

„Relative synchronism“ Synchronous Motion with using the technology objects in TIA V16 & CMMT-AS-PN

This application note describes how to use the technology objects to activate a Synchronous Motion (relative synchronism) with 2 CMMT-AS-PN.
Called Leading-Axis (master) - Following-Axis (slave).

CMMT-AS-PN

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1 Components/Software used

Type/Name	Version Software/Firmware	Date of manufacture
CMMT-AS-C4-3A-PN-S1	17.0.8.48	05.02.2020
CMMT-AS-C2-3A-PN-S1	17.0.8.48	05.02.2020
Automation Suite	1.3.2.4	13.01.2020
CMMT-AS Plug-in	1.3.1.9	28.02.2020
TIA Portal	V16	02.12.2019
Technology objects	V5	04.01.2019

Table 1.1: 1 Components/Software used



Information

This AppNote describes the procedure with the CMMT-AS motor controller. The CMMT-AS servo drive controller and CMMT-ST servo drive controller for extra-low voltage are based on the same software platform. Therefore, the described settings can also be used as a reference for its parameterization. It is hereby expressly pointed out, that this has not been explicitly tested and therefore the function cannot be guaranteed!

1.1 Topology of the tested/used system

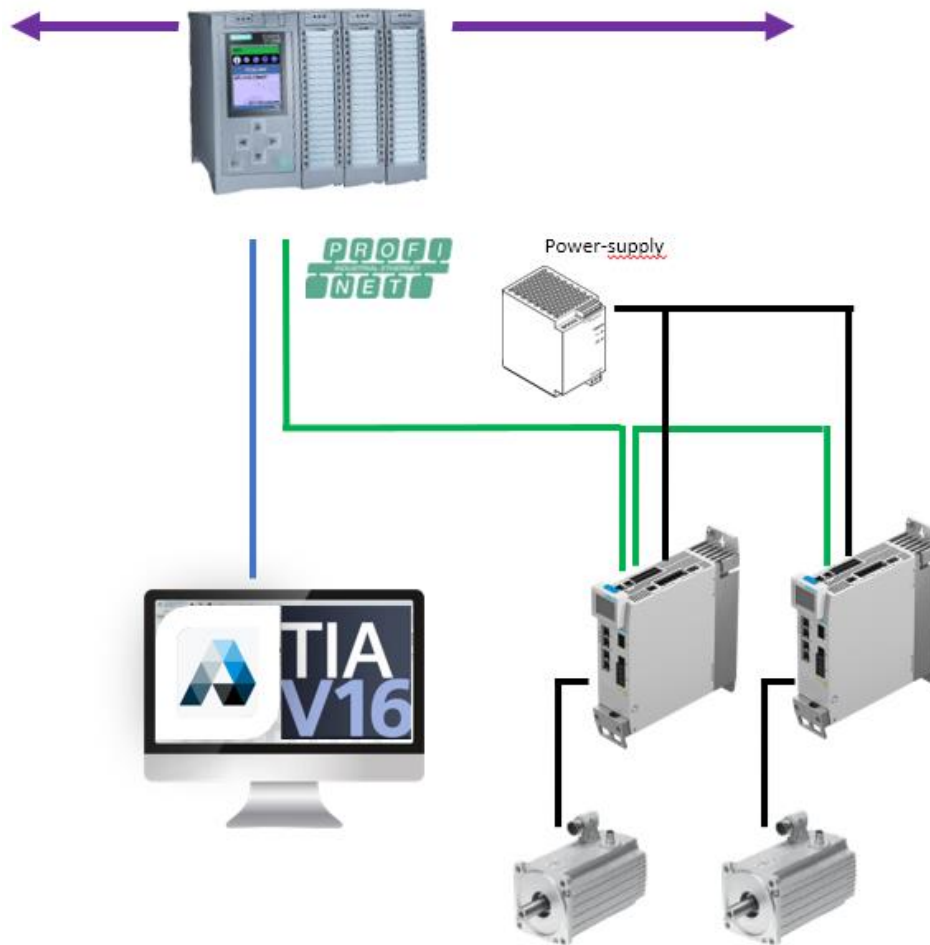


Figure 1.1 : overview of tested system

Please refer to the picture above and make sure all wires are correctly placed and connected
To configure and run the system for commissioning, it is necessary to install named software in the table 1.1 above on your laptop or other PC system which you will do commissioning with.

1.2 Application description

The Application Note describes the connectivity and configuration of the servo drives CMMT-AS-...-PN within a PROFINET network controlled via S7-1500 PLC. The used bus protocol within this Application Note is an Application Class 4 (Motion Control) and Telegram 106 (there is no special reason to use the Telegram 106 for the Synchronous Motion, it has to be one which supports Application Class 4 & IRT). In this Application Note we use the terms “Leading-Axis” as the Master-Axis and “Following-Axis” as the Slave-Axis”.

This is a relative synchronism application without specifying a synchronous position and can be realised with a non-technology CPU.

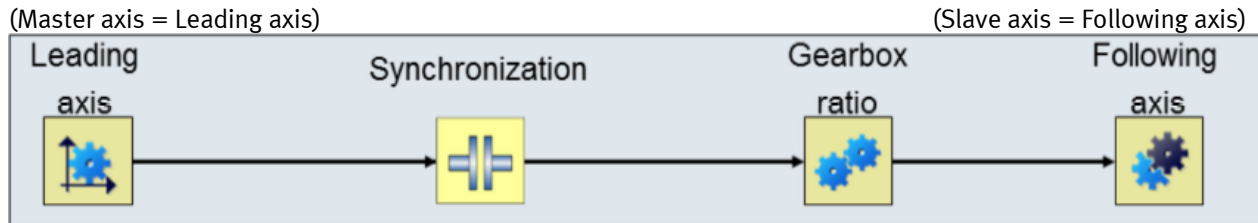
It is targeted at people who are already familiar with this protocol, Festo Automation Suite and Siemens TIA Portal software.

2 Synchronization

Synchronization establishes the relationship between the leading axis and following axis. Synchronization begins with the start of an **"MC_GearIn"** job.

*See for the details of the function block **MC_Gear** in chapter [4.3.2 Gearing with "MC_GearIn"](#)

Principle representation of Synchronous Motion:



3 Configuration of parameters in Automation Suite

3.1 Automation Suite related parameters

Start with the related parameters for the application and do not cover the general settings for the configuration of the drive.

The parameters that are related to the communication with the host system is under the Fieldbus tab.

- Reference Values

Shown values of the configuration must match to the configuration settings within the technology objects.

Reference values		
Base value velocity (user unit)	3000,00	rpm
Base value speed (controller)	3000,00	rpm
Base value acceleration	600,00	rpm/s
Base value deceleration	600,00	rpm/s

Base value speed (controller)

0x453B8000 (FLOAT32) P1.11280701.0.0

Specifies the base value speed for the configuration tool with operating mode AC4. This value must be the same for controller and servo drive. A change of this value will be also applied to the corresponding parameter in the actual user unit.

Default 3000,00 rpm

3.2 AC4 parameters in Festo Automation Suite

AC4			
Maximum	10000,00	U/min	■
Maximales Drehmoment Motor oder Servoantriebsregler	2,214	Nm	■
Buszykluszeit (KPC)	0,00	s	■
Verstärkungsfaktor Positionsregler (ohne DSC)	31,99432		■
Verstärkungsfaktor Positionsregler (mit DSC)	31,99432		■
Auflösung pro Umdrehung für Gn_XIST	Auflösung pro Umdreh		■
Anzahl Umdrehungen	16384		■
Bits in Gn_XIST1	0		■
Bits in Gn_XIST2	0		■
Zähler	1		■
Nenner	1		■
Geberschnittstelle 1	100,00	mm/U	■

3.3 Telegram selection

Select Telegram 106 under the PZD (process data) telegram selection in tab Fieldbus

Connection properties	
PZD telegram selection	Telegram (1) ▲
Current application class	Telegram (1)
	Telegram (2)
	Telegram (3)
	Telegram (4)
	Telegram (5)
	Telegram (6)
	Telegram (7)
	Telegram (9)
	Telegram (102)
	Telegram (103)
	Telegram (105)
	Telegram (106)
	Telegram (111)

Details of the used Standard Telegram 106 – cut out from the CMMT-AS documentation

Standard Telegram 106

Rotational speed setpoint value 32 bit with 2 position encoders, torque reduction and DSC

Supported application class: AC4

PZD	Setpoint value	Actual value
1	STW1	ZSW1
2	NSOLL_B	NIST_B
3		
4	STW2	ZSW2
5	MOMRED	MELDW
6	G1_STW	G1_ZSW
7	G2_STW	G1_XIST1
8	XERR	
9	KPC	G1_XIST2
10		
11		G2_ZSW
12		
13		G2_XIST1
14		
15		G2_XIST2

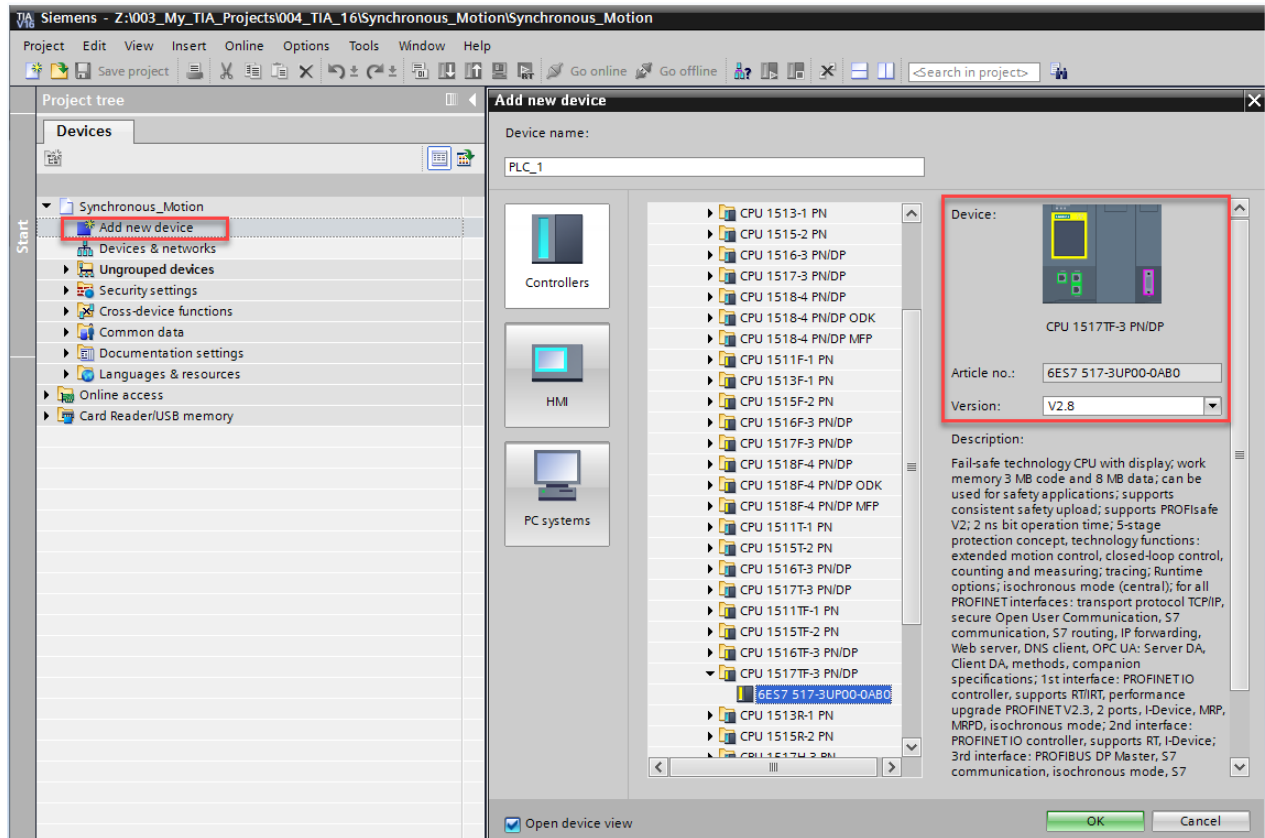
Tab. 734 Standard Telegram 106

4 Configuration TIA Portal

4.1 Creating the hardware configuration in TIA Portal

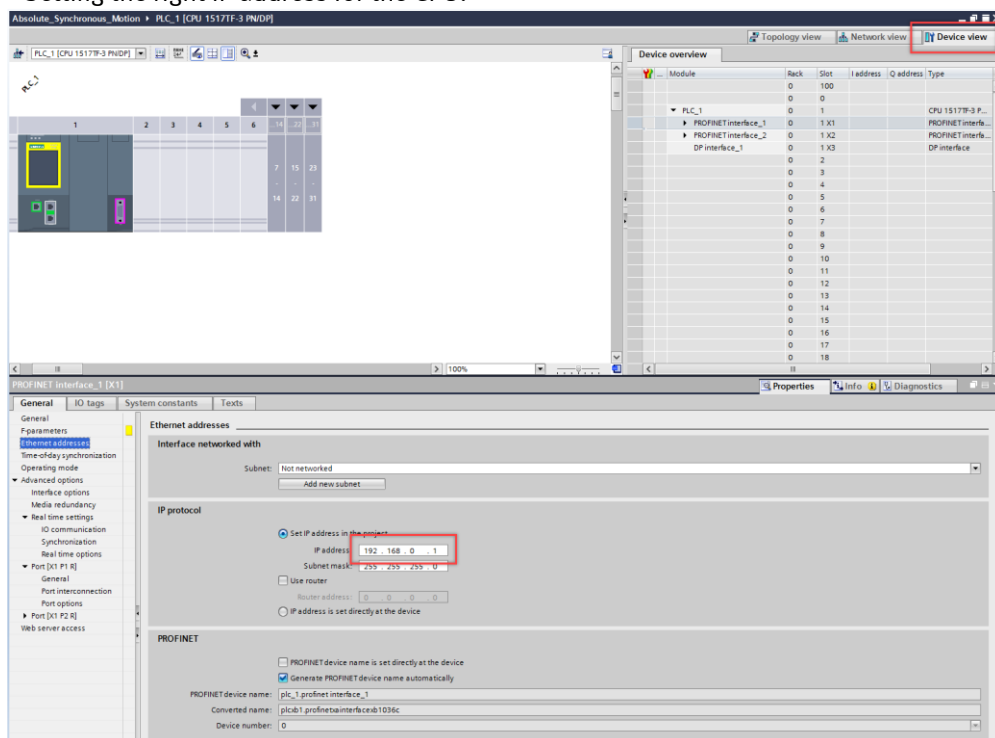
4.1.1 Create new project

Create a new project and add your PLC with the right firmware version:



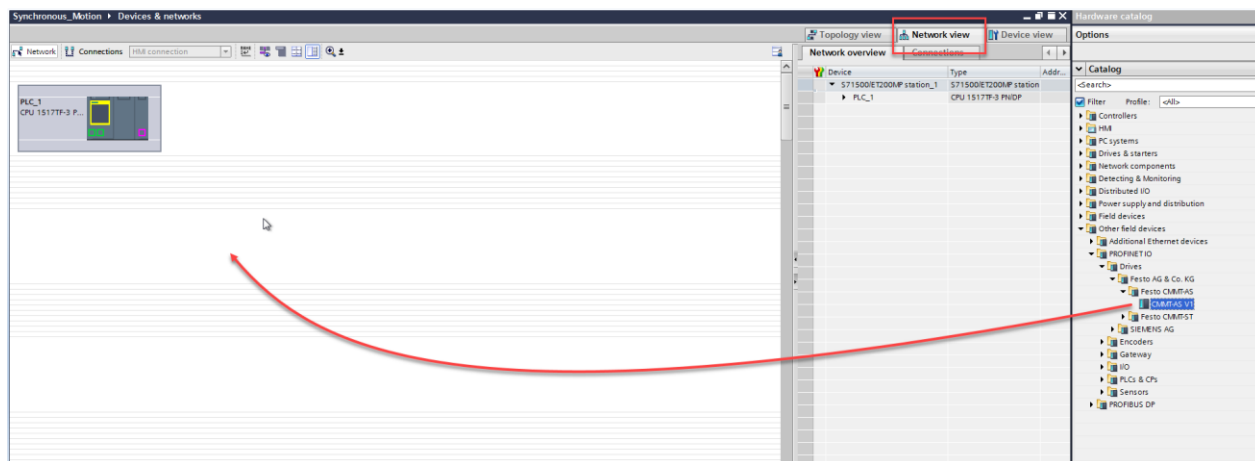
4.1.2 Setting the IP-address

Setting the right IP address for the CPU:



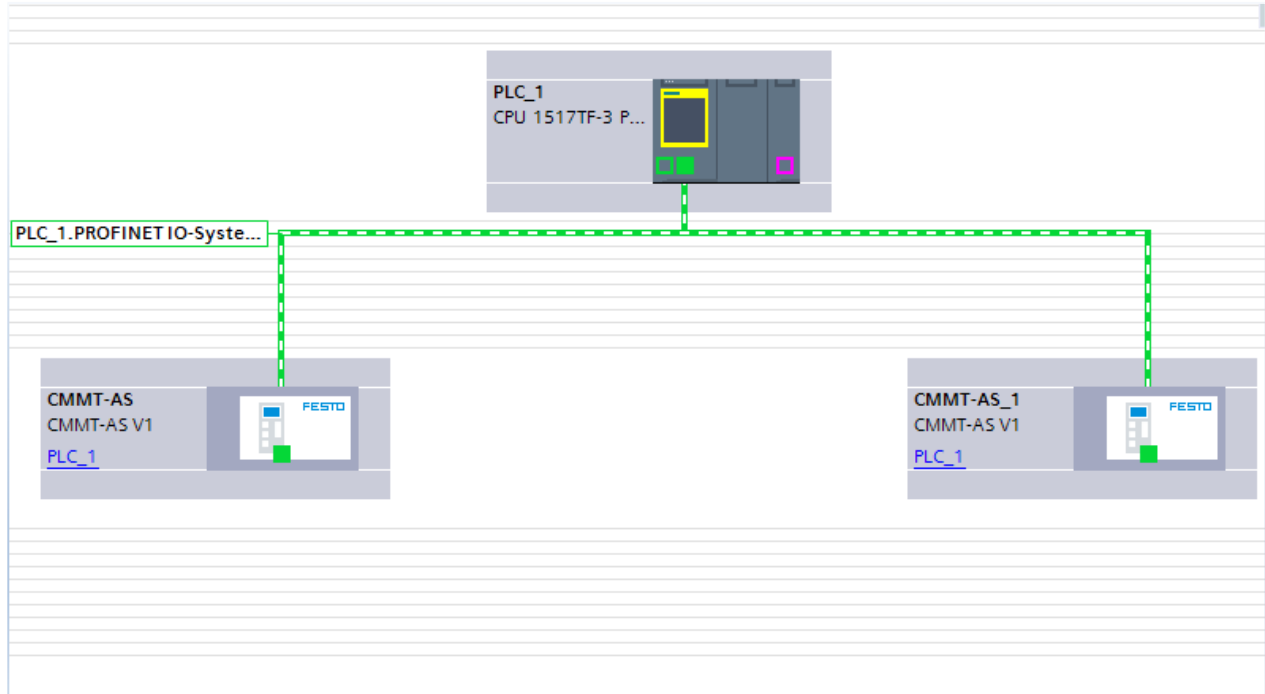
4.1.3 Select CMMT

Go to the 'Device Configuration' tab, select 'Network View' and search for the CMMT in the Hardware Catalog. Place the CMMT-AS into the "Network" by drag and drop. Two times for Leading & Following-Axis:



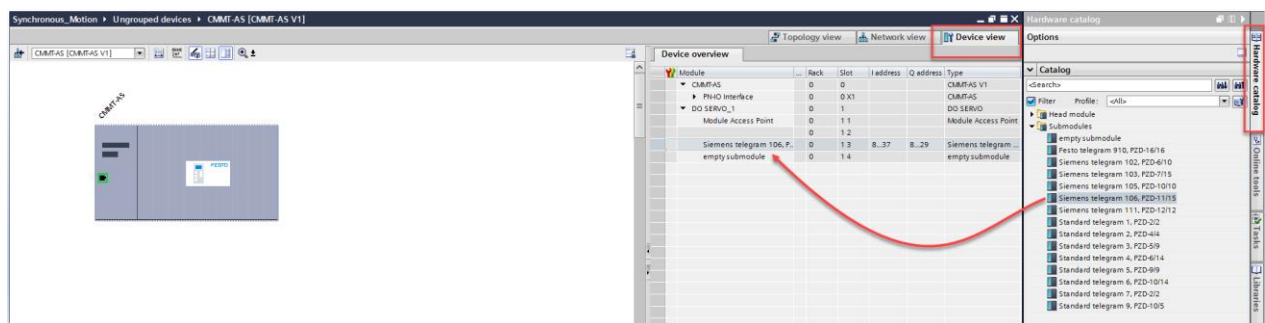
4.1.4 Connect Profinet

To connect the CMMT's with the PLC, click on 'Not Assigned' and select the PROFINET interface. After this, a green line will show the connection between the PLC and CMMT:



4.1.5 Assign Motion telegram

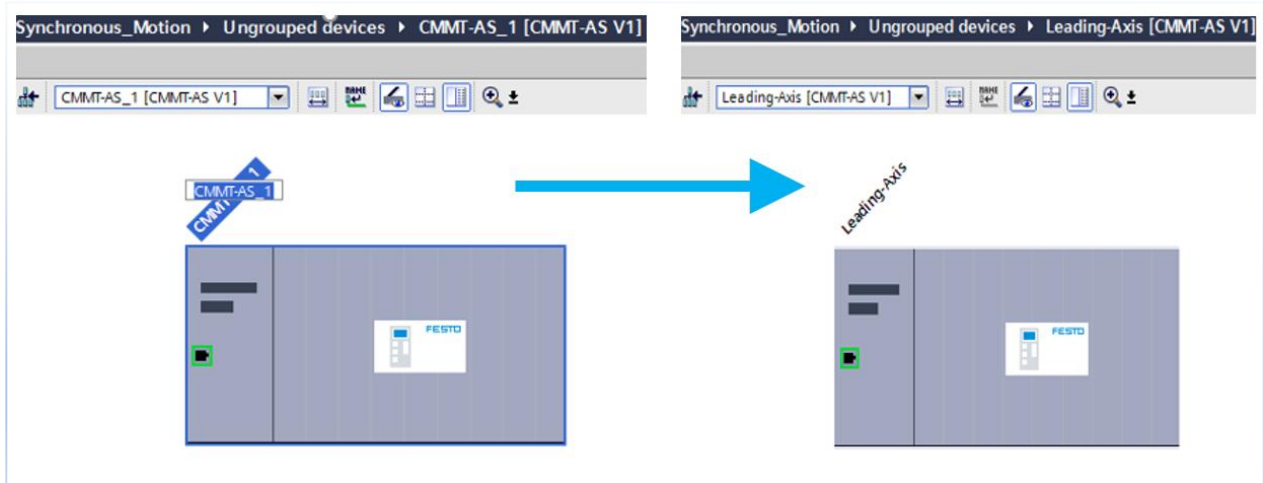
Double click on the CMMT to get into the 'Device View' tab. Available telegrams based on the GSDML file will be offered. To use the CMMT in Motion Control select the Telegram 106 and place it via drag and drop. Do this step for both CMMT-AS



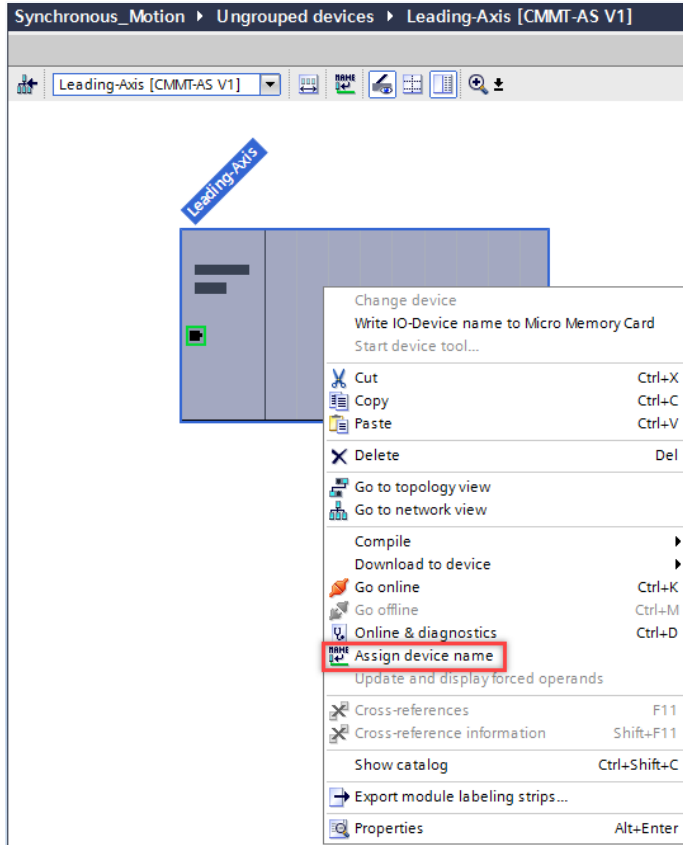
4.1.6 Rename CMMT

To rename the CMMT-AS click into the name field and type the desired name:

- Master axis was named as Leading-Axis
- Slave axis was named as Following-Axis



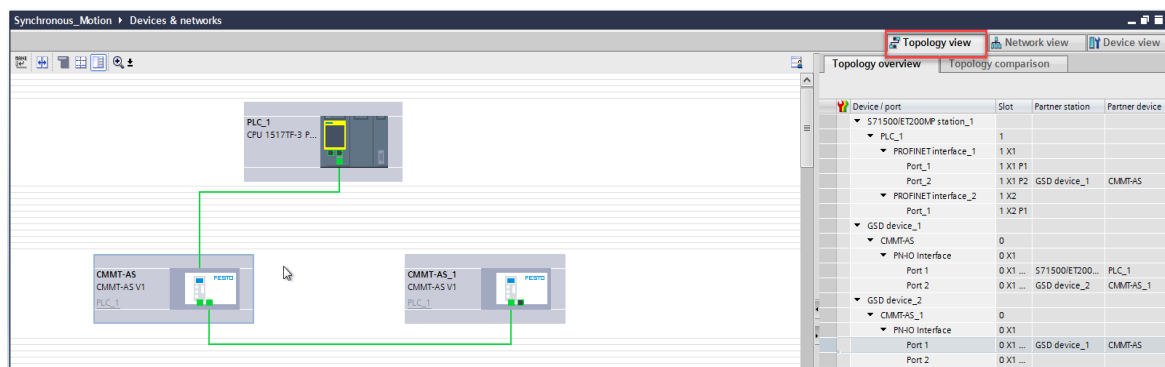
Right click on the CMMT and select 'Assign Device Name'. To do this, access via the PROFINET network connected on port -X19 on the CMMT must be present. This step must be done for both CMMT-AS:



4.1.7 Assign the Topology

Note: Check that the PROFINET wiring present corresponds to the structure of this wiring. If the PROFINET wiring deviates from this, this must also be considered in the topology view.

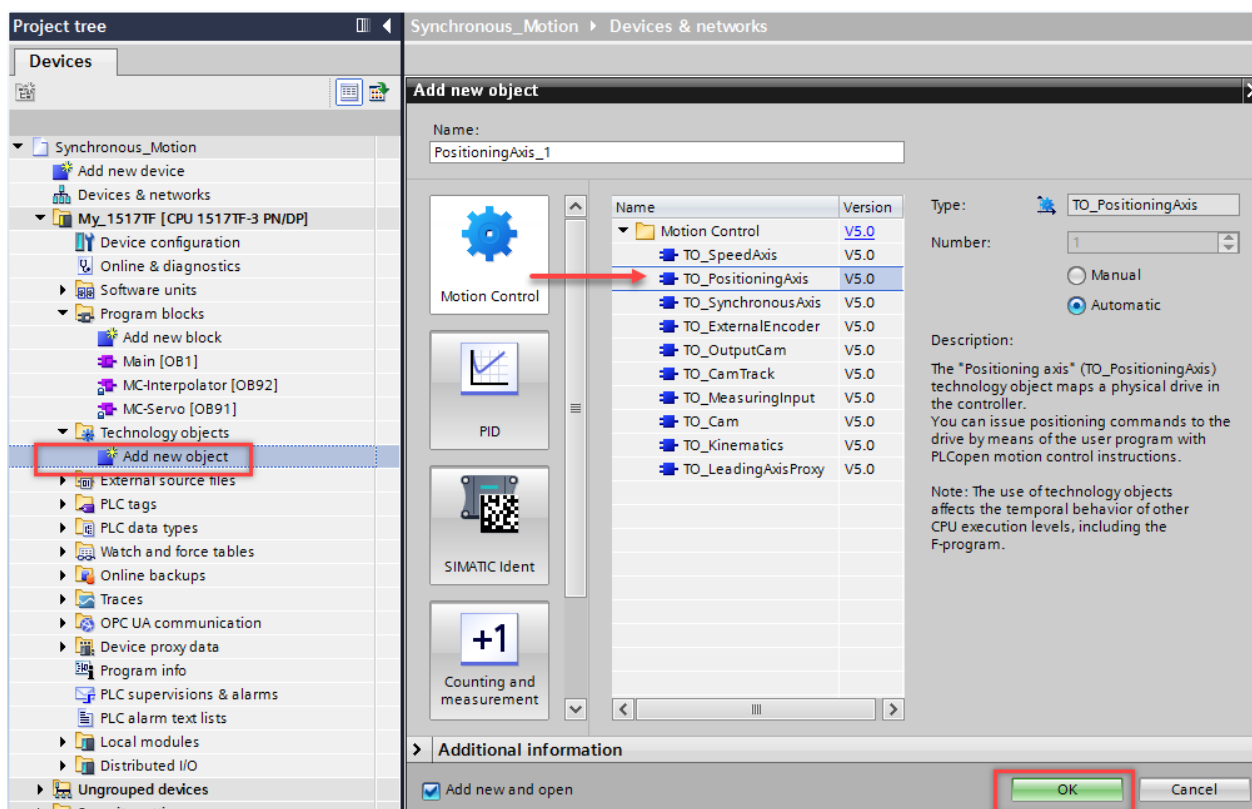
To be able to get the PLC run in IRT (isochronous real time) for motion control application it is a must to define the topology of the system. Therefore select the 'Topology View' in 'Device Configuration' and configure the topology according to the real connection of the hardware structure by drag-and-drop



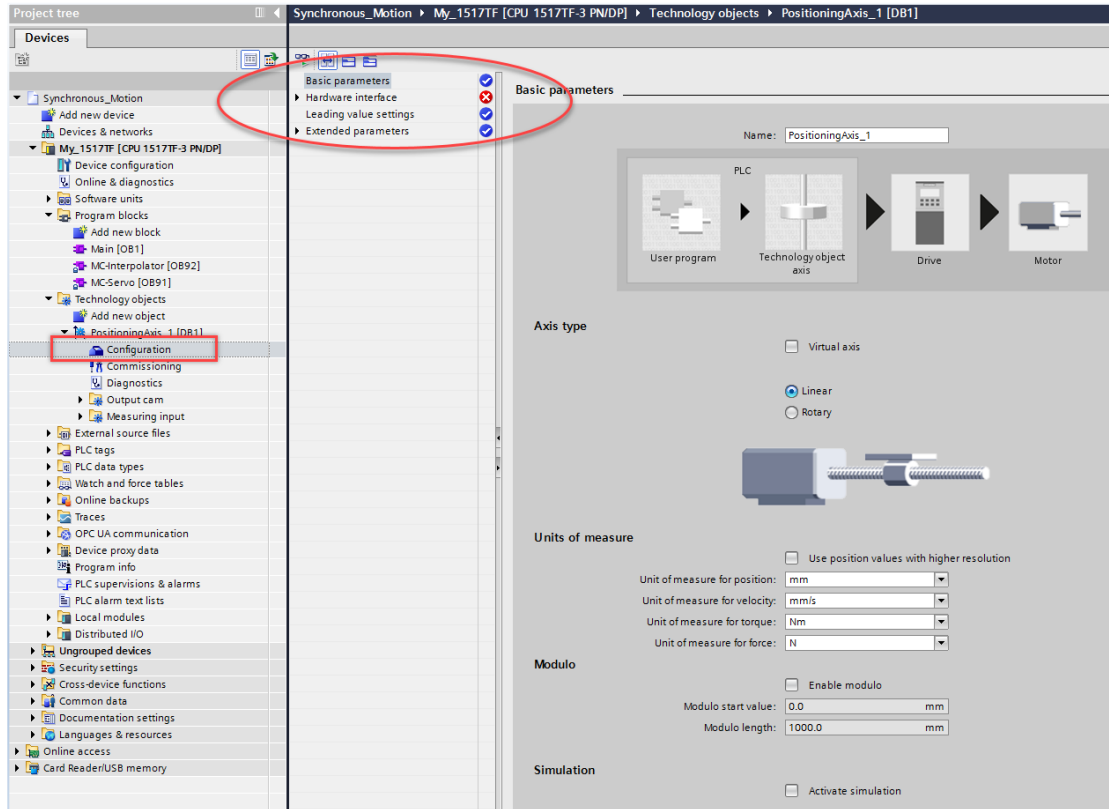
4.2 Configuring the technological object

4.2.1 Adding the technological object

Adding the technological object PositioningAxis for the Leading-Axis (Master-Axis). Go Select the folder "Technology Objects" in the project tree and click on "Add new object". Then select the technology object "TO:PositioningAxis" under motion control list and confirm via OK:



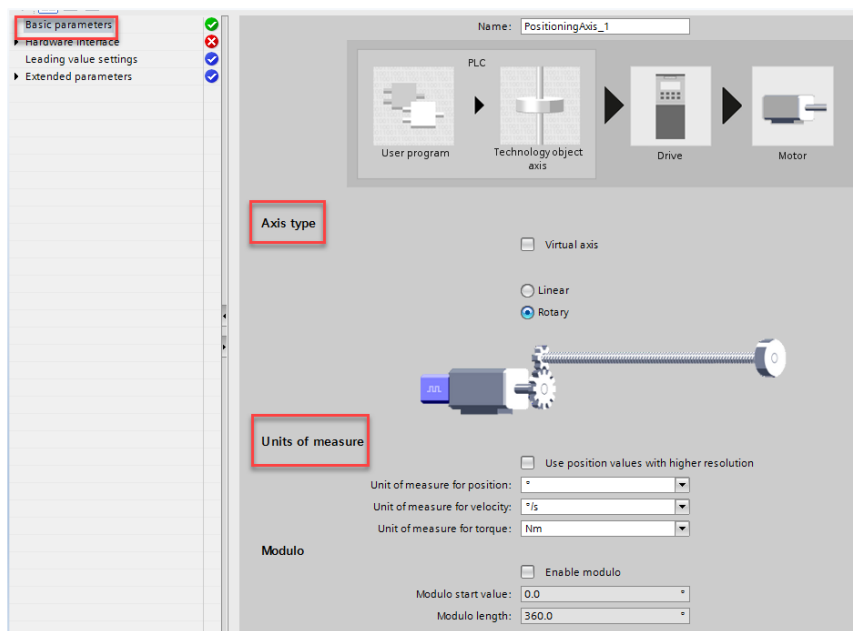
4.2.2 Starting the configuration of the technology object parameters:



Hint regarding the symbols behind parameters:

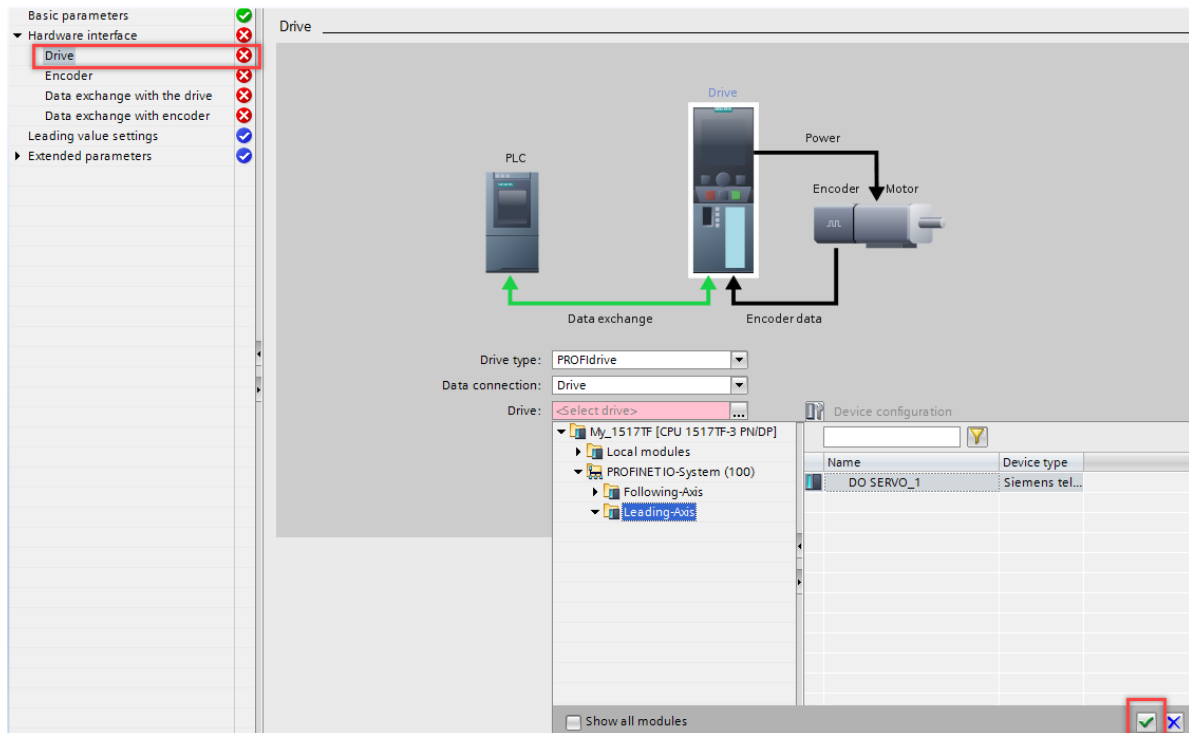
- Blue: the parameters are in default settings
- Red: the parameters must be adjusted/customized according to the application
- Green: the adjustment of the parameters were done and are OK

4.2.3 Selecting the right axis and the Units of measure:



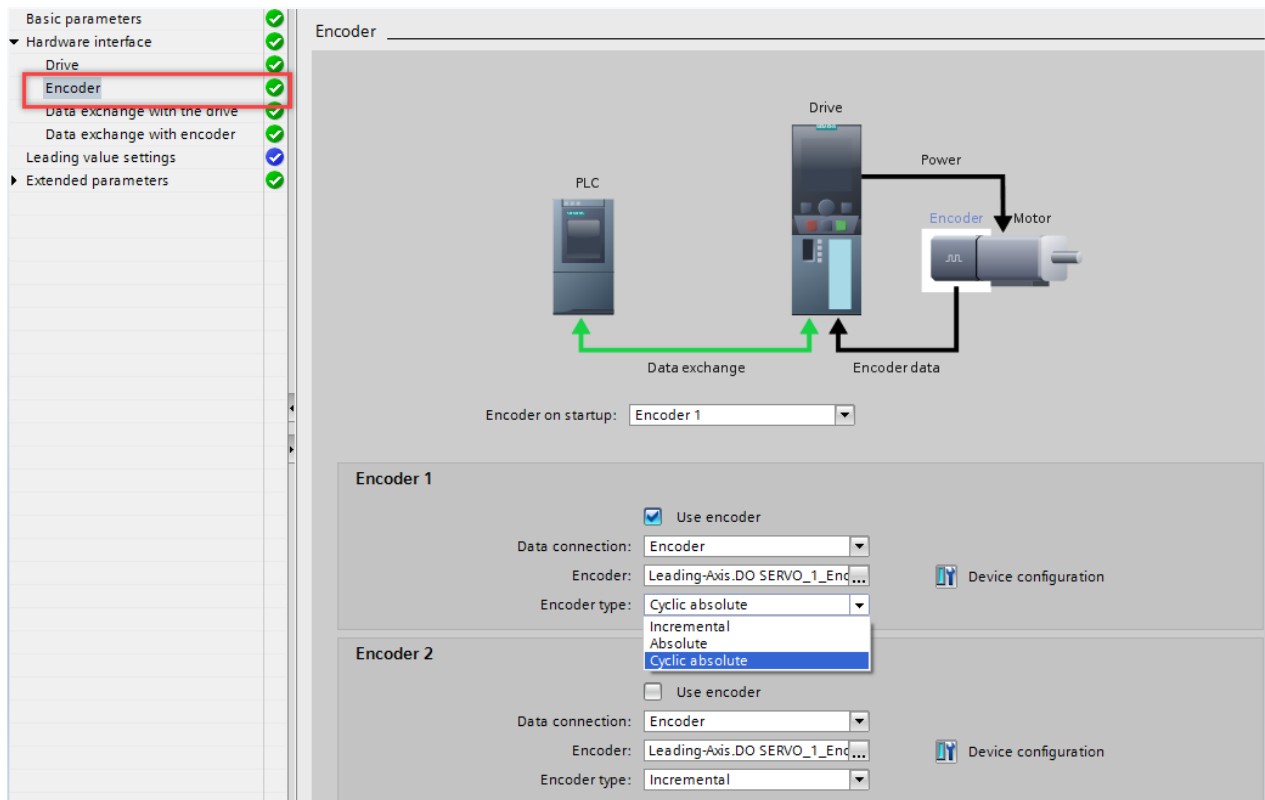
4.2.4 Define the drive for the data exchange.

In this step, it will be defined which drive is going to be assigned to the technology object that is now being configured. Select 'Drive' under Hardware interface and start with the Leading-Axis:



Select the appropriate Encoder Type:

- Incremental for Motor with Incremental Encoder
- Absolute for Motor with Absolute Single Turn Encoder
- Cyclic Absolute for Motor with Absolute Multi Turn Encoder



4.2.5 Take over the appropriate AC4 data from the Automation Suite:

Festo Automation Suite reference parameters which must be transferred to the technology object configuration:
Festo Automation Suite parameters:

Reference values		Dynamic values	
Base value velocity (user unit)	3000,00 rpm	Acceleration	3000,00 rpm/s
Base value speed (controller)	3000,00 rpm	Deceleration	3000,00 rpm/s
Base value acceleration	600,00 rpm/s	Jerk	300000,00 rpm/s ²
Base value deceleration	600,00 rpm/s		

Connection properties		AC4	
PZD telegram selection	Telegram (106)	Maximum	3000,00 rpm
Current application class	Application class 4 (4)	Maximum motor or servo drive torque	2,214 Nm
		Bus cycle time (KPC)	0,00 s
		Amplification factor Position control (without DSC)	31,99432
		Amplification factor Position control (with DSC)	31,99432
		Resolution per revolution for Gn_XIST	Resolution per revoluti
		Number of revolution	16384
		Bits in Gn_XIST1	0
		Bits in Gn_XIST2	0
		Numerator	1
		Denominator	1
		Encoder interface 1	100,00 mm/r

TIA – technology object parameters:

TIA – technology object parameters:

Do not use the two options which are offered by TIA. Because the options are not supported by the CMMT-AS-...-PN firmware yet.

Drive data

Drive telegram: Standard telegram 106

Device configuration

☐ Automatically apply drive values during configuration (offline)
☐ Automatically apply drive values at runtime (online)

Reference speed: 3000.0 1/min

Maximum speed: 3000.0 1/min

Reference torque: 2.214 Nm

The parameters of the drive must match specifications in the device configuration.

Thus the parameters must be taken from the Festo Automation Suite

- Basic parameters ✓
- ▼ Hardware interface ✓
- Drive ✓
- Encoder ✓
- Data exchange with the drive ✓
- Data exchange with encoder ✓
- Leading value settings ✓
- Extended parameters ✓

Data exchange with the drive

Drive data

Drive telegram: Standard telegram 106 Device configuration

☐ Automatically apply drive values during configuration (offline)

☐ Automatically apply drive values at runtime (online)

Reference speed: 3000.0 1/min

Maximum speed: 3000.0 1/min

Reference torque: 2.214 Nm

⚠ The parameters of the drive must match specifications in the device configuration.

Additional data

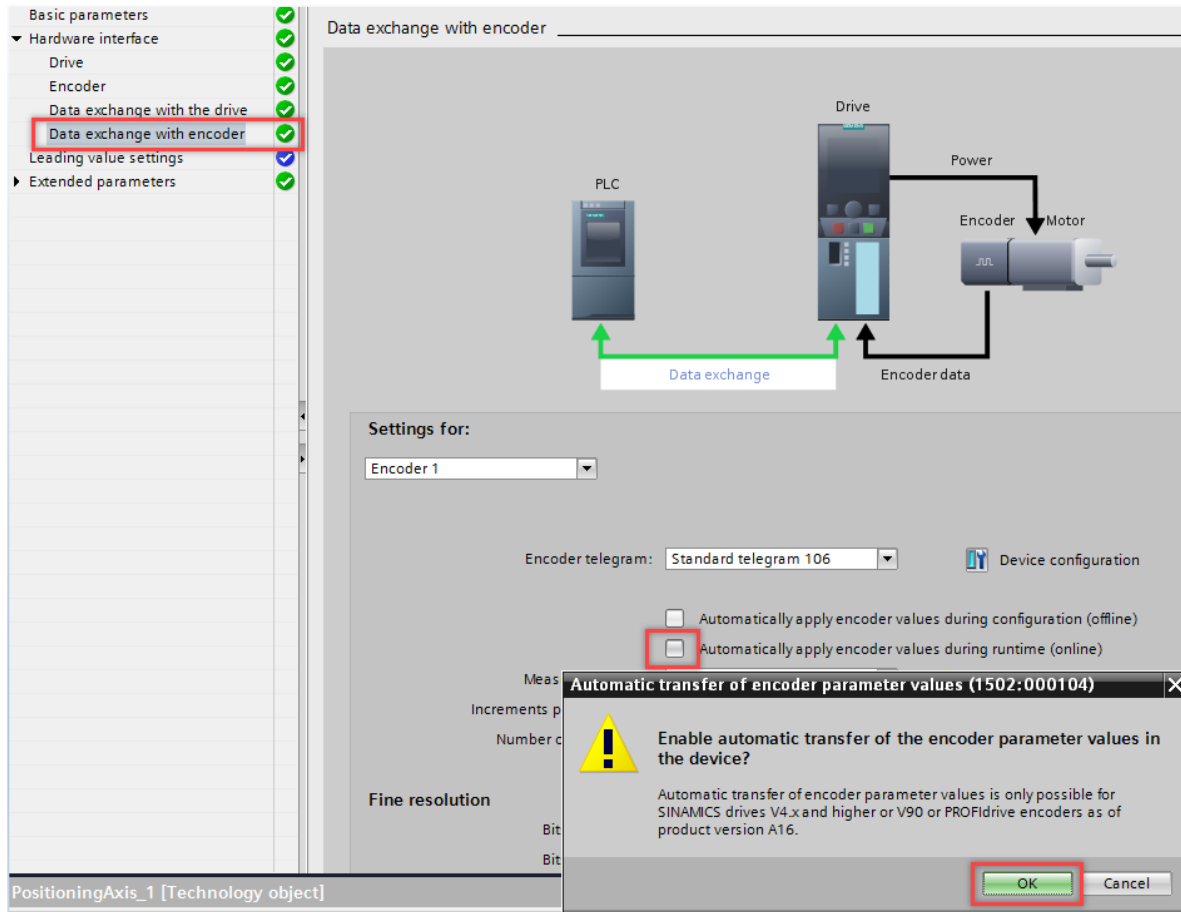
☐ Torque data

Data connection: Additional telegram

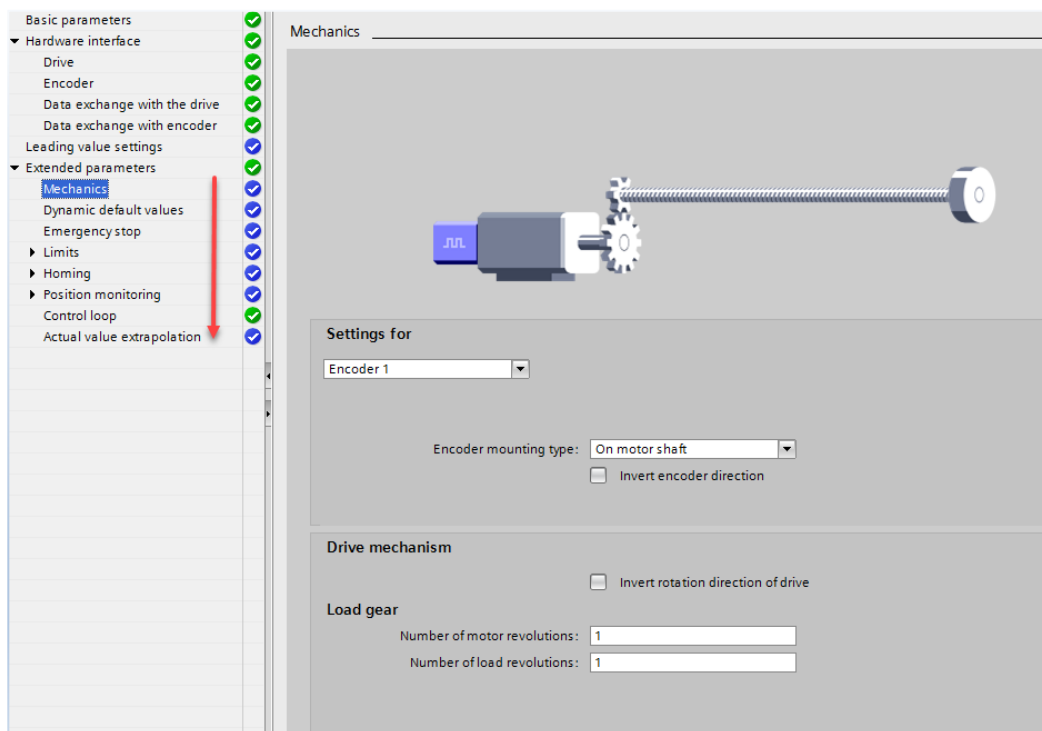
Additional telegram: <not connected>

4.2.6 The encoder data transfer

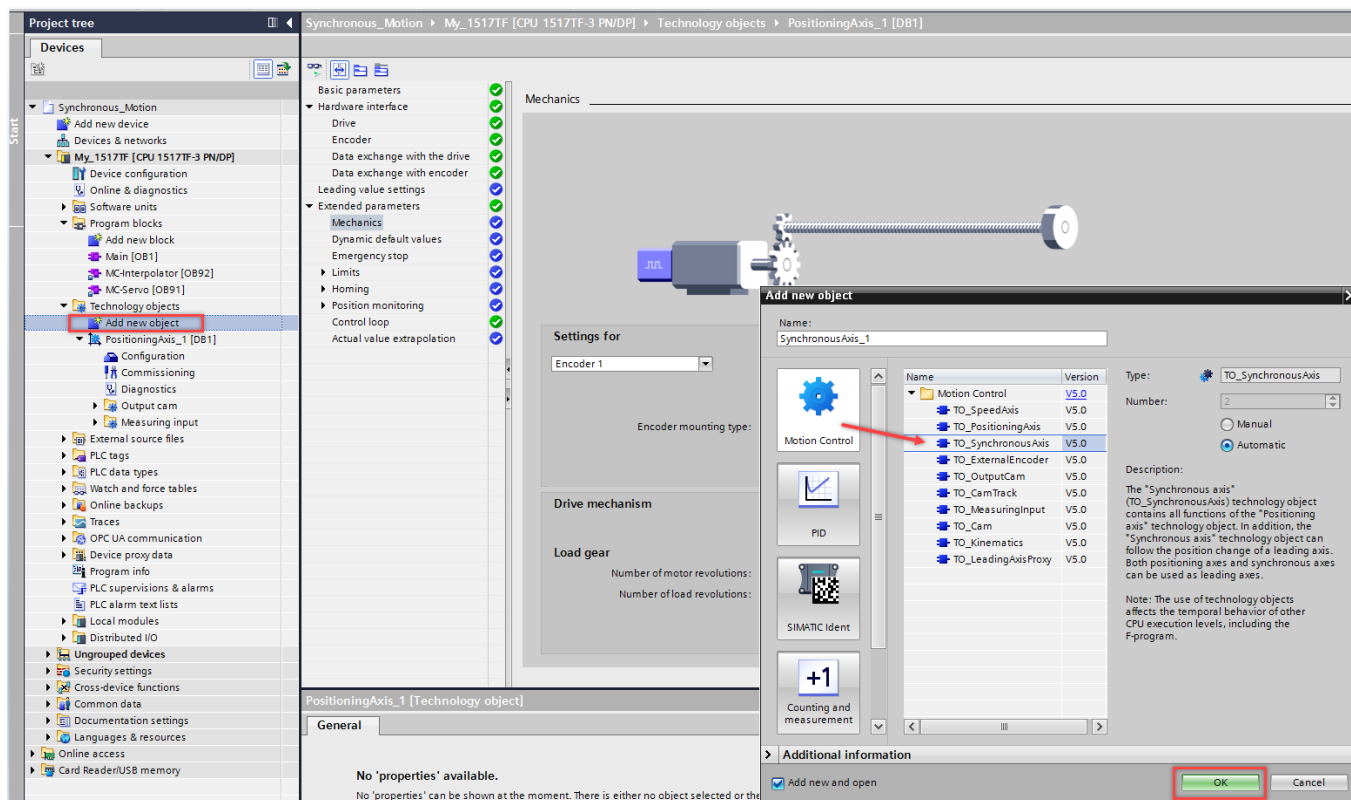
The encoder data are automatically transferred to the technology object after connecting with the drive. Flag on “Automatic data exchange for encoder values (online)”. On this step the parameters will be applied automatically. This option is supported by the firmware of the CMMT-AS...-PN:



4.2.7 Set the correct mechanics and the related settings to the axis:



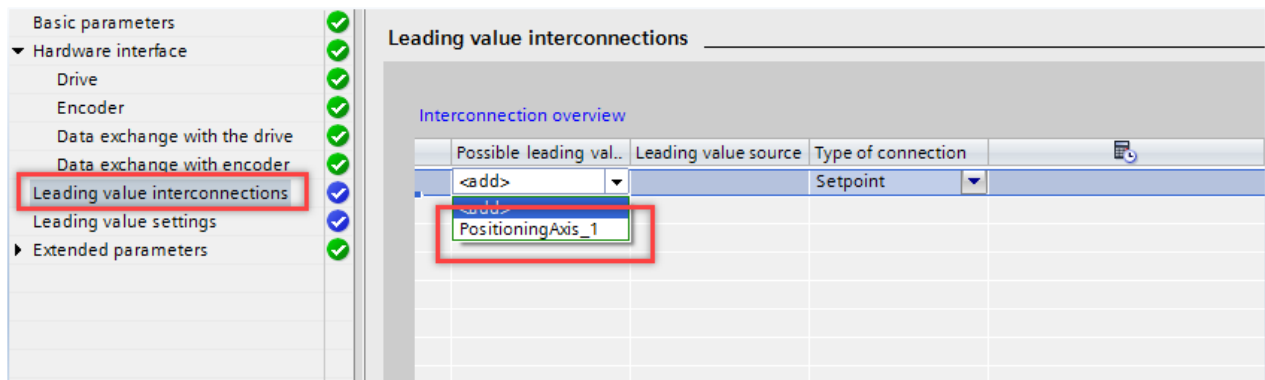
Creating the technological object TO_SynchronousAxis for the 'Following-Axis' (Slave-Axis). Select the folder 'Technology Objects' and click into 'Add new object' again. Select the technology object "TO_SynchronousAxis" under Motion Control list and confirm OK:



Proceed similarly as for the Leading-Axis to configure the Following-Axis.

Additional important setting for the Following_Axis:

Select the Leading_Axis for the "Leading value interconnection" within the settings for the 'TO_SynchronousAxis'.



Available options for the 'Type of connection':

Setpoint:

With setpoint coupling, the position setpoint of the leading axis is used as the leading value for synchronous operation.

The position setpoint of the following technology objects can be interconnected as the leading value for synchronous operation:

- Positioning axis
- Synchronous axis
- Leading axis proxy (only S7-1500T)

➔ There is only the selection "Setpoint" possible with the non-technology CPU (S7-1500).

Actual value:

For applications in which setpoint coupling is not possible (e.g. when using an external encoder) or does not make sense from a technical perspective, the S7-1500T CPU additionally offers actual value coupling for synchronous operation. With actual value coupling, the extrapolated actual position of a technology object is used as the leading value.

The actual position of the following technology objects can be used as the leading value:

- Positioning axis
- Synchronous axis
- External encoder
-

Leading value delay:

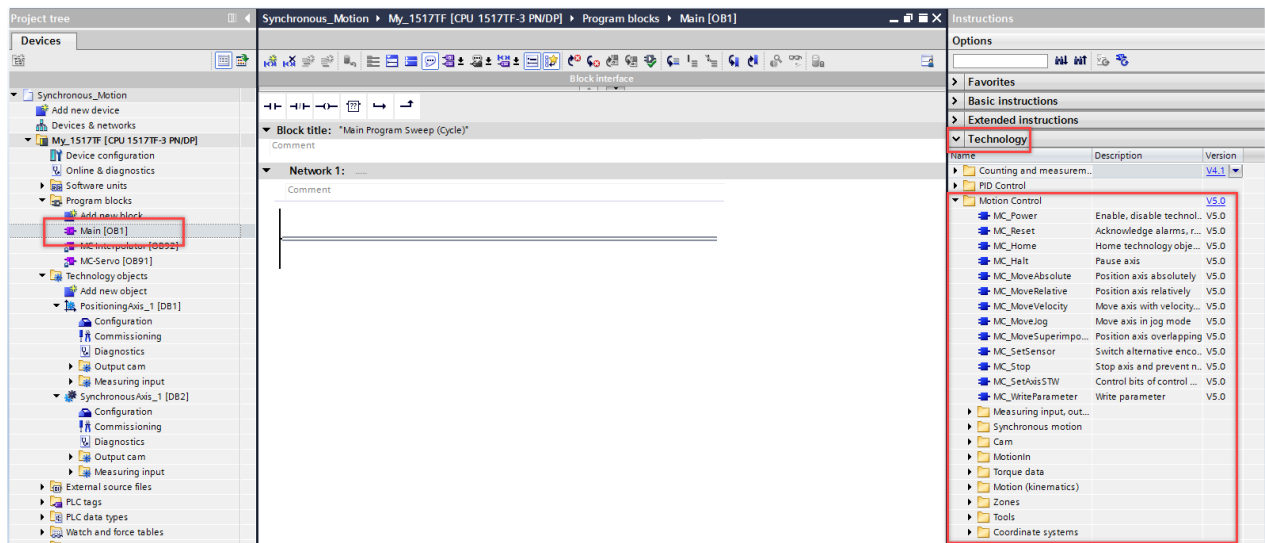
In a cross-PLC synchronous operation, you define with the "Delayed" setting whether the leading value should be delayed for a local synchronous operation.

The leading value of the following technology objects can be delayed:

- Positioning axis
- Synchronous axis
- External encoder

4.3 Creating the S7 program

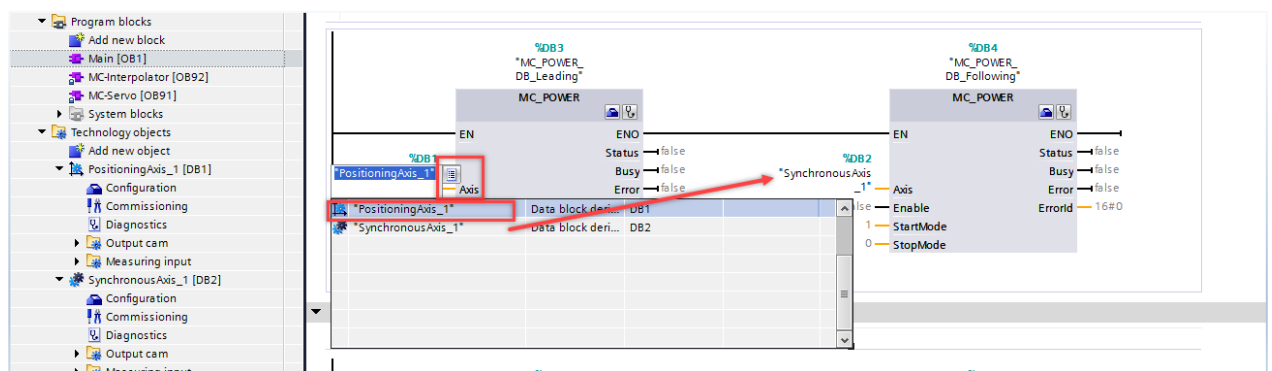
In this application note the calling of the PLC_Open function blocks will be placed in the Main [OB1] directly:



Following function blocks will be used in “Synchronous Motion” application:

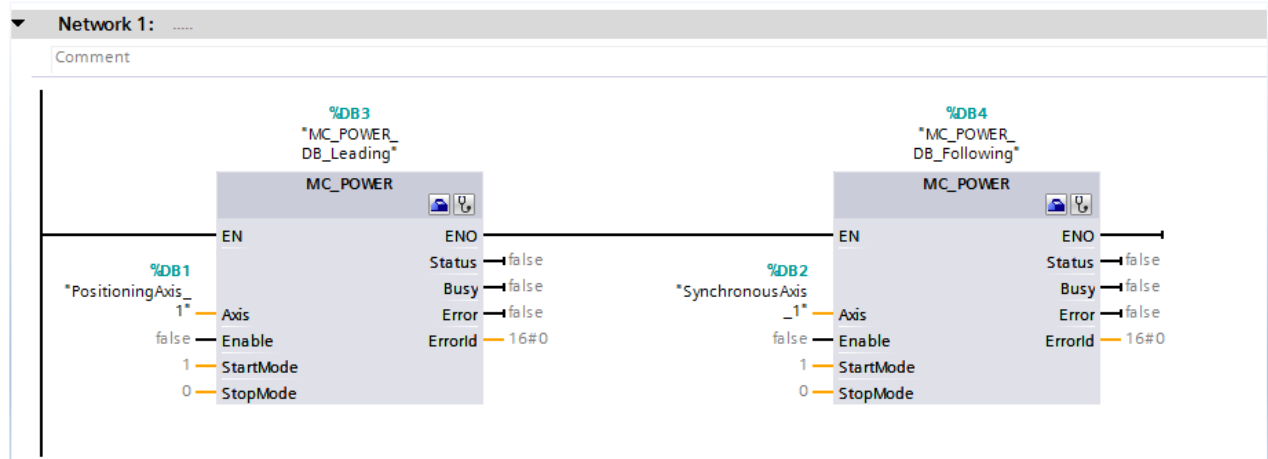
- MC_Power
- MC_Reset
- MC_Halt
- MC_Home
- MC_MoveRelative
- MC_GearIn

Insert the above listed function blocks into the Main OB via drag and drop for each axis (do not copy the FB's because of the instance DB). Then connect the technology objects to the input of the blocks:

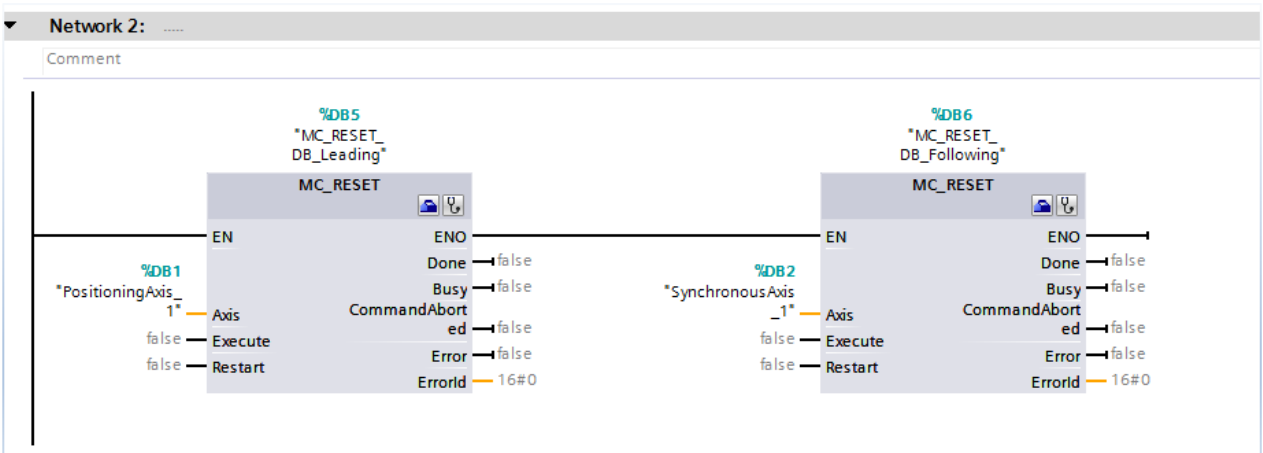


Used program blocks as follows:

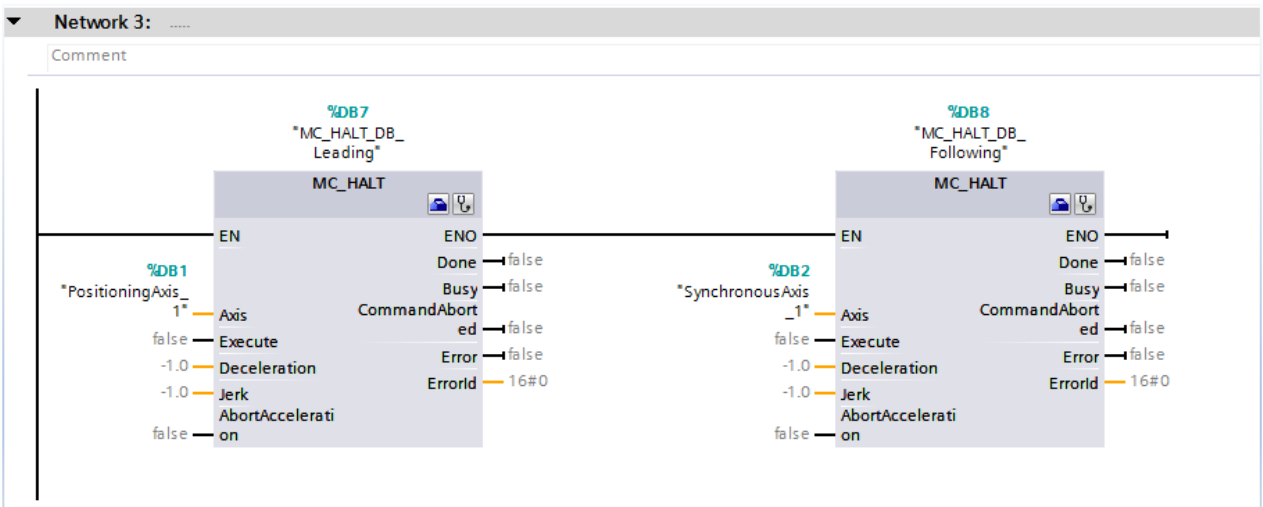
- MC_Power



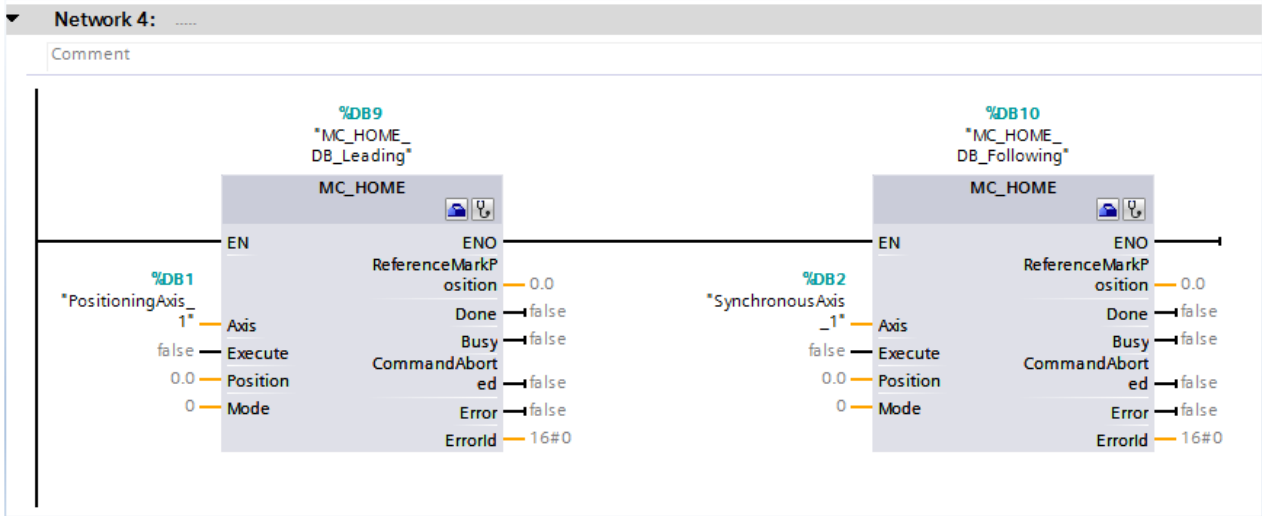
- MC_Reset



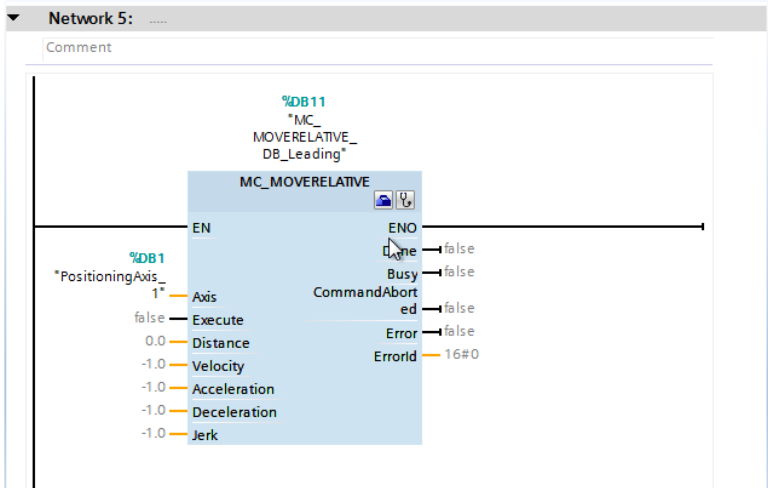
- MC_Halt



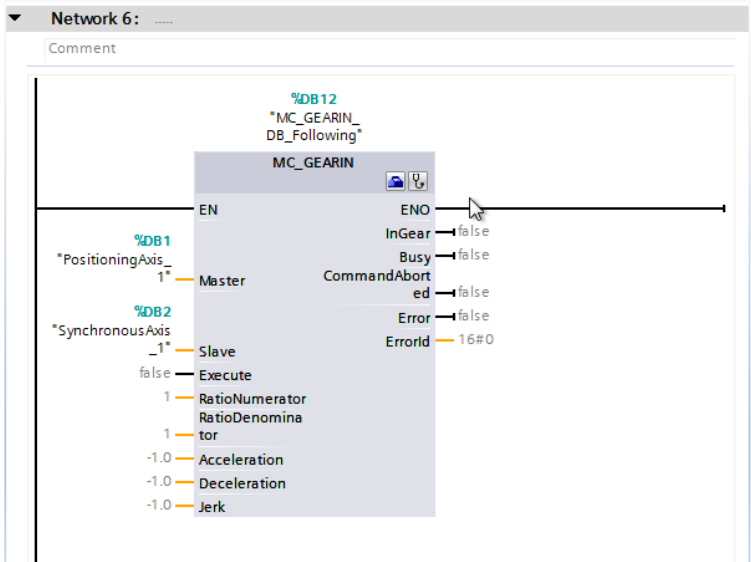
- MC_Home



- MC_MoveRelative



- MC_GearIn



Gearing with "MC_GearIn"

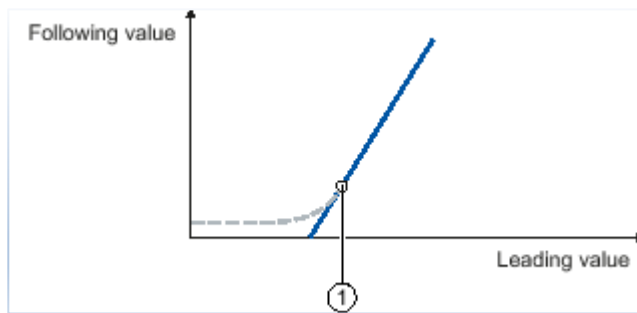
During gearing, the position of the following axis results from the position of the leading axis multiplied by the gear ratio. You specify the gear ratio as a ratio of two integers. The result is a linear synchronous operation function.

Synchronous travel with the Motion Control instruction "MC_GearIn" begins after synchronization when the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio.

Synchronous motion

When a synchronous axis is synchronized to a leading value, the "Synchronous" status is indicated by parameter "MC_GearIn.InGear" = TRUE as well as in the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object. The following axis follows the dynamics of the leading axis according to the gear ratio.

The transmission behavior during gearing is expressed by a linear relationship between the leading value and the following value.



① Position starting from which the leading and following axes move synchronously

The following value is calculated according to the following function:

Position of following axis (following value) = Position ① of following axis + gear ratio × (Position of leading axis - Position ① of leading axis)

Direction

The numerator of the gear ratio is specified as positive or negative. This yields the following behavior:

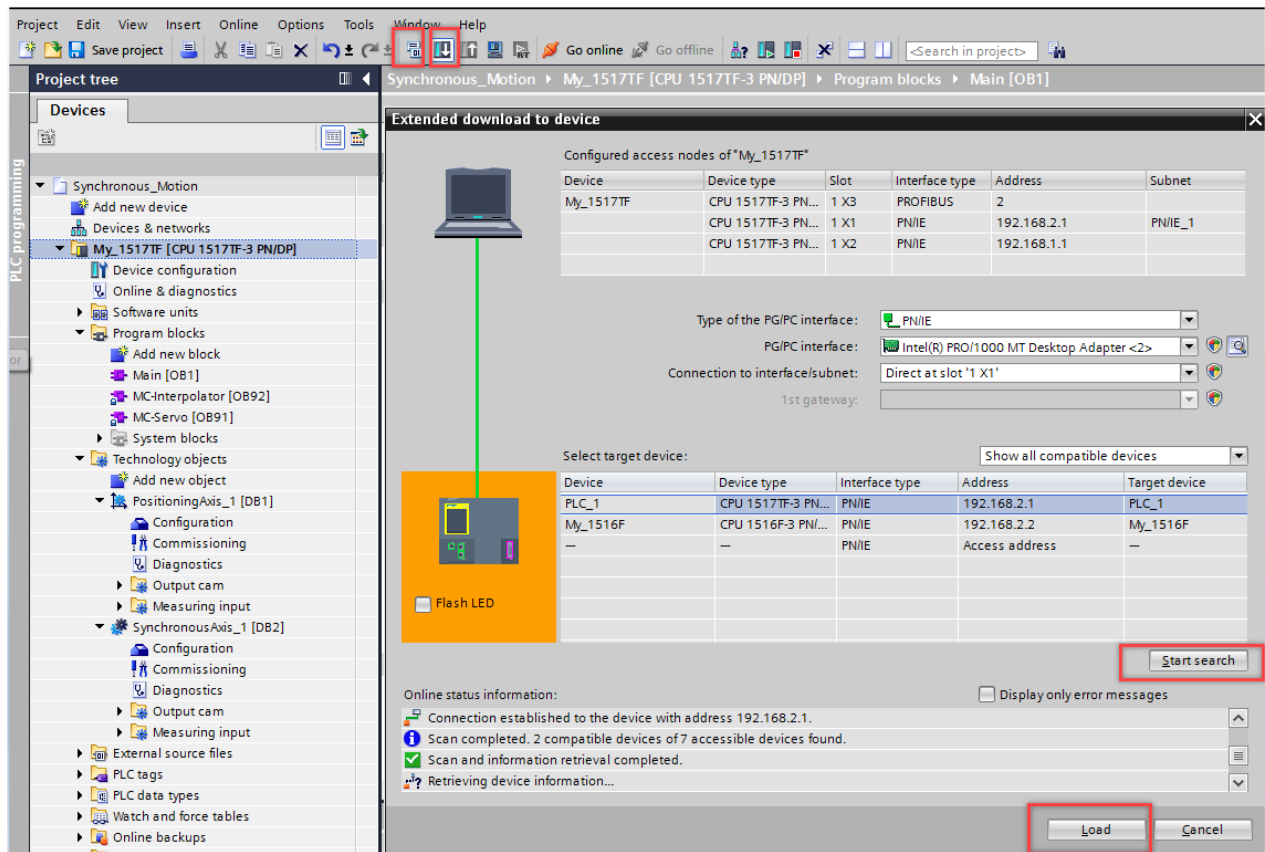
- Positive gear ratio:
The leading and following axes move in the same direction.
- Negative gear ratio:
The following axis moves in the opposite direction to the leading axis.

Explanation regarding the default value [-1.0] on the function block inputs:

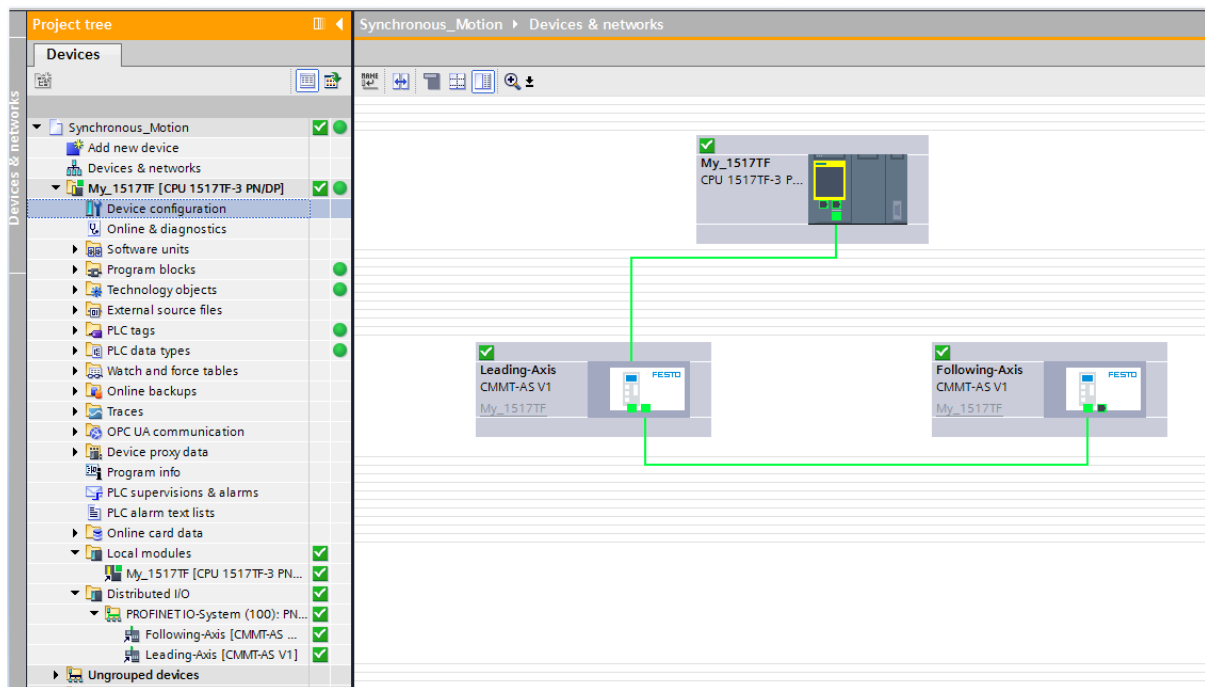
When using the default value on the dynamic parameters, then the parameter values from the configuration of the technology object are present.

MC_MoveRelative: Position axis relatively V5						
Parameter	Declaration	Data type	Default value	Description		
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object		
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge	
Distance	INPUT	LREAL	0.0	Distance for the positioning process (negative or positive)		
Velocity	INPUT	LREAL	-1.0	Velocity setpoint for the positioning		
				> 0.0	The specified value is used.	
				= 0.0	Not permitted	
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)	
Acceleration	INPUT	LREAL	-1.0	Acceleration		
				> 0.0	The specified value is used.	
				= 0.0	Not permitted	
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)	
Deceleration	INPUT	LREAL	-1.0	Deceleration		
				> 0.0	The specified value is used.	
				= 0.0	Not permitted	
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)	
Jerk	INPUT	LREAL	-1.0	Jerk		
				> 0.0	Constant acceleration velocity profile The specified value is used.	
				= 0.0	Trapezoid velocity profile	
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)	
Done	OUTPUT	BOOL	FALSE	TRUE	The target position has been reached. The minimum dwell time has expired (<TO>.PositioningMonitoring.MinDwellTime).	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.	
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.	

4.4 Compile and download the program:



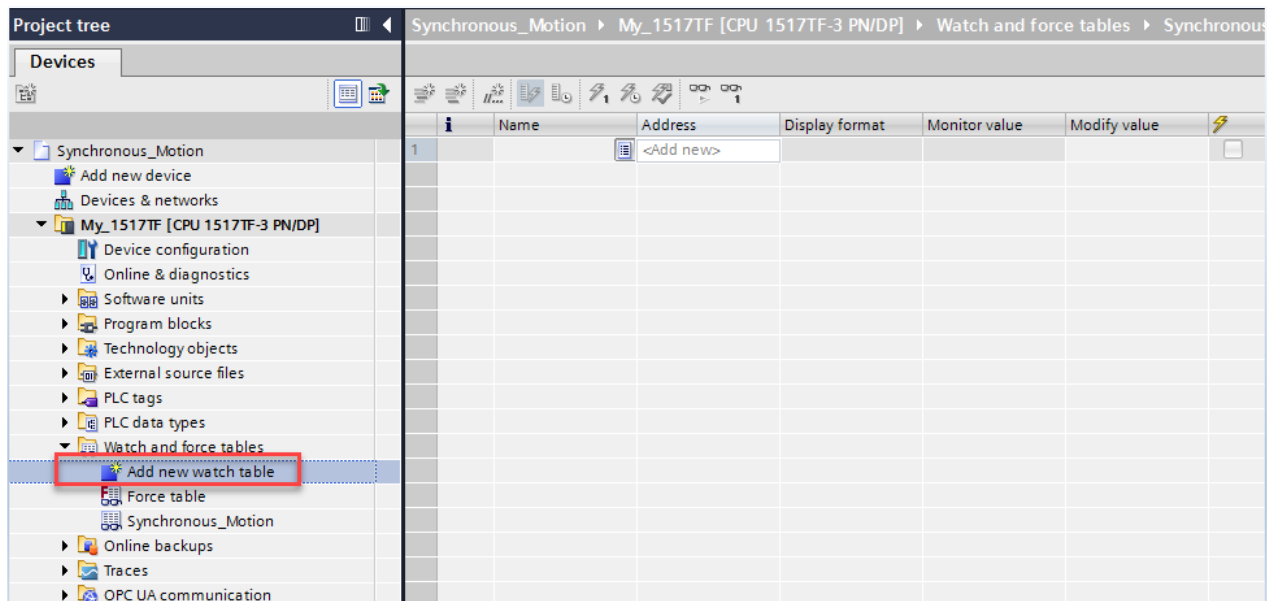
Make sure the PROFINET Network is up and running by checking if all is green and with checkmarks:



4.5 Use the blocks with a “Watch Table”

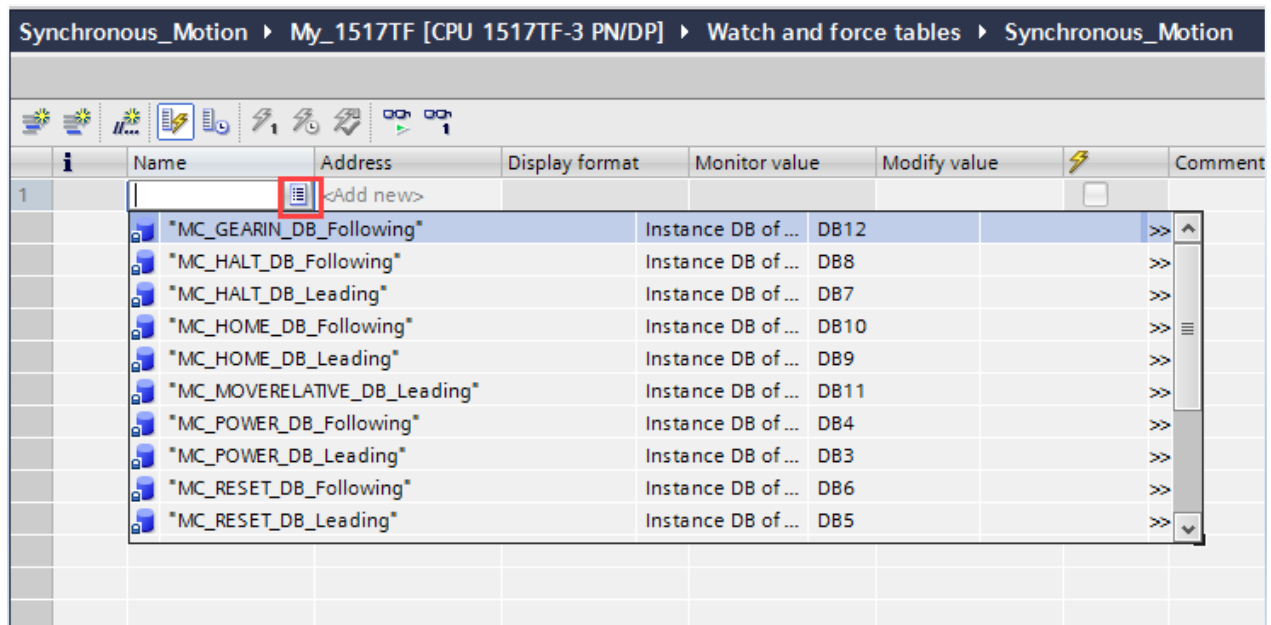
Add and fill Watch Table

Go to the folder “Watch and force tables” under the “Project tree” and double click on ‘Add new watch table’:

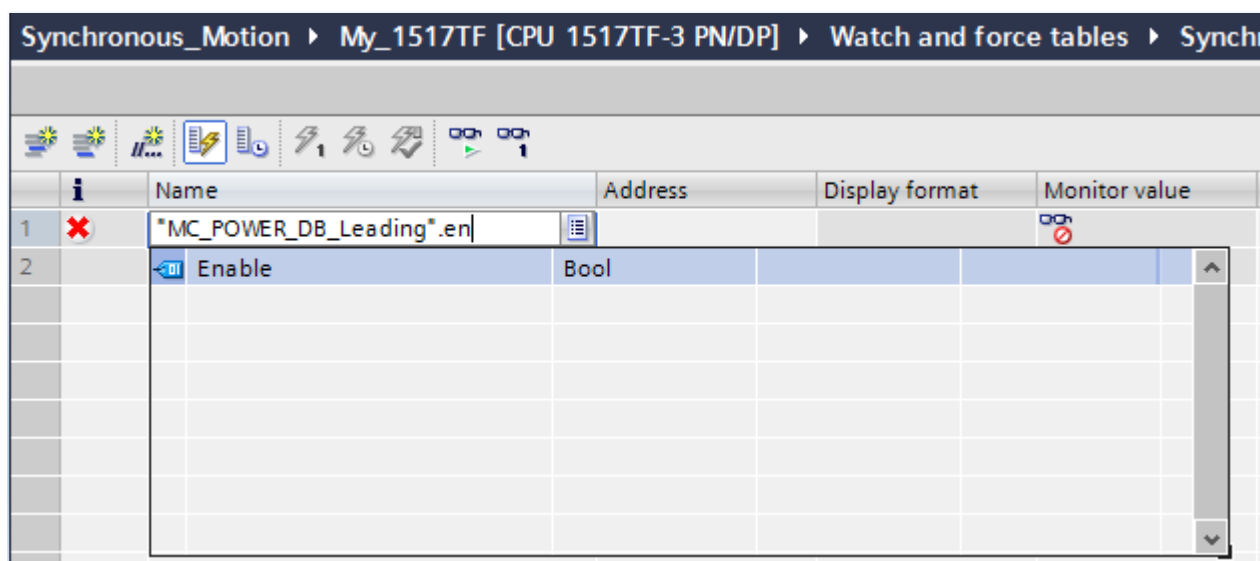


New Watchlist renamed to Synchronous Motion

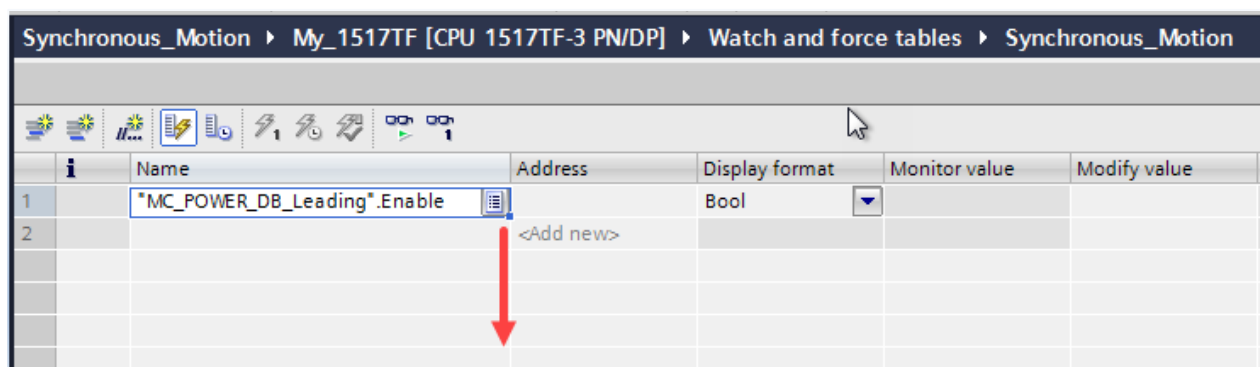
Select the symbol within the empty row and the available function blocks will be listed:



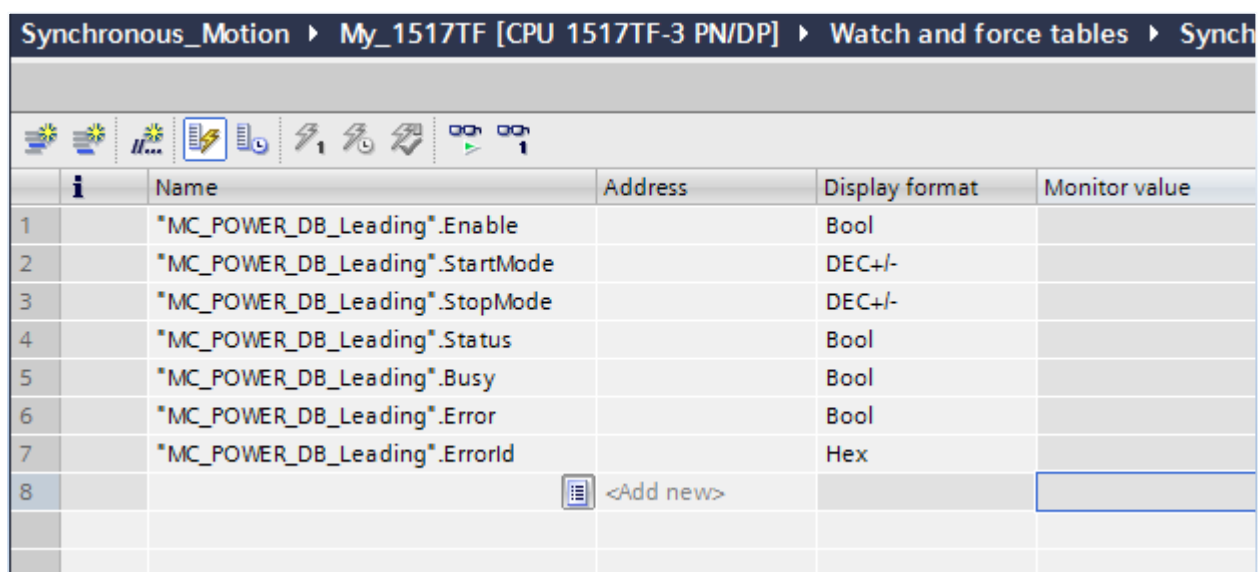
Start with the first function block within the created sequence program in Main OB and start to type the first input (for the MC_Power it is the Enable bit) select the bit and press “Enter” key:



Take your mouse over the little square within the row on the right bottom side and drag it for the amount of the variables within the function block (7 variables for the MC_Power):



And the result will be as following:



Do the same for all the other function blocks

5 Procedure to start the Synchronous Motion

1. Power-on the drives via the MC_Power
2. Perform a homing via the MC_Home (then the TO's will be homed thus the position will be reset and the homed position will be saved permanently within the TO).
When as user the position should be reset on the CMMT-AS side also then do a homing via the FAS to get the same start condition regarding the actual position.
3. When the Following-Axis should be synchronised directly with the Leading-Axis then activate the Following-Axis via the Execute input on the FB "MC_GearIn" before starting the Leading-Axis.

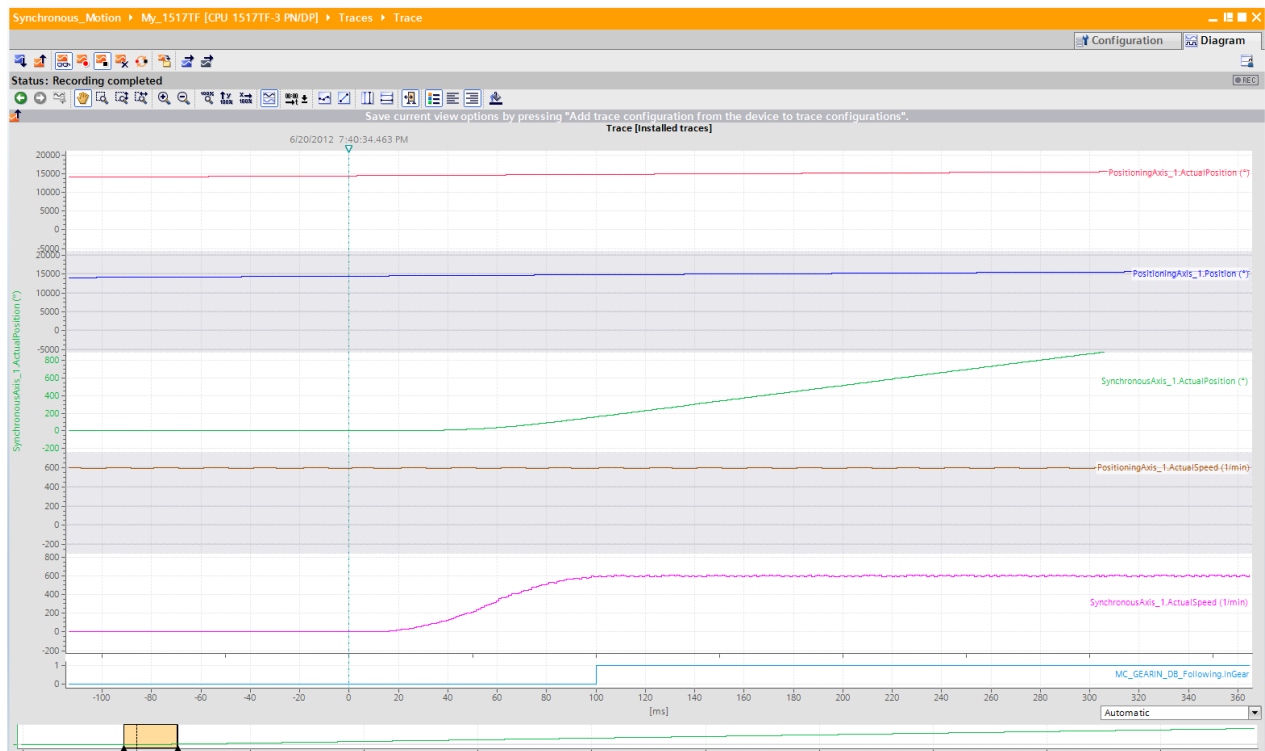
Otherwise the Following-Axis can be started at any time to synchronise on the Leading-Axis.

➔ Following-Axis is ready to start to synchronise to the Leading-Axis.

4. Start the Leading-Axis via the MC_MoveRelative.

6 Trace in TIA of the Synchronous Motion

Following-Axis started after the Leading-Axis was in motion already



- 6.2 Following-Axis was started before the Leading-Axis was in motion. Thus a synchronised start of both drives was visible:

