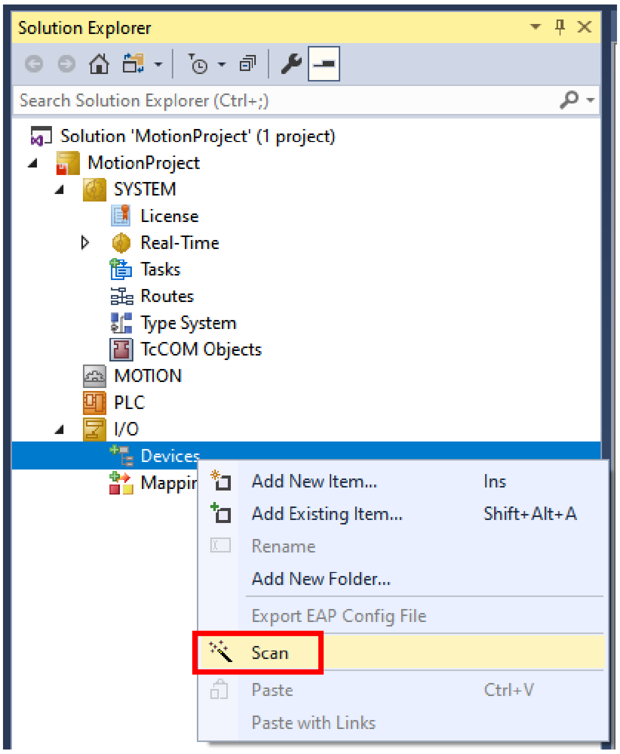
4 Setup an EtherCAT AoE connection from the PLC to the drive

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:

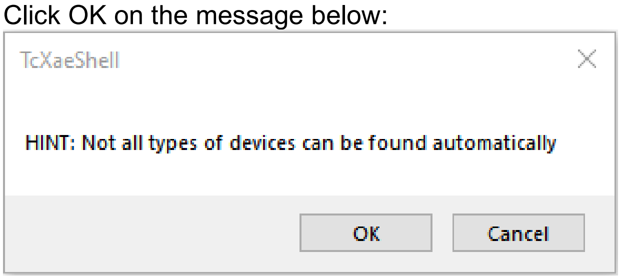


1. Expand the “I/O” category in the project tree, and then right click on “Devices” and select “Scan”:

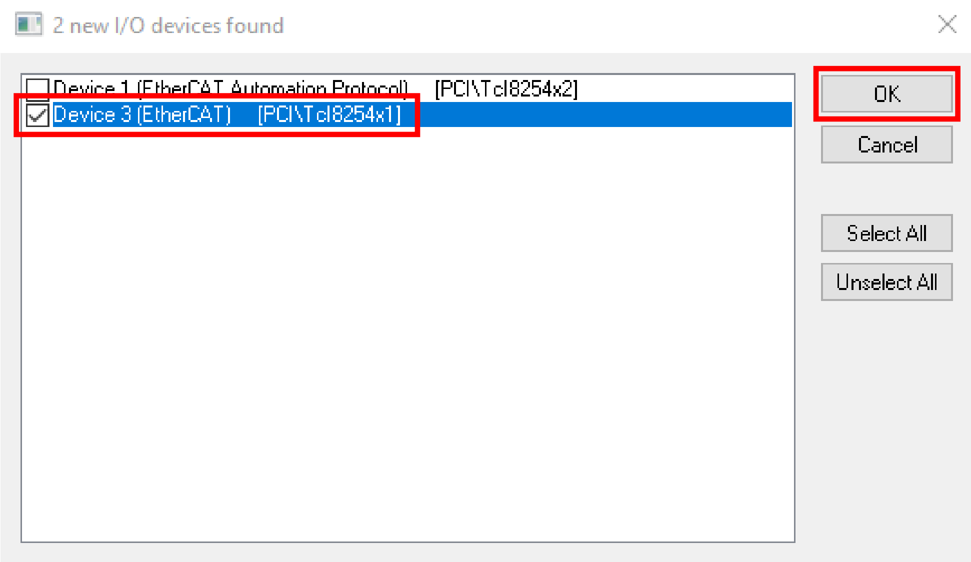


HINT: If “Scan” is greyed out, put TwinCAT in “Config” mode by pressing the following button .

2. Click OK on the message below:

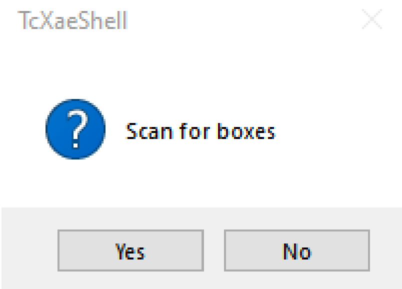


3. Select the “(EtherCAT)” device and then click “OK”.



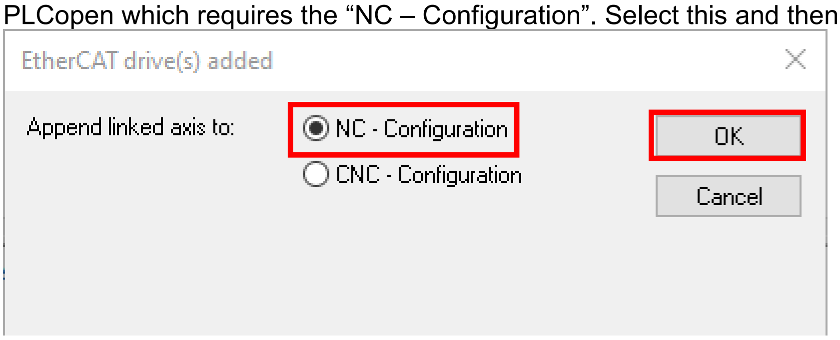
4. Make sure the Control Techniques drive has a suitable Ethernet cable connecting the drives EtherCAT port to the PLC’s EtherCAT port. To use the PLCopen functionality the drive must be either a Unidrive M or a Digitax HD.

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.

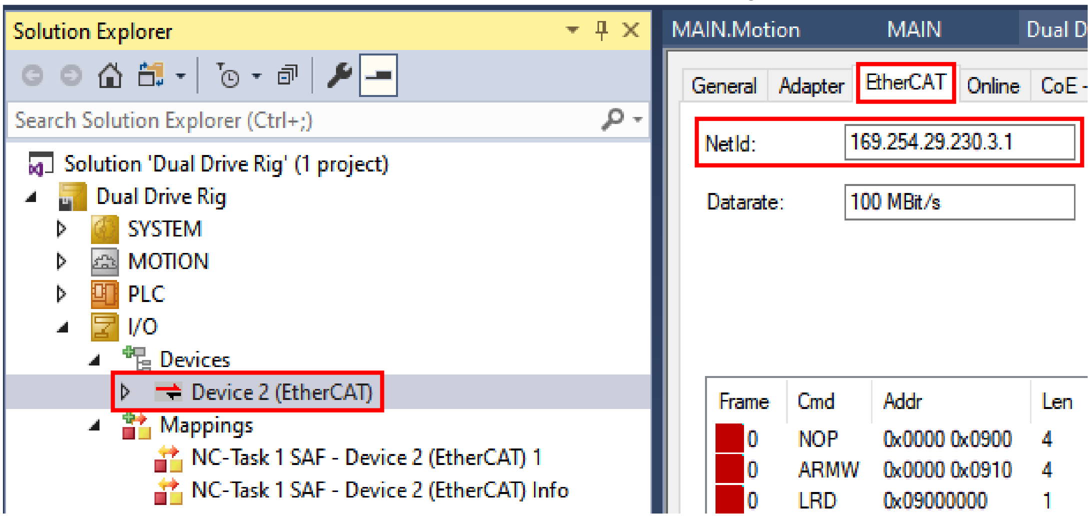


HINT: If there are any issues connecting to the target drives, the ESI files in TwinCAT may not match the firmware in the EtherCAT interface on the drive. The ESI file **must** match the firmware of the EtherCAT module. Section **10.5 How to upgrade EtherCAT Firmware** for details on how to update the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

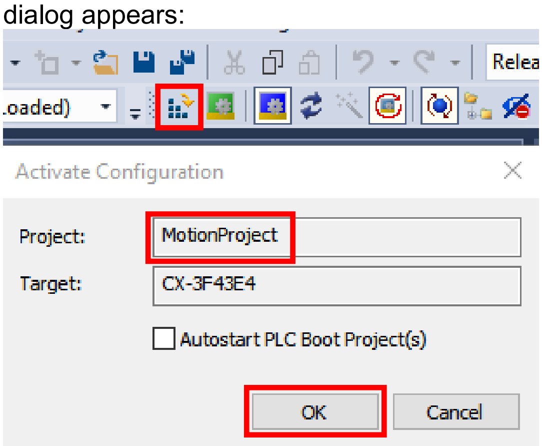


7. When the scan process is completed the PLC/IPC ADS Net ID, (used by Connect), may be located. Double click on the EtherCAT network Master in the Solution Explorer, e.g. “Device 2”, and then select the “EtherCAT” tab. The AMS network ID is given next to “NetId:”.

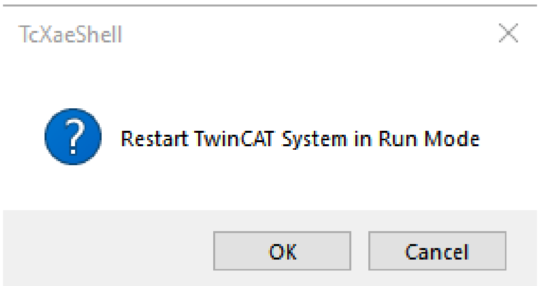


HINT: The EtherCAT port device number varies between different PLCs, depending on the network ports available. In general, the port required will be described as Device (n) (EtherCAT).

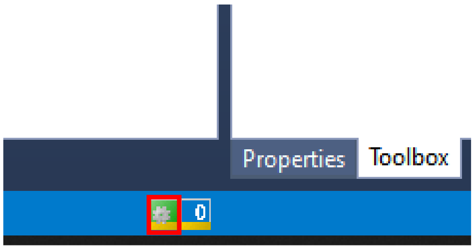
8. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



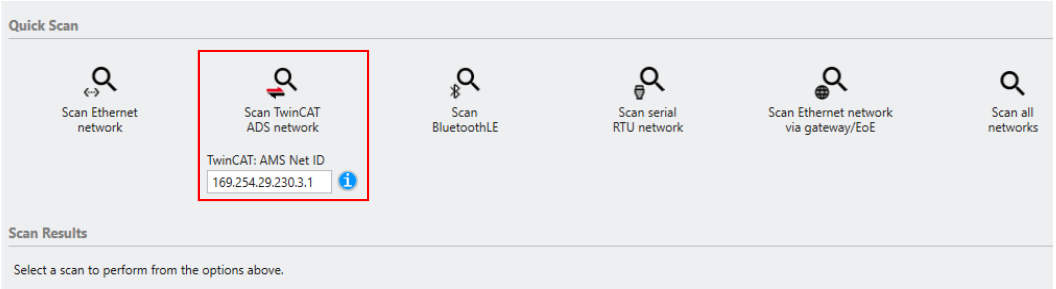
Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



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.

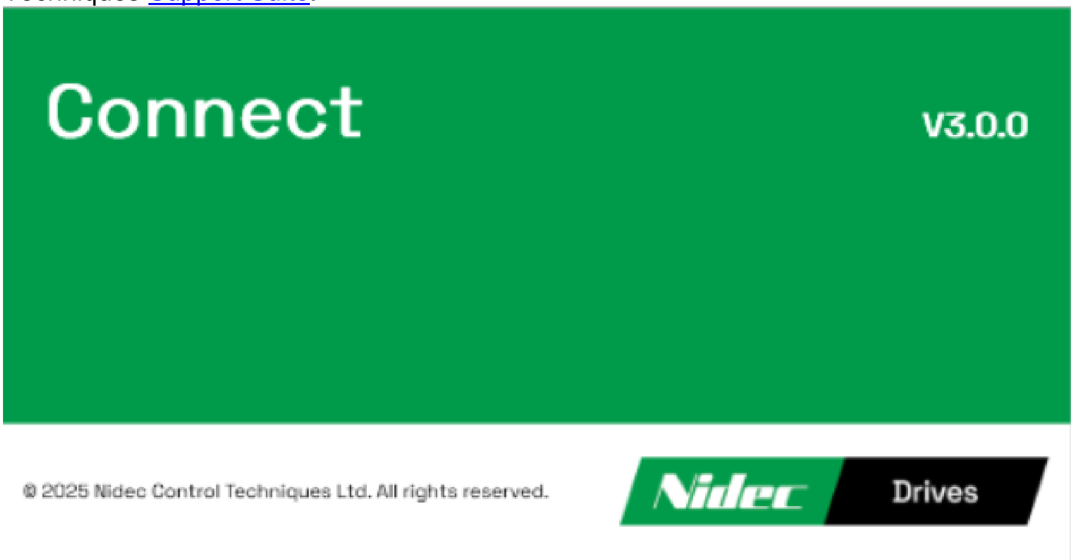


5 Configure the drive using Connect

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

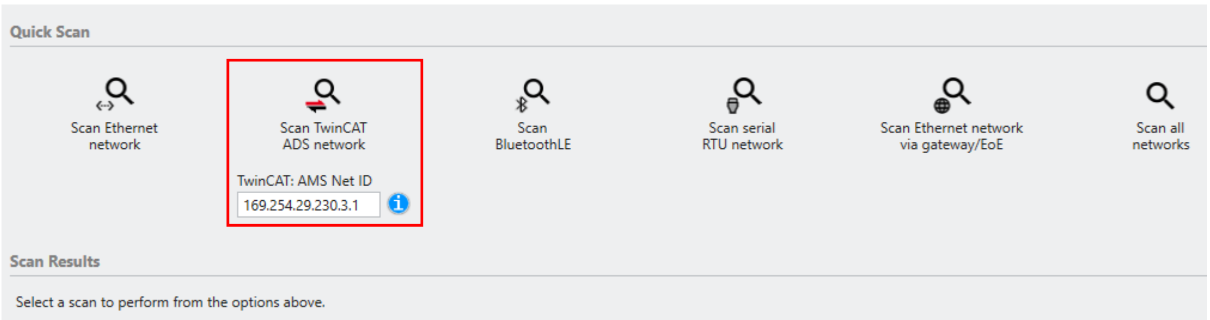
1. Open the Connect PC software by double clicking the “Connect” icon.

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 http://acim.nidec.com/drives/control-techniques, or Control Techniques Support Suite.



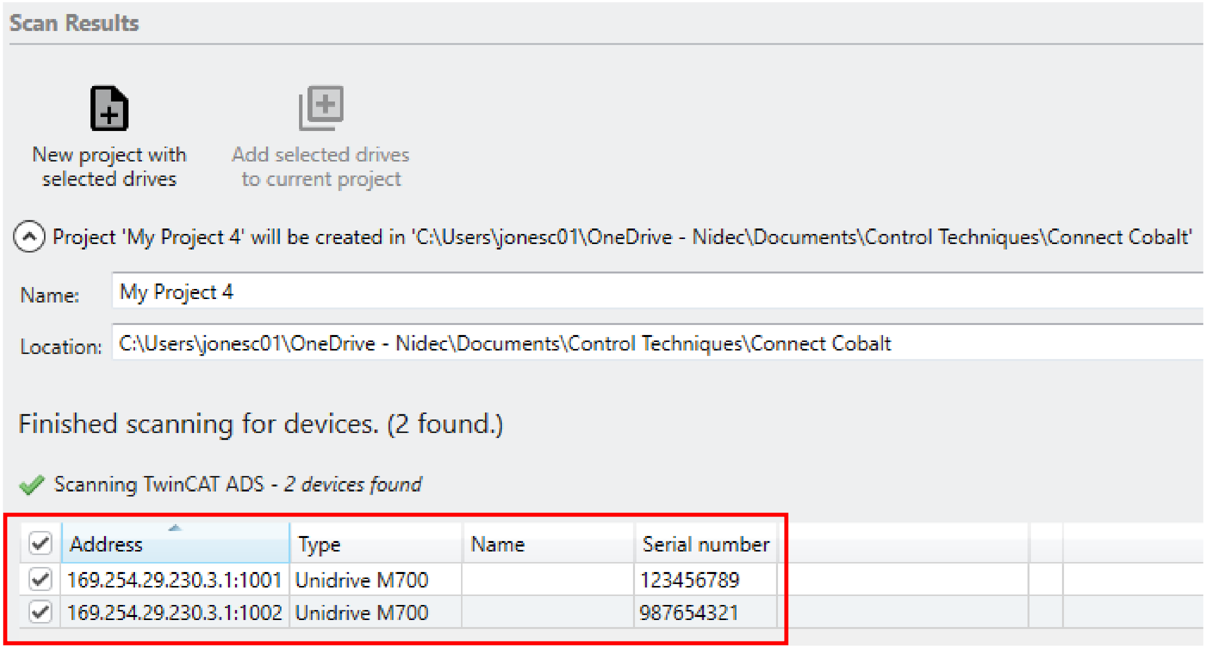
3. When Connect opens select “New project from network scan”.

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



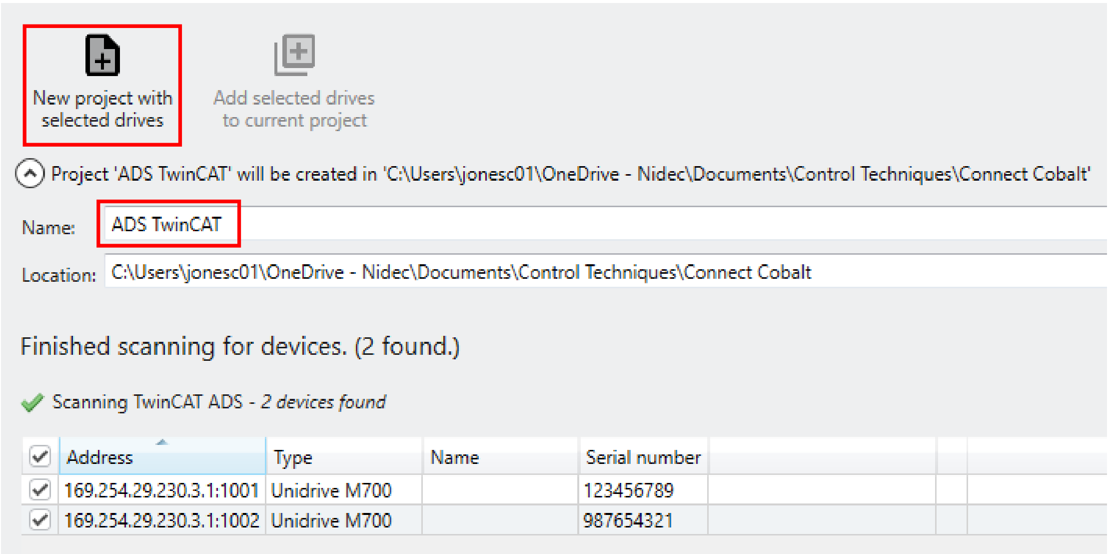
HINT: Section **4 Setup an EtherCAT AoE connection from the PLC to the drive** shows where to get the EtherCAT AMS Net ID / ADS Network ID in TwinCAT.

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

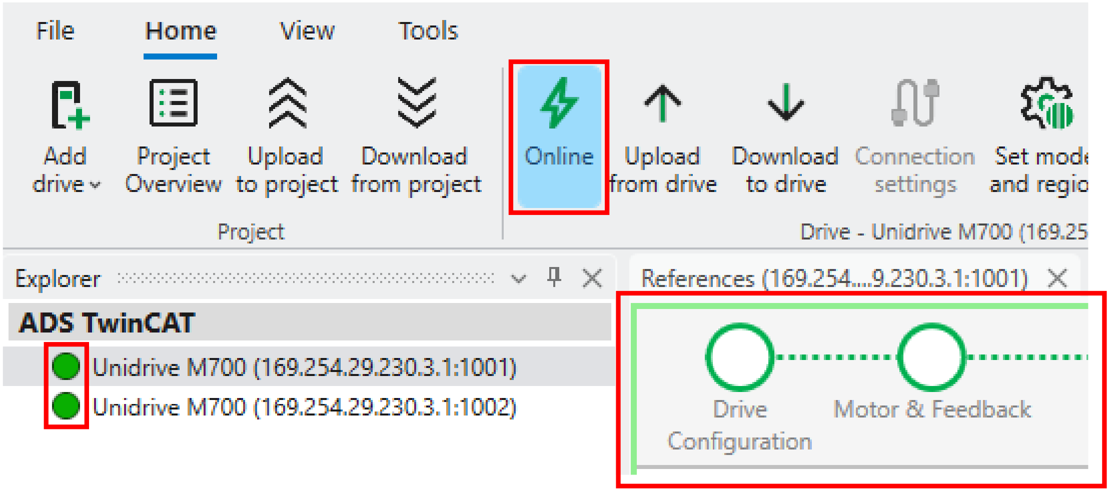


HINT: For this to be successful on an EtherCAT-based network, the Beckhoff TwinCAT PLC/IPC must be running, as indicated by a green "TC" LED on the PLC/IPC and the activated symbol highlighted in TwinCAT.

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

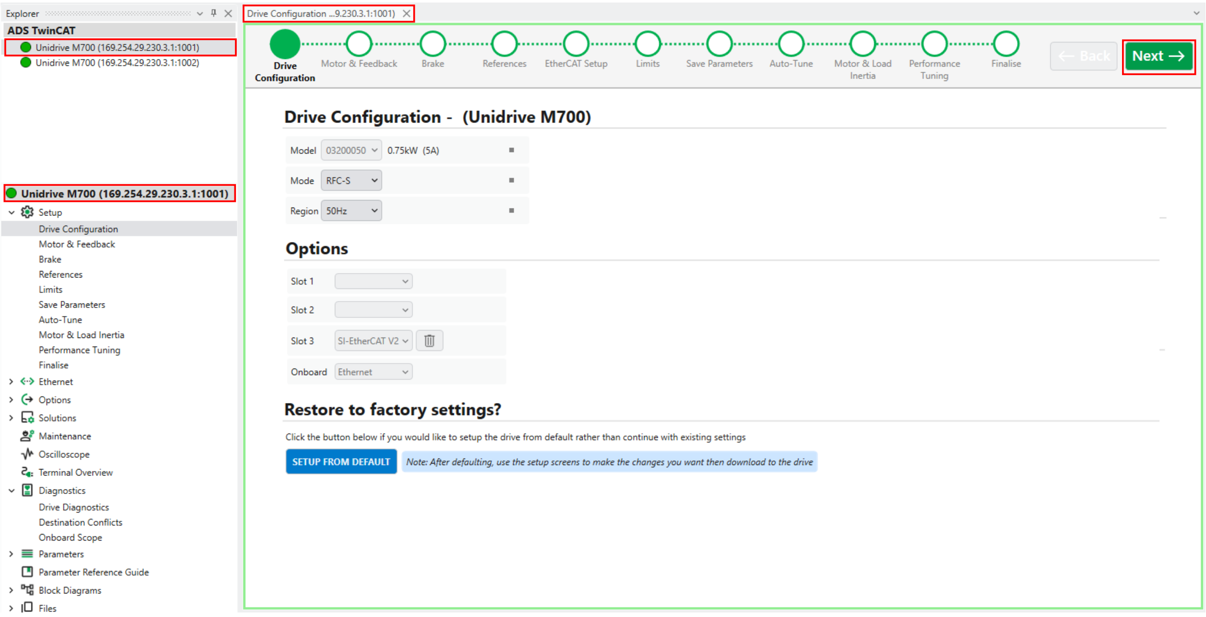


7. When the project opens, all drives on the network will be “Online” as indicated by the blue highlight on the “Online” button, the green dot next to each drive node in the Explorer tree, and the green border around the active tab.



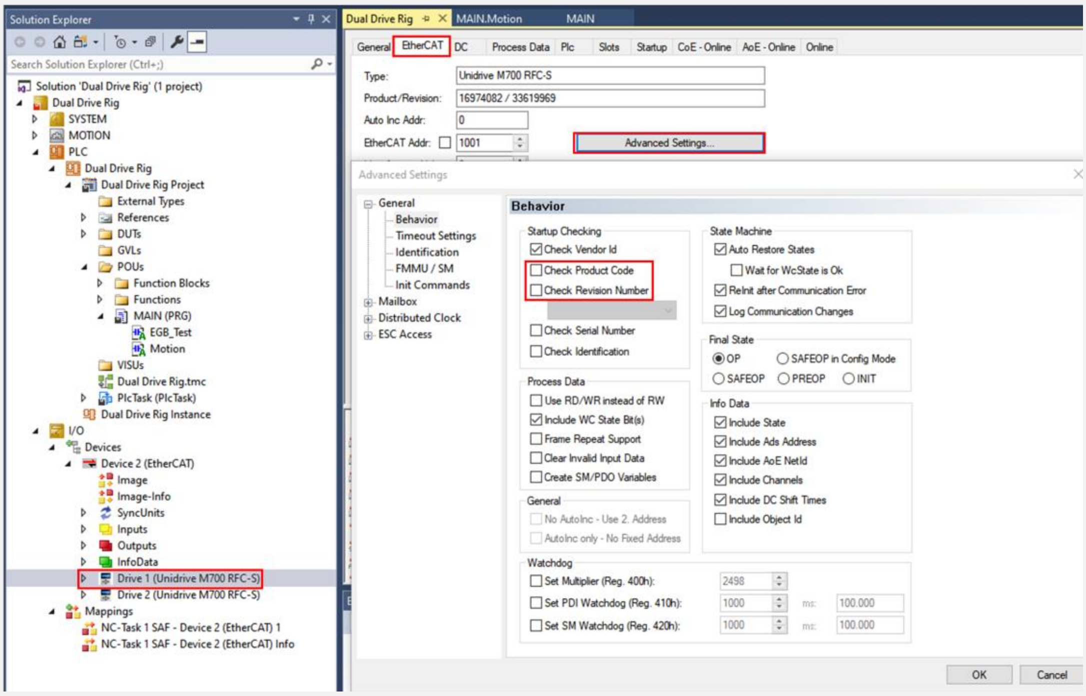
This means that any changes made take direct effect in the drive.

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.

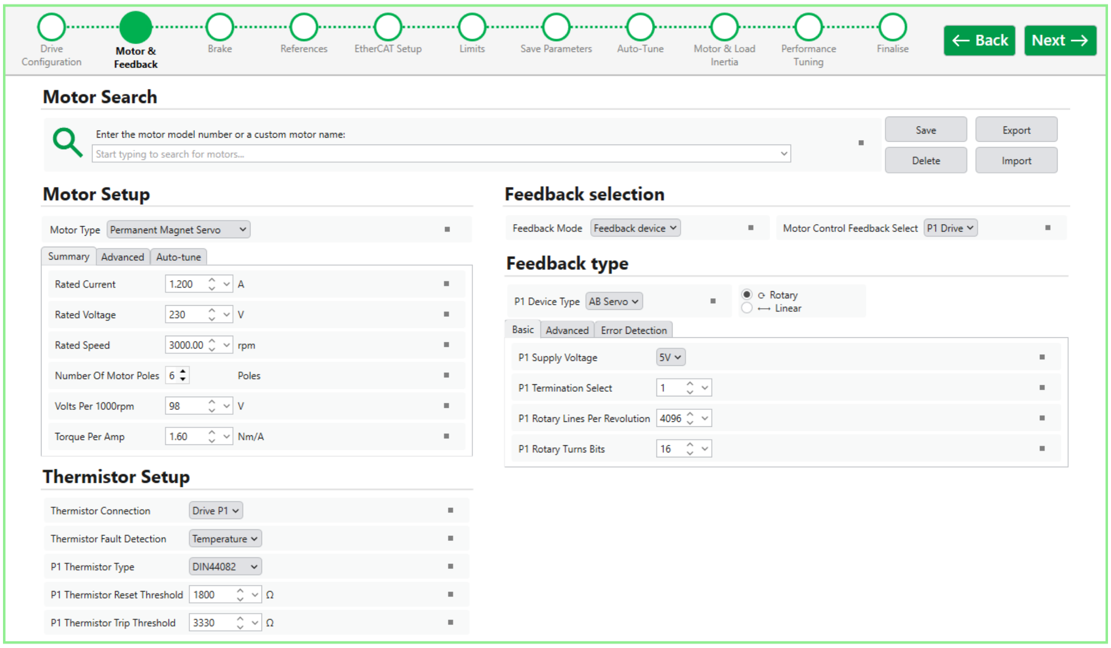
HINT: Has comms been lost after changing the drive mode? This might be because the EtherCAT interface has V1 firmware installed which as a part of the start-up checks includes the drive mode. V2 firmware removes this issue. If the drive mode is changed the comms connection stops completely, in TwinCAT, 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.

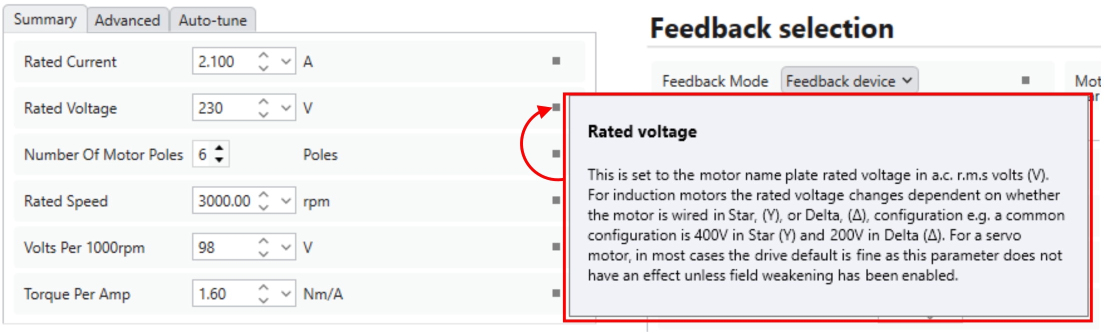
9. Setup the motor and feedback device on the “Motor and Feedback” page. The required data for the motor and feedback device will be available on the motor name plate or the technical data sheet for the motor.



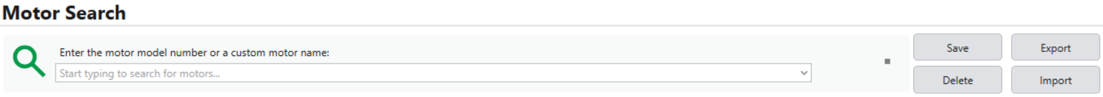
The user must configure the motor, feedback device and thermistor setup here.

For a permanent magnet motor, the user must set the Torque Per Amp field on the motor feedback step. If the value of Kt isn't provided on the rating plate, it approximated by dividing the Motor rated torque by the Motor rated current. For an induction motor, the drive calculates the Kt value from the motor data. This value is used by the motor and load inertia calculation step, which helps make the motor tuning simple with a single slider.

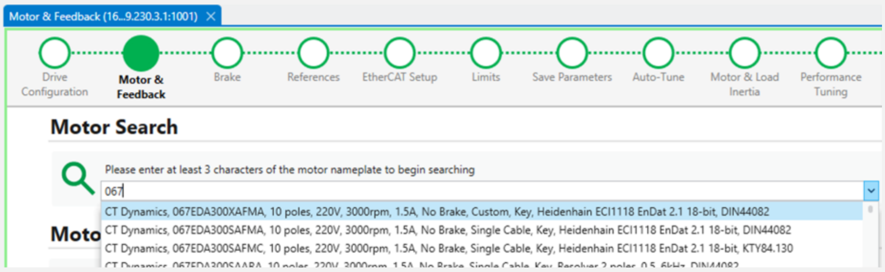
Help is provided throughout Connect using small help trigger squares ■ :



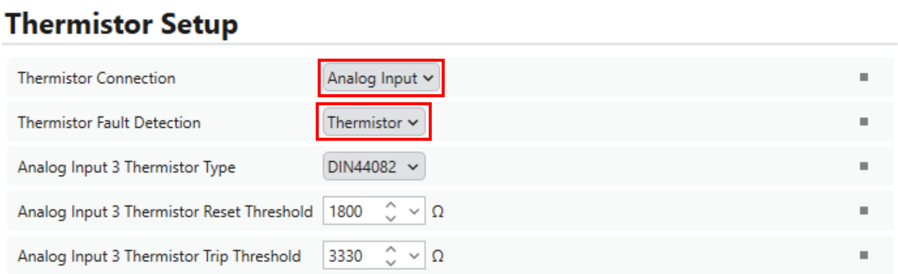
It is possible to save a motor and encoder configuration for later use; these are searchable too.



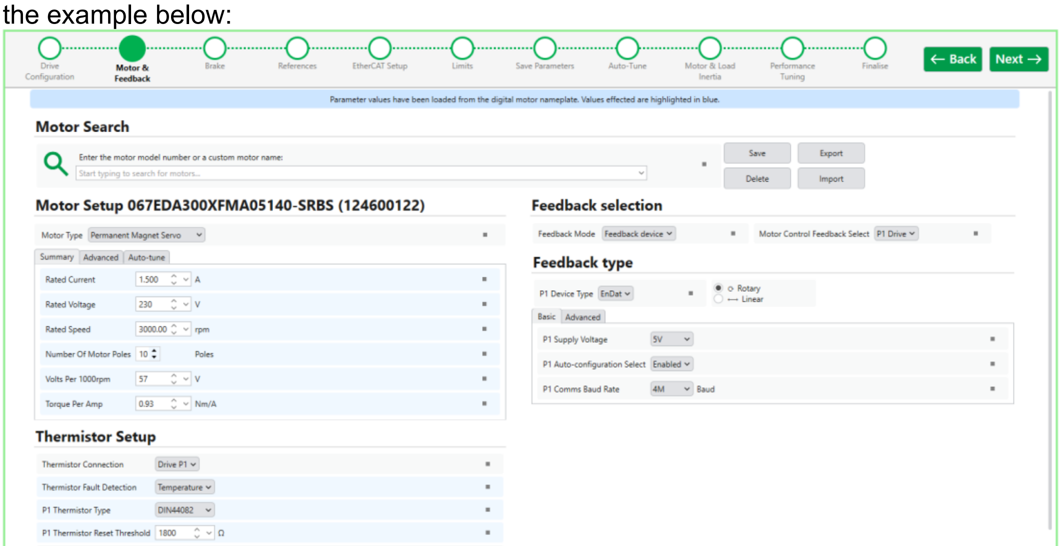
HINT: Control Techniques Dynamics permanent-magnet servo motors and Leroy Somer induction motors and permanent-magnet process motors may be found using the motor search:



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). Set Analogue Input 3 Mode to Thermistor.



If the drive is either a Digitax HD or a Unidrive M with firmware >=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:

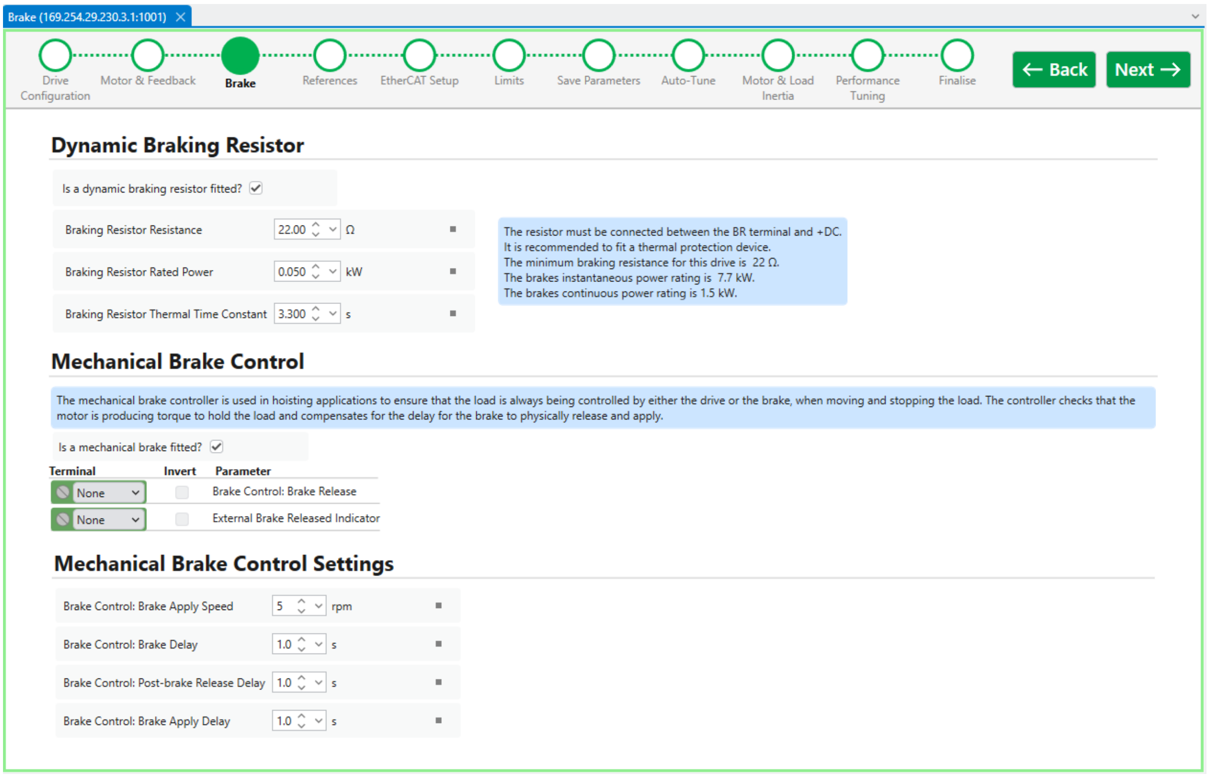


The light blue highlight shows that the electronic nameplate has been loaded. In addition, for EnDat 2.2, EnDat 3.0 and BiSS-C encoders the “Encoder type” fields are also configured automatically.

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.

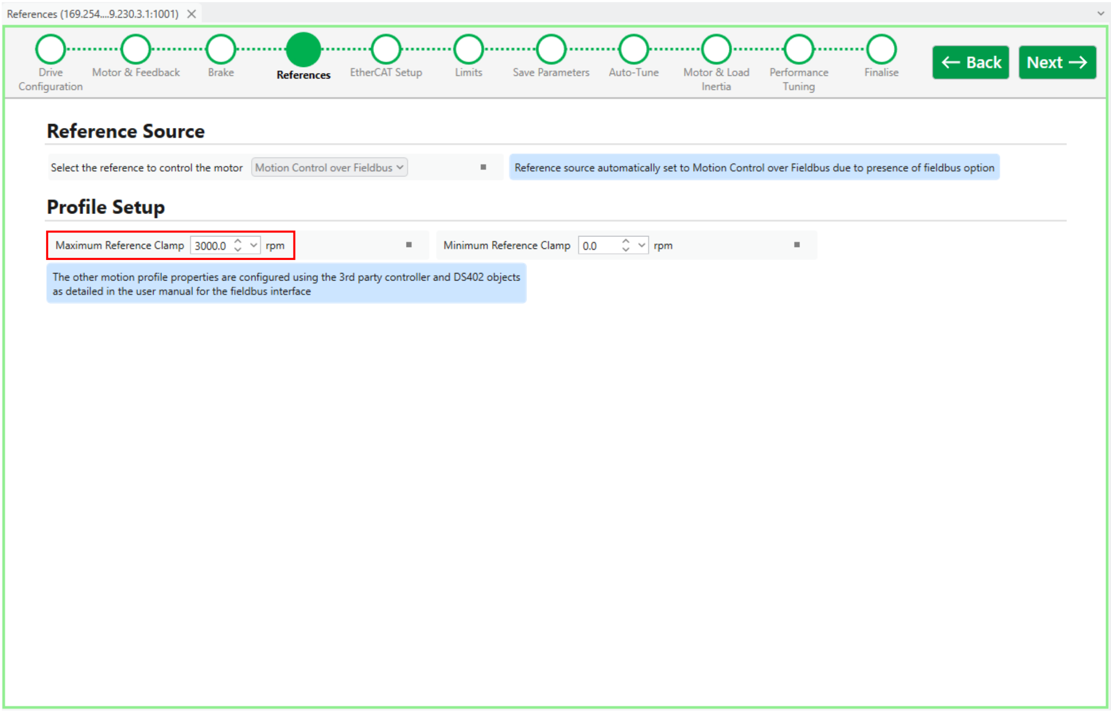
    It is also be used to set up the drives mechanical brake controller. The mechanical brake controller releases and applies the mechanical brake automatically, making sure that the load is always controlled by either the motor or the mechanical brake. It is typically used in hoisting applications. For 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.



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

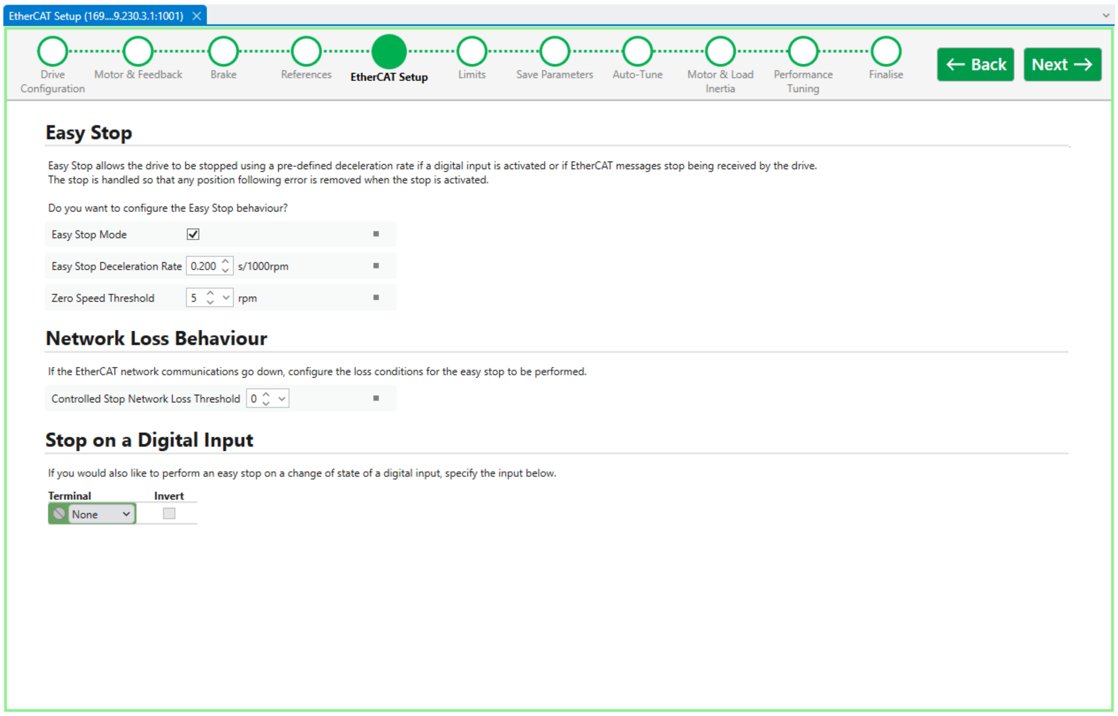
    When finished, click “Next” to move to the reference setup.

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 modified and may be adjusted from this page.



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.



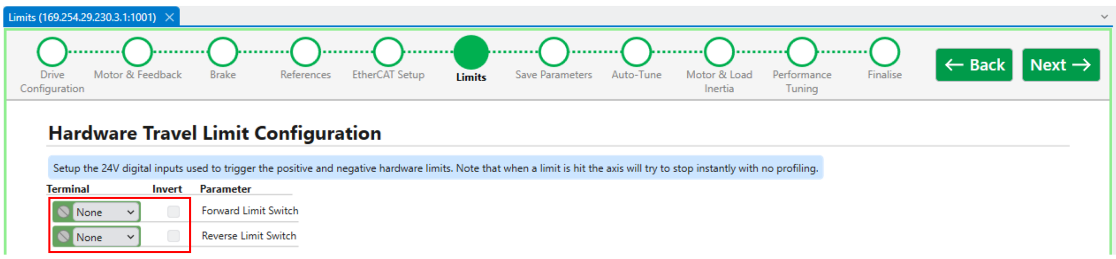
When the “Easy Stop Mode” box is checked, the user can assign a digital input that will cause the axis to stop. The axis is permitted to run when 24V is applied to it, but if 24V is removed the axis will stop, using the “Easy Stop Deceleration Rate”.

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.

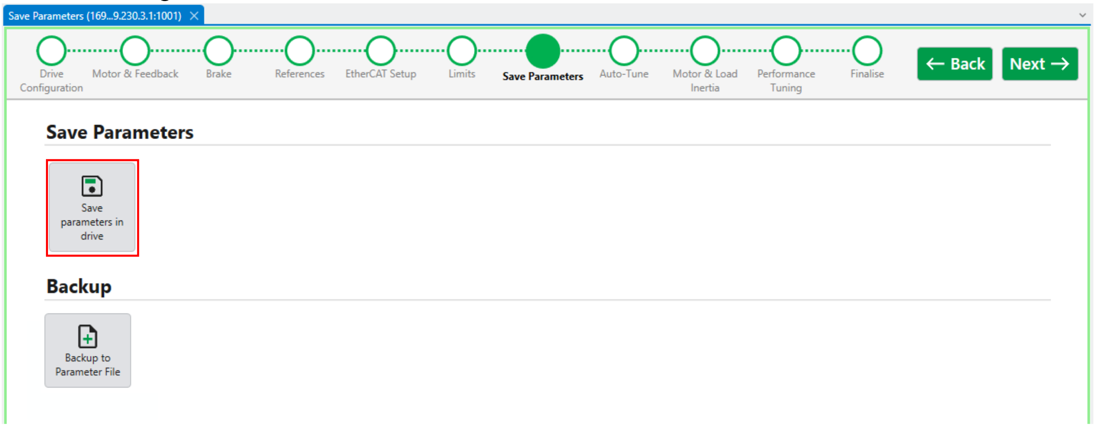
When finished, click “Next” to move to the Limits setup.

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.



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

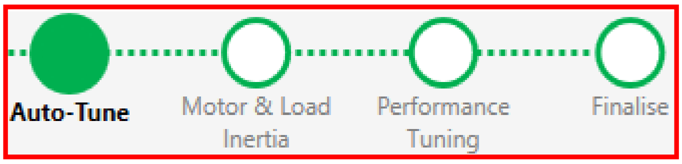
14. The save parameters page allows the parameters configured so far to be saved. It is advised to do this prior to the commissioning activities since the power might have to be removed to correct a hardware issue as a result of a failed Autotune test, such as a reversed motor or encoder wiring.



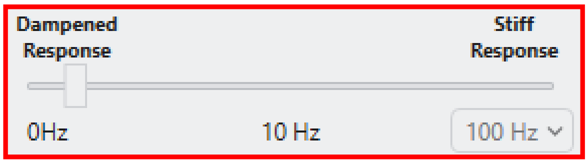
This completes the configuration section of the guided setup. The next section of the manual describes the commissioning of the drive and motor using the remaining steps in the guided setup.

6 Commission the drive and motor using Connect

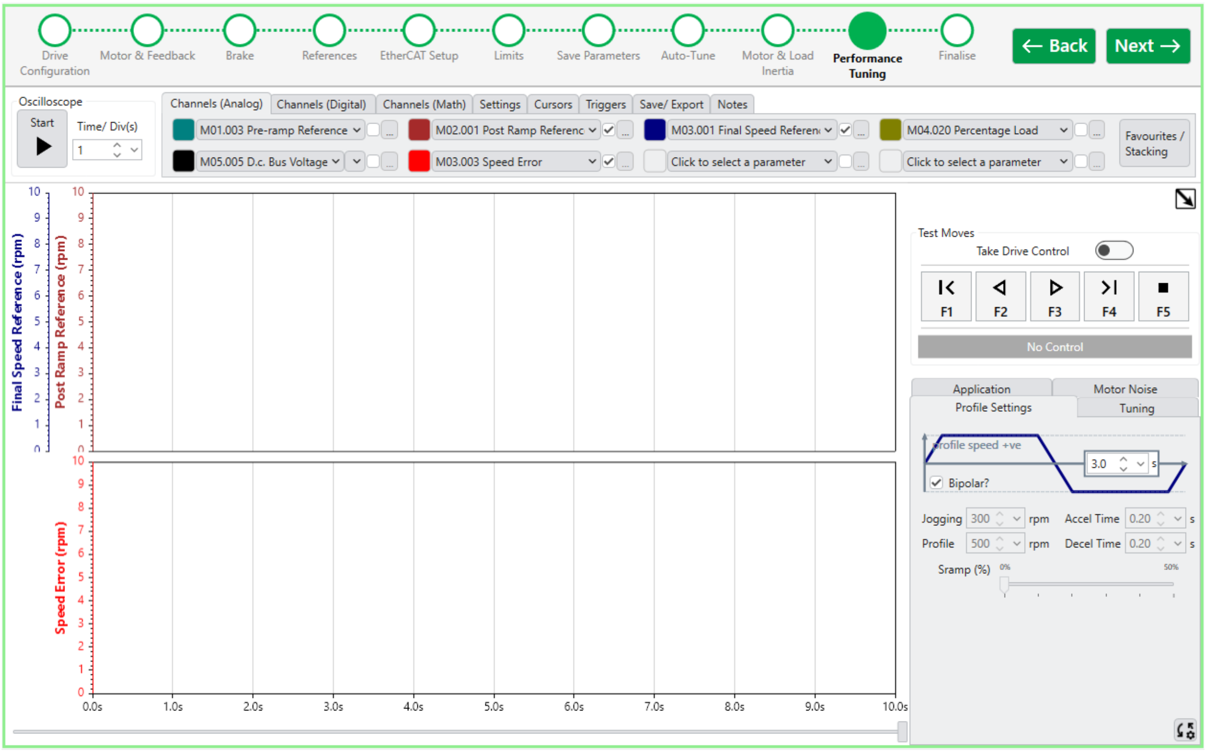
This section describes the process of commissioning the drive and motor in the application using the tools provided in the guided setup, which consist of:



- 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.



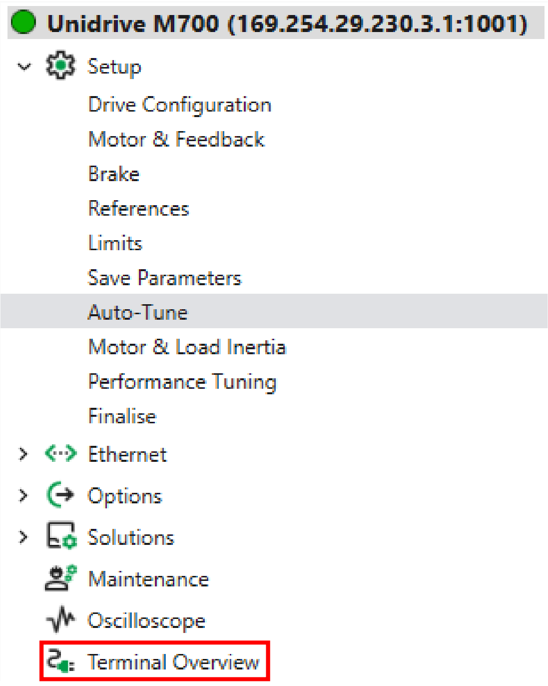
- Performance tuning and test moves. This page is a "one stop shop" with test move controls, motion profile setup, oscilloscope, and tuning controls on a single page ideal for site commissioning using a laptop.

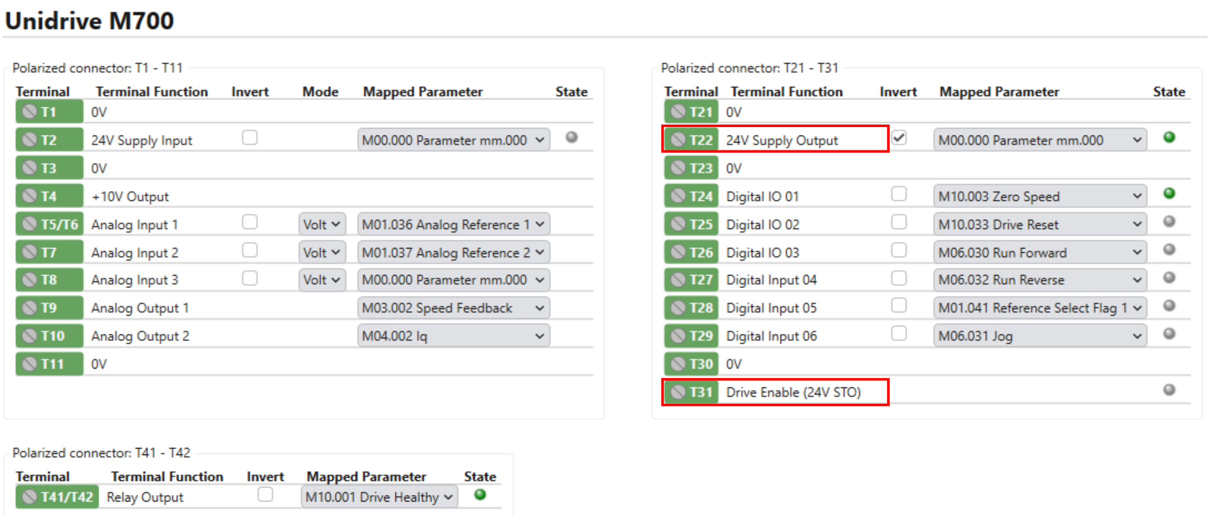


- Finalising the application by saving the tuned parameters and creating a startup list allowing the PLC / IPC to configure the drive, each time the system powers up; this is helpful if the drive must be replaced.

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.



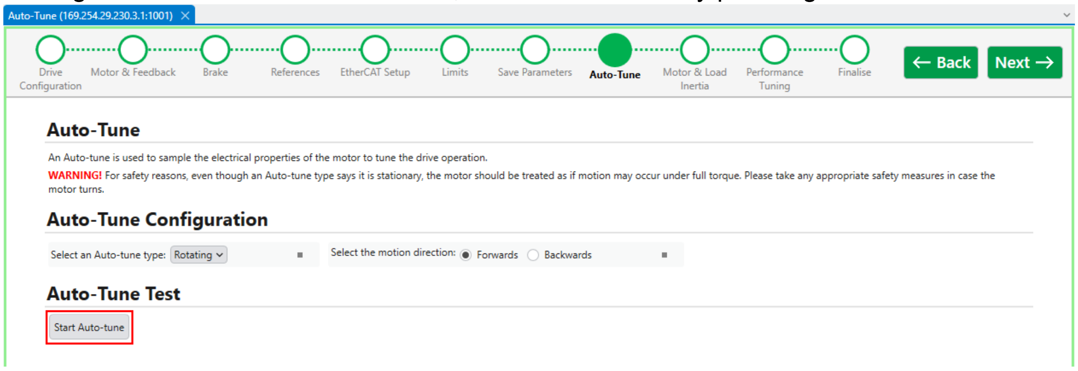


SAFETY: Remove power from the drive before attempting to modify the drive or motor electrical connections.

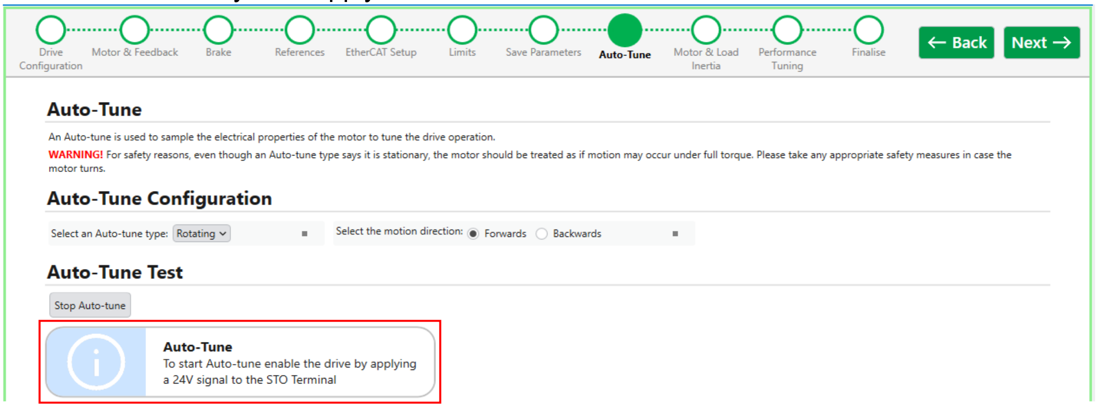
2. Before attempting to run the Auto-tune ensure the STO switch is open i.e. 24V is not connected to the STO terminal(s).

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

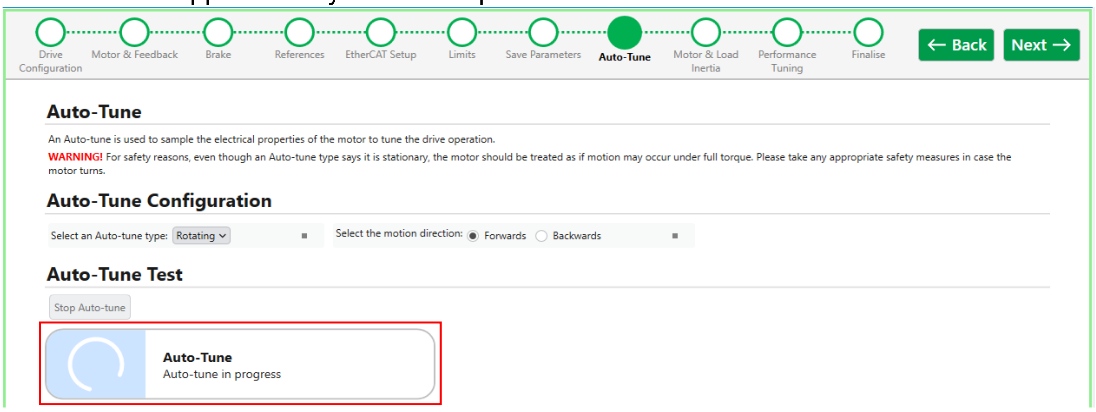
Making sure the motor is safe to move, run the Auto-tune by pressing “Start Autotune”



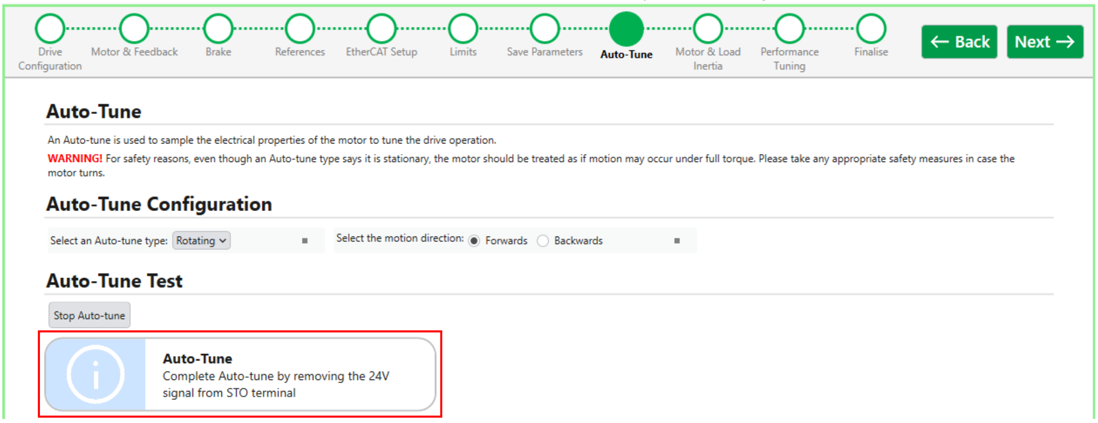
The tool will advise you to apply 24V to the STO terminal to run the test.



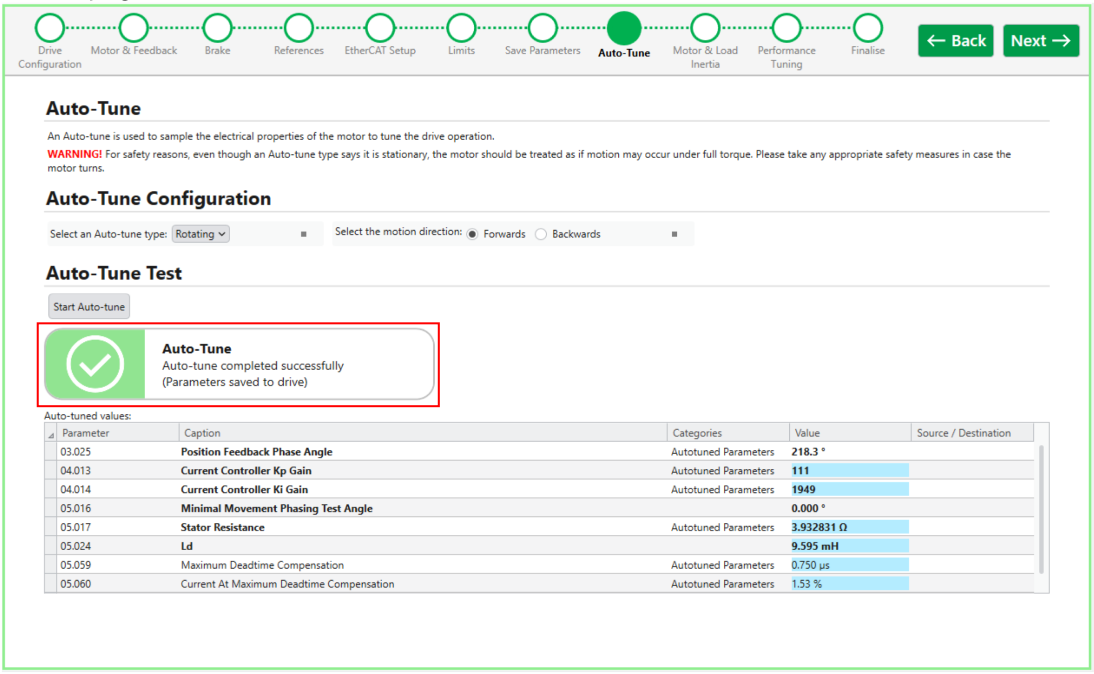
The test takes approximately 30s to complete



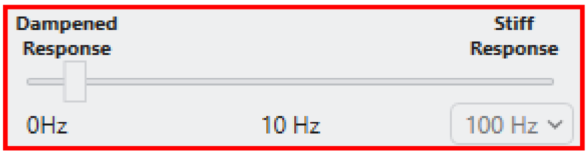
When the test completes, the drive must be disabled by removing 24V from the STO input.



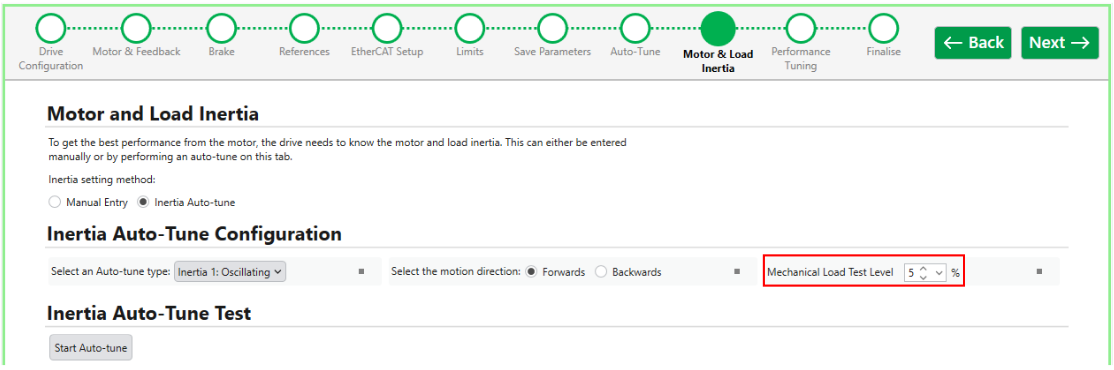
The electrical property autotune is completed. Click next to move to the “Motor and load inertia” page.



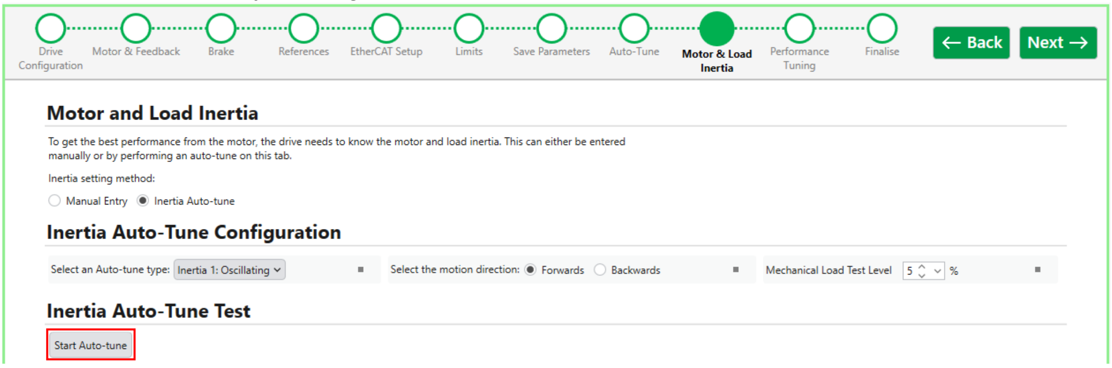
4. The “Motor and load inertia” page configures a test to measure the motor and load inertia. This test is important as it allows the speed loop gains to be configured using a single control slider:



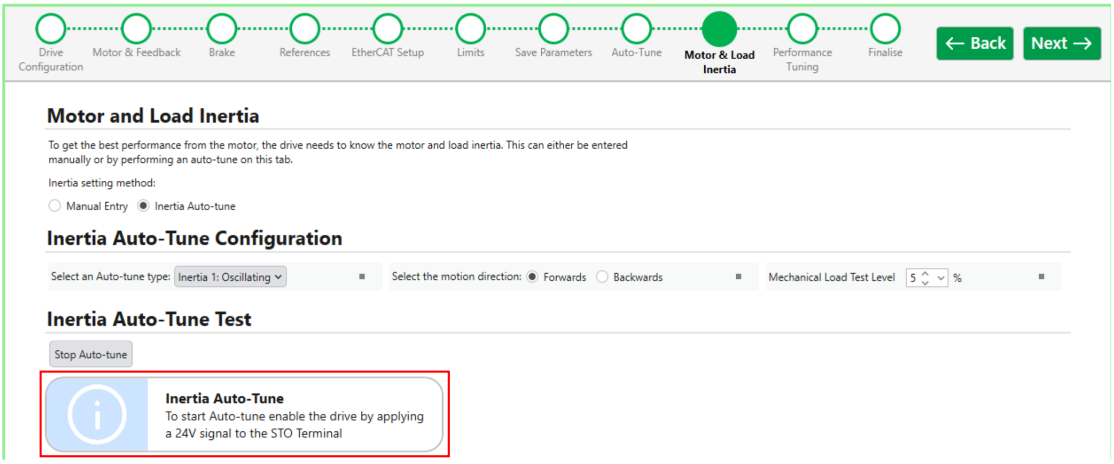
If the motor has a load connected, the default settings will be OK for most systems. Where there is no load i.e. a bare motor shaft it is recommended to increase the “Mechanical Load Test Level” to 5%. If the test fails to identify the inertia, increase the mechanical load test in steps of 5% up until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



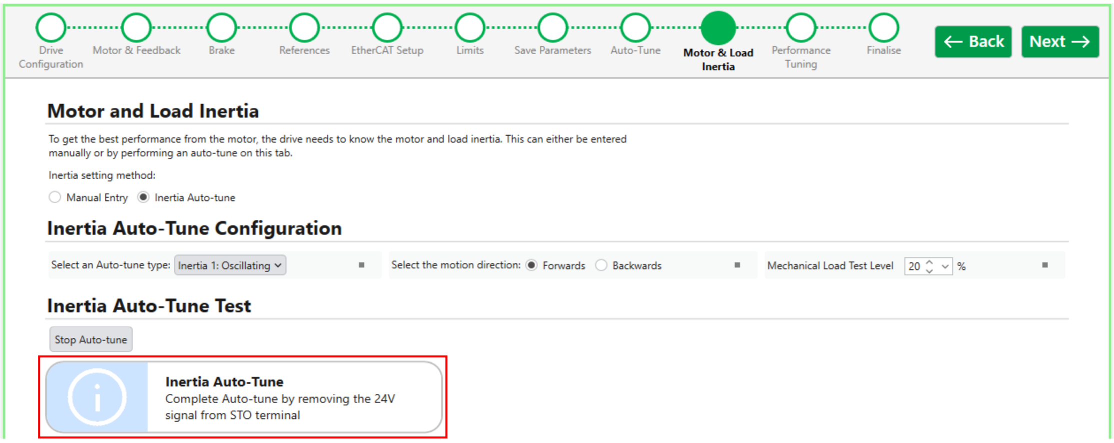
Start the inertia test by clicking “Start Auto-tune”:



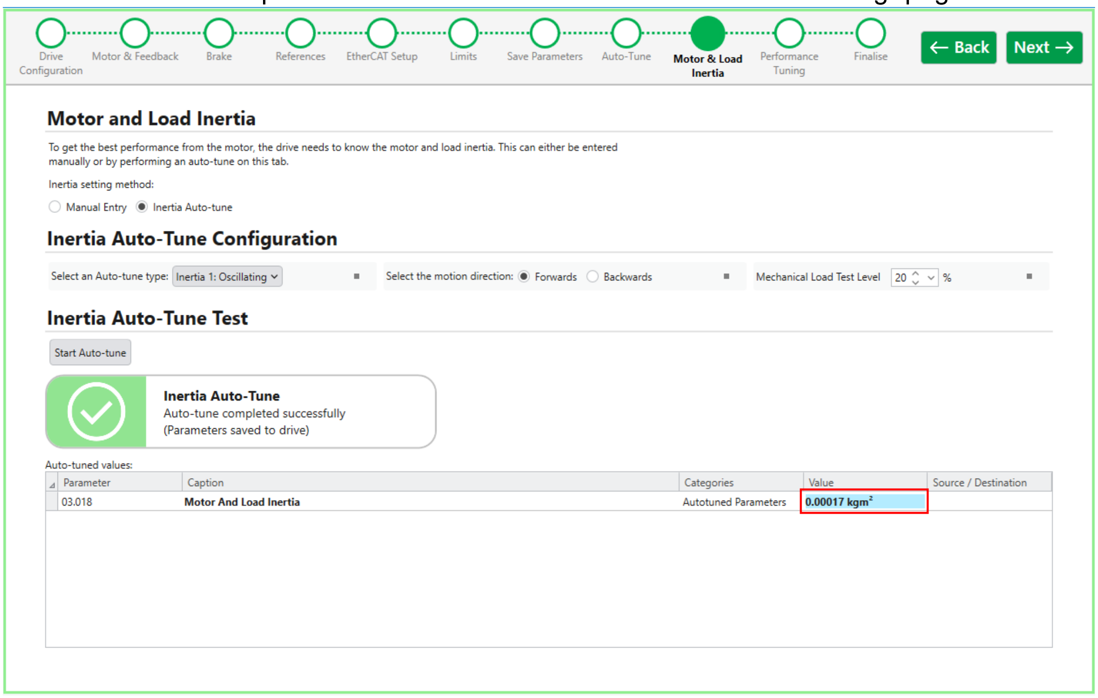
The tool will advise you to close the STO switch to apply 24V to the STO terminal and run the test.



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

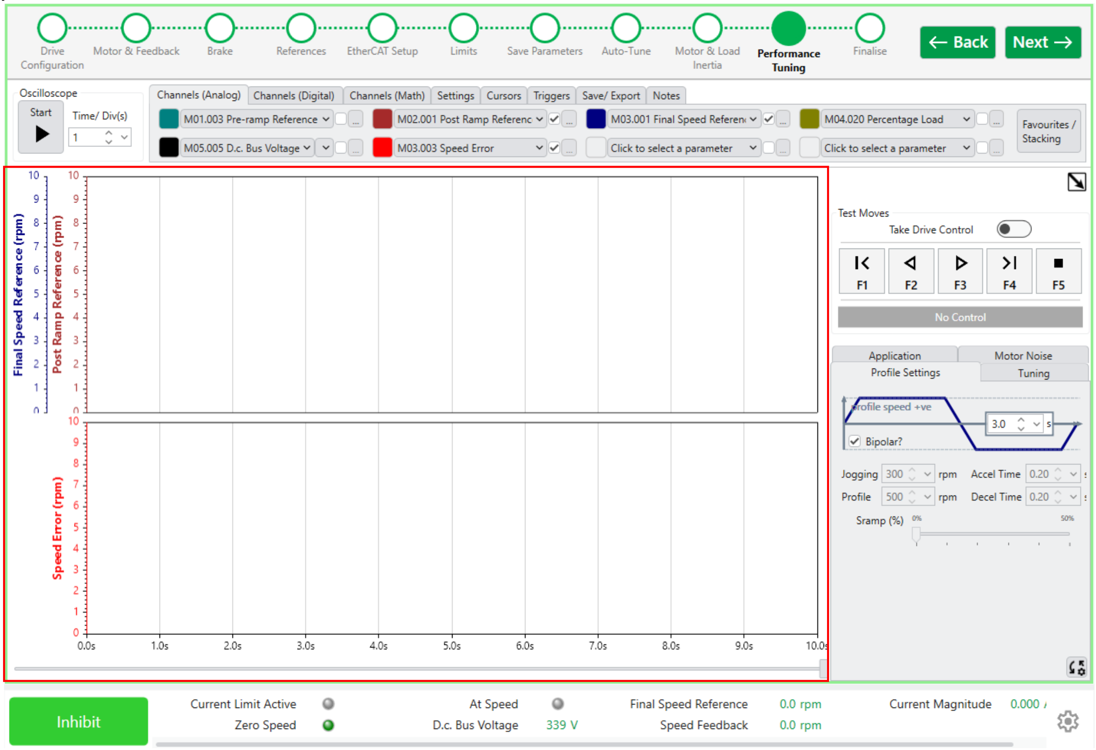


The inertia test is complete. Click Next to move to the “Performance Tuning” page.

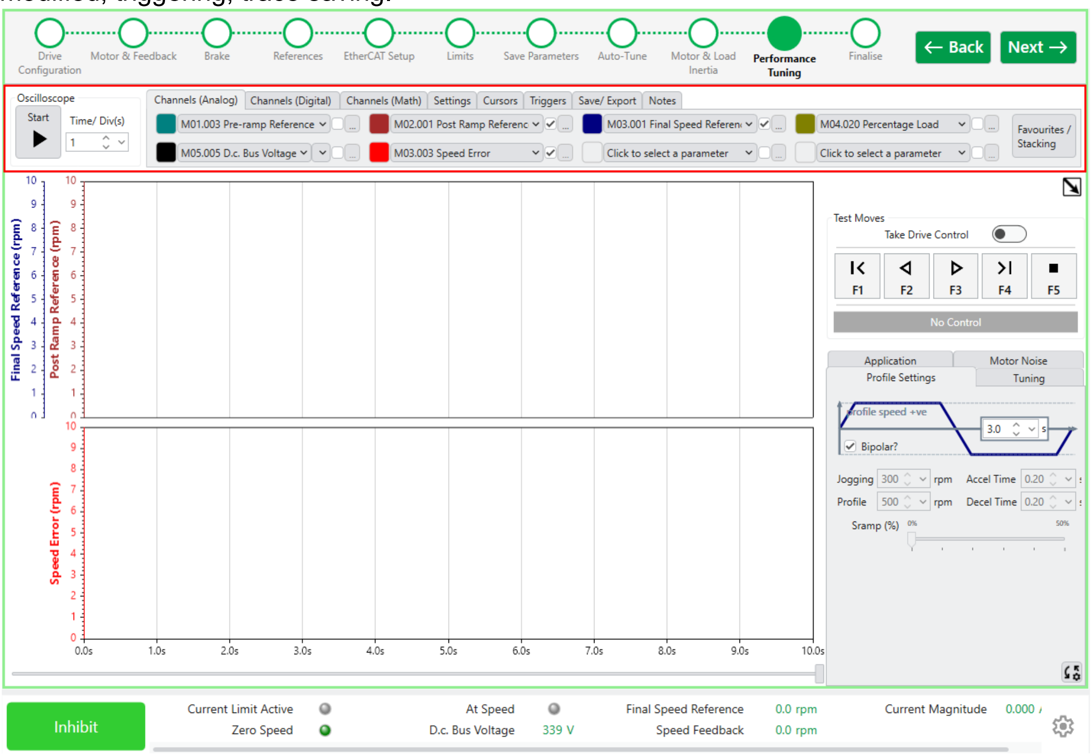


5. The “Performance Tuning” page provides a set of tools on a single page, optimised for laptop use, that are used to commission the drive and motor. The different sections of the tool are described below:

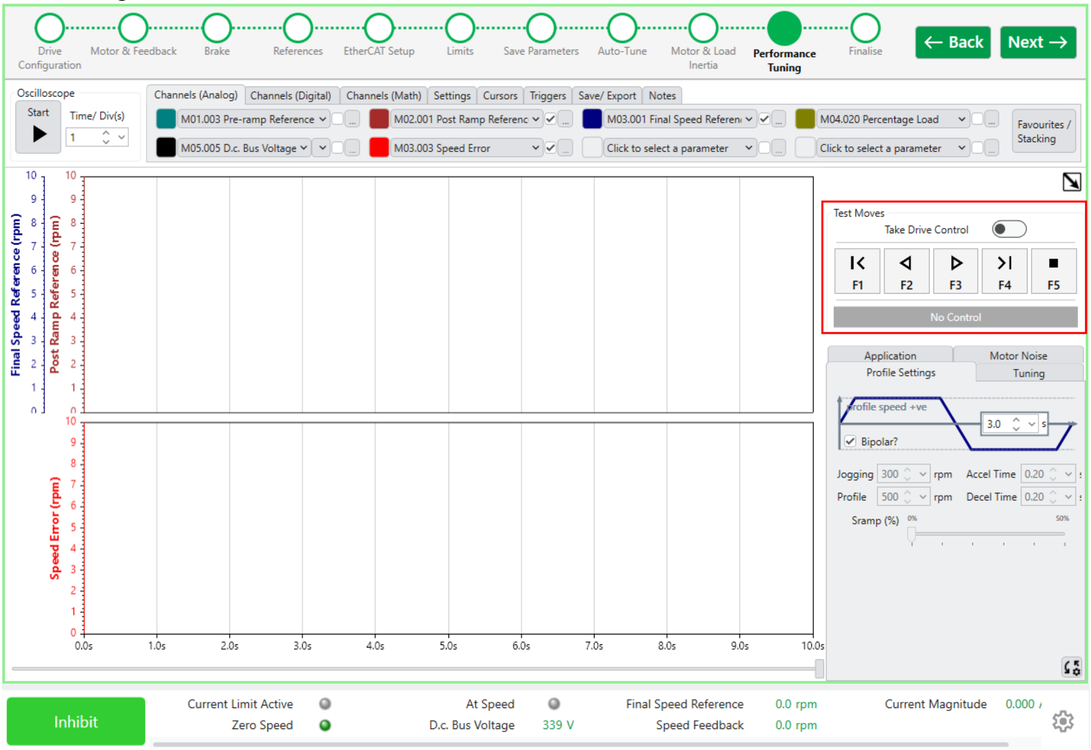
Oscilloscope – to show what is happening to the motor speed while jogging or tuning takes place:



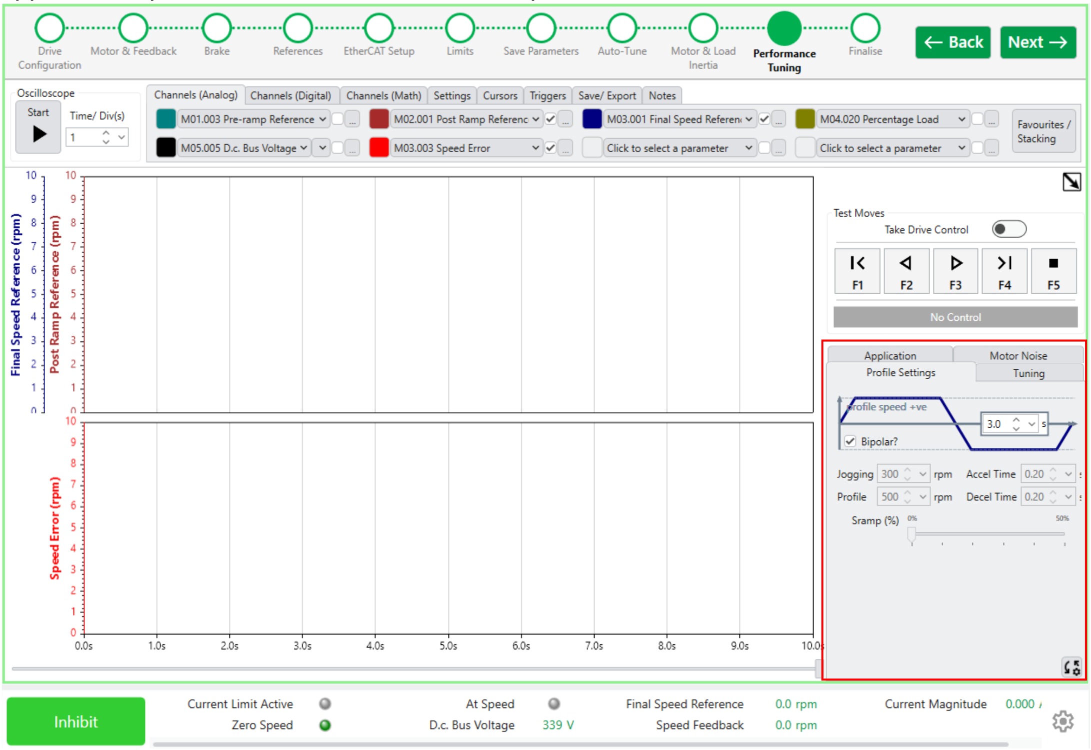
Oscilloscope controls – start and stop the trace, allow channels to be added / removed / modified, triggering, trace saving.



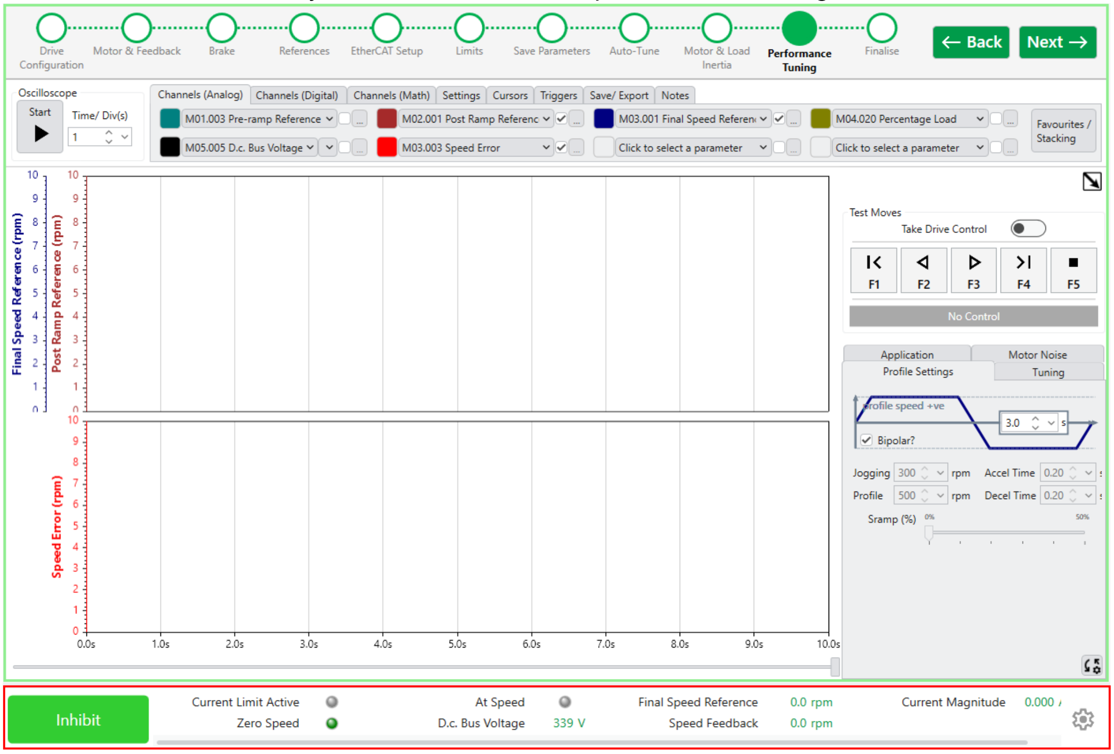
Test move commands – enable the test controls, jog forward / backwards, automatic running as a tuning reference.



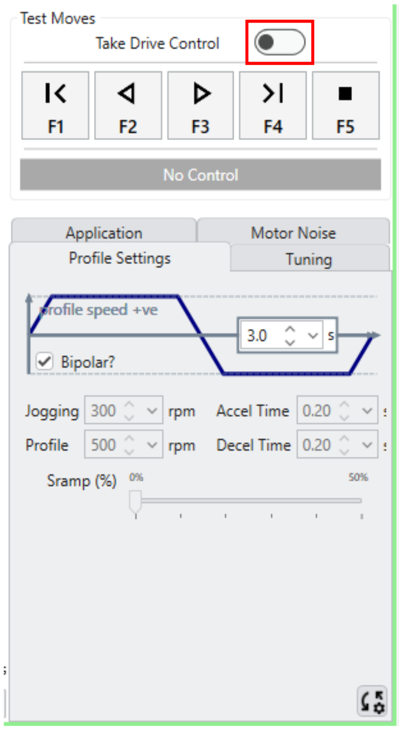
Commissioning tabs – configure the test move motion profile, speed and position loop tuning, application optimisation controls, and noise optimisation controls.



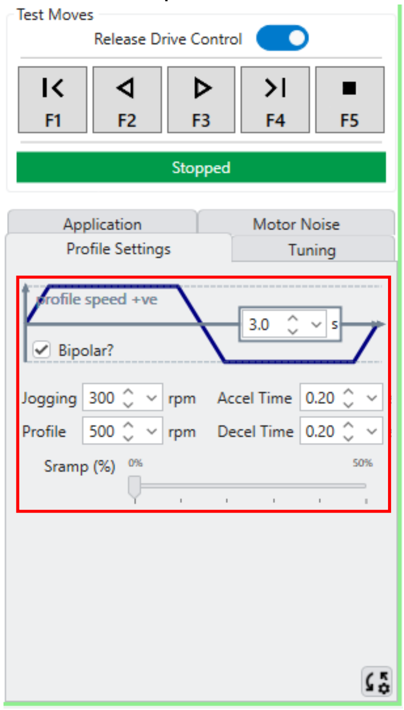
Status control – Shows key values, drive status, trip data and resetting.



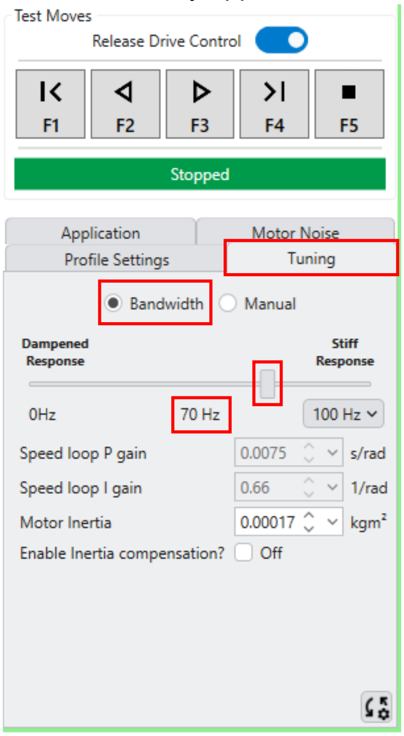
6. Begin commissioning by jogging the axis (slowly) to determine if the motor direction is correct for the application. Ensure it is safe to move the motor. Click on “Take Drive Control” and then apply 24V to the STO input.



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.

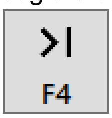


Select the Tuning tab, and then select “Bandwidth” mode. This will give moderate tuning suitable for many applications, with headroom to increase the gains further if required.

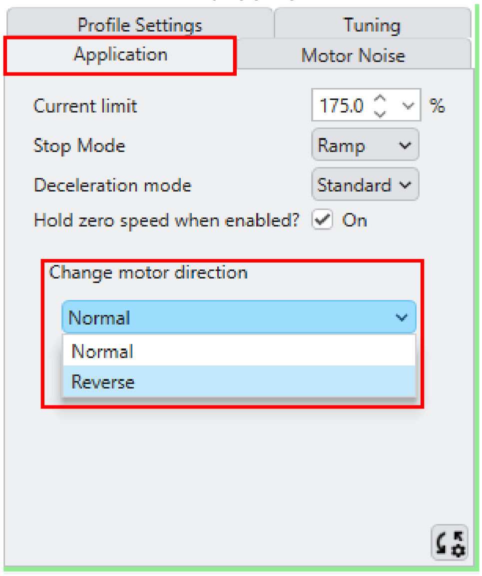


Start the oscilloscope by pressing the Oscilloscope start/stop button.

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

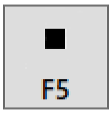


Verify that the movement is stable and that the forward direction of rotation is correct for the application. If the movement is unstable, modify the tuning slider until the desired performance is achieved. If the motor is turning the wrong way when jogging forward, remove 24V from the STO Input, select 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.

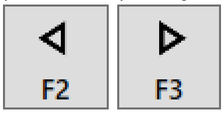


7. If the application axis has hardware limit switches connected, test them by jogging into them gently and prove that the axis stops and that the switches have been connected to the correct terminals.

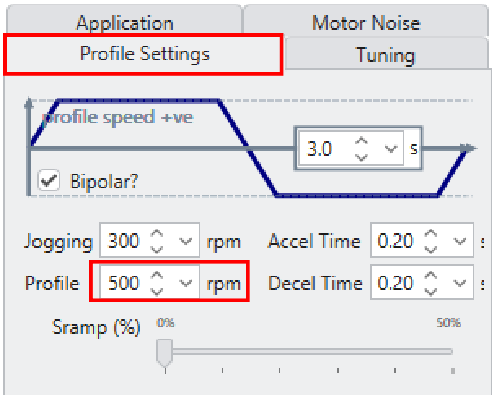
8. Verify the step response of the motor and load by enabling automatic running. Before tuning using these commands make sure that if the axis has physical limits that it is placed in the centre of these limits and that Bipolar mode is selected so that the axis moves back and forth. To stop the axis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



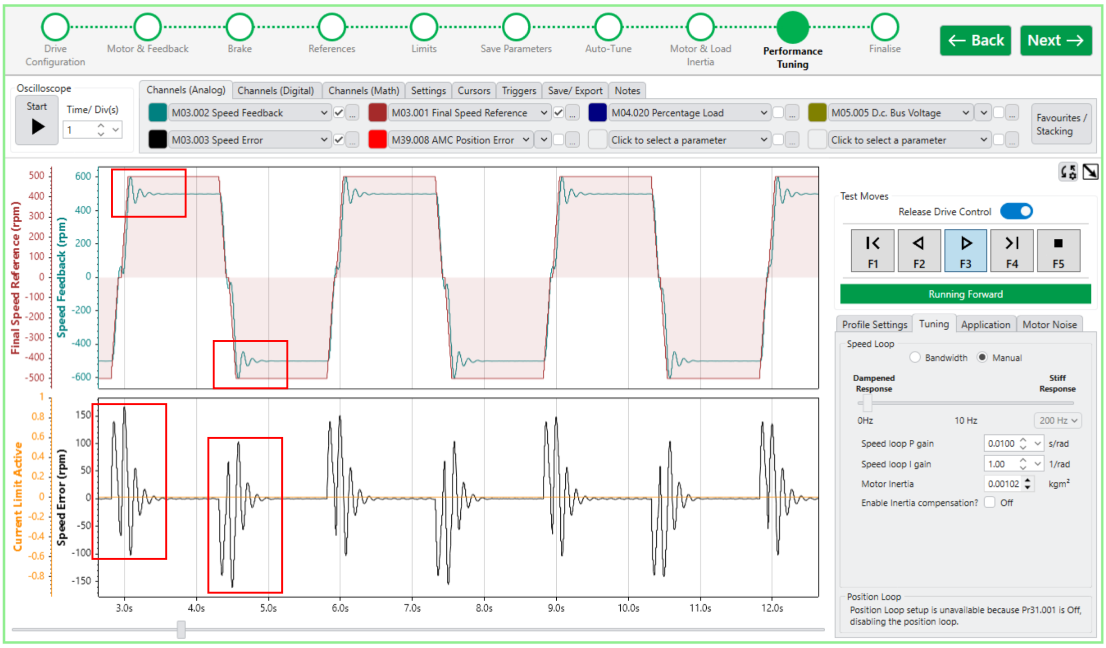
Select the initial direction of travel when automatic running using F2 (backwards) or F3 (Forwards) or by clicking the Run Forwards, Run Backwards buttons:



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.



9. 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:

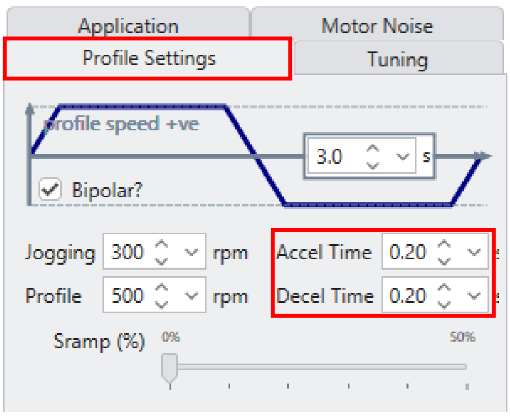


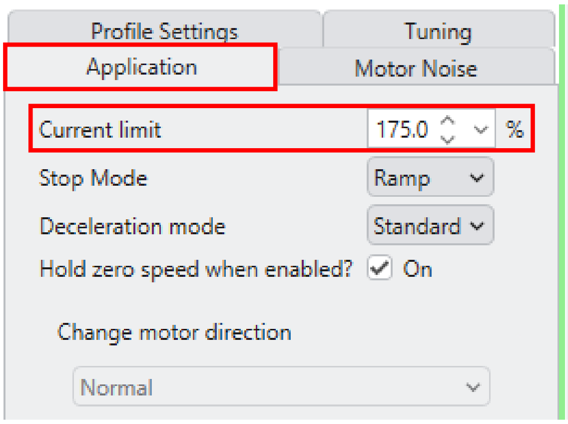
In the previous example trace it can be seen that there is significant speed overshoot caused by the load inertia and default gains. The speed following error shows oscillations when accelerating and decelerating. All of these artifacts can be tuned out easily using "Bandwidth" mode and adjusting the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

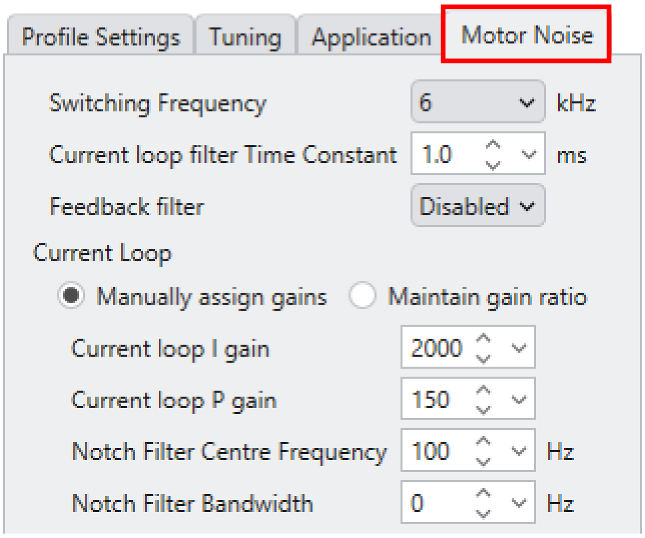
From the previous trace it can be seen that there is no significant speed overshoot, the speed following error isn't oscillating, and the drive isn't going into current limit.

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. If the motor is sounds noisy with the tuned values select the "Motor Noise" tab:



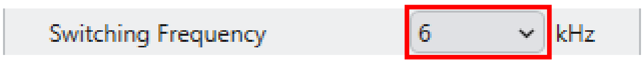
For most applications it is recommended to use a Current Loop Filter Time Constant of 1.0ms, unless the application is ultra-dynamic and needs a very fast response where a lower value is needed. A 1.0ms filter gives a 159Hz response bandwidth, where most systems will be well tuned at between 50Hz and 100Hz.

This helps in the following situations:

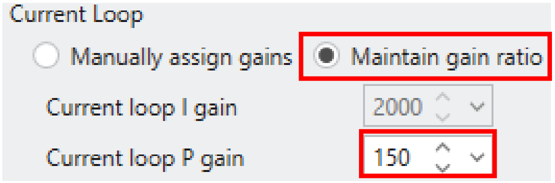
- The speed reference or speed feedback contains a noise component e.g. if the feedback device is of low resolution.
- If the speed loop gains have been raised to the point where the motor noise has become unacceptable, and the required speed loop performance hasn't been reached.
- The application often runs with a low motor speed where encoder quantisation noise is an issue.
- There is mechanical resonance affecting the feedback.

The filter frequency bandwidth with time is 1.0ms = 159Hz, 0.9ms = 177Hz, 0.8ms = 199Hz, 0.7ms = 227Hz, 0.6ms = 265Hz, 0.5ms = 318Hz, 0.4ms = 398Hz, 0.3ms = 530Hz, 0.2Hz = 795Hz, 0.1ms = 1592Hz.

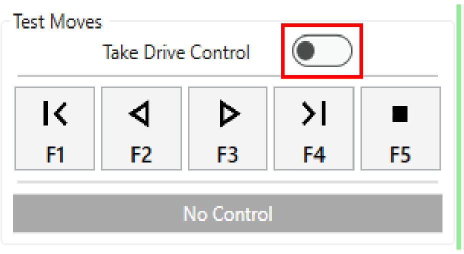
Provided the drive and motor is rated for a higher switching frequency, increasing the switching frequency can reduce audible noise from the motor.



If the motor has a continuing 1kHz tone after the adjusting the switching frequency and the current loop filter, the noise can be improved by making a small reduction in the Current loop P Gain with “Maintain Gain Ratio” selected to keep the balance between the current loop P and I gains.

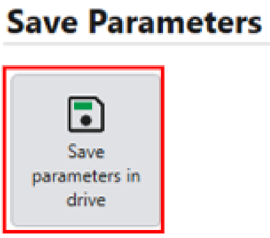


11. This stage of the tuning is complete. Further tuning may be required later to fully optimise the speed loop and position loop when the TwinCAT program provides the motion reference to the drive over EtherCAT PDO. Disable the drive by removing 24V from the STO input, and then disable the test move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



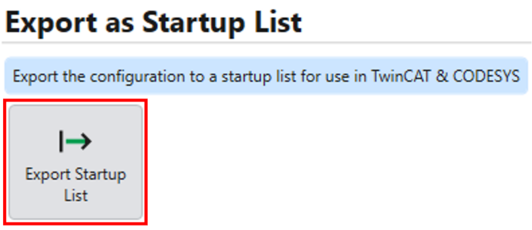
Click Next to move to the “Finalise” page.

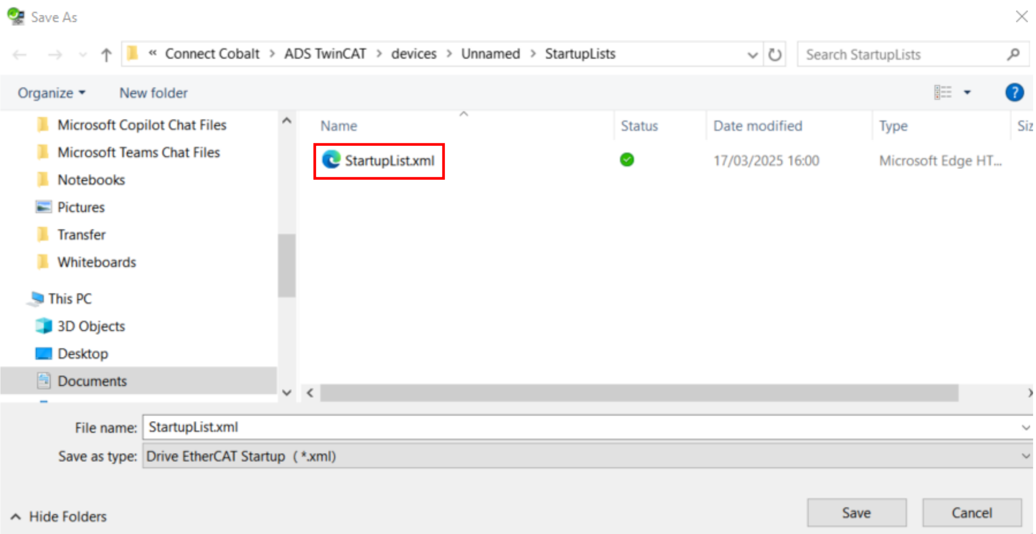
12. Save the tuned parameters in the drive by clicking the “Save Parameters” button:



13. 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.

    It is recommended to perform this after the application software has been written and the position loop has been tuned.

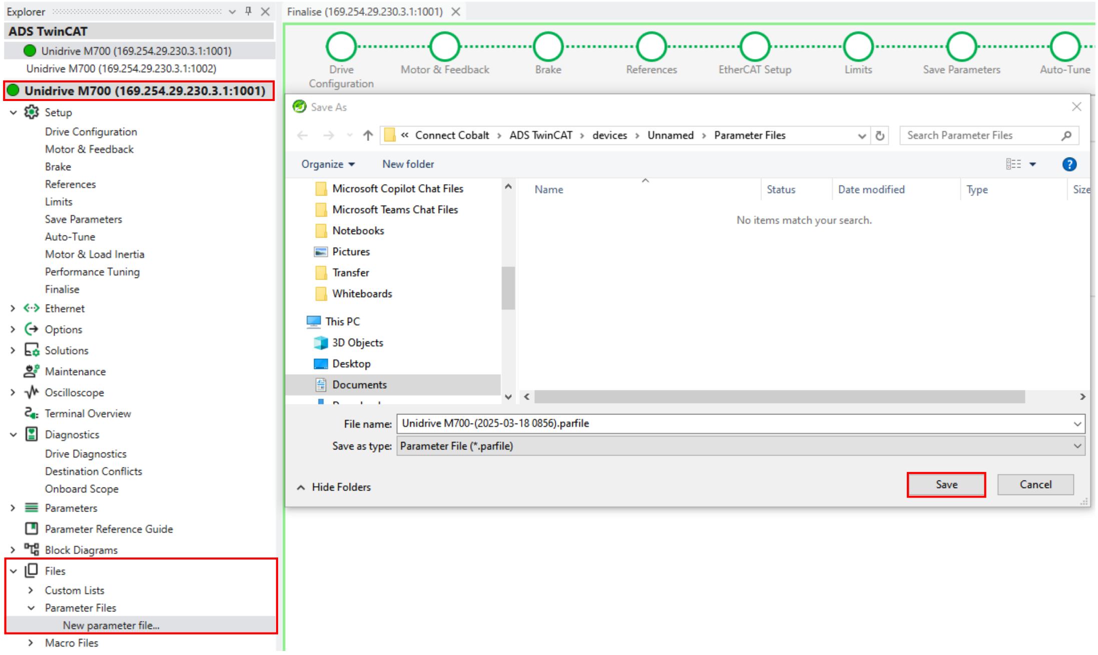
    StartupList.xml is stored in the following location: C:\Users\[USER NAME]\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists.

    See section **10.8 How to use a startup list in TwinCAT** for more information

14. 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 few standard ways in which this feature is used:

    - 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.
    - 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.

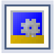
15. It is advised to make a parameter file once tuning has been completed by selecting "Files" > "Parameter Files" > "New parameter file…". This file preserves the final setup of the drive, regardless of what happens to the Connect project later on, and forms a useful future reference of the configuration. 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.



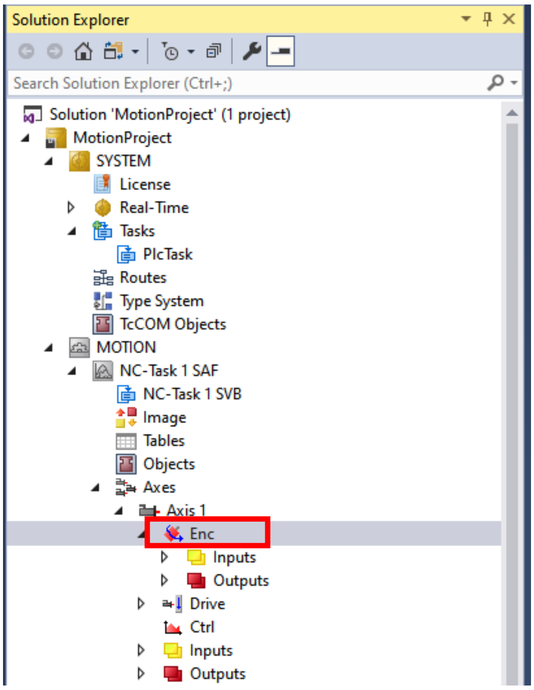
7 TwinCAT Axis Configuration

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**.

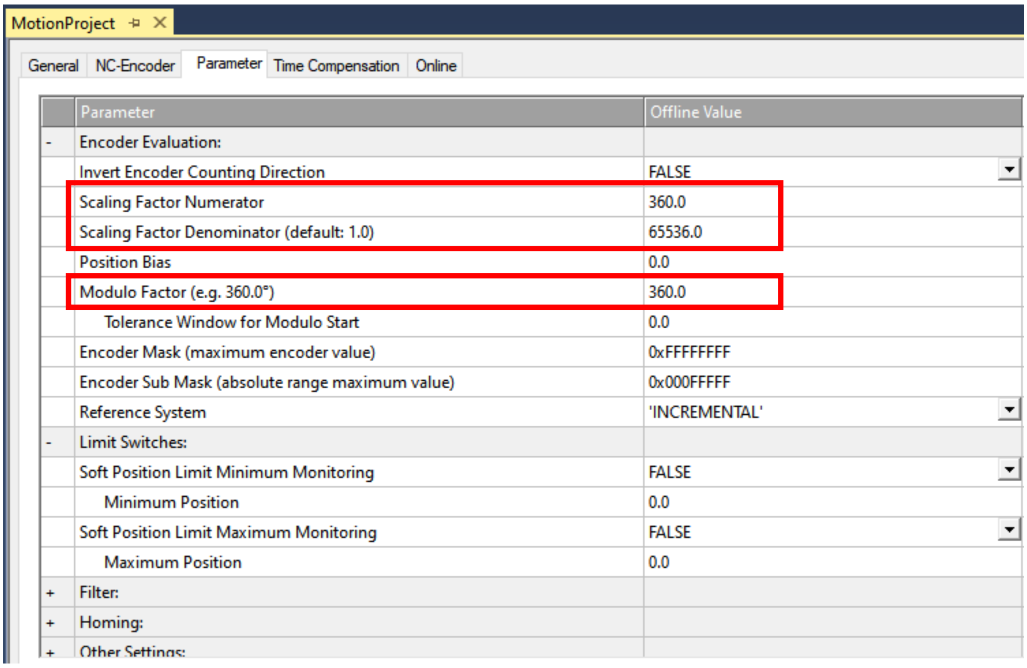
1. Put the IPC /PLC into configure mode by pressing the config mode button.



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”:

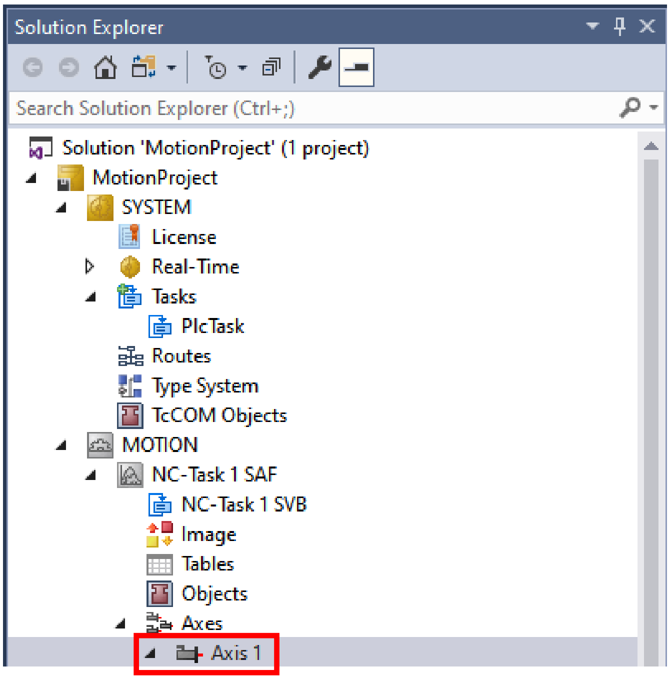


3. The Encoder setup appears. Select the “Parameter” tab. “Scaling Factor Numerator” defines the number of Units represented by the number of encoder counts defined by “Scaling Factor Denominator”. See section **10.4 How to setup axis unit scaling** for more information on how to scale the NC axis units.

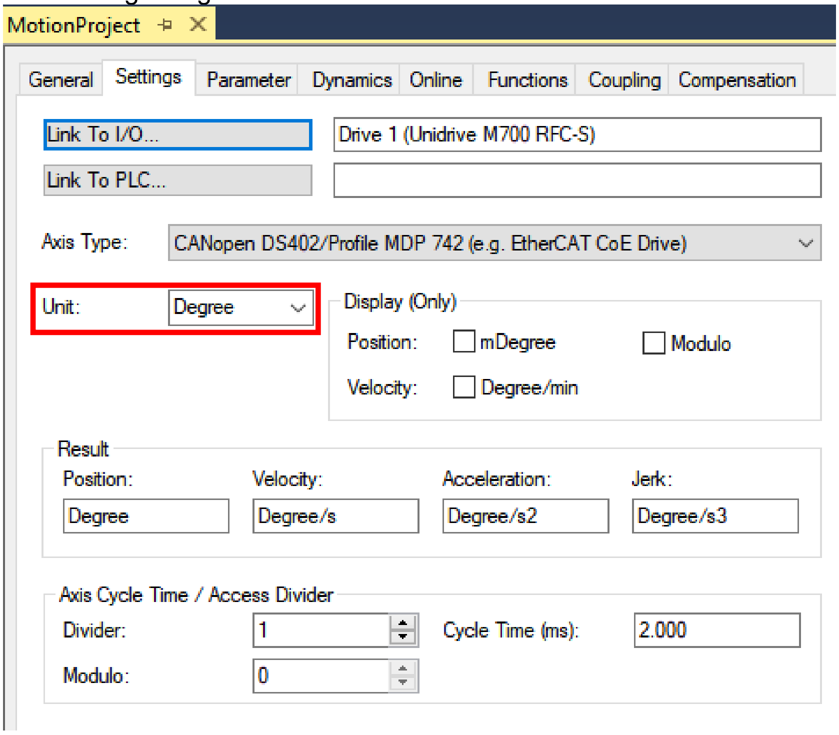


In the example above for 360° there are 65536 counts, so for 1 revolution in encoder counts we have 360°. Other configuration for things like software limits and DS402 Homing are on this tab if needed. The modulo factor only needs to be set if the axis is going to do some modulo positioning using MC_MoveModulo.

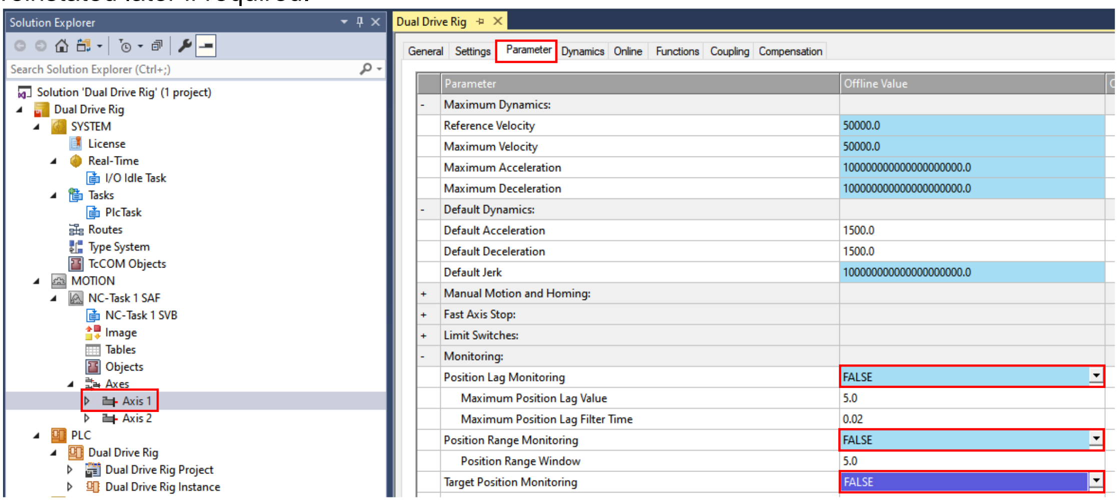
4. Next choose the units that the axis uses. Select “Motion” > “NC-Task 1 SAF” > “Axes” and then double click on “Axis 1”:



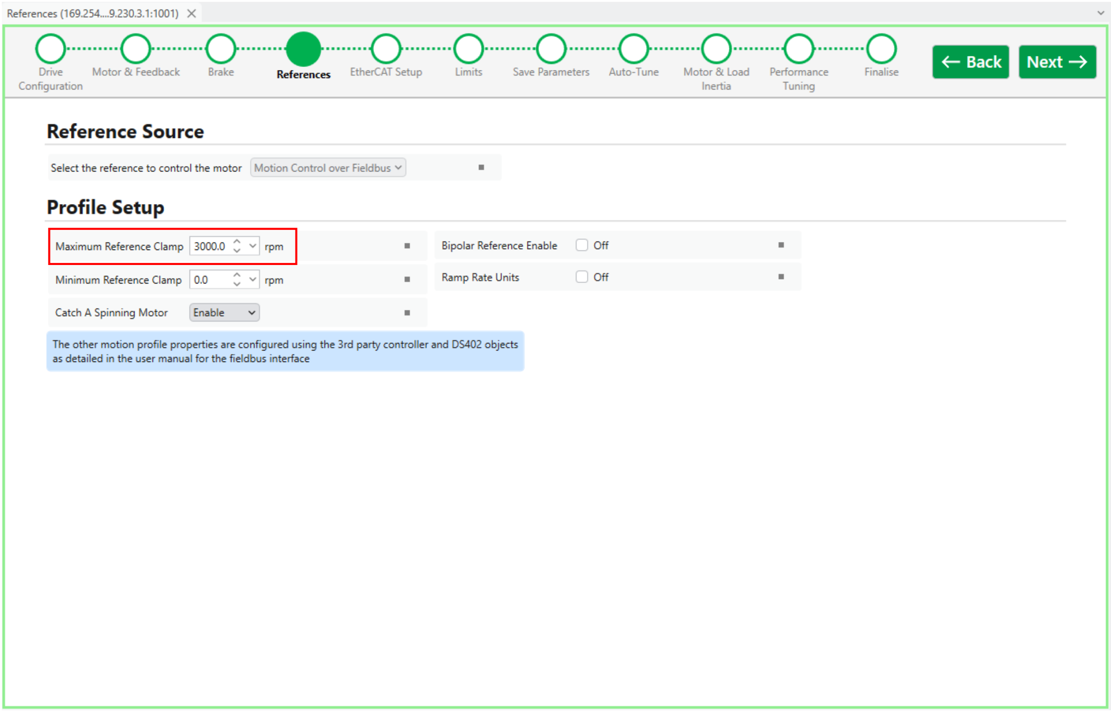
5. The axis setup appears. Select the “Settings” tab, and then change the unit type to something suitable e.g. “Degree”.



6. Turn off the encoder following error limits as these tend to cause nuisanse 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.



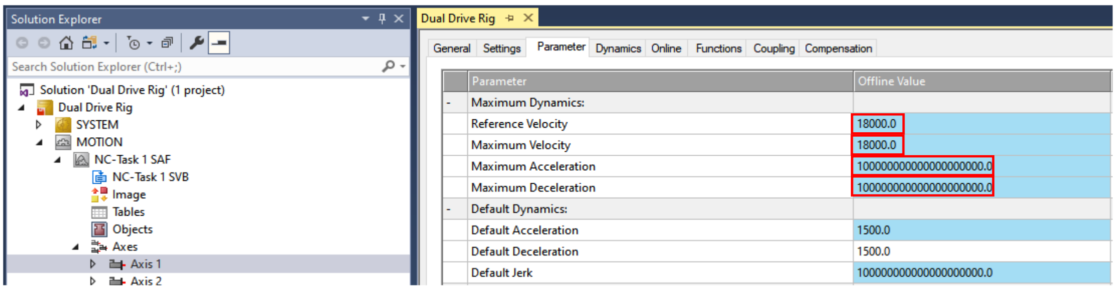
7. Set the maximum dynamics. Typically the “Reference Velocity” and “Maximum Velocity” need to be set to the maximum reference that can be applied to the motor, as shown by Maximum Reference Clamp Pr1.006 or as configured on the “References” page in the Connect guided setup:



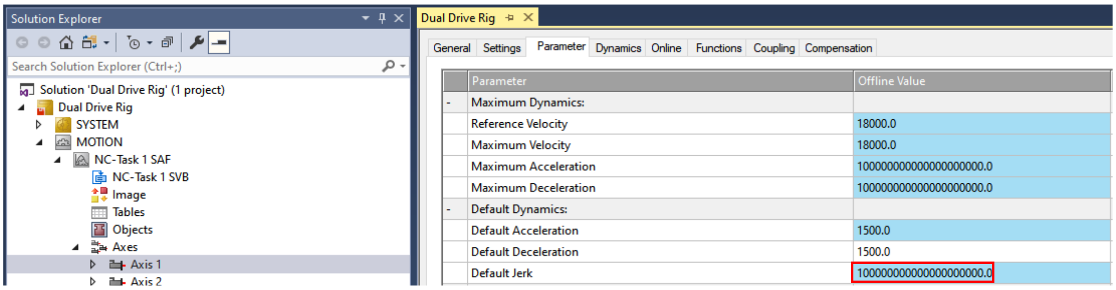
Use the formula provided in section **10.4 How to setup axis unit scaling** to convert the maximum reference speed in rpm into units/s. An example is given below:

> 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.

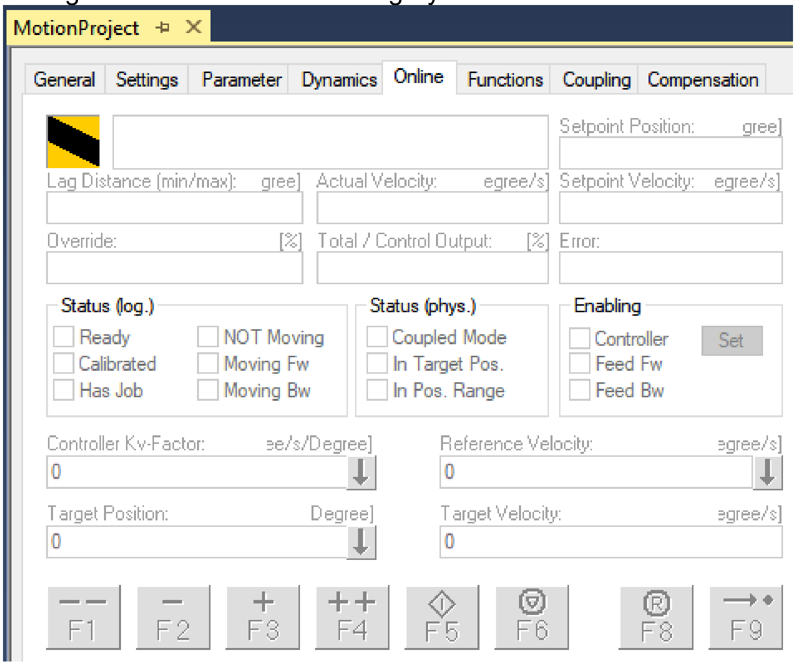


8. Configure the default dynamics for the axis. These are entirely dependent on the specific application. It can be helpful to set the default Jerk to 1E+20, (100000000000000000000), which will invoke a linear acceleration profile if the jerk is left at 0 and will prevent nuisance NC axis errors.

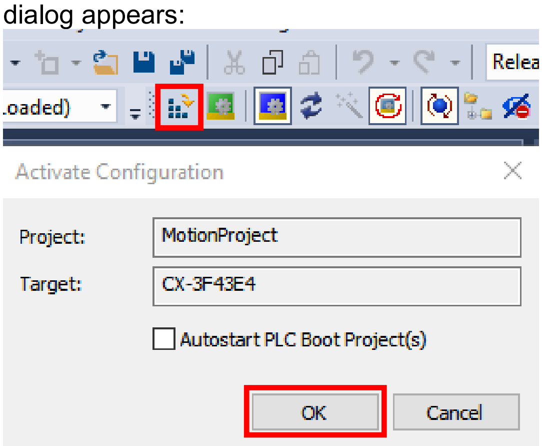


8 Moving the axis using TwinCAT test moves

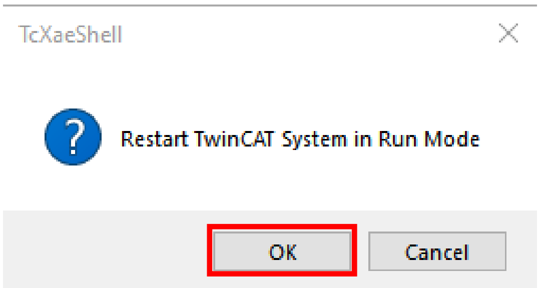
1. Click on the “Online” tab to reveal the test controls. At this point the system will be offline in Config mode so the controls are greyed out.



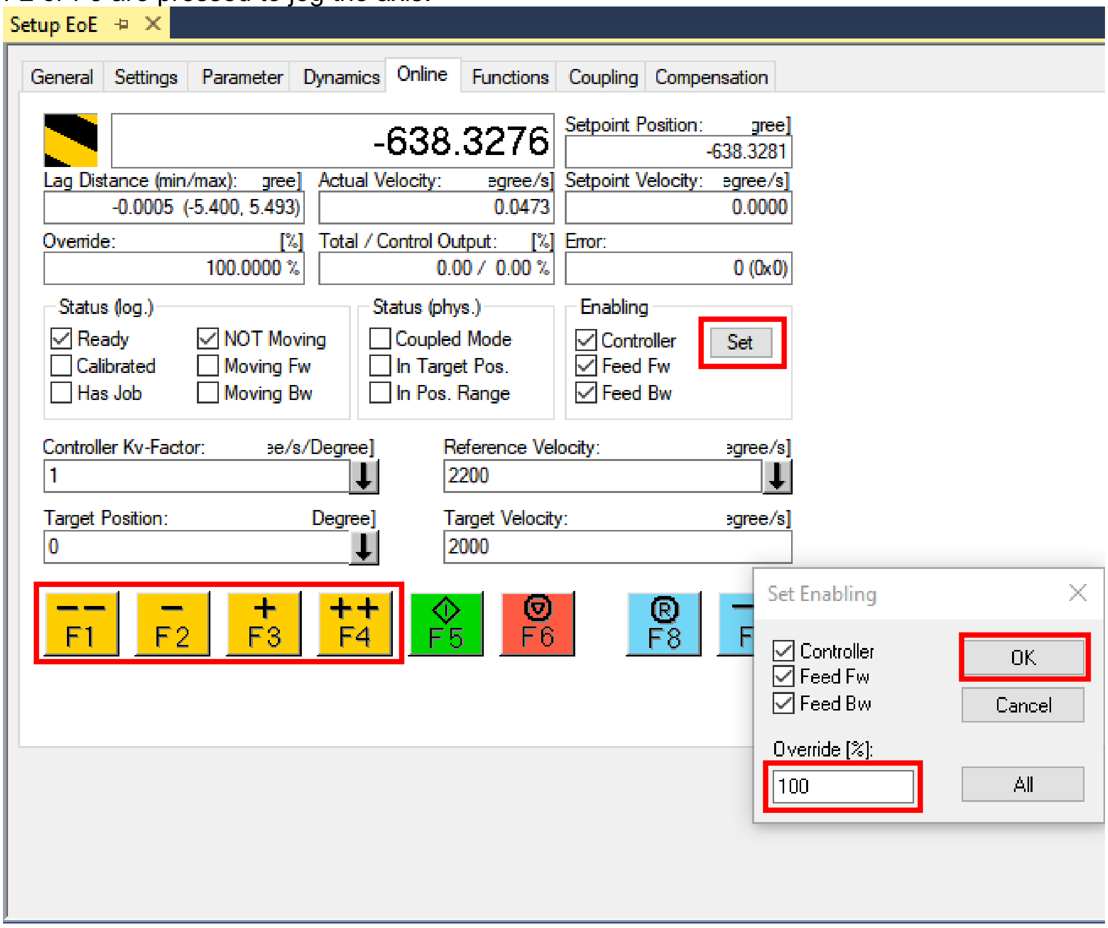
2. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



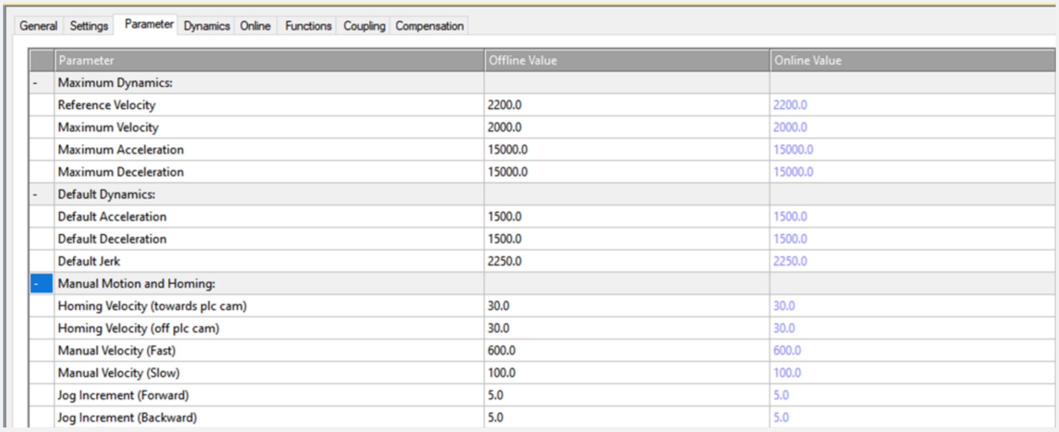
3. Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



4. 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.



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



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.

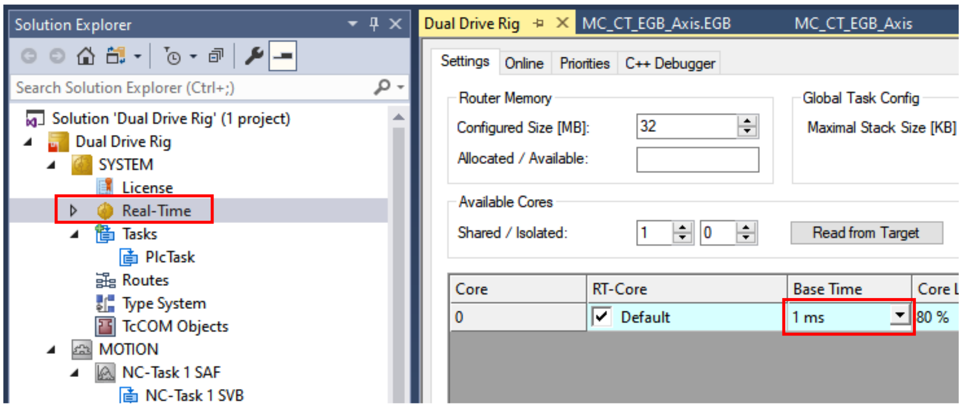
Function	Description
F1	Reverse travel with *Manual Velocity (Fast)*
F2	Reverse travel with *Manual Velocity (Slow)*
F3	Forward travel with *Manual Velocity (Slow)*
F4	Forward travel with *Manual Velocity (Fast)*
F5	Start a direct travel command • Enter the *Target Position* • Enter the *Target Velocity* • 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

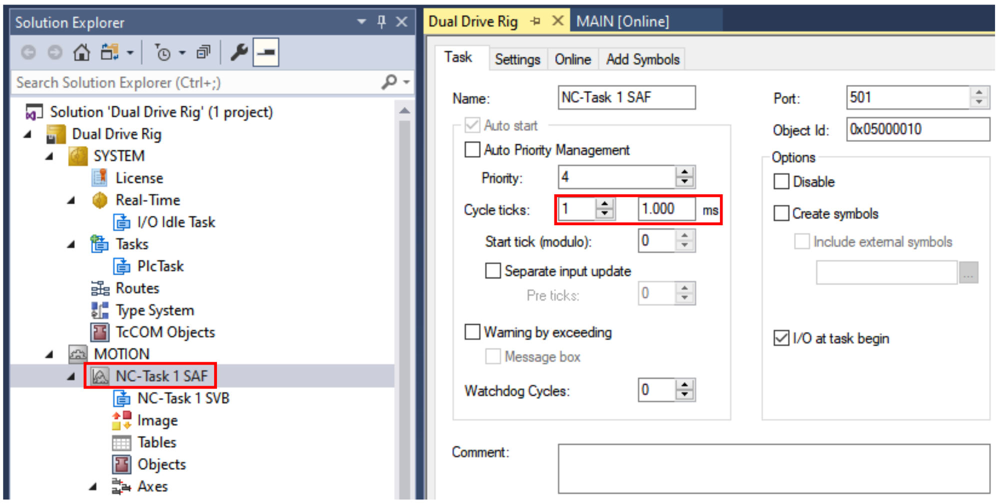
This section describes the basic steps needed to get PLCopen functionality running on a Beckhoff PLC. It is assumed that all the previous steps have been followed and the axis is proven to be working using the test moves control.

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.

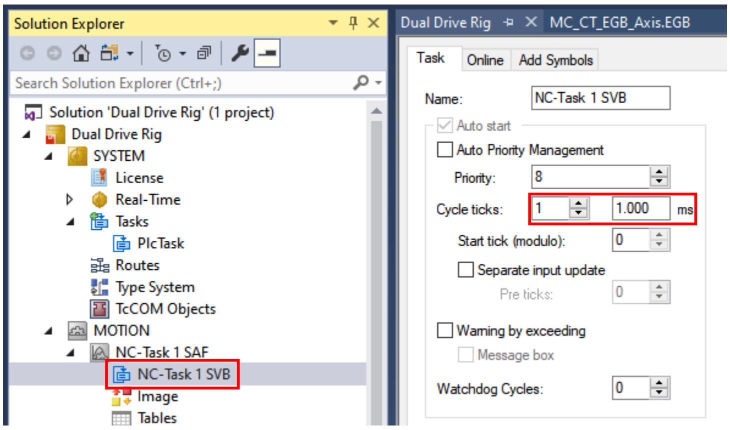
   Set the Base time for real time tasks to 1ms:



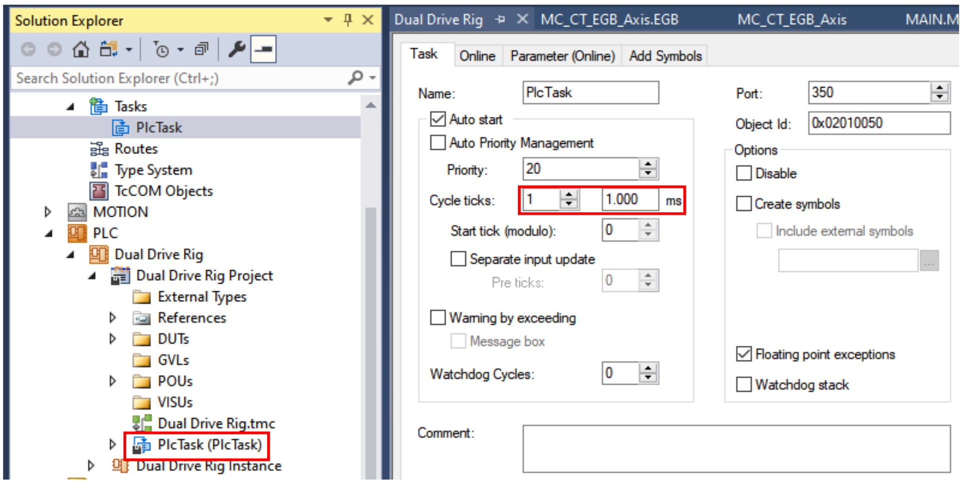
   Set NC-Task 1 SAF to 1ms:



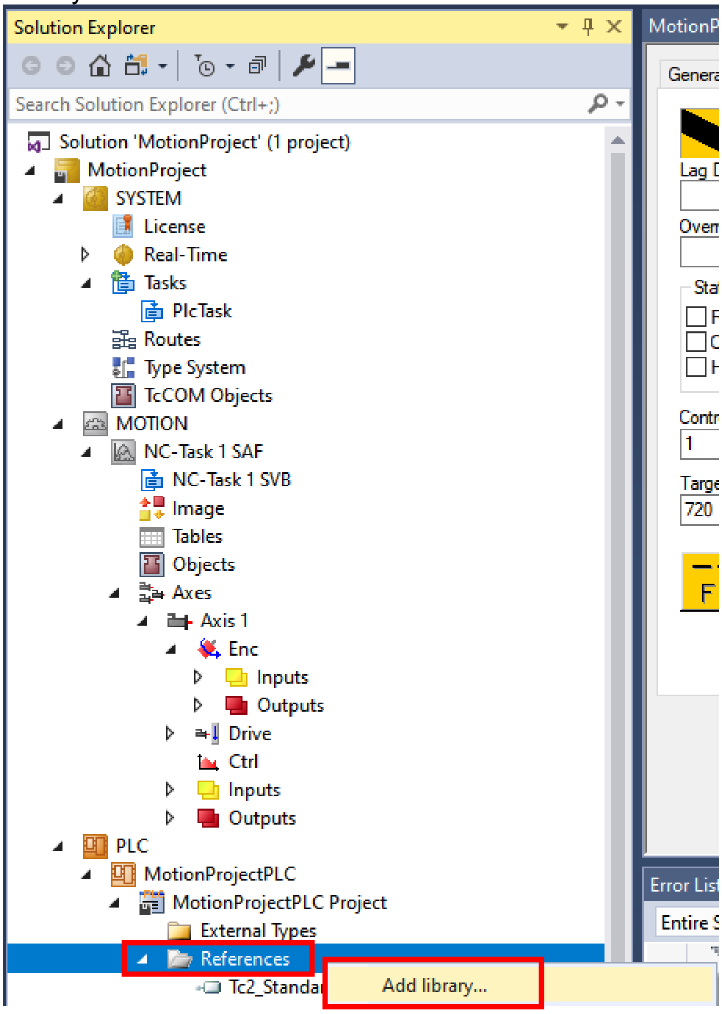
Set NC-Task 1SVB to 1ms:



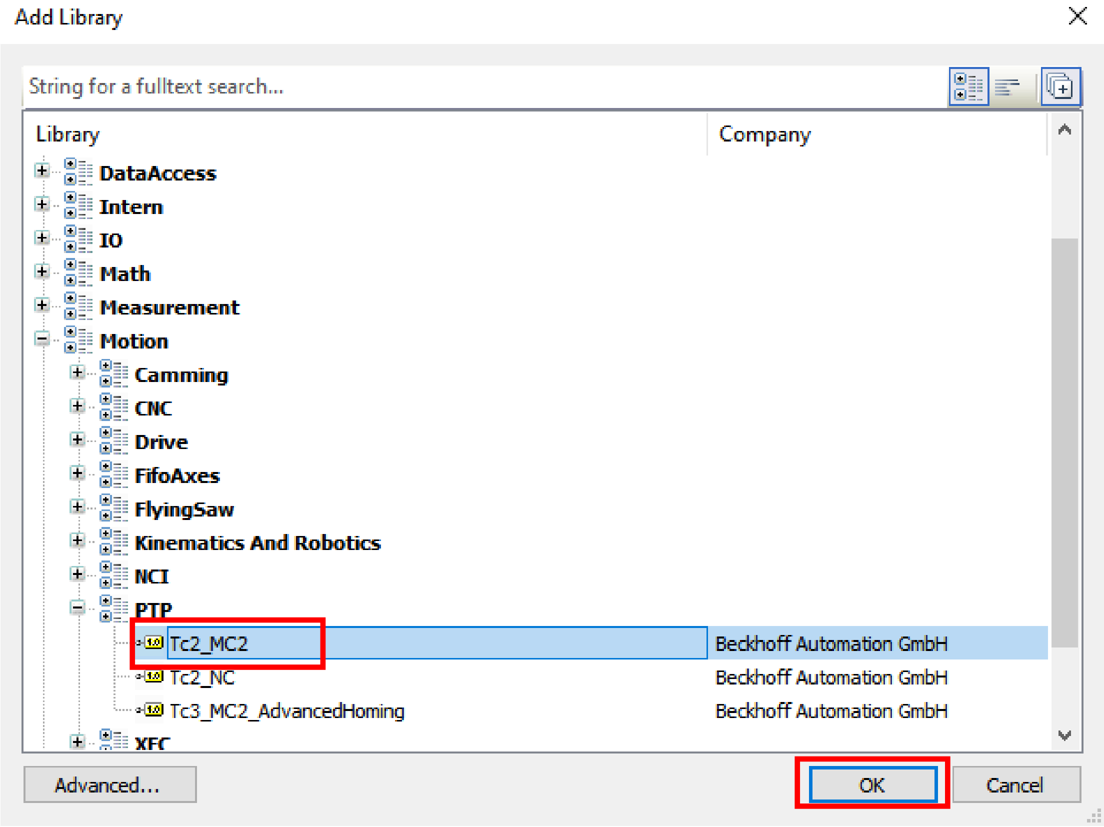
Set the task that the motion code is executed to 1ms:



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..."

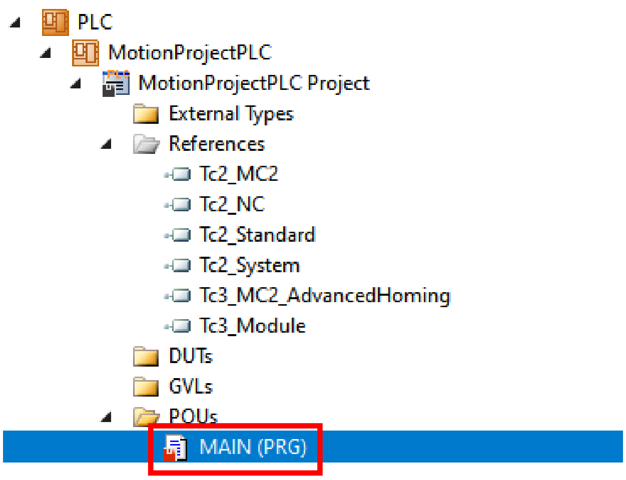


3. Select “Motion” > “PTP” and then highlight “Tc2_MC2” and then click “OK”:

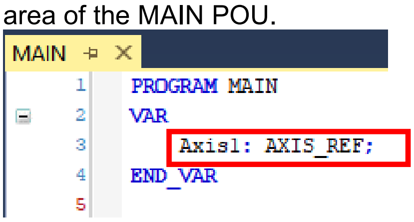


Repeat this process for the other libraries in the “PTP” category.

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

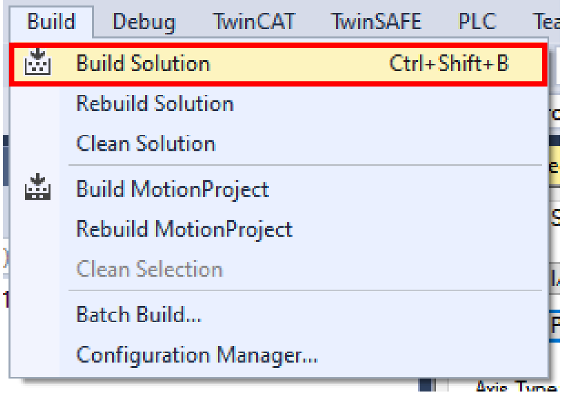


5. In the PLC part of the project add an AXIS_REF. This is the PLCopen axis interface and is referred to in Beckhoff terminology as the “PLC Axis”. Add the following into the declaration area of the MAIN POU.



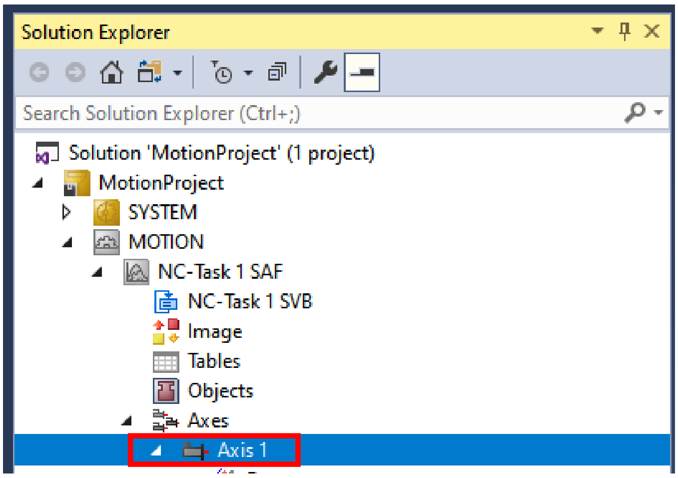
It is best to keep the naming of the axis similar to the project axis.

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

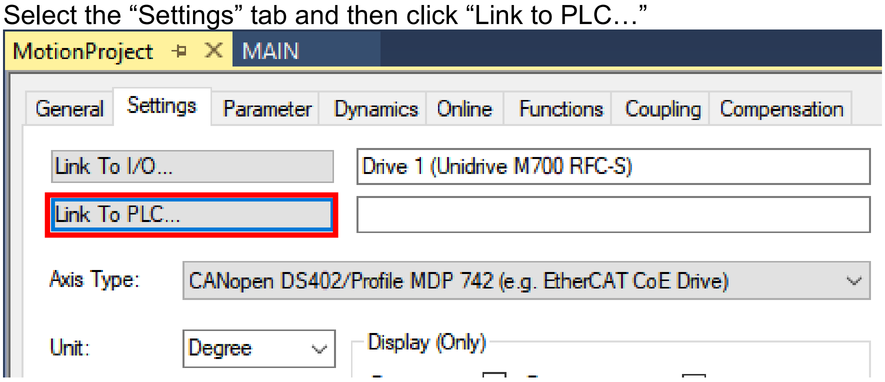


> **HINT:** Failure to do this will result in the PLCopen axis not appearing in the list when linking the PLC Axis to the Motion Axis.

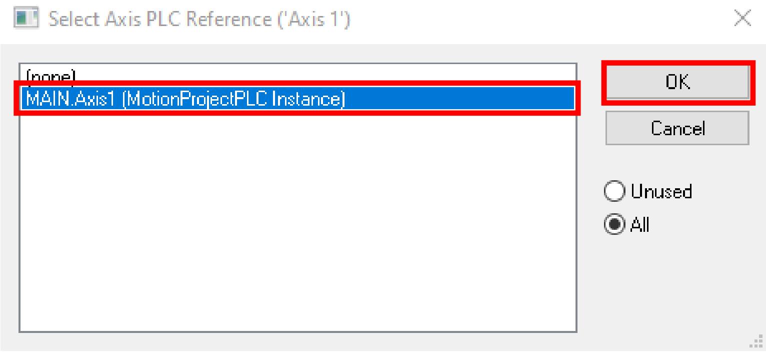
7. Link the PLC Axis to the Motion Axis. Select “Motion” > “NC-Task SAF” > “Axes” and then double click “Axis 1”:



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.

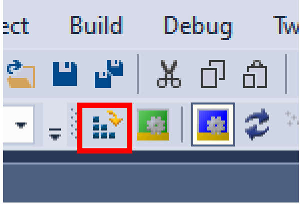
```
MotionProject    MAIN*
PROGRAM MAIN
VAR
    Axis1: AXIS_REF;
    Axis1Power: MC_Power;
    Axis1Status: MC_ReadStatus;
    Axis1Jog: MC_Jog;
END_VAR
```

Next, call the function blocks from the program area:

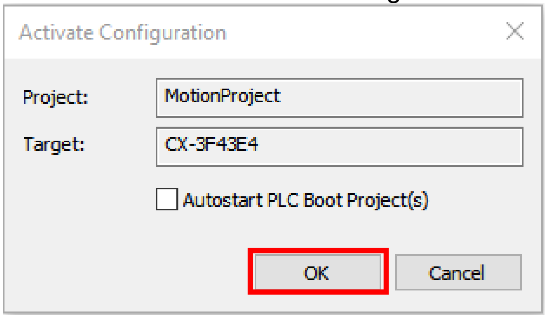
```
Axis1Power(Axis := Axis1);
Axis1Status(Axis := Axis1);
Axis1Jog(Axis := Axis1);
```

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

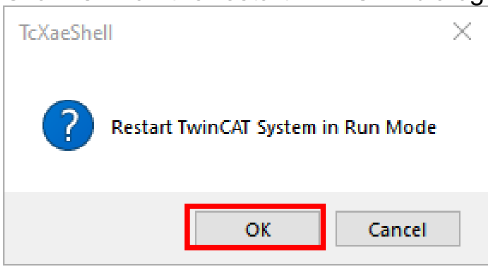
11. Press activate configuration to compile the software, and load it to the target, and set run mode:



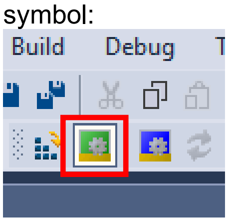
Click “OK” on the “Activate Configuration” dialog



Click “OK” on the restart TwinCAT dialog.

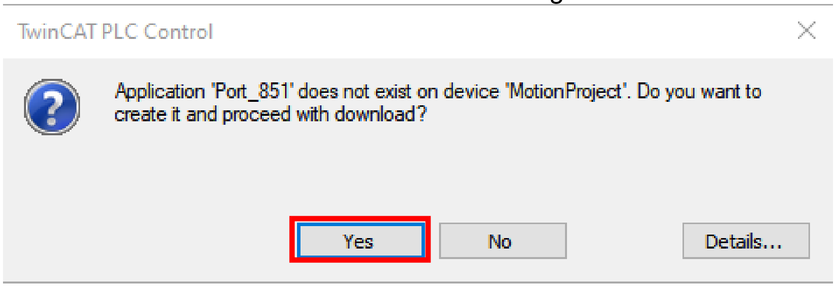


The PLC changes to run mode as shown by the box surrounding the green TwinCAT state symbol:

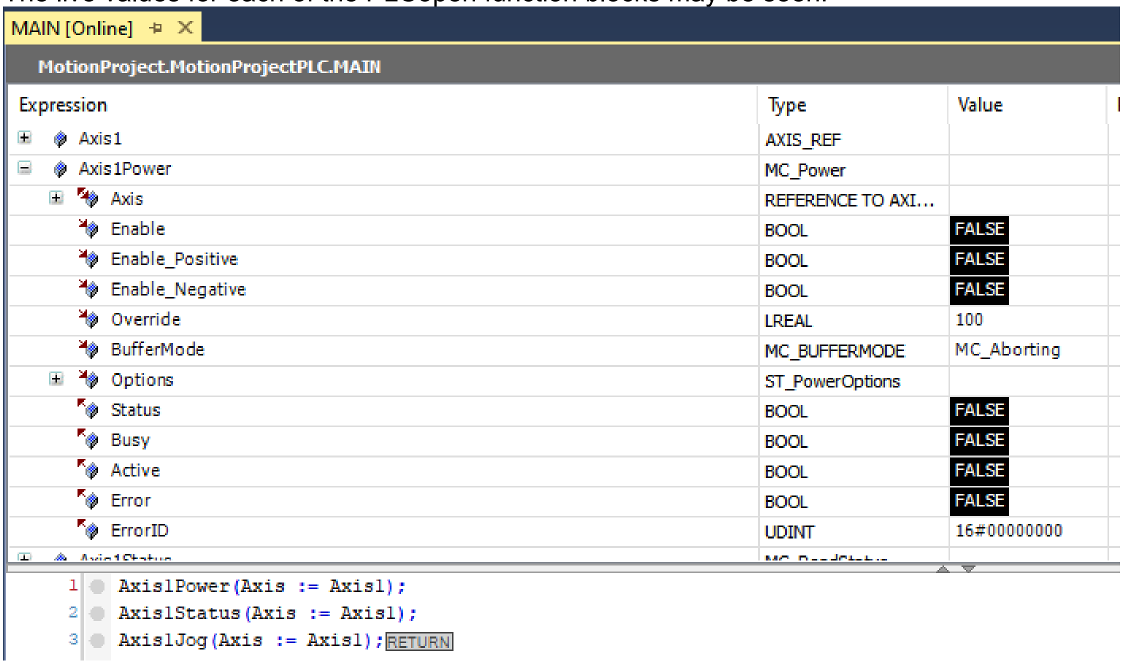


12. Click the login icon to view the code while it runs:

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

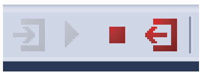


The live values for each of the PLCopen function blocks may be seen:

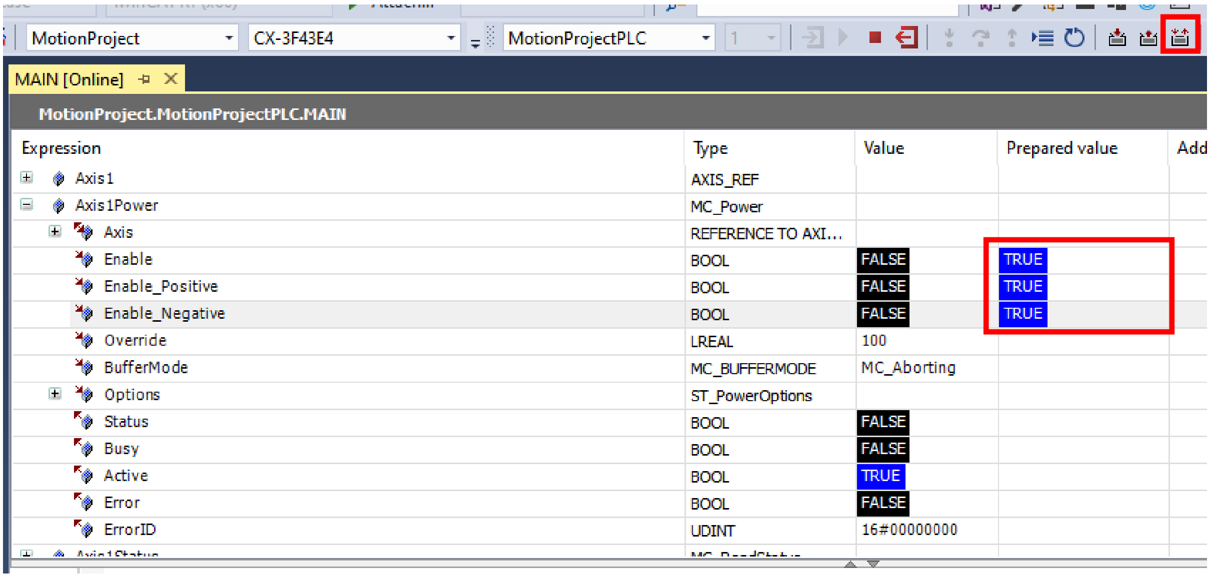


13. Run the application (if it is not already running) by pressing the button.

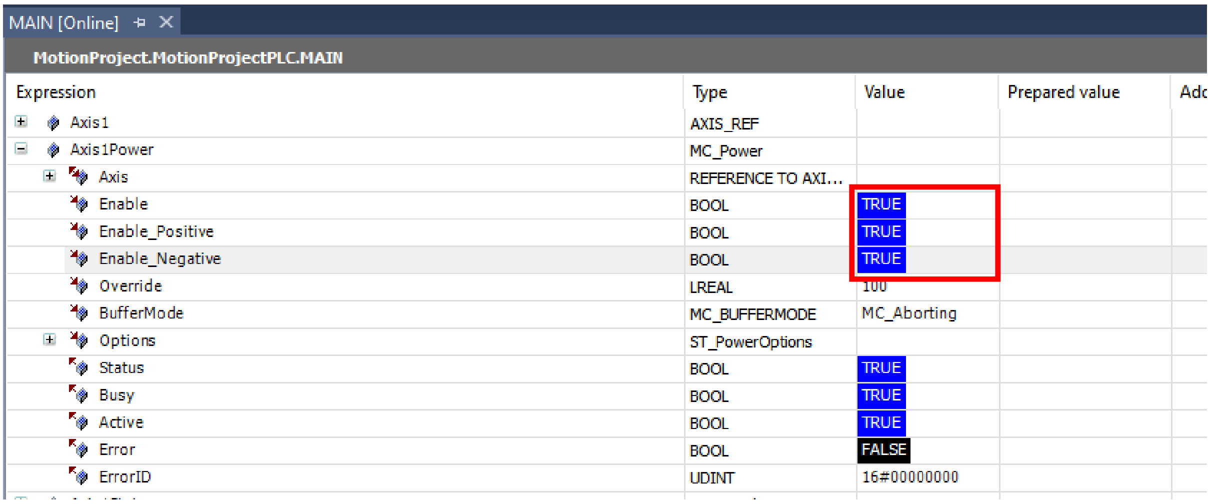
    When the system is running the online tool bar looks like this:



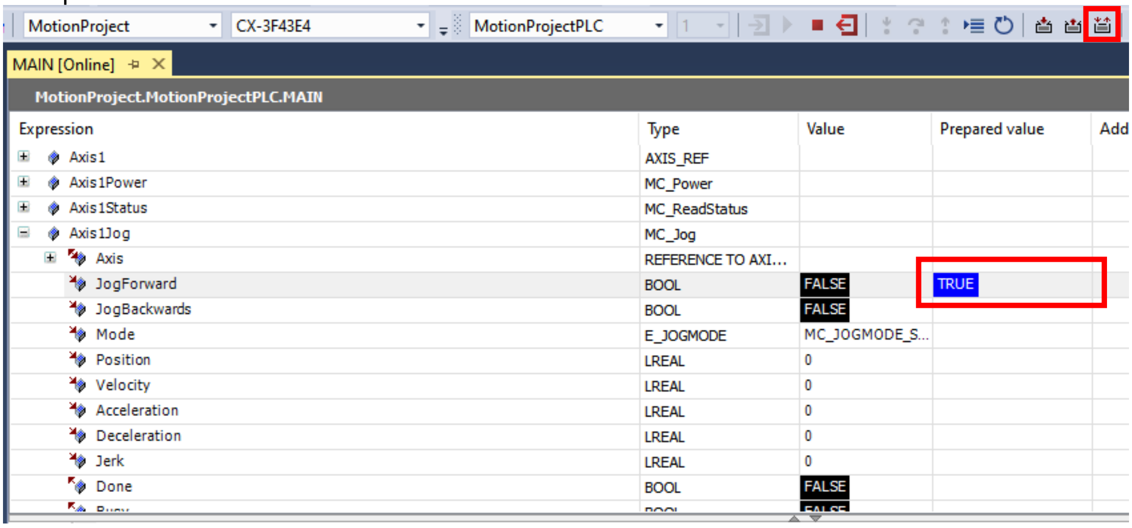
14. To power the axis, apply 24V to the drives STO / Enable input. Expand Axis1Power and then then click in the prepare box to the right of the values of the Enable, Enable_Positive, and Enable_Negative inputs. Press the “Write Values” button or Ctrl+F7 to set the prepared values.



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

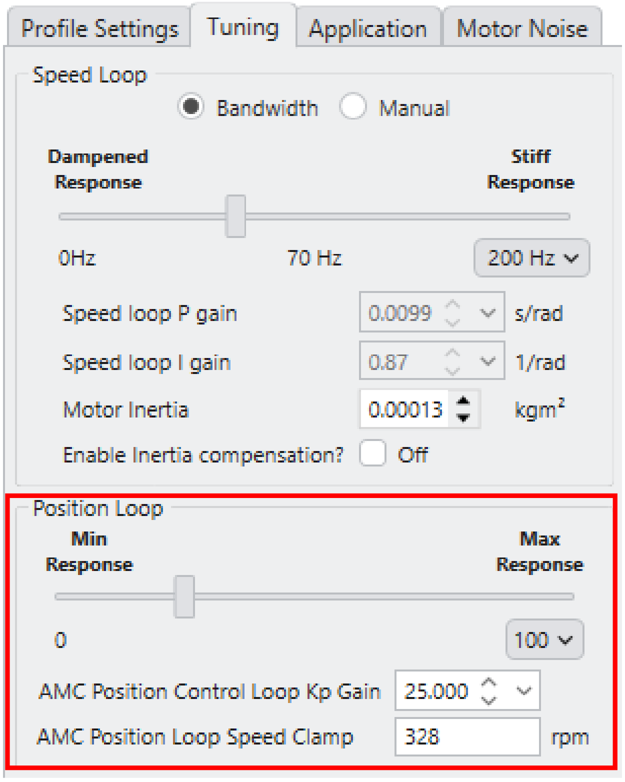


15. The axis may be Jogged by setting the JogForward or JogBackwards bits. If the inputs for Velocity, Acceleration, and Deceleration are left at 0, the default values configured in “Axis 1” > “Parameter” tab. Click in the “Prepared Value” box for JogForward to set it to TRUE and then press the “Write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



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.

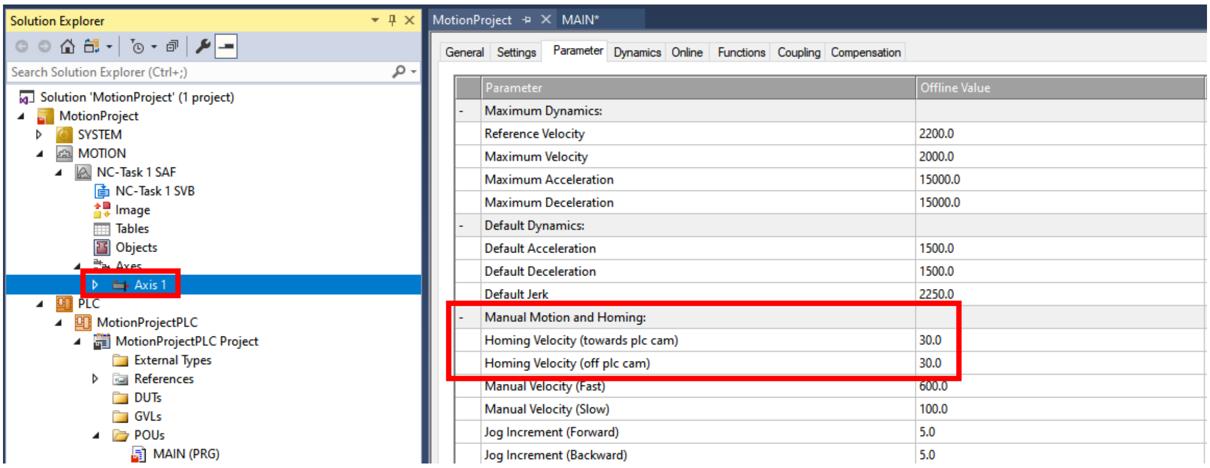
16. When the complete motion system has been programmed, the position loop can be tuned using the worst case working motion profile e.g. one that has the highest acceleration rate and jerk. See section 10.10 How and when to tune the Position Loop.

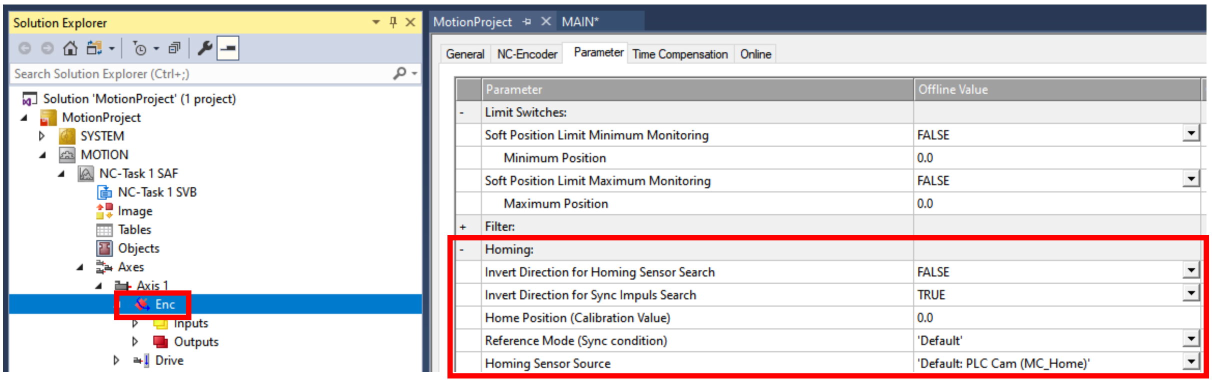


10 How to guides

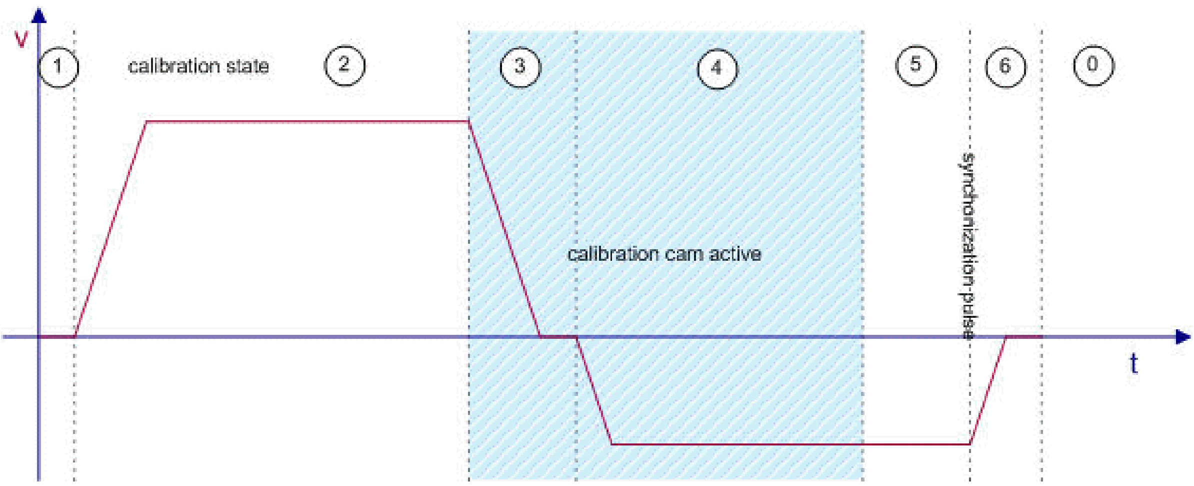
10.1 How to home using MC_Home

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 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.

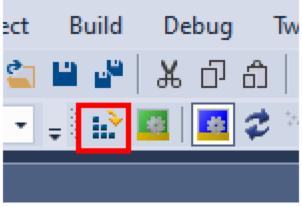
To test the behaviour, use the following steps:

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:

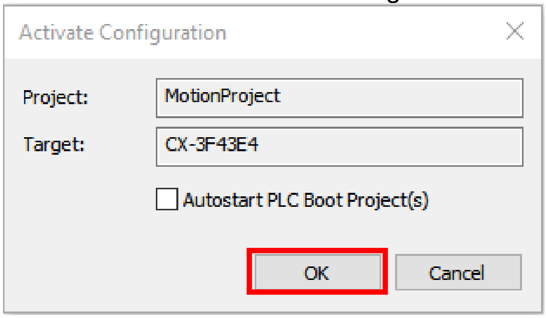
MotionProject | MAIN

```
PROGRAM MAIN
VAR
    Axis1: AXIS_REF;
    Axis1Power: MC_Power;
    Axis1Status: MC_ReadStatus;
    Axis1Jog: MC_Jog;
    Axis1Home: MC_Home;
END_VAR

Axis1Power(Axis := Axis1);
Axis1Status(Axis := Axis1);
Axis1Jog(Axis := Axis1);
Axis1Home(Axis := Axis1);
```

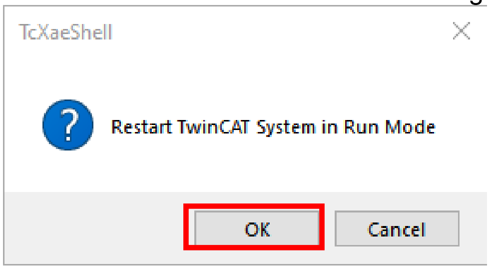
3. Press activate configuration to compile the software, and load it to the target, and set run mode:



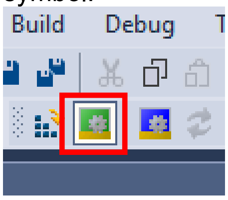
Click "OK" on the "Activate Configuration" dialog



Click "OK" on the restart TwinCAT dialog.

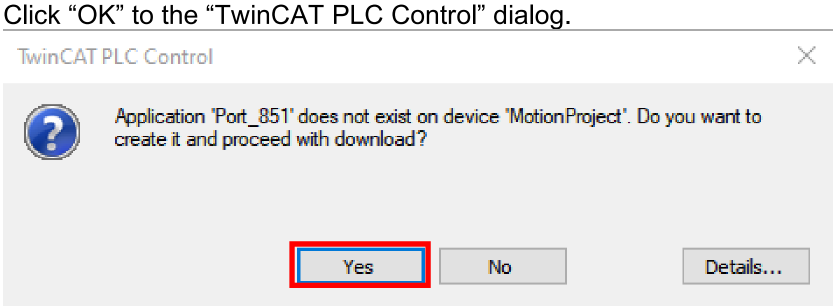


The PLC changes to run mode as shown by the box surrounding the green TwinCAT state symbol:



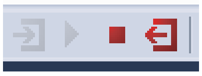
4. Click the login icon  to view the code while it runs:

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

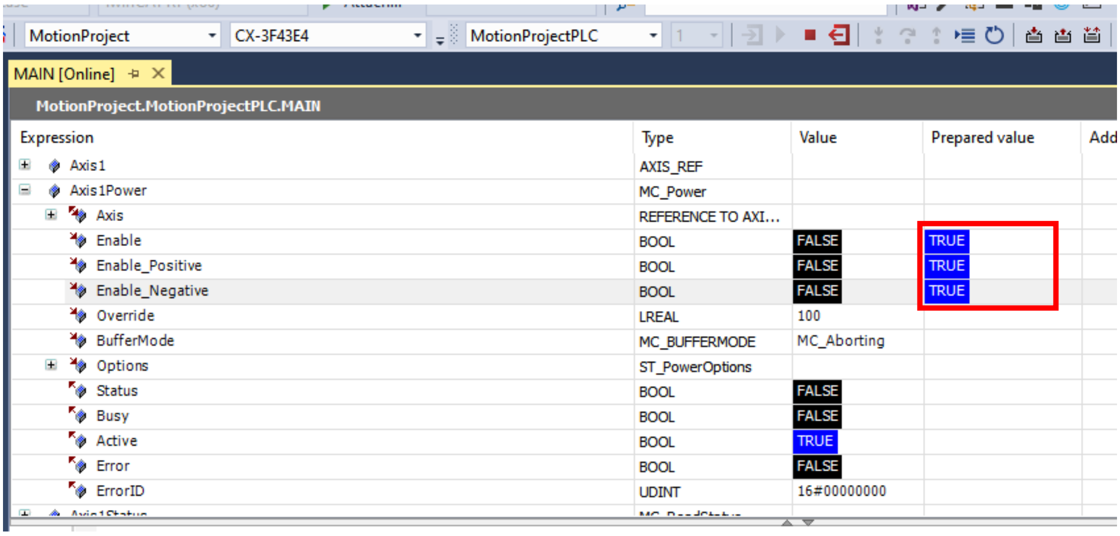


5. Run the application (if it is not already running) by pressing the  button.

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

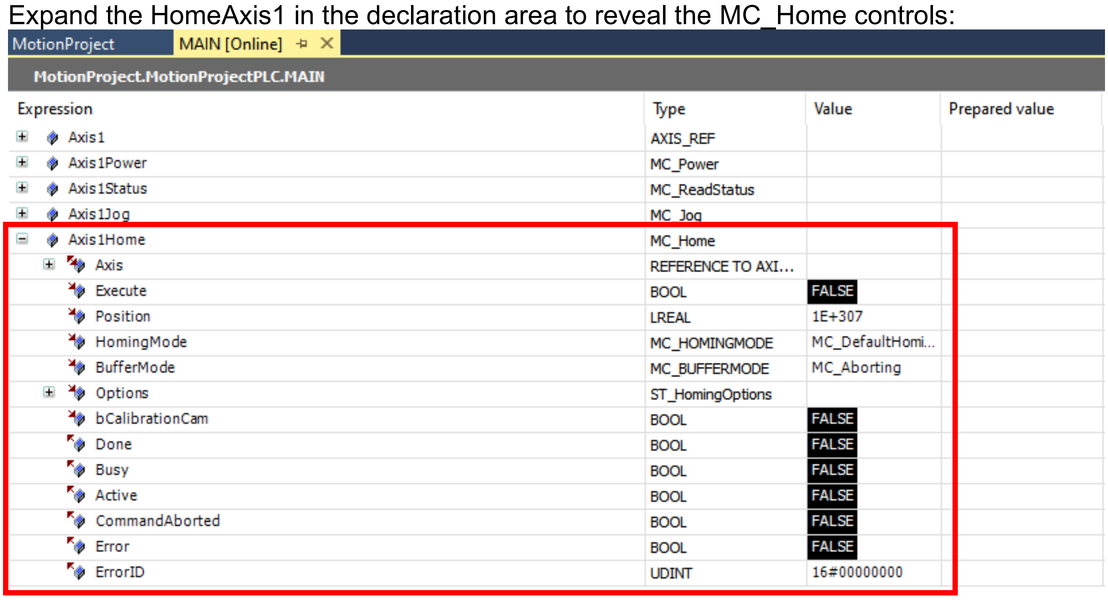
   

6. To power the axis, apply 24V to the drives STO / Enable input. Expand Axis1Power and then then click in the prepare box to the right of the values of the Enable, Enable_Positive, and Enable_Negative inputs. Press the “Write Values” button  or Ctrl+F7 to set the prepared values.



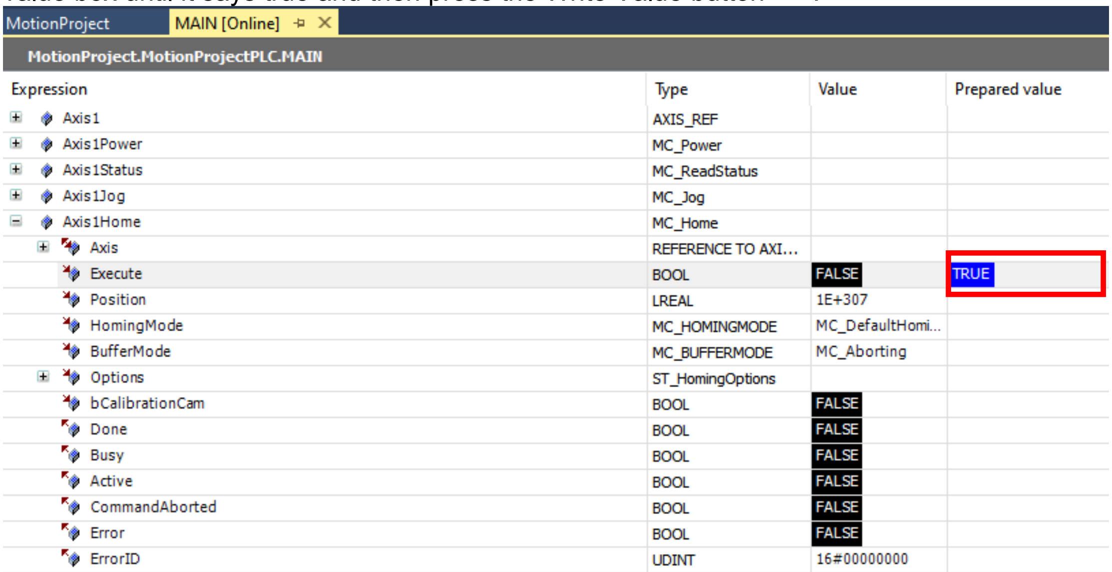
Expression	Type	Value	Prepared value	Add
Axis1	AXIS_REF			
Axis1Power	MC_Power			
Axis	REFERENCE TO AXI...			
Enable	BOOL	FALSE	TRUE	
Enable_Positive	BOOL	FALSE	TRUE	
Enable_Negative	BOOL	FALSE	TRUE	
Override	LREAL	100		
BufferMode	MC_BUFFERMODE	MC_Aborting		
Options	ST_PowerOptions			
Status	BOOL	FALSE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

7. 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		
Axis	REFERENCE TO AXI...		
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 :

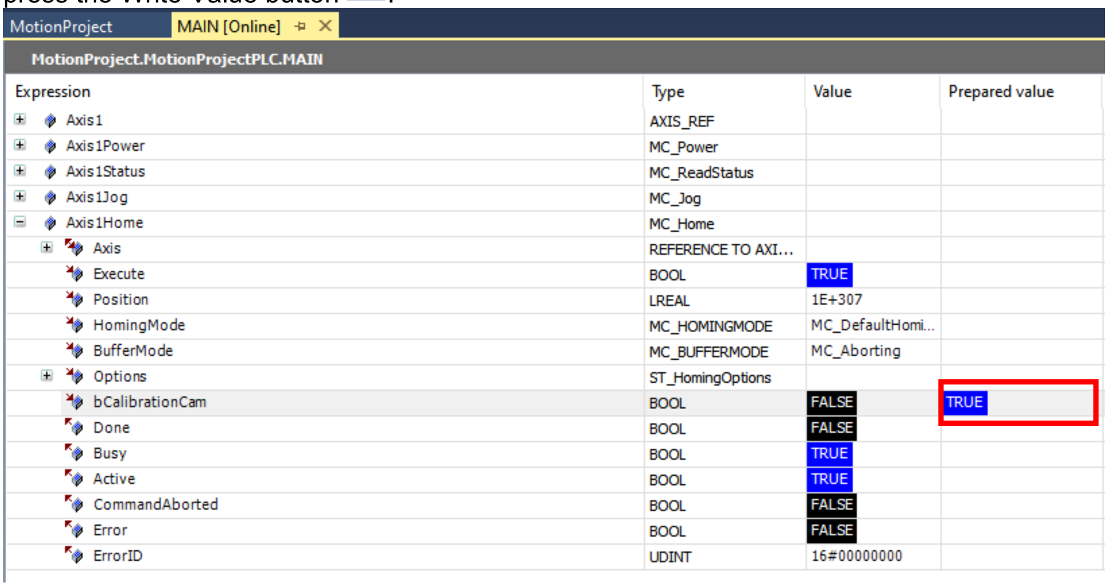


MotionProject | MAIN [Online]

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 :

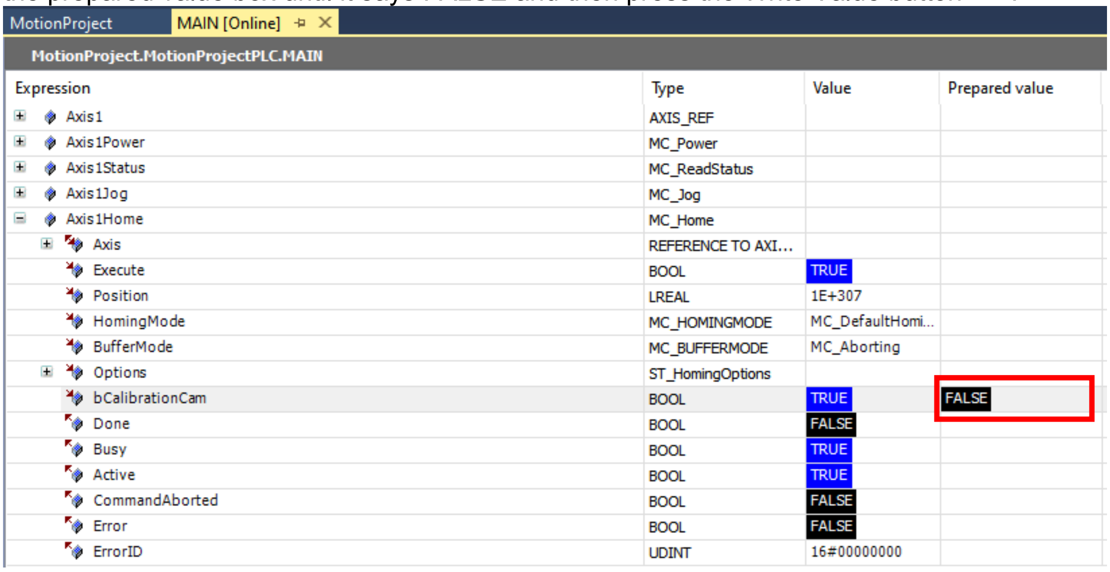


MotionProject | MAIN [Online]

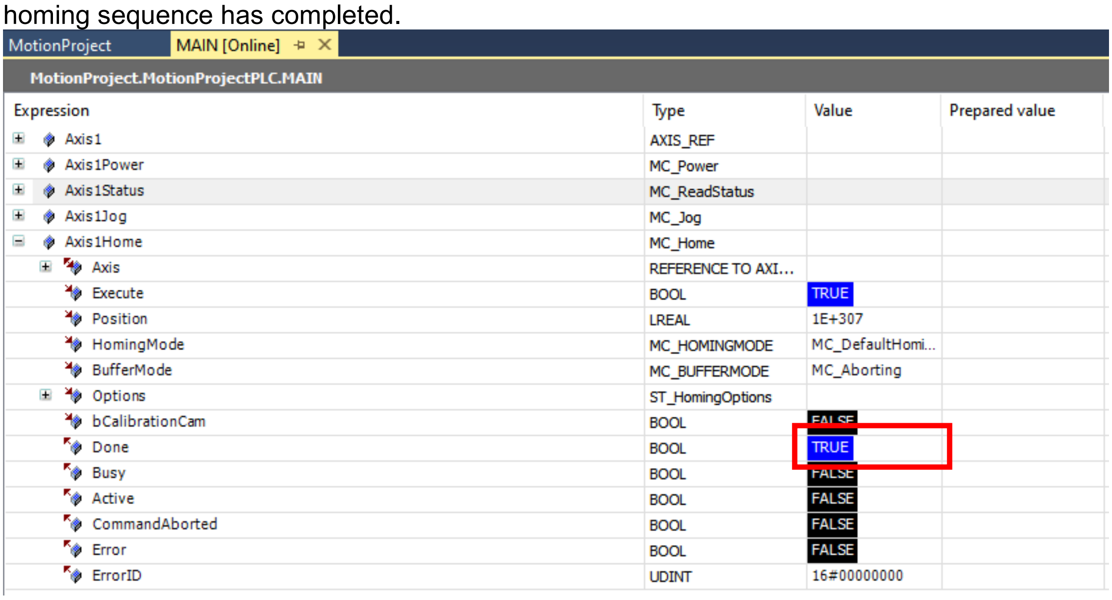
MotionProject.MotionProjectPLC.MAIN

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 :



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



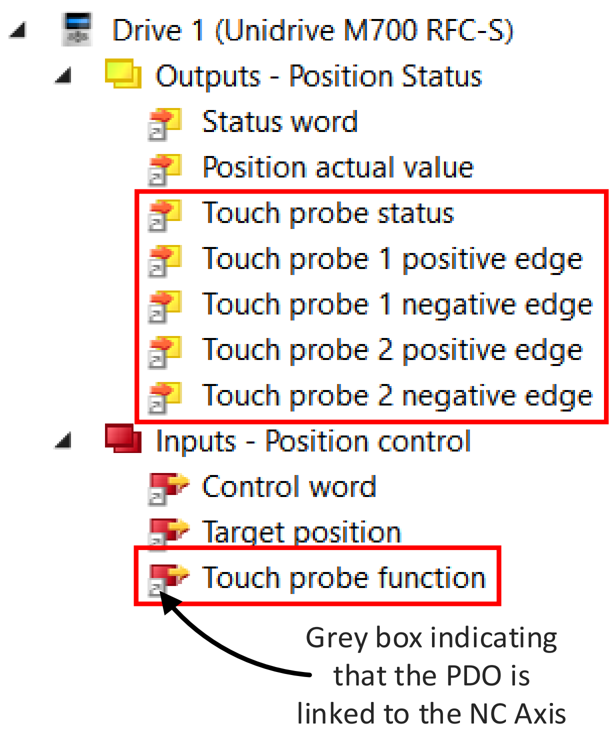
For further information on MC_Home Setup see the Beckhoff Information System
https://infosys.beckhoff.com/

10.2 How to configure PDO mappings

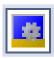
This section covers a range of subjects relating to common automation tasks and configuring PDO mappings.

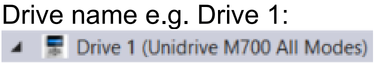
10.2.1 How to map touch probe PDOs

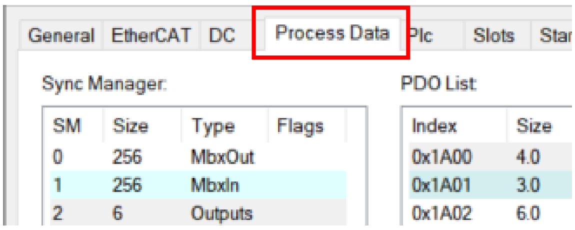
Using the default ESI PDO mappings, the Touch probe functionality is not mapped, and will result in MC_TouchProbe giving an error ID of 0x701 (1793). When Touch Probe 1 and 2 are mapped correctly it looks like this in the project tree:



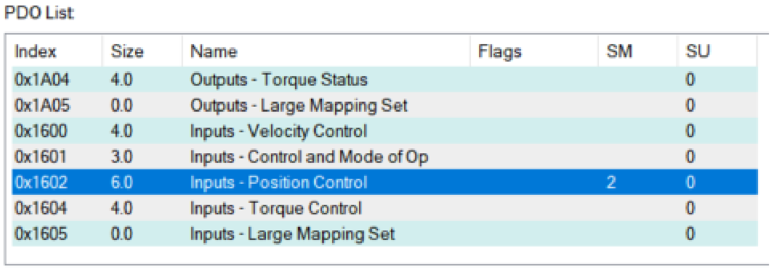
To resolve this, the following steps show how to map the data in:

1. Put TwinCAT in Config mode by clicking on the  button.

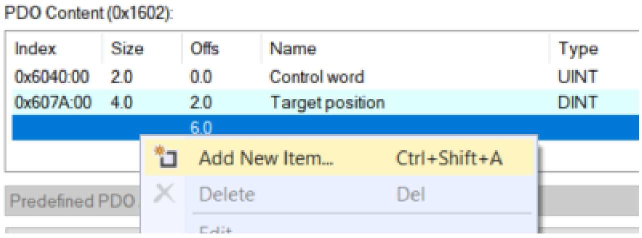
2. Locate the drive to add the links to under “I/O” in the solution explorer. Double click on the Drive name e.g. Drive 1:


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


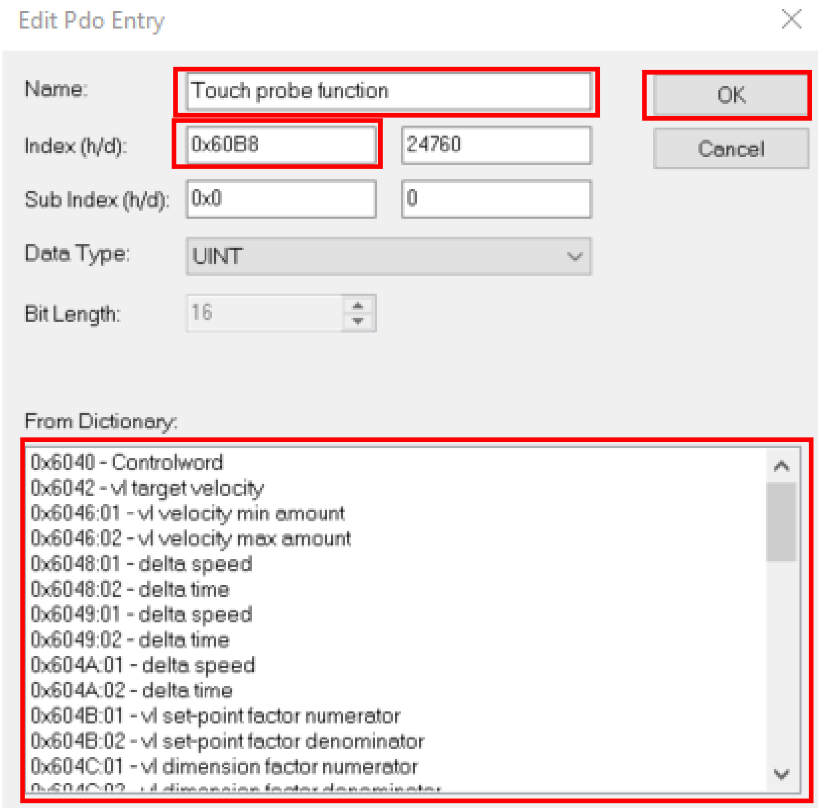
4. To set the PDO List find “Inputs - Position Control” box, and click on it to highlight the selection:



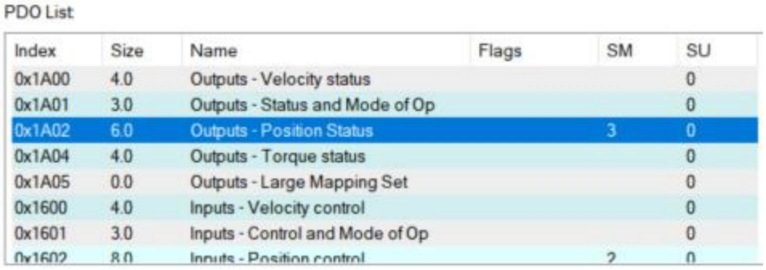
5. Right click in the “PDO Content” box, and right click, then select “Add New Item…”:



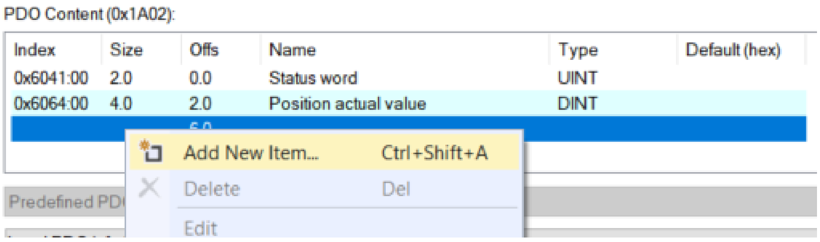
6. When the “Pdo Entry dialog” appears, scroll through the “From Dictionary:” options and look for 0x60B8 or Touch Probe Function. Click on this entry when it has been located. The details of the mapping will be automatically added. Click “OK” when finished.



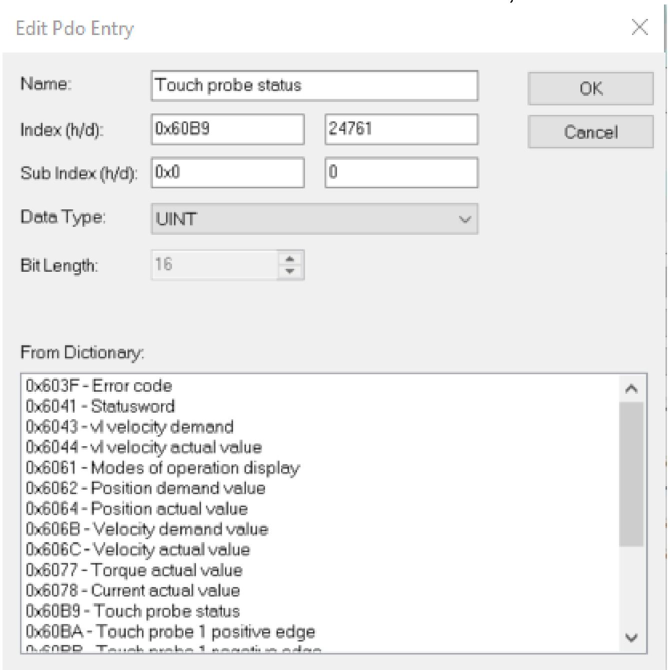
7. This process is repeated for the outputs. Select the PDO list item marked Outputs – Position Status



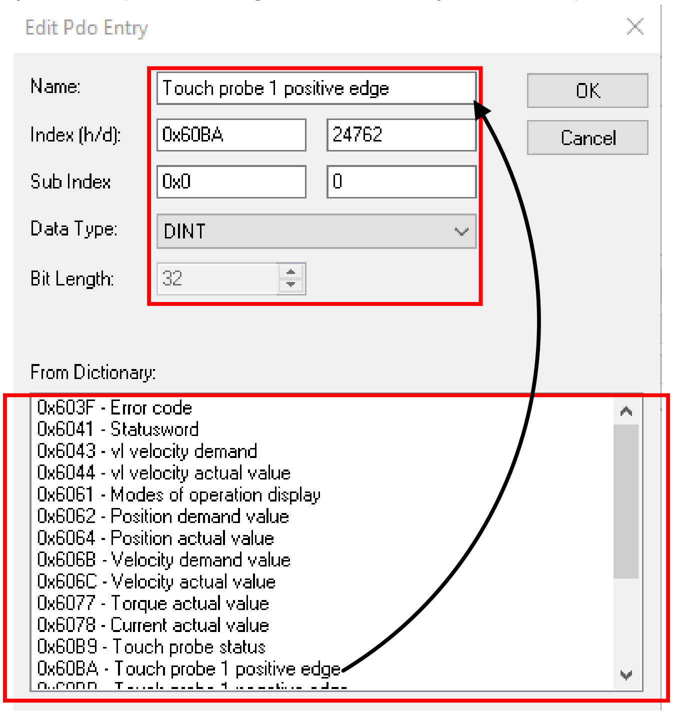
Then add a new item:



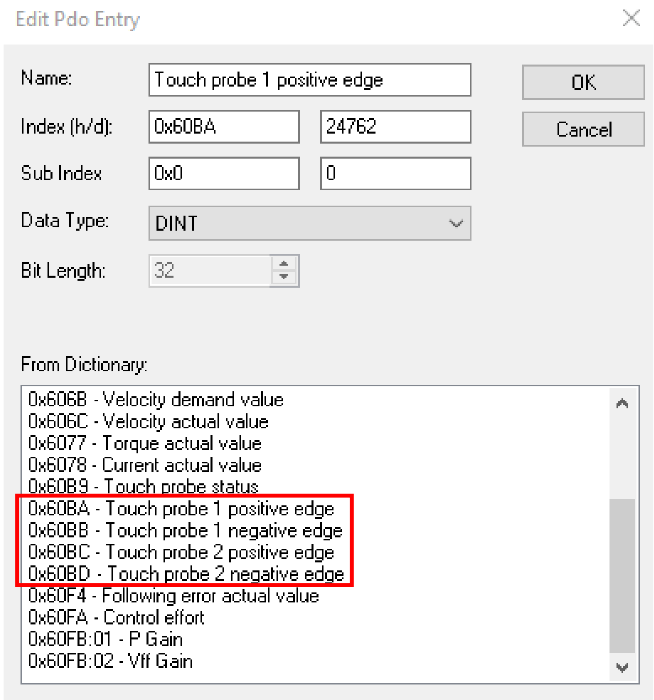
Then Select 0x60B9 – Touch Probe Status, and click OK when completed:



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.



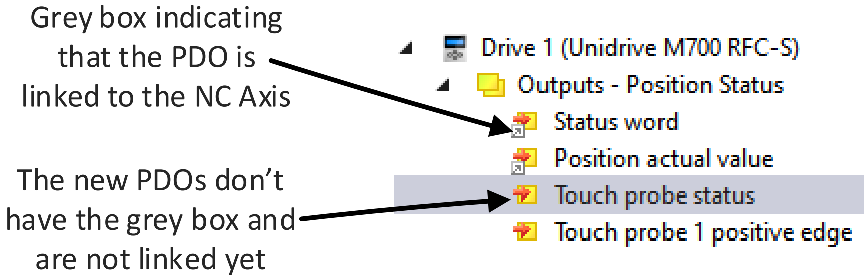
9. It is possible to include all 4 edges if required for Touch probe 1 (negative and positive) and Touch probe 2 (negative and positive):



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

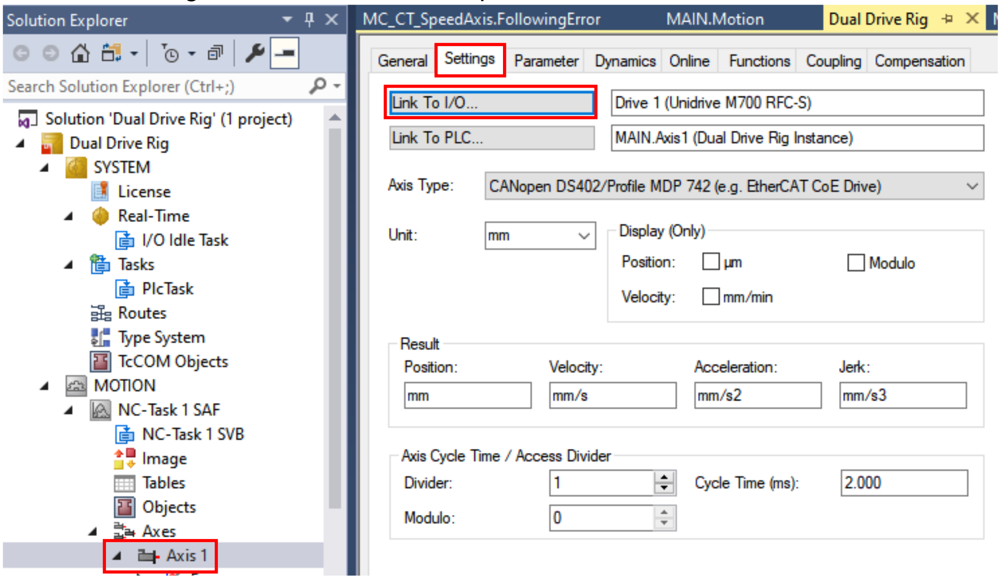
HINT: A minimum of firmware V01.61.00.00 drive firmware and EtherCAT firmware V01.12.00.24 with the associated ESI files are required to use this functionality.

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

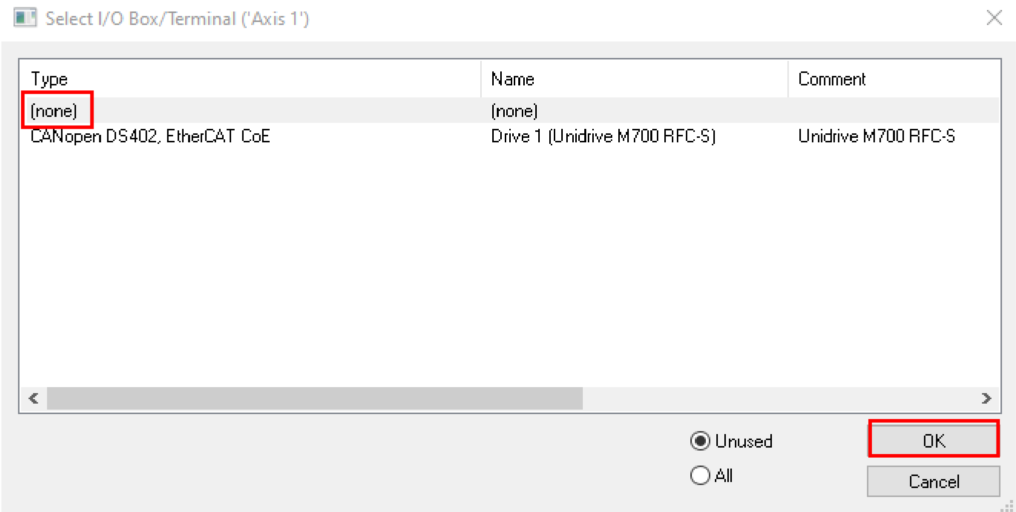


HINT: In the latest versions of TwinCAT the axis linking process happens automatically.

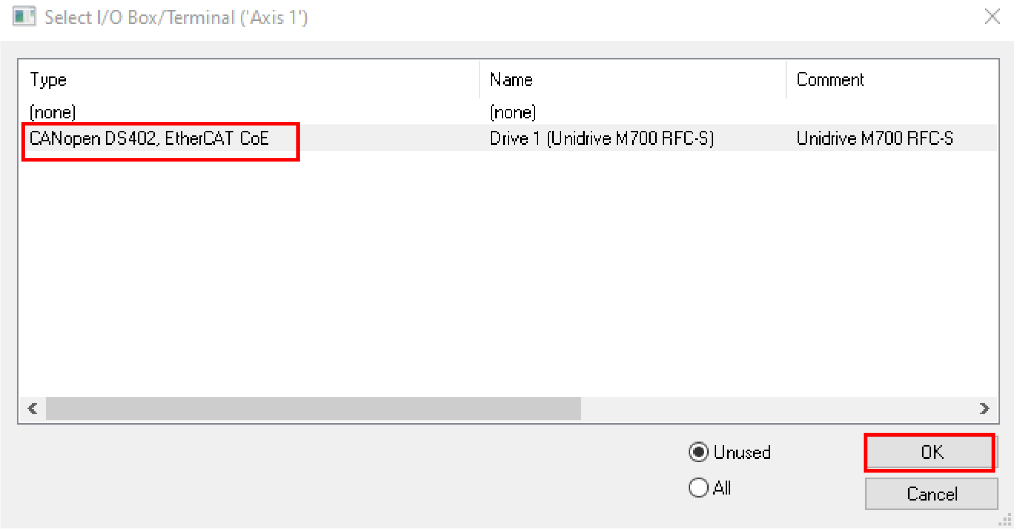
11. To link the new Touch Probe PDOs, double click on the axis associated with the drive and select the settings tab. When the tab is open click on "Link to I/O…":



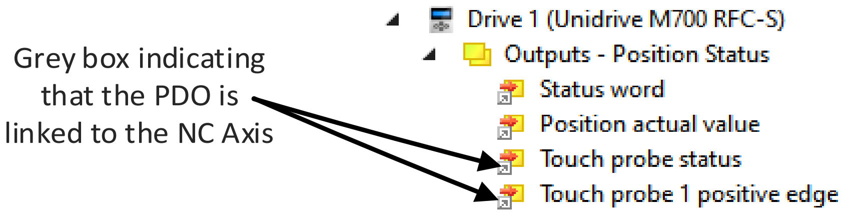
12. When the "Select I/O Box / Terminal" dialog appears, select (none) and then click "OK":



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:

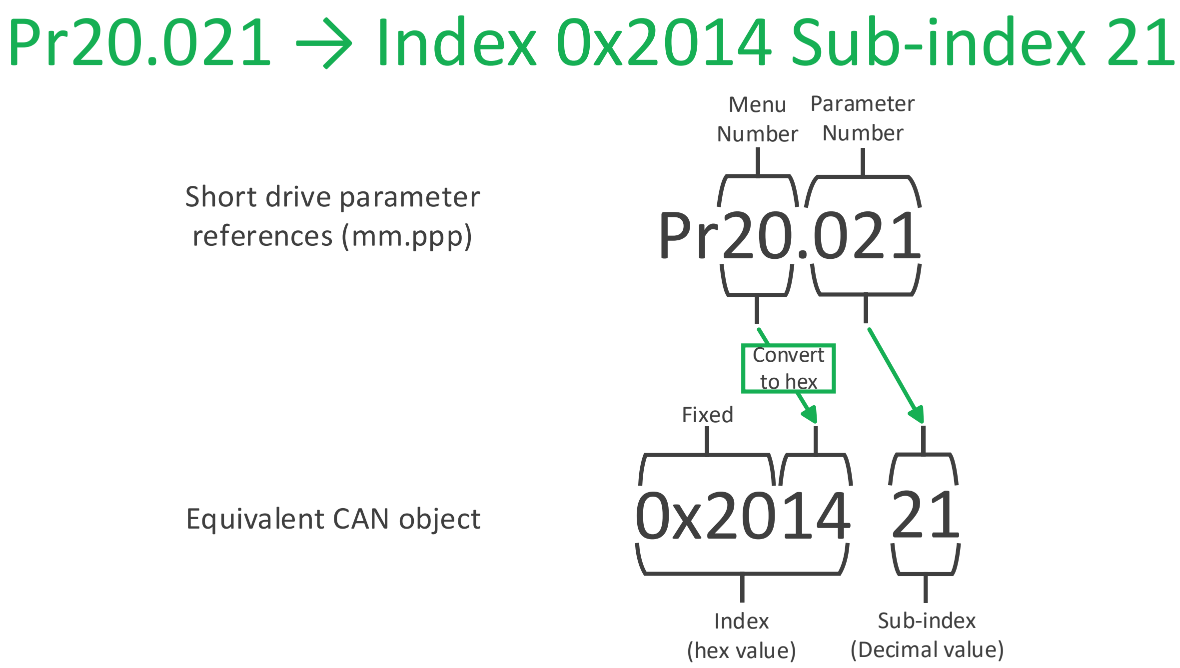
Index = 0x2000 + 0x100 * Slot Number + Menu number (converted to hexadecimal)

Subindex = Parameter number

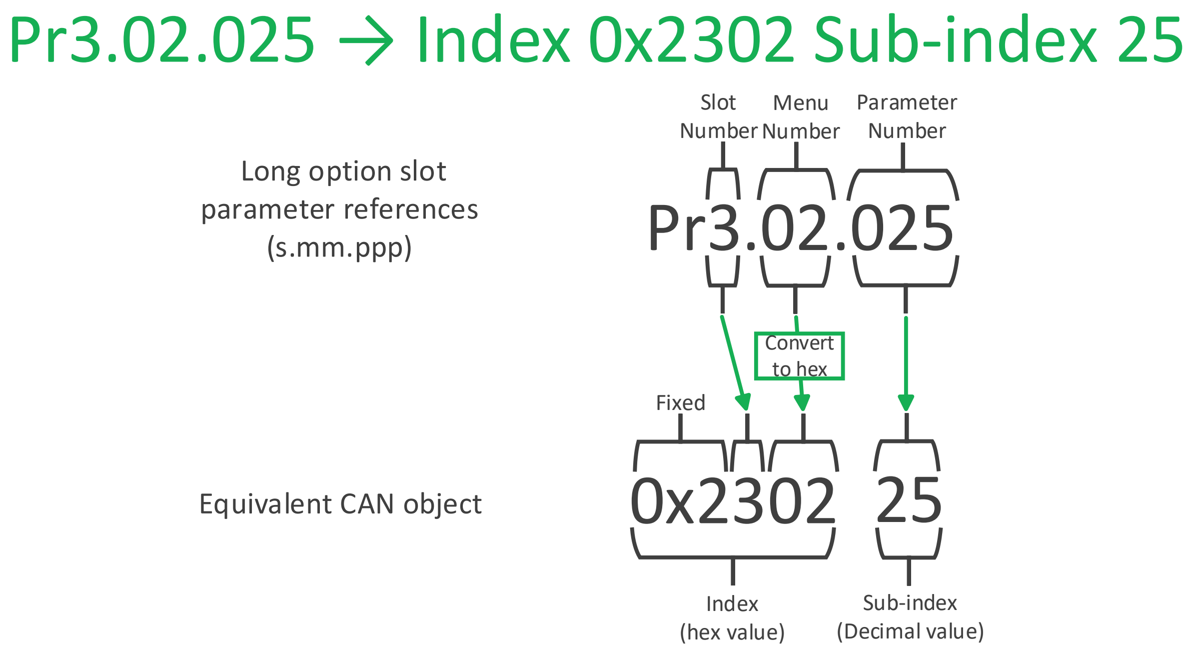
E.g. Drive parameter Pr3.017 is referenced as Index = 2003, Subindex = 17.

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

10.2.2.1 Short drive parameter references

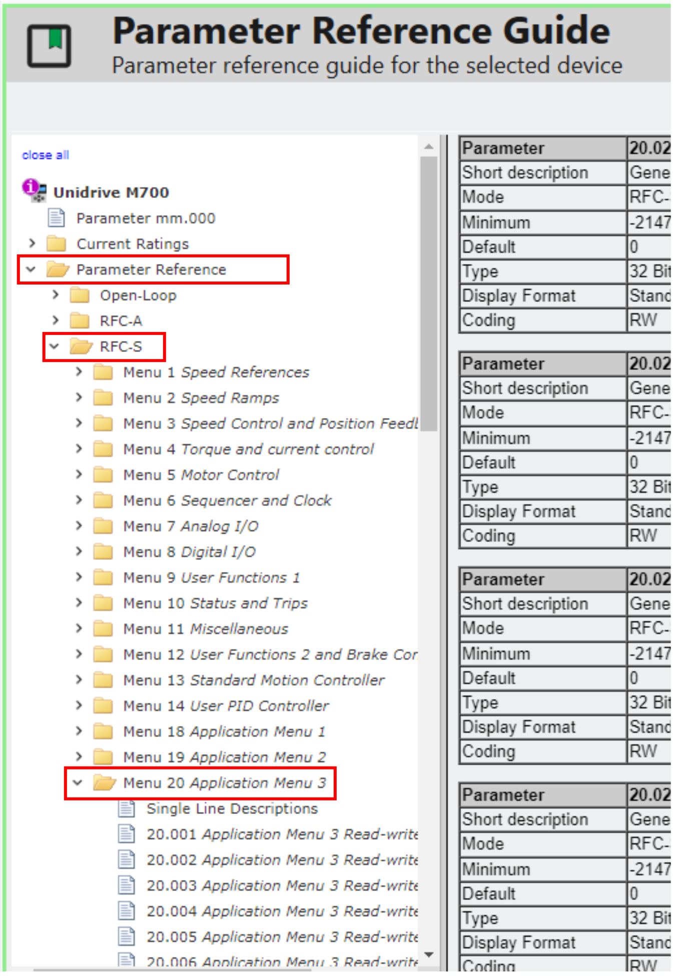


10.2.2.2 Long option parameter references

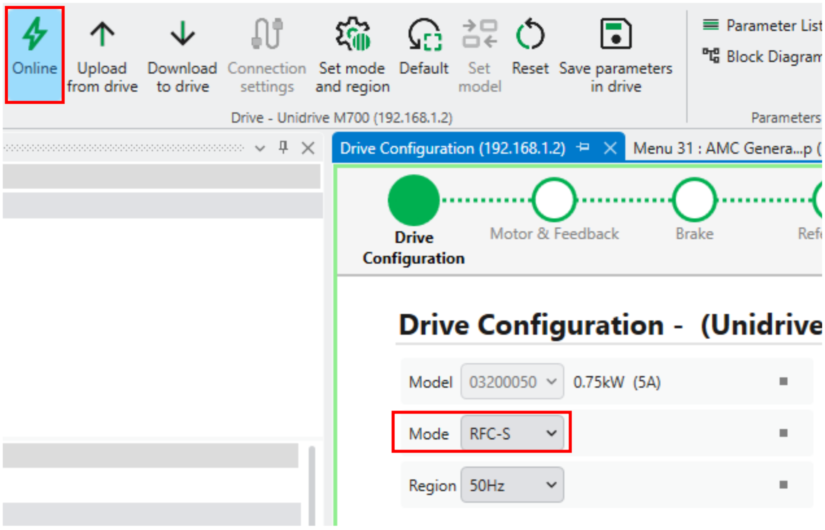


10.2.2.3 How to find the parameter data type

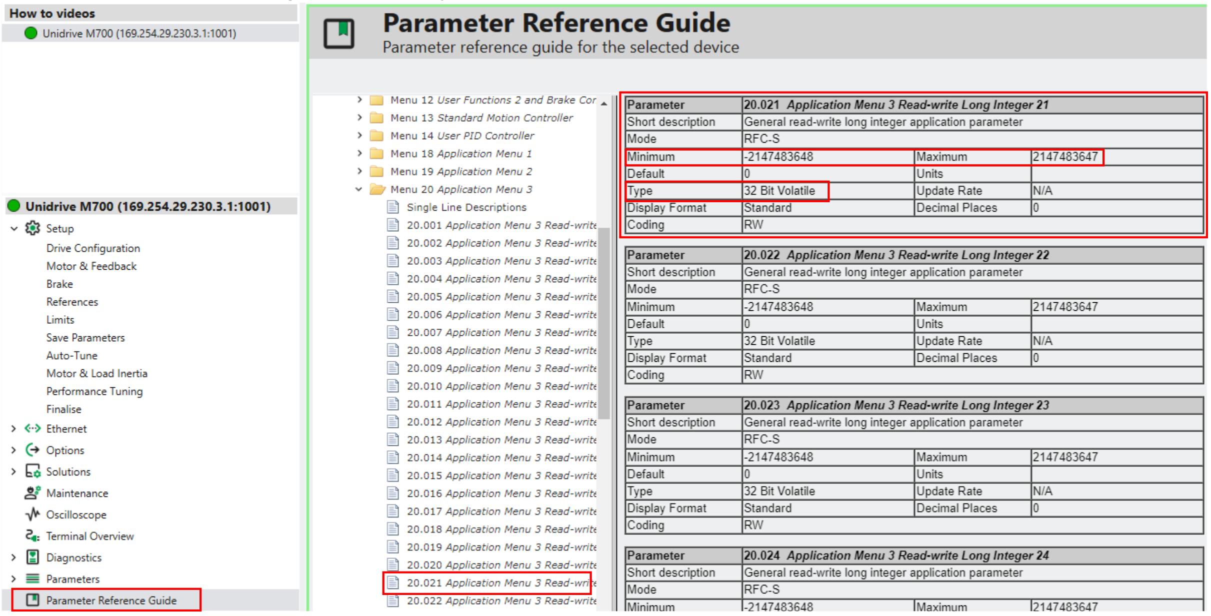
The data type can be found by looking at the parameter reference guide in Connect. Click “Parameter Reference Guide” in the Device tree and then expand “Parameter Reference”, then expand the drive mode e.g. Open-Loop, RFC-A or RFC-S, then select the menu number for the target parameter for the PDO e.g.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



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”.



Select the parameter to get the data type for:



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

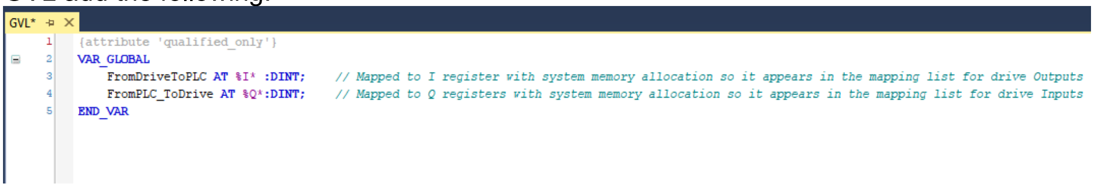
E.g. Pr20.021 is a 32bit value and the range is -2147483648 to 2147483647 which shows that the value is signed, therefore the IEC data type used in TwinCAT is DINT.

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:

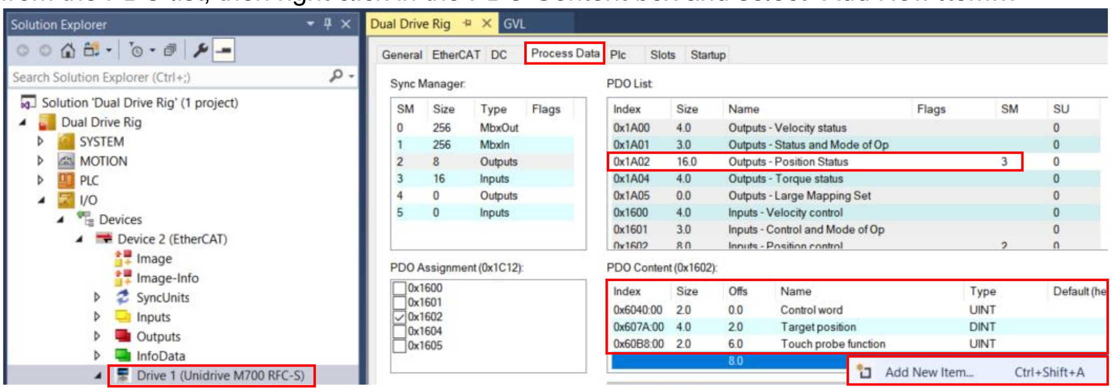


> **HINT:** The variables in the list have been allocated to the I and Q memory areas. This is a key step that allows the variables to be "seen" in the in the PDO linking list. Take care to use the correct memory area where I registers are for data going from the drive to the PLC, and Q registers are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

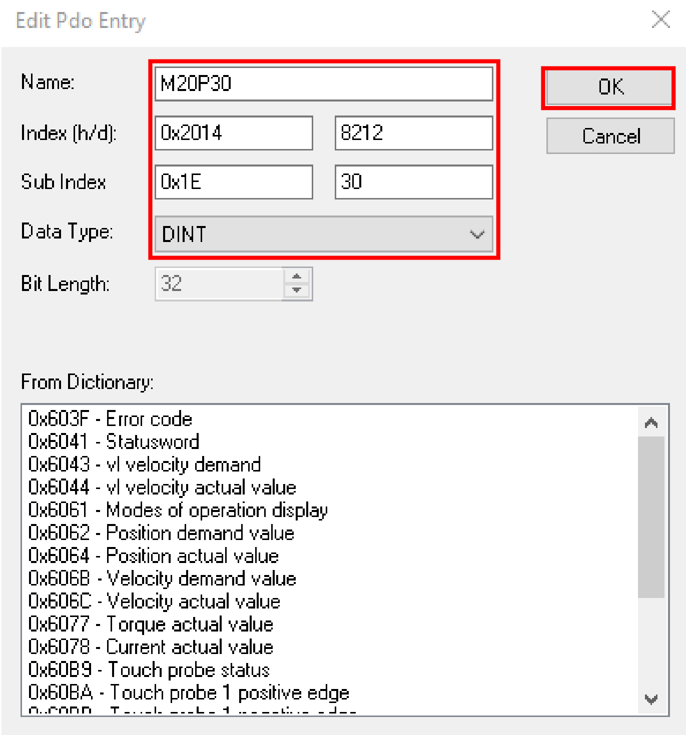
> **HINT:** The "*" used in the memory allocation e.g. %I* allows the TwinCAT system to select which area of the registers should be used. This is recommended.

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.

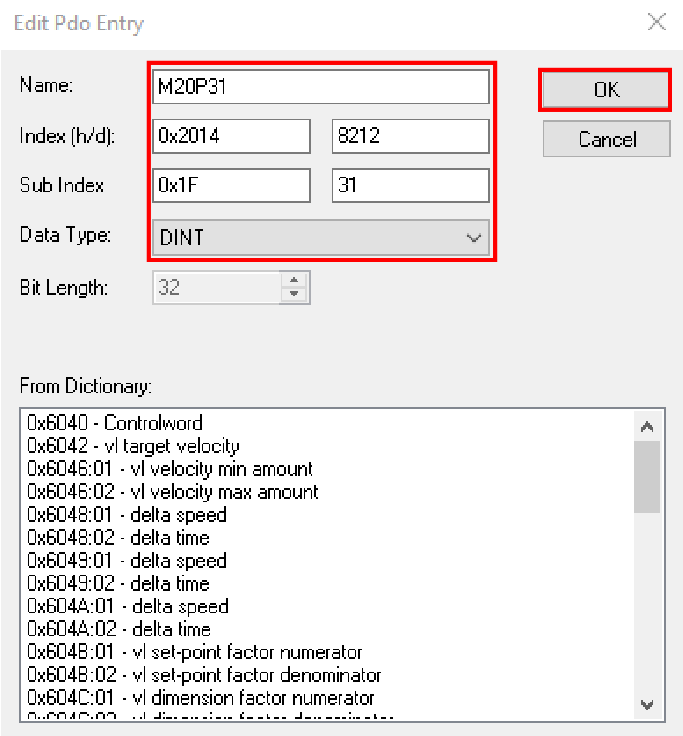
3. In the "Solution Explorer" tree, double click on the drive node to exchange PDO data with to open the drive properties. Next click on the "Process Data" tab, then select the 0x1A02 index from the PDO list, then right click in the PDO Content box and select "Add New Item…"



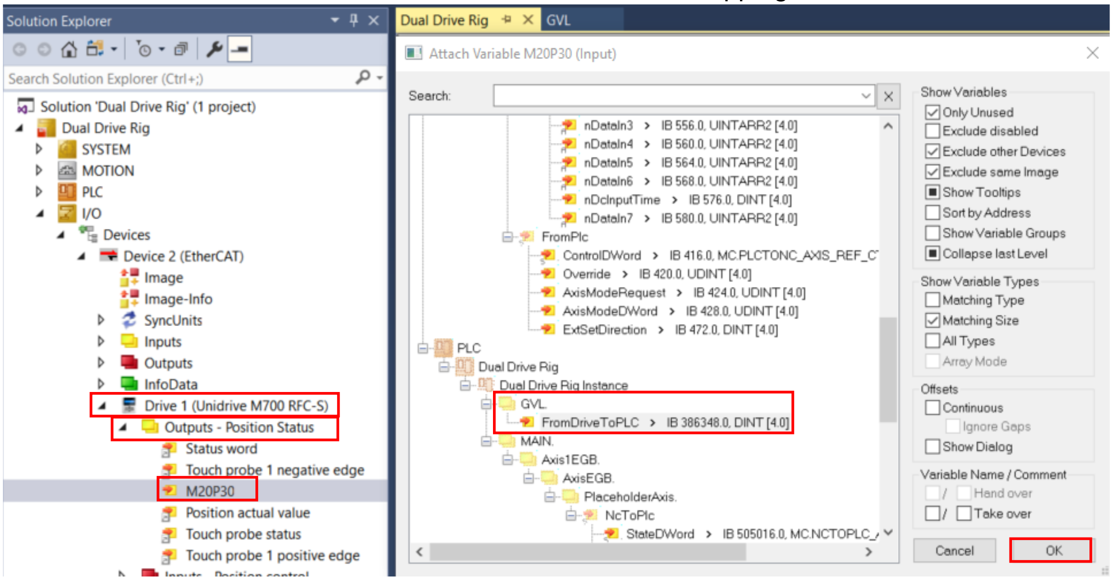
4. How to convert parameter numbers to CANopen object referencesUsing the information in section **10.2.2 How to convert parameter numbers to CANopen object references**, add the reference for the parameter to receive data from. For this example Pr20.030 will be used. Click “OK” when the parameter reference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



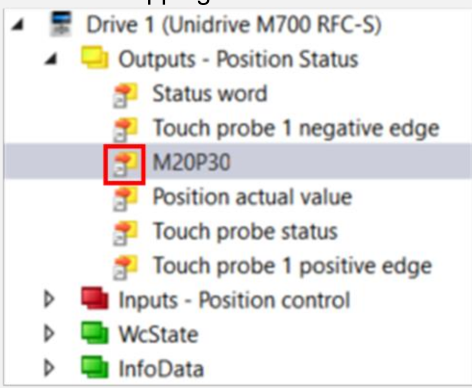
5. Select “0x1602” in the PDO list, then right click in the PDO Content box and select “Add New Item…”. Using the information in section **10.2.2 How to convert parameter numbers to CANopen object references**, add the reference for the parameter to send data to. For this example Pr20.031 will be used.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



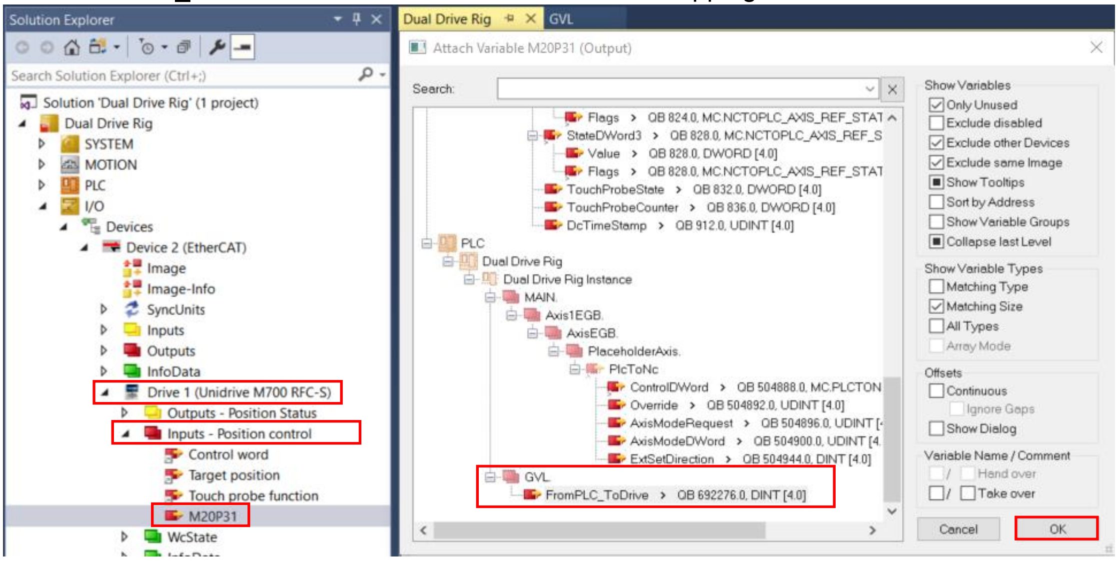
6. Map the Output PDO “M20.P30” to “GVL.FromDriveToPLC”. Expand the tree under the drive to reveal the Output mappings, then double click on the mapping to link. When the “Attach Variable” dialog opens, scroll down the list until “GVL.FromDriveToPLC” is seen. Click on “GVL.FromDriveToPLC” and then click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



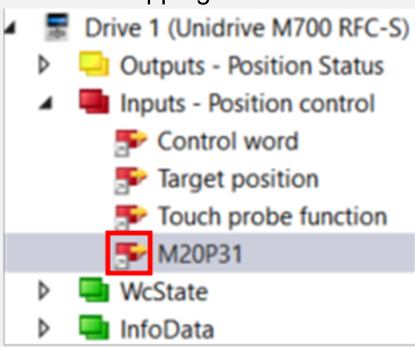
HINT: The link icon is now visible, (small grey box with an arrow inside), indicating that the PDO mapping has been linked.



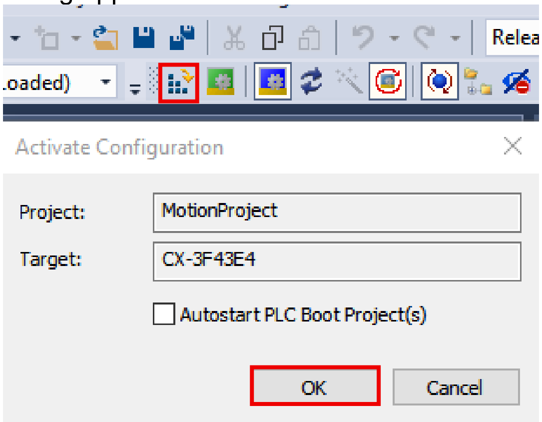
7. Map the Input PDO “M20.P31” to “GVL.FromPLC_ToDrive”. Expand the tree under the drive to reveal the Input mappings, then double click on the mapping to link. When the attach variable dialog opens, scroll down the list until “ GVL.FromPLC_ToDrive” is seen. Click on “ GVL.FromPLC_ToDrive” and then click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



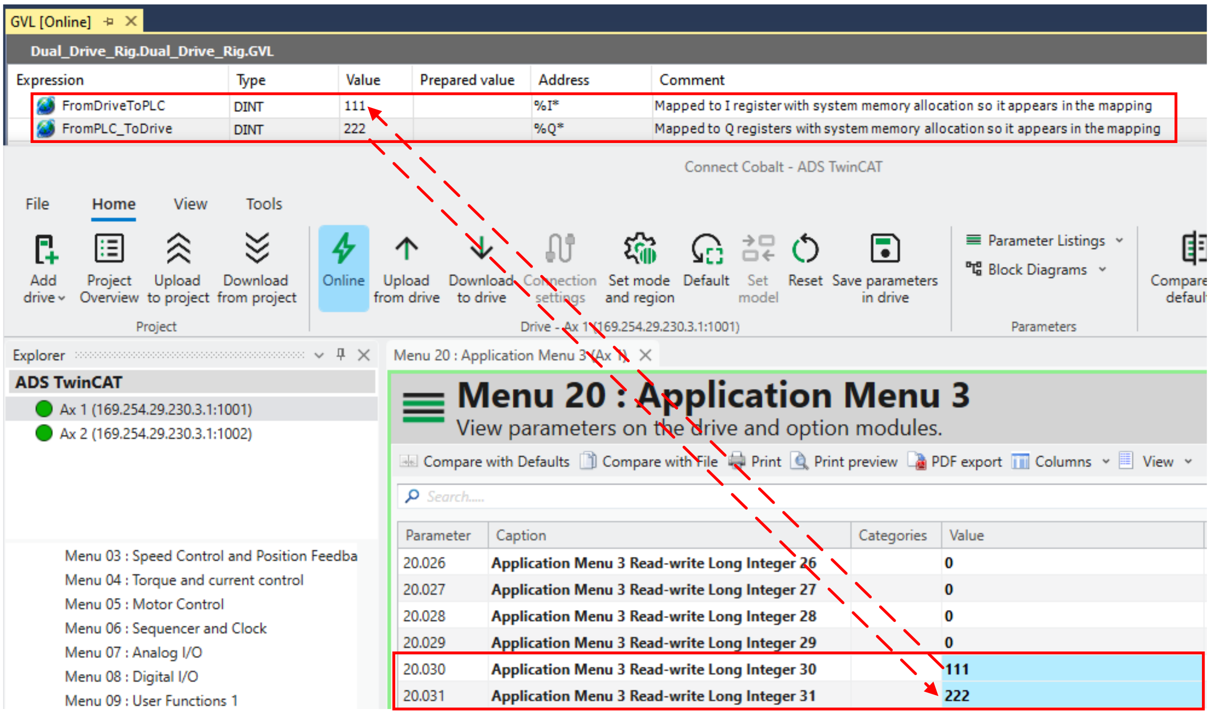
8. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



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.



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

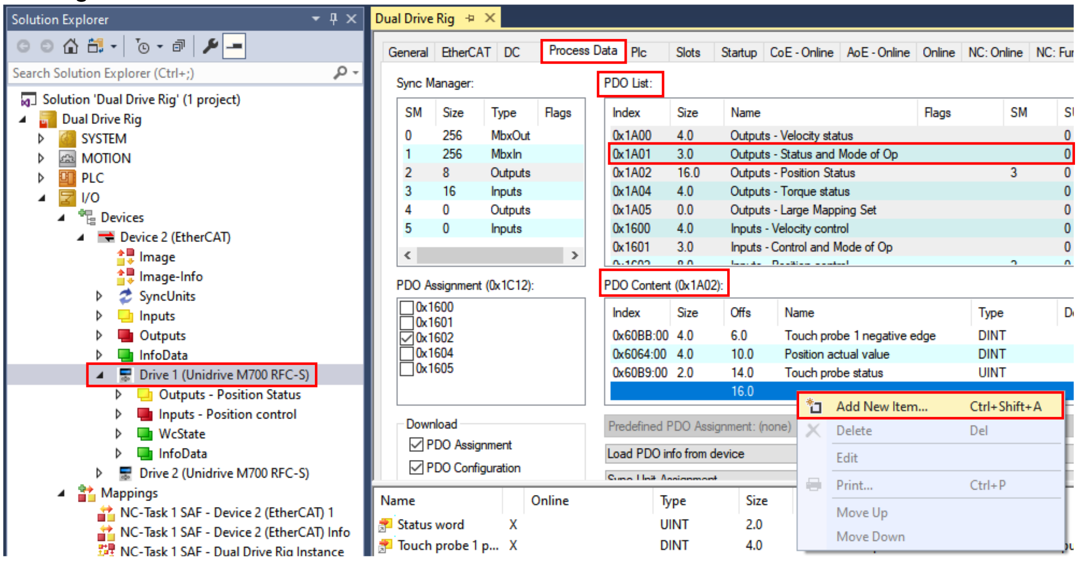
It is possible to map a drive encoder e.g. a line encoder connected to the drive P2 interface or an SI-Universal Encoder module so that could be used as a master position reference for MC_GearIn or MC_CamIn. The following steps show how to configure the mapping and setup the Encoder axis.

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:

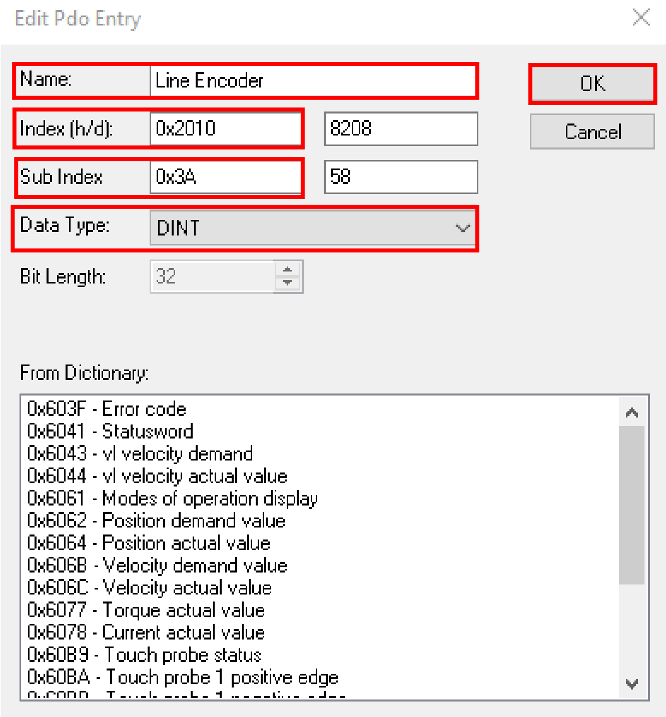
Encoder port	Parameter	Index	Subindex	Data Type
Drive P1	Pr3.058	0x2003	0x3A (58)	DINT (32Bit)
Drive P2	Pr3.158	0x2003	0x9E (158)	DINT (32Bit)
Slot 1 P1	Pr15.058	0x200F	0x3A (58)	DINT (32Bit)
Slot 1 P2	Pr26.058	0x201A	0x3A (58)	DINT (32Bit)
Slot 2 P1	Pr16.058	0x2010	0x3A (58)	DINT (32Bit)
Slot 2 P2	Pr27.058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

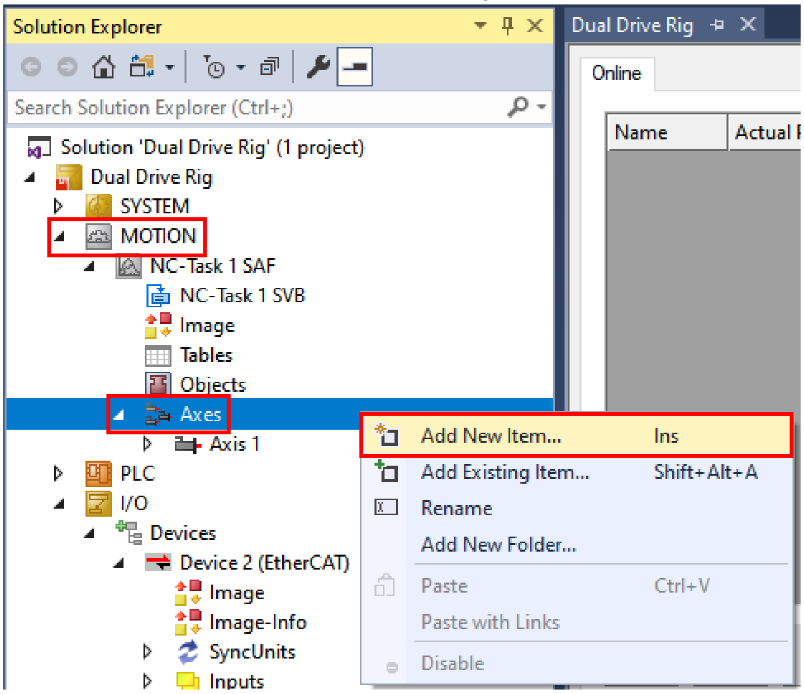
3. In TwinCAT, double click on the EtherCAT slave drive to add the encoder PDO mapping to. When the properties for the slave drive open, select the “Process Data” tab, and then in the “PDO List” select object “0x1A02”. In the “PDO content” box scroll to the bottom of the list and then right click and then select “Add New Item…”



4. 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.

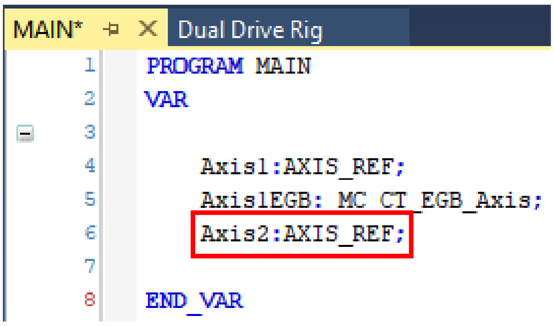


5. In the solution explorer under “Motion”, right click on “Axes” and select “Add New Item…”.

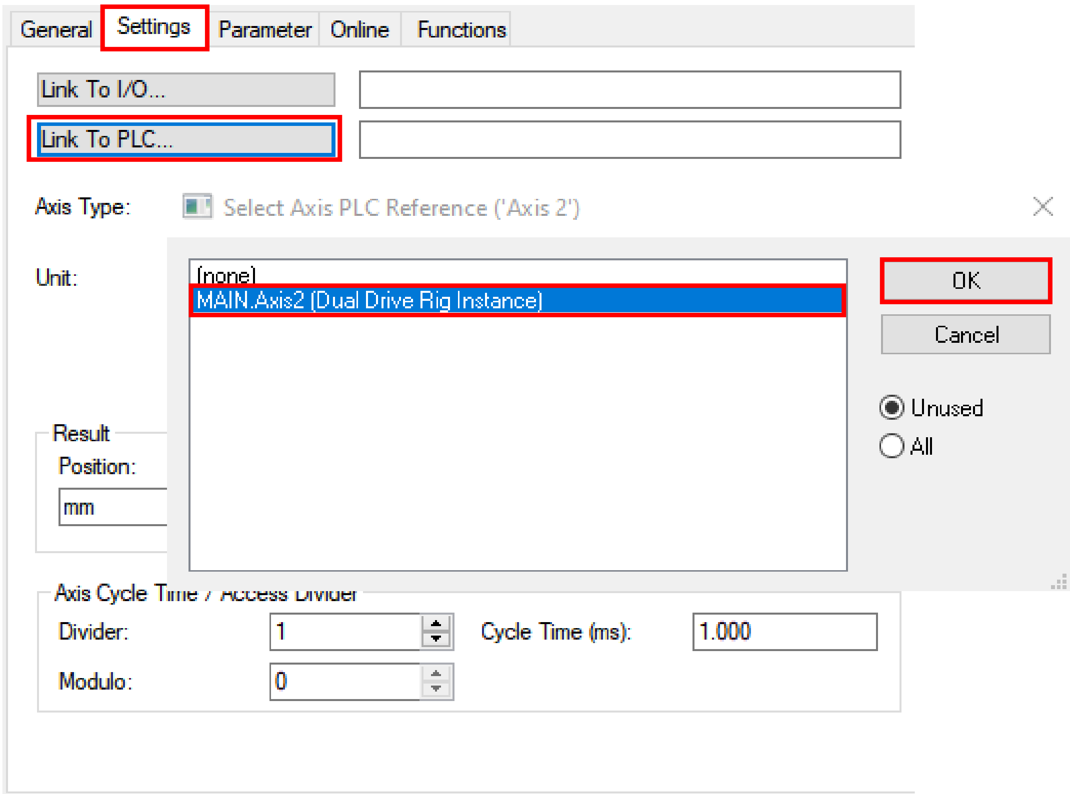


6. When the “Insert NC Axis” dialog opens, change the type to “Encoder Axis”. Click “OK” when finished.

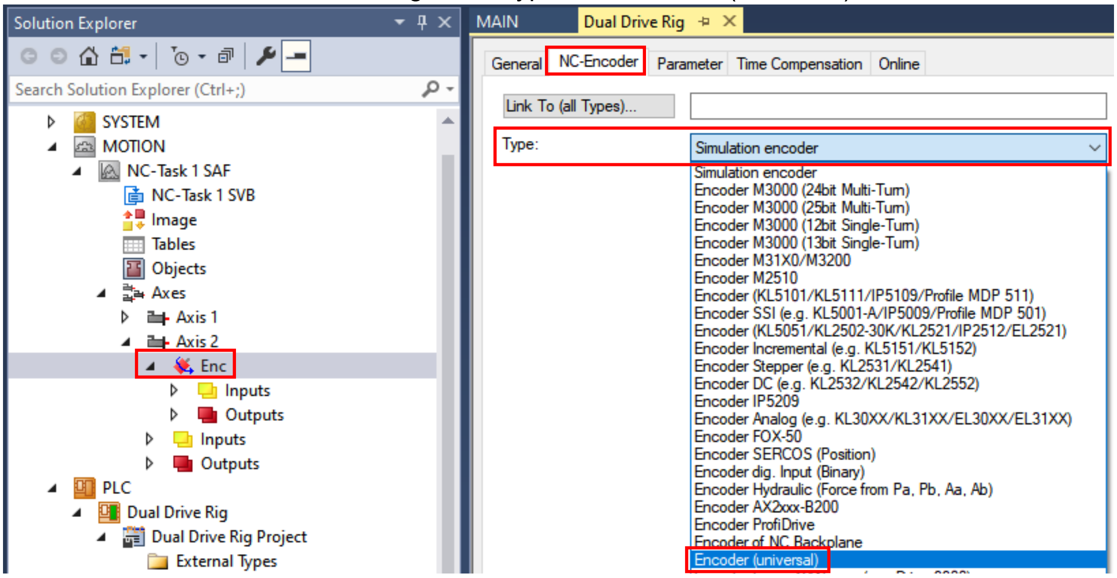
7. In the motion program POU add an instance of AXIS_REF for the Encoder Axis.



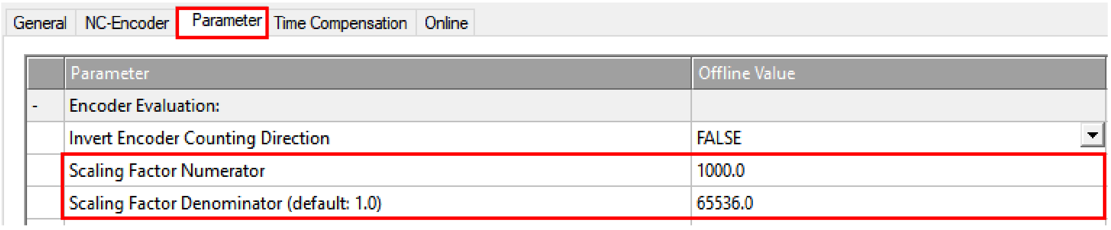
8. In the Solution Explorer tree, double click on the encoder axis, (Axis 2), when the properties for the axis open, select the “Settings” tab. Click “Link To PLC”, and then select the new instance of AXIS_REF, e.g. “Axis2”.



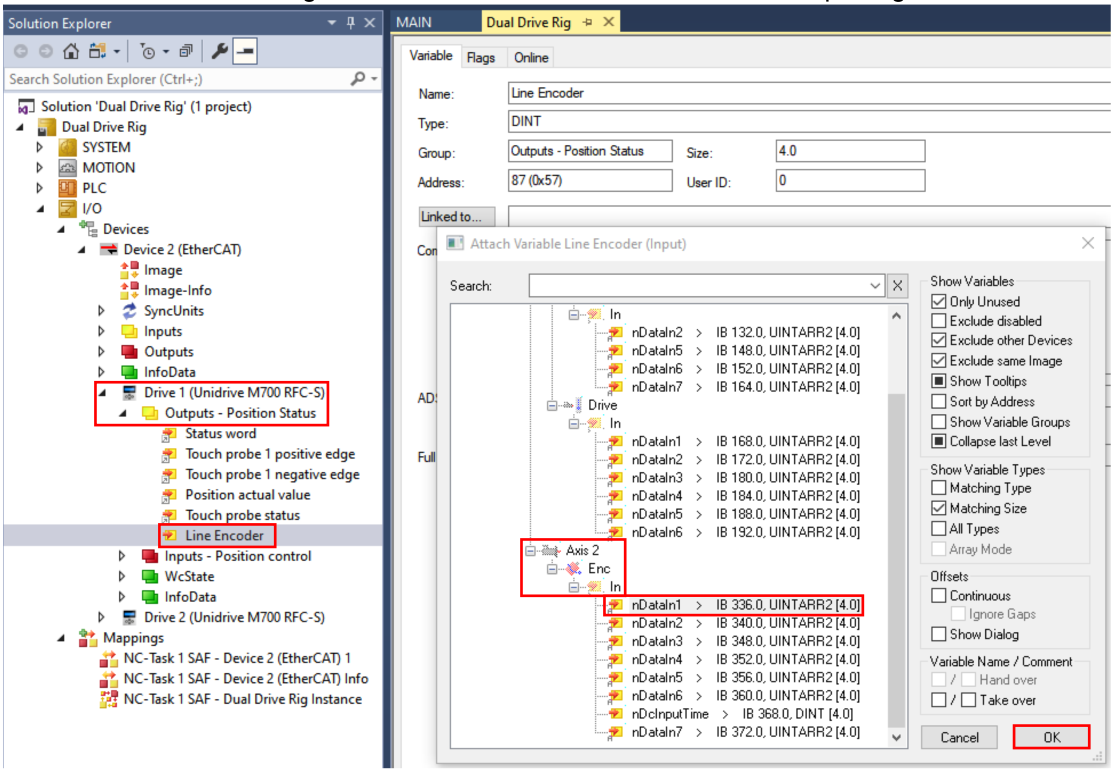
9. Expand the encoder axis and double click on “Enc”, when the properties for the encoder open select the “NC-Encoder” tab. Change the “Type:” to “Encoder (universal)”



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.



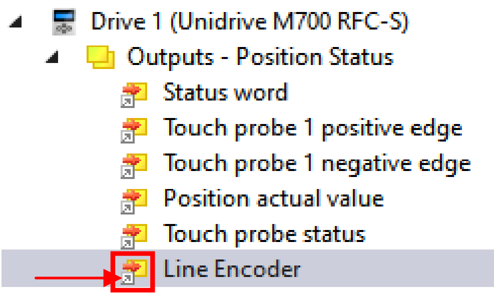
11. Expand the tree for the drive that the encoder is connected to, then open “Outputs”, and double click on the name given to the encoder PDO link created in step 4 e.g. “Line Encoder”.



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”.

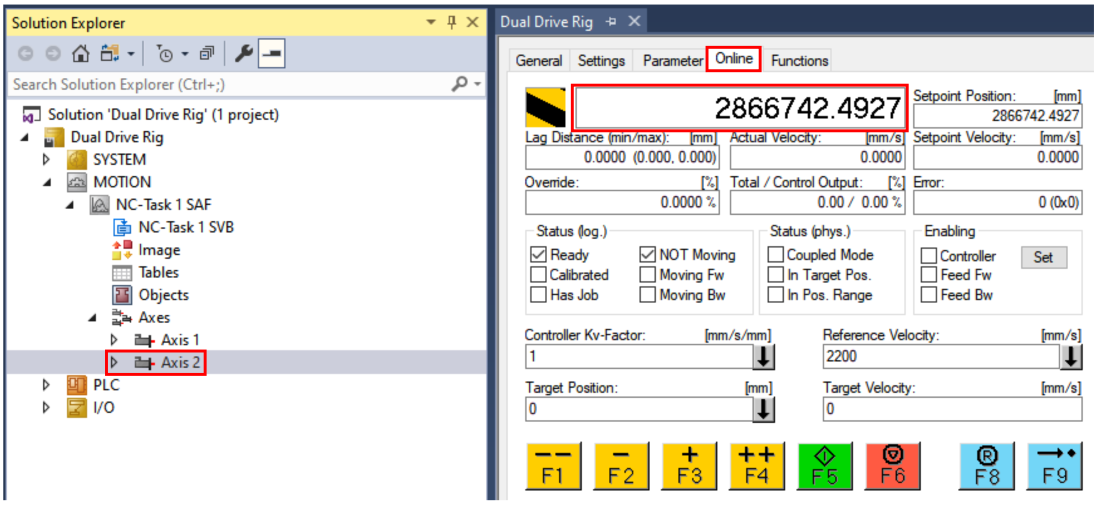
> **HINT:** “nDataIn1” is always where the encoder data is mapped to, regardless of the axis number.

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.

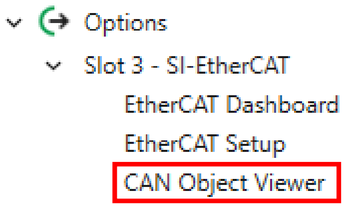


14. The encoder reference can now be used as the master for an MC_GearIn or MC_CamIn by using the axis name e.g. Axis2.

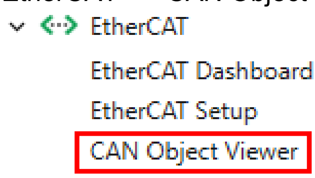
10.3 How to view CAN objects

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.

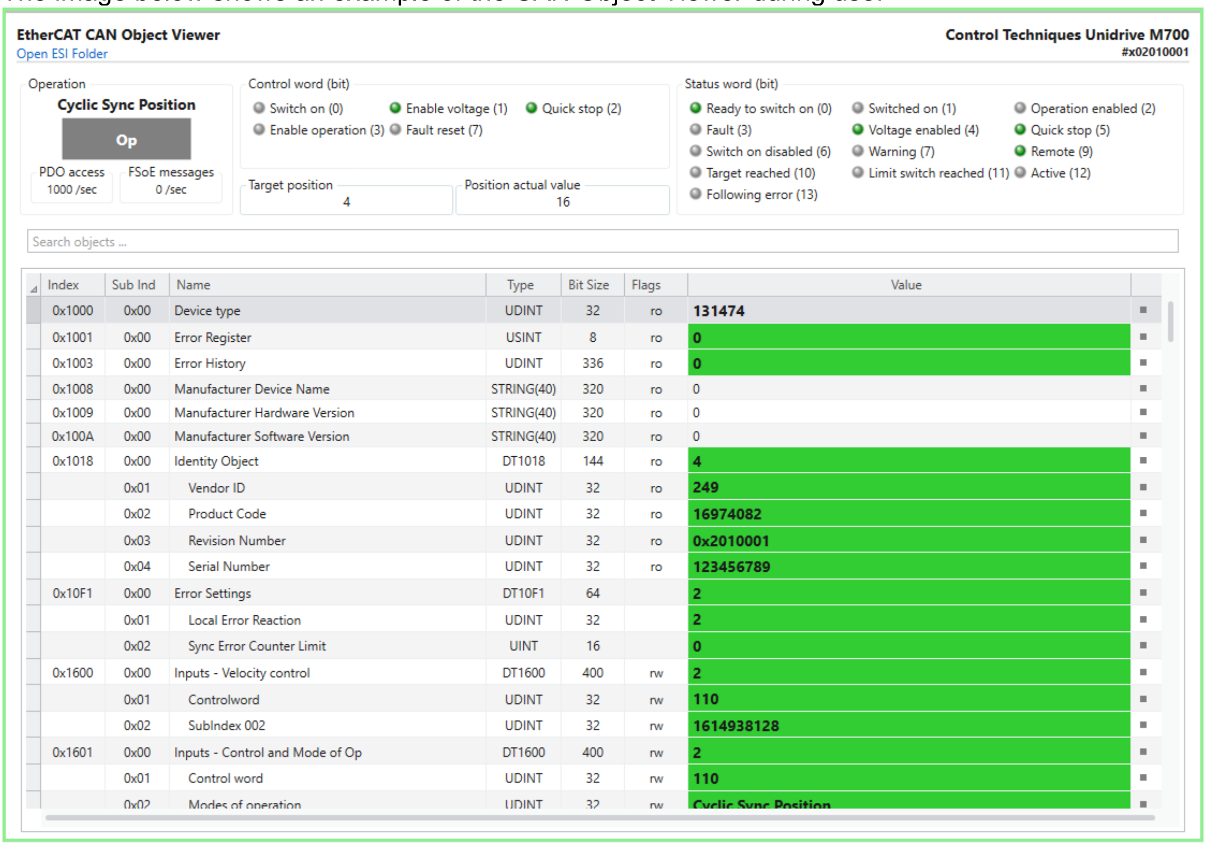
The tool is found in the Drive explorer tree under "Options" > "Slot[n]" > "CAN Object Viewer" where [n] is the drive slot in which the SI-EtherCAT interface is located.



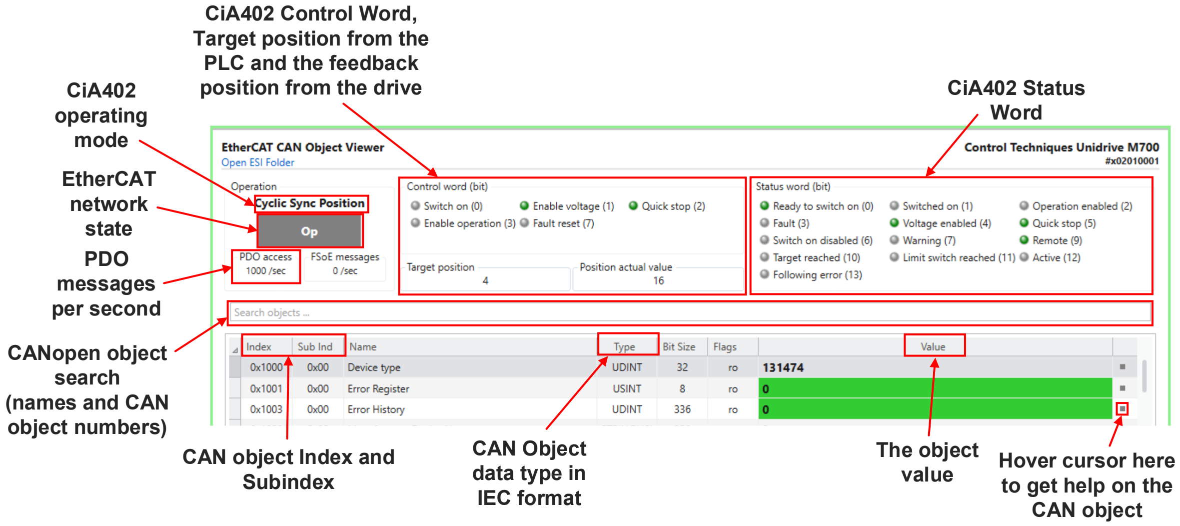
For Dedicated EtherCAT Drives Such as Digitax HD M753 it is found in the drive explorer tree under "EtherCAT" > "CAN Object Viewer".



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

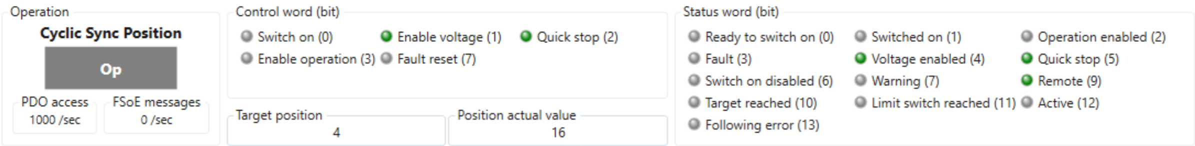


The following image highlights some of the useful features and information available within this tool.



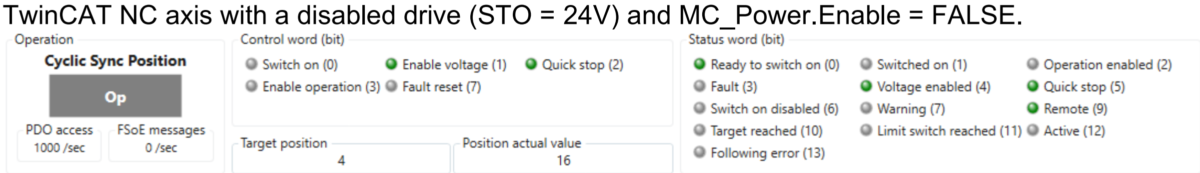
10.3.1 MC_Power Disabled and Drive Disabled

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

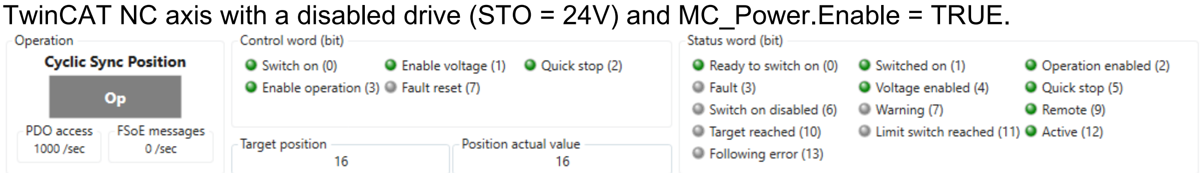
This screenshot acts a guide to understand the expected CiA402 Status and Control word for a TwinCAT NC axis with a disabled drive (STO = 24V) and MC_Power.Enable = FALSE.



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.

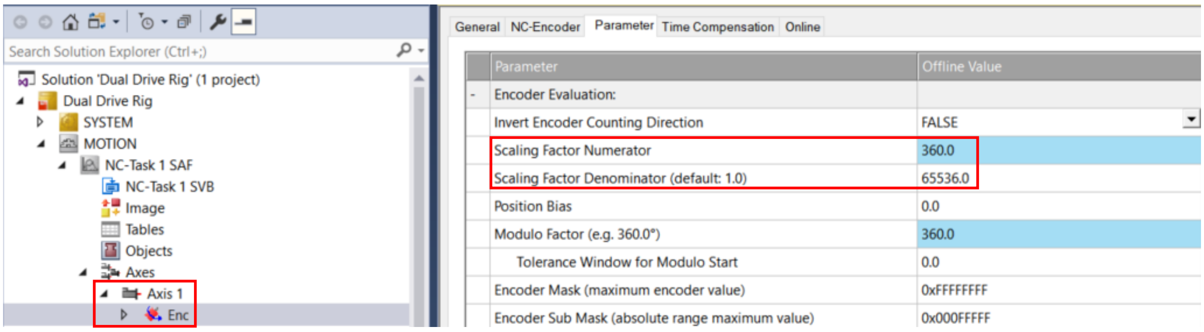
10.4 How to setup axis unit scaling and resolution

Unit scaling in most motion control systems, including a TwinCAT NC axis, requires the user to specify the number of 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 the number of distance units.
- The denominator is the number of position feedback counts 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:



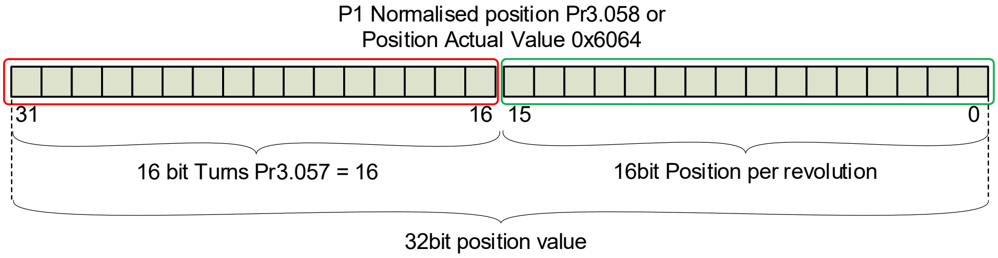
If we add a 4:1 reduction gearbox, the number of rotations at the output of the gearbox is reduced by the gearbox ratio so in this example the scaling numerator is 360 * 1 / 4 = 90.

The encoder resolution used by TwinCAT NC axis is set by drives feedback resolution as defined by Pr3.057 Normalisation Turns, where the number of counts per revolution can be calculated by using the following formula:

$$\text{Encoder Counts Per Revolution} = 2^{(32-\textbf{NormalisationTurns Pr3.057})}$$

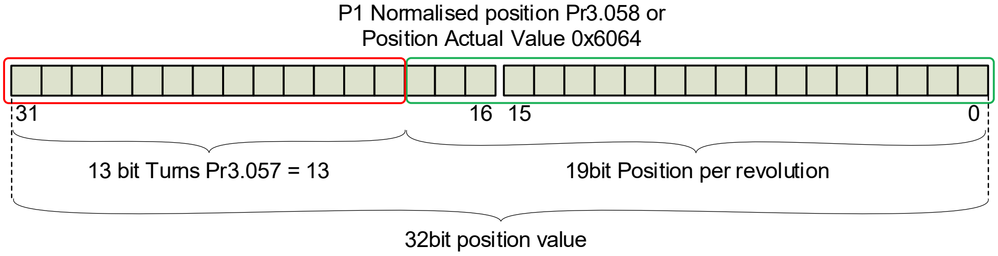
In the drive, the resolution in feedback counts is given by $2^{(32\text{-Pr3.057})}$.

By default, Pr3.057 P1 Normalisation Turns = 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.

For example, if a 19bit per revolution encoder is used, the number of turns bits is reduced to 13 to give 19bits of turns information:



The following table can be used to help with determining the correct turns bits value to use based on the encoders number of counts per revolution.

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 turn's 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 resolution using the startup list in TwinCAT

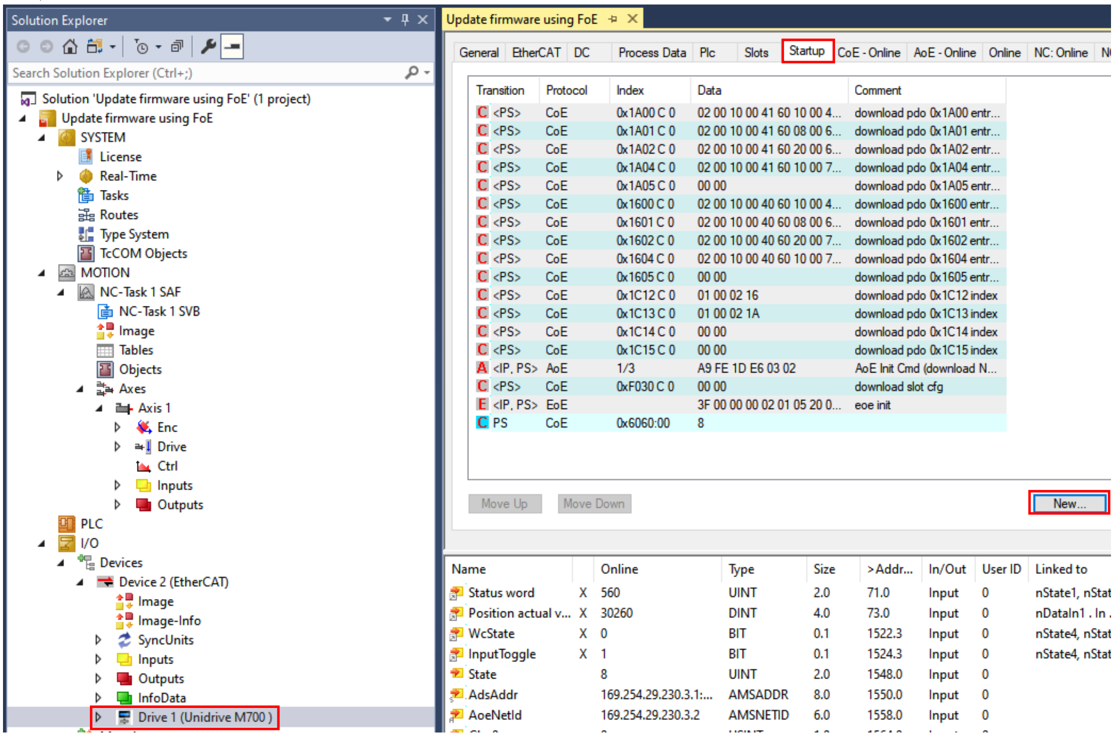
The resolution is configured by default in Pr3.057. See the previous table for the number that the turns bits should be set, (Hex value), to for a particular number of counts per revolution.

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

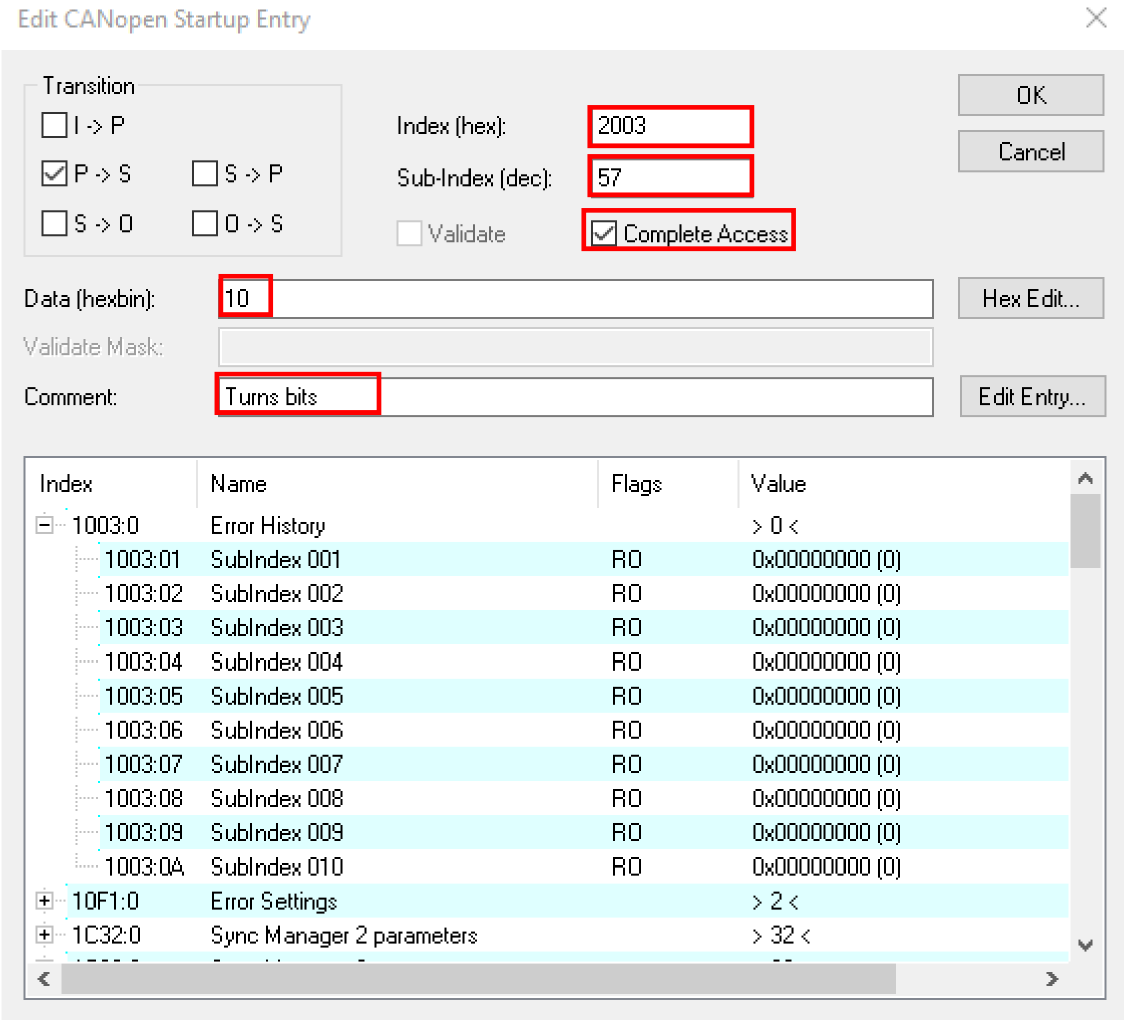
Parameter	Index (hex)	Subindex (dec)	Comment
Pr3.057	2003	57	Turns bits

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

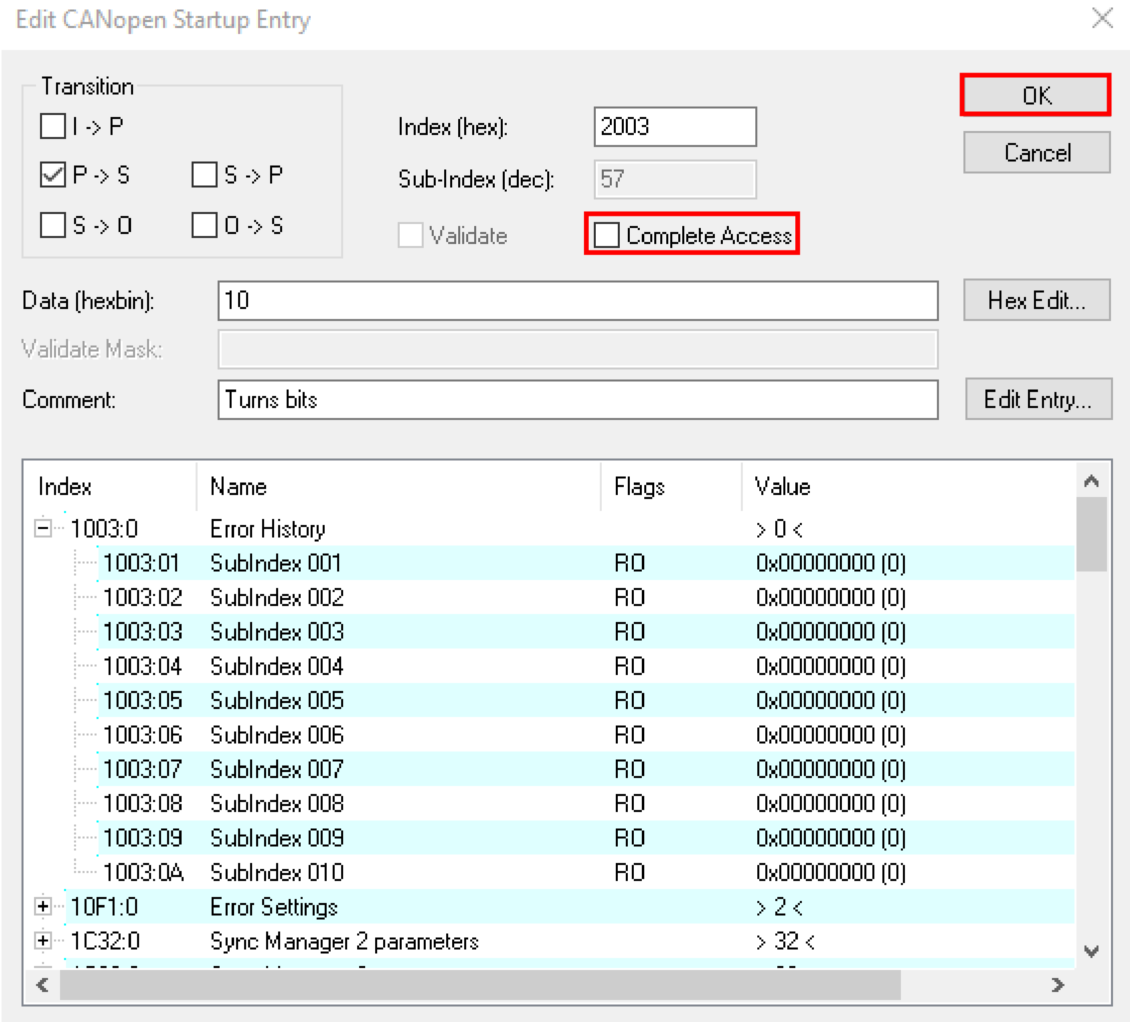
1. Double click on the drive to modify the startup list for, from the properties select the “Startup” tab, and then click “new”.



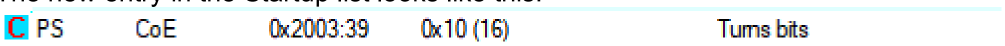
2. When the “Edit CANopen Startup Entry” dialog opens, populate it as shown below and check the “Complete Access” checkbox to allow the Sub-Index to be configured:



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

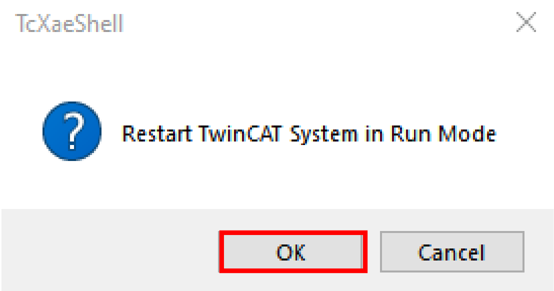


4. The new entry in the Startup list looks like this:



5. Click the Activate Configuration button to apply the startup list. 

6. Click OK on the “Restart TwinCAT System in Run Mode” dialog.



7. 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:

Drive speed in rpm = Speed(Units per s) * 60 / 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 = 166.6rpm

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

NC axis speed = Speed(rpm) * 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 = 20566.6rpm

10.5 How to upgrade EtherCAT Firmware

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

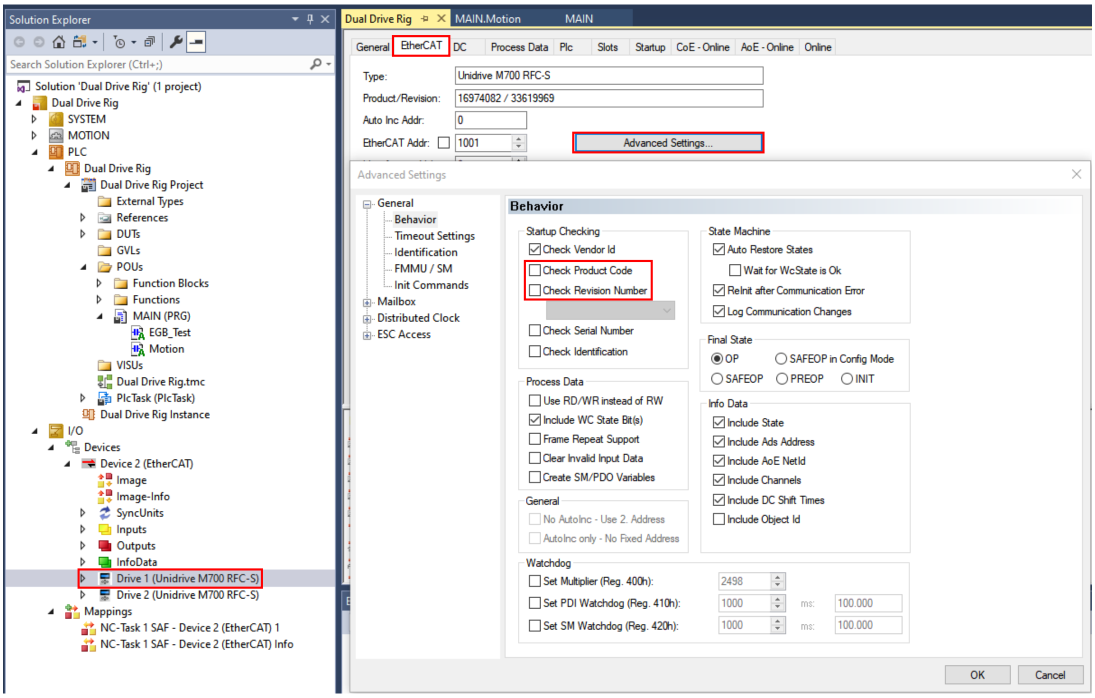
The most common way as described in section **10.5.1 How to upgrade the EtherCAT interface** firmware using Connect shows how to update the firmware using Connect which us used when there is an existing, working connection to the drive, either by ADS or AoE or serial / ethernet communications.

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.



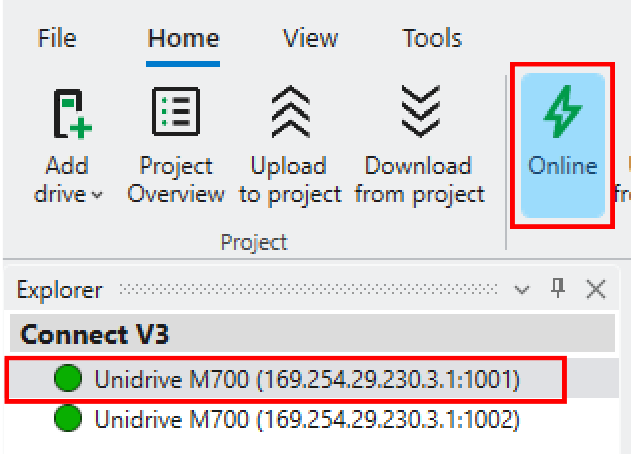
2. Install and open the "Connect" PC tool.

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.

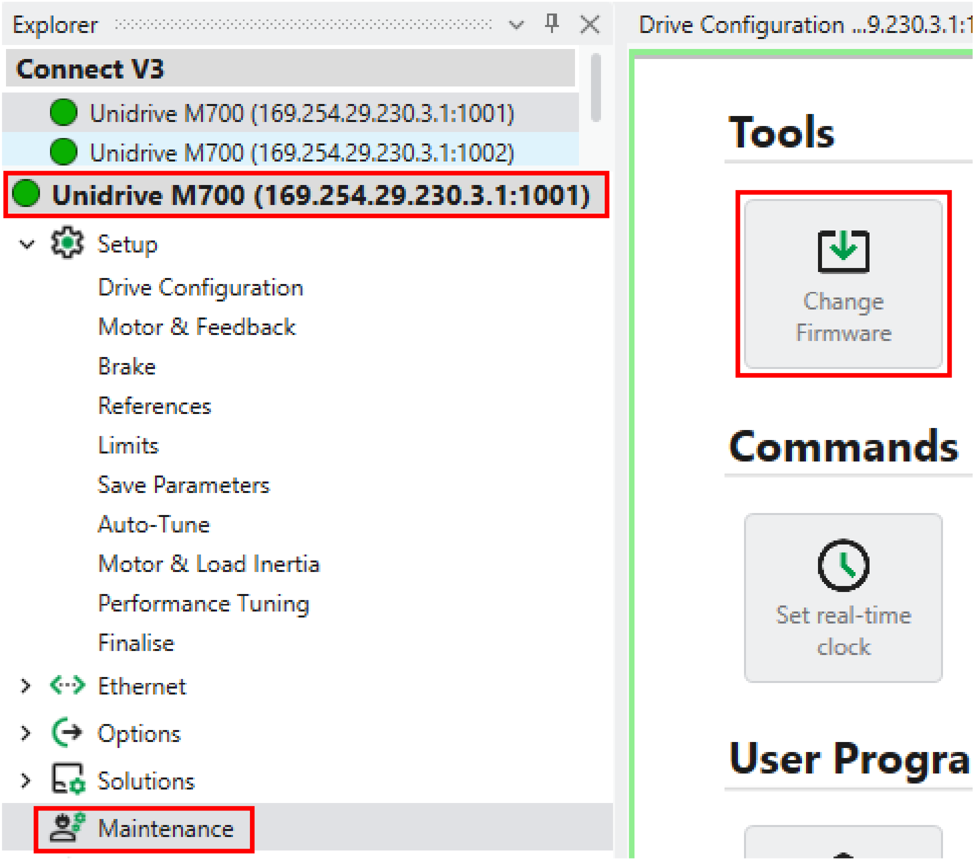
> **HINT:** Ethernet and Serial communications may be used directly with the drive, but any EtherCAT-based communications require an EtherCAT network Master to be configured before the drive can be communicated with such as a PLC or IPC.

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”.

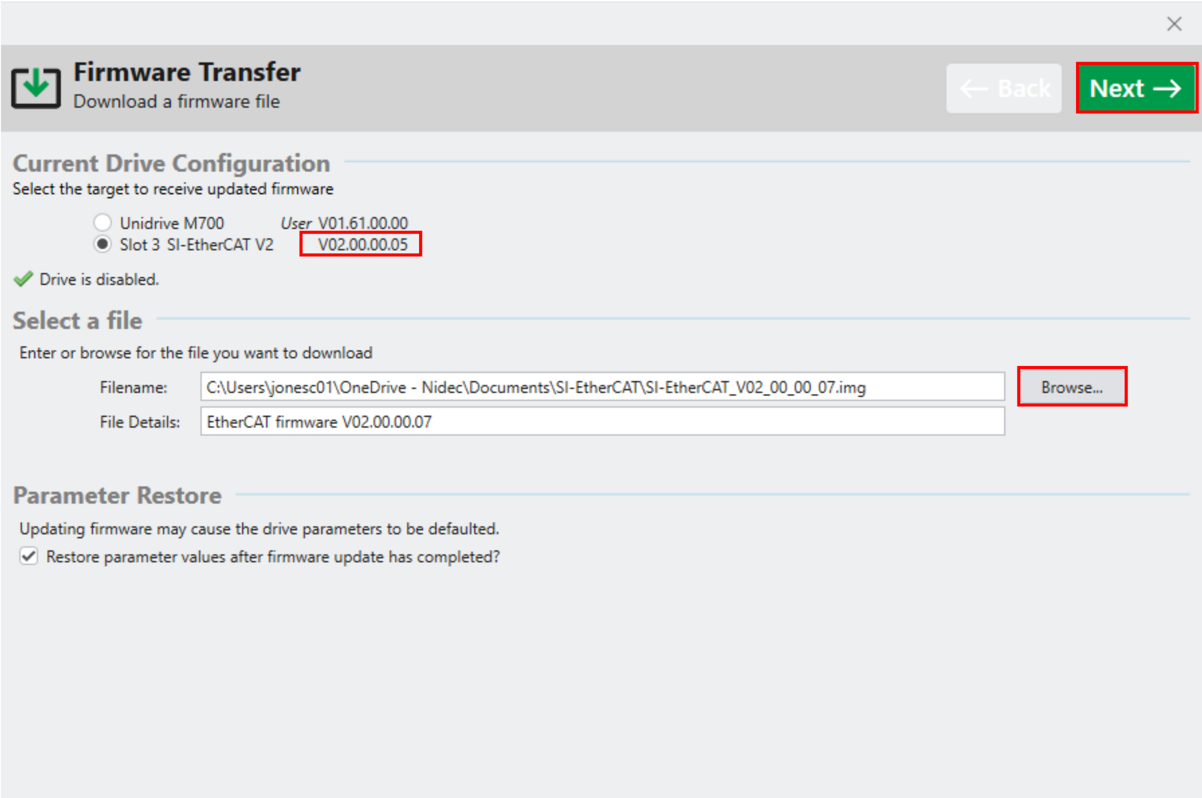


5. From the drive explorer tree double click on “Maintenance” and then “Change Firmware”:



6. 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:



   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.

7. 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.

8. 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.

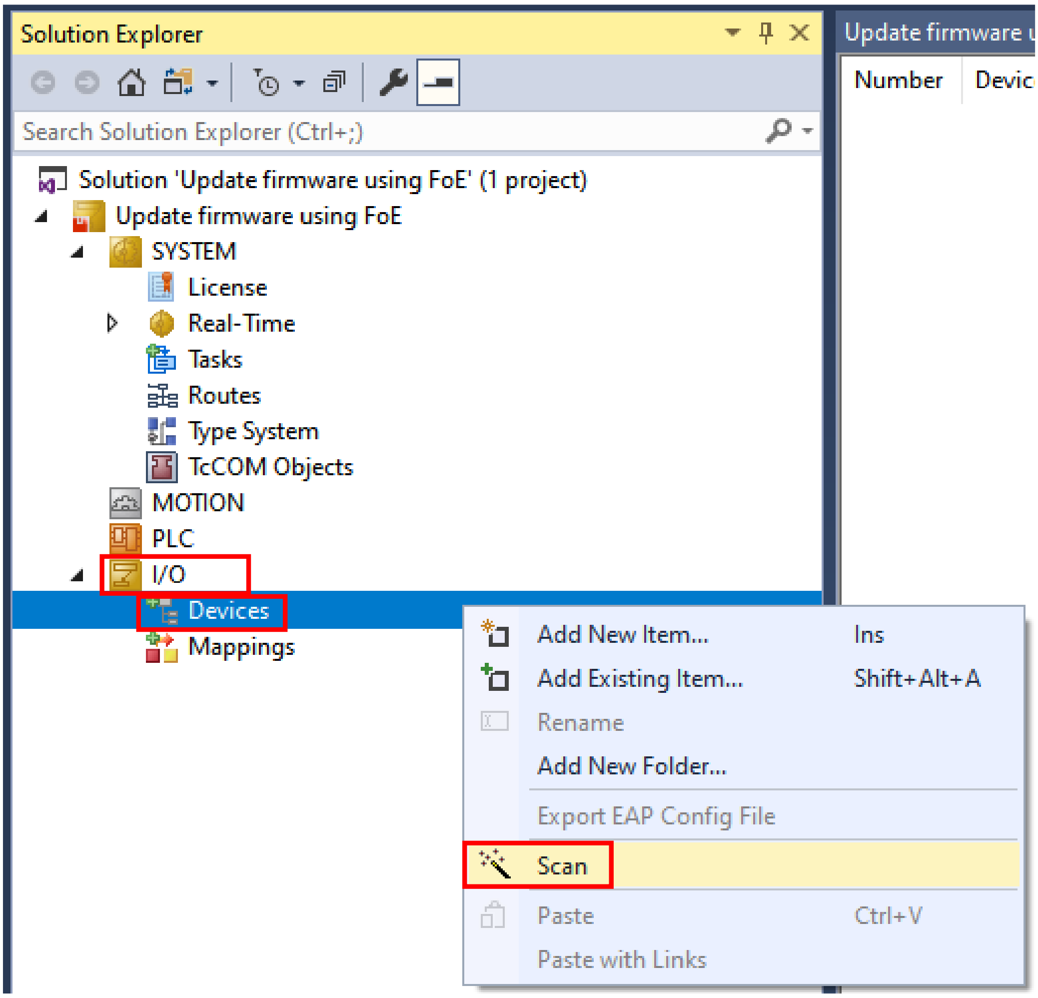
For firmware older than V01.08.00.14 an alternative connection must be made to the drive using Control Techniques RS485 adapter, or using Ethernet and an SI-Ethernet / Factory Fitted Ethernet option, or a KI-Keypad Plus.

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.

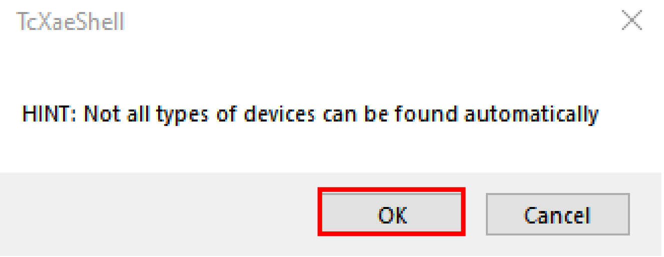
It is assumed that the steps in section **3 Initial TwinCAT project setup** have been followed to create a project before using these steps.

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:

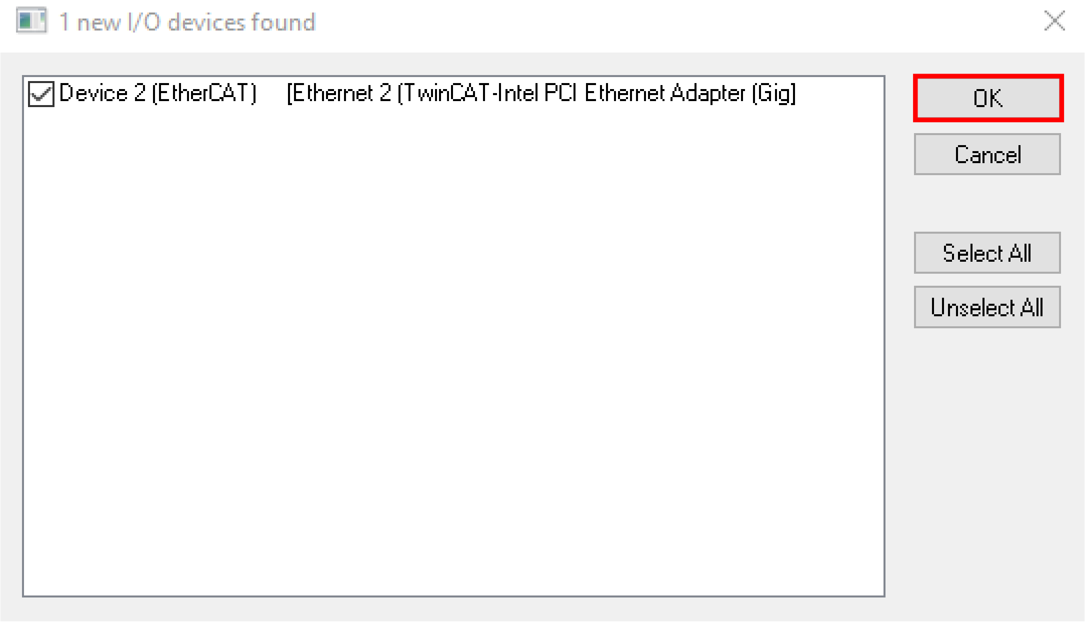
1. Expand "I/O" in the Solution Explorer and then right click on "Devices" and then select "Scan":



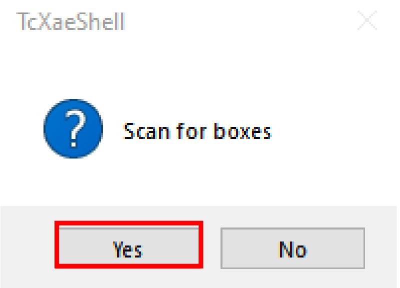
2. Click “OK” to the “HINT: Not all types of devices can be found automatically” pop-up.



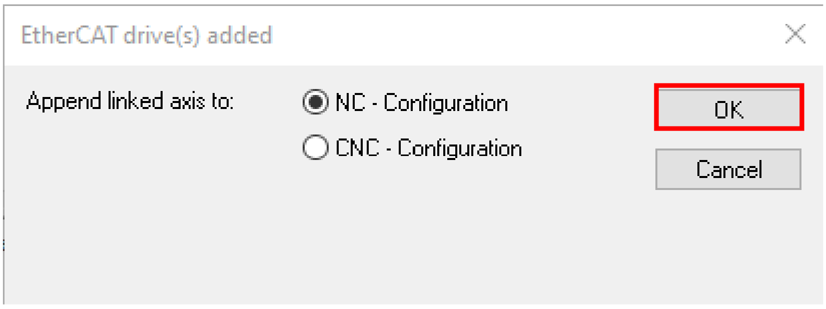
3. After the device search finishes, select the EtherCAT interface and then select “OK”.



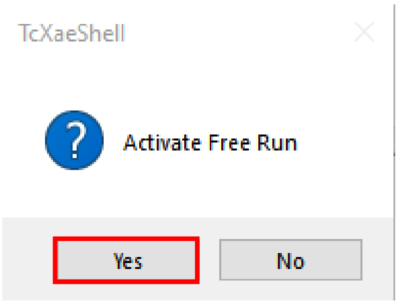
4. Select “Yes” when the “Scan for boxes?” pop-up appears:



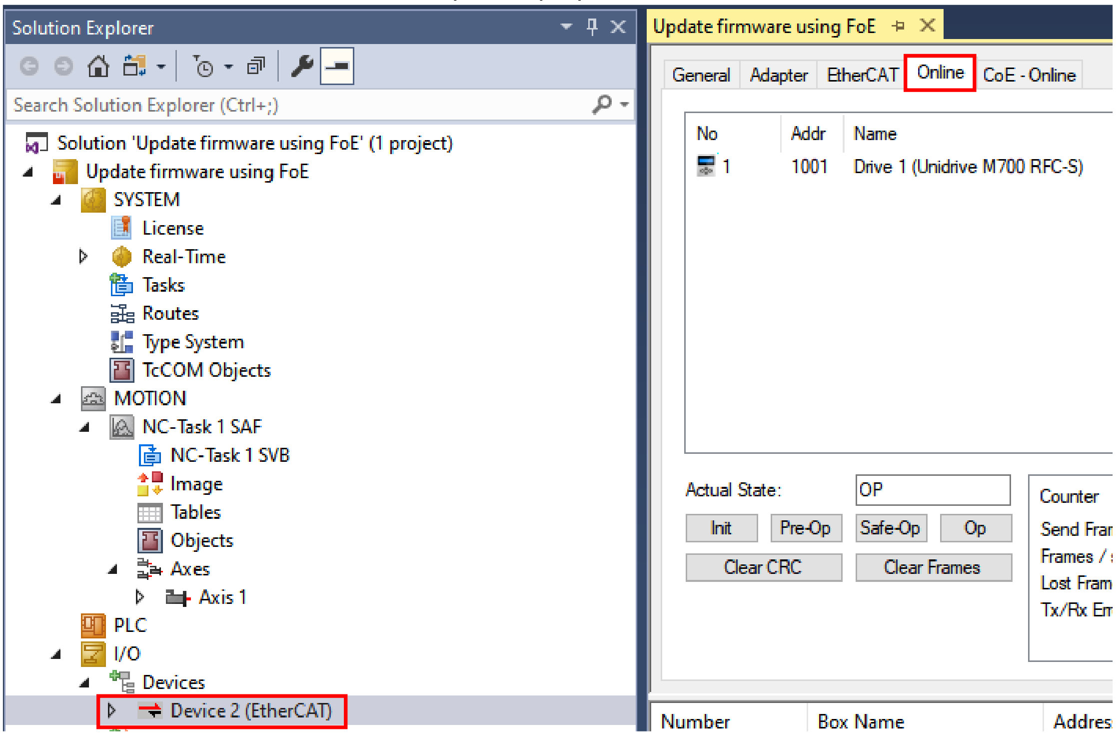
5. Click “OK” to adding “NC – configuration”.



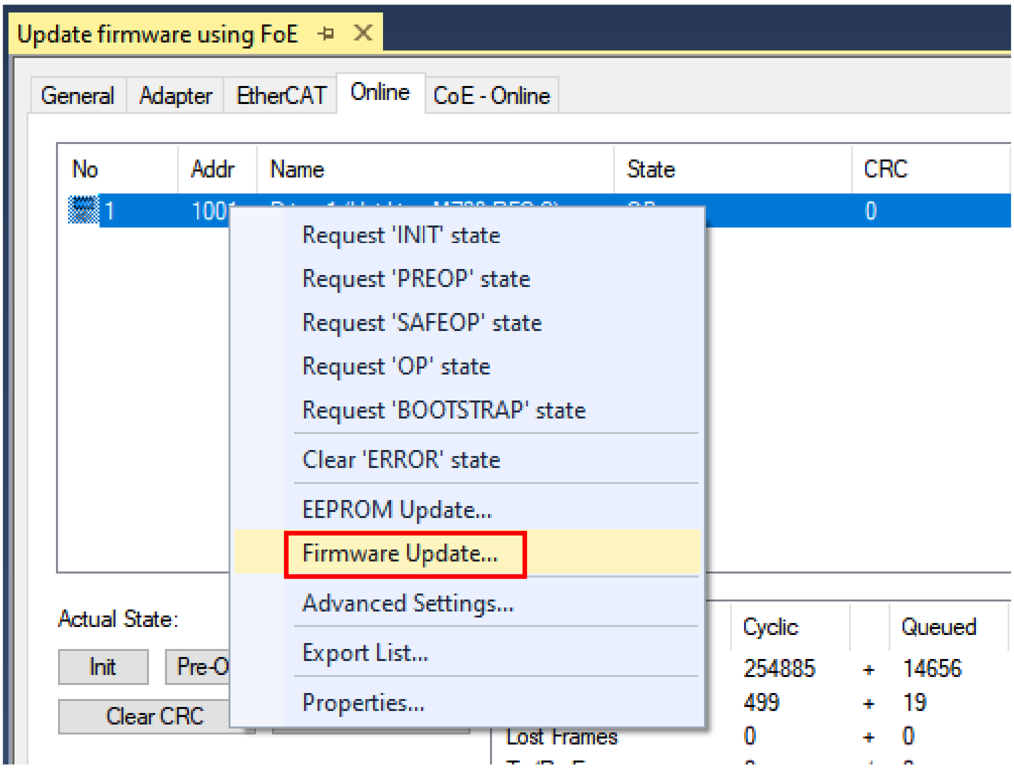
6. Click “Yes” on the “Activate Free Run” pop-up.



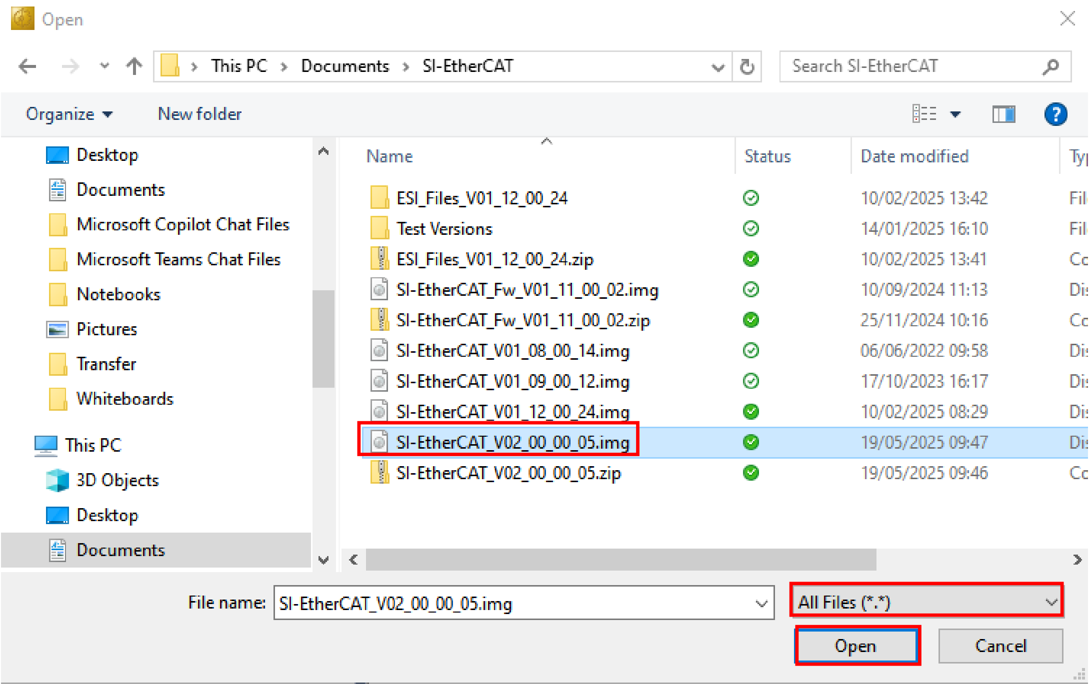
7. Double click the EtherCAT master to open its properties and then select the “Online” tab:



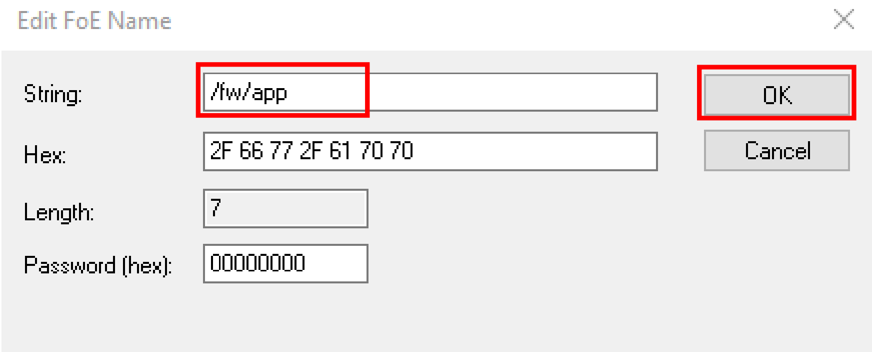
8. Right click on the drive to update and then select "Firmware Update…"



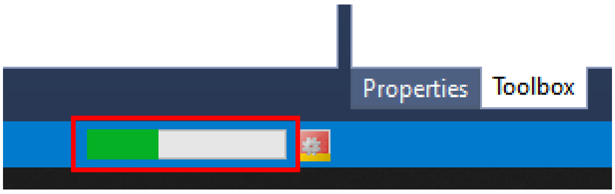
9. The file explorer opens. Set the file type to "All Files (*.*)", then select the firmware file, and then select "Open".



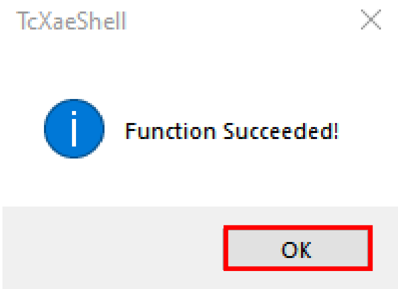
10. When the “Edit FoE Name” pop-up appears change “String:” to the correct file path for the firmware image file which is “/fw/app”, and then select “OK”.



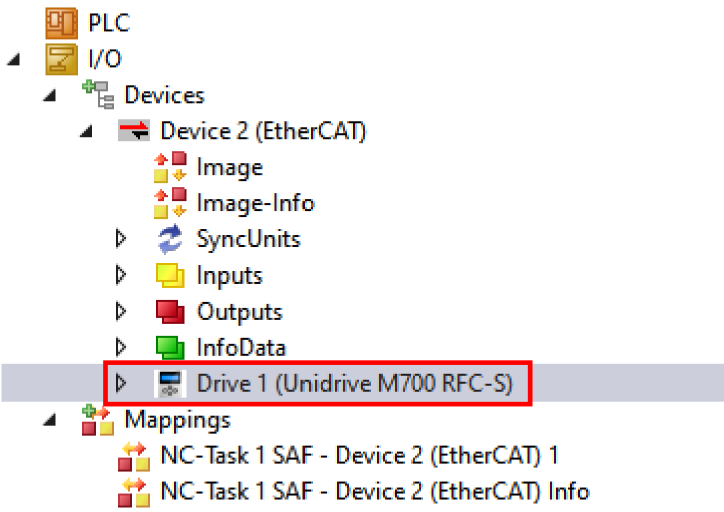
11. The file download runs. Wait until it finishes.



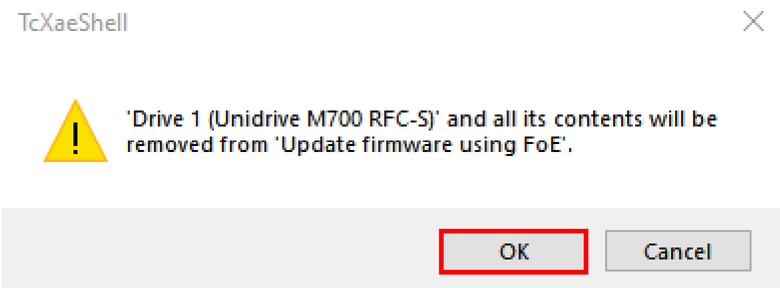
12. When the download completes the “Function Succeeded!” message appears. Click “OK”.



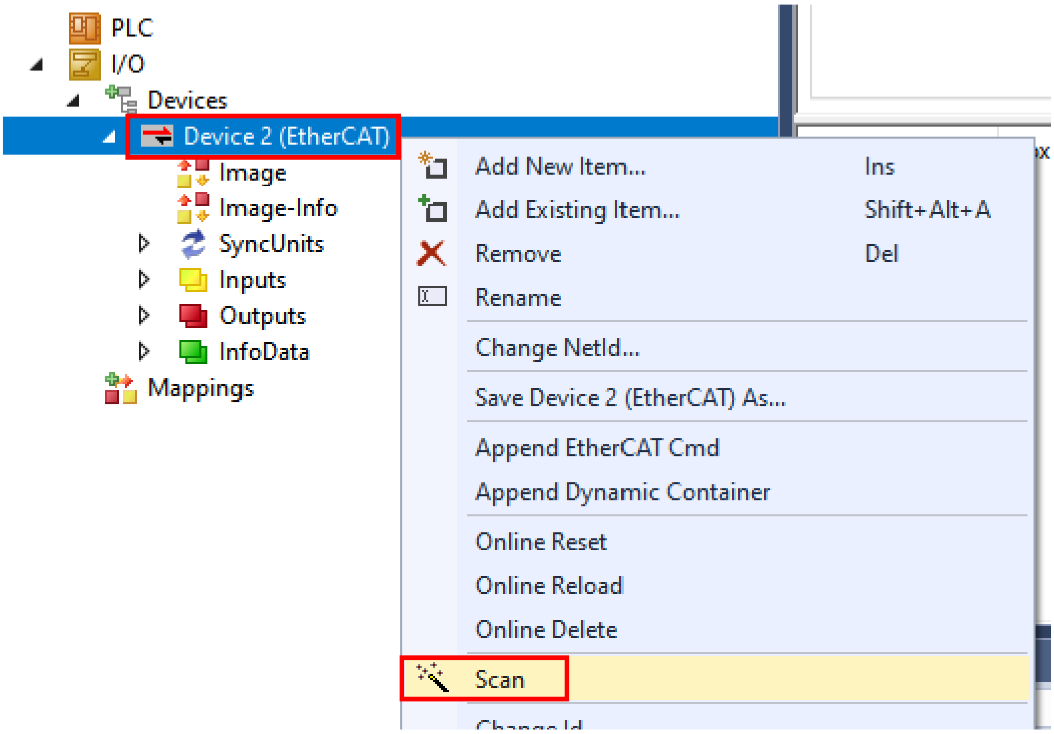
13. Delete the drive that has been updated in the Solution Explorer tree.



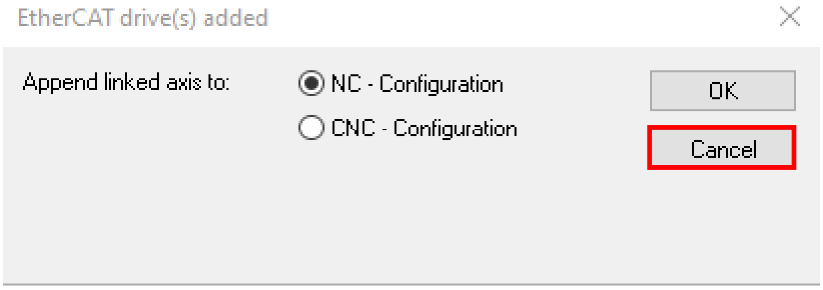
Click “OK” to the following message:



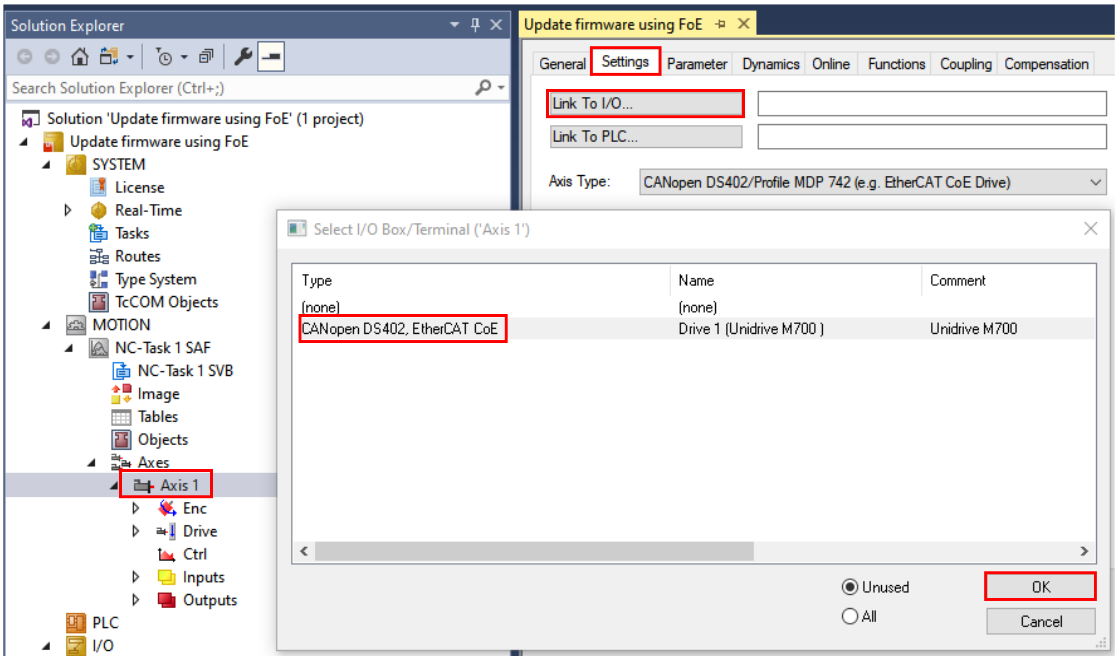
14. Right click on the EtherCAT master in the solution explorer tree and then select “Scan”.



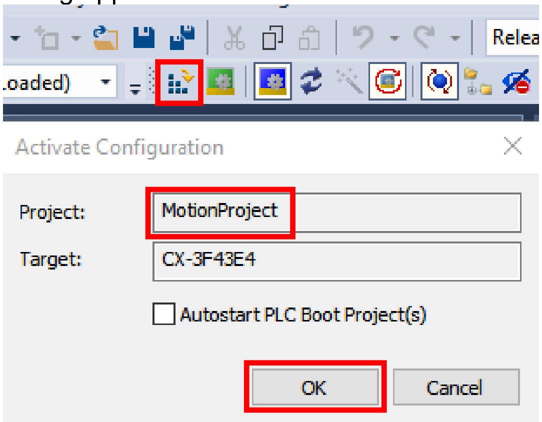
15. When the “EtherCAT drive(s) added” dialog appears select “Cancel” so that another NC axis isn’t added to the project.



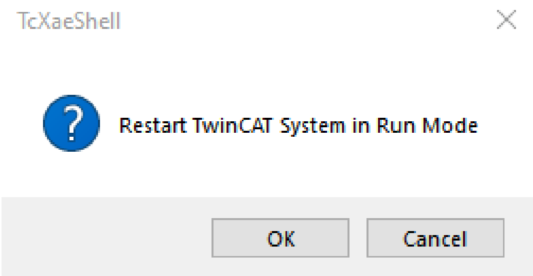
16. Link the NC that was created for the drive axis originally, back to the drive EtherCAT comms by double clicking on the axis e.g. Axis 1 to open it properties and select the “Settings” tab. Click on “Link To I/O…”, select the Drive from the list to link to the axis, e.g. Drive 1, and then select “OK”.



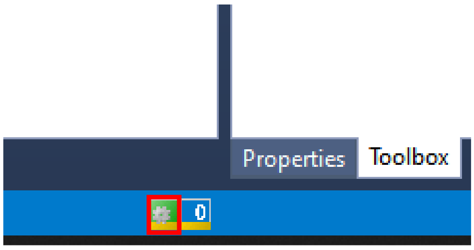
17. Click the “Activate Configuration” button and then click “OK” if the “Activate Configuration” dialog appears:



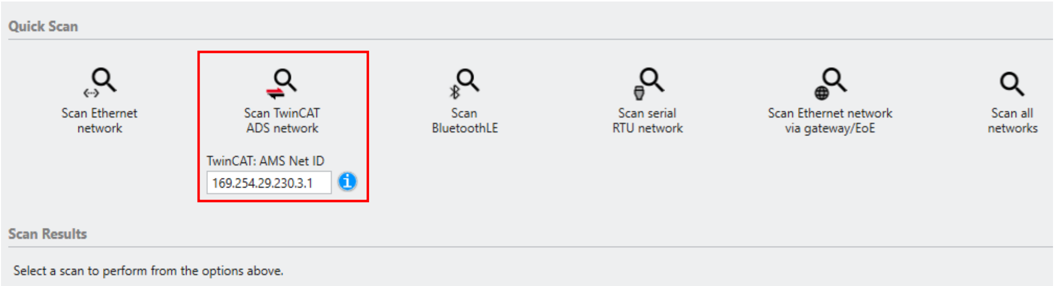
Click “OK” on the “Restart TwinCAT in Run Mode” dialog:



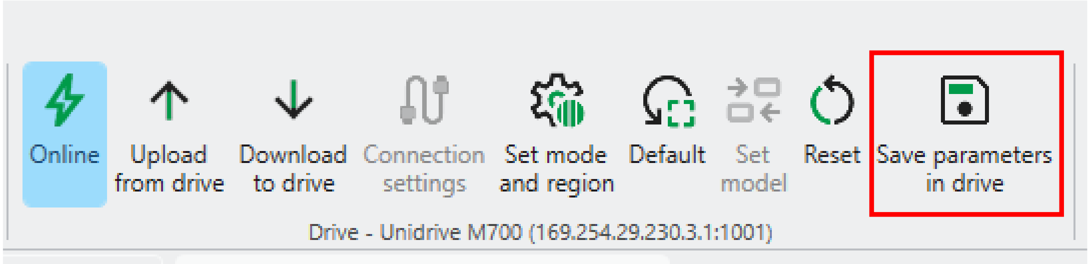
18. If the system is operating properly the status Icon in the bottom right corner of TwinCAT will show a green box with a rotating cog:



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.



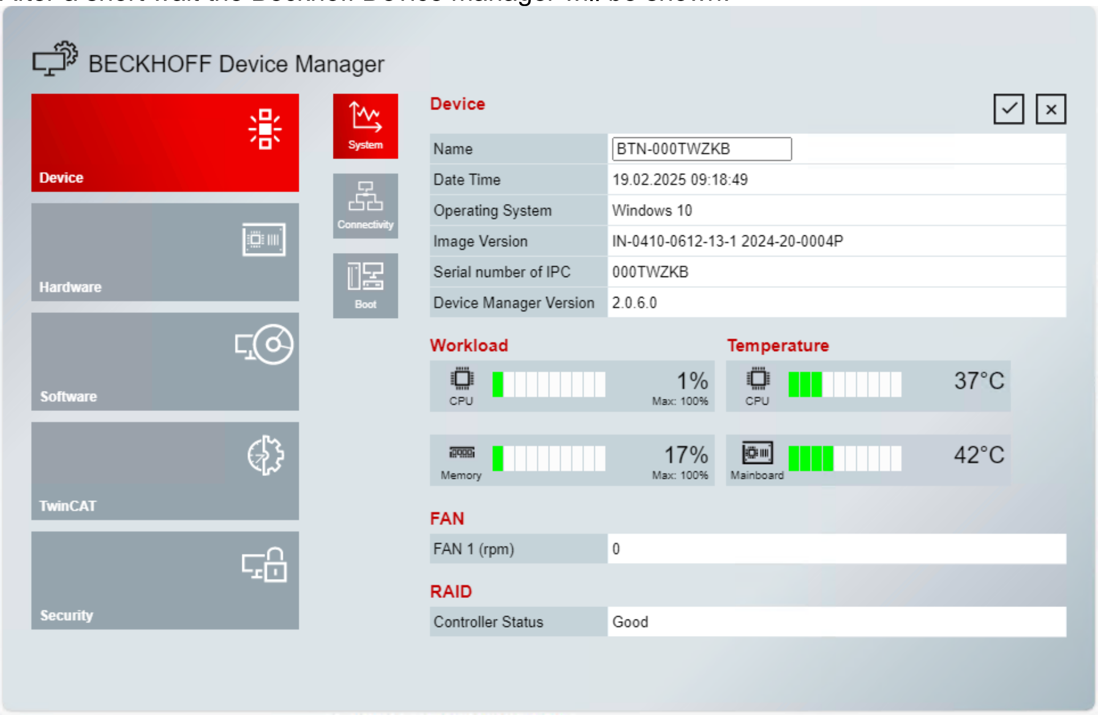
20. If the EtherCAT firmware has been upgraded from V1 to V2 a save is required to acknowledge the update. Start a project as described in section **5 Configure the drive using Connect** and once the project is open, select the drive to save and then click “Save parameters in drive” to complete the process.



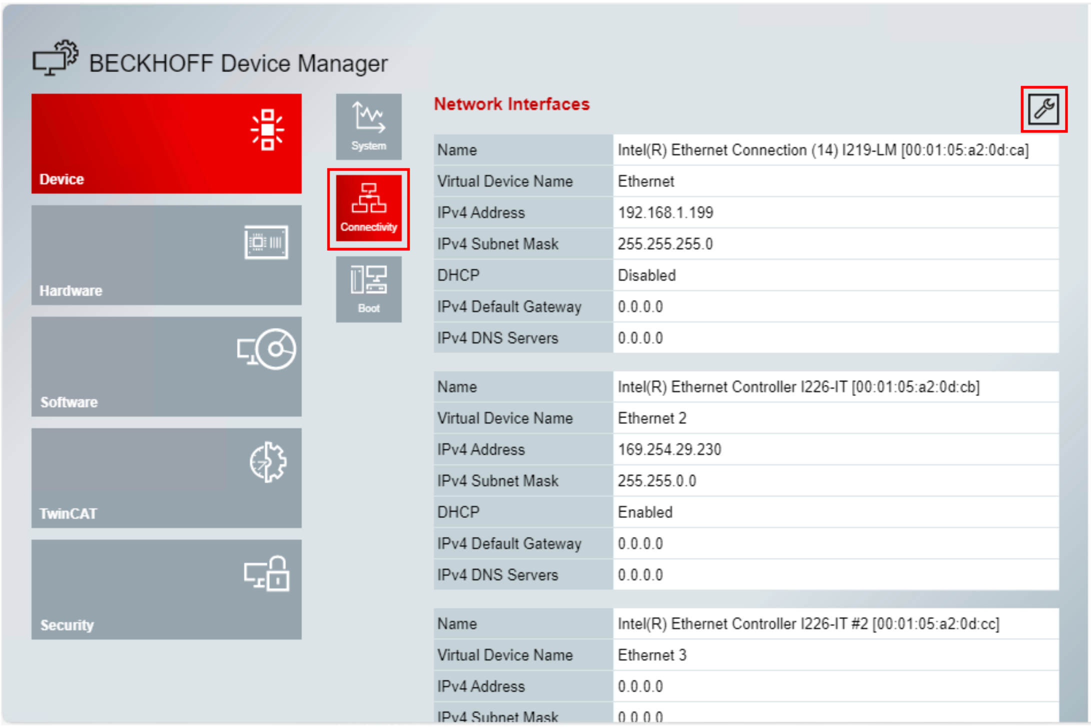
10.6 How to setup a Beckhoff IPC

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.

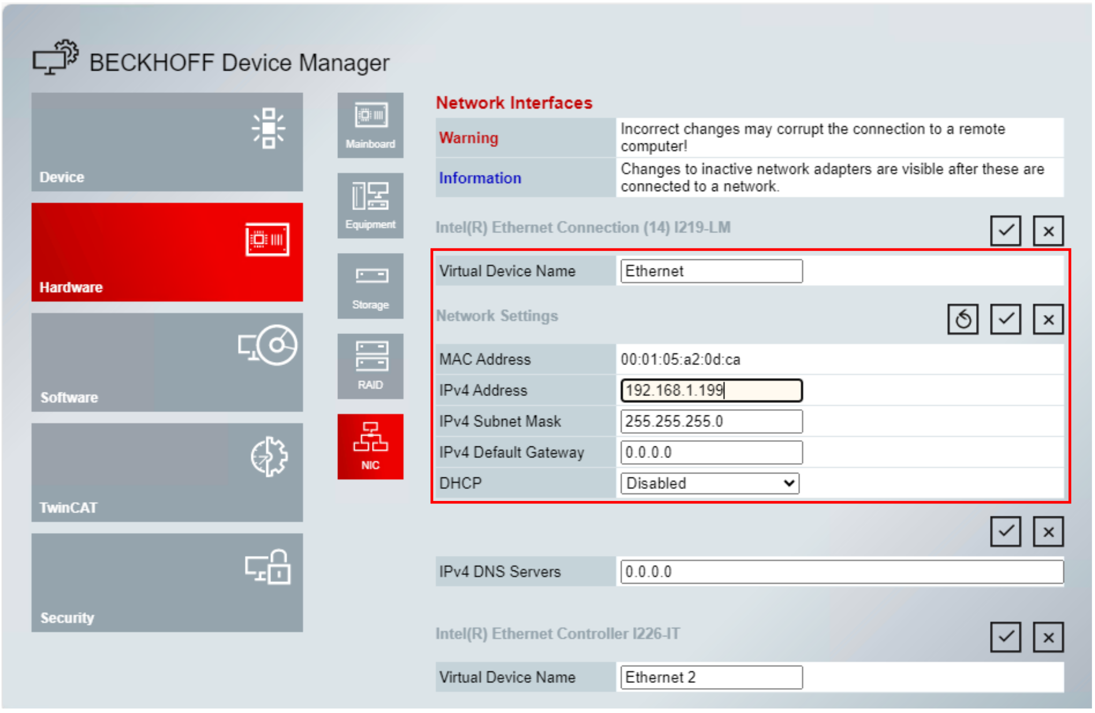
1. Apply 24V to the IPC. Follow the user guide for the IPC for the details on the power connector wiring.
2. Plug a monitor, keyboard and mouse into the IPC.
3. After a short wait the Beckhoff Device manager will be shown:



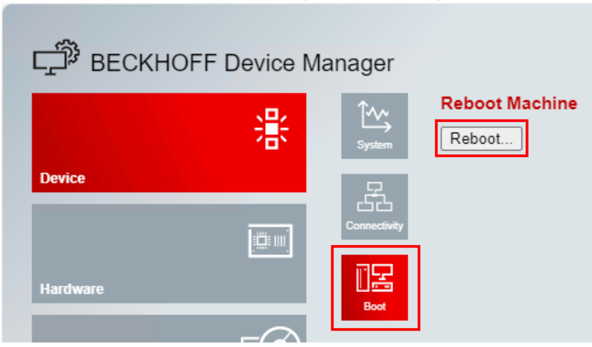
4. Select Connectivity and then click the spanner icon on the top right of the Device Manager to configure a static IP address:



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.



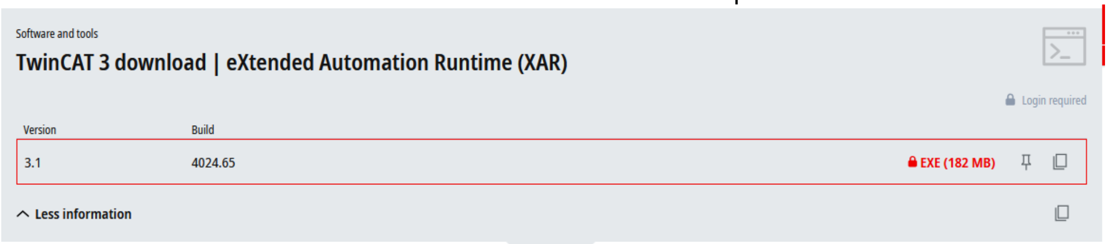
7. Using the command prompt or Powershell, ping the new IP address to make sure it is operational. When the command prompt is shown type “ping ” followed by the IP address assigned e.g. “ping 192.168.1.199”. The screen shot below shows a successful ping:

Windows PowerShell

```
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>
```

8. 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/”.

9. Get the TwinCAT XAR runtime form the Beckhoff website and put it onto a USB stick:

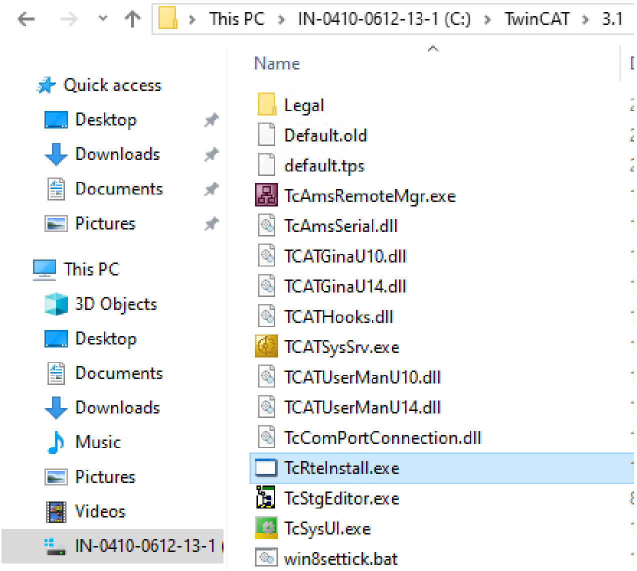


Put the USB stick with the runtime on it into one of the IPCs USB ports.

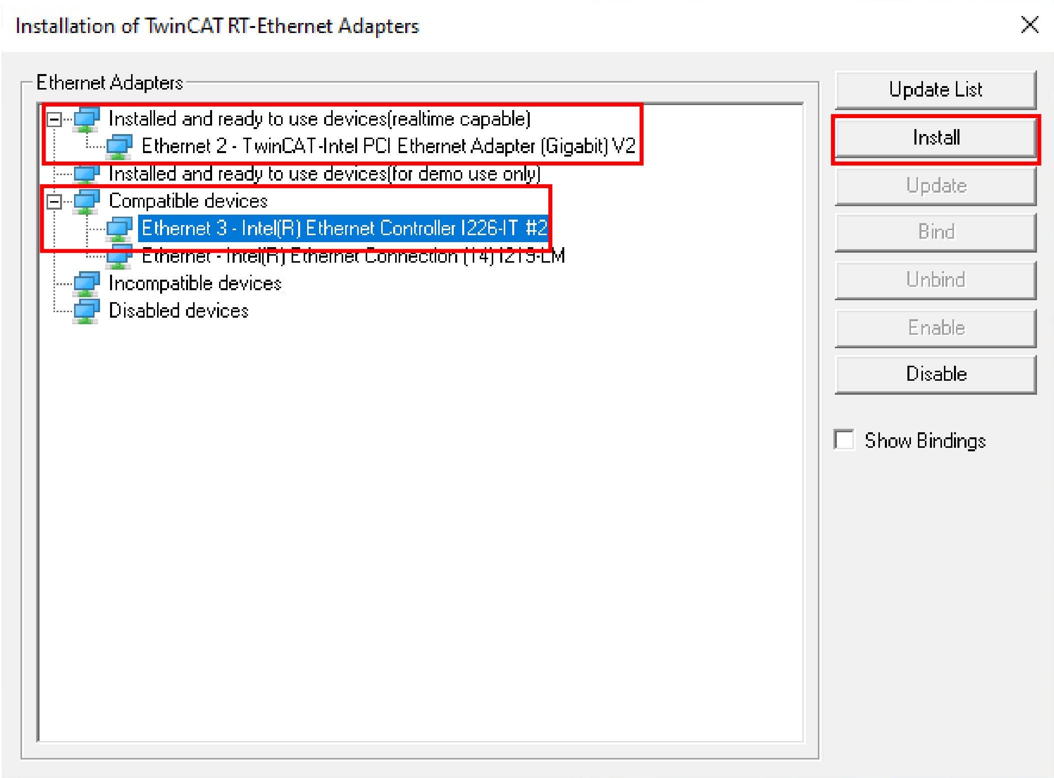
10. Using file explorer on the IPC locate the USB stick, copy the files from the USB to the IPCs documents folder, and then double click on the installer file to start the installation. When the installation completes the IPC must be rebooted.

11. 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 “TcRteInstall.exe”. Double click on this to assign the EtherCAT network port on the IPC.

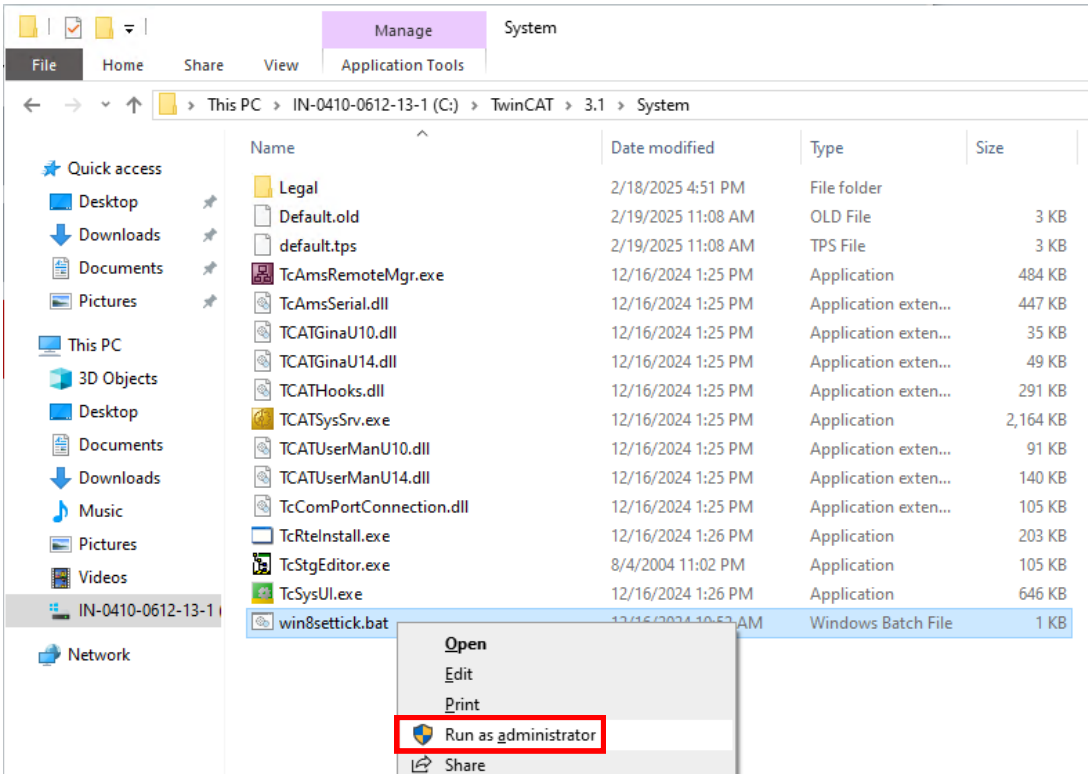


13. When the installer opens, click on the port to become the EtherCAT network port in the “Compatible Devices” list and then click “Install”. When the process is completed the newly installed port will appear in the “Installed and ready to use devices (realtime capable)” list.

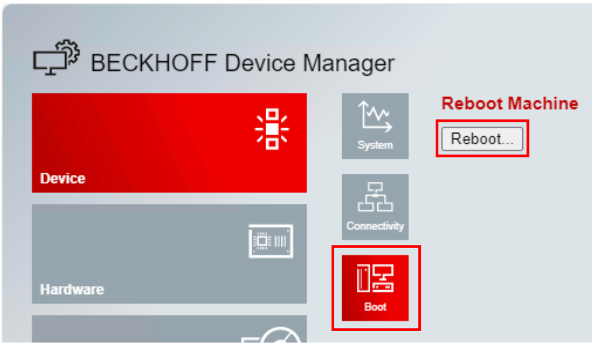


Close the installer when finished

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.

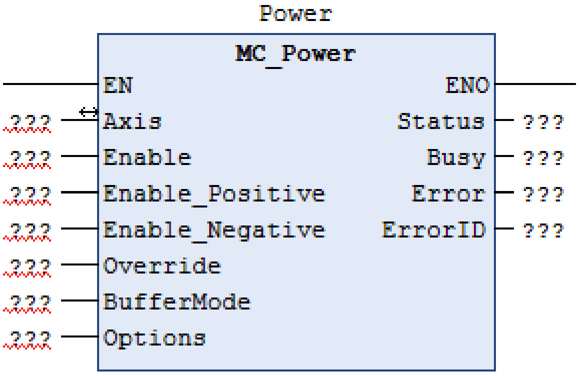


16. The IPC can now be used with TwinCAT.

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

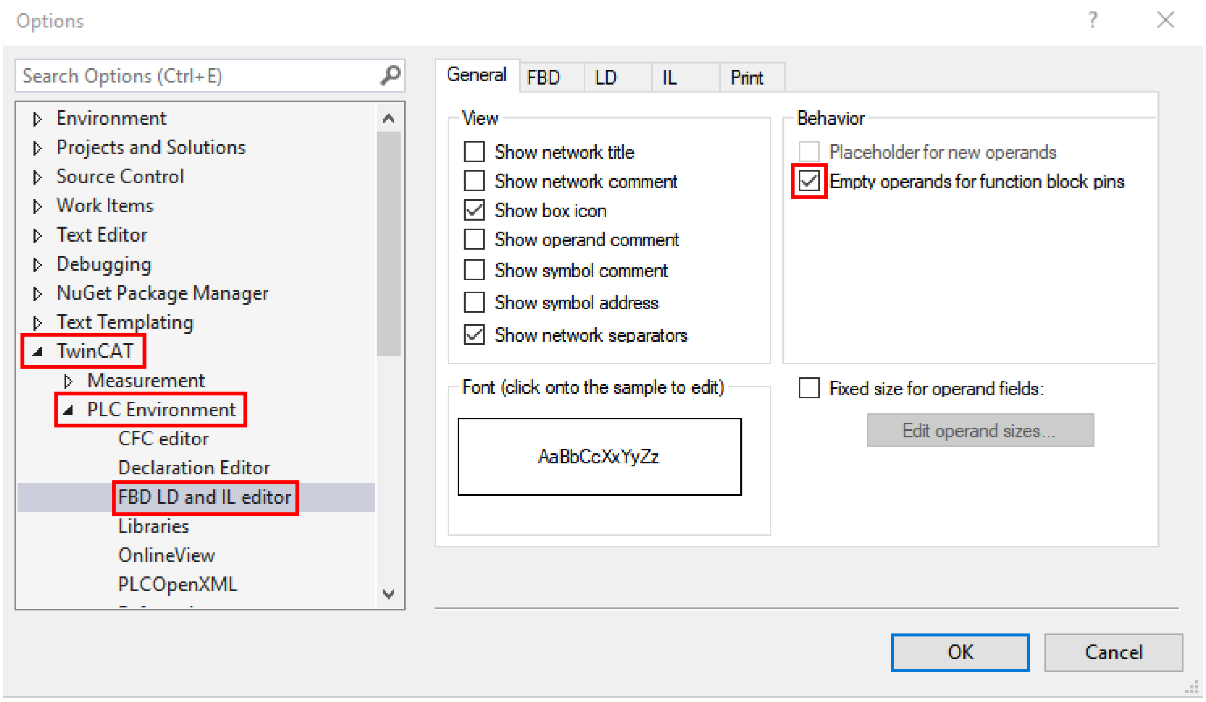
LD diagram language can be a nice way to explore the functionality of the NC axis PLCopen function blocks. Each input and output can be seen side by side, any enumerated values selected, and all output values may be seen.

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.

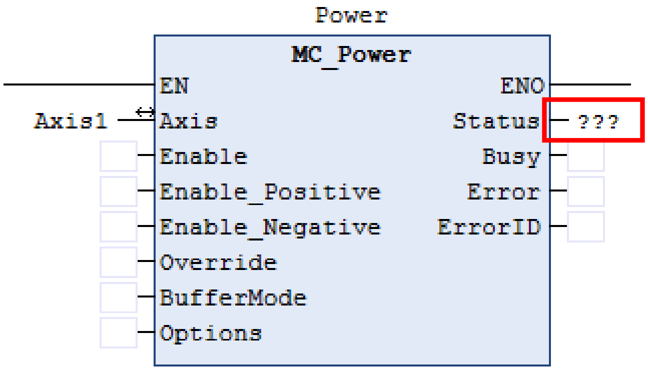


The “???” at the POU’s I/O is optional. The following steps show how to turn this off:

- 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.

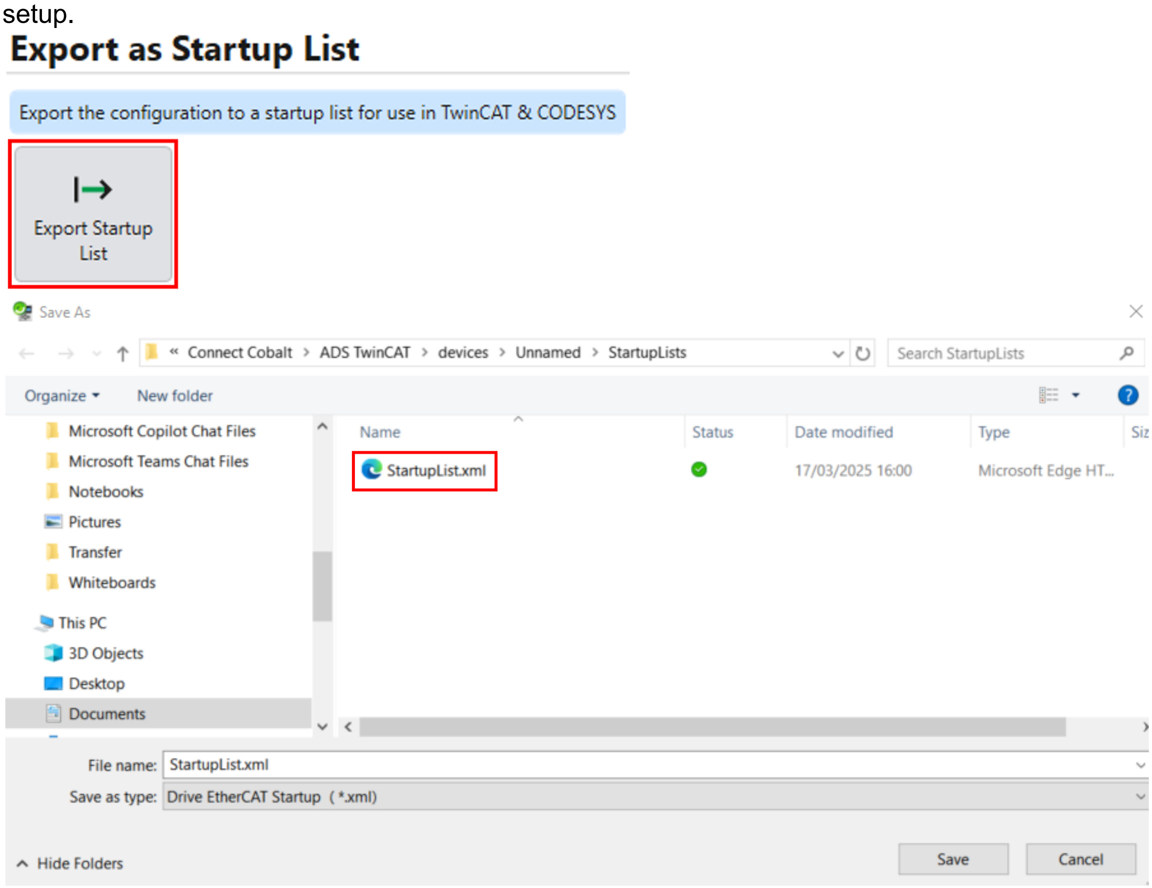
10.8.1 How to import a startup list .xml file from Connect into TwinCAT

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.

This startup list should be generated after the speed and position loops have been tuned so that all of the setup is retained.

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

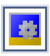
1. An EtherCAT startup list may be generated to preserve the configuration in the TwinCAT PLC/IPC. The startup list is in the form of an startup list .xml file that may be imported into TwinCAT. The export start-up list button can be found on the "Finalize" step in the guided setup.

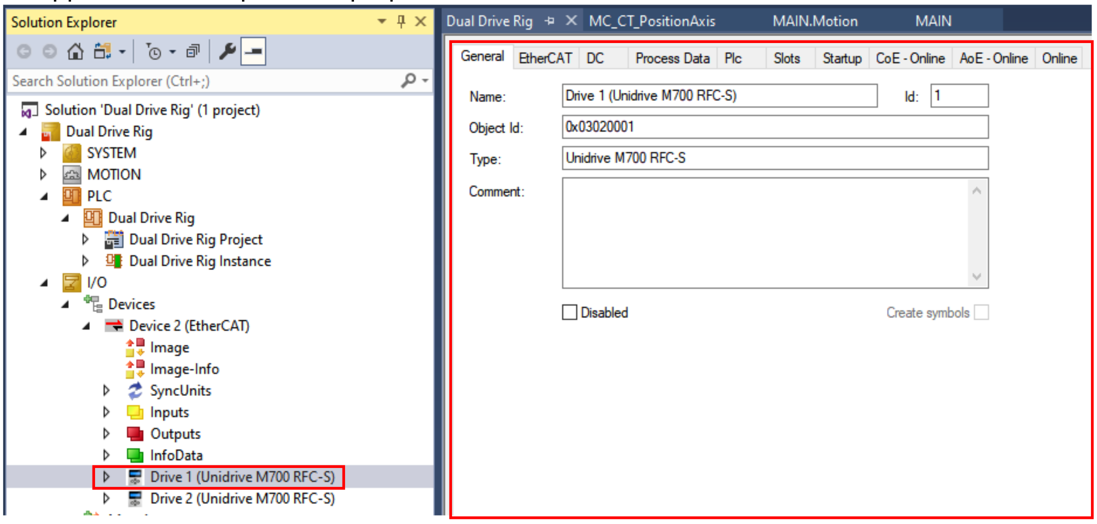
   StartupList.xml is stored in the following location: C:\Users\[USER NAME]\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists.

   Open the TwinCAT project.

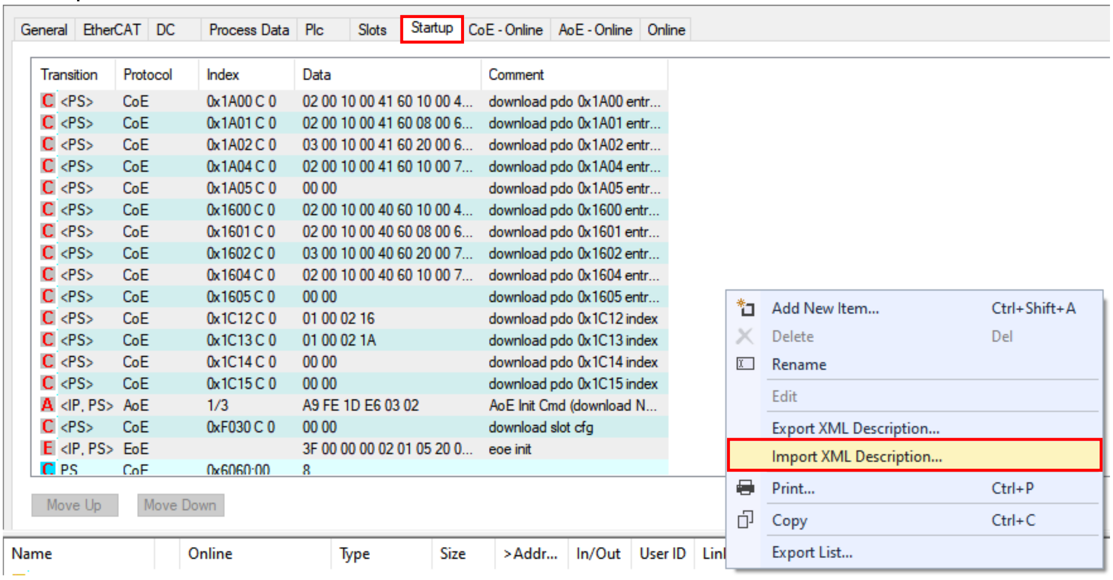
2. Make sure config mode is selected as indicated by the blue config button being highlighted. Click the blue Config button if it is not highlighted.

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.

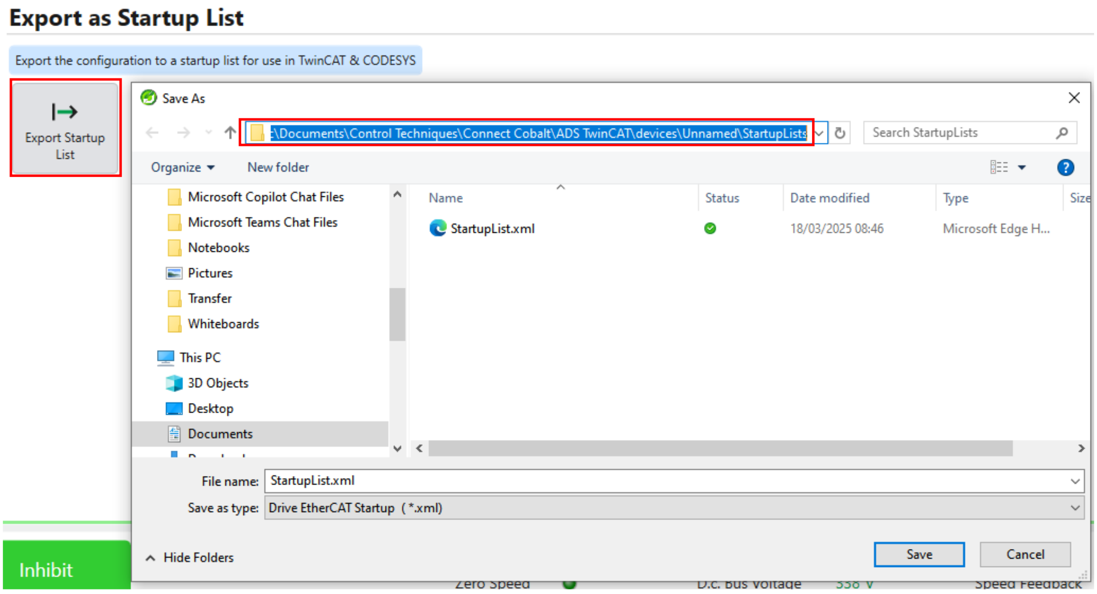


4. Select the Startup tab. Right click anywhere on the startup tab, and select “Import XML Description…”

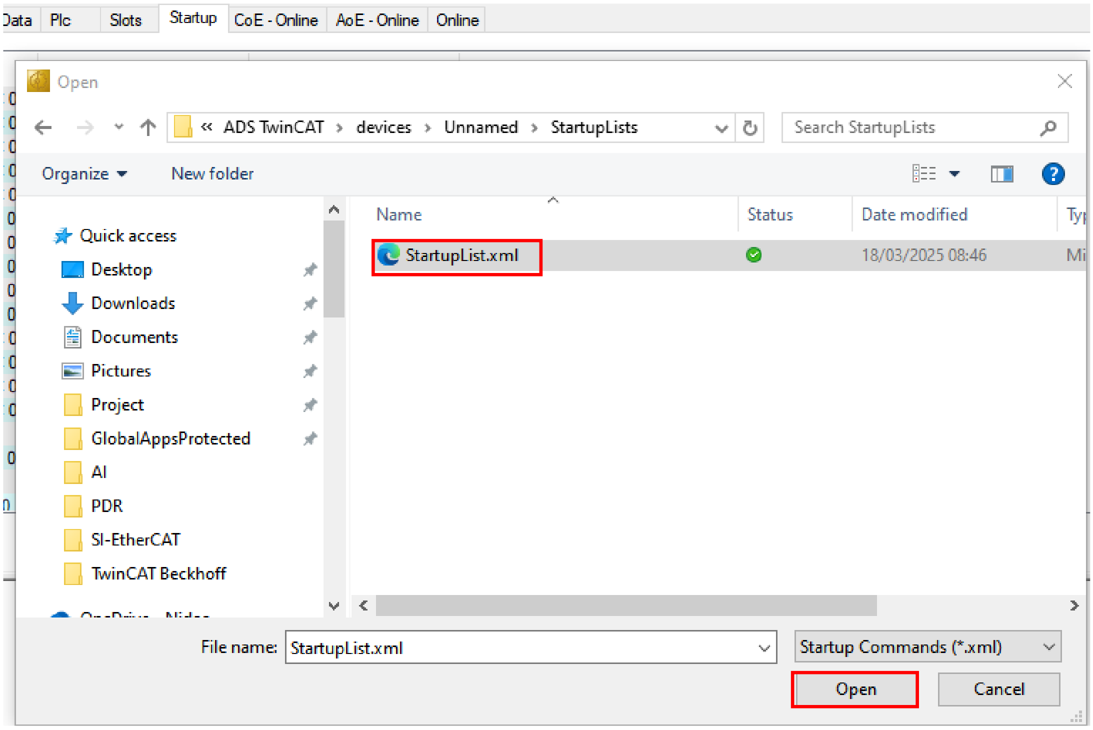


5. Navigate to the location of the startup list generated by Connect. The general form for the path to the .xml file is “C:\Users\[USER NAME]\OneDrive\Documents\Control Techniques\Connect Cobalt\[PROJECT NAME]\devices\[DEVICE NAME]\StartupLists”

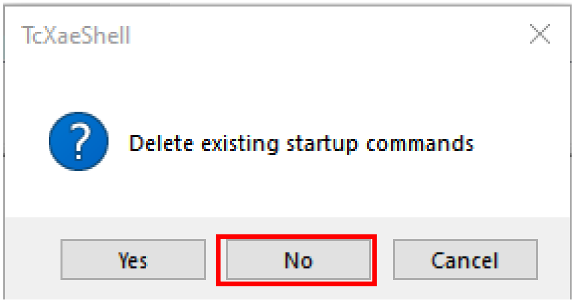
   Alternatively the path for the .xml file can be copied by opening the original Connect project, go to “Setup” > “Finalise” page and then click on “Export Startup List” and then copy the path from the explorer window.



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



6. 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.



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

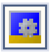
10.8.2 How to add a single CAN object to the TwinCAT Startup List & Cyclic comms loss action

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**.

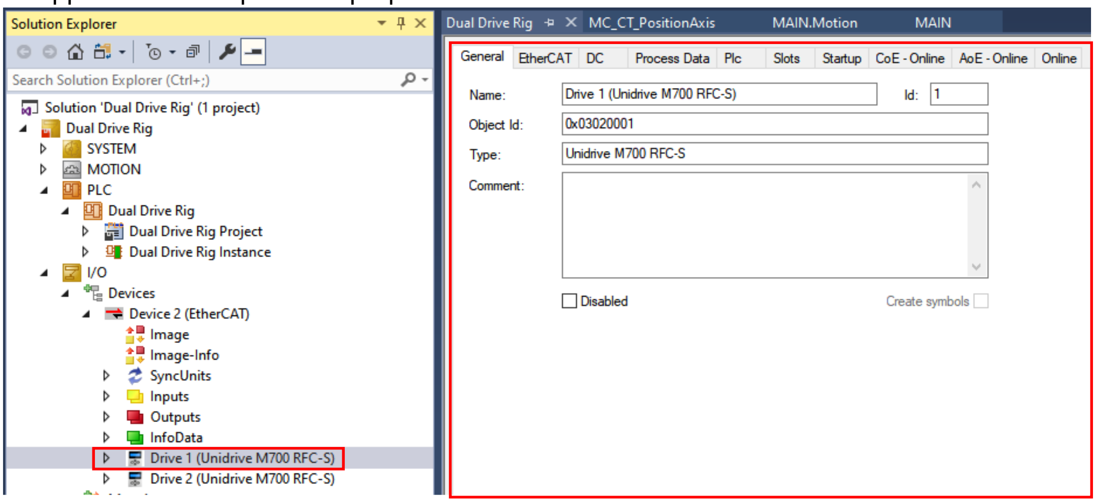
Use the following steps to add ESI specified CANopen objects to the startup list in TwinCAT:

1. Open the TwinCAT project.

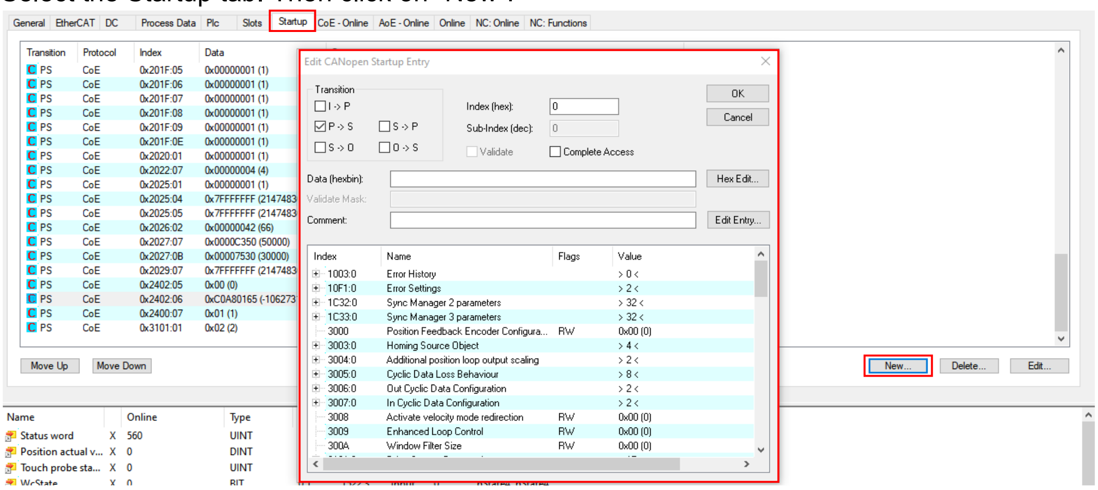
2. Make sure config mode is selected as indicated by the blue config button being highlighted. Click the blue Config button if it is not highlighted. Click "OK" on any following po-up messages.



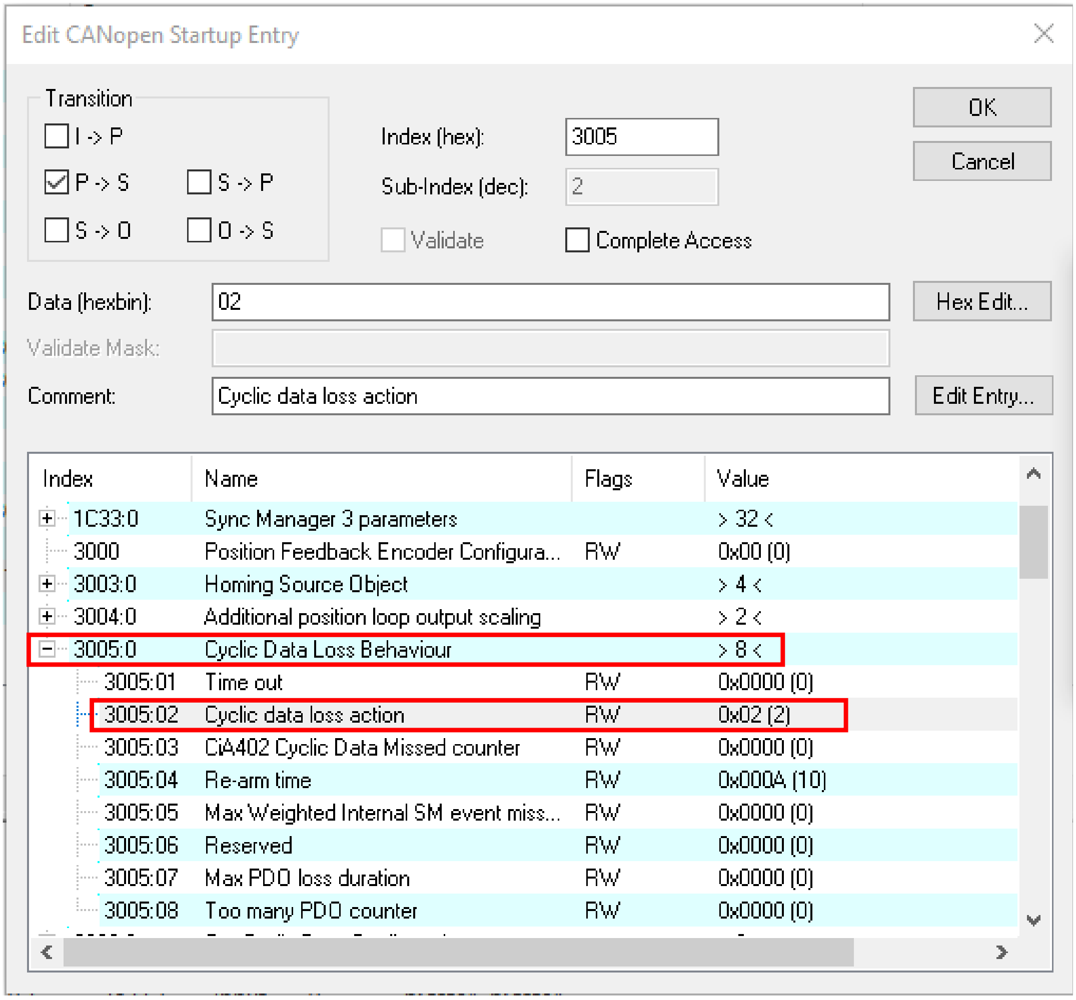
3. Double click on the drive node in the Solution explorer pane, that the startup list .xml file will be applied to. This opens the properties for the drive node.



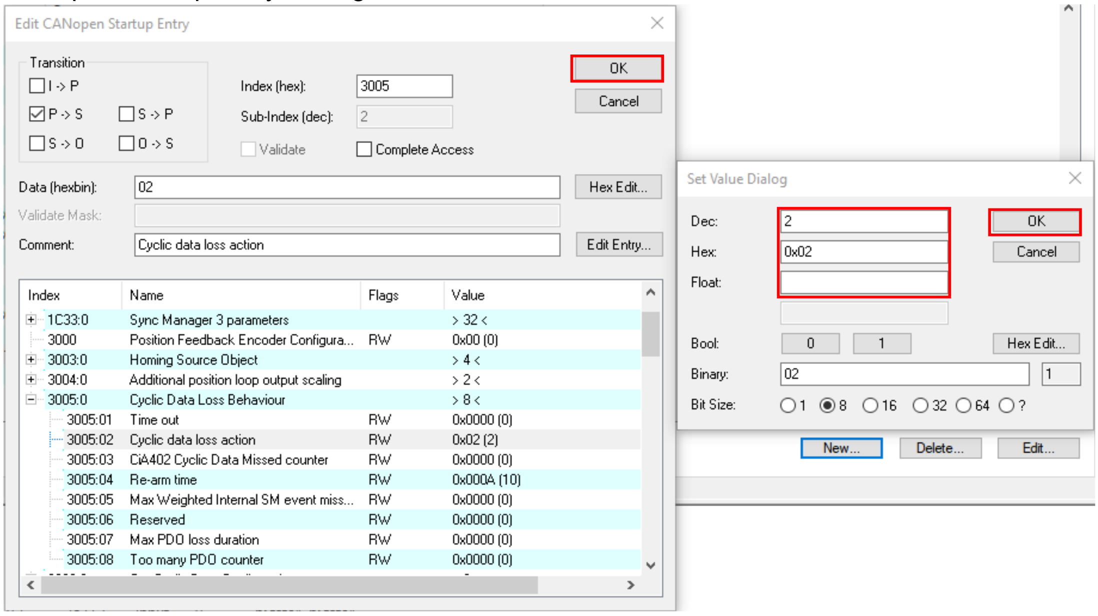
4. Select the Startup tab. Then click on "New":



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

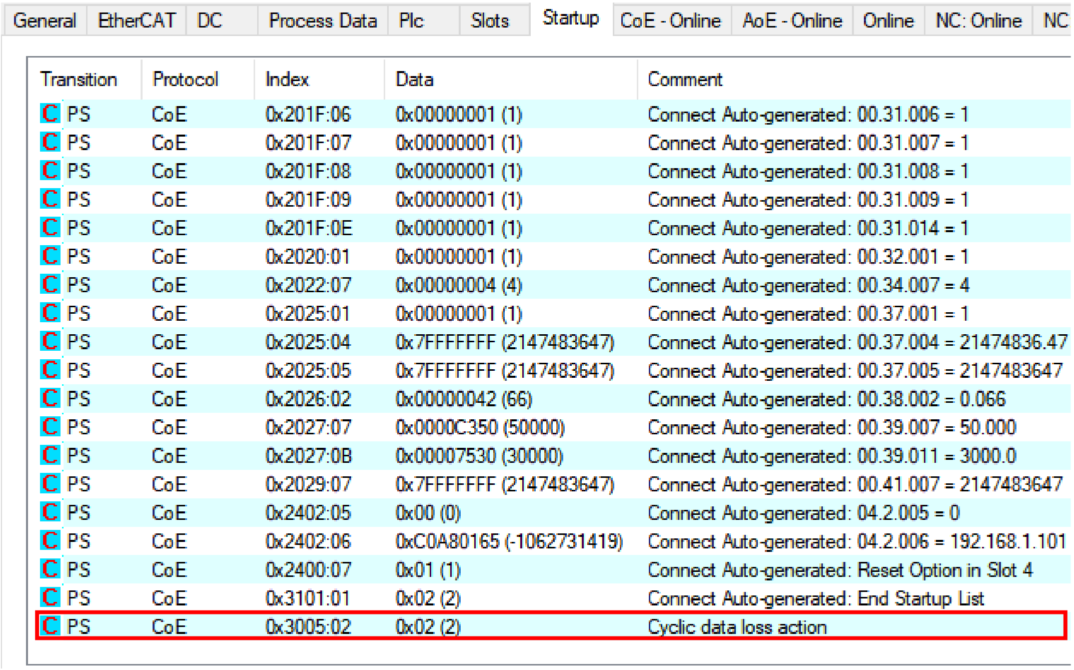


6. Double click on the subindex to open the “Set Value Dialog”. Enter the value as either a decimal or hex value. When finished click “OK” in the “Set Value Dialog” and the “Edit CANopen Startup Entry” dialog.



HINT: Data is entered in this tool in hex with the byte pair values entered in reverse endian format. This means the least significant byte pair is entered first followed by the other byte pairs with increasing significance. E.g. a 32bit value in conventional hex format is written as 0x 12 34 56 78, but in reverse endian format it is entered as 0x 78 56 34 12.

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



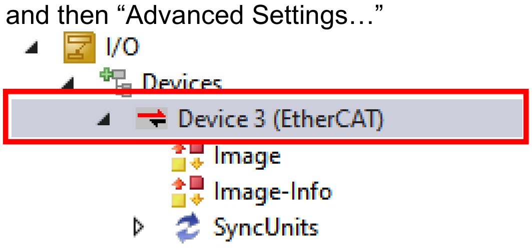
Transition	Protocol	Index	Data	Comment
C PS	CoE	0x201F:06	0x00000001 (1)	Connect Auto-generated: 00.31.006 = 1
C PS	CoE	0x201F:07	0x00000001 (1)	Connect Auto-generated: 00.31.007 = 1
C PS	CoE	0x201F:08	0x00000001 (1)	Connect Auto-generated: 00.31.008 = 1
C PS	CoE	0x201F:09	0x00000001 (1)	Connect Auto-generated: 00.31.009 = 1
C PS	CoE	0x201F:0E	0x00000001 (1)	Connect Auto-generated: 00.31.014 = 1
C PS	CoE	0x2020:01	0x00000001 (1)	Connect Auto-generated: 00.32.001 = 1
C PS	CoE	0x2022:07	0x00000004 (4)	Connect Auto-generated: 00.34.007 = 4
C PS	CoE	0x2025:01	0x00000001 (1)	Connect Auto-generated: 00.37.001 = 1
C PS	CoE	0x2025:04	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.37.004 = 21474836.47
C PS	CoE	0x2025:05	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.37.005 = 2147483647
C PS	CoE	0x2026:02	0x00000042 (66)	Connect Auto-generated: 00.38.002 = 0.066
C PS	CoE	0x2027:07	0x0000C350 (50000)	Connect Auto-generated: 00.39.007 = 50.000
C PS	CoE	0x2027:0B	0x00007530 (30000)	Connect Auto-generated: 00.39.011 = 3000.0
C PS	CoE	0x2029:07	0x7FFFFFFF (2147483647)	Connect Auto-generated: 00.41.007 = 2147483647
C PS	CoE	0x2402:05	0x00 (0)	Connect Auto-generated: 04.2.005 = 0
C PS	CoE	0x2402:06	0xC0A80165 (-1062731419)	Connect Auto-generated: 04.2.006 = 192.168.1.101
C PS	CoE	0x2400:07	0x01 (1)	Connect Auto-generated: Reset Option in Slot 4
C PS	CoE	0x3101:01	0x02 (2)	Connect Auto-generated: End Startup List
C 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.

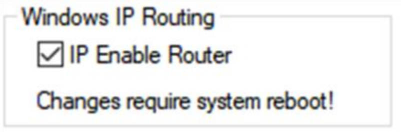
10.9 How to setup an EtherCAT EoE connection

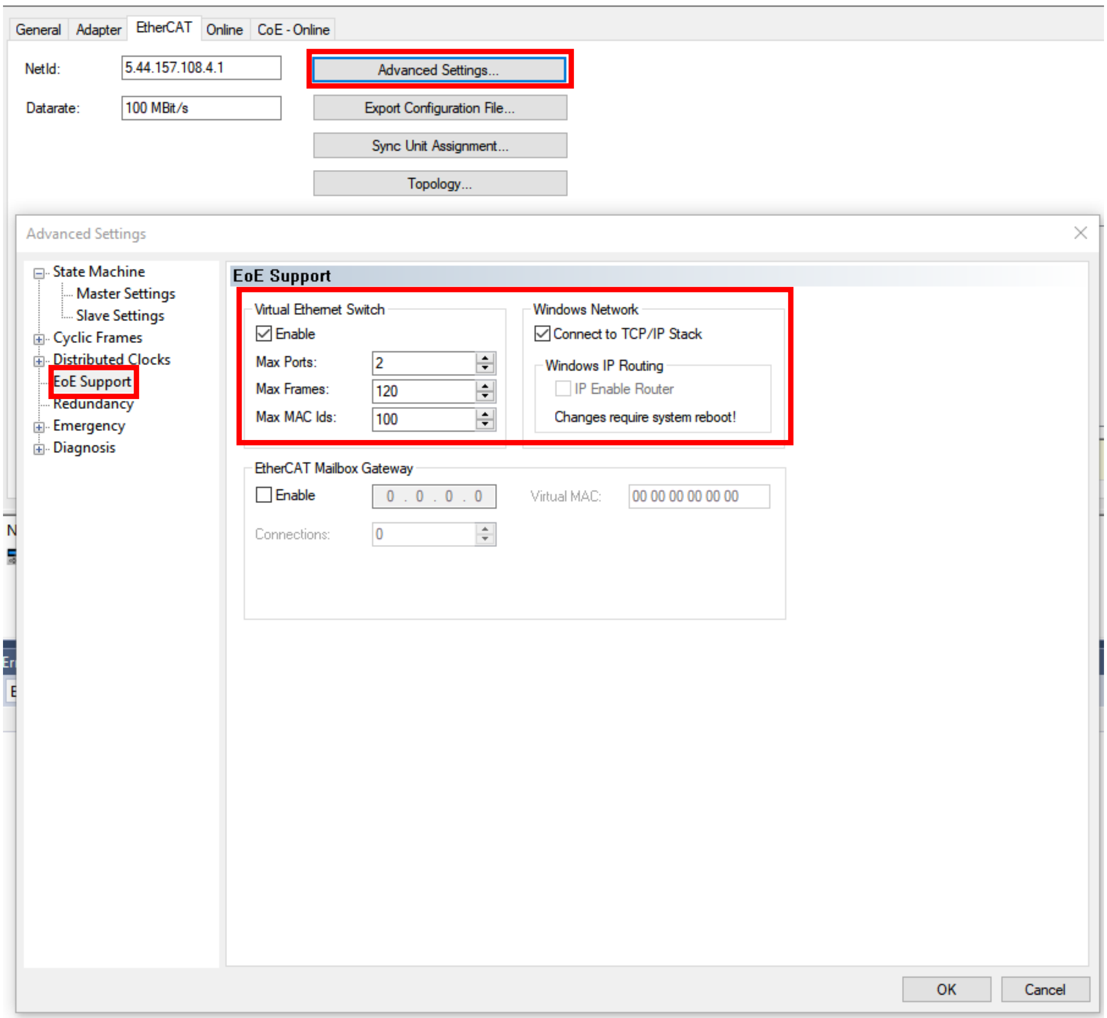
This section details how to establish an EoE (Ethernet Over EtherCAT) connection after the controller and axis has been added to the project as shown by section **3 Initial TwinCAT project** setup.

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

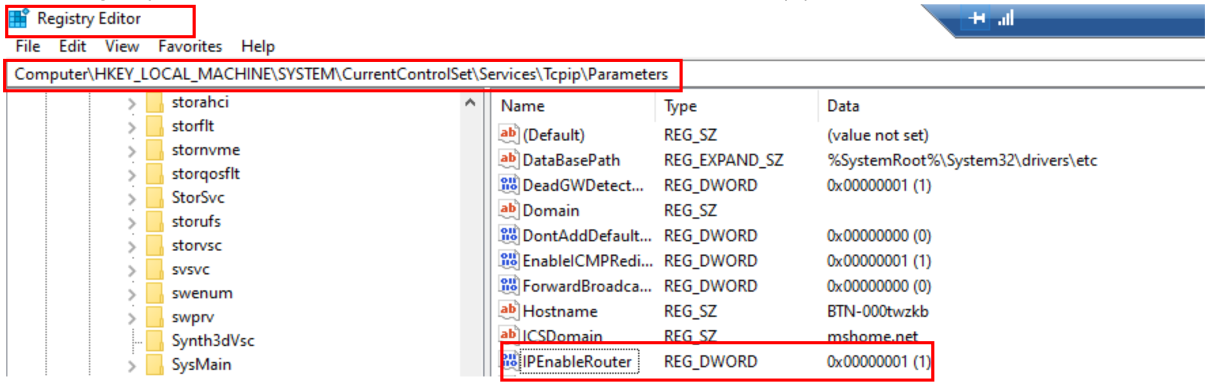


HINT: For IPCs and PLCs, the “Windows IP Routing” checkbox must be checked to allow the IPC to act as a router for the EoE messages.



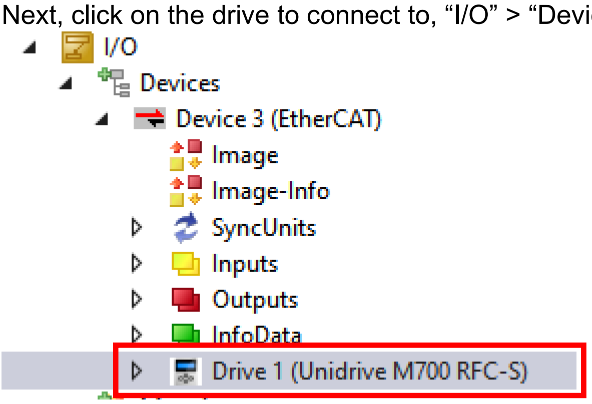


In the registry for the IPC this sets IPEnableRouter to 0x00000001(1)



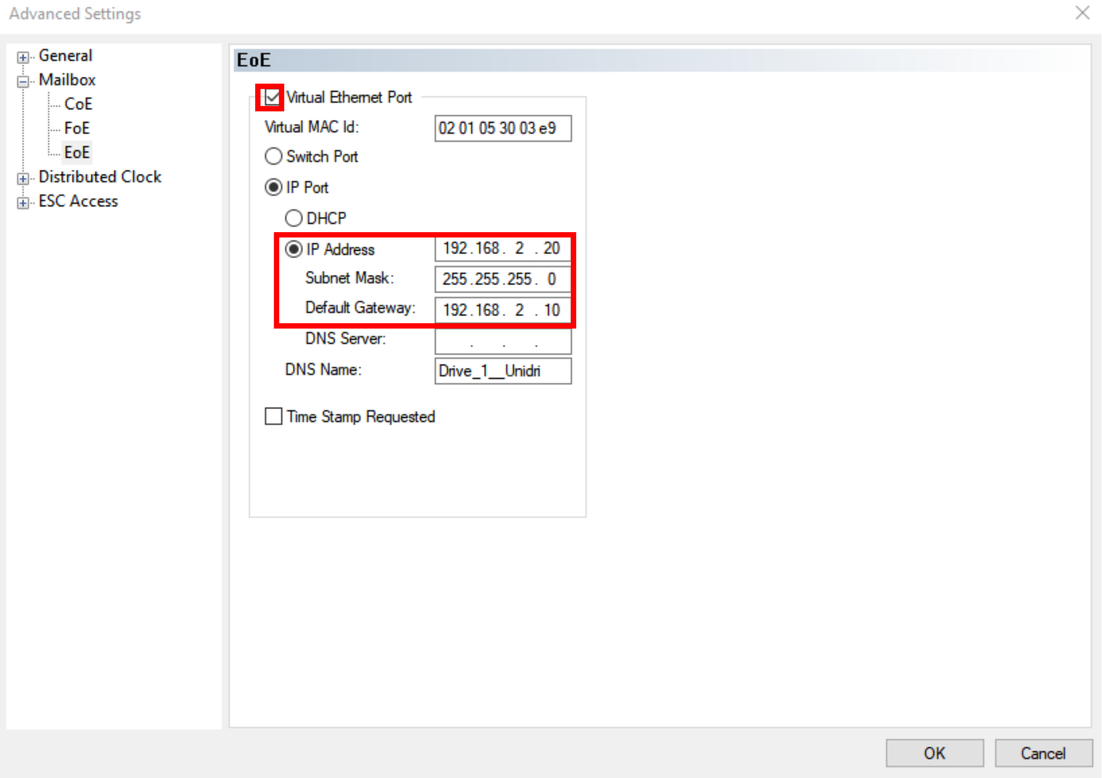
Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters

2. 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…”

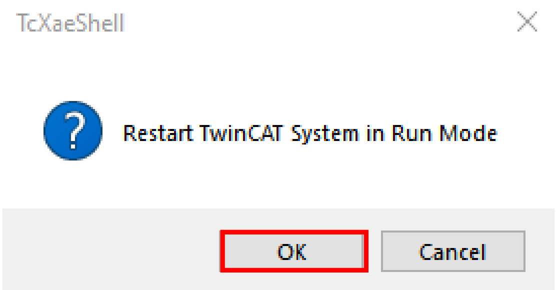
3. When the “Advanced Settings” tab opens select “Mailbox” > “EoE”:



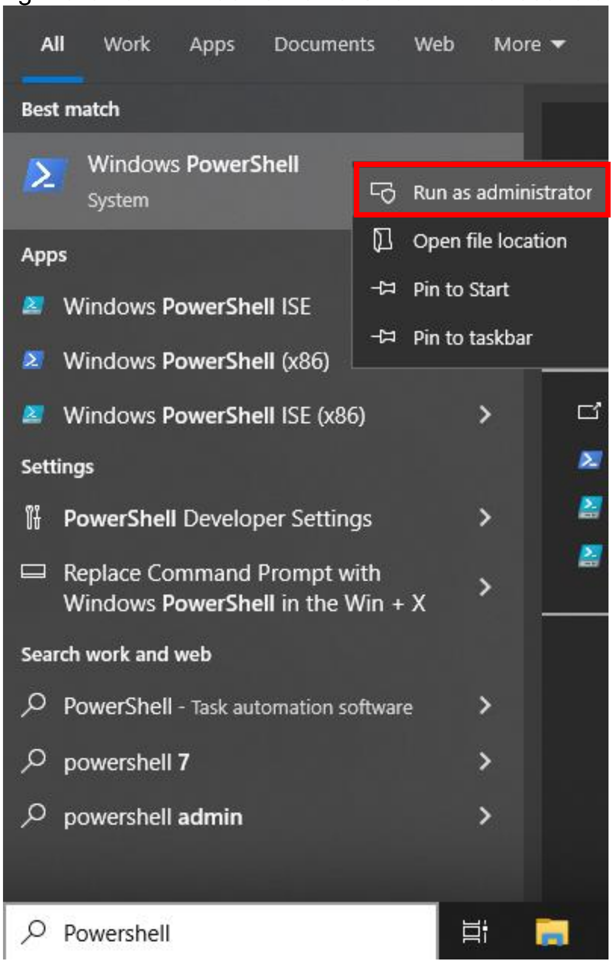
Check the “Virtual Ethernet Port” box, then set the “IP Port” and “IP Address” radio buttons. The “IP Address” is set to the IP address that you would like the drive to have, which must not clash with the PLC’s EtherCAT port IP address, e.g. 192.168.2.20. The subnet mask is set to 255.255.255.0. the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

4. Download the configuration to the PLC by clicking on Activate Configuration .

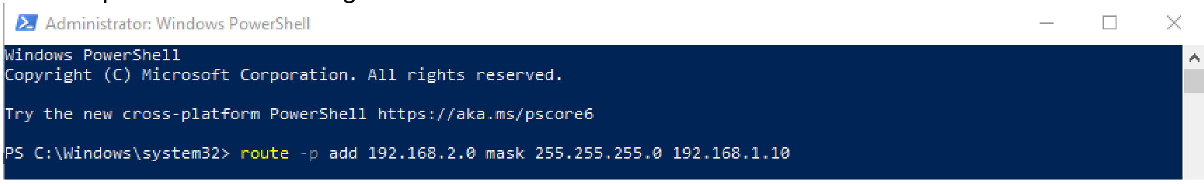
5. Click OK on the “Restart TwinCAT System in Run Mode” dialog.



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:



In this example:

a. “route -p add” gives a permanent route that will persist even when the power is cycled on the PC.
b. “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.
c. Subnet mask is “255.255.255.0”
d. 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.
e. The complete route add command is shown below so it may be copied and pasted:

route -p add 192.168.2.0 mask 255.255.255.0 192.168.1.10

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:

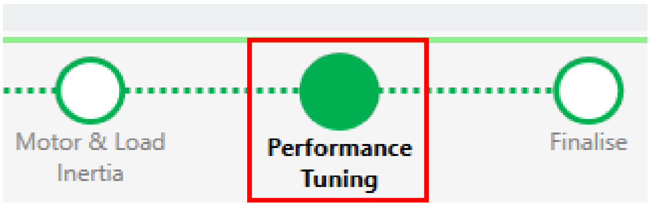
- The drive is enabled by applying 24V to the STO terminal.
- The drive is healthy i.e. no trips.
- MC_Power has been used, successfully, to power on the axis.
- If a keypad is fitted, the display indicates “Run”.
- If Connect is online, the status in the bottom left shows “Run”.

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.

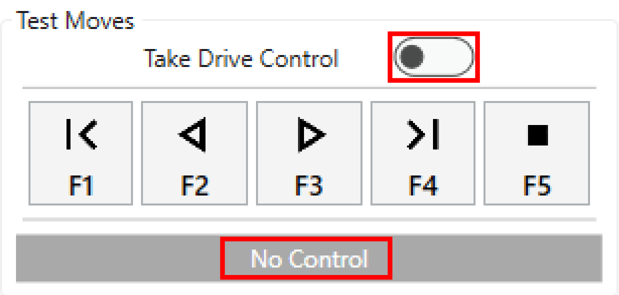
In many cases the default position loop p gain of 25.00 will give reasonable performance, but in cases where there are tight tolerances, the position loop performance can be increased to suit the requirement.

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

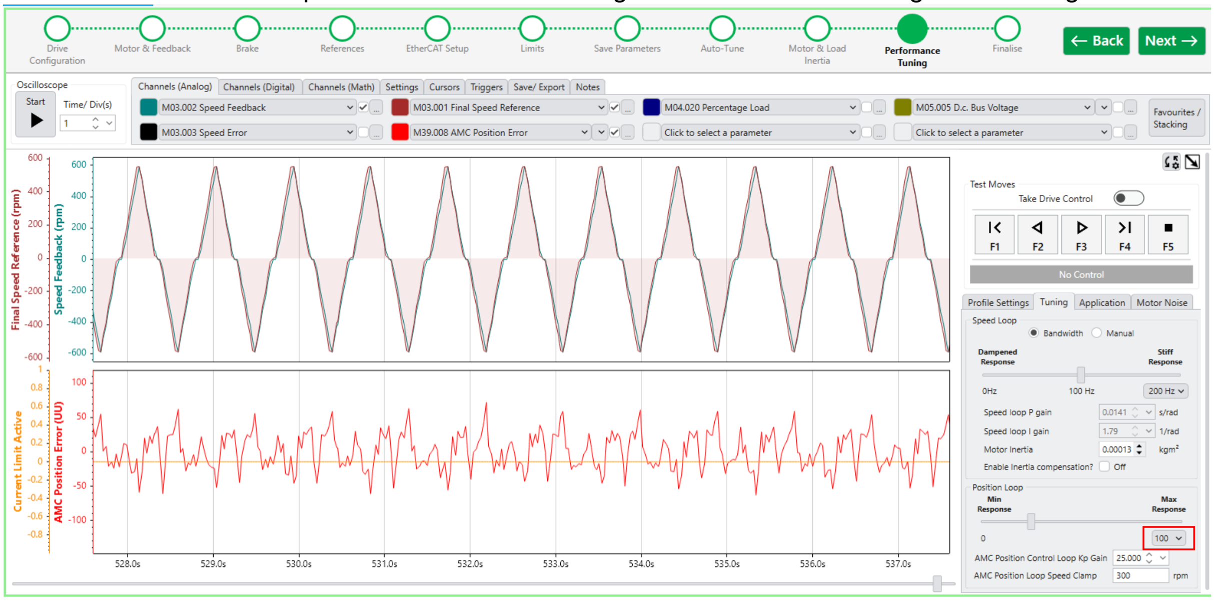


<u>Don’t</u> enable the test move control. The test moves status must say “No Control” to leave the application software in control of the drive and therefore the drive position loop active, ready for tuning.



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.

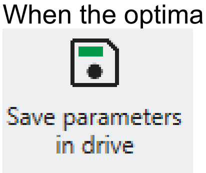
If the P Gain needs to be pushed above 100 the range can be increased using the following control:



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.



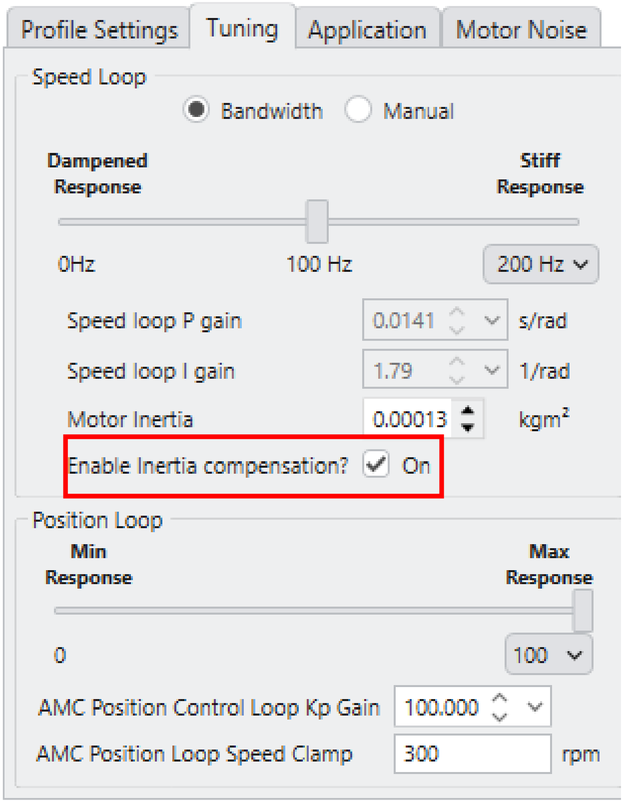
10.11 How and when to use inertia compensation

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.

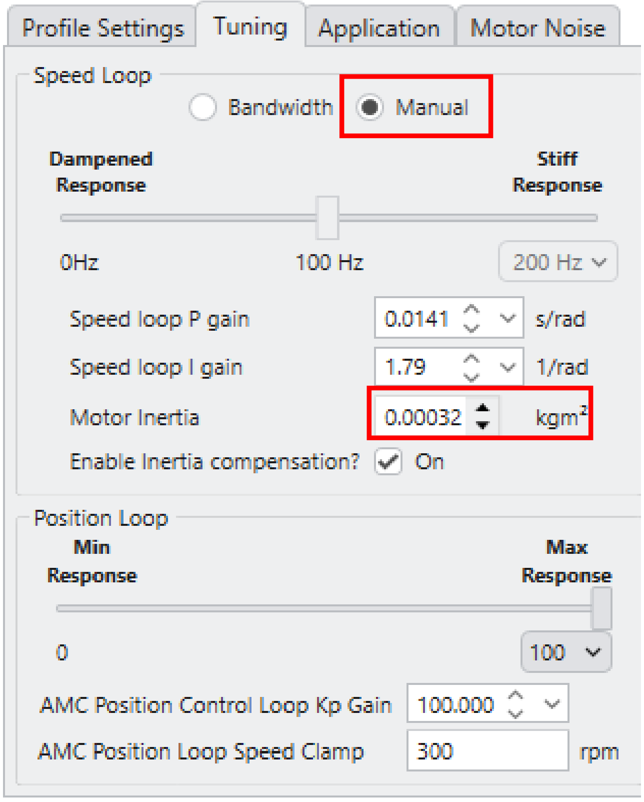
Before using this feature the speed and position loops must be tuned first as described in sections **6 Commission the drive and motor using Connect** and **10.10 How and when to tune the Position Loop**.

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



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.

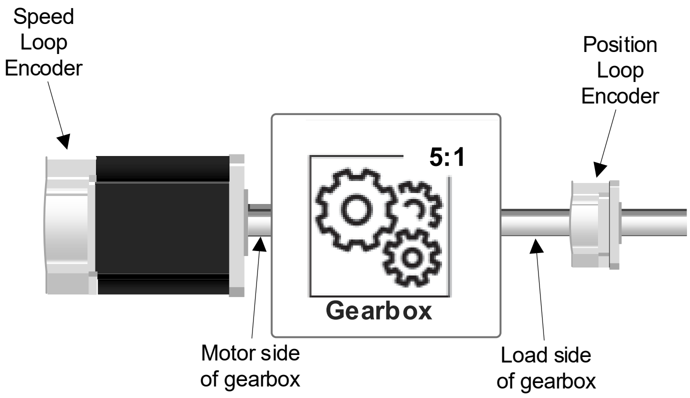
Before modifying the "Motor Inertia" make a note of the original value so it can be restored later if required.



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.

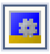


This type of system compensates for any backlash or torsional effects in the gearbox, resulting in a greater level of positioning accuracy at the load.

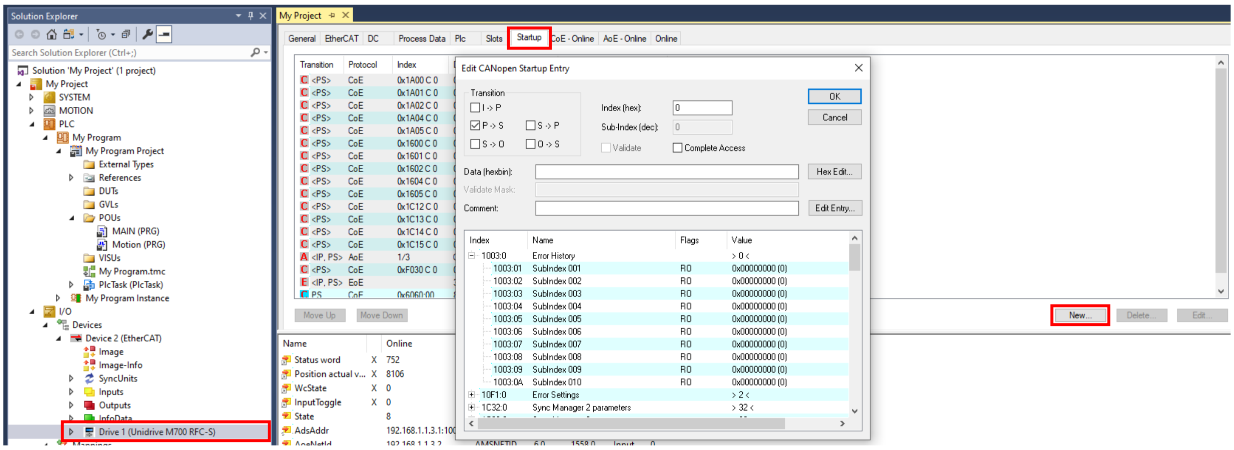
For this example, it is assumed that the motor encoder is connected the drives P1 interface, whilst the position feedback encoder will be connected to the drives P2 interface. Therefore, we need to configure the following CANopen over EtherCAT (CoE) objects:

- 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 using the startup list.

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.


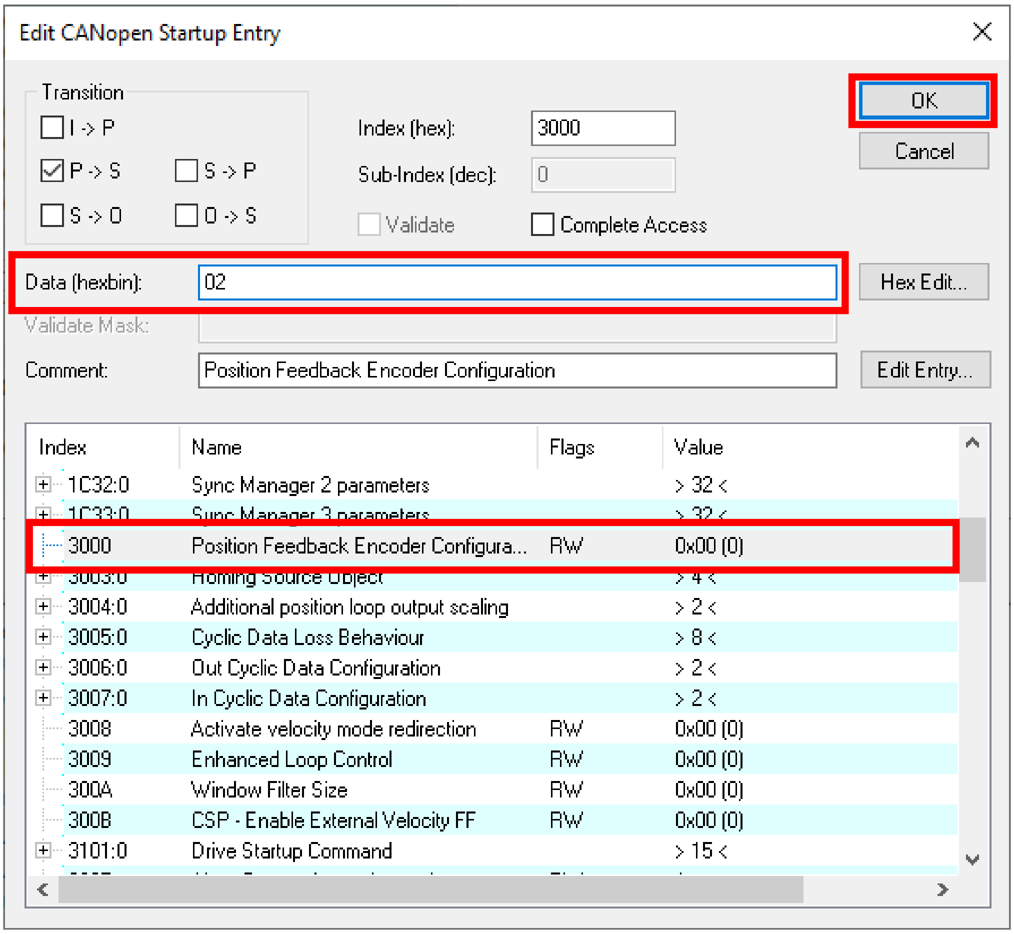
3. From the project tree, double click on “Drive1” and select the “Startup” tab followed by the “New…” button:



4. 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:

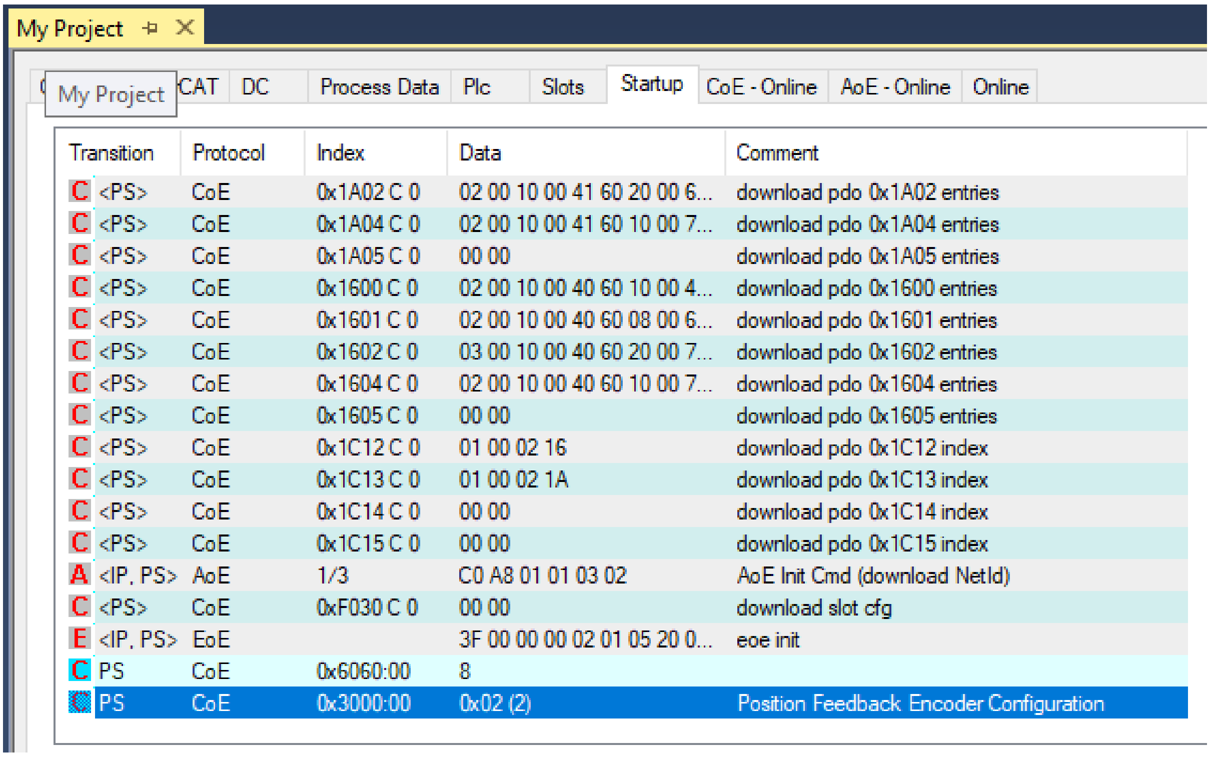
0 – The feedback source for the position controller will match the drive motor control feedback source (see below for details).

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.

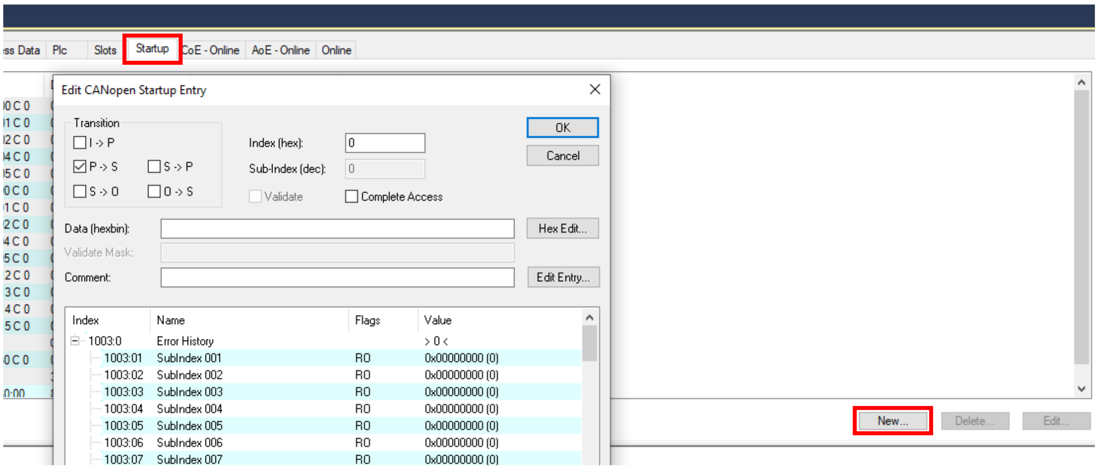
This object will be read upon a transition from the EtherCAT Pre-operational state to the Safe operational state.

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



Transition	Protocol	Index	Data	Comment
C <PS>	CoE	0x1A02 C 0	02 00 10 00 41 60 20 00 6...	download pdo 0x1A02 entries
C <PS>	CoE	0x1A04 C 0	02 00 10 00 41 60 10 00 7...	download pdo 0x1A04 entries
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>	EoE		3F 00 00 00 02 01 05 20 0...	eoe init
C PS	CoE	0x6060:00	8	
PS	CoE	0x3000:00	0x02 (2)	Position Feedback Encoder Configuration

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



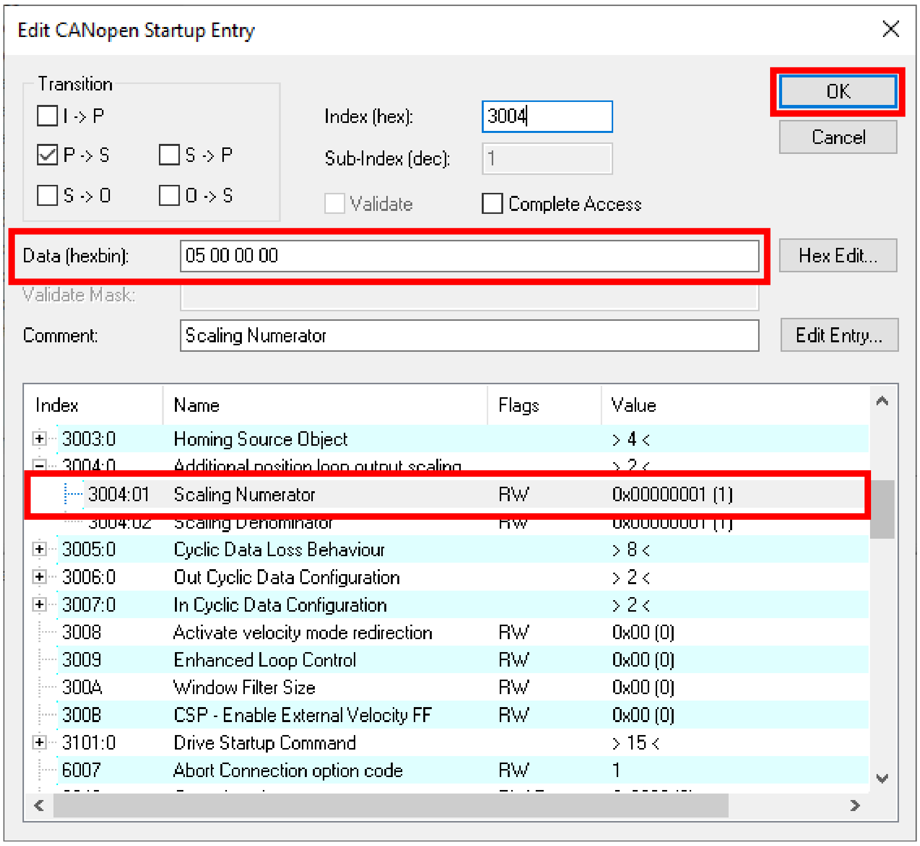
7. The “Edit CANopen Startup Entry” dialog will be displayed.

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

   The value of the numerator is the number motor revolutions at the gearbox input required to achieve the distance of the denominator which is the number of gearbox output revolutions.

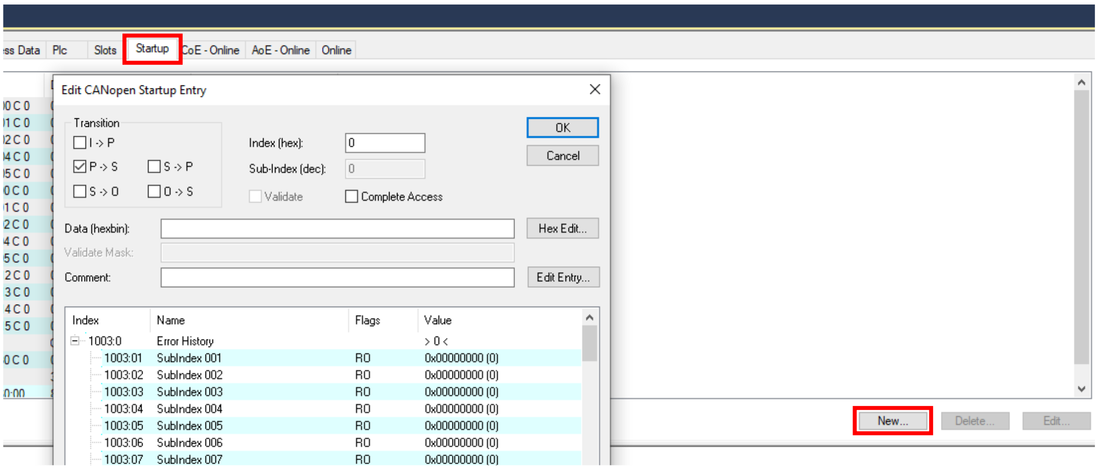
   For example, if a motor is coupled to a 5:1 step-down gearbox and no other gearing is used in the system, the value of 5 should be entered into the numerator “Value” field.

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



HINT: The values specified in the “Data (hexbin)” are in the hex format, e.g. hex 14 = decimal 20 etc.
“Data” is entered in reverse endian format where the least significant bytes are entered first followed by next most significant and so on. This is a quirk of the TwinCAT Start up list editor.
E.g. conventional format hex value is 0x 12 34 56 78, however in reverse endian format it is entered as 0x 78 56 34 12.

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



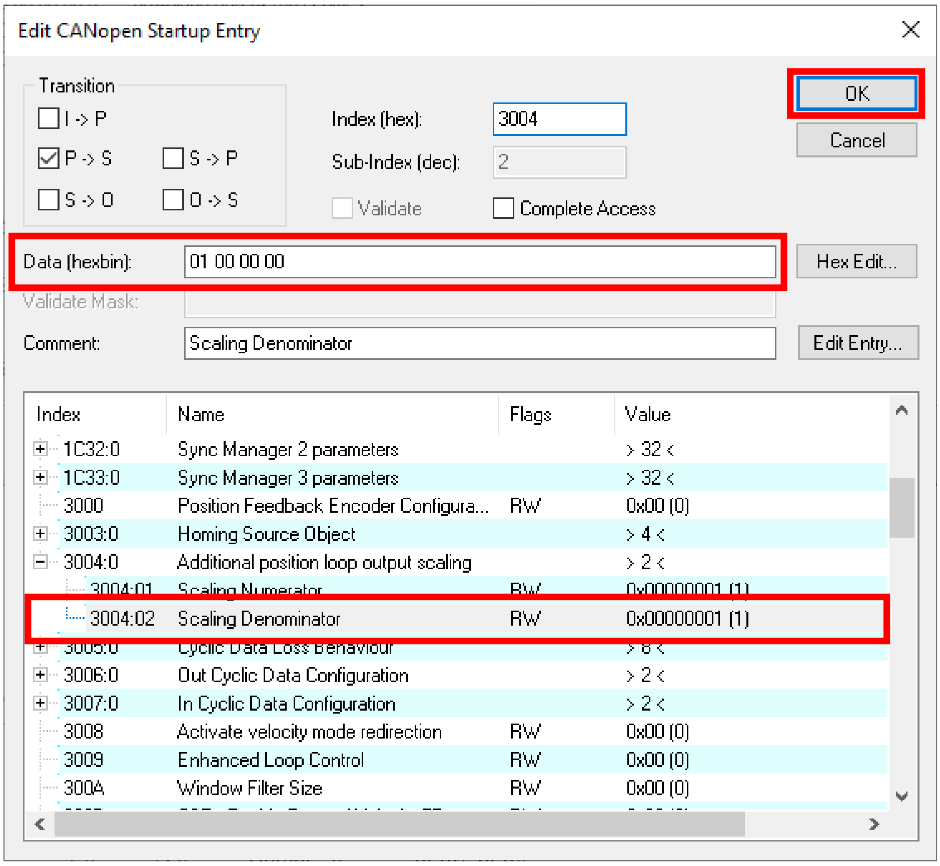
9. The “Edit CANopen Startup Entry” dialog will be displayed.

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

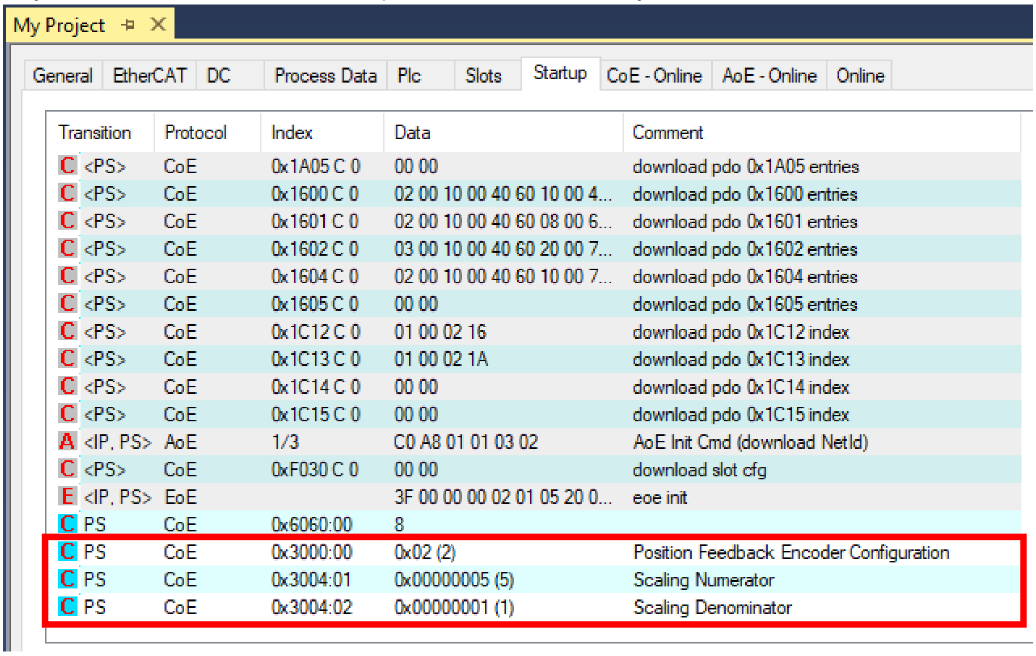
   The value of the denominator is the number of revolutions at the gearbox output required to achieve the distance of the numerator which is the number of gearbox input revolutions.

   For example, if a motor is coupled to a 5:1 step-down 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”.



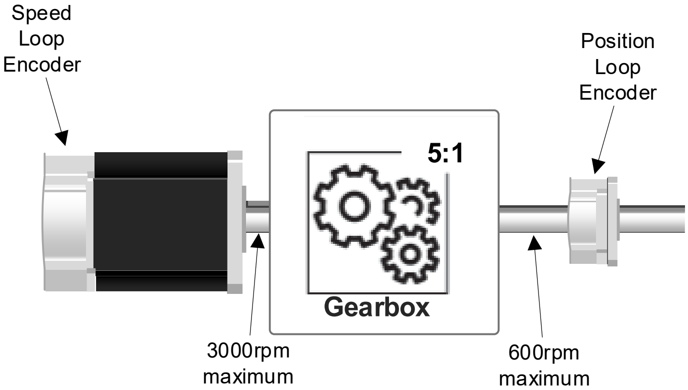
10. The Scaling Numerator, Scaling Denominator and Position Feedback Encoder Configuration mappings will now be present in the “Startup” list which means their values will be written to the specified CoE objects on startup of the PLC / IPC / Controller. A drive configured in this way will use the P2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



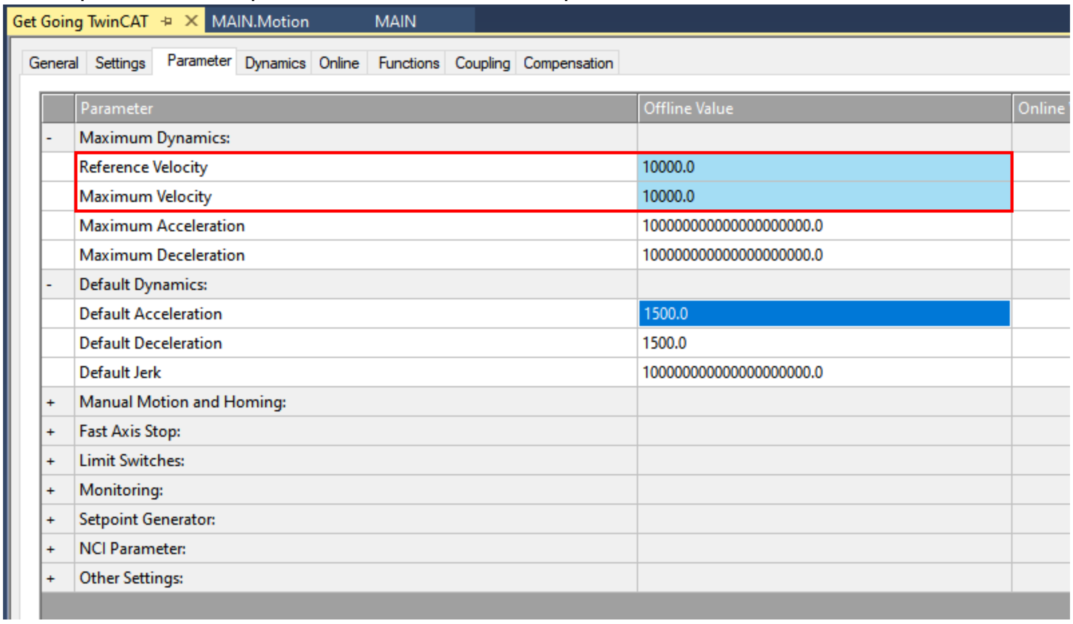
Transition	Protocol	Index	Data	Comment
C <PS>	CoE	0x1A05 C 0	00 00	download pdo 0x1A05 entries
C <PS>	CoE	0x1600 C 0	02 00 10 00 40 60 10 00 4...	download pdo 0x1600 entries
C <PS>	CoE	0x1601 C 0	02 00 10 00 40 60 08 00 6...	download pdo 0x1601 entries
C <PS>	CoE	0x1602 C 0	03 00 10 00 40 60 20 00 7...	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>	EoE		3F 00 00 00 02 01 05 20 0...	eoe 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. Make sure that the axis limits take the gearbox ratio into account.

    For example, if the gearbox ratio is 5:1 stepdown and the motor rated speed is 3000rpm, the maximum speed at the position loop encoder is 3000rpm * 1 / 5 = 600rpm.



    If the scaling of the position loop encoder is 1000units per revolution, the maximum velocity is 600rpm*1000units per revolution/60 seconds per minute = 10000units/s.



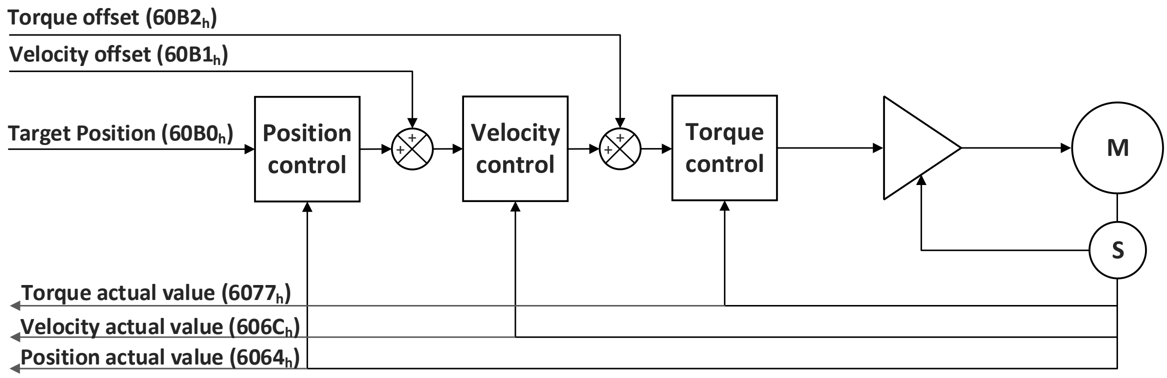
	Parameter	Offline Value	Online
-	Maximum Dynamics:		
	Reference Velocity	10000.0	
	Maximum Velocity	10000.0	
	Maximum Acceleration	1000000000000000000000.0	
	Maximum Deceleration	1000000000000000000000.0	
-	Default Dynamics:		
	Default Acceleration	1500.0	
	Default Deceleration	1500.0	
	Default Jerk	1000000000000000000000.0	
+	Manual Motion and Homing:		
+	Fast Axis Stop:		
+	Limit Switches:		
+	Monitoring:		
+	Setpoint Generator:		
+	NCI Parameter:		
+	Other Settings:		

12. Test to see if the scaling is correct by running at constant speed and make sure that that the positional following error seen in Pr39.008 using Connect doesn’t have a significant offset in it, i.e. the positional error should average out at close to 0.

10.13 How to apply velocity feedforward to an NC axis

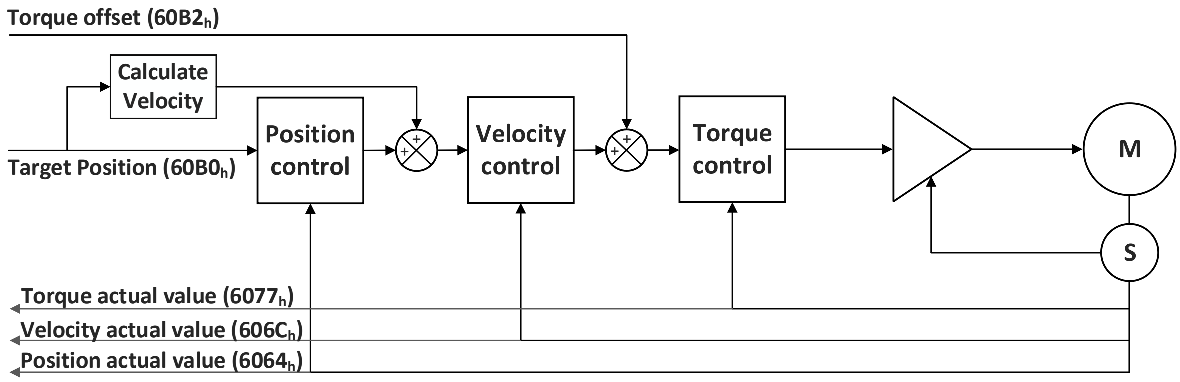
This section relates to velocity feedforward with a NC axis being controlled using EtherCAT and DS402 in CSP (Cyclic Synchronous Position) mode, where the velocity calculated by the NC axis motion profiler is fed forwards directly to the target axis which improves the granularity of the velocity profiling, giving the smoothest operation. The velocity feedforward must be PDO mapped to 0x60B1 and enabled by setting 0x300B = 1. The velocity feedforward is calculated from Axis.NcToPlc.SetVelo. This gives 100x better velocity reference resolution.

The velocity feedforward functionality is only available with >=V02.00.00.16 EtherCAT firmware and ESI files.



(Control when 0x300B = 1)

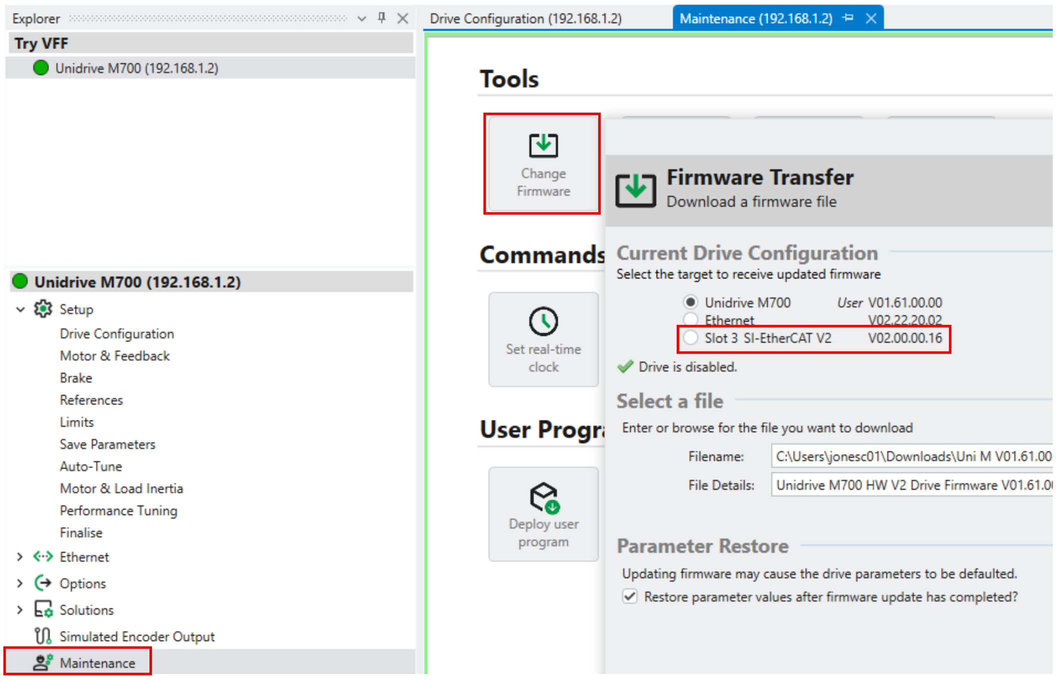
For a normal axis using the default setup i.e. no velocity feedforward implemented, the drive calculates the velocity feedforward term by differentiating the position reference passed into 0x60B0. This tends to be noisier since the velocity granularity is based on whole position units.



(Control when 0x300B = 0 (Default))

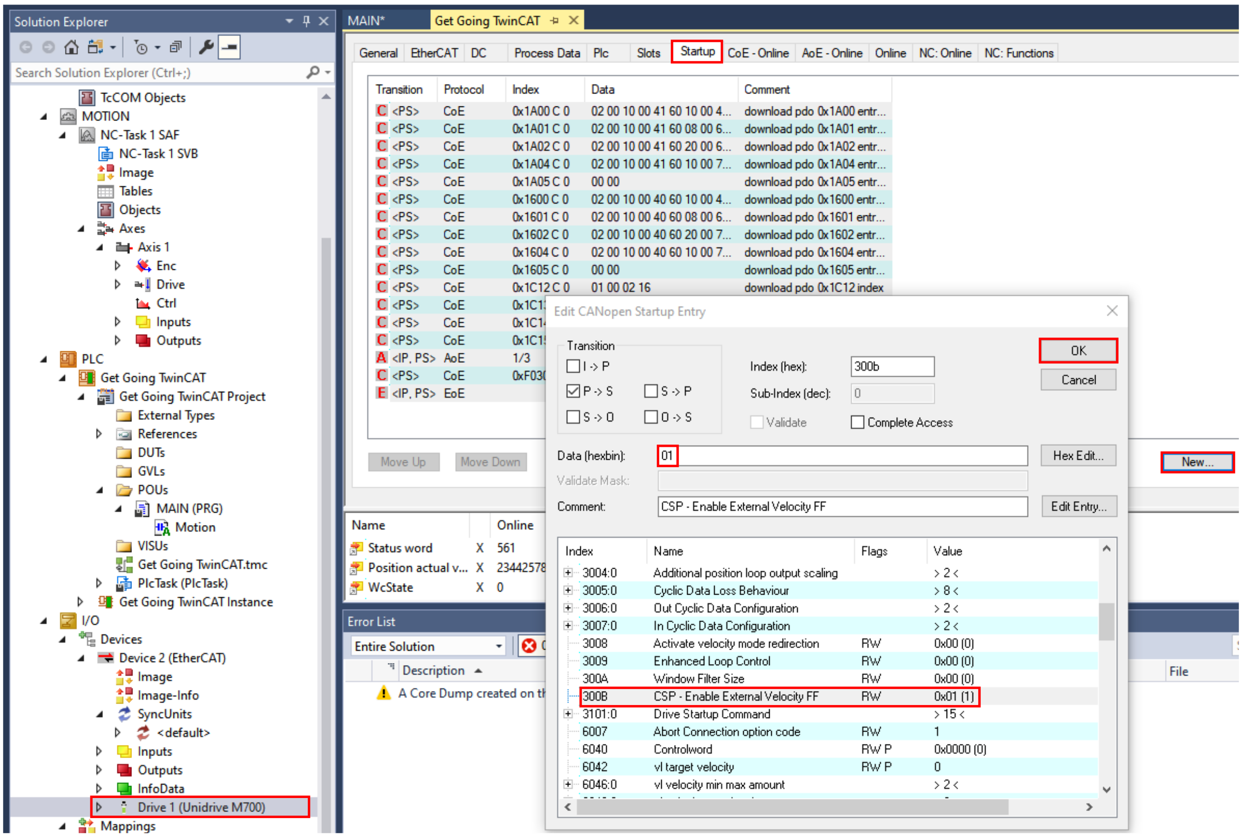
Use the following steps to configure the velocity feedforward:

1. Make sure that the firmware in the EtherCAT interface e.g. SI-EtherCAT is at least V02.00.00.16. This is the version that supports the feedforward mechanism. In Connect select “Maintenance” > “Change Firmware”. All firmware versions for the drive and options will be listed.

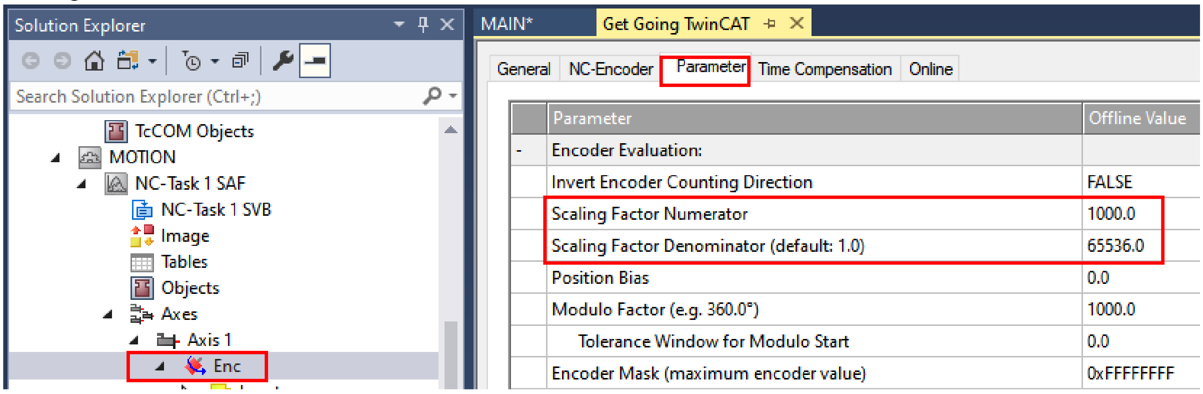


2. Put TwinCAT in Config mode by clicking on the  button.

3. Enable the velocity feedforward term by setting 0x300B =1 in the startup list. Double click on the EtherCAT slave in the “Solution Explorer” tree. Select the “Startup” tab. From the list select the entry that starts with “300B”. When the PDO link boxes update, set “Data” to “01”. Click “OK” when finished.



4. For a normal NC Axis i.e. not a CNC axis, the user must calculate the velocity feedforward reference manually. To do this, open the axis in the solution explorer and check the encoder scaling:



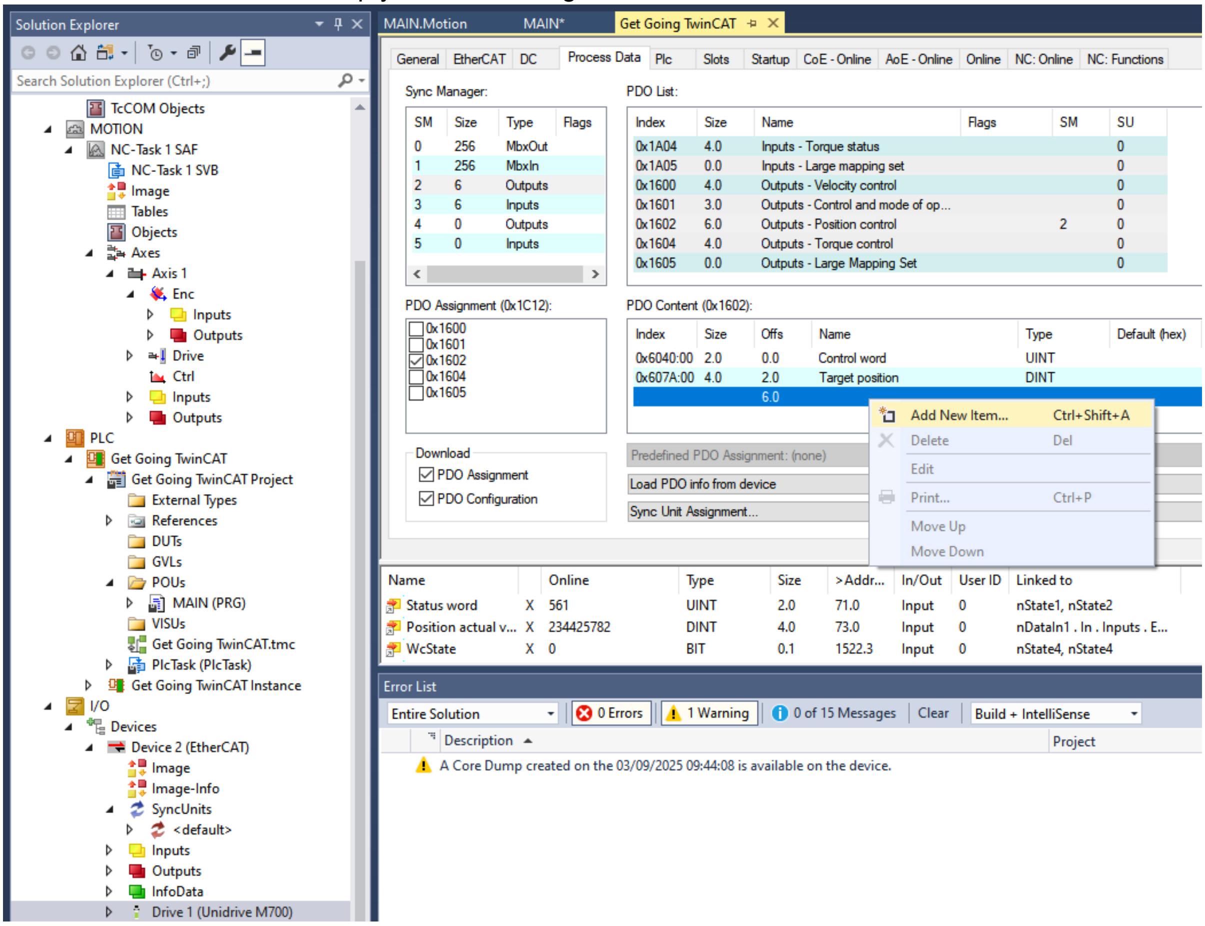
For the purposes of this description A numerator of 1000 units per revolution, and a scaling denominator of 65536 encoder counts per revolution is used.

Add the highlighted code in the following code snippet to the PLC programming area e.g. “Main”. This reads the velocity from the axis and then converts it to into a velocity feedforward reference in Encoder Counts per Second suitable for use with the Velocity Offset 0x60B1. “VelocityFeedForward” is mapped to PLC Q registers using “AT %Q*” so that the PDO can be linked with the feedforward value.

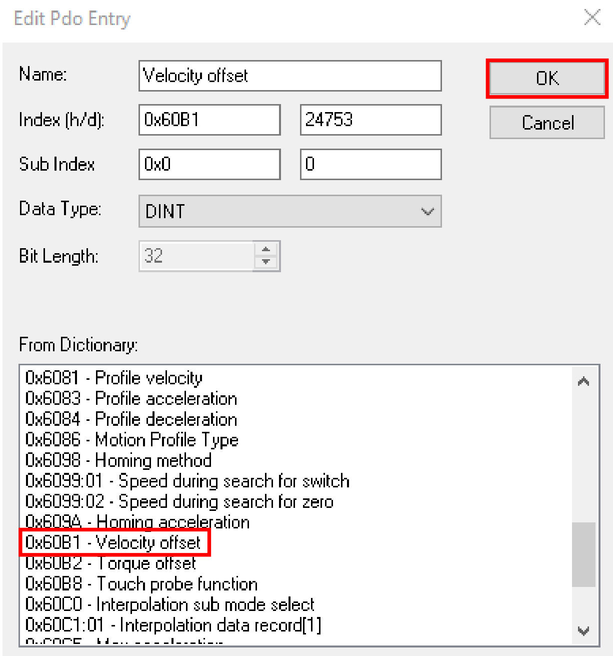
```
PROGRAM MAIN
VAR
    Axis1:AXIS_REF;
    Axis1Power: MC_Power;
    Axis1Jog:MC_Jog;
    Axis1Reset:MC_Reset;
    VelocityFeedForward AT %Q*: DINT;
END_VAR

// Calculate the velocity feedforward in encoder counts per second
VelocityFeedForward := LREAL_TO_DINT(Axis1.NcToPlc.SetVelo * 65536 / 1000);
```

Build the code (Ctrl+Shit+B) after making this change so that “VelocityFeedForward” is selectable in the PDO linking editor.

5. Add a PDO mapping to 0x60B1. Double click on the EtherCAT slave drive, then select the “Process Data” tab. In the “PDO List” select the row that starts “0x1602”. In the “PDO Content” window select an empty row and the right click and select “Add New Item…”

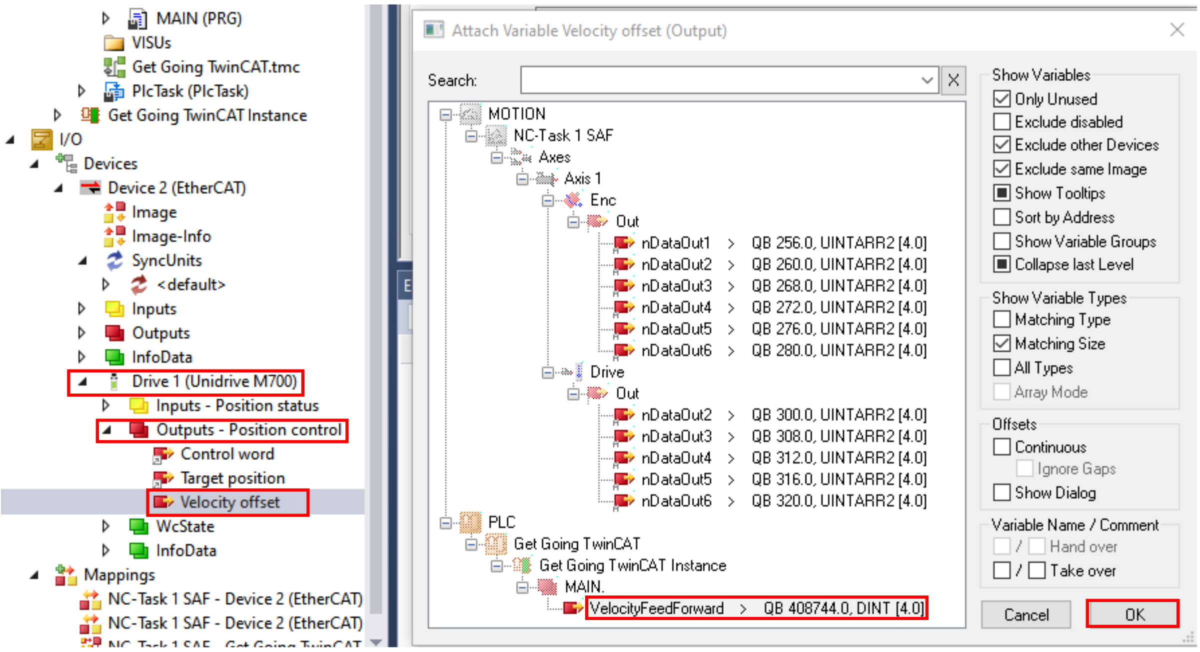


When the “Edit PDO Entry” dialog starts, select “0x60B1 – Velocity Offset” from the dictionary and then click “OK”.



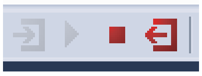
The PDO is now mapped.

6. Link the PDO mapping to the calculated velocity feedforward value. Expand the EtherCAT slave drive, then expand “Outputs – Position control”. Double click on “Velocity Offset” to open the “Attach Variable Velocity offset (Output)” dialog. Select “VelocityFeedForward” from the list and click “OK”.



7. The setup is complete. Save the changes by pressing  and activate the configuration by pressing . Click the login icon  to load / view the code while it runs. 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:

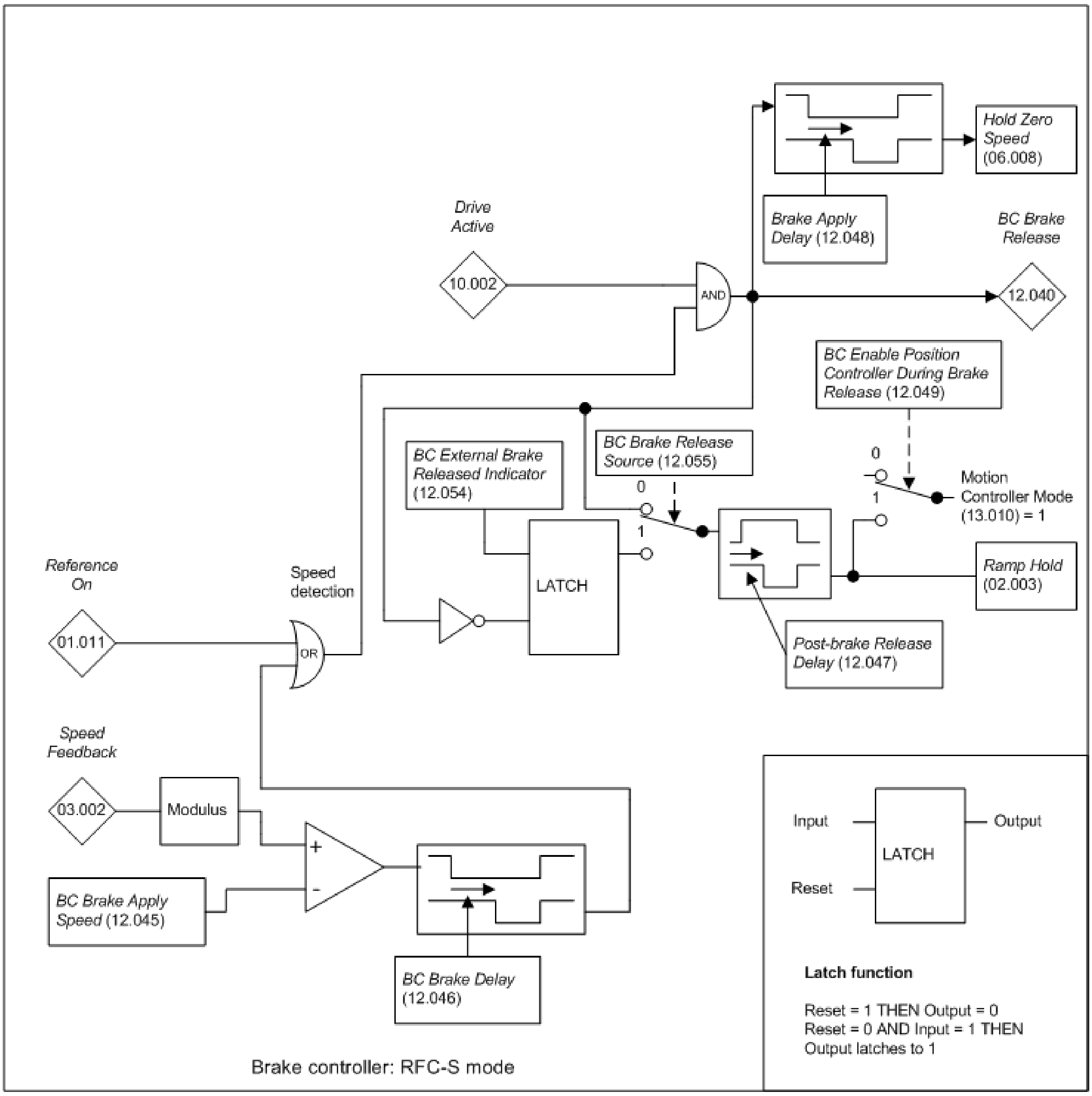


11 Additional information

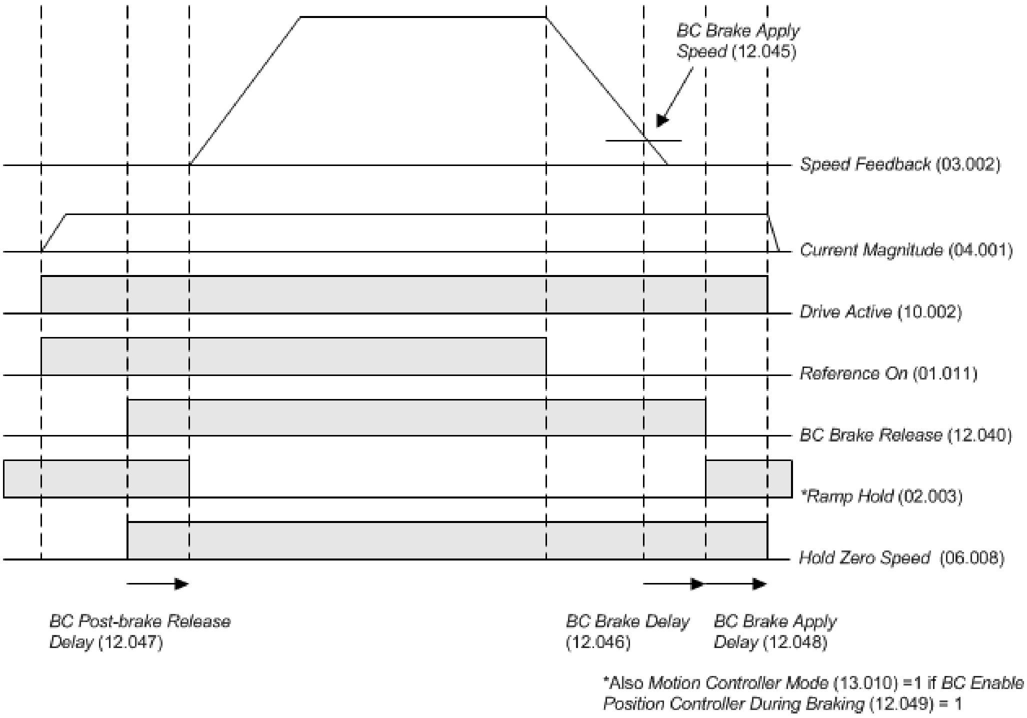
11.1 Mechanical brake controller logic

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.



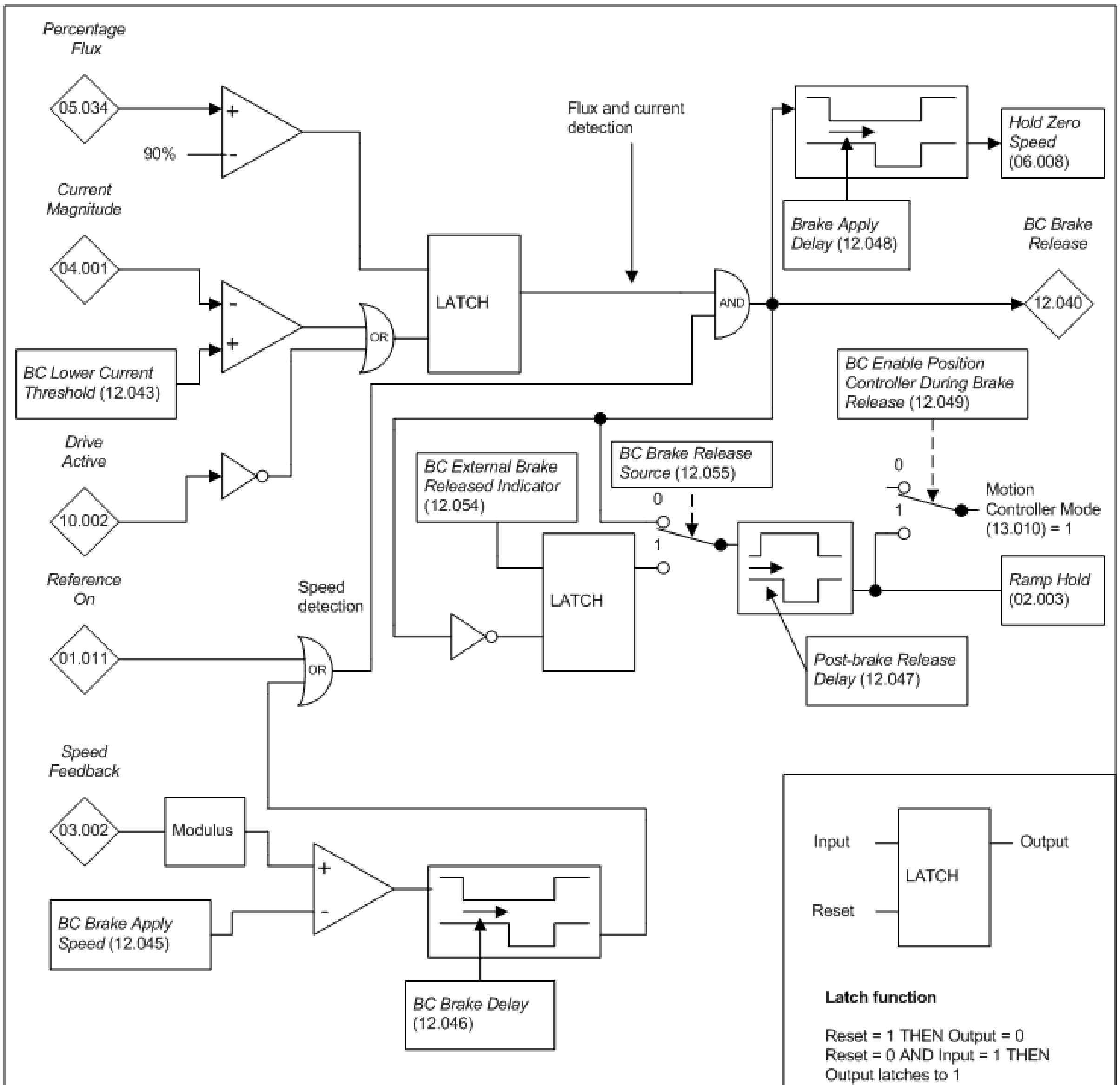
Brake controller: RFC-S mode



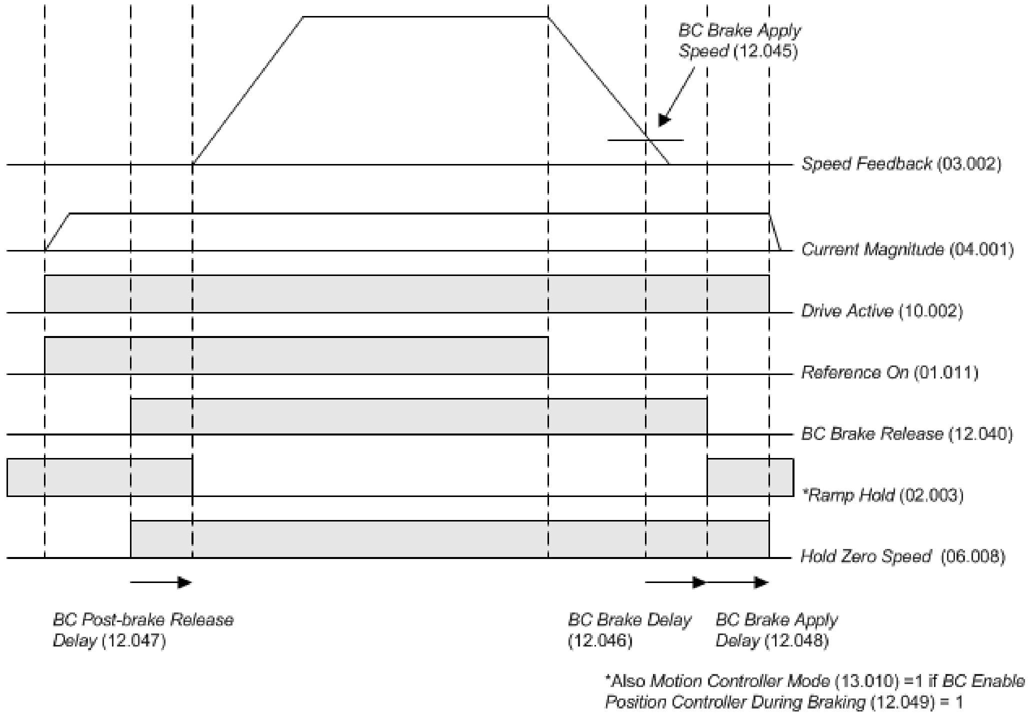
Brake controller sequence: RFC-A mode (*BC Mode* (12.052) = 0) and RFC-S mode

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.



Brake controller: RFC-A mode (*BC Mode* (12.052) = 0)



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

Connect with us

www.controltechniques.com

www.kbelectronics.com

Nidec Control Techniques Limited. Registered Office: The Gro, Newtown, Powys SY16 3BE.

Registered in England and Wales. Company Reg. No. 01236886.