

TwinCAT 3 Motion



Manual

NC PTP: Quick Starting Guide

TwinCAT 3

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BECKHOFF

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1 Foreword

1.1 Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:

EP1590927, EP1789857, DE102004044764, DE102007017835

with corresponding applications or registrations in various other countries.

The TwinCAT Technology is covered, including but not limited to the following patent applications and patents:

EP0851348, US6167425 with corresponding applications or registrations in various other countries.

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1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability






All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

 DANGER	<p>Serious risk of injury! Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.</p>
 WARNING	<p>Risk of injury! Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.</p>
 CAUTION	<p>Personal injuries! Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.</p>
 Attention	<p>Damage to the environment or devices Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.</p>
 Note	<p>Tip or pointer This symbol indicates information that contributes to better understanding.</p>

2 TF5000 | TC3 NC PTP 10 Axes TF5010 | TC3 NC PTP Axes Pack 25 TF5020 | TC3 NC PTP Axes Pack unlimited



TwinCAT Motion Control PTP implements Motion Control for point-to-point movements in software. The axes are represented by axis objects and provide a cyclic interface, e.g. for the PLC. This axis object is then linked to a corresponding physical axis. In this way, the most diverse axis types with the most diverse fieldbus interfaces can be connected abstractly with the axis objects, which always offer an identical configuration interface. The control of the axes can be configured in various conformations (position or velocity interface) and various controllers. The axes are configured in TwinCAT Engineering.

- TF5000: Up to 10 axes on a maximum of 255 axes included developable
TF5010: Extension of TC3 NC PTP 10 up to a maximum of 25 axes
TF5020: Extension of TC3 NC PTP 10 up to a maximum of 255 axes
- supports electrical and hydraulic servo drives, frequency converter drives, stepper motor drives, DC drives, switched drives (fast/slow axes), simulation axes and encoder axes
- supports various encoders such as incremental encoder, absolute encoder, digital interface to the drives such as EtherCAT, SERCOS, SSI, Lightbus, PROFIBUS DP/MC, pulse train
- standard axis functions such as start/stop/reset/reference, velocity override, master/slave couplings, electronic gearbox, online distance compensation
- programming is carried out via PLCopen-compliant IEC 61131-3 function blocks
- convenient axis commissioning options
- online monitoring of all axis state variables such as actual/setpoint values, releases, control values, online axis tuning
- forcing of axis variables
- configuration of all axis parameters, such as measuring system, drive parameters and position controller
- configurable controller structures: P control, PID control, PID with velocity pre-control, PID with velocity and acceleration pre-control
- online master/slave and slave/master conversion
- flying saw (diagonal saw)
- cam plates (support by TC3 Cam Design Editor [optional])
- FIFO axes (optional)
- external set point value generators
- multi-master coupling

Motion Configuration

Motion Configuration

NC PTP FunctionsNC PTP Functions

PLC LibrariesPLC Libraries

3 Quick Starting Guide

Within this Section

In section Quick Starting Guide we show you ...

- ... in the exemplification of communicating via EtherCAT how you insert a motion controller and a motor into the IO configuration, ...
- ... how to create a PLC axis variable, ...
- ... how to link a motion controller and a PLC axis variable with an NC-axis, ...
- ... how to create a simulation axis.

We show you, ...

- ... how to move an axis manually, ...
- ... a small PLC example program for controlling an axis, ...
- ... a record with TwinCAT 3 Scope for our small PLC example program.

3.1 NC-Axes within the MOTION-Subtree

Within this Section

In section “NC-Axes within the MOTION-Subtree” you learn, ...

- ... where you find NC-axes within the MOTION-subtree, ...
- ... where you can do settings for NC-axes.

Numerical Control

The abbreviation NC stands for

- Numerical Control.
- An NC-axis creates an image of a servo axis in software.

For creating this image of hardware in software you can join

- NC-axes

with

- PLC axis variables

and

- servo controllers within an IO configuration

within the framework of an NC configuration.

If you do not find a servo controller available within an IO configuration, you can set up

- a simulation axis.

In section

- [Simulation Axis \[► 11\]](#)

you learn more on setting up a simulation axis.

Subtree for NC-Axes: Structure

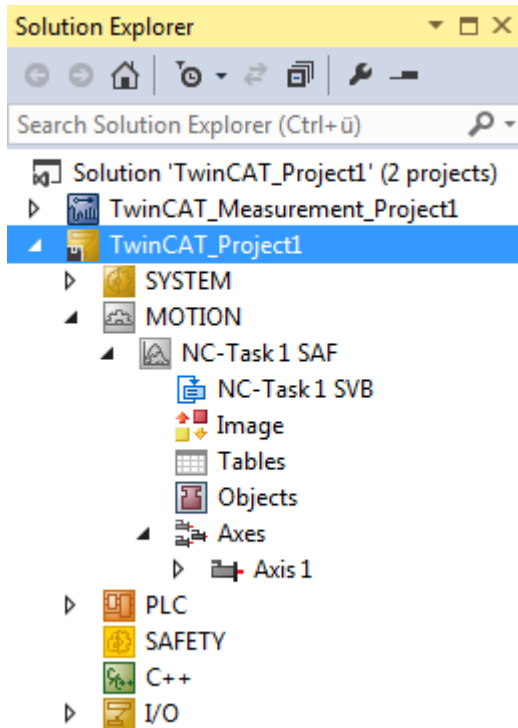
Further Informations

You can find further informations for inserting an NC-axis in section

- [Inserting an NC Configuration \[► 19\]](#).

Open the

- Solution Explorer.
- If an NC configuration has been added, the MOTION-subtree contains an SAF-Task-Subtree.
- The SAF-Task-Subtree contains an Axes-subtree.



- NC-Task 1 SAF
- In German: SAF-Task. That means Block Execution Task.
 - Task in that setpoint generation is done.
 - Task that feeds the fieldbus IO of NC.

- NC-Task 1 SVB
- In German: SVB-Task. That means Block Preparation Task.
 - Linking and Look-Ahead of NCI segments.
 - Without impact on single axis movements (PTP).
 - Does not feed fieldbus IO of NC.

- Image
- NC process image.

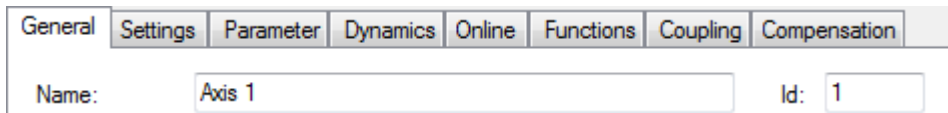
- Tables
- Tables.
 - E.g. for Cam Plates.

- Objects
- Further TCom objects for e.g. TF5400 Advanced Motion Pack.

- Axes
- NC-axis configuration.
 - Is drawn up automatically.
 - Double-clicking opens an online dialog.
 - If the TwinCAT-System has been started with the current configuration:
This online dialog shows the most important current setpoint values and actual values of NC-axes that have been configured under this configuration.

Tabs for an NC-Axis

A double click on the NC-axis “Axis 1” opens the choice for the tabs shown in the figure below.



3.2 Simulation Axis

Within this Section

In section Simulation Axis you learn ...

- ... how to set up an NC-axis as a simulation axis.

Further Informations

In section

- [PLCopen \[▶ 31\]](#)

you can find further informations

- on setting up a PLC axis variable.

In section

- [Inserting an NC Configuration \[▶ 19\]](#)

you can find further informations

- on inserting an NC-axis.

In section

- [Button “Link To PLC...” \[▶ 23\]](#)

you can find further informations

- on connecting an NC-axis with a PLC axis variable.

Simulation Axis

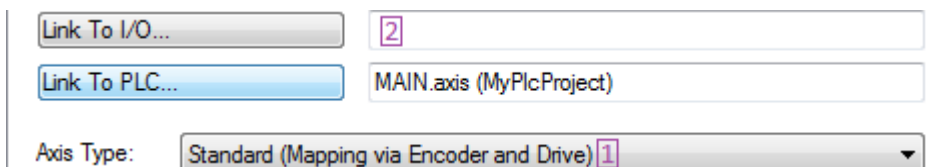
You can configure an NC-axis as a simulation axis.

- A simulation axis is not connected with motor hardware. Thus, it is not connected via the IO configuration.

Axis Type

Settings-Dialog:

Settings for an NC-simulation-axis that is joined with the PLC axis variable `axis` in program `MAIN`:



[1] Select this entry.

[2] Stays empty.


Setting Up a Simulation Axis

1. Select within the Axes-subtree the NC-axis that you want to set up as a simulation axis.
2. Open the Settings-dialog for this NC-axis.
3. Select entry Standard (Mapping via Encoder and Drive) [1] within the DropDown box Axis Type.
4. For a simulation axis the entry Link To I/O... [2] stays empty.

⇒ You have the NC-axis selected in the Axes-subtree configured as a simulation axis.


3.3 IO Configuration

Within this Section

 Note	<p>Simulation</p> <p>When you work in simulation without motor hardware, you can skip section IO Configuration and continue reading in section NC Configuration [▶ 19].</p>
--	--

In section IO Configuration you learn, ...

- ... how to automatically insert a servo controller into the IO Configuration by carrying out a Scan, ...
- ... how to set up an NC Task and NC-Axes belonging to this task automatically for inserted servo controllers, ...
- ... how to alternatively insert a servo controller into the IO Configuration manually.

 Note	<p>Hardware connected?</p> <p>For automatically detecting hardware successfully this hardware has to be connected to the target system.</p>
---	--

3.3.1 Detecting Servo Amplifiers Automatically

Scan


We explain a Scan of the IO Configuration employing


- EtherCAT

and a connected

- servo amplifier of the AX5000 series

as an example.

 Note	<p>CONFIG Mode</p> <p>For an IO Configuration Scan the target system has to reside in CONFIG Mode.</p>
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 Note	<p>Third Party Products</p> <p>Generally, an IO Configuration Scan works for third party products, too, but not without exception.</p>
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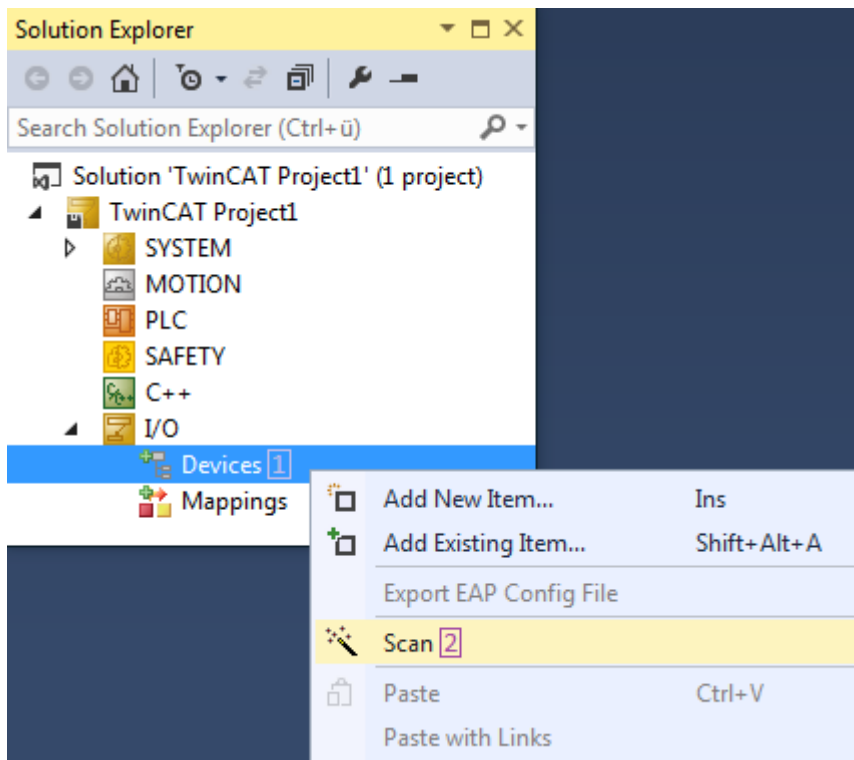
Further Informations

Following

- [TwinCAT 3 Engineering](http://infosys.beckhoff.com/content/1033/tc3_engineering_overview/html/tc3_engineering_intro.htm) or
http://infosys.beckhoff.com/content/1033/tc3_engineering_overview/html/tc3_engineering_intro.htm

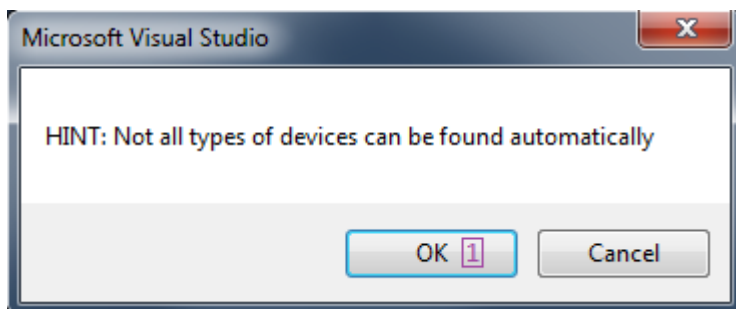
you can find further informations on automatically finding IO subscribers using the Scan function.

Starting the Scan



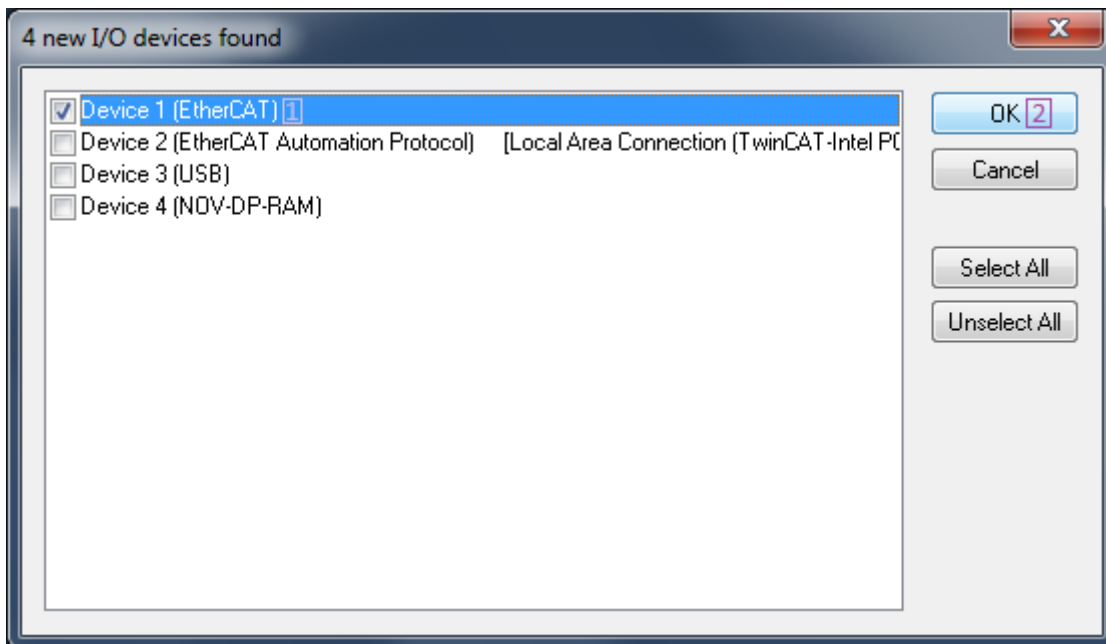
- ✓ Within the IO tree there is the entry Devices [1].
 1. Right-click on the entry Devices [1].
 - ⇒ A context menu opens.
 2. Choose the entry Scan [2].
 - ⇒ The automatic reading in of the device configuration begins.
 - ⇒ A message box opens. It notes that not all device types can be detected automatically.

Not All Device Types ...



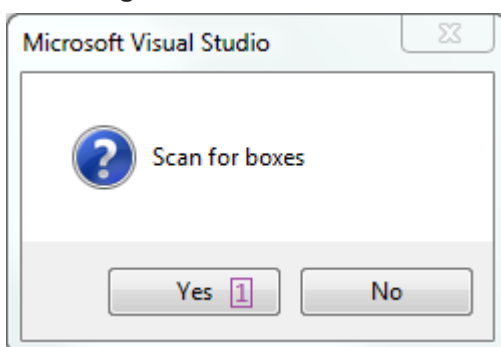
- ✓ A message box is open. It notes that not all device types can be detected automatically.
 1. Confirm this note by pressing the OK [1] button.
 - ⇒ A dialog opens. It displays those IO devices that have been found.

Selecting IO Devices



- ✓ A dialog shows those IO devices that have been found.
- ✓ An IO device can be selected with a checkbox.
 1. If it has not been selected yet, select that IO device using checkbox [1] for that you want to configure a servo controller.
 2. If they have not been deselected yet, deselect those IO devices using checkboxes for that you do not want to configure a servo controller.
 3. Press the OK [2] button to confirm your settings.
- ⇒ The device for that you want to configure a servo controller will be enlisted within the IO tree as child element of the node Devices.
- ⇒ A message box opens that asks whether you want to search for further boxes.

Searching for New Boxes



- ✓ A message box is opened asking whether you want to search for new boxes. Boxes like that may be e.g. IO terminals or servo amplifiers.
 1. Press the Yes [1] button of this asking message box.
- ⇒ IO devices found will be added.
- ⇒ A dialog opens that tells you that servo amplifiers have been found. You will be asked whether servo amplifiers shall be scanned for connected motors.

Scanning Motors

This automatic function corresponds to inserting a servo amplifier into the IO configuration manually as described in section

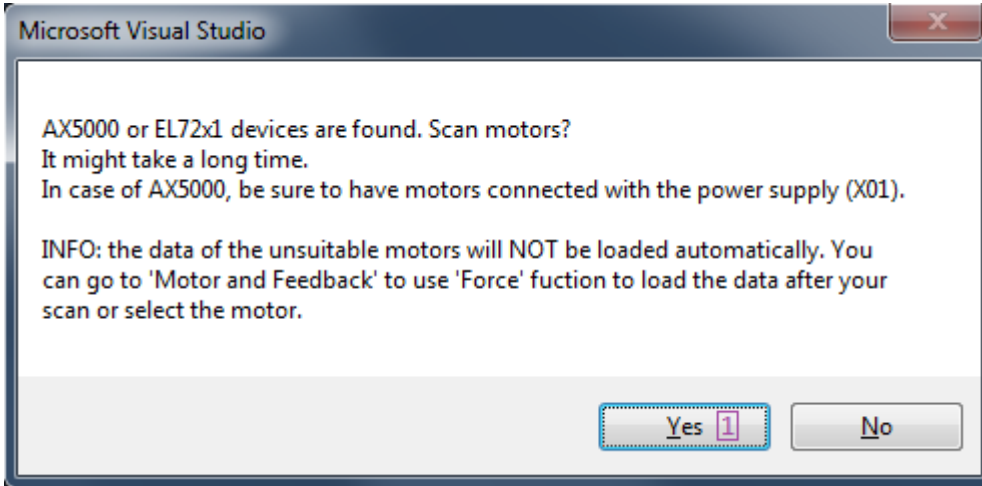
- [Inserting Servo Amplifiers Manually](#) [▶ 17].



Note

Beckhoff Motors with Digital Model Plate

- Detecting motors automatically is only possible for motors from the Beckhoff company with a digital model plate, i.e. for motors that have an encoder.
- If it is not possible to detect a motor automatically, parameters of a motor can be set within the TwinCAT Drive Manager manually.
Setting motor parameters manually may be important for diagnostic purposes, too.



- ✓ A dialog asks you whether motors shall be scanned.
 1. Answer this question pressing the Yes [1] button.
- ⇒ Motors that have been found will be added to the configuration within the IO tree.
- ⇒ A dialog opens that asks whether the motor added to the IO configuration shall be added to the NC configuration and shall be linked to the NC configuration.
- ⇒ If the option NC-Configuration has been chosen and confirmed, the corresponding logical axes for setpoint generation are created and linked automatically.
- ⇒ The Scan has been done for the selected devices of connected hardware and is finished yet. Finally, for the selected devices of connected hardware a configuration within the IO tree has been set up.

Servo Amplifier: Further Informations

Following

- [AX5000 System Manual HW2 - Version 2.0](http://infosys.beckhoff.com/content/1033/ax5000_system_doku_hw2/index.html) or http://infosys.beckhoff.com/content/1033/ax5000_system_doku_hw2/index.html

you can find further informations on servo amplifiers of the AX5000 series.

Following

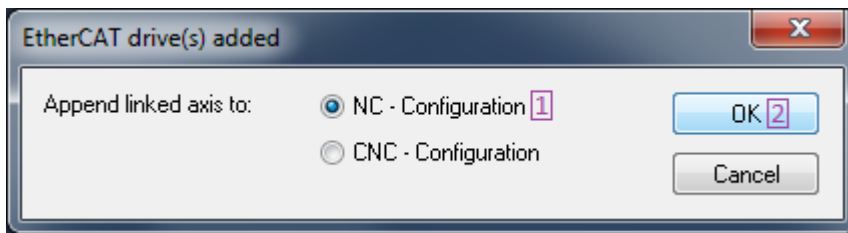
- [AX5000 TwinCAT Drive Manager](http://infosys.beckhoff.com/content/1033/ax5000_tcdriivemanager/html/tcdm_title.htm) or http://infosys.beckhoff.com/content/1033/ax5000_tcdriivemanager/html/tcdm_title.htm

you can find further informations on the TwinCAT Drive Manager for parameterization of servo amplifiers of the AX5000 series.

EtherCAT drive(s) added

This automatic function corresponds to creating and linking an NC-axis manually as described in sections

- [Inserting an NC Configuration \[▶ 19\]](#),
- [Button "Link To I/O..." \[▶ 25\]](#).



- ✓ The dialog “EtherCAT drive(s) added” is opened.
- ✓ This dialog offers the possibility to add the axis inserted in the IO configuration to the NC configuration or to the CNC configuration and to link it to the respective configuration.
 1. Use the radio button to choose option NC-Configuration [1] if you want to add the inserted axis to the NC configuration.
 2. Confirm your choice using the OK [2] button.
 3. If you do not want to add those axes inserted in the IO configuration to the NC configuration and not to the CNC configuration either, you have later the opportunity for axes inserted in the IO configuration to create NC-axes or CNC-axes manually and link them with those axes inserted in the IO configuration. Informations on that you can find in section [NC Configuration](#) [▶ 19].
 - ⇒ You have chosen the option NC-Configuration [1] and confirmed with the OK [2] button.
- ⇒ The axis inserted in the IO configuration is added to the NC configuration and linked to the NC configuration.
- ⇒ While doing the NC configuration within the MOTION-subtree an NC-Task is created.
- ⇒ The NC-Task-subtree contains a subtree named Axes.
- ⇒ For each axis created in the NC configuration a module is created within the Axes-subtree. Each of those created modules receives a default name. For instance, Axis 1, Axis 2,
- ⇒ Each axis within a subtree within the NC configuration is linked with an axis configured within the IO configuration.

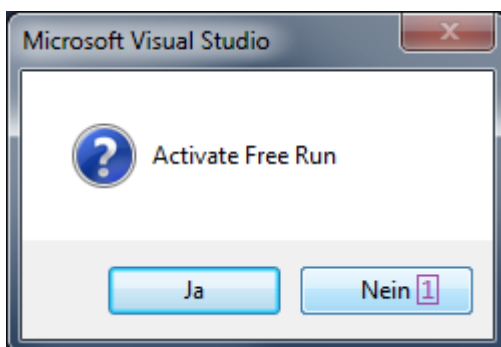
Activate Free Run

When the

- Free Run Mode

is activated

- IO variables of supported bus terminals can be read and written without any configured and activated task.
- For that the target system has to reside in Configuration Mode.



- ✓ A message box asks whether the Free Run Mode shall be activated.
 1. If you do not want to activate Free Run Mode, answer this question with No [1].
- ⇒ After you have pressed the No [1] button, this message box closes and the Free Run Mode will not be activated.

**Note****IO, MOTION****The Configuration Becoming Active: Activate Configuration**

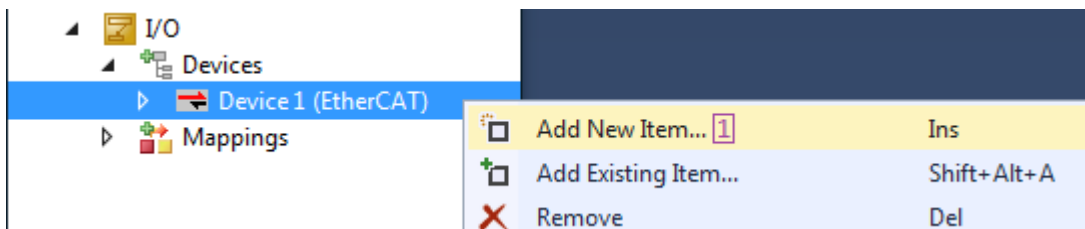
- A configuration takes effect on a target system only if it is activated for this target system.
- As well an IO Configuration determined by Scan has to be activated for the intended target system.
- Likewise, you have to activate a configuration within the MOTION-subtree for the target system intended.
- For that, use Choose Target System to choose the target system desired by you.
- Afterwards, activate the configuration for the target system chosen by you using the Activate Configuration button.

3.3.2 Inserting Servo Amplifiers Manually

Inserting a Servo Amplifier into the IO Configuration Manually

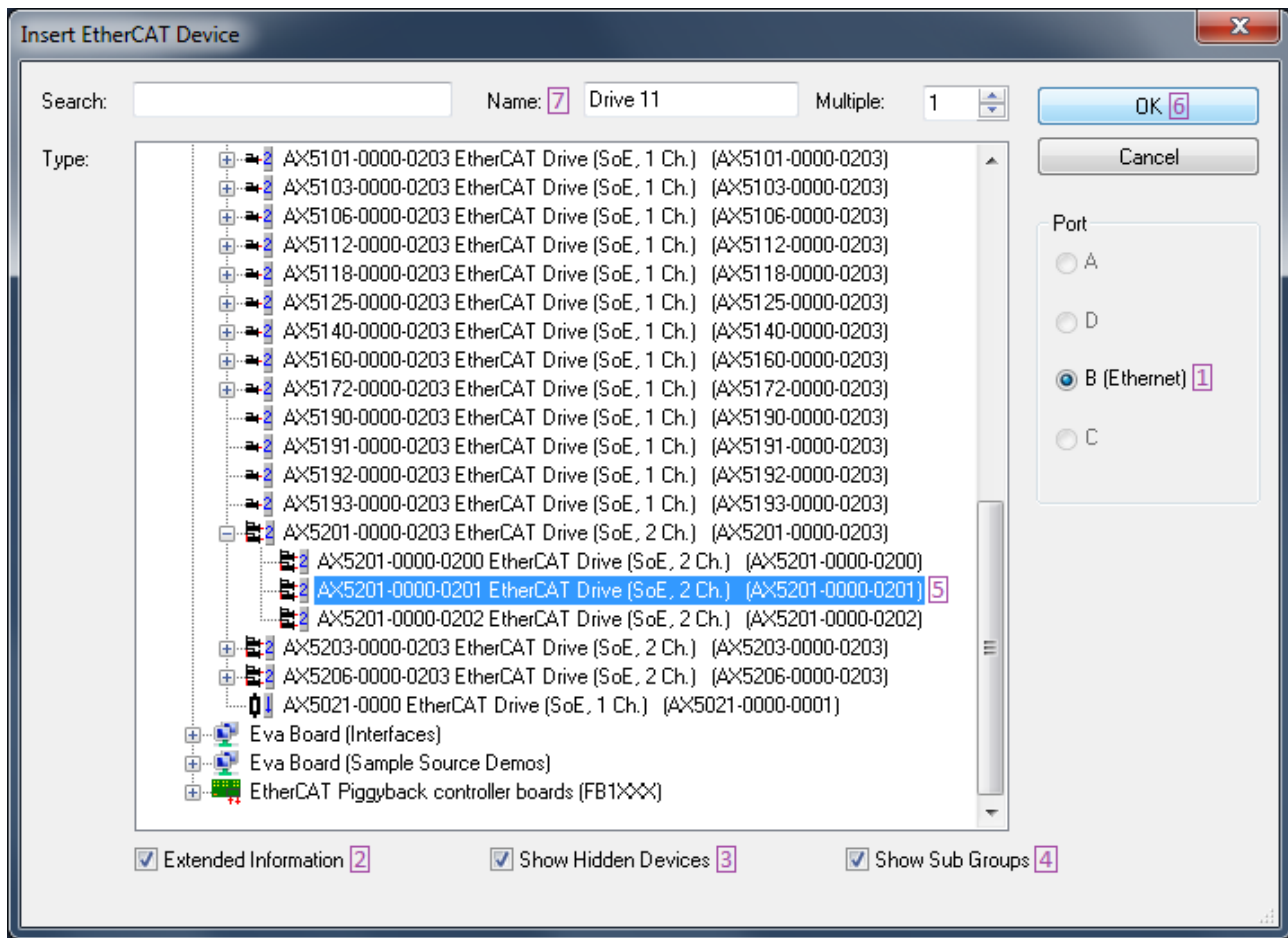
Alternatively, to an automatic Scan you can insert a servo amplifier into the IO Configuration manually, too.

Add New Item...



- ✓ The Devices node within the IO tree has at least one EtherCAT master device as child element.
 1. Within the IO tree right-click on the EtherCAT master device to that you want to add a servo drive.
 - ⇒ A context menu opens.
 2. Select the context menu item Add New Item... [1].
 - ⇒ The dialog Insert EtherCAT Device opens.

Dialog: Insert EtherCAT Device



- ✓ The Insert EtherCAT Device dialog is opened.
- ✓ Within the Type-subtree there is the entry Drives within the devices tree.
 1. If necessary, use the radio button within Port [1] to set the matching option for a preceding module port at that the servo drive shall be attached.
Following
http://infosys.beckhoff.com/content/1033/tc3_engineering_overview/html/tc3_engineering_intro.htm
you can find further informations on that.
 2. Within the devices tree open within the Type-subtree the subtree Drives.
 3. As required, if the servo amplifier demanded by you does not show up within the Drives-subtree, check one or several of the checkboxes Extended Information [2], Show Hidden Devices [3] and Show Sub Groups [4].
 4. Select that drive [5] within the extended subtree Drives that you want to insert.
⇒ The OK [6] button is activated.
 5. Within the text box Name [7] possibly fill in a name for that drive that you want to insert into the IO configuration.
 6. Use the OK [6] button to confirm your settings.
- ⇒ The axis selected by you has been added to the IO configuration, possibly exhibiting the name filled in by you.
- ⇒ The EtherCAT drive(s) added (see section [Detecting Servo Amplifiers Automatically](#) [▶ 12]) dialog opens.

3.4 NC Configuration

Within this Section

In section NC configuration you learn, ...

- ... how you can add an NC task to the NC configuration manually, ...
- ... how you can add NC-axes to an NC task, ...
- ... how you can link an NC-axis to an axis variable of a PLC project, ...
- ... using the example of a servo amplifier of the AX5000 series, how you can link an NC-axis to a servo amplifier within the IO configuration.

The abbreviation NC stands for Numerical Control.

Inserting and Linking NC Software Packages or CNC Software Packages

Within the dialog EtherCAT drive(s) added described in section

- [Detecting Servo Amplifiers Automatically](#) [▶ 12],

you can select whether you want to create

- an NC configuration or
- a CNC configuration

within the MOTION-subtree.

By creating a respective configuration you insert either

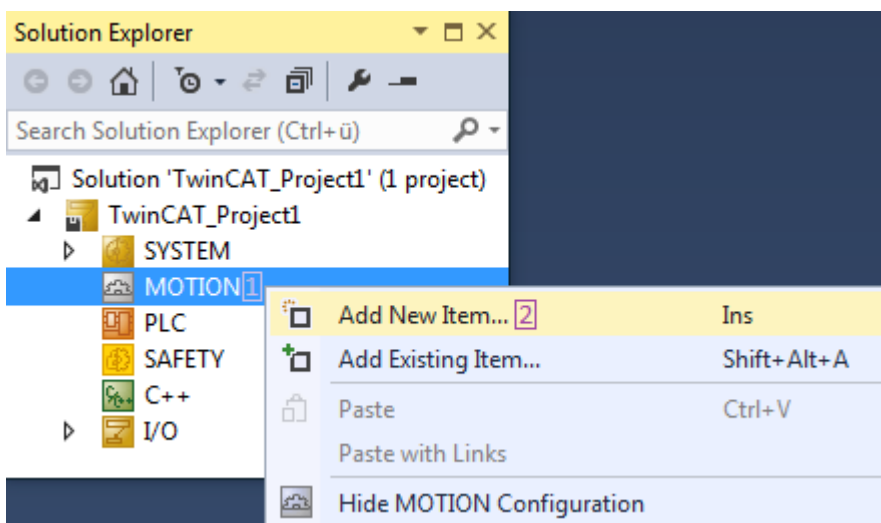
- NC software packages or
- CNC software packages

as parts of the total configuration into your TwinCAT project. Furthermore, you link the axis inserted into the IO Configuration

- to an NC-axis or
- to a CNC-axis.

3.4.1 Inserting an NC Configuration

Motion: Add New Item...

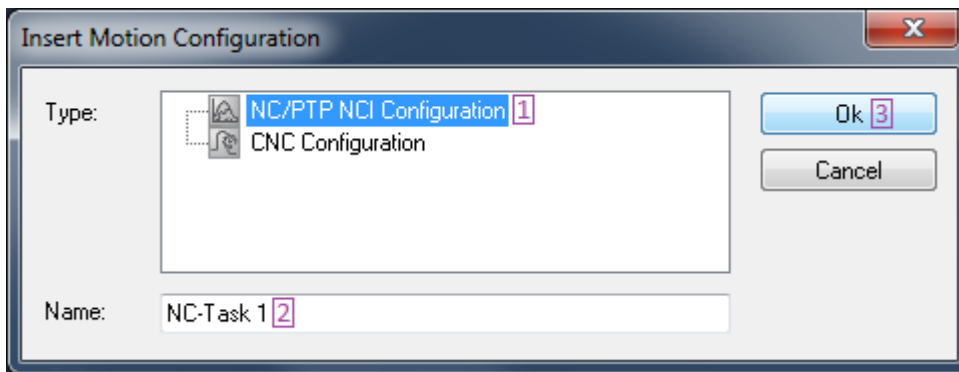


1. Right-click on the MOTION [1] node.
⇒ A context menu opens.

2. Select the context menu item Add New Item... [2].

⇒ The dialog Insert Motion Configuration opens.

Dialog: Insert Motion Configuration



[1] Choose this entry if you want to add an NC Configuration.

[2] Give the NC configuration that you want to add a name.

[3] Confirm your settings.

Insert a Motion Configuration

✓ The dialog Insert Motion Configuration is opened.

1. If you want to add an NC Configuration, choose at the tree element Type the entry NC/PTP NCI Configuration [1].

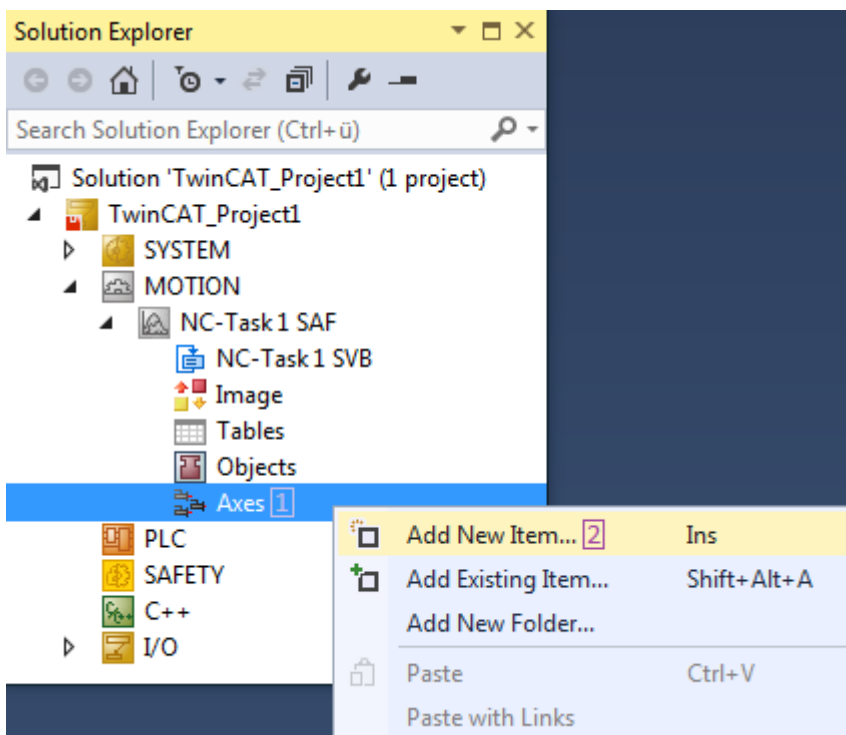
2. Give the NC configuration that you want to insert a name using the text box Name [2].

3. Confirm your settings using the Ok [3] button.

⇒ Within the MOTION-subtree an NC task is inserted.

⇒ The subtree of the NC task contains the entry Axes.

Axes: Insert New Element...



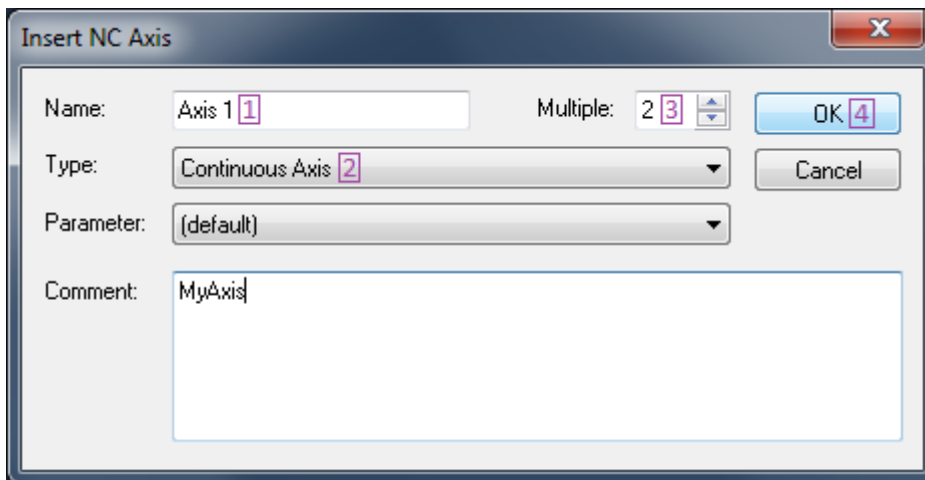
1. Right-click on the node Axes [1].

⇒ A context menu opens.

2. Select entry Add New Item...“ [2] within this context menu.

⇒ The dialog Insert NC Axis opens.

Dialog: Inserting an NC-axis



✓ With the dialog Insert NC Axis opened you can add to the corresponding NC task one or several axes.

1. Within the text box Name [1] you have the possibility to give the axis you want to insert a name.

2. Choose the entry Continuous Axis [2] within the drop-down list Type [2] if you want to insert one continuous axis or several continuous axes.

A continuous axis is e.g. a servo-axis, a DC-axis or a stepper axis.

3. With the NumericUpDown control element Multiple [3] you can add several axes with equal settings in one step.

4. Confirm your settings using the OK [4] button.

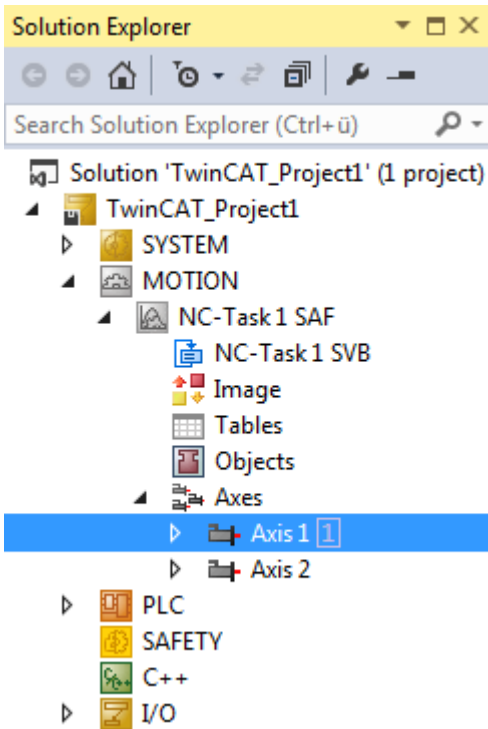
⇒ To the Axes-subtree e.g. two axes have been added.

⇒ In the example those two axes got the names Axis 1 and Axis 2 as default names.

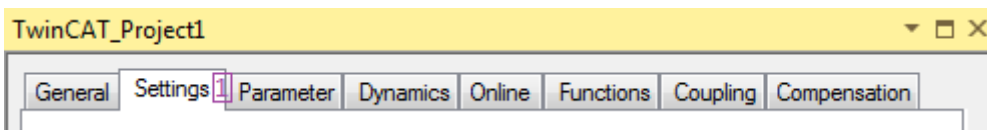
⇒ For each axis inserted you have the opportunity to open the Settings dialog.

⇒ Within the Settings dialog you can link an axis of an NC task to a matching axis within the IO Configuration and to an axis within the PLC configuration.

3.4.2 Linking an NC Software Package



[1] Double-click on the NC-axis for that you want to open a dialog.

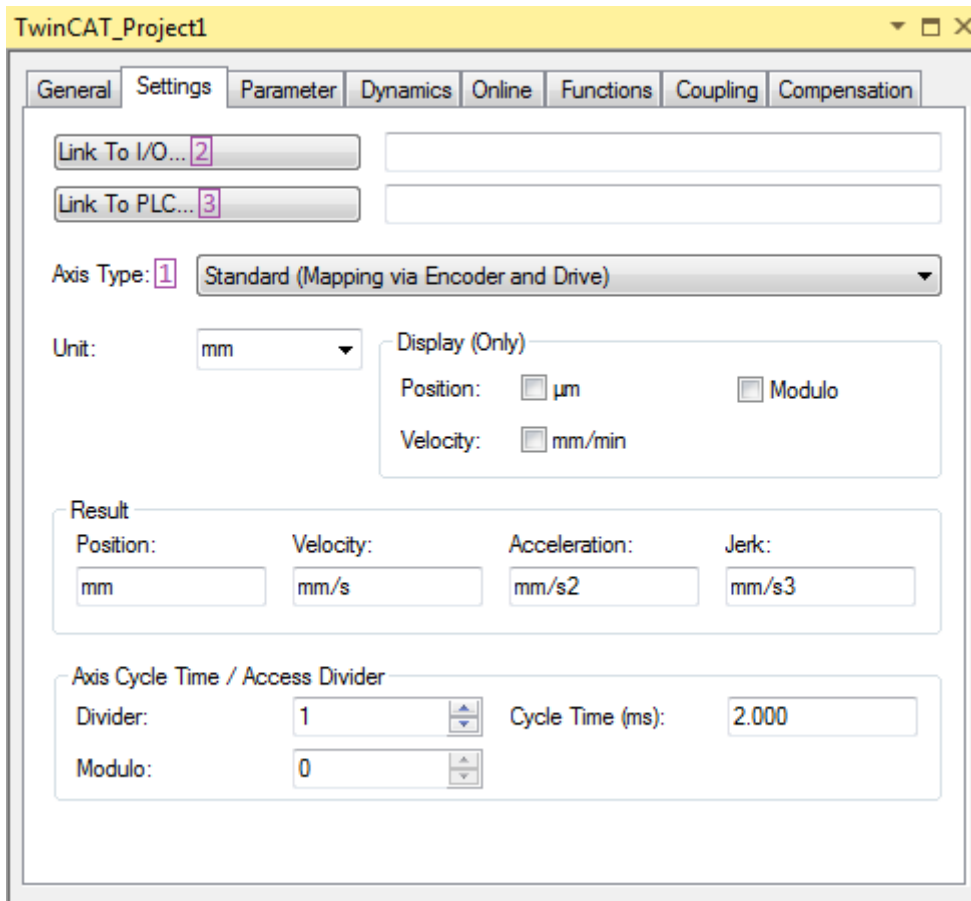


[1] Select tab Settings.

Opening the Dialog Settings [1] for an NC-Axis

1. Double-click on the NC-axis for that you want to open the Settings [1] dialog.
2. Select tab Settings [1].

⇒ The Settings [1] dialog has been opened for the NC-axis intended by you to be opened.



Drop-Down List Axis Type [1]

- The Drop-Down List Axis Type [1] exhibits the value Standard (Mapping via Encoder and Drive), if the axis selected in the NC Configuration is not linked to any device within the IO Configuration.

Buttons Link To I/O... [2] and Link To PLC... [3]

Using the button Link To I/O... [2] you link the interface of the NC Software Package

- with a Servo Amplifier within the IO Configuration.

Using the button Link To PLC... [3] you link the interface of the NC Software Package

- with an Axis Variable of a PLC Project.



Note

The Configuration Becoming Active: Activate Configuration

- A configuration becomes active on a target system only if it is activated for this target system.
- You have to activate a configuration within the Settings dialog for the desired target system, too.
- To do that you select the target system you desire using Choose Target System.
- Afterwards, activate the configuration for the target system selected by you using the Activate Configuration button.

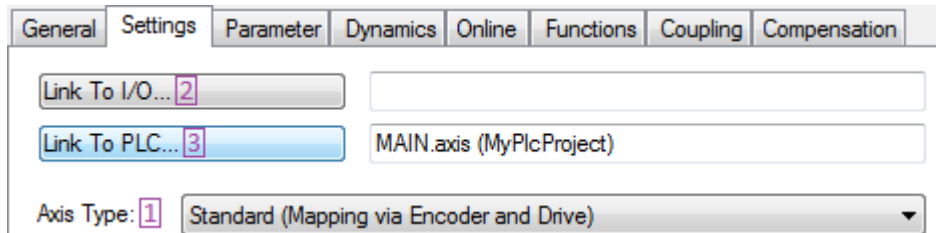
3.4.3 Button “Link To PLC...”

Linking a PLC Project

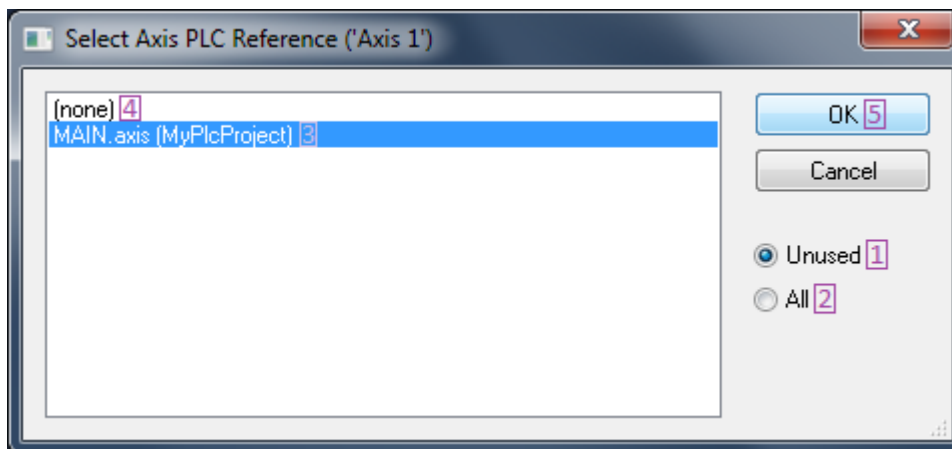
There is cyclic communication from NC to PLC and the other way round. To establish this communication NC-axes have to be linked to the PLC.

Requirements:

- Within a PLC project that you want to link an axis variable of type `AXIS_REF` has been declared. (Compare to section [Short Example Program for Driving to a Target Position](#) [▶ 35].)
- The PLC project with the axis variable of type `AXIS_REF` has been build successfully.

**Opening the Dialog Select Axis PLC Reference...**

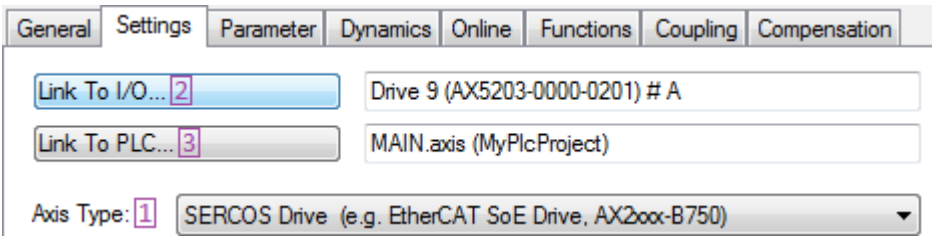
- ✓ Within a PLC project an axis variable of type `AXIS_REF` has been created.
 - ✓ The PLC project containing the axis variable of `AXIS_REF` type has been built successfully. *Solely axis variables whose PLC project has been built successfully after their declaration are displayed within the Select Axis PLC Reference... dialog.*
 - ✓ The text box on the right of the Link To PLC... [3] button shows with which axis variable of type `AXIS_REF` the axis selected within the NC configuration has been linked.
 - ✓ You want to change this link, create a link or cancel a link.
 1. Open for that axis within the NC configuration that you want to link with an axis variable of type `AXIS_REF` or whose link you want to cancel the Settings dialog.
 2. Press the Link To PLC... [3] button.
- ⇒ The dialog Select Axis PLC Reference... opens.

Select the Axis Variable

- ✓ *Merely axis variables whose PLC project has been built successfully after their declaration are displayed in the Select Axis PLC Reference... dialog.*
 - ✓ The dialog Select Axis PLC Reference... is opened.
 1. Select option Unused [1] to display all those axis variables of type `AXIS_REF` in the list box that are not linked.
 2. Select option All [2] to display all axis variables of type `AXIS_REF` in the list box. Thus, it is possible to change established configurations.
 3. Within the list box select that axis variable [3] of type `AXIS_REF` with that you want to link the axis selected within the NC configuration.
 4. Select the entry (none) [4] if you do not want to link any axis variable or you want to cancel a link existing to an axis variable.
 5. Confirm your choice using the OK [5] button.
- ⇒ The axis selected within the NC configuration is linked according to your choice.

- ⇒ The text box on the right of the Link To PLC... [2] button displays with which axis variable of AXIS_REF type the axis selected within the NC configuration has been linked.

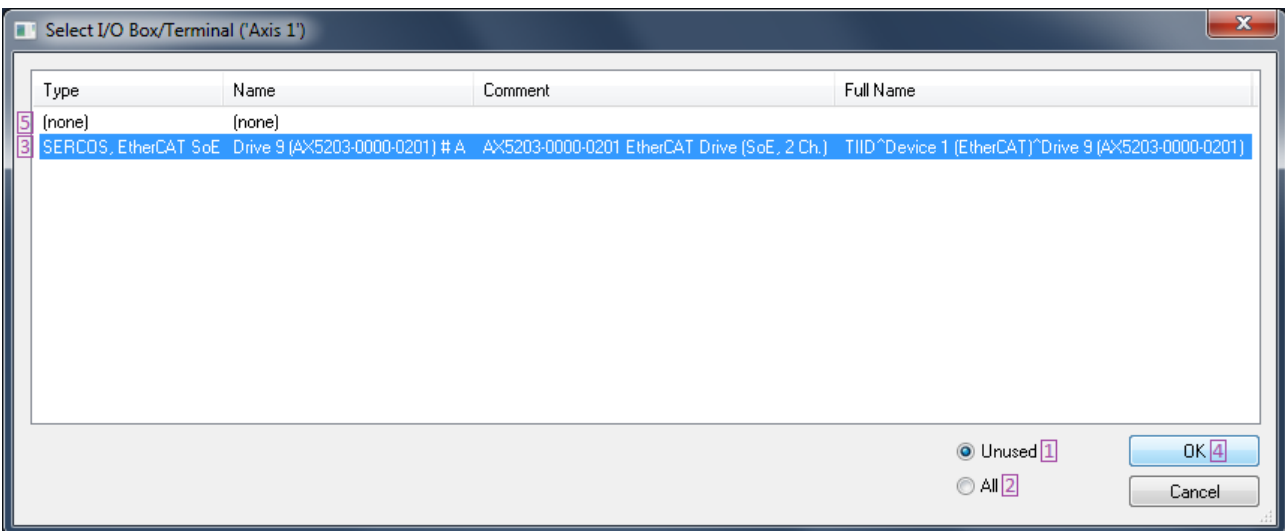
3.4.4 Button “Link To I/O...”



Opening the Dialog Select I/O Box/Terminal ...

- ✓ The text box on the right of button Link To I/O... [2] displays the device within the IO configuration with that the axis selected in the NC configuration is linked.
- ✓ You want to change this link.
 1. Press the Link To I/O... [2] button.
- ⇒ The dialog Select I/O Box/Terminal ... opens.

Select Servo Drive



- ✓ The Select I/O Box/Terminal ... dialog is opened.
 1. Select the Unused [1] option for all unused servo drives to be displayed in the table.
 2. Select the option All [2] for all configured servo drives to be displayed in the table. Thus, it is possible to change current configurations.
 3. Within the selection table select the configured servo drive [3] that you want to link to the axis selected in the NC configuration.
 4. Confirm your selection with the OK [4] button.
- ⇒ The axis link has been changed according to your selection.
- ⇒ The text box on the right of the Link To I/O... [2] button displays the device within the IO Configuration to that the axis selected within the NC Configuration has been linked.
 - Select entry (none) [5] in the Select I/O Box/Terminal ... dialog if you do not want to link a device within the IO Configuration or you want to cancel a link to a device within the IO Configuration that has been established earlier.
 - In the example the drop-down list Axis Type [1] exhibits the value SERCOS Drive (e.g. EtherCAT SoE Drive, AX2xxx-B750) after the NC-axis has been linked to the servo amplifier Drive 9 (AX5203-0000-0201) # A.

3.5 Position Limits

Within this Section



Note

Within this section Position Limits purely functional settings are explained that are not safety functions in the sense of safety technology.

In section Position Limits we give you some advice, ...

- ... how you can prevent a collision.

In section Position Limits you learn, ...

- ... how to activate software limit switches, ...
- ... how to activate position lag monitoring.

NC-Axis: Parameters

	Parameter	Offline Value	Online Value	Type	Unit
-	Limit Switches:				
	Soft Position Limit Minimum Monitoring	TRUE ^[1]	TRUE	B	
	Minimum Position	-10.0 ^[4]	-10.0	F	mm
	Soft Position Limit Maximum Monitoring	TRUE ^[2]	TRUE	B	
	Maximum Position	100.0 ^[5]	100.0	F	mm
-	Monitoring:				
	Position Lag Monitoring	TRUE ^[3]	TRUE	B	
	Maximum Position Lag Value	5.0 ^[6]	5.0	F	mm
	Maximum Position Lag Filter Time	0.02 ^[7]	0.02	F	s

[1], [2] Software Limit Switch:
Set to the value `TRUE` at each place.

[3] Position Lag Monitoring:
Set to the value `TRUE`.

[4], [5] Software Limit Switch:
Set a value at each place that leaves sufficient freedom for movements and excludes the possibility of a collision.

[6], [7] Position Lag Monitoring:
Set a value at each place that leaves sufficient freedom for control and excludes the possibility of a collision.

Position Limits




CAUTION

To avoid a collision ...

- ... activate the software limit switches, ...
- ... activate the position lag monitoring, ...
- ... we recommend to use axes rotating freely for a first commissioning.

Scaling Factor and Rotation Direction

 CAUTION	<p>Scaling Factor and Rotation Direction</p> <p>Moreover, regard that you did not set</p> <ul style="list-style-type: none"> • Scaling Factor and • Rotation Direction <p>yet. You can set Scaling Factor and Rotation Direction within the</p> <ul style="list-style-type: none"> • Drive Manager <p>of a servo amplifier. To do that double-click on that servo amplifier within the</p> <ul style="list-style-type: none"> • IO Configuration <p>for that you would like to open the Drive Manager.</p>
---	---

Activate Software Limit Switches

1. Select the NC-axis within the Axes-subtree for that you want to activate software limit switches.
 2. Open the Parameter dialog for this NC-axis.
 3. Set value `TRUE` for the parameter Limit Switches: Soft Position Limit Minimum Monitoring. For that, use the corresponding drop-down list in table column Offline Value.
 4. Set value `TRUE` for the parameter Limit Switches: Soft Position Limit Maximum Monitoring. For that, use the corresponding drop-down list in table column Offline Value.
 5. Set with the parameter Limit Switches: Minimum Position for the minimum position value that can be driven to a value that leaves sufficient freedom for movement and inhibits the possibility of a collision.
 6. Set with the parameter Limit Switches: Maximum Position for the maximum position value that can be driven to a value that leaves sufficient freedom for movement and inhibits the possibility of a collision.
- ⇒ You have activated the software limit switches for the NC-axis selected within the Axes-subtree.

Activating Position Lag Monitoring

1. Select the axis within the Axes-subtree for that you want to activate the software limit switches.
 2. Open the dialog Parameter for this NC-axis.
 3. Set the parameter Monitoring: Position Lag Monitoring on the value `TRUE`. For that, use the corresponding drop-down list within the table column Offline Value.
 4. Use the parameter Monitoring: Maximum Position Lag Value to set a maximum position lag value allowed that leaves sufficient freedom for control and excludes the possibility of a collision. Habitually, the default value is a good value.
 5. Set the parameter Monitoring: Maximum Position Lag Filter Time on a value that leaves sufficient freedom for control and excludes the possibility of a collision. Habitually, the default value is a good value.
- ⇒ For the NC-axis selected within the Axes-subtree you have activated the position lag monitoring.

3.6 Moving an Axis Manually




Within this Section

In section Moving an Axis Manually you learn ...

- ... how to use the Online dialog for an NC-axis to set the general enable with respect to software and the general controller enable, ...
- ... how to use the Online dialog for an NC-axis to set the feed enable for an NC-axis for the positive and negative move direction, ...
- ... how to use the Online dialog for an NC-axis to move an axis manually.

Configuration Mode

- In Config Mode the Online dialog for an NC-axis is shown grayed out.

	Moving an Axis Manually - Link To PLC...
Note	<p>For moving an axis manually:</p> <ul style="list-style-type: none"> • Within the Settings dialog of the NC-axis set the entry Link To PLC... on value (none). • Or stop the PLC program (button Stop).
	Moving an Axis Manually - Activate Configuration
Note	<p>For moving an axis manually: Activate the configuration to transfer changes of the configuration to the target system.</p>
	Severe Risk of Injury due to Axis Movement!
DANGER	<p>Due to commissioning there is a movement of axes. Because of this, parts of the human body may be injured severely. Keep a suitable safe distance from moving parts. Do not stay within the area of movement!</p>

Run Mode, Controller Enable, Moving Axes Manually

For moving axes manually ...

- ... restart the TwinCAT System in Run Mode.


The

- Online dialog for an NC-axis

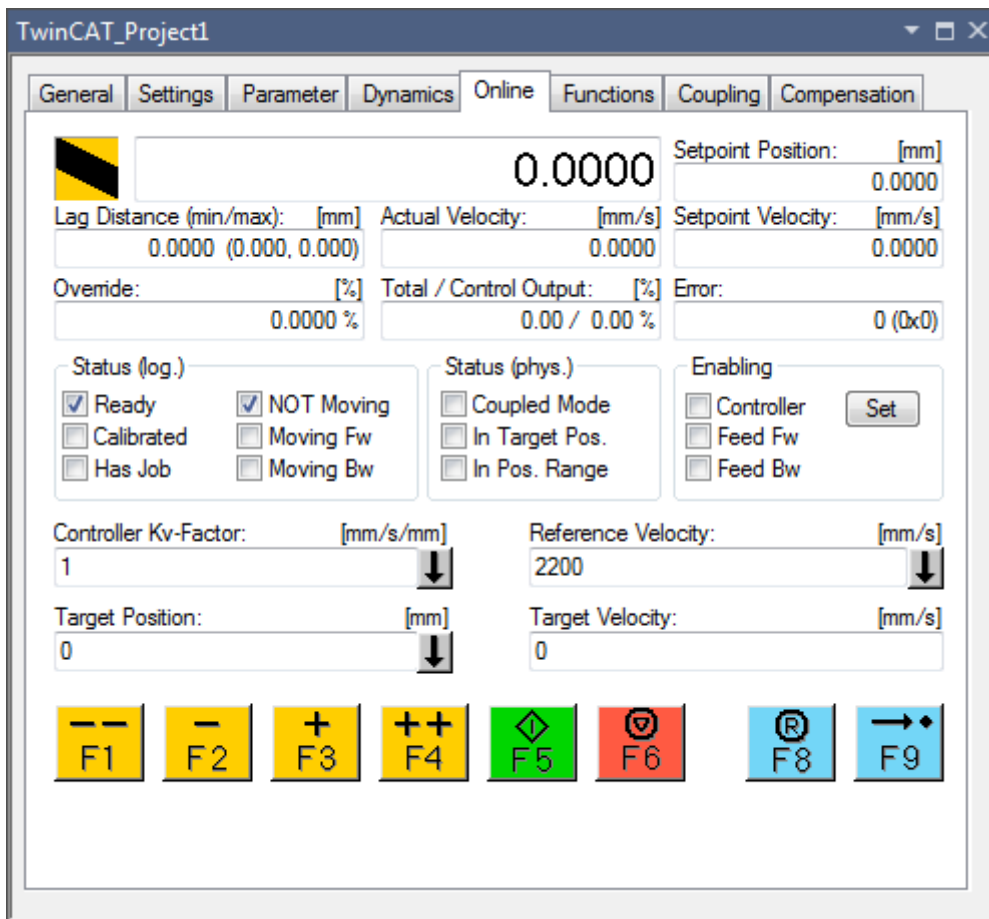
is suitable as

- commissioning visualization

for a first commissioning of an axis.

	Axis Position at a First Commissioning
WARNING	<p>Usually, prior to a first commissioning the axis position displayed is wrong. Therefore, preceding a first commissioning a homing sequence should be carried out or as a zero position offset a position bias should be applied.</p>

After you have restarted the TwinCAT System in Run Mode, within the Online dialog for the NC-axis Standard (Mapping via Encoder and Drive) the checkboxes



- Ready and
- NOT Moving,

each in the field Status (log.), are checked.

For moving axes manually ...

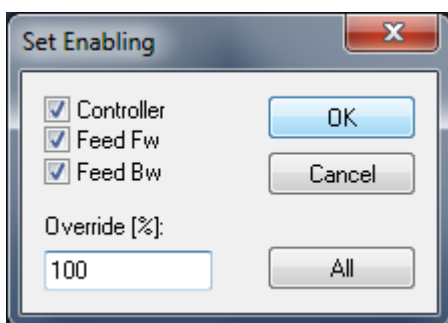
- ... set the controller enable, ...
- move the axes with the buttons F1 - F6 and F8 - F9.

Setting the Controller Enable

- For setting the controller enable the servo drive has to be ready for operation.

- Ready
- If checked, the servo drive is ready for operation.
 - Generally, the simulation axis is ready for operation.

Within the Online dialog of an NC-axis within the field Enabling the Set button opens the Set Enabling dialog for setting the controller enable for the corresponding axis.



- Controller**
- Necessary for the positional control to be active.
 - Without controller enable the controller is not active.
 - If linked to PLC: Corresponds to the `Enable` input of the `MC_Power` function block.
- Feed Fw**
- Without feed enable in positive direction the axis cannot be started in positive direction.
 - If the axis moves in positive direction while the feed enable in positive direction is taken away, then the axis is stopped.
If afterwards the feed enable is enabled again undoing this previous taking away, then the axis does not begin to move automatically again.
 - If linked to PLC: Corresponds to the `Enable_Positive` input of the `MC_Power` function block.
- Feed Bw**
- Without feed enable in negative direction the axis cannot be started in negative direction.
 - If the axis moves in negative direction while the feed enable in negative direction is taken away, then the axis is stopped.
If afterwards the feed enable is enabled again undoing this previous taking away, then the axis does not begin to move automatically again.
 - If linked to PLC: Corresponds to the `Enable_Negative` input of the `MC_Power` function block.
- Override**
- Influences the velocity percentage of all drive commands. It is $0 \leq \text{Override} \leq 100.0$.

The Buttons F1 - F6 and F8 - F9



- Moving the axis with the buttons F1 - F6 and F8 - F9.

- F1 Move the axis fast into negative moving direction.
- F2 Move the axis slowly into negative moving direction.
- F3 Move the axis slowly into positive moving direction.
- F4 Move the axis fast into positive moving direction.
- F5 Move the axis with target velocity to target position.
- F6 Stop axis movement.
- F8 Reset.
- F9 Start homing sequence.

3.7 PLCopen

Within this Section

In section PLCopen you learn, ...

- ... how to add a reference to your PLC project to be able to use Motion Control according to the PLCopen standard.

In section PLCopen we introduce to you briefly ...

- ... the MC-axis variable `AXIS_REF`, ...
- ... the `MC_Power` function block for enabling an axis, ...
- ... the `MC_MoveAbsolute` function block for moving an axis to a target position.

Further Informations

Following

- [TwinCAT 3 PLC Lib: Tc2_MC2](http://infosys.beckhoff.com/content/1033/tcplclib_tc2_mc2/index.html) or http://infosys.beckhoff.com/content/1033/tcplclib_tc2_mc2/index.html

you can find further informations

- on Motion Control according to the PLCopen standard,
- on the TwinCAT 3 PLC Library Tc2_MC2.

Following

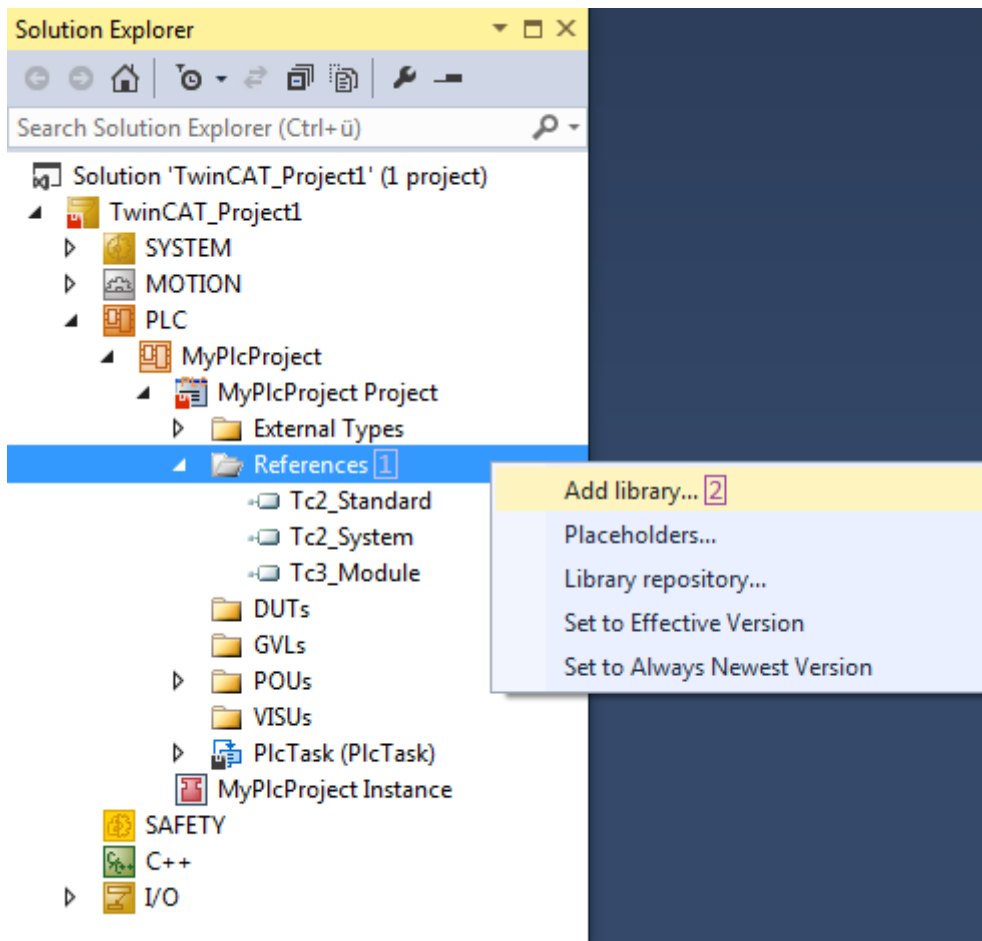
- [PLC](http://infosys.beckhoff.com/content/1033/tc3_plc_intro/index.html) or http://infosys.beckhoff.com/content/1033/tc3_plc_intro/index.html

you can find further informations

- on PLC programming.

Opening the Add Library Dialog

- To be able to use Motion Control according to the PLCopen standard you have to add a reference to your PLC project.

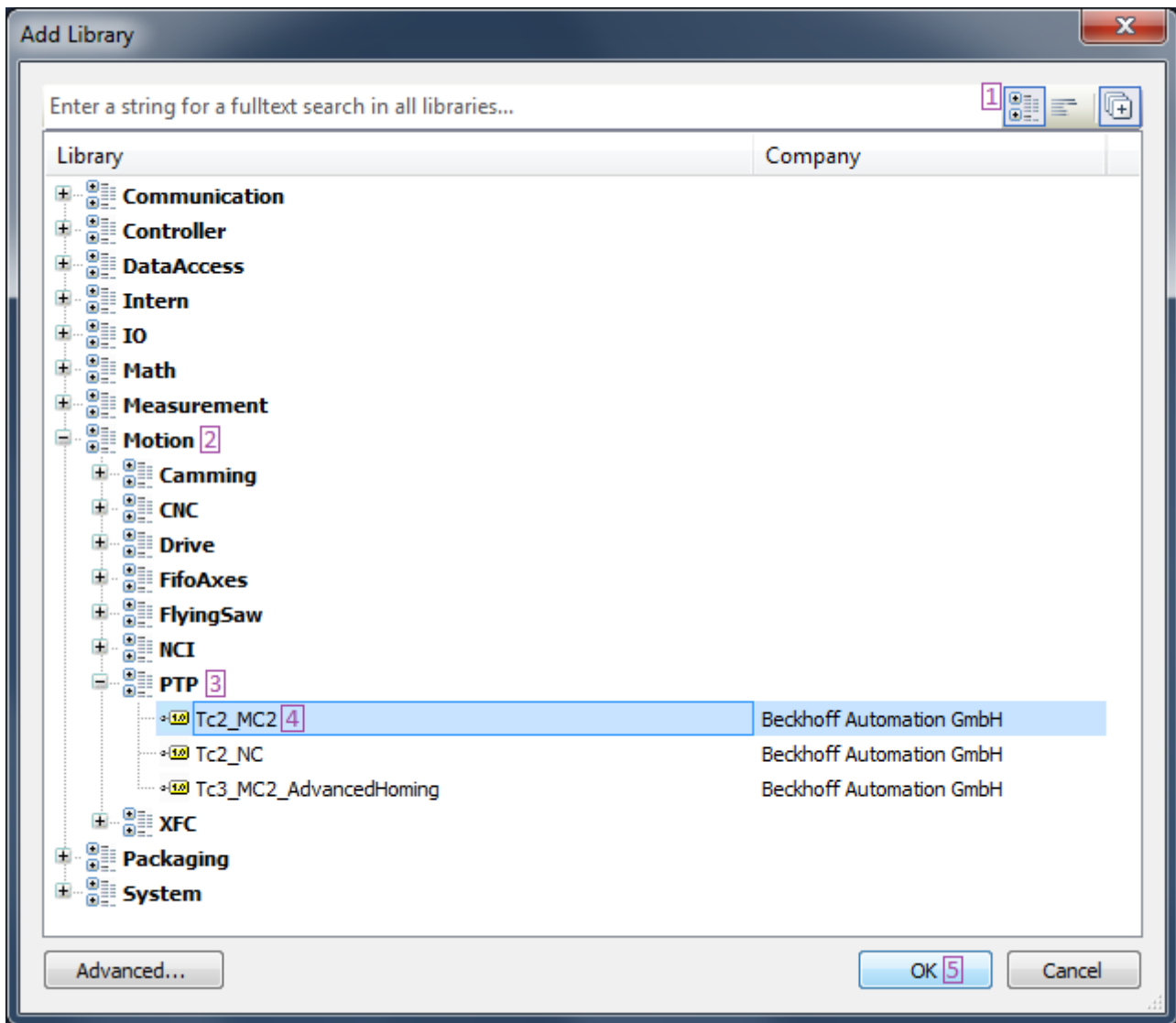


- ✓ You have created a new PLC project, e.g. a new Standard PLC Project.
- 1. Right-click on the folder References [1] within that PLC project to that you want to add a reference.
 - ⇒ A context menu opens.
- 2. Click on the context menu item Add library... [2].
 - ⇒ The dialog Add Library opens.

Select Library

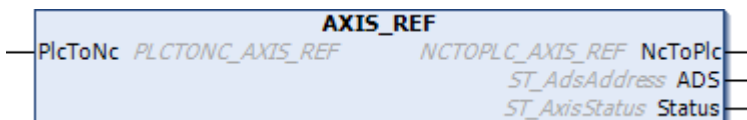
Tc2_MC2 is the standard library for

- Motion Control according to the PLCopen standard,
- PTP Motion (Point to Point Motion) and
- axis administration.



- ✓ The Add Library dialog is opened.
 - 1. Select the library that you want to add to the PLC project.
 - 2. For that you switch the Add Library dialog into the Category View [1] if it resides in a different view.
 - 3. Expand the Motion [2] subtree.
 - 4. Expand the PTP [3] subtree within the Motion [2] subtree.
 - 5. Select the Tc2_MC2 [4] library.
 - 6. Confirm your selection with the OK [5] button.
- ⇒ A reference to the Tc2_MC2 [4] library is established within that PLC project to that you want to add this reference.

MC Axis Variable



- Our PLC axis variable `MAIN.axis` is of `AXIS_REF` data type.

The data type `AXIS_REF`

- contains informations of an axis,
- provides an interface between PLC and NC,
- is passed to MC function blocks as reference to an axis.



Note

Refreshing the State Data Structure in `AXIS_REF`

The State data structure `Status` of type `ST_AxisStatus`

- contains additional or worked up State information for an axis,
- contains diagnosis information for an axis,
- is not updated cyclically, but has to be updated by the PLC program.

The call of the action `ReadStatus()` of `AXIS_REF`

- updates the State data structure,
- should be done once at the beginning of each PLC cycle.

Within a PLC cycle

- State information does not change,
- after calling `ReadStatus()` can be referred to the current State information in `AXIS_REF` within the whole PLC program.

The nature of the State data structure is purely informational. Thus, its use is not necessary urgently. Still, not to be misleading the State data structure has to be used correctly if used.

```
PROGRAM MAIN
VAR
  axis: AXIS_REF;
END_VAR
```

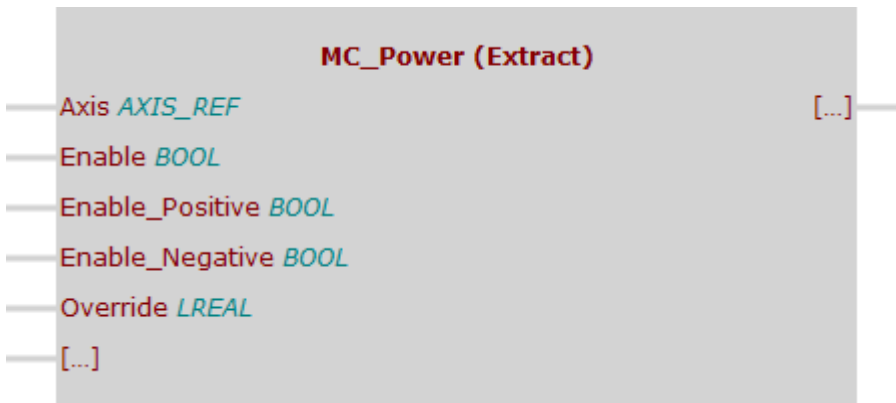
```
axis.ReadStatus();
```

Simulation Axis

Link To I/O...	[3]
Link To PLC...	MAIN.axis (MyPlcProject) [1]
Axis Type:	Standard (Mapping via Encoder and Drive) [2]

- [1] For moving the axis employing MC function blocks we linked our local MC axis variable `MAIN.axis` to the NC-axis.
- [2] Under Axis Type we set the simulation axis Standard (Mapping via Encoder and Drive) as NC-axis.
- [3] For a simulation axis the entry Link To I/O... stays empty.

MC_Power



- The function block `MC_Power` switches the axis enable with respect to software.

MC_Power: Inputs (Extract)

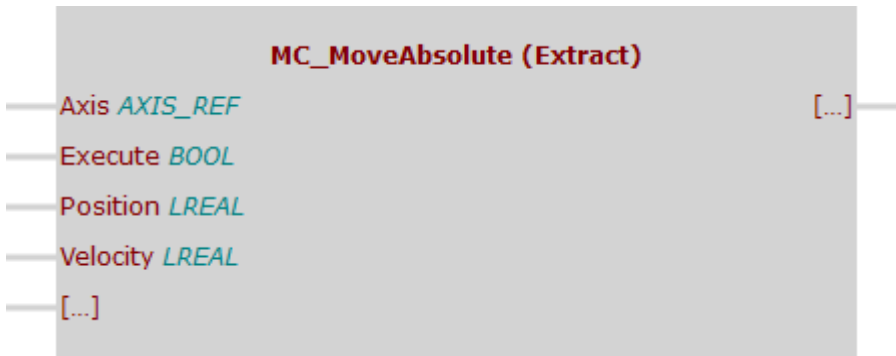
- Enable: BOOL; Sets the general axis enable with respect to software and the general controller enable for an axis. Enable is given if `Enable = TRUE`. Corresponds to the checkbox Controller in the dialog Set Enabling. Enable is given if checkbox is hooked.

- Enable_Positive: BOOL; Sets the feed enable for the positive drive direction of an axis. Enable is given if `Enable_Positive = TRUE`. Corresponds to the checkbox Feed Fw in the dialog Set Enabling. Enable is given if checkbox is hooked.

- Enable_Negative: BOOL; Sets the feed enable for the negative drive direction of an axis. Enable is given if `Enable_Negative = TRUE`. Corresponds to the checkbox Feed Bw in the dialog Set Enabling. Enable is given if checkbox is hooked.

- Override: LREAL; Influences the velocity for all drive commands in percentage. The equation $0 \leq \text{Override} \leq 100.0$ holds.

MC_MoveAbsolute



- The function block MC_MoveAbsolute starts a positioning towards an absolute target position and monitors the axis movement along the whole path of movement.

MC_MoveAbsolute: Inputs (Extract)

- Execute: BOOL; A rising edge at this input executes the command.

- Position: LREAL; Absolute target position onto that positioning shall be done.

- Velocity: LREAL; Maximum velocity with that the axis should be moved. A positive value.

Short Example Program for Moving an Axis to a Target Position

Our program MAIN puts on view a short example with that an axis should be moved to a target position.

PROGRAM MAIN: Declaration

```
PROGRAM MAIN
VAR
  axis: AXIS_REF;
  fbAxisPower: MC_Power;
  fbAxisMoveAbsolute: MC_MoveAbsolute;
  bEnable: BOOL := FALSE;
  fOverride: LREAL := 100;
  bMove: BOOL := FALSE;
  fTargetPosition: LREAL := 90;
  fTargetVelocity: LREAL := 5;
END_VAR
```

PROGRAM MAIN: Implementation

```

axis.ReadStatus();

fbAxisPower(
  Axis:= axis,
  Enable:= bEnable,
  Enable_Positive:= bEnable,
  Enable_Negative:= bEnable,
  Override:= fOverride,
  BufferMode:= ,
  Options:= ,
  Status=> ,
  Busy=> ,
  Active=> ,
  Error=> ,
  ErrorID=> );

fbAxisMoveAbsolute(
  Axis:= axis,
  Execute:= bMove,
  Position:= fTargetPosition,
  Velocity:= fTargetVelocity,
  Acceleration:= ,
  Deceleration:= ,
  Jerk:= ,
  BufferMode:= ,
  Options:= ,
  Done=> ,
  Busy=> ,
  Active=> ,
  CommandAborted=> ,
  Error=> ,
  ErrorID=> );

```

MAIN: Local Variables

<code>axis: AXIS_REF;</code>	Instance of an MC-axis. This instance can be linked to an NC-axis.
<code>fbAxisPower: MC_Power;</code>	Instance variable of the MC_Power function block.
<code>fbAxisMoveAbsolute: MC_MoveAbsolute;</code>	Instance variable of the MC_MoveAbsolute function block.
<code>bEnable: BOOL := FALSE;</code>	Switches the inputs <code>Enable</code> , <code>Enable_Positive</code> and <code>Enable_Negative</code> of the MC_Power function block.
<code>fOverride: LREAL := 100;</code>	Override value for the <code>Override</code> input of the MC_Power function block.
<code>bMove: BOOL := FALSE;</code>	A positive edge switches the input <code>Execute</code> of the MC_MoveAbsolute function block.
<code>fTargetPosition: LREAL := 90;</code>	Target position value for the <code>Position</code> input of the MC_MoveAbsolute function block.
<code>fTargetVelocity: LREAL := 5;</code>	Target velocity value for the <code>Velocity</code> input of the MC_MoveAbsolute function block.

3.8 Moving Axes with MC_Power and MC_MoveAbsolute

Within this Section

Within section Moving Axes with MC_Power and MC_MoveAbsolute you learn ...

- ... how to set the general enable with respect to software and the general controller enable, and the feed enable for positive move direction and the feed enable for negative move direction for an NC-axis using the MC_Power function block, ...
- ... how to move to a target position using the MC_MoveAbsolute function block.

NC-Axis: Online

After we

- have restarted the TwinCAT system in Run Mode,

within the Online dialog for the NC-axis Standard (Mapping via Encoder and Drive) the checkboxes

- Ready and
- NOT Moving,

each in the field Status (log.), are selected.



Severe Risk of Injury due to Axis Movement!

Due to commissioning there is a movement of axes. Because of this, parts of the human body may be injured severely. Keep a suitable safe distance from moving parts. Do not stay within the area of movement!

MAIN [Online]: MC_Power

- We log in the compiled PLC project using the Login button.
- We start the PLC program using the Start button.

The screenshot displays the TwinCAT Project1 - MAIN [Online] window. The top part shows a variable declaration table for the program MAIN. The bottom part shows the corresponding ladder logic code.

Expression	Type	Value	Prepared value	Address	Comment
axis	AXIS_REF				
fbAxisPower	MC_Power				
fbAxisMoveAbsolute	MC_MoveAbsolute				
bEnable	BOOL	TRUE			
fOverride	LREAL	100			
bMove	BOOL	FALSE			
fTargetPosition	LREAL	90			
fTargetVelocity	LREAL	5			

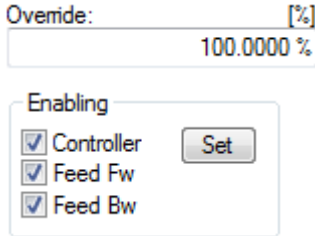
```

1 axis.ReadStatus();
2
3 fbAxisPower(
4   Axis:= axis,
5   Enable TRUE := bEnable TRUE,
6   Enable_Positive TRUE := bEnable TRUE,
7   Enable_Negative TRUE := bEnable TRUE,
8   Override 100 := fOverride 100,
9   BufferMode:= ,
10  Options:= ,
11  Status=> ,
12  Busy=> ,
13  Active=> ,
14  Error=> ,
15  ErrorID=> );
16
17 fbAxisMoveAbsolute(
18  Axis:= axis,
19  Execute FALSE := bMove FALSE,
20  Position 90 := fTargetPosition 90,
21  Velocity 5 := fTargetVelocity 5,
22  Acceleration:= ,
23  Deceleration:= ,
24  Jerk:= ,
25  BufferMode:= ,
26  Options:= ,
27  Done=> ,
28  Busy=> ,
29  Active=> ,
30  CommandAborted=> ,
31  Error=> ,
32  ErrorID=> ); RETURN

```

1. For our program MAIN we open the Start view.
2. Within the Declaration part of our program MAIN we set the local variable `bEnable` on the value `TRUE`.

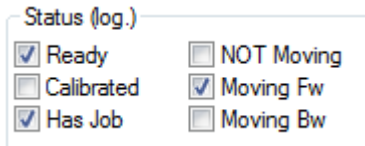
- ⇒ Thus, for the axis `axis` the general enable with respect to software and the general controller enable has been set, the feed forward for positive drive direction has been set and the feed forward for negative drive direction has been set.
- ⇒ Within the Online dialog of the NC-axis the text box Override displays the percentage value `100.0000` corresponding to the value of variable `fOverride`.
- ⇒ Within the Online dialog of the NC-axis in the field Enabling the checkboxes Controller, Feed Fw and Feed Bw are set.



MAIN [Online]: MC_MoveAbsolute

- ✓ The Online view for our program `MAIN` is opened.
- ✓ The variable `bMove` exhibits the value `FALSE`.
- 1. Within the Declaration part of our program `MAIN` we set the variable `bMove` on the value `TRUE` and thus create a positive edge.
- ⇒ That way within the Implementation part the input `Execute` of the `MC_MoveAbsolute` function block receives the value `TRUE` and a positive edge.
- ⇒ While moving the axis the checkbox NOT Moving is unchecked and the checkboxes Moving Fw and Has Job are checked within the Online dialog of the NC-axis within field Status (log.).
- ⇒ When the NC-axis has reached its target position, the checkboxes Moving Fw and Has Job are unchecked, and the checkbox NOT Moving is checked, again.
- ⇒ When the NC-axis has reached its target position, within the field Status (phys.) the checkboxes In Target Pos. and In Pos. Range are set.

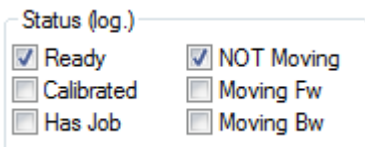
While moving the axis within the field Status (log.)



- Moving Fw,
- Has Job

are set.

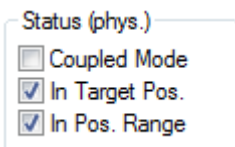
When the NC-axis has reached its target position within the field Status (log.)



- NOT Moving

is set

and within the field Status (phys.)



- In Target Pos. and
- In Pos. Range

are set.

- We set the variable `bMove` on the value `FALSE`, again, to be able to create a positive edge later as required.

Reset Enable with respect to Software

1. We reset variable `bEnable` back to the value `FALSE`.
 - ⇒ Thus, we reset the feed enable for the positive drive direction, the feed enable for the negative drive direction, the general enable with respect to software and the general controller enable for the NC-axis.
 - ⇒ Within the Online dialog of the NC-axis the Override value is reset on value `0.0000`.
 - ⇒ Within the field Enabling in the Online dialog of the NC-axis the checkboxes Controller, Feed Fw and Feed Bw are reset.

Override: [%]

Enabling

Controller

Feed Fw

Feed Bw

3.9 Scope

Within this Section

Within section Scope you learn, ...

- ... how to record a YT diagram for path of movement and velocity of movement with TwinCAT 3 Scope.

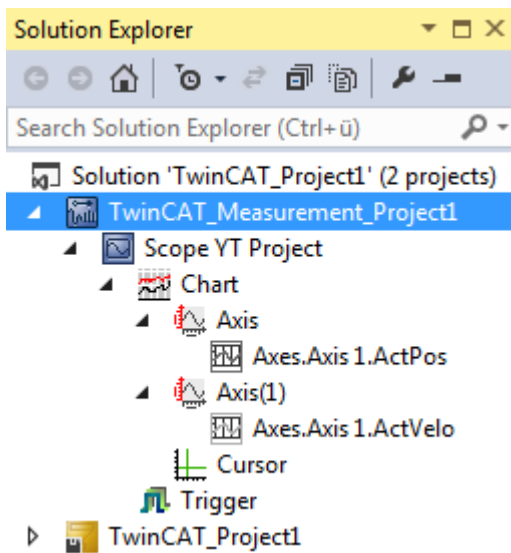
TwinCAT 3 Scope

Using TwinCAT 3 Scope variables in TwinCAT can be

- recorded (TwinCAT 3 Scope View) and
- displayed graphically (TwinCAT 3 Scope View).

Subtree for a TwinCAT Measurement Project

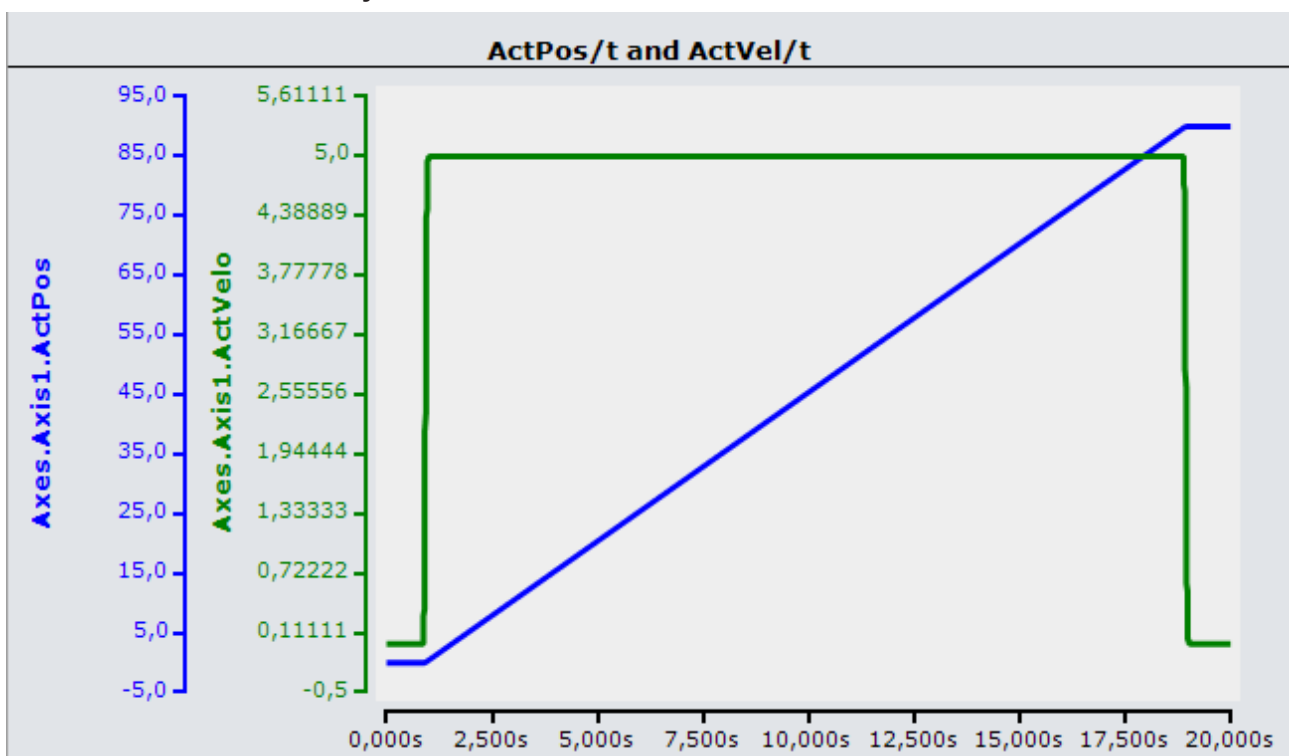
For a TwinCAT Measurement project an own subtree is created within the Solution Explorer.



Recording a YT Diagram

1. We create a TwinCAT Measurement project.
 2. Within the TwinCAT Measurement project we create a Scope YT Project.
 - ⇒ A YT Chart is created.
 3. We add a second axis to the YT Chart.
 4. At one Y-axis we let Scope display the value of variable `ActPos` of the NC-axis of the NC configuration.
 5. At the other Y-axis we let Scope display the value of variable `ActVelo` of the NC-axis of the NC configuration.
 6. Shortly before we begin to move our NC-axis, we start with the Record button a record for our YT Chart.
 7. Shortly after our NC-axis has reached its target position, we stop with the Stop Record button our record for our YT Chart.
- ⇒ A Scope record visualizes path of movement and velocity of movement over time for our NC-axis movement.

Drive Path and Drive Velocity



Scope : Further Informations

Following

- [TF3300 TC3 ScopeServer](http://infosys.beckhoff.com/content/1033/tf3300_tc3_scopeserver/index.html) or
http://infosys.beckhoff.com/content/1033/tf3300_tc3_scopeserver/index.html

you find further informations on the TwinCAT 3 Scope Server.

Following

- [TE13xx | TC3 ScopeView](http://infosys.beckhoff.com/content/1033/te13xx_tc3_scopeview/index.html) or
http://infosys.beckhoff.com/content/1033/te13xx_tc3_scopeview/index.html

you find further informations on the TwinCAT 3 Scope View.