rexroth
A Bosch Company

CODESYS SoftMotion & IndraDrive – EtherCAT CoE

Platform	**CODESYS V3**
Controller	**CODESYS SoftMotion Win V3 x64**
Fieldbus	**EtherCAT CoE**
Document type	**Start-up document**
Document version	**V1.2**

Bosch Rexroth AG

Table of Contents

1. Introduction and Scope

CODESYS SoftMotion provides motion control functions for sophisticated movement with coordinated axes for compatible PLC and SoftPLC systems. These are made available to the user through several blocks bundled in various SM3 libraries. This document covers only the blocks present in the *SM3_Basic* library.

This document provides the necessary information for an end user, on how to configure and use *Rexroth IndraDrives* as motion axes with *CODESYS SoftMotion* (SM hereafter) system. The communication fieldbus is *EtherCAT CoE* (CAN Application Protocol over EtherCAT). The SM will be the fieldbus Master and the drive will be fieldbus Slave.

2. General Information

2.1 Device and Package Management

Since device and package installation would vary for supported devices, it is not covered in detail in this document. The general procedure for device and package management for CODESYS is available in the online help. The links are provided below.

- Managing Devices
- Management of Packages and Licenses

2.2 Version Information

The version information for all the components used when this document was made.

2.2.1 CODESYS

Development system	CODESYS V3.5 SP11 Patch 6 (download link)
CODESYS SoftMotion SL	4.9.0.0 (download link for package)
SM3_Basic library	4.9.0.0
IODrvEtherCAT library	3.5.11.40

2.2.2 Controller

Controller	CODESYS SoftMotion Win V3 x64

2.2.3 IndraDrive

Supported drives	IndraDrive MPx20 and newer (MPC, MPB and MPE)	
Device desc. file	Packaged along with SoftMotion 4.9.0.0	
Online store	Rexroth website	
Support information	Hotline	+49 9352 40-50 60
	Email	service.svc@boschrexroth.de
	Forum	Drives support forum

2.3 System Overview

A schematic of how the CODESYS PLC and the drives are connected is shown in the image below.

- The PLC can be programmed from the CODESYS IDE over its engineering port.
- The drives can be configured from IndraWorks Ds over their engineering port (direct connection) or the fieldbus FKM port (EoE or ADS interface)

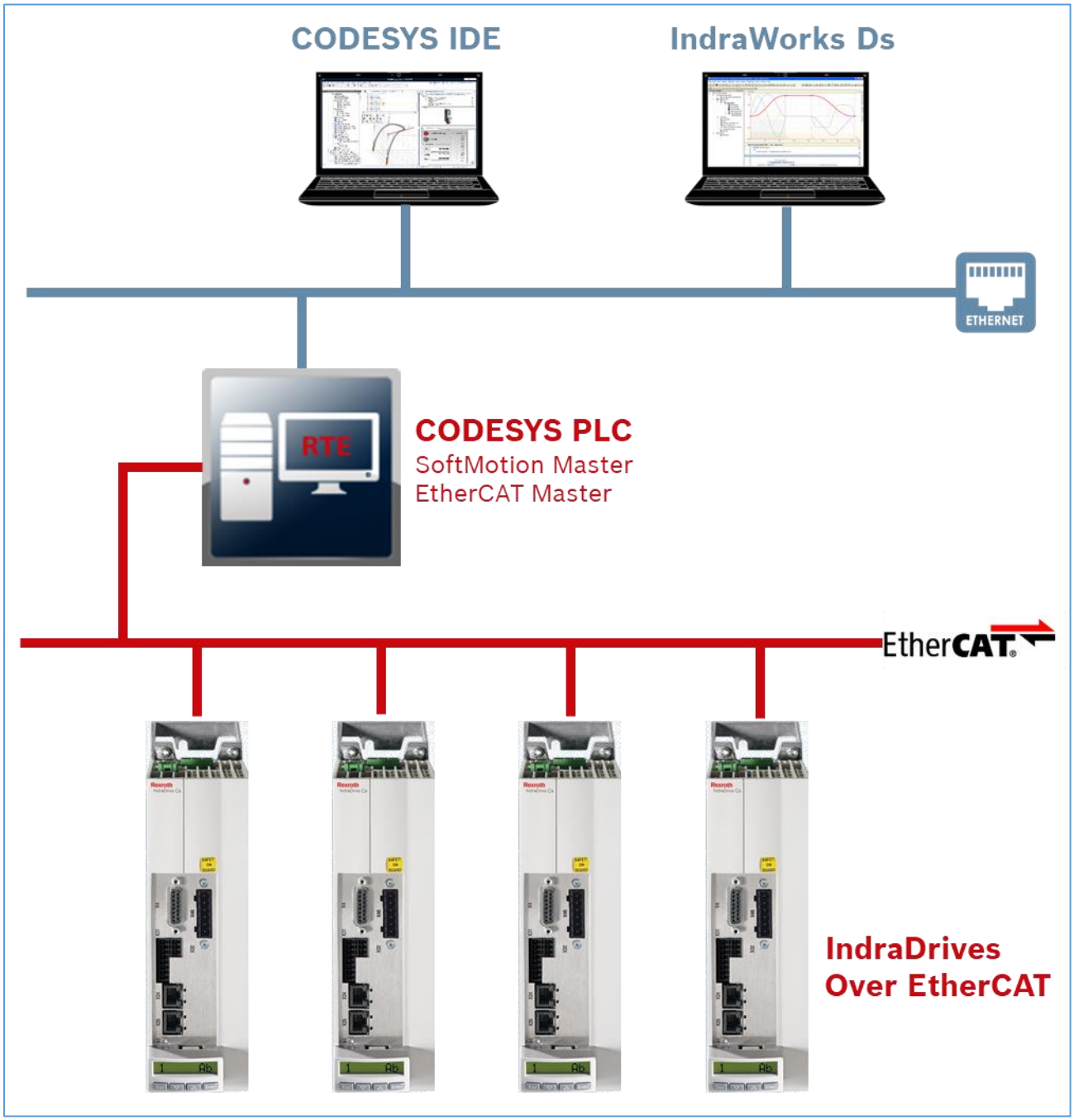

Fig 01: System Overview

3. Configuration – IndraWorks Ds

3.1 EtherCAT CoE FWS for IndraDrive

The IndraDrive can be ordered, to be preset to EtherCAT CoE protocol out-of-the-box by purchasing it with the following firmware option (FWS).

Type code	FWS-INDRV*-MP*-**VRS-NN-ETHERCATCOE
Material number	R911370459
Description	Ethernet protocol preset – EtherCAT CoE

The procedure given in the rest of section 3 can be ignored by purchasing this option, making it easy for the end user. Instead, it can be used to verify that the settings are applied correctly.

3.2 Configuring IndraDrive in IndraWorks Ds

3.2.1 Master Communication

The master communication for the drive should be set to *CAN Application Protocol over EtherCAT (CoE)* as shown in the image below.

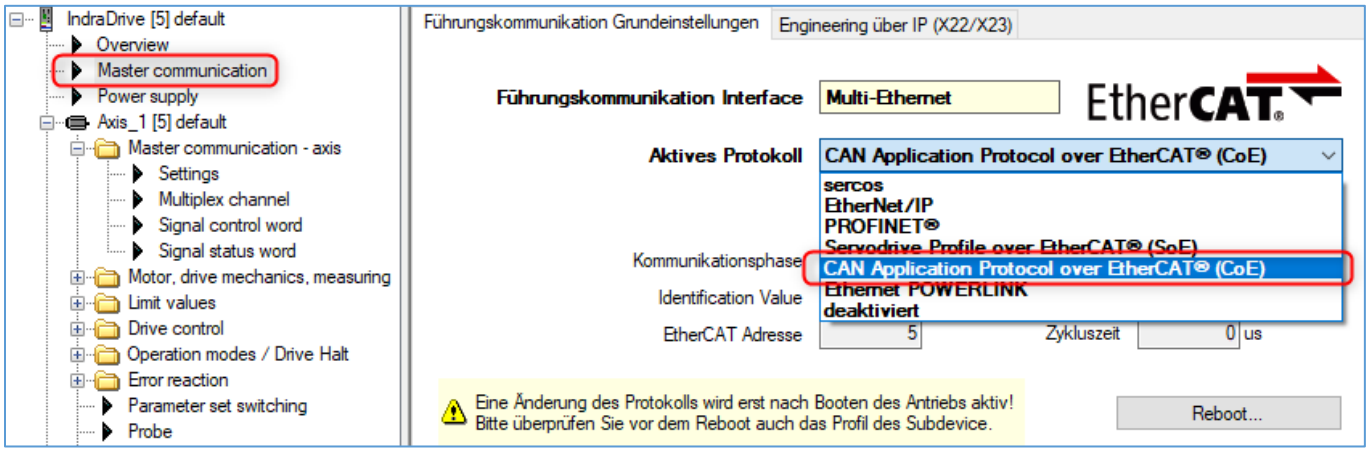

Fig 02: Master communication selection

When the master communication is changed, there could be a prompt to change the *Profiletype* to *CiA402 Drive profile*. This is necessary for CoE and so the profile type must be set as shown in the image below.

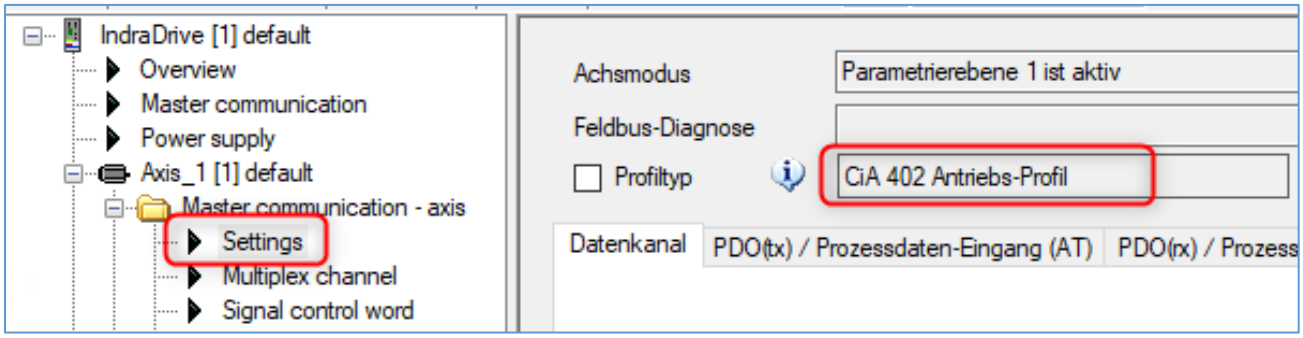

Fig 03: Profiletype setting

The drive must then be rebooted for the master communication to become active.

4. Configuration – CODESYS

4.1 Device Description Files and Libraries

The necessary IndraDrive device description files and libraries, for SoftMotion over EtherCAT CoE are automatically installed with the SoftMotion package 4.9.0.0.

- SoftMotion package download link
- Installing CODESYS packages

4.2 Configuring EtherCAT Master

1. Create a new CODESYS project with the necessary PLC device.
2. Right click on the PLC Device and click on *Add Device* option in the sub-menu as shown in the image below.

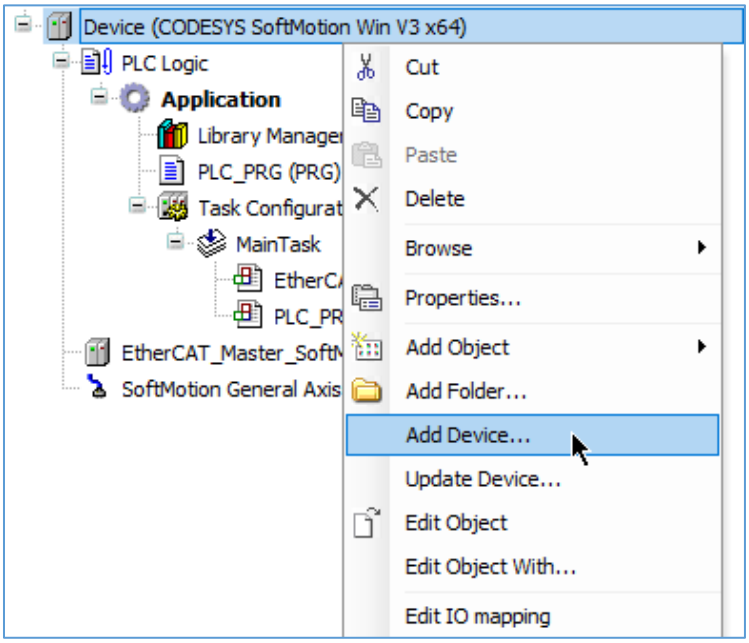

Fig 04: Add Device

3. The Add Device dialog will now open. Choose the *EtherCAT Master SoftMotion* under *EtherCAT* fieldbus (as shown in the image below) and click on the Add Device button.

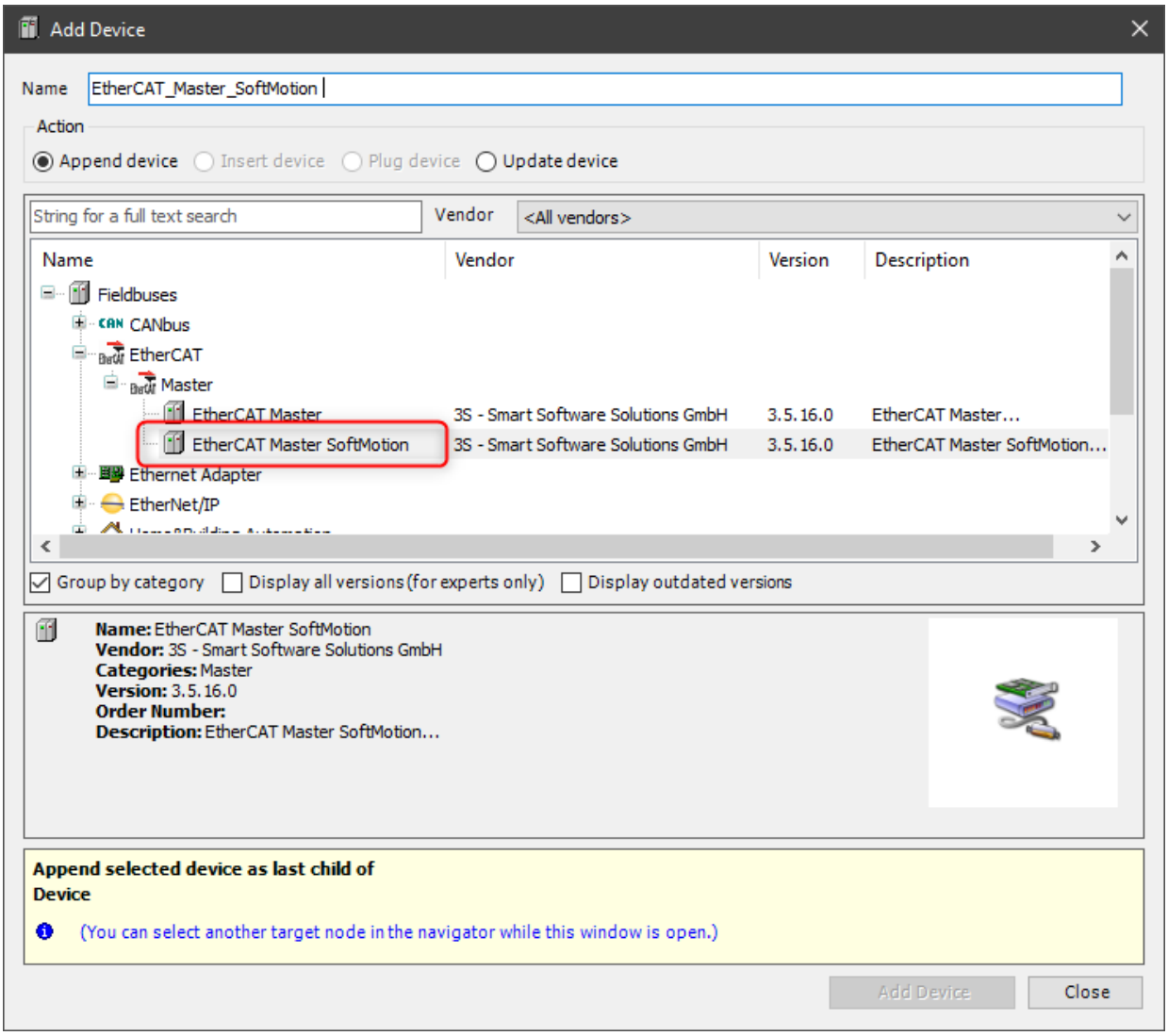

Fig 05: Add Device

4. The *EtherCAT_Master_SoftMotion* is now added under the PLC device as shown in the image below.

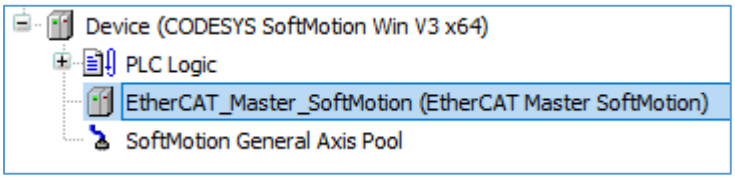

Fig 06: Device Tree

5. Open the EtherCAT master settings and configure the NIC and the Distributed Clock settings as required. The below image is only a representation of a configured EtherCAT SoftMotion master.

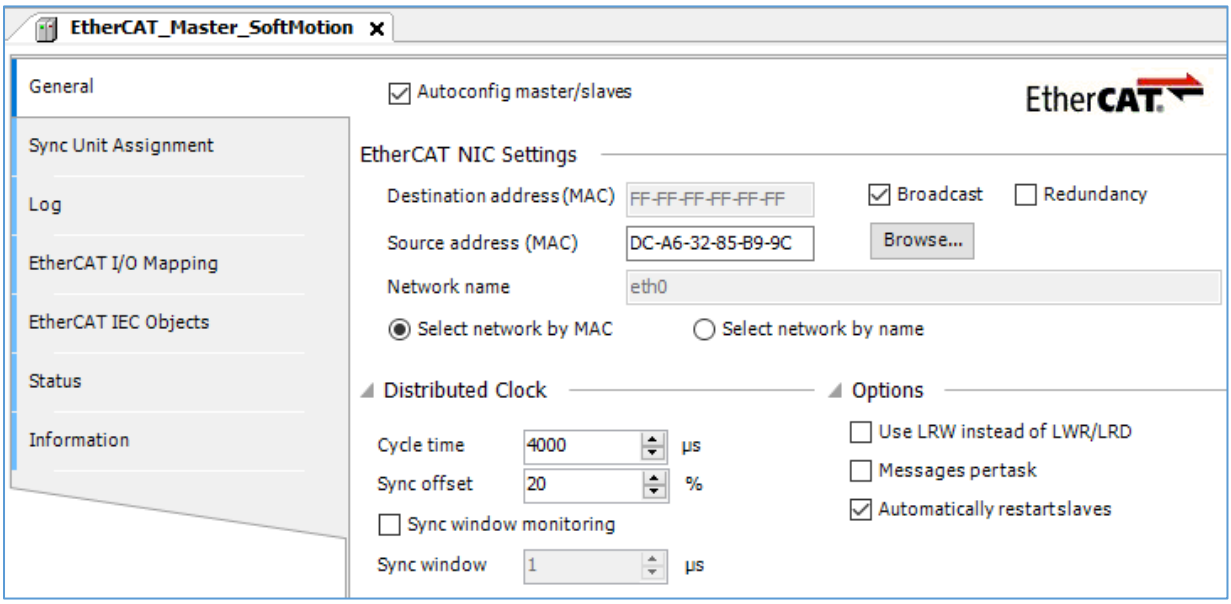

Fig 07: EtherCAT master settings page

4.3 Adding and Configuring IndraDrive

1. Right click on the EtherCAT_Master_SoftMotion device in the device tree and click on the *Add Device* option in the sub-menu as shown in the image below.

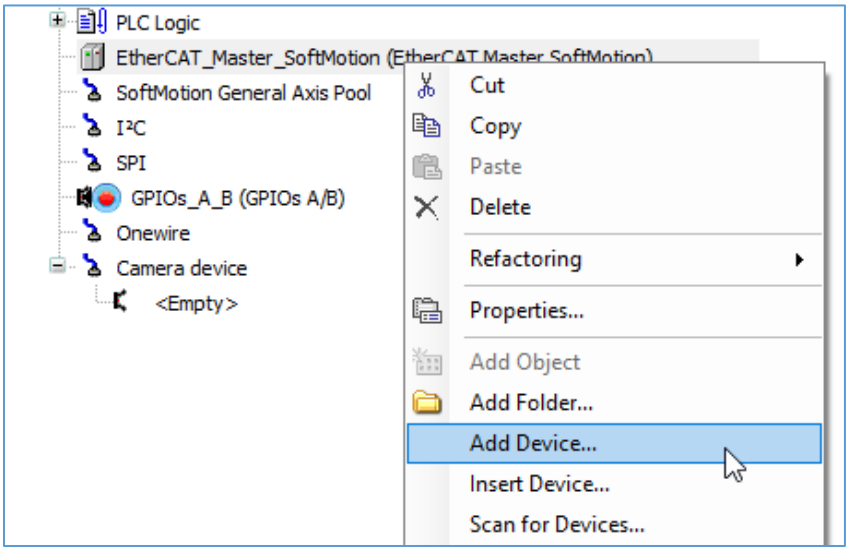

Fig 08: Add Device

2. The Add Device dialog opens. Under Fieldbuses -> EtherCAT -> Slave -> IndraDrive MPx20/21 CoE, choose the required drive to be added, and click on the *Add Device* button. There could be two drives with the same name, if CoE devices were previously imported from the IndraDrive CoE device description XML file. One of these is the standard EtherCAT slave drive (imported from IndraDrive CoE XML file), and the other one is the SoftMotion EtherCAT slave drive (installed automatically with SoftMotion 4.9.0.0). It is important to add the SoftMotion drive here, as the standard drive does not have an associated SoftMotion axis.

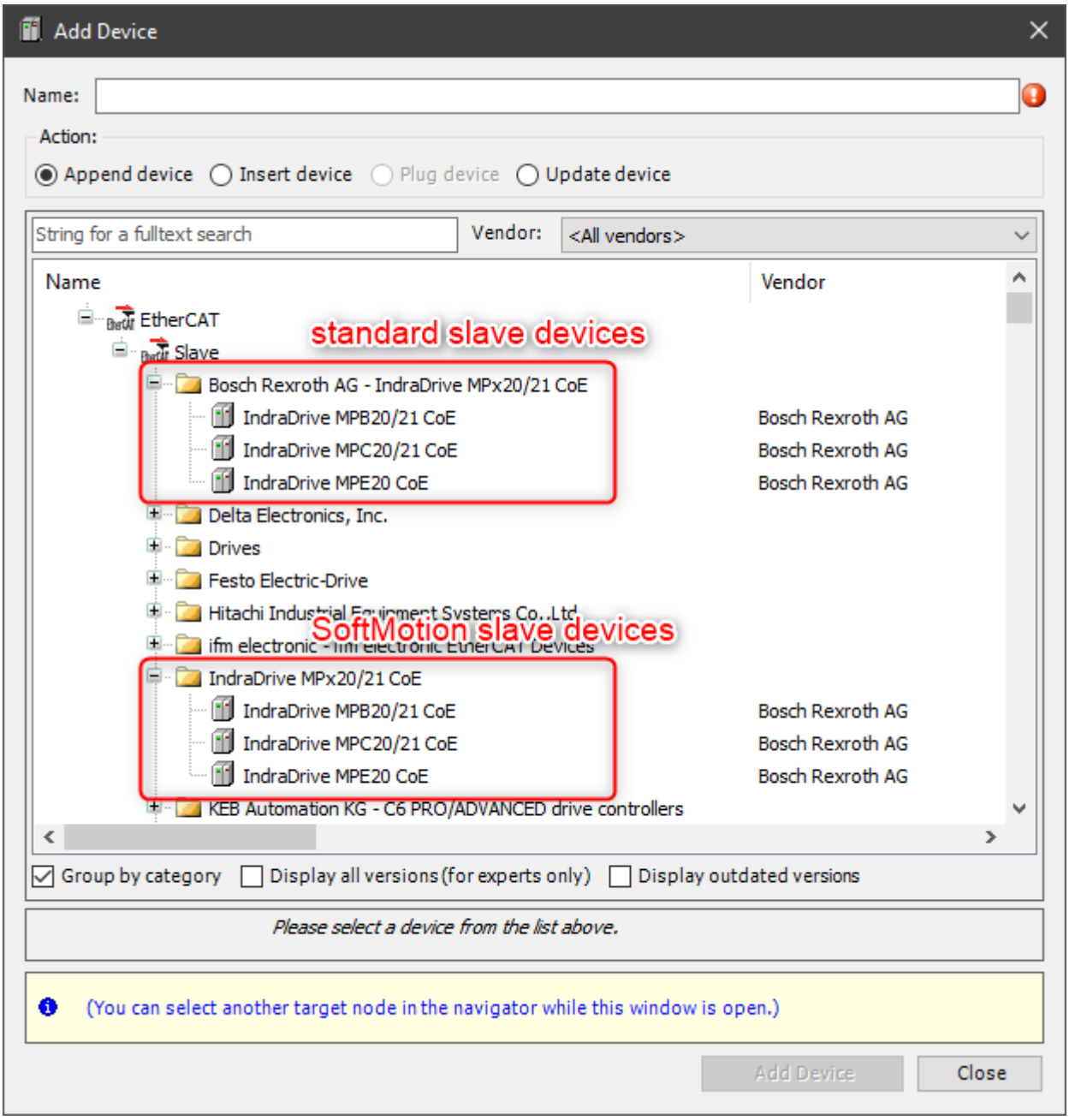

Fig 09: Add Device

3. The drive along with its SM3_CoE axis is now added under the EtherCAT_Master_SoftMotion in the device tree as shown in the image below. Also, the corresponding IndraDrive_CoE library is automatically added to the library manager.

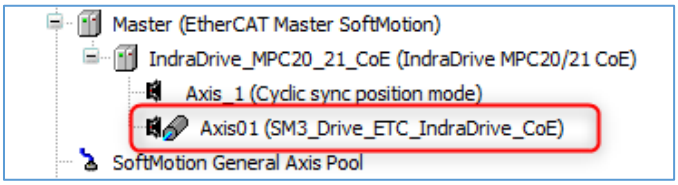

Fig 10: Device tree

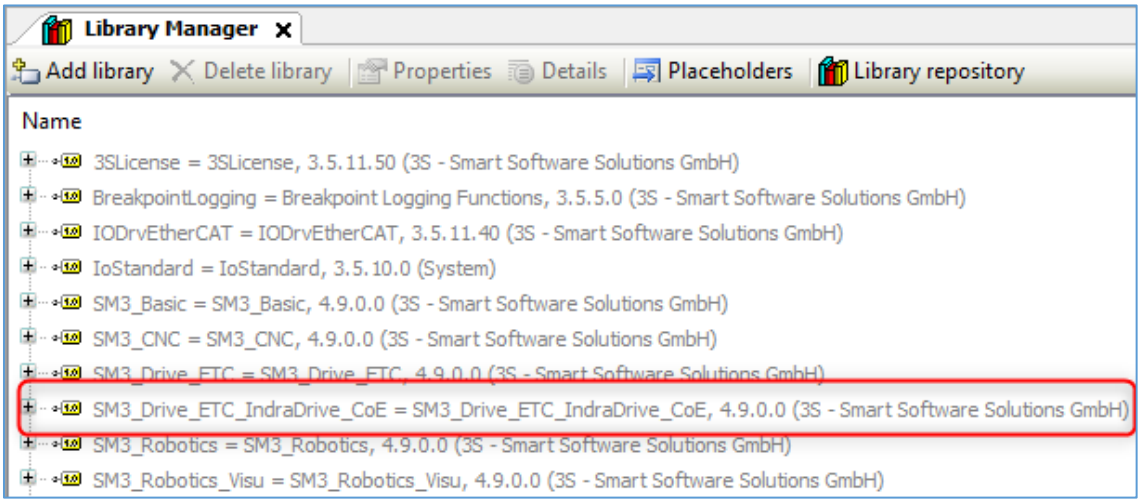

Fig 11: Library Manager

4. Double click on the drive device to open the settings page for the drive. Make the EtherCAT settings as necessary. If *EoE (Ethernet over EtherCAT)* needs to be enabled for the drive, tick the *Expert Settings* checkbox in the *General* tab. The *EoE Settings* tab will now be available. EoE is necessary if the user needs to access the drive over its IP address (EoE IP address), for e.g. connecting to the drive from IndraWorks Ds or ctrlX Drive Engineering software.

5. Double click on the SM3_Drive_ETC_IndraDrive_CoE axis device to open its settings. Configure the Axis type and the Scaling values in the General tab and the Scaling/Mapping tab as required. The scaling can also be automatically matched to the drive settings using the function block *FB_RexrothAxisScaling* (explained in section 6). Leave the Automatic Mapping selected as shown in the image below.

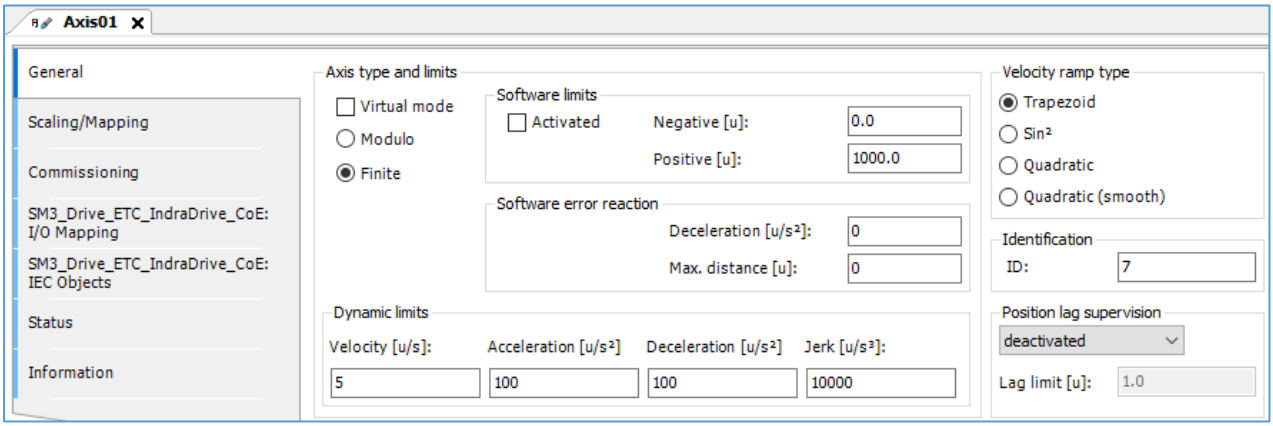

Fig 12: SoftMotion Axis – General settings

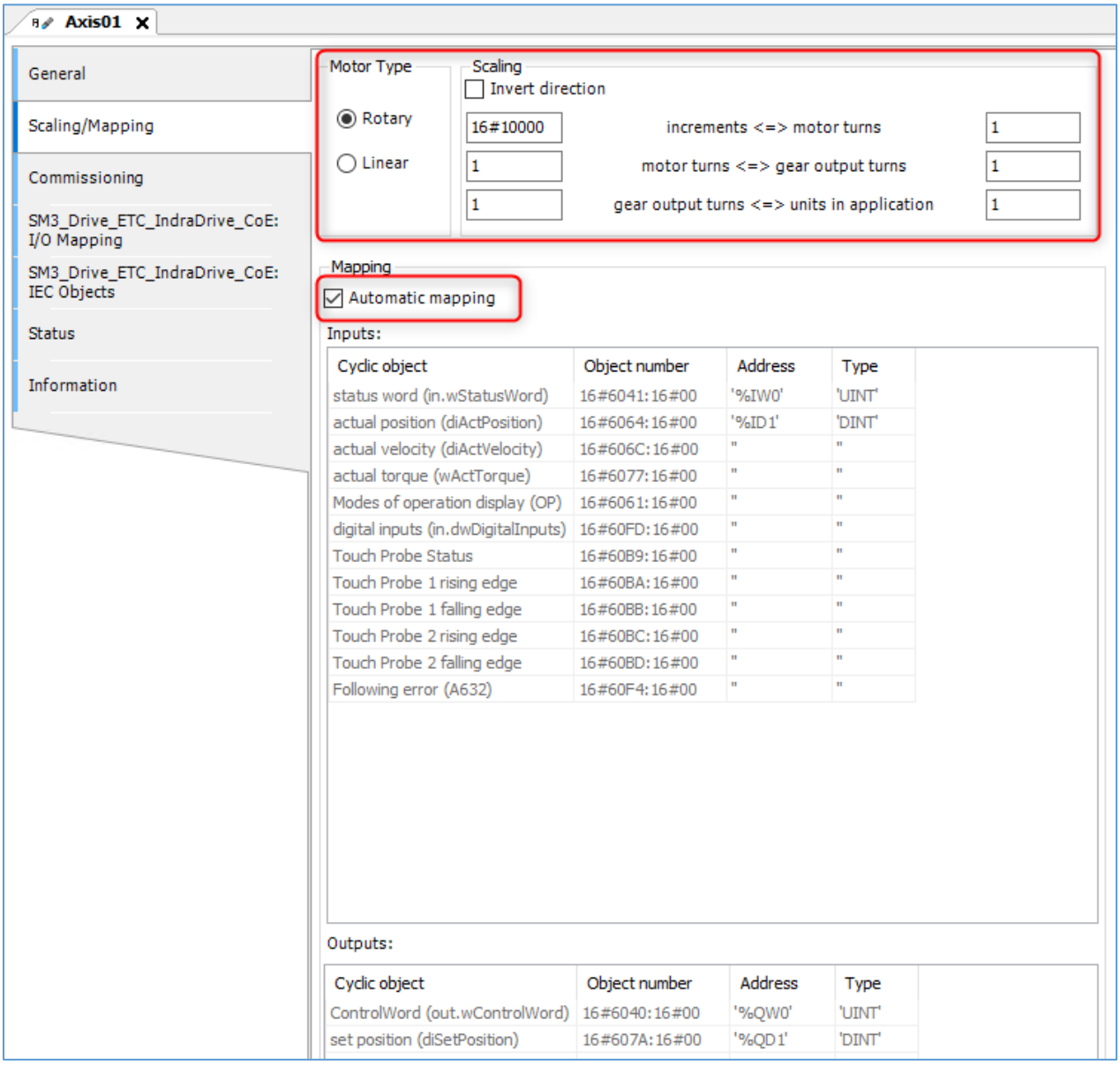

Fig 13: SoftMotion Axis – Scaling/Mapping settings

6. The bus cycle data exchange configuration must be set for the Cyclic sync position mode axis and the SM3_Drive_ETC_IndraDrive_CoE axis as shown in the images below.

   - Cyclic sync position mode axis → Enabled 2 (always in bus cycle task)

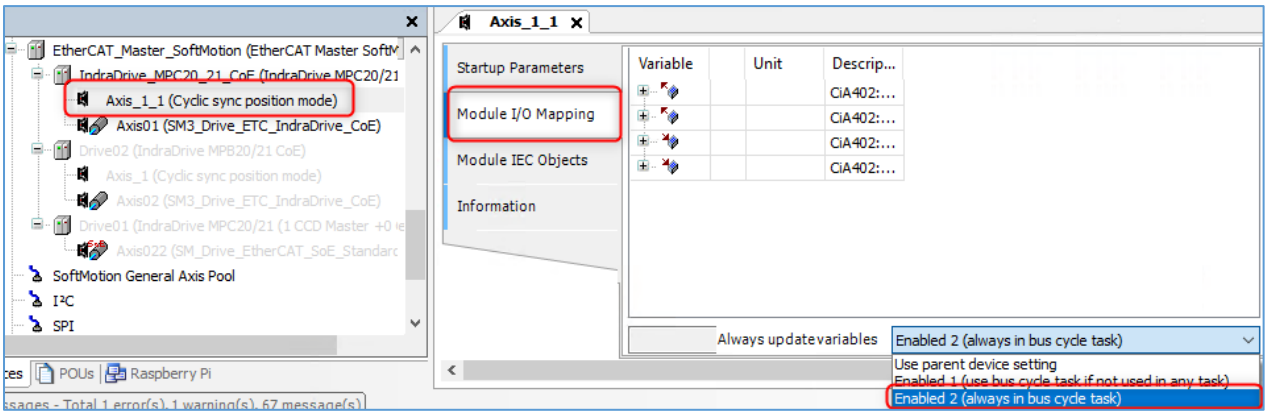

Fig 14: Settings for cyclic sync position mode axis

   - SM3_Drive_ETC_IndraDrive_CoE axis → EtherCAT_Task (or the bus cycle task)

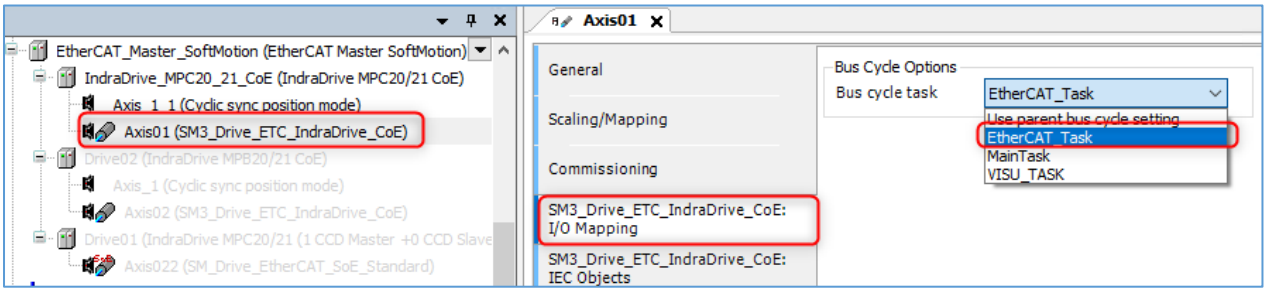

Fig 15: Settings for SM3_Drive_ETC_IndraDrive_CoE axis

7. The configuration is now complete. The CoE SoftMotion axis can be used with the motion function blocks in the SM3_Basic library.

5. Writing Motion Programs & Using the built-in Visualization Templates

5.1 Creating a Motion POU & Linking to Motion Task

1. Create a new POU of the type PRG and provide it a suitable name. Use this POU to write all the motion function blocks.

2. This POU must be called under the *EtherCAT_Task* as shown in the image below. This is necessary because the motion POU, which contains the instances of the motion function blocks must be called under the motion task (which is the *EtherCAT_Task* in this case).

   It should be noted that this is applicable only for motion function blocks like *MC_Jog*, *MC_Home*, *MC_MoveVelocity* etc. Administrative function blocks like *MC_Power* and *MC_Reset* can be called from any PLC task.

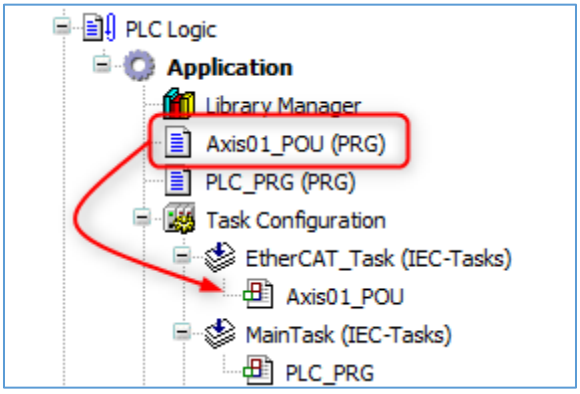

Fig 16: Motion POU linked under EtherCAT_Task

5.2 Linking the SoftMotion CoE Axis to Motion Function Blocks

In most of the motion function blocks, there is an input named *Axis* which provides the reference of a reference of the SoftMotion Axis to the motion block. Here the ETC_IndraDrive_CoE axis created under the IndraDrive must be linked to the *Axis* input of the motion blocks as shown in the image below.

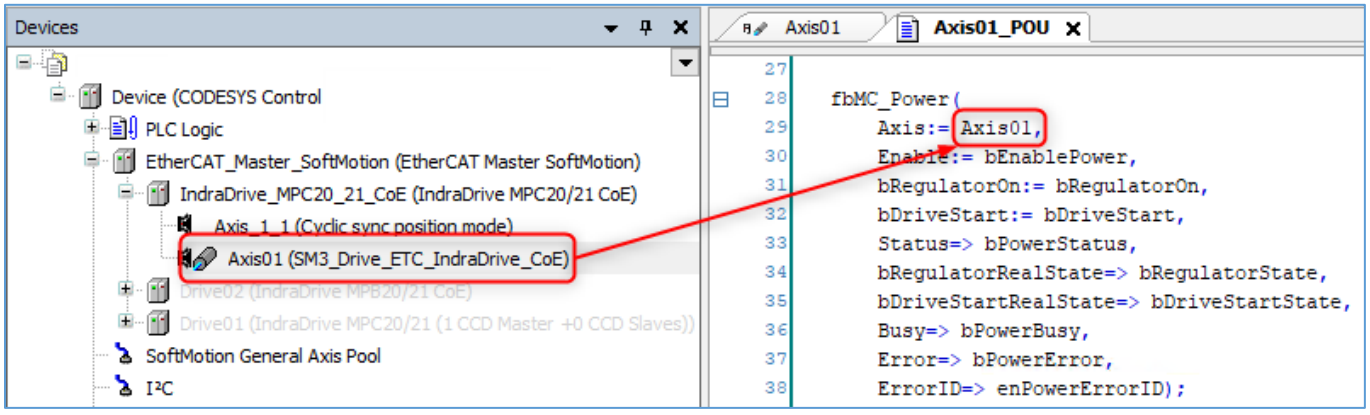

Fig 17: Linking SoftMotion CoE Axis to motion blocks

More information about CODESYS SoftMotion itself and the SM3_Basic library can be found in the online help links provided below.

- CODESYS SoftMotion Online Help
- SM3_Basic Library Online Help

When an error occurs when using one of the motion blocks, a detailed diagnostic information can be found in the SoftMotion CoE Axis page as shown in the image below.

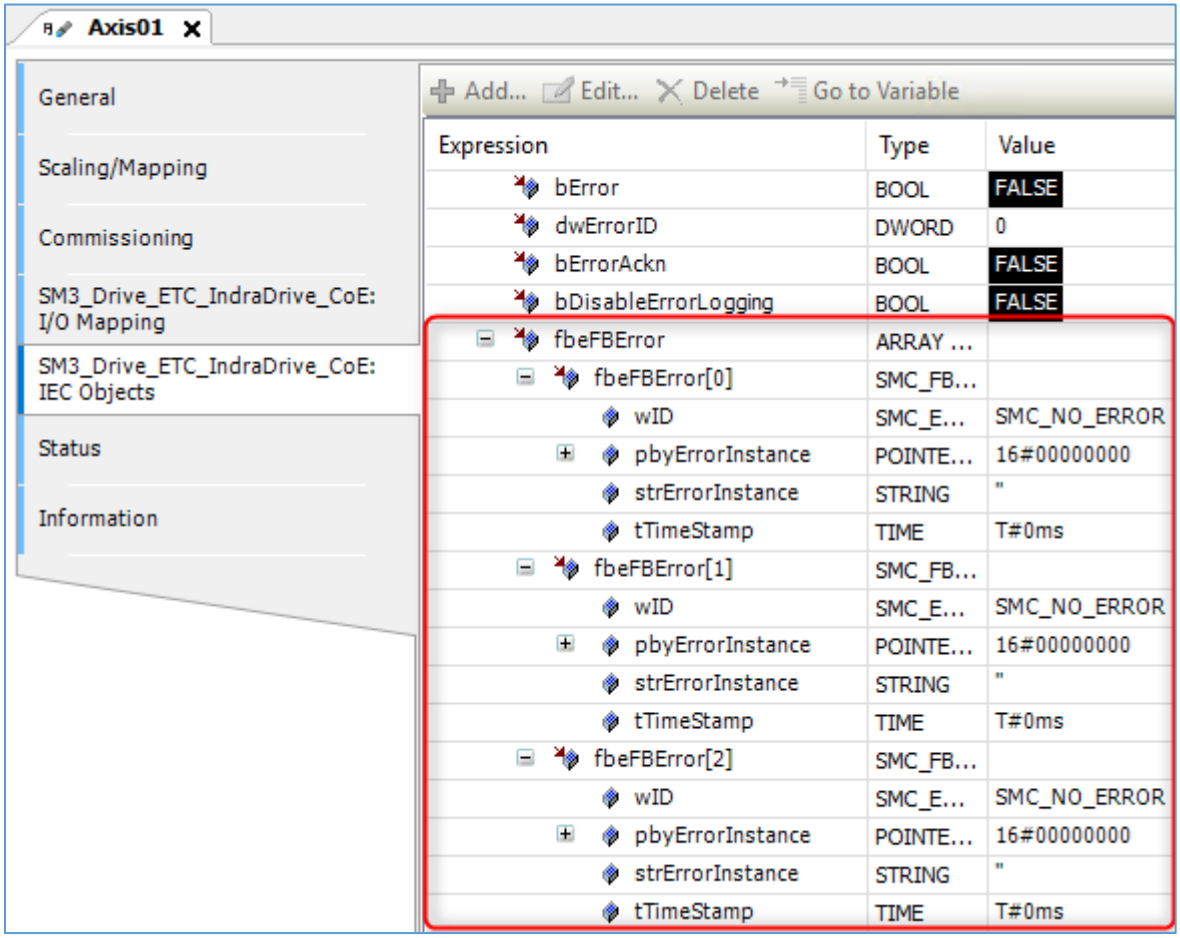

Fig 18: Detailed error information

5.3 Built-in Visualization Templates

The SM3_Basic library has a wealth of built-in visualization templates that can be used directly by a programmer to test functionality of a motion function block with minimal code. One example is given below for the function block *SMC_ChangeGearingRatio*.

1. Create an instance of the function block *SMC_ChangeGearingRatio* in the motion POU as shown in the image below. Provide link to the motion axis via the *Axis* input. No need to create variables for inputs or outputs.

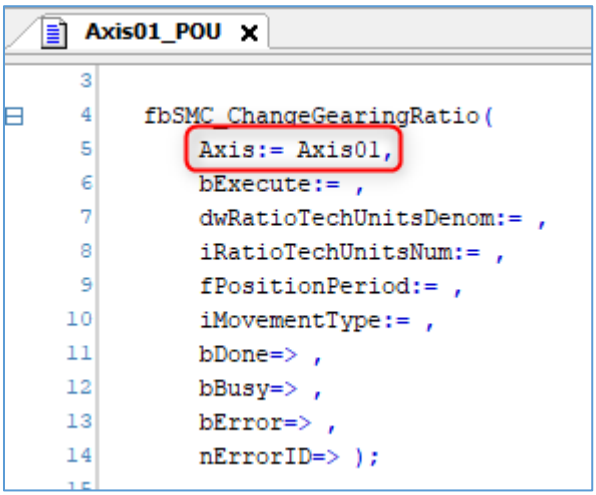

Fig 19: Motion POU

2. Add a visualization to the project -> right click on Application -> Add object -> Visualization

3. Open the created visualization. From the *Visualization Toolbox* on the right, select the *SM3_Basic* tab. Find the template *VISU_SMC_ChangeGearingRatio* as shown in the image below. Drag and drop the template onto the visualization.

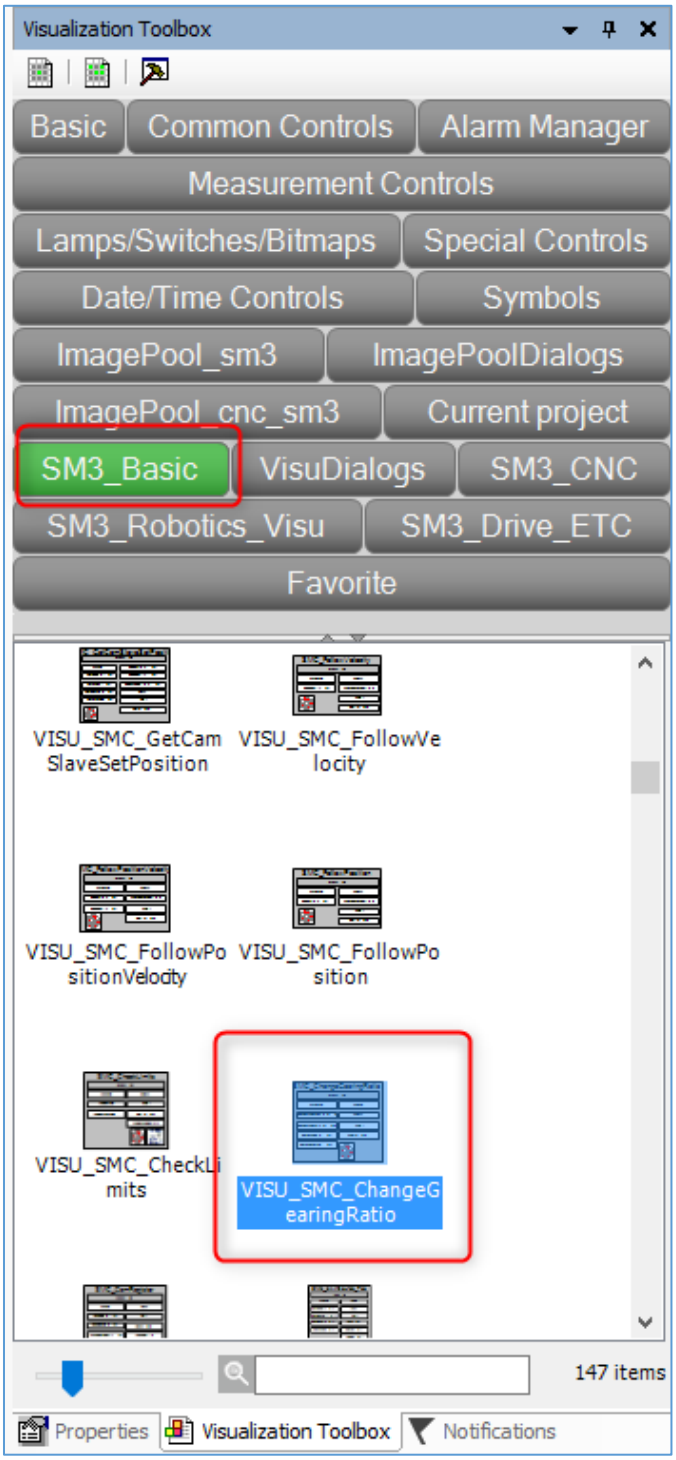

Fig 20: Visualization Toolbox

4. The Assign parameters dialog will open for the visualization template. Browse and choose the instance of the *SMC_ChangeGearingRatio* function block created in the motion POU and click OK. Now the inputs and outputs of the visualization are automatically mapped to the function block instance as shown in the image below and can be directly used.

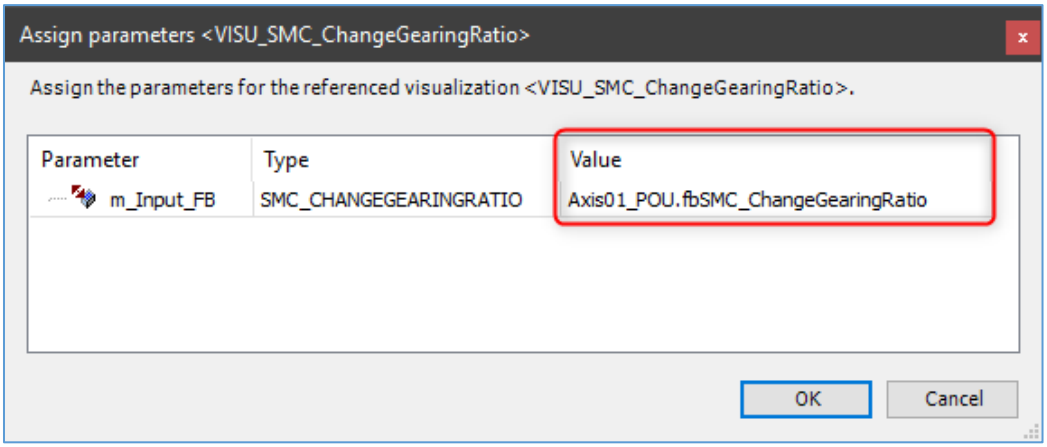

Fig 21: Assign parameters

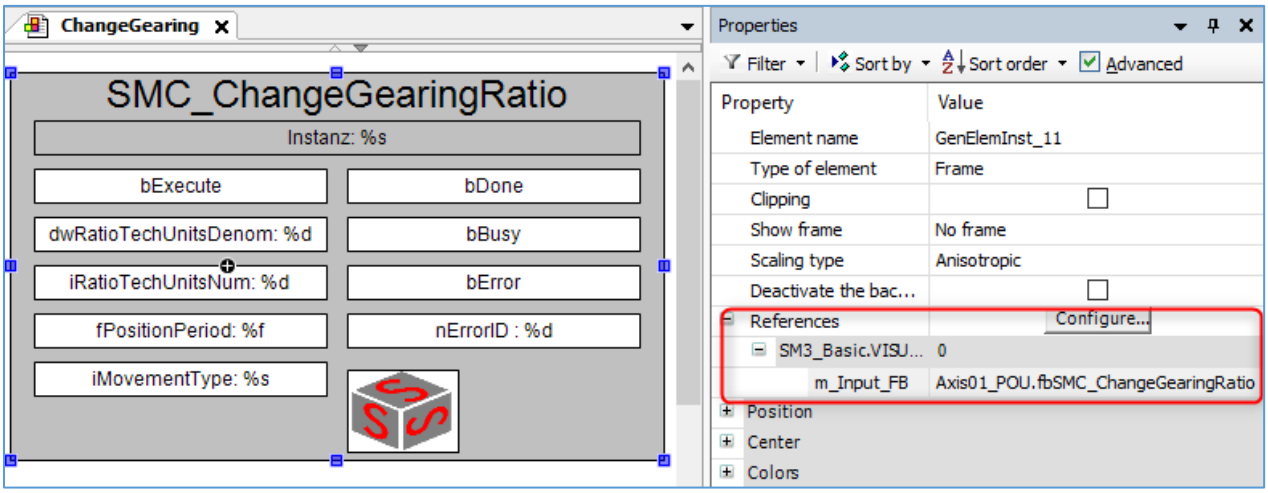

Fig 22: Visualization template and Reference

5. Like the example given above, there are lot of templates available in the SM3_Basic library which the user can directly use to verify the functionality of the SoftMotion CoE axis and the motion blocks.

6. FB_RexrothAxisScaling

6.1 Description

The function block *FB_RexrothAxisScaling* can automatically set the scaling settings for the position data of an CODESYS soft motion axis associated with an IndraDrive, so that the scaling matches with the mechanical settings on the drive. The function block can do this by reading the corresponding parameters over the acyclic EtherCAT channel. This works over both SoE and CoE communication. This function block becomes a useful tool, when the user wants to match the axis settings between the drive and the SM axis, by making the entire process automatic.

The function block internally uses blocks from the *IODrvEtherCAT or EtherCATStack* library. The CODESYS PLC must support this library for the function block to operate properly. Also, the function block can apply the scaling values only when the axis is powered off – otherwise SMC_Error will be observed.

Usage of this function block is not recommended in the following cases. The scaling values must be set manually as explained in the section 4.3.

- *IODrvEtherCAT* or *EtherCATStack* library is not supported
- Function block gives an error which could not be resolved
- The applied scaling values are erroneous

Note: The user must exercise extreme caution once the scaling values are set and ensure that the applied values are correct and the axis movement is as desired, before normally operating the axis.

6.2 Installation and Usage

The function block *FB_RexrothAxisScaling* is packaged into an installable library named *RexrothSM_Helper* to make it easy for the end user. This library is available in the *Library* folder in the package. The steps to install the library and using the function block are given below.

1. Open CODESYS software.
2. Open the *Library Repository* from the *Tools* menu.
3. Click on the *Install* button.

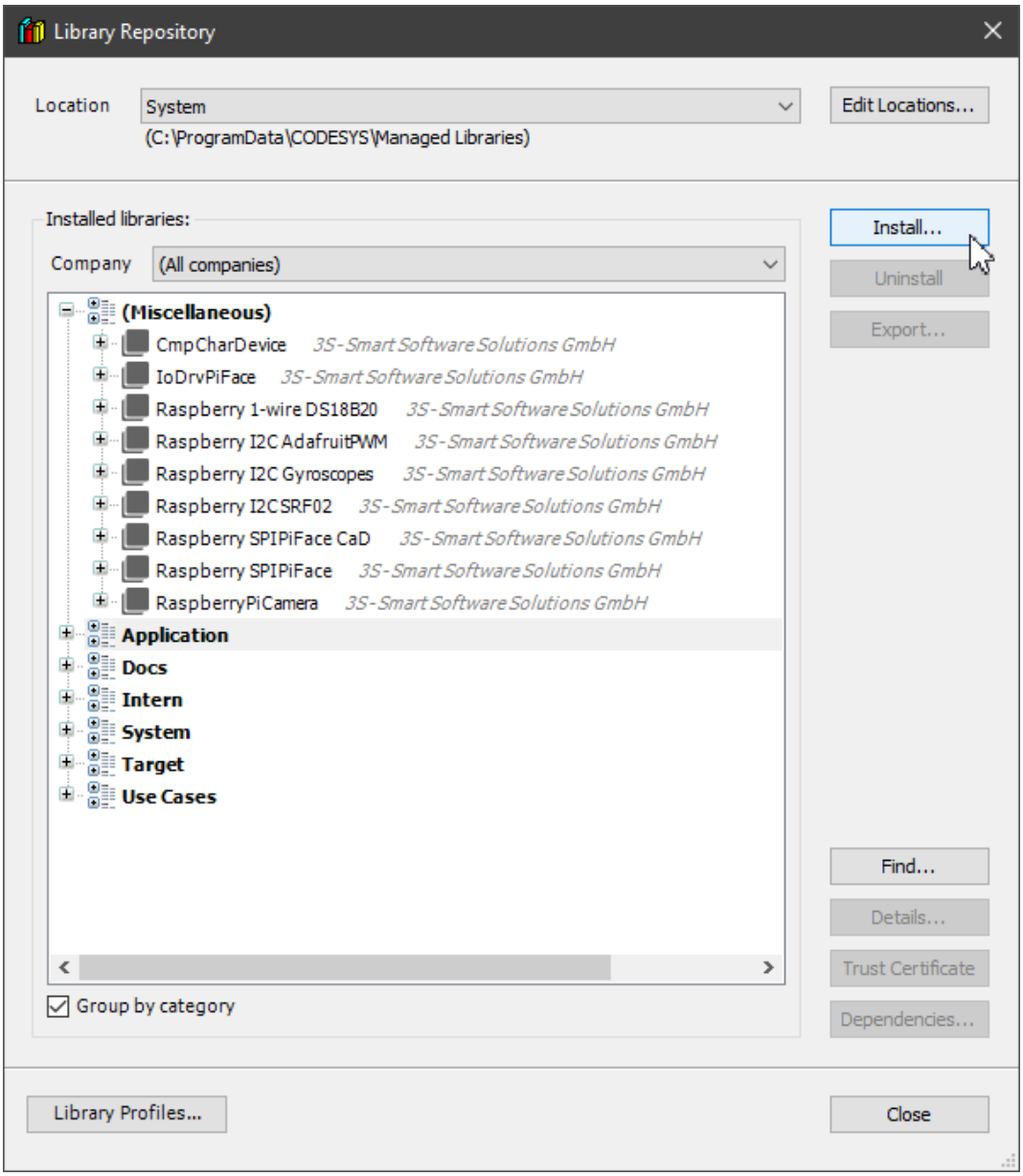

Fig 23: Library Repository

4. Browse and select the *RexrothSM_Helper.library* available in the package; File type should be set to All files.

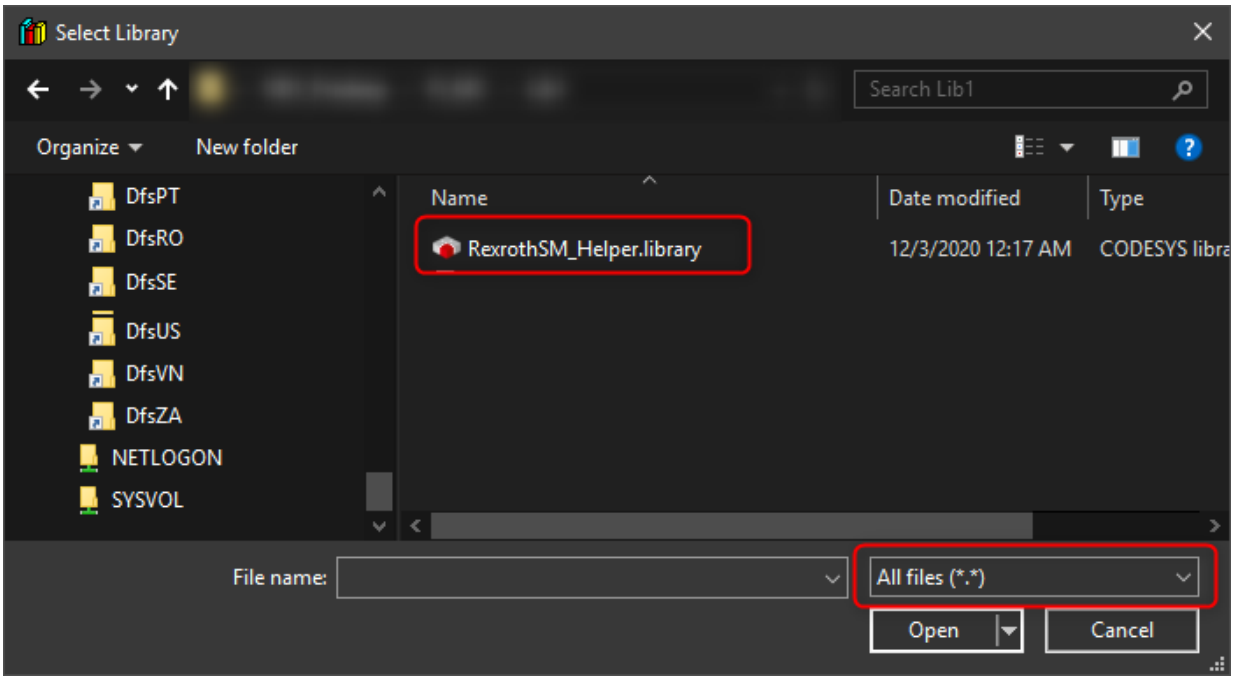

Fig 24: Library selection

5. The library is now installed in the CODESYS development system.

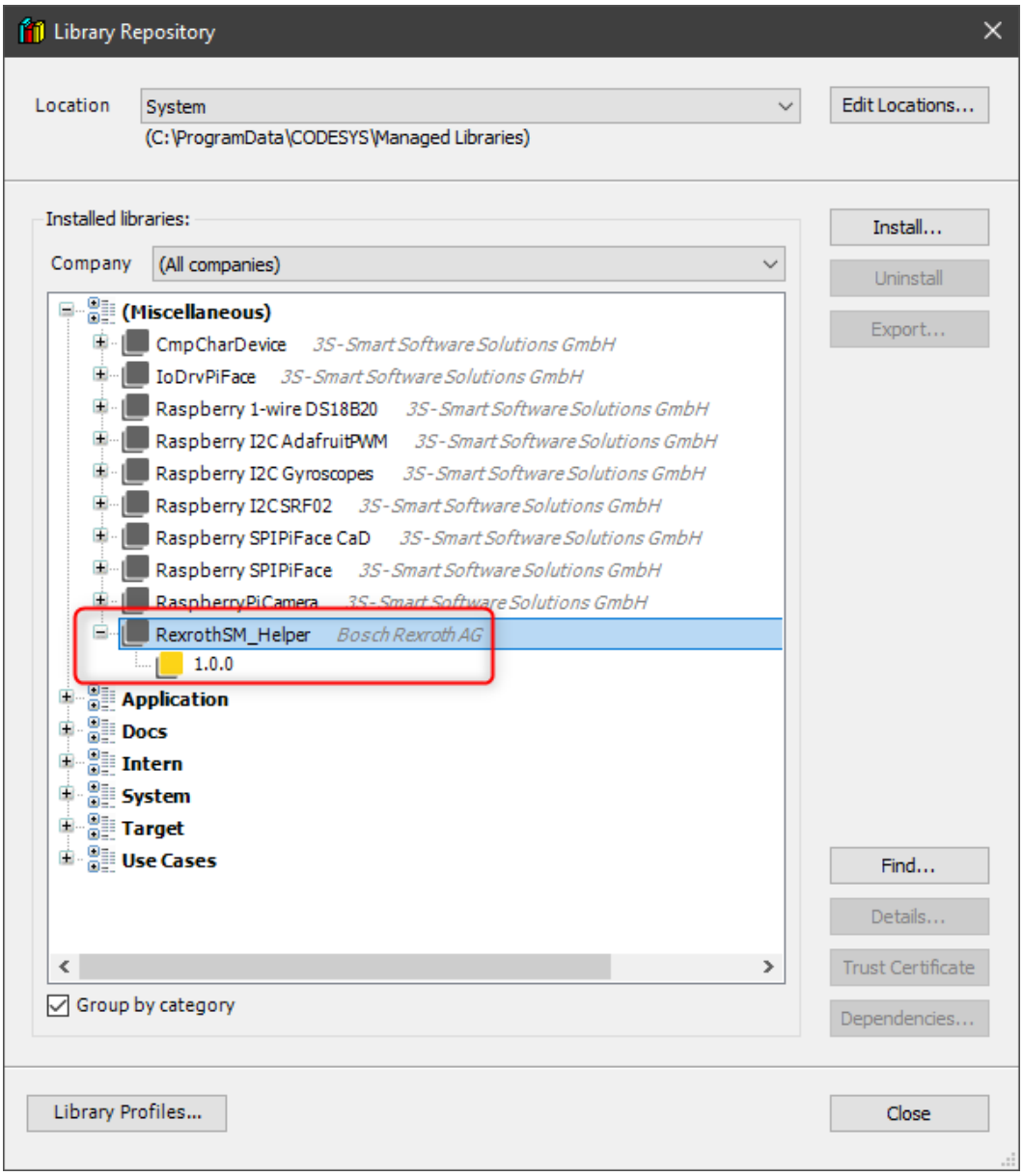

Fig 25: Library Repository

6. Now the library needs to be added to the CODESYS motion project.
7. Open the CODESYS project and open the Library Manager.
8. Click on the *Add Library* button to open the *Add Library* window.

9. Browse and select the RexrothSM_Helper library and click *OK*.

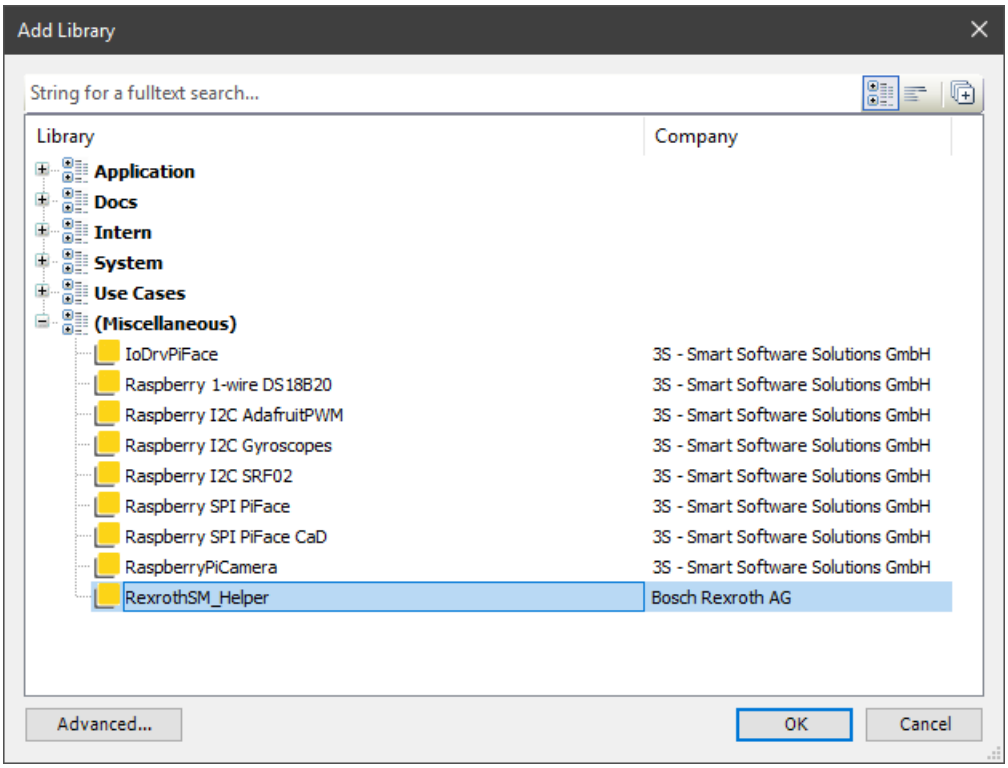

Fig 26: Add Library dialog

10. The library is now added to the project's library manager.

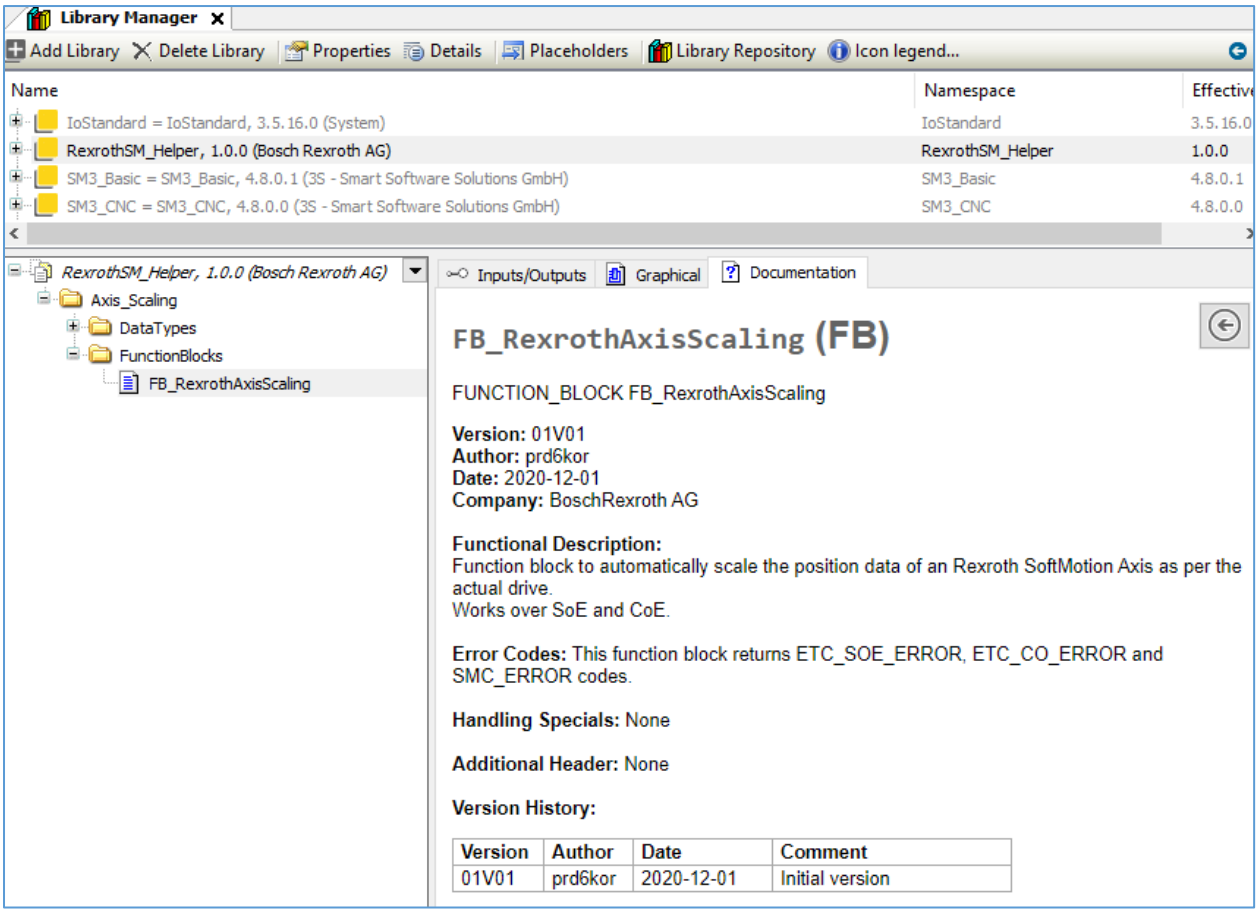

Fig 27: Library Manager

11. Create an instance of the *FB_RexrothAxisScaling* function block in the user program, provide the reference to the SoftMotion axis, the axis number and the EtherCAT master index and the function block is ready to operate.

```
fbRexrothAxisScaling(
    Execute:= bExecute,
    MasterIndex:= usiMasterIndex,
    ECATAddr:= 1001,
    Busy=> bBusy,
    Done=> bDone,
    Error=> bError,
    ErrorID=> udiErrorID,
    ErrorCodeSoE=> enErrorCodeSoE,
    ErrorCodeCoE=> enErrorCodeCoE,
    AxisErrorCode=> enAxisErrorCode,
    Axis:= Axis01);
```

Fig 28: Function block instance

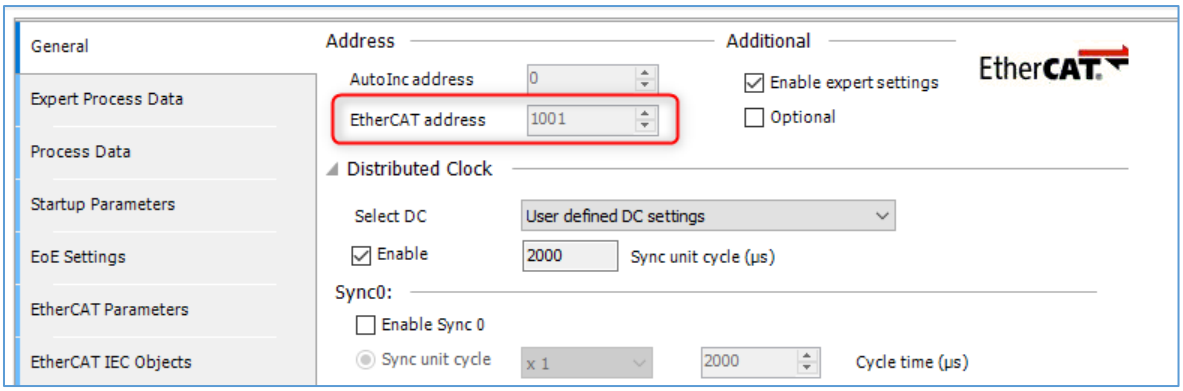

Fig 29: EtherCAT address

6.3 Interface Description

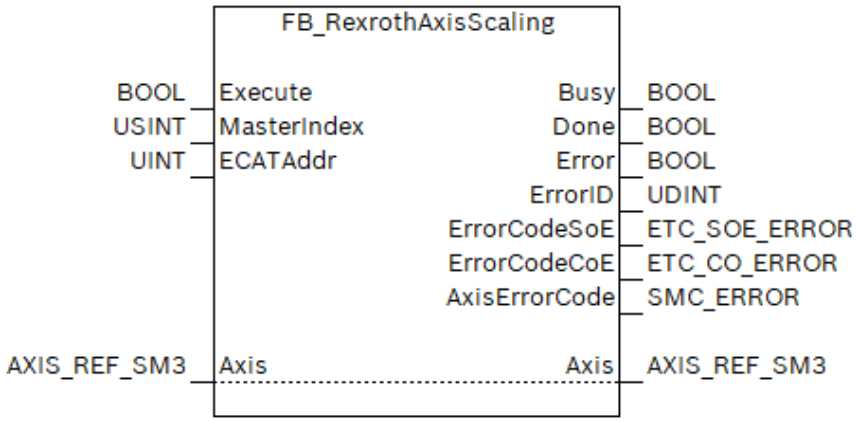

Fig 30: Function block interface

6.4 Input and Output Description

I/O Type	Name	Data Type	Description
VAR_INPUT	Execute	BOOL	Execute function block operation on rising edge of this input
	MasterIndex	USINT	Index of the EtherCAT master to which the drive is connected – the index of the first master is 1
	ECATAddr	UINT	EtherCAT address of the drive as shown in section 6.2
VAR_OUTPUT	Busy	BOOL	Function block is busy executing the operation
	Done	BOOL	Operation complete
	Error	BOOL	Error occurred during execution
	ErrorID	UDINT	Error code from the function block – see section 6.6
	ErrorCodeSoE	ETC_SOE_ERROR	Error code returned by the internal SoE function block – see section 6.6
	ErrorCodeCoE	ETC_CO_ERROR	Error code returned by the internal CoE function block – see section 6.6
	AxisErrorCode	SMC_ERROR	Error code returned by the internal SoftMotion function block – see section 6.6
VAR_IN_OUT	Axis	AXIS_REF_SM3	Reference to the SoftMotion axis

6.5 Min / Max / Default Values and Takeover of Inputs

Name	Data type	Min. value	Max. Value	Default Value	Takeover
Execute	BOOL			FALSE	Continuous
MasterIndex	USINT	0	NA	1	Rising edge of Execute
ECATAddr	UINT	0	NA	1001	Rising edge of Execute

6.6 Error Handling

When the function block *FB_RexrothAxisScaling* encounters an error, the Error output is set, and various error code information are provided to the user through the three error code outputs available. The error could be generated within the function block or by one of the function blocks internally used. These are explained below.

6.6.1 Output – ErrorID

This output provides the error codes generated within the function block itself (type UDINT). They are listed below.

Error code	Comment
0	No error
1001	The Axis driver for the referenced soft motion axis is not supported – set the axis scaling manually
1002	Function block entered an invalid state – execute the function block again – if encountered repeatedly then set the axis scaling manually
1003	The scaling data read from the drive is invalid – set the axis scaling manually

6.6.2 Output – ErrorCodeSoE

This output provides the error codes generated by the ETC_SoE function blocks from the EtherCAT Stack library (type ETC_SOE_ERROR). More information on these error codes are available in the EtherCAT library documentation or at the CODESYS online help.

6.6.3 Output – ErrorCodeCoE

This output provides the error codes generated by the ETC_CO function blocks from the EtherCAT Stack library (type ETC_CO_ERROR). More information on these error codes are available in the EtherCAT library documentation or at the CODESYS online help.

6.6.4 Output – AxisErrorCode

This output provides the error codes generated by the SoftMotion function blocks from the SM3_Basic library (type SMC_ERROR). More information on these error codes are available in the SM3_Error library documentation or at the CODESYS online help.

6.7 Axis Scaling with CiA402 Profile:

There are some changes to the default scaling exponent values with the CiA402 profile, when compared to the exponent values for preferred scaling with other profiles, especially for linear motion. This can lead to jerky or blocky movement in the SoftMotion axis, after executing an automatic scaling with the *FB_RexrothAxisScaling* function block. In this case, the user needs to verify that, the resolution of the position unit (minimum incremental command value from the SoftMotion master) in the drive is not very high. Look at the example below.

With CiA402 profile, the unit for linear movement is 'm' with a default exponent value of -4 as seen in the image below. In this case, the resolution of the position data becomes 0.1mm with 1 decimal place (as opposed to the default 4 decimal places). So, the smallest position command increment that is possible from the SoftMotion master is 0.1 mm, which is too big and will cause a blocky movement in the axis.

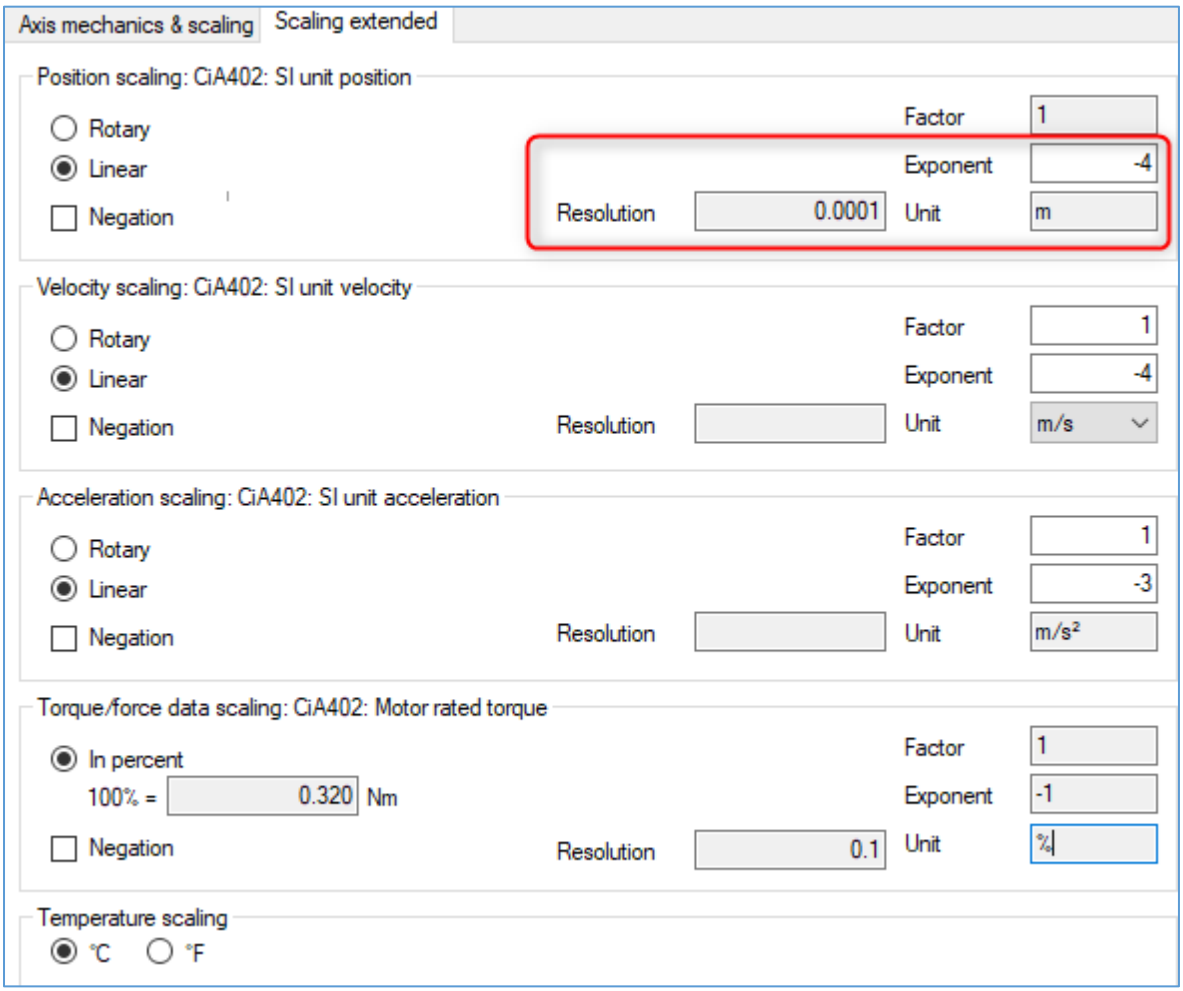

Fig 31: Axis scaling extended

This problem can be worked around by setting the exponent value to -7, which gives a precision of 4 decimal places for linear position data (this is also the exponent value for preferred scaling for linear movement). This in turn makes the smallest position command increment from the SoftMotion master to 0.0001mm instead of 0.1mm, which prevents blocky movement at the axis.

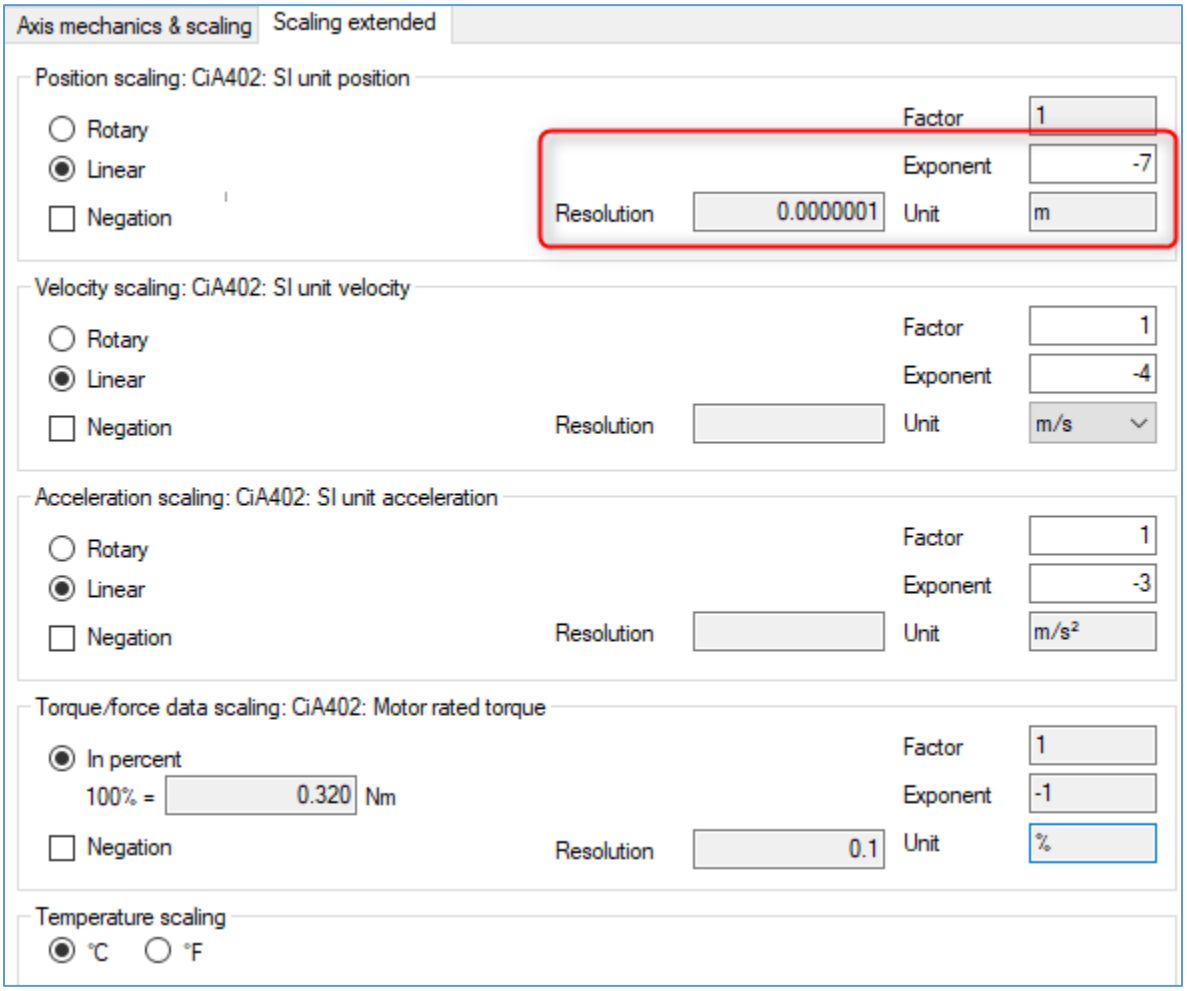

Fig 32: Axis scaling extended

7. Document History

Version	Date (dd.mm.yyyy)	Author	Comment
1.0	03.12.2020	PRD6KOR	Initial version
1.1	24.02.2021	PRD6KOR	Updated for SoftMotion 4.9.0.0
1.2	02.03.2021	PRD6KOR	Added information about EtherCAT CoE FWS