

BECKHOFF New Automation Technology

Manual | EN

TF50x0

TwinCAT 3 | NC PTP

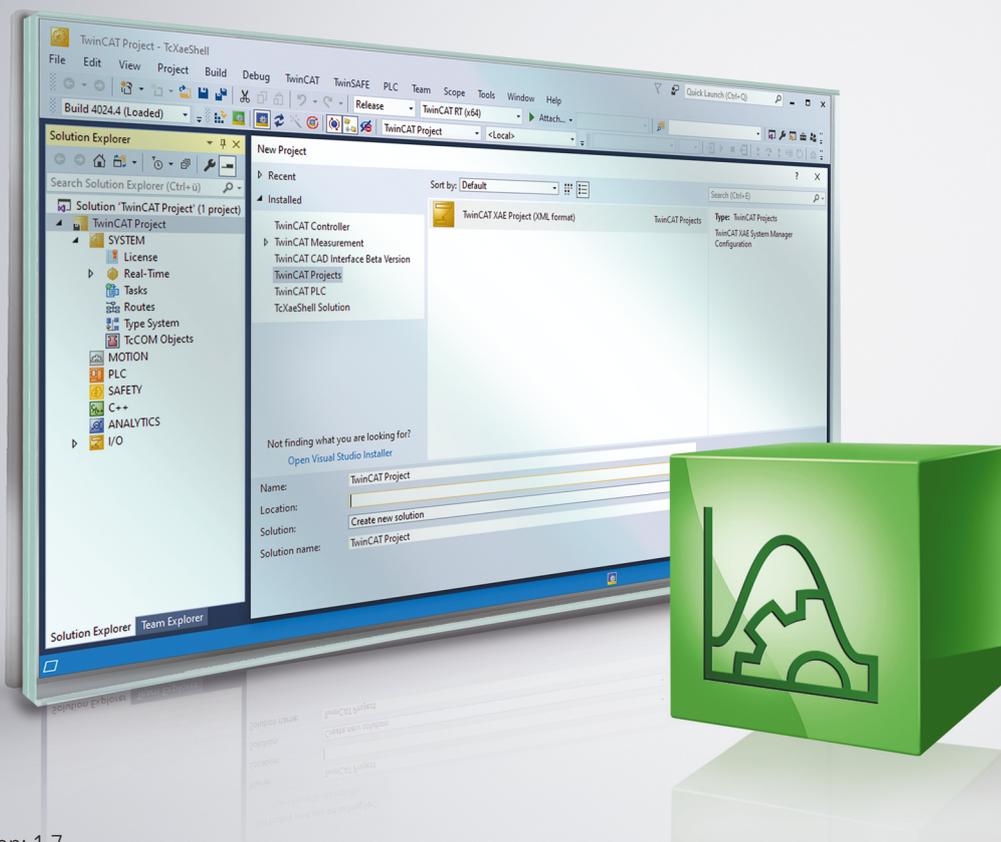


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1 Foreword

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 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, EP1456722, EP2137893, DE102015105702
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

Serious risk of injury!

Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.

WARNING

Risk of injury!

Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.

CAUTION

Personal injuries!

Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.

NOTE

Damage to the environment or devices

Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.



Tip or pointer

This symbol indicates information that contributes to better understanding.

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In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our <https://www.beckhoff.com/secguide>.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

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2 TF5000 - TF5020 | TC3 NC PTP Axes



TC3 NC PTP implements Motion Control in software for Point-to-Point movements. The axes are represented by axis objects and provide a cyclic interface, e.g. for the PLC. This axis object is then linked with 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 (extendable up to a maximum of 255 axes).
- TF5010: Extension of TC3 NC PTP 10 to up to 25 axes (extendable to a maximum of 255 axes).
- TF5020: Extension of TC3 NC PTP 10 to up to 255 axes.

TC3 NC PTP:

- 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.
- Provides standard axis functions such as start/stop/reset/referencing, velocity override, master/slave couplings, electronic gearing, online distance compensation.
- Programming is carried out via PLCopen-compliant IEC 61131-3 function blocks.
- Provides convenient axis commissioning options.
- Contains online monitors for all axis state variables, such as actual/setpoint values, enables, control values, online axis tuning.

Further scopes/options of TC3 NC PTP:

- Forcing of axis variables.
- Configuration of all axis parameters, such as measuring system, drive parameters and position controller.
- Configurable controller structures: P-controller, PID controller, 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 (supported by TC3 CAM Design Editor [optional]).
- FIFO axes (optional).
- External set value generators.
- Multi-master coupling.

Further information

- [PLC Libraries](#)
- [ADS Specification of the NC](#)

3 Quick Starting Guide

This documentation shows the first steps from axis configuration to the movement of axes on the basis of various examples.

On the basis of an example you will find out how to:

- insert a servo drive and a motor into the IO configuration,
- create a PLC axis variable,
- link a servo drive and a PLC axis variable with an NC axis,
- create a simulation axis.

We also show you how to:

- manually move an axis,
- create a simple PLC sample program to control an axis,
- start a recording with the TwinCAT 3 Scope for the above PLC sample program.

3.1 NC-Axes within the MOTION-Subtree

On this page you will find out where you can find and set NC axes in the MOTION subtree.

Numerical Control (NC)

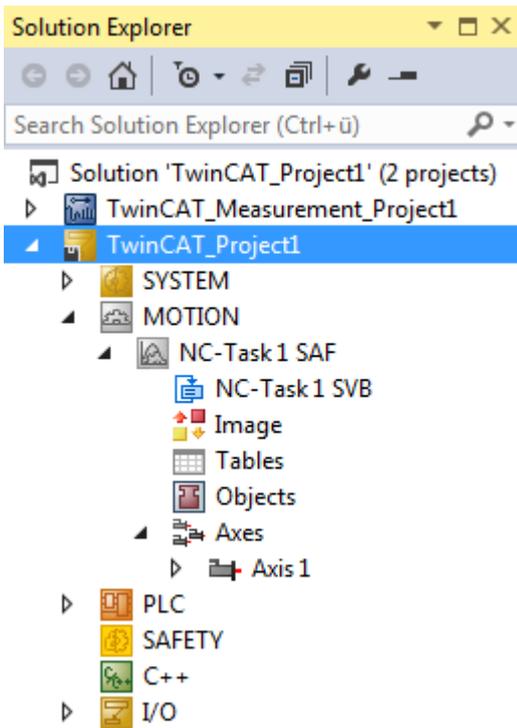
An NC axis maps a motor axis in software.

For this mapping of hardware in software, you can connect NC axes to PLC axis variables and servo drives within an IO configuration as part of an NC configuration.

- If no servo drive is available within an IO configuration, you can set up a [simulation axis](#) [► 12].

Subtree for NC axes: Structure

- Open the **Solution Explorer**.
- If an NC configuration has already been added, the MOTION subtree contains an SAF task subtree.
- The Axes axis level is located underneath the SAF task. This contains the NC axes.



Further information on inserting an NC axis can be found in the section [Inserting an NC configuration](#) [► 18].

- NC task 1 SAF**
- SAF task.
 - Task for the block execution (**Satzausführung**).
 - Task in which the setpoint generation takes place.
 - Task that communicates with the fieldbus IO of the NC.

- NC task 1 SVB**
- SVB task.
 - Task for the block preparation (**Satzvorbereitung**).
 - Linking and "Look-Ahead" of NCI segments.
 - No effect on single-axis movements (PTP).
 - Not responsible for the fieldbus IO of the NC.

- Image**
- NC process image.

- Tables**
- Tables.
 - For example for cam plates.

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

- Axes**
- NC axis configuration.
 - Created automatically.
 - Double-clicking opens an online dialog.
 - If the TwinCAT system has been started with the current configuration: this online dialog displays the most important current setpoints and actual values of the NC axes configured in this configuration.

Tab for an NC axis

Double-clicking the NC axis **Axis 1** opens the selection for the tabs in the figure below.

General	Settings	Parameter	Dynamics	Online	Functions	Coupling	Compensation
Name:	Axis 1					Id:	1

3.2 Simulation Axis

In the following section you will find out how to set up an NC axis as a simulation axis.

A simulation axis is not linked with drive hardware via the IO configuration.

Axis type

Settings dialog:

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

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

[1] Select this entry.

[2] Remains empty.

Setting up a simulation axis

1. In the axis level, select the NC axis that you wish to set up as a simulation axis.
2. Open the **Settings** dialog for this NC axis.
3. In the drop-down box for the axis type, select the entry **Standard (Mapping via Encoder and Drive)** [1].
4. For a simulation axis the entry **Link To I/O...** [2] remains empty.
⇒ You have set up the NC axis as a simulation axis.

Further information

- Creating a PLC axis variable: [Motion Control in the PLC project](#) [► 28]
- Adding an NC axis: [Inserting an NC configuration](#) [► 18]
- Linking an NC axis with a PLC axis variable: ["Link To PLC..." button](#) [► 22]

3.3 IO Configuration

In the section "IO configuration", various methods of inserting a servo drive into the IO configuration are shown.

● Simulation

i If you work in simulations without drive hardware, you can skip the section "IO configuration" and continue reading in the section "NC configuration" [► 18].

● Hardware connected?

i For successful automatic detection of hardware, this hardware must also be connected to the target system.

3.3.1 Detecting servo drives automatically

Scan

In the example shown, a scan of the IO configuration of EtherCAT and of a connected servo drive from the AX5000 series is performed.

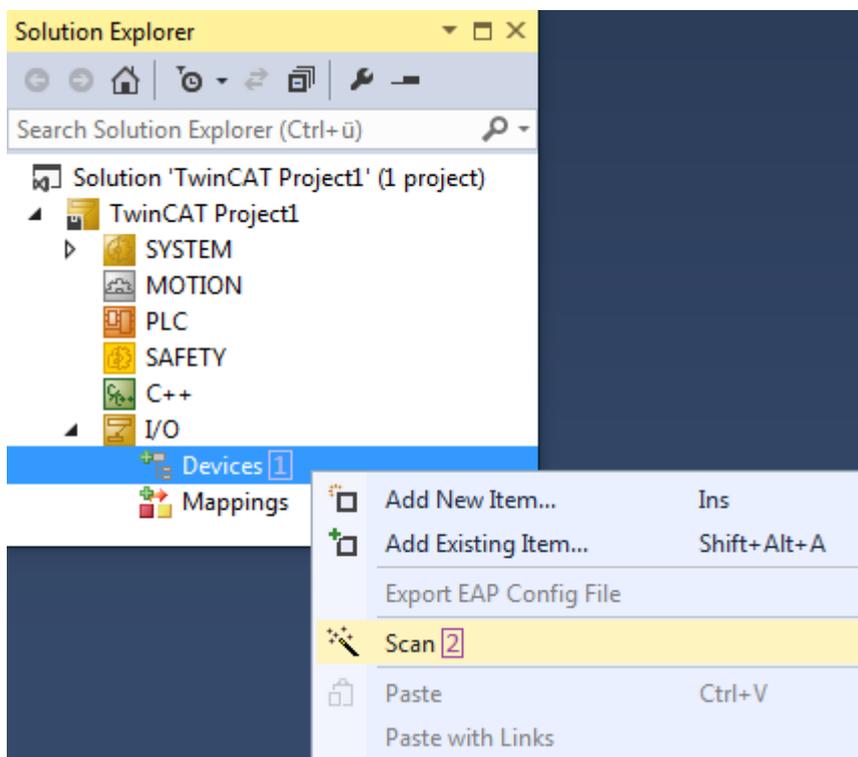
● CONFIG mode

i The target system must be in CONFIG mode for a scan of the IO configuration.

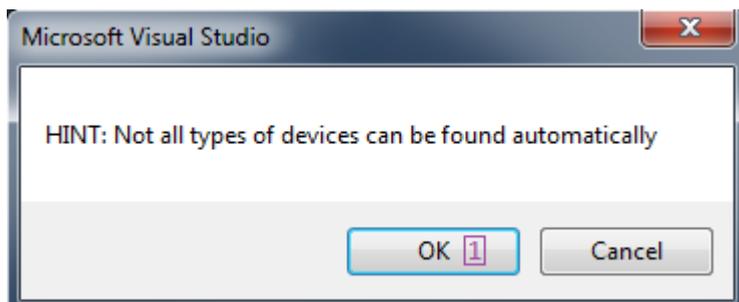
● Third-party products

i In general, a scan also works for third-party products, but not without exception.

Start Scan



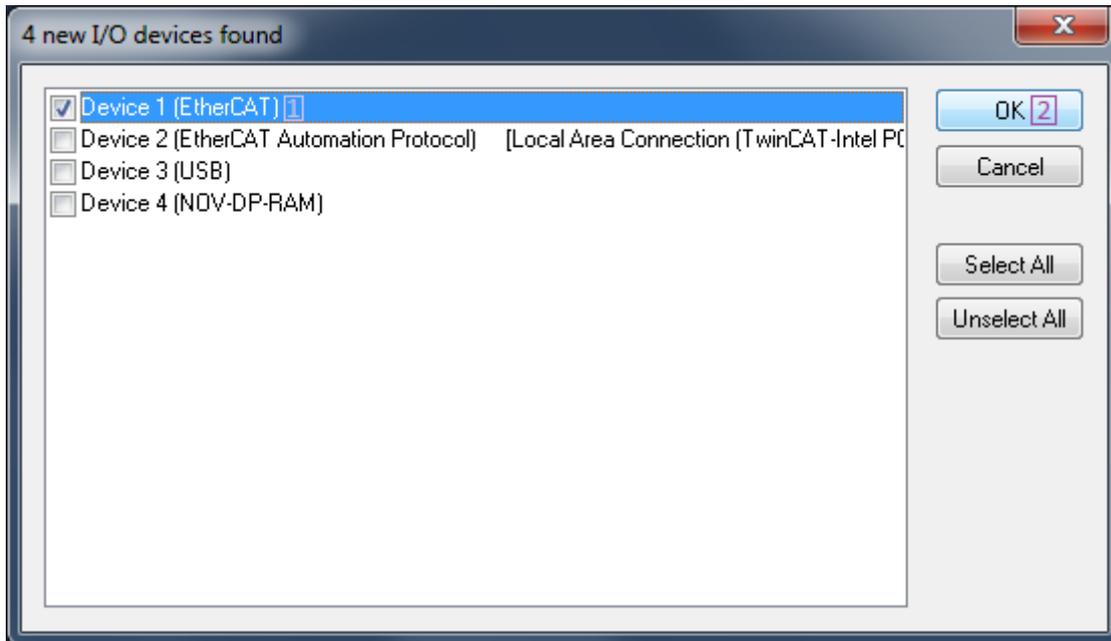
- ✓ The IO tree contains an entry called **Devices** [1].
- 1. Right-click the entry **Devices** [1].
 - ⇒ A context menu opens.
- 2. Select the entry **Scan** [2].
 - ⇒ Automatic reading of the device configuration begins.
 - ⇒ A message box opens. It contains a notice that not all device types can be detected automatically.



- ✓ A message box is open. It contains a notice that not all device types can be detected automatically.

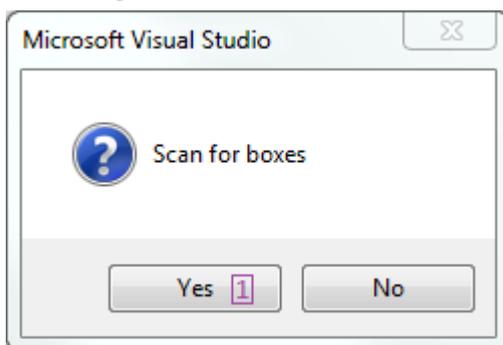
1. Confirm this notice with the **OK** button [1].
- ⇒ A dialog opens. It shows the IO devices found.

Selecting IO devices



- ✓ A dialog shows the IO devices found.
 - ✓ An IO device can be selected with a checkbox.
1. If not already selected, select the IO device for which you wish to configure a drive with the checkbox [1].
 2. If not already deselected, deselect the IO devices for which you do not wish to configure a drive with the other checkboxes.
 3. Actuate the **OK** button [2] to confirm your settings.
- ⇒ The device for which you wish to configure a drive is entered in the IO tree under the **Devices** node.
- ⇒ A message box opens, asking whether you wish to search for new boxes.

Searching for new boxes



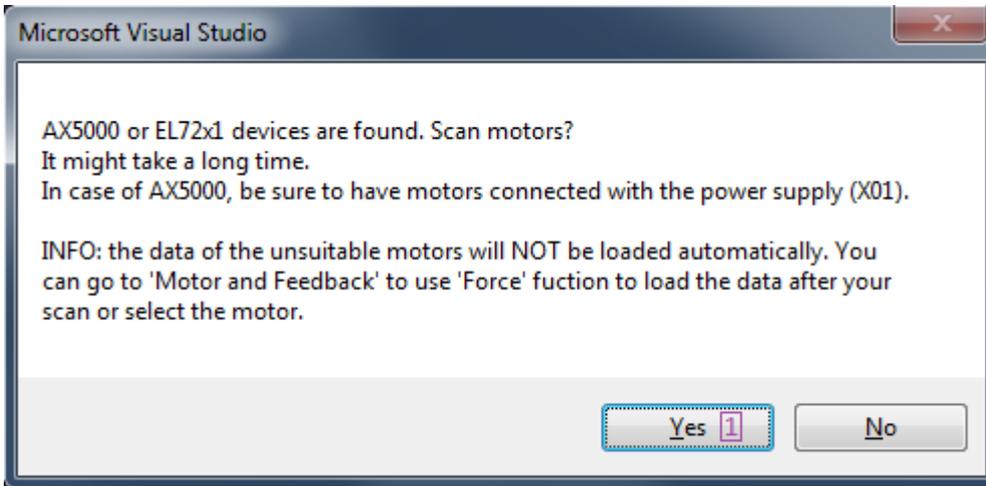
- ✓ A message box that asks you whether you wish to search for new boxes is open. Such boxes could be, for example, IO terminals or servo drives.
1. Confirm the message box with the **Yes** button [1].
- ⇒ The IO devices found will be appended.
- ⇒ A dialog opens, informing you that servo drives have been found. You will be asked whether servo drives should be scanned for connected motors.

Scanning motors

This automatic function corresponds to the manual insertion of a servo drive in the IO configuration, as described in [Inserting servo drives manually](#) [► 16].

i Beckhoff motors with digital name plate

- The automatic detection of motors is only possible with motors from Beckhoff with a digital name plate, i.e. with an encoder.
- If automatic detection is not possible, the parameters of a motor can be set manually in the Twin-CAT Drive Manager.
The manual setting of motor parameters can also be important for diagnostic purposes.



- ✓ In a dialog you will be asked whether a scan for motors should be performed.
- 1. Answer this question by actuating the **Yes** button [1].
- ⇒ Motors found are appended to the configuration in the IO tree.
- ⇒ A dialog opens, asking whether the motor appended to the IO configuration should be added to the NC configuration and linked to the NC configuration.
- ⇒ If the option **NC-Configuration** has been selected and confirmed, the associated logical axes will be automatically created and linked for the setpoint generation.
- ⇒ The scan has been completed for the selected devices of the connected hardware.
The result is that a configuration has been created in the IO tree for the selected devices of the connected hardware.

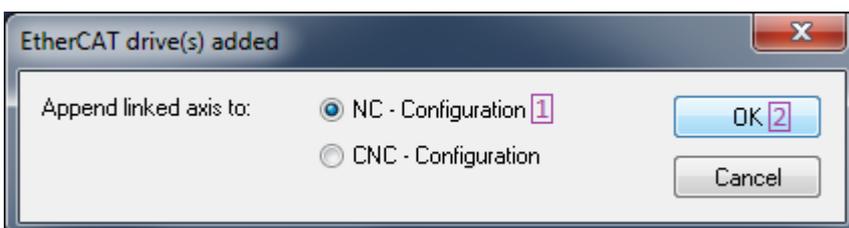
Drive amplifiers: Further information

- [AX5000 SystemManual HW2 - Version 2.0](#)
- [AX5000 - TwinCAT Drive Manager](#)

EtherCAT drive(s) added

This automatic function corresponds to the manual creation and connection of an NC axis in the sections

- [Inserting an NC configuration, \[▶ 18\]](#)
- [Button "Linked with I/O...". \[▶ 23\]](#)



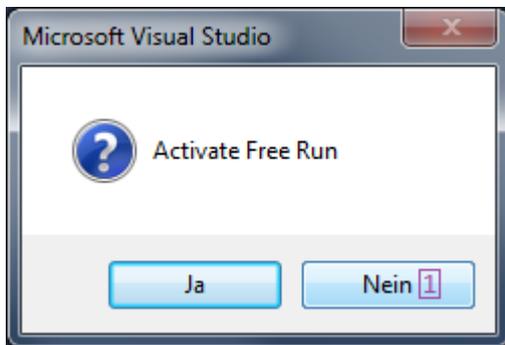
- ✓ The **EtherCAT drive(s) added** dialog is open.
- ✓ This dialog offers you the option of adding the axes inserted into the IO configuration to the NC configuration or to the CNC configuration and connecting them with the respective configuration.
- 1. Select the option field **NC-Configuration** [1] if you wish to add the inserted axis to the NC configuration.
- 2. Confirm your selection with the **OK** button [2].

3. If you do not wish to add the axes inserted into the IO configuration to the NC configuration or to the CNC configuration, you have the option later on of manually creating NC axes or CNC axes for the axes inserted into the IO configuration and of connecting them with the axes inserted into the IO configuration. Information on this can be found in the section "[NC configuration](#)" [▶ 18].

- ⇒ You have selected the option **NC-Configuration** [1] and confirmed it with the **OK** button [2].
- ⇒ The axis inserted into the IO configuration is added to the NC configuration and connected to the NC configuration.
- ⇒ Within the scope of the NC configuration, an NC-Task is created in the MOTION tree.
- ⇒ The NC-Task subtree contains a subtree with the name "Axes".
- ⇒ A module is created in the Axes subtree for each axis created in the NC configuration. Each of the modules created is given a default name, e.g. "Axis 1", "Axis 2",
- ⇒ Each axis in a subtree within the NC configuration is linked with an axis configured within the IO configuration.

Enabling Free Run

If the Free Run mode is enabled, IO variables can be read from and written to supported Bus Terminals without a configured and enabled task. The target system must be in configuration mode for this.



- ✓ A message box asks whether the Free Run mode should be enabled.
- 1. To enable the Free Run mode, confirm the message box with "Yes"
- 2. If you don't wish to enable the Free Run mode, answer this question with **No** [1].
- ⇒ After actuating the **No** [1] button, the message box closes and the Free Run mode is not enabled.

i IO, MOTION Activation of the configuration: **Activate Configuration**

- A configuration only becomes effective on a target system when it is activated for this target system.
- An IO configuration determined by a scan also has to be activated for the intended target system.
- Likewise, you have to activate a configuration in the MOTION subtree for the intended target system.
- To do this, select your desired target system under **Choose Target System**.
- Then activate the configuration for your chosen target system with the **Activate Configuration** button.

3.3.2 Inserting servo drives manually

Manually inserting servo drives into the IO configuration

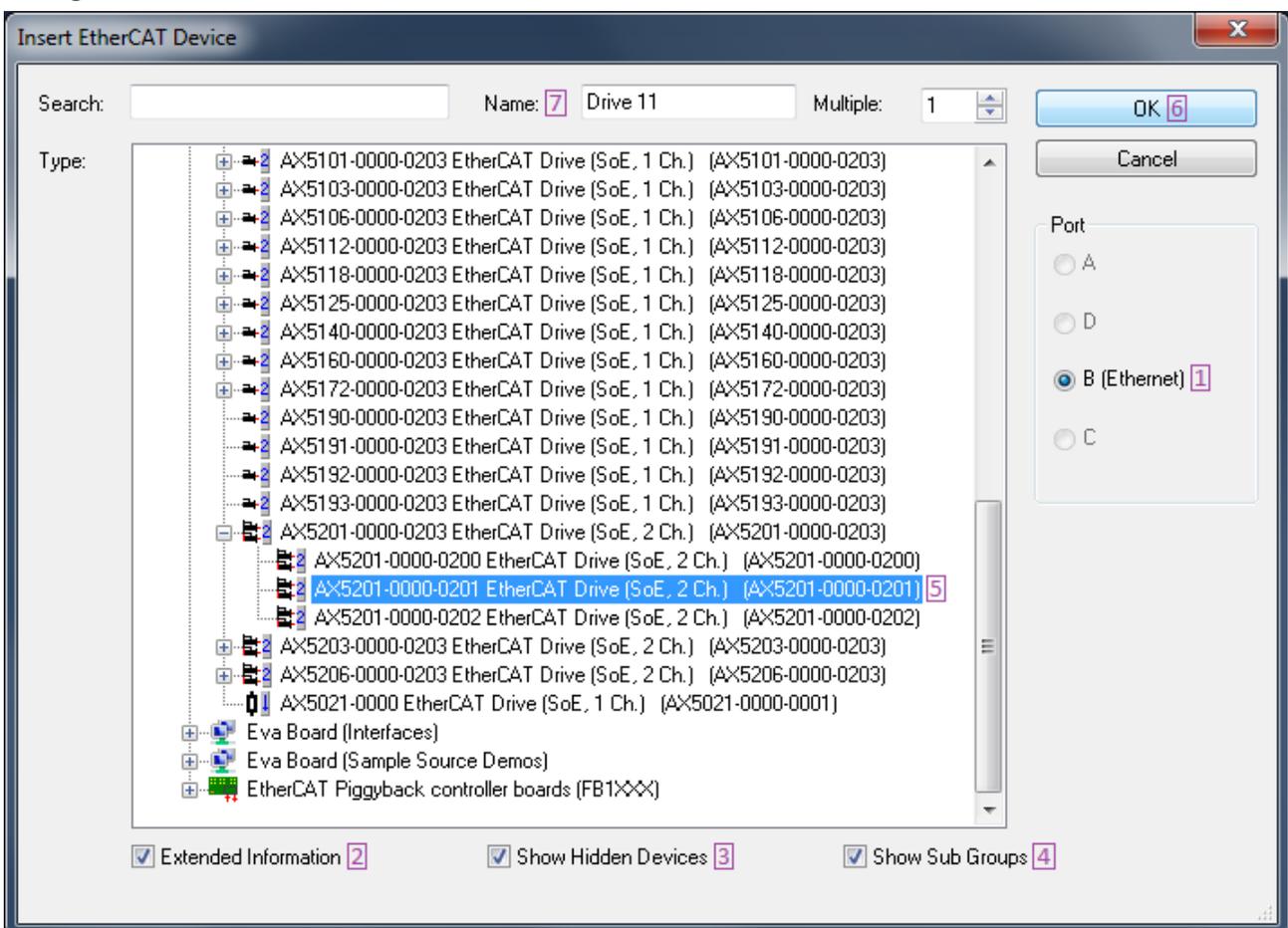
As an alternative to an automatic scan, you can also manually insert a servo drive into an IO configuration.

Add New Item...



- ✓ At least one EtherCAT Master device is inserted in the IO tree under **Devices**.
- 1. In the IO tree, right-click the EtherCAT Master device to which you wish to add a drive.
 - ⇒ A context menu opens.
- 2. Select the context menu entry **Add New Item... [1]**.
 - ⇒ The dialog **Insert EtherCAT Device** opens.

Dialog: Insert EtherCAT Device



- ✓ The dialog **Insert EtherCAT Device** is open.
- ✓ The **Drives** entry is located under **Type** in the device tree.
 1. If necessary, use the radio button under **Port [1]** to set the appropriate option for a port of the predecessor module to which the drive is to be appended.
 2. Open the **Drives** subtree under **Type** in the device tree.
 3. If necessary, if the servo drive you are looking for does not appear in the **Drives** subtree, check one or more of the checkboxes **Extended Information [2]**, **Show Hidden Devices [3]** and **Show Sub Groups [4]**.
 4. In the open **Drives** subtree, select the drive [5] that you wish to insert.
 5. If necessary, enter a name for the drive that you wish to insert into the IO configuration in the **Name** text box [7].

6. Actuate the **OK** button [6] to confirm your settings.
 - ⇒ The axis you selected has been added to the IO configuration, if applicable under the name you entered.
 - ⇒ The dialog **EtherCAT drive(s) added** opens (see section [Automatically reading a drive amplifier \[► 13\]](#)).

3.4 NC Configuration

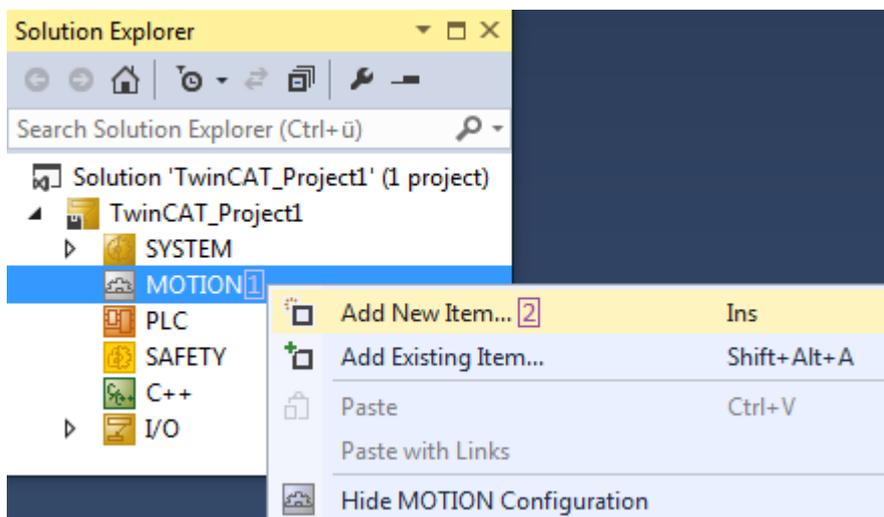
The section NC configuration shows the various options for linking NC axes and how they are manually added.

Integrating and linking NC software packages or CNC software packages

In the dialog **EtherCAT drive(s) added**, which is described in the section [Automatically reading of drive amplifiers \[► 13\]](#), choose whether you wish to create an NC configuration or a CNC configuration in the MOTION subtree.

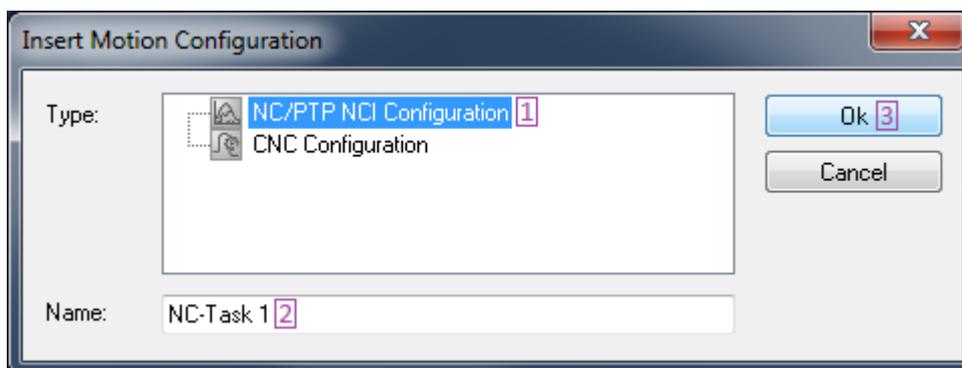
3.4.1 Inserting an NC Configuration

Motion: Add New Item...



1. Right-click the node MOTION [1].
 - ⇒ A context menu opens.
2. Select the context menu entry **Add New Item...** [2].
 - ⇒ The dialog **Insert Motion Configuration** opens.

Dialog: Insert Motion Configuration



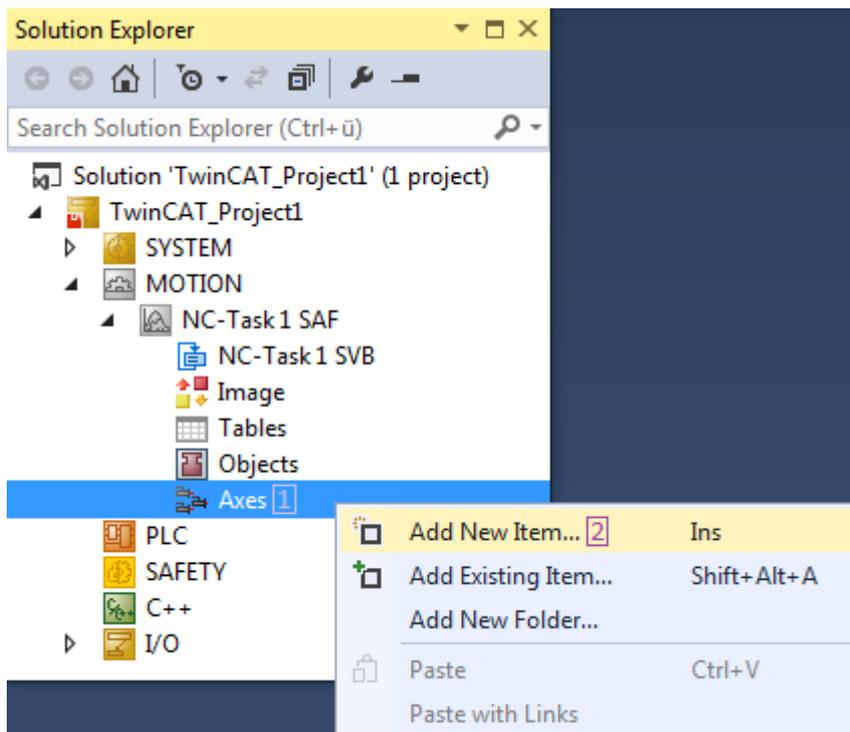
- [1] Select this entry if you wish to add an NC configuration.

- [2] Give a name to the NC configuration that you wish to insert.
- [3] Confirm your settings.

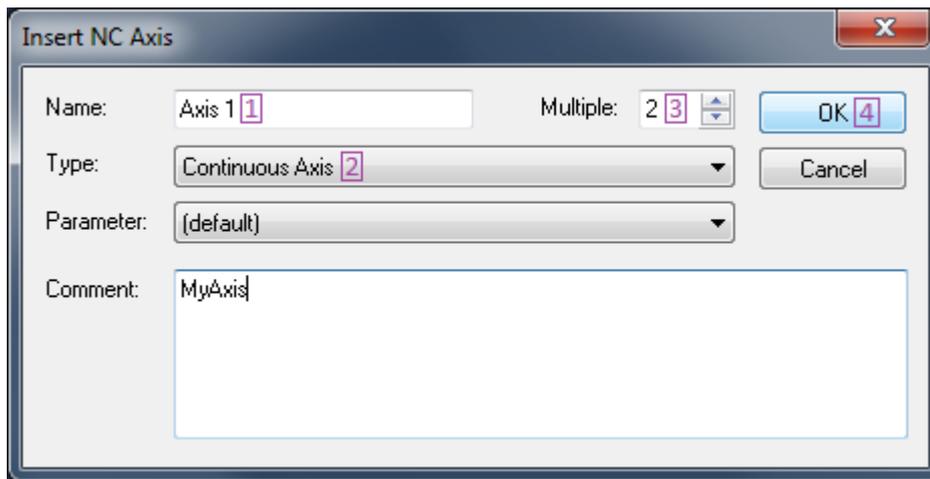
Inserting a motion configuration

- ✓ The dialog **Insert Motion Configuration** is open.
- 1. If you wish to add an NC configuration, select the entry **NC/PTP NCI Configuration** [1].
- 2. In the text box **Name** [2] give a name to the NC configuration that you wish to insert.
- 3. Confirm your settings with the **Ok** button [3].
- ⇒ An NC task is inserted in the MOTION subtree.
- ⇒ The subtree of the NC task contains the entry **Axes**.

Axes: Add New Item...



1. Right-click the node **Axes** [1].
 - ⇒ A context menu opens.
2. In the context menu, select the entry **Add New Item...** [2].
 - ⇒ The dialog **Insert NC Axis** opens.

Dialog: Adding an NC axis

✓ With the opened dialog **Insert NC Axis** you can add one or more axes to the associated NC task.

1. The text box **Name** [1] provides you with the option to give a name to the axis that you wish to insert.

2. In the drop-down box **Type** [2], select **Continuous Axis** [2] if you wish to insert one or more continuous axes.

A continuous axis is, for example, a servo axis, a DC axis or a stepper axis.

3. You can add several axes with the same settings in a single step using the numeric up/down control element **Multiple** [3].

4. Confirm your settings with the **OK** button [4].

⇒ For example, two axes have been added to the subtree **Axes**.

⇒ In the example, these two axes have been given the names "Axis 1" and "Axis 2" as default names.

⇒ For each of the inserted axes you have the option to open the Settings dialog.

⇒ In the **Settings** dialog you can connect the axis of an NC task with an appropriate axis inside the IO configuration and with an axis inside the PLC configuration.



The parameters for the axis commissioning can be found at the end of this documentation.

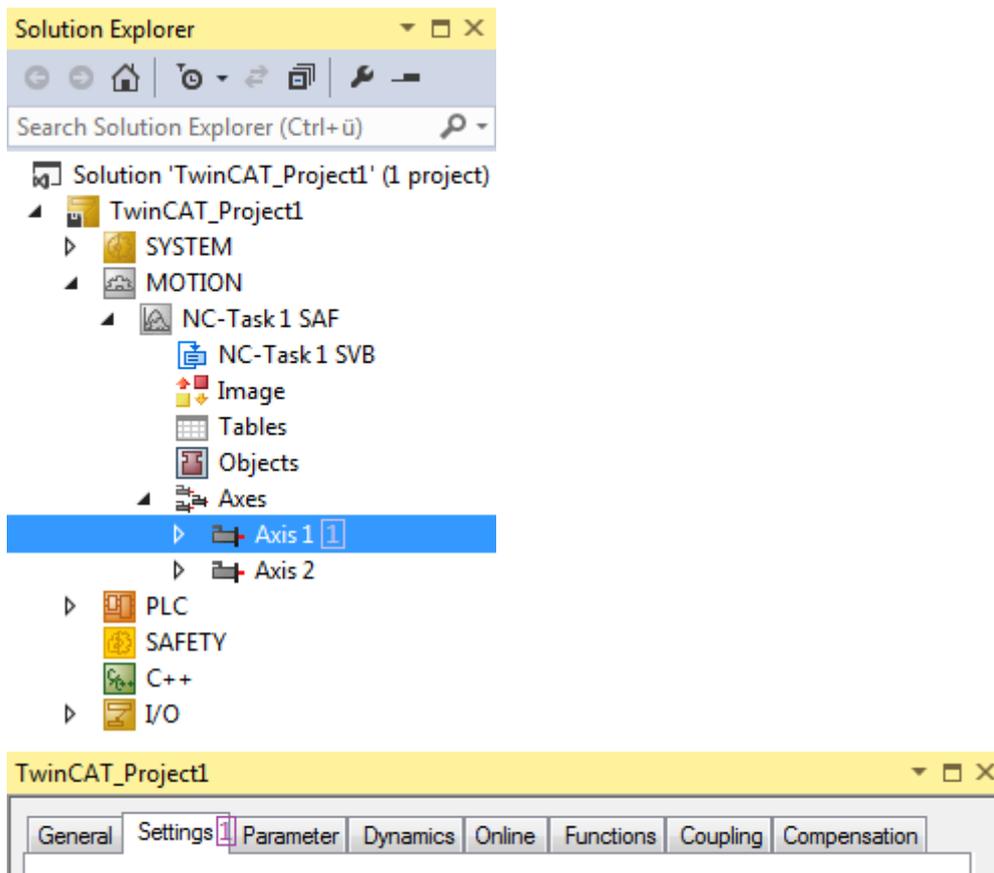
3.4.2 Linking an NC Software Package

Opening the Settings dialog for an NC axis

1. Double-click the NC axis [1] for which you wish to open a dialog.

2. Select the **Settings** tab [1].

⇒ The **Settings** dialog opens.



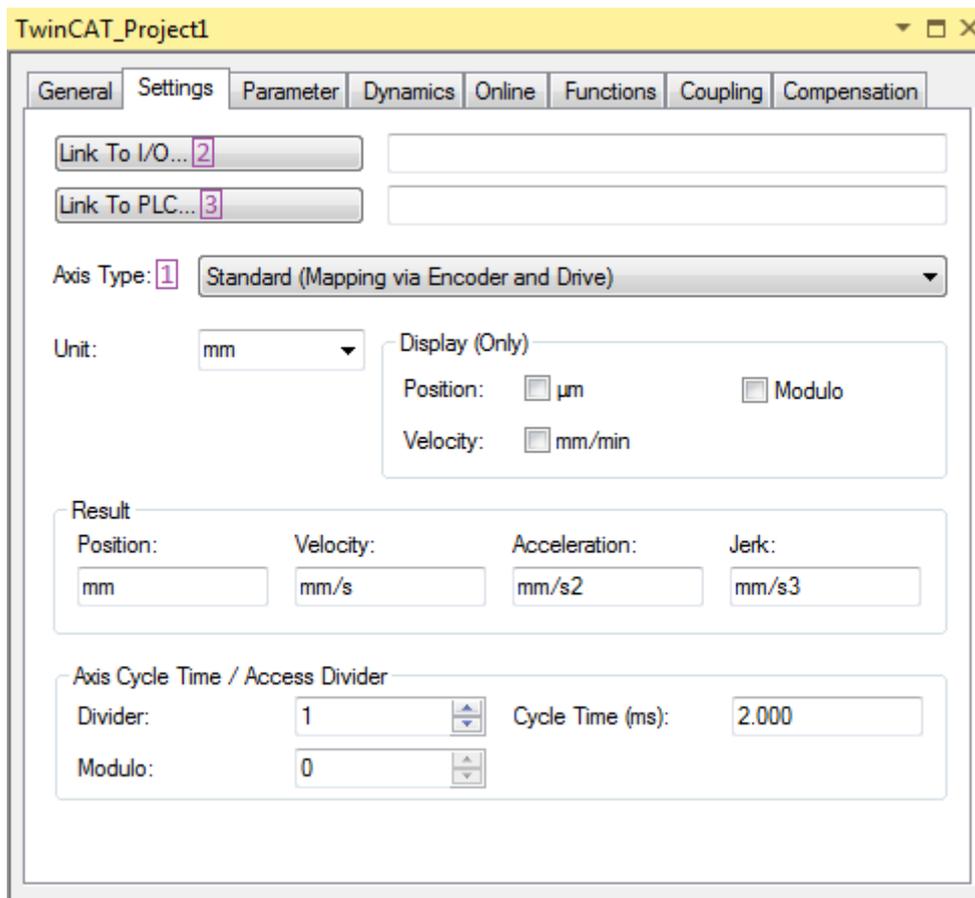
Drop-down list box Axis Type

The drop-down list box **Axis Type** [1] assumes the value "Standard (Mapping via Encoder and Drive)" if the axis selected in the NC configuration is not linked with any device inside the IO configuration.

Link To I/O... and Link To PLC... buttons

With the **Link To I/O...** button [2] you connect the interfaces of the NC software package with a servo drive inside the IO configuration.

With the **Link To PLC...** button [3] you connect the interfaces of the NC software package with an axis variable of a PLC project.



i Coming into effect of the configuration Activate Configuration

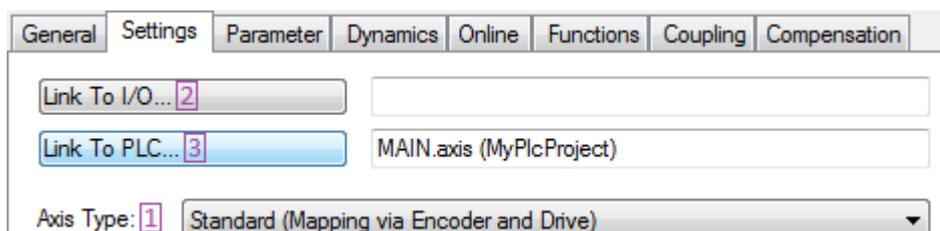
- A configuration only becomes effective on a target system when it is activated for this target system.
- You also have to activate a configuration in the **Settings** dialog for the intended target system.
- To do this, select your desired target system under **Choose Target System**.
- Then activate the configuration for your chosen target system with the **Activate Configuration** button.

3.4.3 Button “Link To PLC...”

Connecting a PLC project

There is cyclic communication from the NC to the PLC and vice versa. NC axes must be linked with the PLC in order to set up this communication.

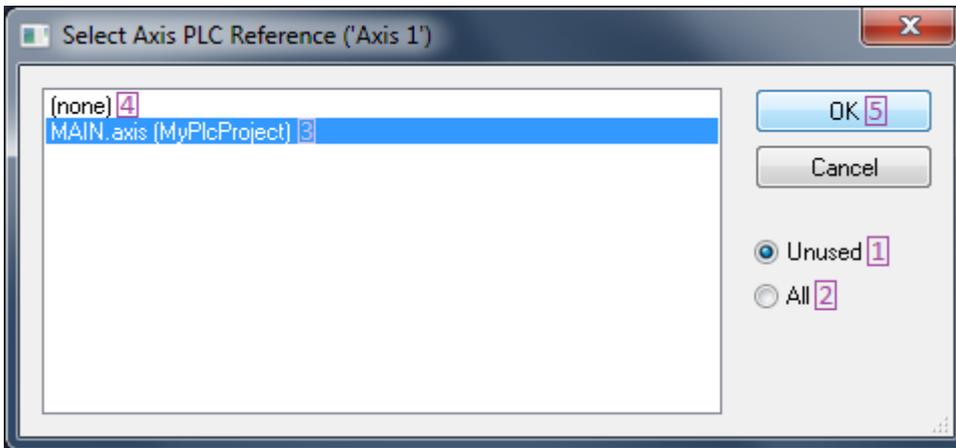
Opening the dialog Select Axis PLC Reference...



- ✓ An axis variable of the type `AXIS_REF` has been created in a PLC project.
- ✓ The PLC project with the axis variables of the type `AXIS_REF` has been successfully created. Only axis variables whose PLC project has been successfully created after their declaration are displayed in the dialog **Select Axis PLC Reference...**

- ✓ The text box to the right of the **Link To PLC...** button [3] shows the axis variables of the type `AXIS_REF` with which the axis selected in the NC configuration is linked.
 - ✓ If you wish to change this link, create a link or cancel a link:
 1. Open the **Settings** dialog for the axis inside the NC configuration that you wish to link with an axis variable of the type `AXIS_REF` or whose link you wish to cancel.
 2. Actuate the **Link To PLC...** button [3].
- ⇒ The dialog **Select Axis PLC Reference...** opens.

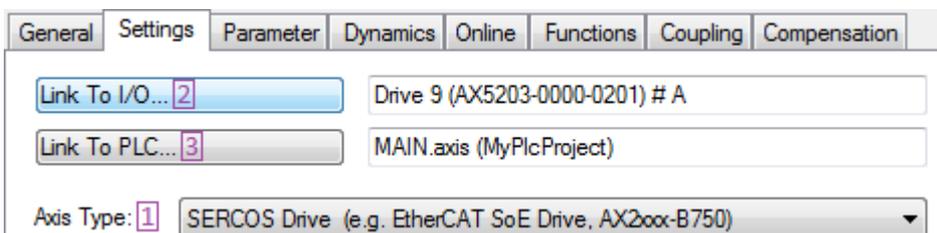
Selecting an axis variable



1. Use the **Unused** option box [1] to display all unlinked axis variables of the type `AXIS_REF` in the list box.
 2. Use the **All** option box [2] to display all axis variables of the type `AXIS_REF` in the list box. In this way it is possible to change existing configurations.
 3. In the list box, select the axis variable [3] of the type `AXIS_REF` with which you wish to link the axis selected in the NC configuration.
 4. Select the entry **(none)** [4] if you do not wish to link any axis variable or if you wish to cancel an existing link to an axis variable.
 5. Confirm your selection with the **OK** button [5].
- ⇒ The axis selected in the NC configuration is linked according to your choice.

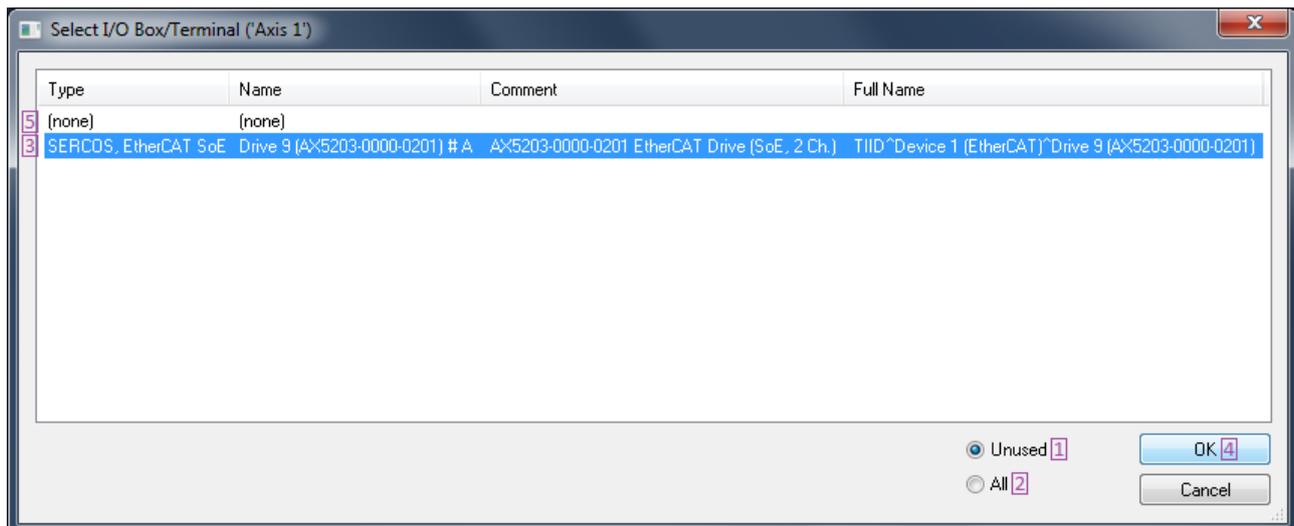
3.4.4 Button “Link To I/O...”

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



- ✓ The text box to the right of the **Link To I/O...** button [2] shows the device inside the IO configuration with which the axis selected in the NC configuration is linked.
 - ✓ If you wish to change this link:
 1. Actuate the **Link To I/O...** button [2].
- ⇒ The dialog **Select I/O Box/Terminal ...** opens.

Selecting a drive



1. Use the **Unused** option box [1] to display all unused drives in the table.
 2. Use the **All** option box [2] to display all configured drives in the table. In this way it is possible to change existing configurations.
 3. In the selection table, select the configured drive [3] that you wish to link with the axis selected in the NC configuration.
 4. Confirm your selection with the **OK** button [4].
- ⇒ The link has been changed according to your selection.
- ⇒ The text box to the right of the **Link To I/O...** button [2] shows the device inside the IO configuration with which the axis selected in the NC configuration is linked.
1. In the dialog Select I/O Box/Terminal ..., select the entry **(none)** [5] if you do not wish to link any device inside the IO configuration or if you wish to cancel an existing link to a device inside the IO configuration.

In the example, the drop-down list box **Axis Type** [1] has assumed the value "SERCOS Drive (e.g. EtherCAT SoE Drive, AX2xxx-B750)" after the NC axis was linked with the servo drive "Drive 9 (AX5203-0000-0201) # A".

3.5 Position Limits

The section "Limits for positions" shows how a collision can be prevented and how, for example, the software limit switch or the position lag monitoring can be enabled.



Purely functional settings are explained in the section "Limits for positions"; these are not safety functions in the sense of safety technology.

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

Collision-prevention measures

NOTE
If the commissioning is not carried out correctly, this can lead to a collision and damage.
<ul style="list-style-type: none"> • Activate the software limit switch. • Activate the position lag monitoring. • Use freely rotating axes for initial commissioning.

NOTE
An incorrect scaling factor and an incorrect direction of rotation can cause damage.
<ul style="list-style-type: none"> • Inside the IO configuration, double-click the servo drive for which you wish to open the Drive Manager. • Set the scaling factor and the direction of rotation in the Drive Manager.

Activating the software limit switches

1. Select the NC axis for which you wish to activate the software limit switches.
 2. Open the **Parameters** dialog for this NC axis.
 3. Set the value of the parameter Limit Switches: Soft Position Limit Minimum Monitoring [1] to `TRUE`. To do this, use the associated drop-down box in the table column Offline Value.
 4. Set the value of the parameter Limit Switches: Soft Position Limit Maximum Monitoring [2] to `TRUE`. To do this, use the associated drop-down box in the table column Offline Value.
 5. With the parameter Limit Switches: Minimum Position [4] for the smallest position value that can be driven to, set a value that allows sufficient freedom of movement while ruling out the possibility of a collision.
 6. With the parameter Limit Switches: Maximum Position [5] for the largest position value that can be driven to, set a value that allows sufficient freedom of movement while ruling out the possibility of a collision.
- ⇒ You have activated the software limit switches for the selected NC axis.

Activating the position lag monitoring

1. Select the NC axis for which you wish to activate the software limit switches.
 2. Open the **Parameters** dialog for this NC axis.
 3. For the parameter Monitoring: Position Lag Monitoring [3], set the value `TRUE`. To do this, use the associated drop-down box in the table column Offline Value.
 4. With the parameter Monitoring: Maximum Position Lag Value [6], set a value for the largest permissible position lag that allows sufficient control freedom while ruling out the possibility of a collision. The default value is usually OK.
 5. For the parameter Monitoring: Maximum Position Lag Value [7], set a value that allows sufficient control freedom while ruling out the possibility of a collision. The default value is usually OK.
- ⇒ You have activated the position lag monitoring for the selected NC axis.

3.6 Moving an Axis Manually

On this page you will find out how axes can be moved manually from the System Manager.

Configuration mode

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

● Manual movement - Link To PLC...



For a manual movement:

In the **Settings** dialog of the NC axis, set the entry **Link To PLC...** to the value "(none)" or stop the PLC program with the **Stop** button.

● Manual movement – Activate configuration



For manual movement: Enable the configuration in order to transfer configuration changes to the target system.

⚠ DANGER

Risk of injury due to movement of axes!

The commissioning results in a movement of axes. There is a risk of injury to body parts.

- Maintain a suitable safety distance.
- Do not remain within the movement range.

Run mode, controller enable, movement

For manual movement you have to restart the TwinCAT system in Run mode.

The **Online** dialog for an NC axis is suitable as a commissioning visualization for the initial commissioning of an axis.

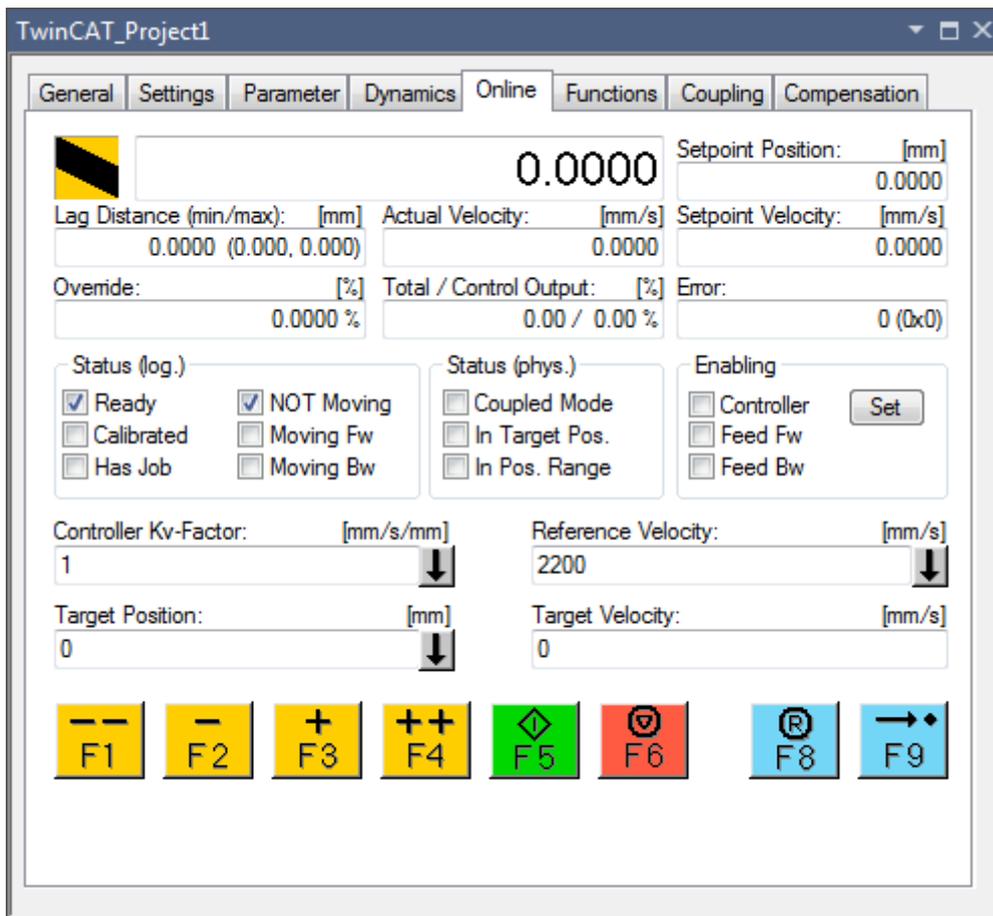
⚠ WARNING

Axis position during initial commissioning

As a rule, the axis position is displayed incorrectly before initial commissioning.

- Therefore, perform homing before initial commissioning.
- Or apply a position voltage as a zero position offset.

After you have restarted the TwinCAT system in Run mode, the **Ready** and **NOT Moving** checkboxes are each checked in the **Status (log.)** group box in the **Online** dialog for the NC axis Standard (Mapping via Encoder and Drive).



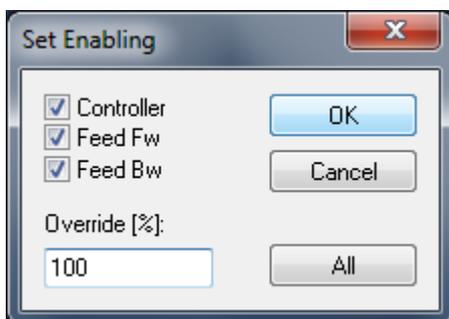
1. To move manually, first set the controller enable.
2. Move with the buttons **F1 - F6** and **F8 - F9**.

Setting the controller enable

The drive must be ready to operate in order to set the controller enable.

- Ready**
- If set, the drive is ready to operate.
 - The simulation axis is ready to operate as a rule.

The **Set** button in the **Enabling** group box in the **Online** dialog of an NC axis opens the **Set Enabling** dialog to set the controller enable for the corresponding axis.



- Controller**
- Required for position control to be active.
 - The controller is not active without the controller enable.
 - If linked to the PLC: Corresponds to the `Enable` input of the `MC_Power` function block.

- Feed Fw**
- The axis cannot be started in the positive direction without an enable in the positive direction.

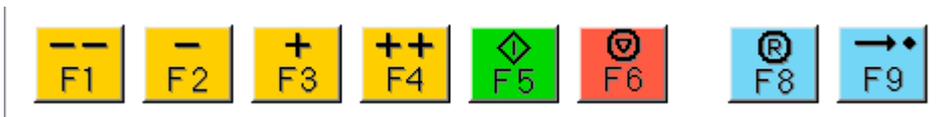
- If the axis is moving in the positive direction and the enable in the positive direction is canceled, the axis will be stopped.
If this cancelation of the enable is then undone again, the axis will not automatically restart.
- If linked to the PLC: Corresponds to the `Enable_Positive` input of the `MC_Power` function block.

Feed Bw

- The axis cannot be started in the negative direction without an enable in the negative direction.
- If the axis is moving in the negative direction and the enable in the negative direction is canceled, the axis will be stopped.
If this cancelation of the enable is then undone again, the axis will not automatically restart.
- If linked to the PLC: Corresponds to the `Enable_Negative` input of the `MC_Power` function block.

Override

- Influences the velocity of all travel commands as a percentage. It is $0 \leq \text{Override} \leq 100.0$.

The buttons F1 - F6 and F8 - F9

- Move with the buttons F1 - F6 and F8 - F9.

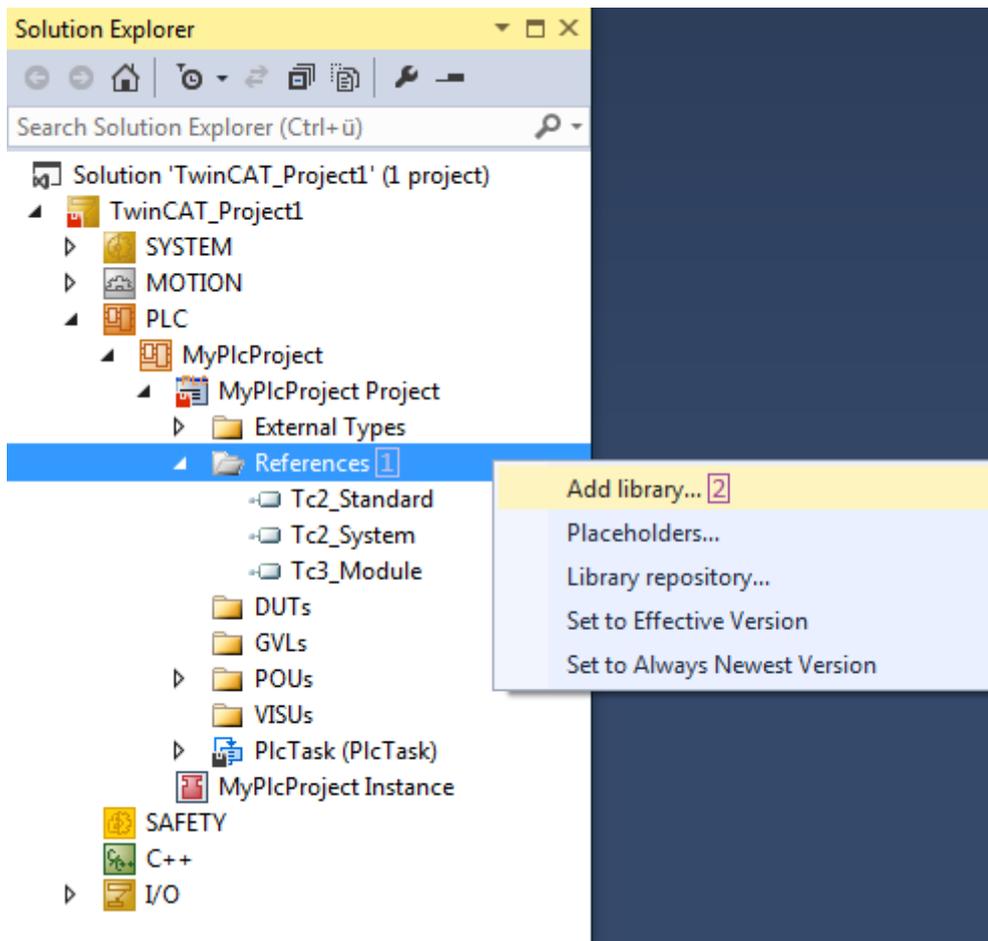
- F1** Fast movement in the negative direction of travel.
- F2** Slow movement in the negative direction of travel.
- F3** Slow movement in the positive direction of travel.
- F4** Fast movement in the positive direction of travel.
- F5** Movement at target velocity to the target position.
- F6** Stops axis movement.
- F8** Reset
- F9** Starts the homing sequence.

3.7 Motion Control in the PLC project

On this page you will find out how to implement motion control from the PLC project in accordance with PLCopen.

Opening the "Add Library" dialog

In order to be able to use motion control in accordance with **PLCopen**, you must add a reference to your PLC project.

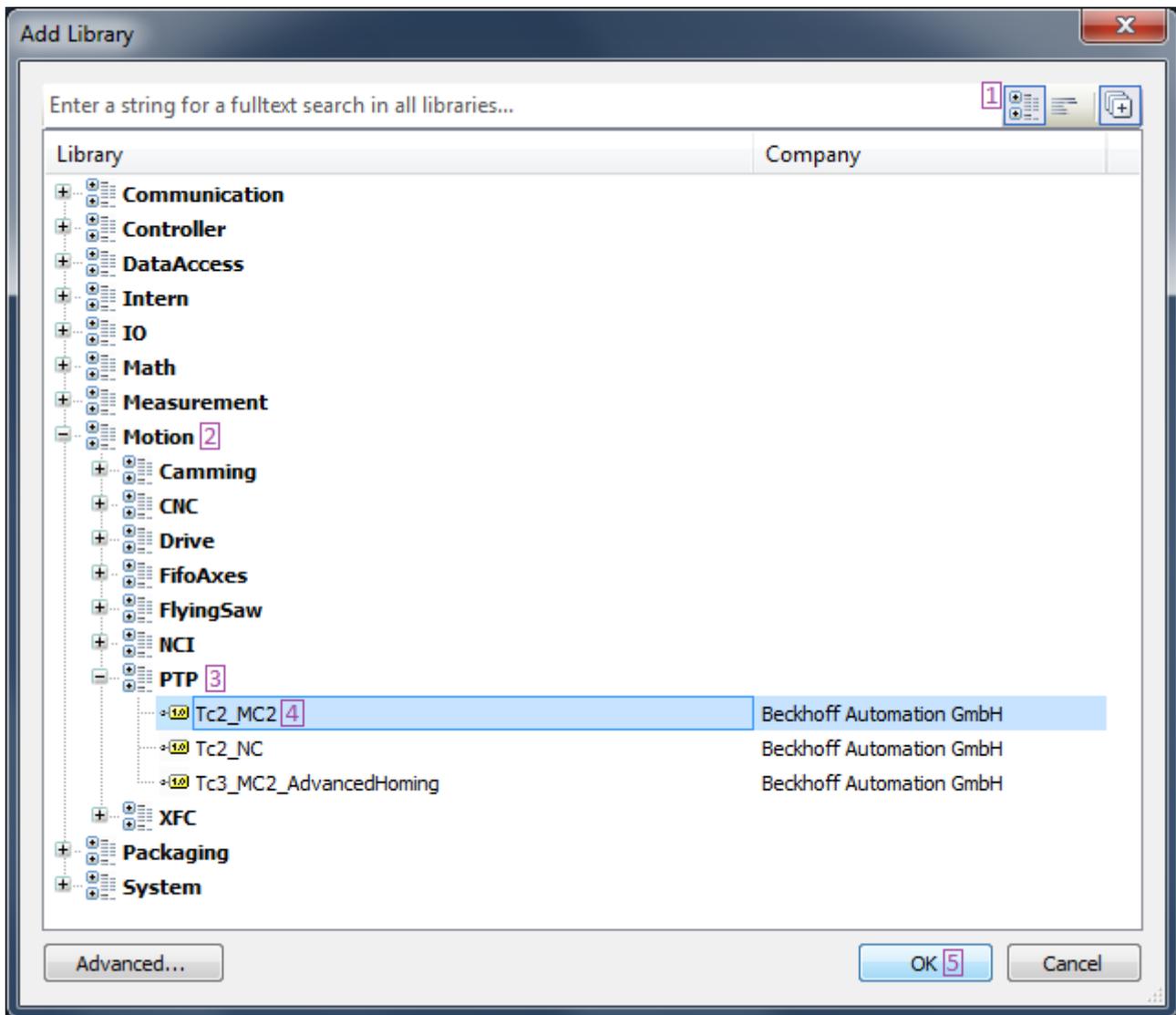


1. Create a new PLC project.
2. Right-click the **References** folder [1] in the PLC project to which you wish to add a reference.
 - ⇒ A context menu opens.
3. Click the entry **Add library...** [2] in the context menu.
 - ⇒ The **Add Library...** dialog opens.

Selecting a library

Tc2_MC2 is the default library

- for motion control in accordance with PLCopen,
- PTP motion (Point to Point Motion) and
- axis management.



- ✓ The **Add Library** dialog is open.
 - 1. Select the library that you wish to add to the PLC project.
 - 2. To do this, switch the **Add Library** dialog to the **Category View** [1] if it is in a different view.
 - 3. Expand the **Motion** subtree [2].
 - 4. Expand the **PTP** subtree [3].
 - 5. Select the **Tc2_MC2** library [4].
 - 6. Confirm your selection with the **OK** button [5].
- ⇒ A reference to the **Tc2_MC2** library [4] is created in the PLC project to which you wish to add this reference.

MC axis variable



The PLC axis variable `MAIN.axis` has the data type `AXIS_REF`.

The data type `AXIS_REF`:

- contains information about an axis,
- is an interface between the PLC and the NC and
- is given to the MC function blocks as a reference to an axis.

i Refreshing the status data structure in AXIS_REF

The status data structure `Status` of the type `ST_AxisStatus` contains additional or prepared status and diagnostic information about an axis. The structure is not cyclically refreshed, but has to be updated by the PLC program

Calling the `ReadStatus()` action from `AXIS_REF` updates the status data structure and should be done once at the beginning of each PLC cycle.

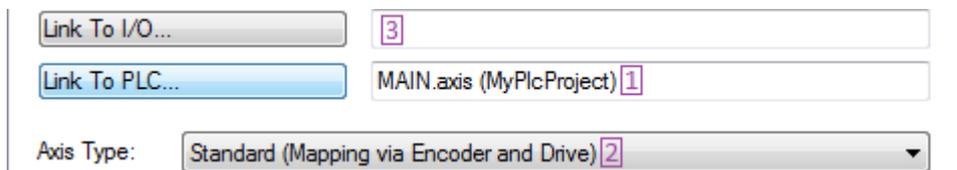
The status information does not change within a PLC cycle. After calling `ReadStatus()`, the current status information can be accessed in `AXIS_REF` within the entire PLC program.

The nature of the status data structure is purely informative. Therefore, its use is not mandatory.

```
PROGRAM MAIN
VAR
  axis: AXIS_REF;
END_VAR

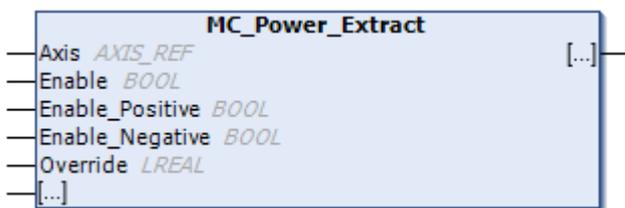
axis.ReadStatus();
```

Simulation axis



- [1] The local MC axis variable `MAIN.axis` is connected to the NC axis for movement with MC function blocks.
- [2] The simulation axis **Standard (Mapping via Encoder and Drive)** is set as the NC axis under **Axis Type**.
- [3] The entry **Link To I/O...** remains empty for a simulation axis.

MC_Power



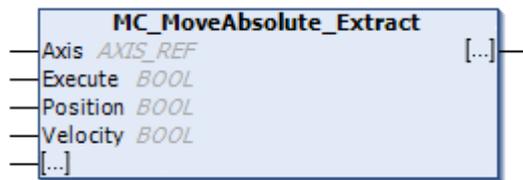
The function block **MC_Power** switches the software enabling of an axis.

MC_Power: Inputs (excerpt)

- Enable: BOOL;** Sets the general software and controller enabling for an axis. Enabled if `Enable = TRUE`. Corresponds to the **Controller** checkbox in the **Set Enabling** dialog. Enabled if the checkbox is checked.
- Enable_Positive: BOOL;** Sets the feed enabling for an axis for the positive travel direction. Enabled if `Enable_Positive = TRUE`. Corresponds to the **Feed Fw** checkbox in the **Set Enabling** dialog. Enabled if the checkbox is checked.
- Enable_Negative: BOOL;** Sets the feed enabling for an axis for the negative travel direction. Enabled if `Enable_Negative = TRUE`. Corresponds to the **Feed Bw** checkbox in the **Set Enabling** dialog. Enabled if the checkbox is checked.

Override: LREAL; Influences the velocity of all travel commands as a percentage. It is $0 \leq \text{Override} \leq 100.0$.

MC_MoveAbsolute



- The function block **MC_MoveAbsolute** starts the positioning to an absolute target position and monitors the axis movement over the entire travel path.

MC_MoveAbsolute: Inputs (excerpt)

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

Position: LREAL; Absolute target position to be used for positioning.

Velocity: LREAL; Maximum travel velocity. A positive value.

Sample program for moving to a target position

The **MAIN** program shows a short example with which a target position is to be moved to.

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 with 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>	Positive edge switches the <code>Execute</code> input 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.

Further information

- [TwinCAT 3 PLC Lib: Tc2_MC2](#)
- [PLC](#)

3.8 Movement with MC_Power and MC_MoveAbsolute

In this section you will find out how to set the general software and controller enable and the enable for the positive and negative direction of travel for an axis and how to move to a target position.

NC axis: Online

- After the TwinCAT system has been restarted in Run mode, the **Ready** and **NOT Moving** checkboxes are each checked in the **Status (log.)** group box in the **Online** dialog for the NC axis **Standard (Mapping via Encoder and Drive)**.

DANGER

Risk of injury due to movement of axes!

The commissioning results in a movement of axes. There is a risk of injury to body parts. Keep an appropriate safety distance, and stay clear of the operating space.

MAIN [Online]: MC_Power

1. Log in the compiled PLC project with the **Login** button.
2. Start the PLC program with the **Start** button.

The screenshot displays the TwinCAT Project1 - MAIN [Online] window. The top section shows a variable declaration table for the program. Below the table, the ladder logic code is visible, showing the initialization of the `axis` object and the `fbAxisPower` and `fbAxisMoveAbsolute` function blocks.

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

```

3. Open the online view for the MAIN program.
4. In the declaration part of the MAIN program, set the local variable `bEnable` to `TRUE`.
 - ⇒ As a result, the general software and controller enable has been set for the `axis` and the feed enable has been issued for the positive and negative direction of travel.
 - ⇒ In the **Online** dialog of the NC axis, the **Override** text box contains the percentage value `100.0000`, corresponding to the value of the variable `fOverride`.
 - ⇒ In the **Online** dialog of the NC axis, the **Controller**, **Feed Fw** and **Feed Bw** checkboxes are checked in the **Enabling** group box.

Override: [%]

Enabling

Controller

Feed Fw

Feed Bw

MAIN [Online]: MC_MoveAbsolute

- ✓ The online view for the MAIN program is open.
 - ✓ The variable `bMove` has the value `FALSE`.
1. In the declaration part of the MAIN program, set the variable `bMove` to the value `TRUE`, thus generating a rising edge.
 - ⇒ In the implementation part, this gives the `Execute` input of the `MC_MoveAbsolute` function block a value of `TRUE` and a rising edge.
 - ⇒ While moving, the **Online** dialog in the **Status (log.)** group box of the NC axis unchecks the **NOT Moving** checkbox and checks the **Moving Fw** and **Has Job** checkboxes.
 - ⇒ When the NC axis has arrived at the target position, the **Moving Fw** and **Has Job** checkboxes are unchecked and the **NOT Moving** checkbox is checked again.
 - ⇒ When the NC axis has arrived at the target position, the **In Target Pos.** and **In Pos. Range** checkboxes in the **Status (phys.)** group box will be checked.

While moving, the **Moving Fw** and **Has Job** checkboxes in the **Status (log.)** group box are checked.

Status (log.)

Ready NOT Moving

Calibrated Moving Fw

Has Job Moving Bw

When the NC axis has arrived at the target position, the **NOT Moving** checkbox in the **Status (log.)** group box is checked.

Status (log.)

Ready NOT Moving

Calibrated Moving Fw

Has Job Moving Bw

And the **In Target Pos.** and **In Pos. Range** checkboxes in the **Status (phys.)** group box are checked.

Status (phys.)

Coupled Mode

In Target Pos.

In Pos. Range

Set the variable `bMove` back to the value `FALSE` in order to be able to generate a new rising edge later if necessary.

Resetting the software enable

1. Set the variable `bEnable` back to the value `FALSE`.
 - ⇒ By doing this you cancel the feed enable for the positive direction of travel, the feed enable for the negative direction of travel and the general software and controller enable for the NC axis.
 - ⇒ In the **Online** dialog of the NC axis, the value **Override** is reset to the value `0.0000`.
 - ⇒ In the **Online** dialog of the NC axis, the **Controller**, **Feed Fw** and **Feed Bw** checkboxes in the **Enabling** group box are unchecked.

Override: [%]

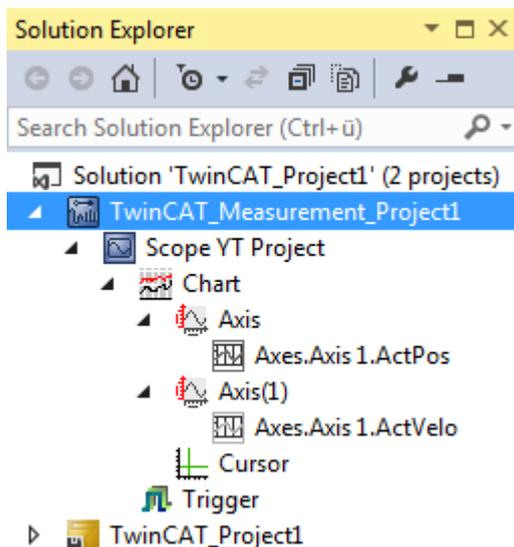


3.9 TwinCAT 3 Scope

This section shows how TwinCAT 3 Scope can be used to record a YT chart for travel path and travel velocity. With TwinCAT 3 Scope, variables can be recorded (TwinCAT 3 Scope Server) and displayed graphically (TwinCAT 3 Scope View).

Subtree for a TwinCAT Measurement project

A separate subtree is created for a TwinCAT Measurement project in the **Solution Explorer**.

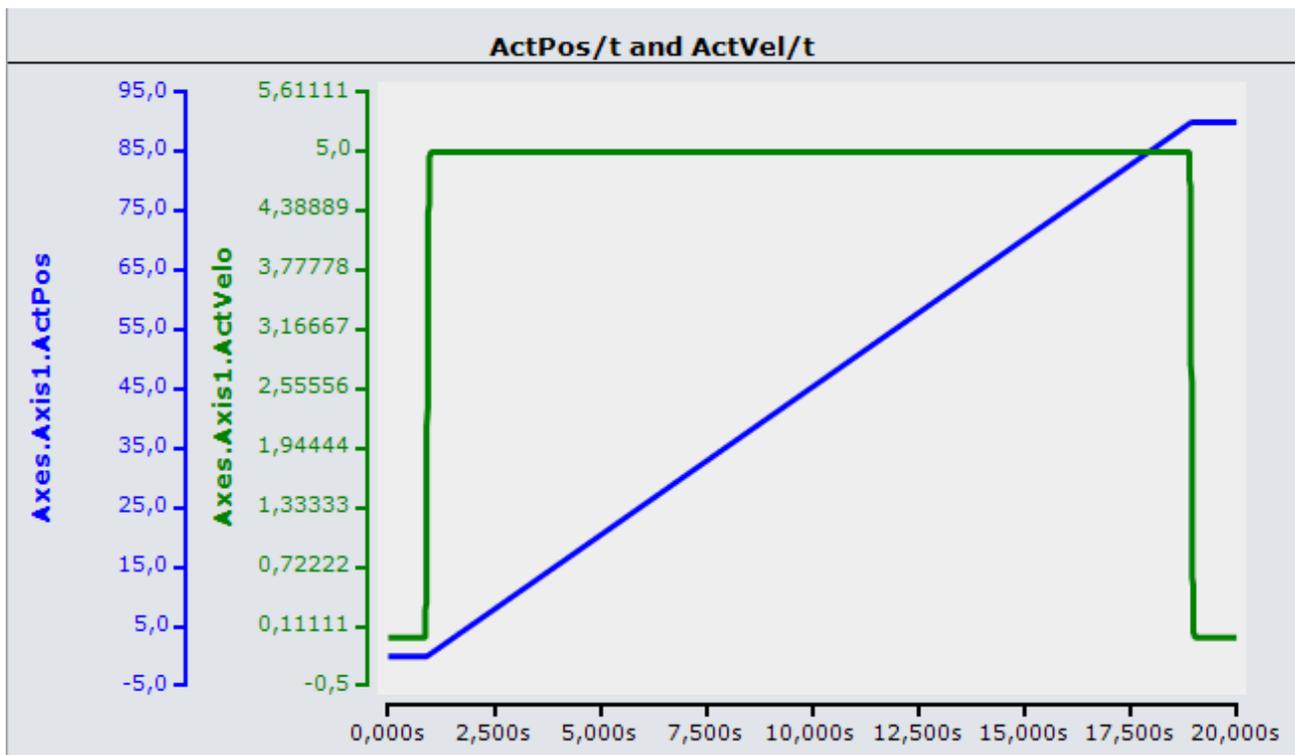


Recording a YT chart

1. Create a TwinCAT Measurement project.
2. Create a **Scope YT Project** in the TwinCAT Measurement project.
 - ⇒ A YT Chart is created.
3. Add a second axis to the YT chart.
4. The value of the `ActPos` variable of the NC axis from the NC configuration is plotted on one Y axis.
5. The value of the `ActVelo` variable of the NC axis from the NC configuration is plotted on the other Y axis.
6. Just before you move the NC axis, start a recording for the YT Chart with the **Record** button.
7. Shortly after the NC axis arrives at the target position, use the **Stop Record** button for the YT chart to stop the recording.

⇒ A TwinCAT 3 Scope recording illustrates the travel path and travel velocity over time when moving with the NC axis.

Travel path and travel velocity

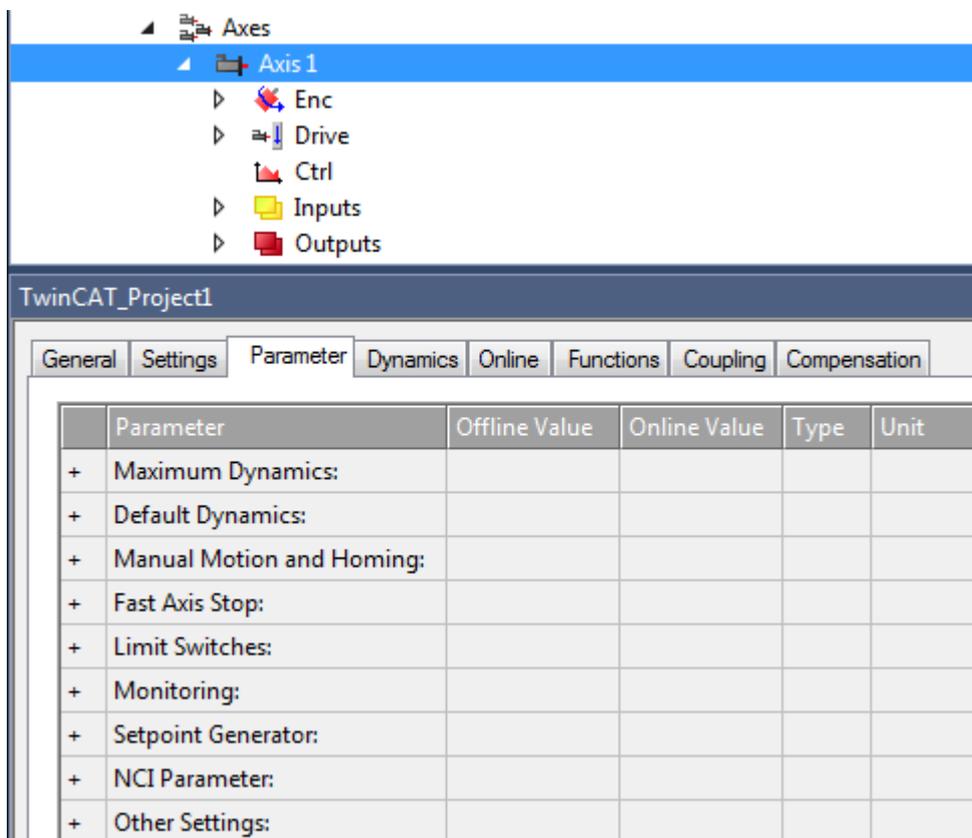


Further information

- [TF3300 TC3 ScopeServer](#)
- [TE13xx | TC3 ScopeView](#)

4 Parameters for Motion

4.1 Axes | Axis 1



At “MOTION | NC-Task 1 SAF | Axes | Axis 1” the file card Parameter displays the parameter groups

- Maximum Dynamics,
- Default Dynamics,
- Manual Motion and Homing,
- Fast Axis Stop,
- Limit Switches,
- Monitoring,
- Setpoint Generator,
- NCI Parameter,
- Other Settings.

4.1.1 Reference Velocity

Parameter	Offline Value	Online Value	Type	Unit
- Output Settings:				
Reference Velocity	2200.0		F	mm/s
at Output Ratio [0.0 ... 1.0]	1.0		F	
Parameter	Offline Value	Online Value	Type	Unit
- Position and Velocity Scaling:				

Minimum Drive Output Limitation [-1.0 ... 1.0]	-1.0		F	
Maximum Drive Output Limitation [-1.0 ... 1.0]	1.0		F	

At MOTION | NC-Task 1 SAF | Axes | Axis 1 | Drive | Parameter.

Solely Reference Velocity also at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter | Maximum Dynamics.

Analogously, for different identifiers.

Reference Velocity at Output Ratio [0.0 ... 1.0]

Scaling and Physical Limit

For analog control the Reference Velocity at a certain Output Ratio matches the analog input control signal with the resulting physical velocity of axis motion. Furthermore, for control via a digital interface, e.g. SoE or CoE, and for analog control the Reference Velocity at Output Ratio 1.0 prescribes a physical velocity limit not to be exceeded by setpoint generation and positional control.

Proportional Relationship for Analog Control

When drive controllers with analog inputs for their velocity control are used, the Reference Velocity combines e.g. an input bias value for control with a physical velocity or a number of revolutions per minute of the controlled axis. Comparatively, the analog input bias value may result from a kind of potentiometer dividing a voltage range for control. Similarly, a controlling current may be applied as an input source. For zero control signal there is zero physical velocity. At a particular Output Ratio there is a corresponding Reference Velocity, thus establishing a proportional relationship. For analog control, e.g. ±10V, the Reference Velocity at Output Ratio 1.0 prescribes the setpoint velocity at the corresponding maximum output of e.g. 10V.

Pair of Numbers

Some drive setups may not be put into operation at their upper physical velocity limit corresponding to an Output Ratio of 1.0. Instead, at a reasonably reduced velocity allocated for first driving experiences the Reference Velocity may be determined at a reduced Output Ratio lower than 1.0. Thus, the link between controlling input signal and physical velocity of motion is established by a pair of numbers, the Reference Velocity and the Output Ratio adjoined to it. Internally, the scaling calculation is done by TwinCAT and it calculates a Reference Velocity at Output Ratio 1.0. When for an Output Ratio 1.0 an axis is controlled at its designed upper physical boundary setpoint, it is controlled at its reference velocity.

Reference Velocity and Maximum Velocity

The Reference Velocity at Output Ratio 1.0 determines an upper physical limit for velocity control. So far, there is no appropriate way to go faster. On the other hand, the parameter Maximum Velocity establishes an upper limit for velocity control from a logical point of view. So far, there is no intended accomplishment to drive beyond the Maximum Velocity limit, even though this might be physically possible up to the boundary set by the Reference Velocity at Output Ratio 1.0. The Reference Velocity at Output Ratio 1.0 should not succeed the Maximum Velocity. When the Maximum Velocity exceeds the Reference Velocity at Output Ratio 1.0, an error message will be thrown. Likewise, at an axis start velocities exceeding the Reference Velocity at Output Ratio 1.0 will be rejected by an NC error. Tacitly, cyclic controller output is limited to the Reference Velocity at Output Ratio 1.0 without throwing an error.

Minimum Drive Output Limitation [-1.0 ... 1.0]

To limit velocity and thus to protect hardware a lower output limit can be set for driving the axis. If just a part of the output data type is valid it is necessary to limit the minimum output value. The Minimum Drive Output Limitation is a directionally dependend limitation of the total output. The value 1.0 corresponds to unlimited output of 100%. Typically, using this parameter one refers to a velocity output signal for the drive in connection with position control. In exceptional cases the application of this parameter may refer to a torque value or a current value.

Maximum Drive Output Limitation [-1.0 ... 1.0]

To limit velocity and thus to protect hardware an upper output limit can be set for driving the axis. If just a part of the output data type is valid it is necessary to limit the maximum output value. The Maximum Drive Output Limitation is a directionally dependend limitation of the total output. The value 1.0 corresponds to unlimited output of 100%. Typically, using this parameter one refers to a velocity output signal for the drive in connection with position control. In exceptional cases the application of this parameter may refer to a torque value or a current value.

4.1.2 Maximum Dynamics, Default Dynamics

Parameter	Offline Value	Online Value	Type	Unit
Maximum Dynamics:				
Maximum Velocity	2000.0		F	mm/s
Maximum Acceleration	15000.0		F	mm/s ²
Maximum Deceleration	15000.0		F	mm/s ²
Parameter	Offline Value	Online Value	Type	Unit
Default Dynamics:				
Default Acceleration	1500.0		F	mm/s ²
Default Deceleration	1500.0		F	mm/s ²
Default Jerk	2250.0		F	mm/s ³

Dynamic-Parameters

- Velocity *Vel*,
- Acceleration *Acc*,
- Deceleration *Dec*,
- Jerk.

The *jerk* is the derivative of acceleration or deceleration with respect to time. Thus, it describes how quickly acceleration or deceleration change.

“Maximum Dynamic-Values” and “Default Dynamic-Values”

- Range of Values*
- Absolute values.
 - Unsigned.
 - Positive.
 - Different from *zero*.

- Limits*
- With respect to their absolute values, “maximum dynamic-values” exceed their corresponding “default dynamic-values”.
 - Formally allowed: With respect to its absolute value, a “maximum dynamic-value” equals its corresponding “default dynamic-value”.

Tc2_NC2 Library, Tc2_MC2 Library

- Tc2_NC2, Tc2_MC2 Default values*
- If the input value "0.0" is assigned to a motion function block for one of the dynamics parameters "Acc, Dec or Jerk", the value "0.0" is replaced by a default value for this parameter.

- If no input value is assigned to a motion function block for one of the dynamic parameters "Acc, Dec or Jerk", this dynamic parameter is set to "0.0", and the value "0.0" is replaced by a default value for this parameter.

*Tc2_NC2, Tc2_MC2
Maximum dynamics*

- The maximum dynamic range is regarded as an actual physical limit for the corresponding axis.
- Values exceeding the values prescribed by the maximum velocity are not accepted and will lead to an error.
- Values that exceed the maximum acceleration and deceleration are accepted and not rejected.

*Tc2_NC2
"Online
Transformation"*

- During an "Online Transformation" from slave to master, various measures are taken to prevent the maximum velocity being exceeded or the direction of movement being reversed.
- Examples of such measures are increasing the jerk or increasing the acceleration or deceleration to the maximum value.
- From slave to master: Decoupling a slave axis in an accelerated or decelerated movement.

Tc3_McCoordinatedMotion Library, Tc3_McCollisionAvoidance Library

*Tc3_Mc
CoordinatedMotion
Tc3_Mc
CollisionAvoidance
Default Values*

- If for one of the dynamic-parameters "Acc, Dec, jerk" the input value "0.0" is assigned to a motion function block, this assignment leads to an error that means that this value is not allowed.
- If for one of the dynamic-parameters "Acc, Dec, jerk" you would like to refer to a default value at a motion function block, this parameter has to be set to the constant value "MC_Default".

*Tc3_Mc
CoordinatedMotion
Tc3_Mc
CollisionAvoidance
Maximum Dynamics*

Vel, Acc, Dec

- For the dynamic-parameters "Vel, Acc, Dec" the parameterized values are used.
- For the dynamic-parameters "Vel, Acc, Dec" maximum values can be parameterized at a motion function block using the constant value "MC_Maximum".

Jerk

- There is no maximum value for the jerk.
- The jerk is set to the value "unlimited". Simultaneously, a three-phase-profile or a three-phase-acceleration-setter is applied for motion.

Default Values

- It is allowed to parameterize default values that exceed their corresponding maximum values.
- If a default value is parameterized that exceeds its corresponding maximum value, a warning will be given, but no error is thrown.
- At a Tc3_McCoordinatedMotion-function block or a Tc3_McCollisionAvoidance-function block parameterized default values using the constant value *MC_Default* will be mutually limited to the corresponding maximum values without giving an error message.

4.1.3 Manual Motion and Homing

Parameter	Offline Value	Online Value	Type	Unit
-----------	---------------	--------------	------	------

- Manual Motion and Homing:				
Homing Velocity (towards plc cam)	30.0		F	mm/s
Homing Velocity (off plc cam)	30.0		F	mm/s

bCalibrationCam

A boolean input of MC_Home. It evaluates the signal of a reference cam. This reference signal may be coupled into the control unit via a digital input.

Homing Velocity (towards plc cam)

Velocity used by an MC_Home function block driving towards a reference cam within the standard homing sequence when the HomingMode MC_DefaultHoming is selected and the input bCalibrationCam is evaluated.

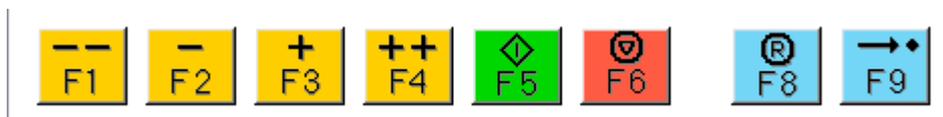
Homing Velocity (off plc cam)

Velocity used by an MC_Home function block driving off a reference cam within the standard homing sequence when the HomingMode MC_DefaultHoming is selected and the input bCalibrationCam is evaluated.

Parameter	Offline Value	Online Value	Type	Unit
- Manual Motion and Homing:				
Manual Velocity (Fast)	600.0		F	mm/s
Manual Velocity (Slow)	100.0		F	mm/s

Buttons in the Online Dialog

The buttons -- F1, - F2, + F3 and ++ F4 are in the "MOTION | NC-Task 1 SAF | Axes | Axis 1 | Online" dialog.



Manual Velocity (Fast)

Online

Velocity used for MOTION | NC-Task 1 SAF | Axes | Axis 1 | Online | -- F1.

Velocity used for MOTION | NC-Task 1 SAF | Axes | Axis 1 | Online | ++ F4.

Analogously, for different identifiers.

MC_Jog

Velocity used by an MC_Jog function block applied on the axis when its input JogForward or its input JogBackwards is TRUE and MC_JOGMODE_STANDARD_FAST is selected as its Mode.

Manual Velocity (Slow)

Online

Velocity used for MOTION | NC-Task 1 SAF | Axes | Axis 1 | Online | - F2.

Velocity used for MOTION | NC-Task 1 SAF | Axes | Axis 1 | Online | + F3.

Analogously, for different identifiers.

MC_Jog

Velocity used by an MC_Jog function block applied on the axis when its input JogForward or its input JogBackwards is TRUE and MC_JOGMODE_STANDARD_SLOW is selected as its Mode.

Parameter	Offline Value	Online Value	Type	Unit
Manual Motion and Homing:				
Jog Increment (Forward)	5.0		F	mm
Jog Increment (Backward)	5.0		F	mm

Jog Increment (Forward)

Unused.

Explicitly, this parameter is not used in any current TC3 motion library. Still, this parameter itself can be read or be written or be employed by the user indirectly, e.g. within a user-made function block or within an HMI.

Jog Increment (Backward)

Unused.

Explicitly, this parameter is not used in any current TC3 motion library. Still, this parameter itself can be read or be written or be employed by the user indirectly, e.g. within a user-made function block or within an HMI.

MC_JOGMODE_INCHING

The MC_Jog function block enables an axis to be moved via manual keys. The key signal can be linked directly to the JogForward or the JogBackwards input. The desired operating mode is prescribed by the input Mode. Applying mode MC_JOGMODE_INCHING a rising edge at one of the jog inputs moves the axis by a certain distance that is assigned at the input Position.

Additional Information: MC_Jog

Following

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

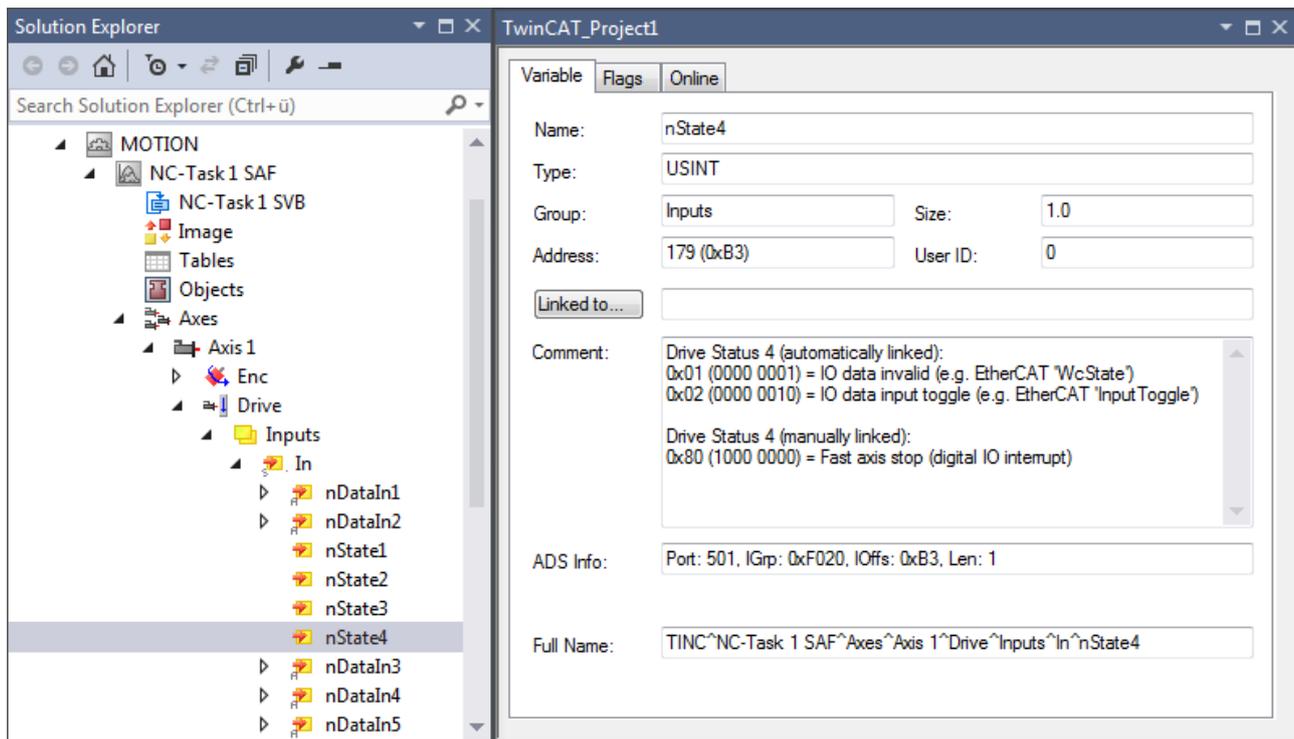
you can find further information on MC_Jog.

4.1.4 Fast Axis Stop

Fast Axis Stop

Parameter	Offline Value	Online Value	Type	Unit
Fast Axis Stop:				
Fast Axis Stop Signal Type (optional)	'OFF (default)'	<input type="button" value="v"/>	E	
Fast Acceleration (optional)	0.0		F	mm/s ²
Fast Deceleration (optional)	0.0		F	mm/s ²
Fast Jerk (optional)	0.0		F	mm/s ³

Usually a stop is triggered by PLC code using MC_Stop. However, there are special applications within that the time delay of stop has to be as small as possible. Within this situation the input Drive.Inputs.In.nState4 comes into play triggering a stop directly without being mapped via the PLC process image.



Drive Status 4 (manually linked):
0x80 (1000 0000) = Fast Axis Stop (digital IO interrupt)

Variable nState4

The variable Drive.Inputs.In.nState4 can be mapped to any event source. Note its data type `USINT` and the bit `nState4.7` being responsible for the Fast Axis Stop.

Fast Axis Stop

For an axis the Fast Axis Stop is performed when its Drive.Inputs.In.nState4.7 variable exhibits the signal type that is selected within the drop-down list "Fast Axis Stop Signal Type (optional)" and differs from "OFF (default)".

Signal Type

The "Fast Axis Stop Signal Type (optional)" enumeration specifies six elements:

- OFF (default)
For any signal type that the Drive.Inputs.In.nState4.7 variable exhibits no Fast Axis Stop is performed.
- Rising Edge
A Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit exhibits a rising edge.
- Falling Edge
A Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit exhibits a falling edge.
- Both Edges
A Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit exhibits a rising edge and a falling edge, respectively. Alternatively, a Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit exhibits a falling edge and a rising edge, respectively.
- High Active
A Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit appears high active.
- Low Active
A Fast Axis Stop is performed when the Drive.Inputs.In.nState4.7 bit appears low active.

Optional

An optional fast axis parameter has to differ from zero to be applied when a Fast Axis Stop is performed.

Acceleration, Deceleration, Jerk

When a Fast Axis Stop is performed on the corresponding axis within the boundaries prescribed by the “Maximum Dynamics” the “Fast Acceleration (optional)” float value accelerates the axis, the “Fast Deceleration (optional)” float value decelerates the axis and the “Fast Jerk (optional)” float value is applied. When a Fast Axis Stop is not performed, not any fast axis parameter is applied.

Additional Information: MC_Stop

Following

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

you can find further information on MC_Stop.

4.1.5 Limit Switches

Parameter	Offline Value	Online Value	Type	Unit
Limit Switches:				
Soft Position Limit Minimum Monitoring	FALSE		B	
Minimum Position	0.0		F	mm
Soft Position Limit Maximum Monitoring	FALSE		B	
Maximum Position	0.0		F	mm

Limit Switches

The Limit Switches parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Limit Switches parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Enc | Parameter.

Analogously, for different identifiers.

Soft Position Limit Minimum Monitoring

FALSE: Soft Position Limit Minimum Monitoring is not activated.

TRUE: Soft Position Limit Minimum Monitoring is activated.

Minimum Position

Lower position boundary for the axis not to be descended when the Soft Position Limit Minimum Monitoring is activated. Commands that violate this lower boundary are rejected.

Soft Position Limit Maximum Monitoring

FALSE: Soft Position Limit Maximum Monitoring is not activated.

TRUE: Soft Position Limit Maximum Monitoring is activated.

Maximum Position

Upper position boundary for the axis not to be exceeded when the Soft Position Limit Maximum Monitoring is activated. Commands that violate this upper boundary are rejected.

4.1.6 Monitoring

Parameter	Offline Value	Online Value	Type	Unit
Monitoring:				
Position Lag Monitoring	TRUE		B	
Maximum Position Lag Value	5.0		F	mm
Maximum Position Lag Filter Time	0.02		F	s

Position Lag Monitoring

When position lag monitoring is performed, the Position Lag Error is monitored, and if prescribed limits of position and time are exceeded, a runtime error is thrown.

Position Lag Error = Actual Position - Current Setpoint Position.

The Position Lag Monitoring parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Position Lag Monitoring parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Ctrl | Parameter.

Analogously, for different identifiers.

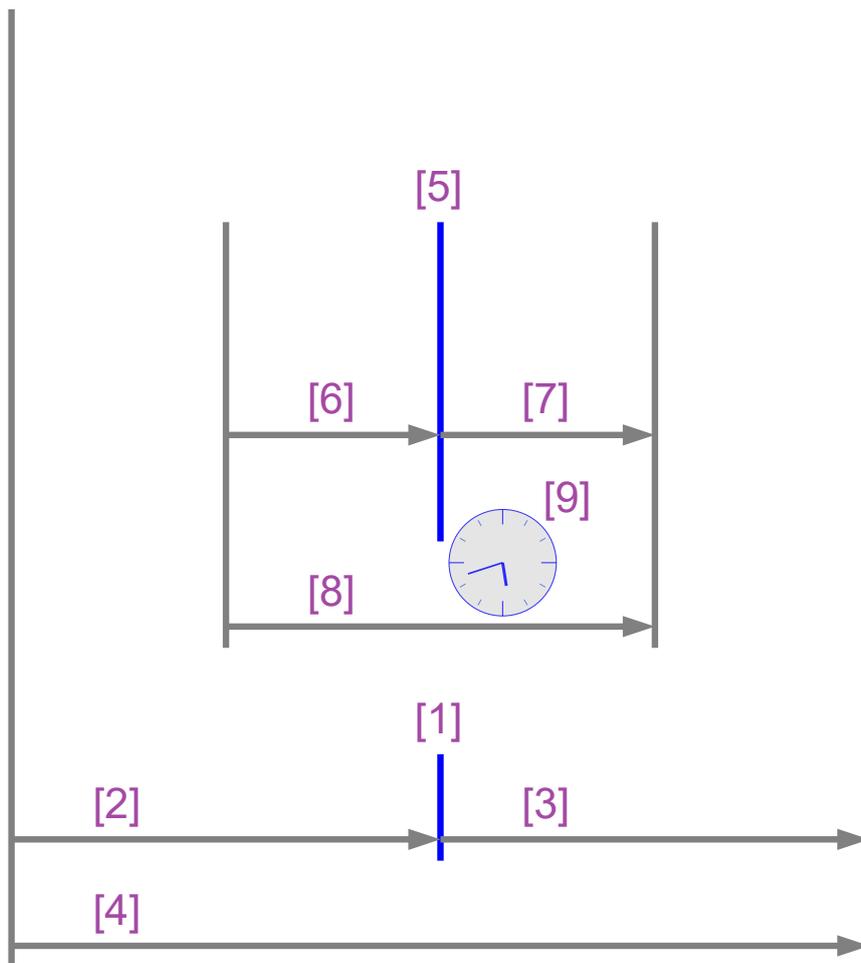
TRUE: Position Lag Monitoring is activated.

FALSE: Position Lag Monitoring is not activated.

Maximum Position Lag Value and Maximum Position Lag Filter Time

The Maximum Position Lag Value is the upper boundary for the permitted position lag error not to be exceeded for a time longer than the Maximum Position Lag Filter Time when the Position Lag Monitoring is activated. Otherwise, the NC axis will be stopped instantaneously by a zero voltage output and the NC axis will be placed into the logical "error" state throwing the error 0x4550.

Parameter	Offline Value	Online Value	Type	Unit
Monitoring:				
Position Range Monitoring	TRUE		B	
Position Range Window	5.0		F	mm
Target Position Monitoring	TRUE		B	
Target Position Window	2.0		F	mm
Target Position Monitoring Time	0.02		F	s



Position Range Monitoring

- [1] • Nominal value of the target position.
- [2] • Position Range Window.
- [3] • Position Range Window.
- [4] Variable `Axis.Status.InPositionArea`:
 - If the parameter “Position Range Monitoring” is set on `TRUE` and ...
 - ... if the actual position resides within this range [4],
 - then the variable `Axis.Status.InPositionArea` is set on `TRUE`.



NC-Online: “In Pos. Range” – `Axis.Status.InPositionArea`

The value of variable `Axis.Status.InPositionArea` corresponds to the state of the checkbox “In Pos. Range” within the group box “Status (phys.)” of the NC-Online dialog. If the variable `Axis.Status.InPositionArea` is set on `TRUE`, the checkbox “In Pos. Range” is checked.

Target Position Monitoring

- [5] • Nominal value of the target position.
- [6] • Target Position Window.
- [7] • Target Position Window.
- [8], [9] Target position:
- Target Position Monitoring*
- If the parameter “Target Position Monitoring” is set on `TRUE` and ...
 - ... if the actual position resides for at least the duration “Target Position Monitoring Time” [9] uninterruptedly until actual time within this range [8],
 - then the variable `Axis.Status.InTargetPosition` is set on `TRUE`.



NC-Online: “In Target Pos.” – `Axis.Status.InTargetPosition`

The value of the variable `Axis.Status.InTargetPosition` corresponds to the state of the checkbox “In Target Pos.” within the group box “Status (phys.)” of the NC-Online dialog. If the variable `Axis.Status.InTargetPosition` is set on `TRUE`, the checkbox “In Target Pos.” is checked.

Parameter	Offline Value	Online Value	Type	Unit
Monitoring:				
In-Target Alarm	FALSE		B	
In-Target Timeout	5.0		F	s

In-Target Alarm

`FALSE`: The In-Target Alarm is not activated.

`TRUE`: The In-Target Alarm is activated.

In-Target Timeout

When the In-Target Alarm is activated and the axis does not stay within the Target Position Window for the In-Target Timeout time, the NC axis reports the error `0x435C`. Thereby, time measurement is started when the axis has reached its nominal position.

Parameter	Offline Value	Online Value	Type	Unit
Monitoring:				
Motion Monitoring	FALSE		B	
Motion Monitoring Window	0.1		F	mm
Motion Monitoring Time	0.5		F	s

Motion Monitoring

Motion Monitoring checks whether an axis is actually moving while it is executing a motion command. This makes it possible, for example, to detect the mechanical blocking of an axis at an early stage.

The parameter is set to `TRUE` to activate Motion Monitoring, otherwise no monitoring takes place.

Motion Monitoring Window

The Motion Monitoring Window defines the distance that the encoder (actual position) should be expected to travel during one cycle of the NC SAF task. Here a value/distance/length of some encoder increments can be set.

Motion Monitoring Time

Monitoring starts as soon as the axis executes a motion command and ends when the axis comes to a logical standstill. If its actual position does not change by more than the Motion Monitoring Window in at least one NC cycle during the Motion Monitoring Time, the NC axis outputs the error 0x435D.

4.1.7 Setpoint Generator

Parameter	Offline Value	Online Value	Type	Unit
Setpoint Generator:				
Setpoint Generator Type	7 Phases (optimized)		E	

Setpoint Generator Type

The only available option is “7 Phases (optimized)”.

Parameter	Offline Value	Online Value	Type	Unit
Setpoint Generator:				
Velocity Override Type	Reduced (iterated)		E	

Velocity Override Type

Reduced (iterated): The override is based on the maximum velocity of the profile calculated by the setpoint generator. Confer to parameter description at “MOTION | NC-Task 1 SAF | Axes | Axis 1 | Maximum Dynamics | [Maximum Velocity \[▶ 40\]](#)”.

Original (iterated): The override is based on the maximum parameterized velocity of the actual command currently performed. Thus, it can happen that e.g. 80 percent override and 100 percent override result in the same nominal velocity.

Look at section [Path Override \(Interpreter Override Types\) \[▶ 79\]](#) for more information on path override.

4.1.8 NCI Parameters

Parameter	Offline Value	Online Value	Type	Unit
NCI Parameter:				
Rapid Traverse Velocity (G0)	2000.0		F	mm/s

Rapid Traverse Velocity (G0)

The Rapid Traverse Velocity is used, when a G0 interpreter command is running. Look at section [Rapid Traverse \[▶ 81\]](#) for a short description of the G0 interpreter command.

Parameter	Offline Value	Online Value	Type	Unit
NCI Parameter:				
Velo Jump Factor	0.0		F	

Tolerance ball auxiliary axis	0.0		F	
-------------------------------	-----	--	---	--

Segment Transitions

Segments are geometrical objects. We regard them as curves in terms of differential geometry that are parameterized by their `arc` length.

A segment transition from a segment S_{in} to a segment S_{out} is classified in geometrical terms as type C_k . Thereby, k is a natural number (including 0) describing k continuous `arc` length differentials for each segment and corresponding k^{th} derivatives at the transition point.

C_0 transitions: Have a knee-point at the transition point.

C_1 transitions: Appear smooth, but are not smooth in dynamic terms. At the segment transition point there is a step change in acceleration.

C_2 transitions: Are dynamically smooth their smoothness merely being restricted by jerk.

C_k transitions: Are dynamically smooth.

Segment Dynamics

Velocity v : The segment setpoint velocity v changes from v_{in} to v_{out} at the segment transition. At the segment transition the setpoint velocity is always reduced to the lower one of the two values.

Acceleration a : At the segment transition the current path acceleration is always reduced to zero.

Jerk j : At the segment transition the jerk changes according to the segment transition geometry. This jerk change can cause significant step change in dynamics.

Velocity Reduction Modes for C_0 Transitions

Several reduction methods are available for C_0 transitions. One of them is the VELOJUMP reduction method. The VELOJUMP reduction method reduces the velocity after permitted step changes in velocity for each axis.

The VELOJUMP Reduction Method for C_0 Transitions

Basically, $v_{link} = \min(v_{in}, v_{out})$. For the axis $[i]$ the permitted absolute step change in velocity is $v_{jump}[i] = C_0[i] * \min(A+[i], -A-[i]) * T$. Thereby, $C_0[i]$ is the reduction factor, $A+[i]$, $A-[i]$ are the acceleration or deceleration limits for the axis $[i]$ and T is the cycle time. The VELOJUMP reduction method ensures that the path velocity at segment transition v_{link} is reduced, whereby the absolute step change in the axis setpoint velocity of axis $[i]$ is at most $v_{jump}[i]$. Nevertheless, v_{min} has priority: If v_{link} is less than v_{min} , v_{link} is set to v_{min} . In case of movement reversal with no programmed stop there will be a step change in axis velocity.

Velo Jump Factor

The reduction factor $C_0[i]$ is the Velo Jump Factor.

Tolerance ball auxiliary axis

Look at section [Tolerance Ball \[▶ 82\]](#) for more information.

Parameter	Offline Value	Online Value	Type	Unit
NCI Parameter:				
Max. position deviation, aux. axis	0.0		F	

Max. position deviation, aux. axis

Introduced for future enhancements.

4.1.9 Other Settings

Parameter	Offline Value	Online Value	Type	Unit
Other Settings:				
Position Correction	FALSE		B	
Filter Time Position Correction (P-T1)	0.0		F	s

Position Correction

The Position Correction can be activated at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Position Correction can be activated at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Enc | Parameter.

Analogously, for different identifiers.

FALSE: The Position Correction is disabled.

TRUE: The Position Correction is enabled.

The variable `axis.PlcToNc.PositionCorrection` is of data type `LREAL` and belongs to the structure `PLCTONC_AXIS_REF`. If Position Correction is enabled, this variable adds an additional offset onto the target position. Note, that this correction does not affect software limits.

Filter Time Position Correction (P-T1)

The filter time for the PT-1 filter that filters variations within the Actual Position Correction with the filter time set here. Consult section [PT1 Filter \[► 81\]](#) for more information on a PT1 filter.

See also:

MC_PositionCorrectionLimiter

- [TwinCAT 3 PLC Lib: Tc2_MC2](#)

The function block `MC_PositionCorrectionLimiter` adds the correction value `PositionCorrectionValue` to the actual position value of the axis. Depending on the `CorrectionMode` the position correction value is either written directly or filtered.



To use the `MC_PositionCorrectionLimiter` function block successfully the Position Correction has to be enabled by setting the parameter Position Correction TRUE.

Parameter	Offline Value	Online Value	Type	Unit
Other Settings:				
Backlash Compensation	FALSE		B	
Backlash	0.0		F	mm

Backlash Compensation and Backlash

These parameters remain merely for compatibility issues. Do not use them within new projects. See [NC Backlash Compensation](#) for further information.

Parameter	Offline Value	Online Value	Type	Unit
Other Settings:				
Error Propagation Mode	'INSTANTANEOUS'		E	
Error Propagation Delay	0.0		F	s

Error Propagation Mode

For the slave axis the error propagation can be delayed.

'INSTANTANEOUS': Error propagation will be not delayed.

'DELAYED': Error propagation will be delayed by the Error Propagation Delay.

Error Propagation Delay

The delay time by that error propagation for the slave axis will be delayed if 'DELAYED' is selected as Error Propagation Mode.

When within runtime an error appears at a slave axis the corresponding master axis will be set to error state not before the time assigned here has elapsed. A state of interest of the slave axis, in particular its error state, can be watched by PLC code. Thus, the erroneous slave axis may be uncoupled to safely prevent the whole axis combine from falling into error state.

Parameter	Offline Value	Online Value	Type	Unit
Other Settings:				
Couple slave to actual values if not enabled	FALSE		B	
Velocity Window	1.0		F	mm/s
Filter Time for Velocity Window	0.01		F	s

Couple slave to actual values if not enabled

FALSE: Not Coupled.

TRUE: Coupled. The slave axis will follow the actual master position while and even though the master is disabled.

Velocity Window and Filter Time for Velocity Window

The coupled slave axis follows the master axis within the Velocity Window. When velocity deviations beyond the Velocity Window exceed the Filter Time for Velocity Window, an error will be thrown.

Parameter	Offline Value	Online Value	Type	Unit
Other Settings:				
Allow motion commands to slave axis	TRUE		B	
Allow motion commands to external setpoint axis	FALSE		B	

Allow motion commands to slave axis

Generally speaking, an axis is in PTP mode for the whole time. The point is to transform a slave axis into a master axis indirectly. Thus, it is uncoupled implicitly without PLC code having to engage MC_GearOut.

TRUE: To the slave axis a PTP command can be triggered without having to set the axis into PTP mode before.

FALSE: Before a PTP command can be triggered to the slave axis, the slave axis has to be set into PTP mode.

Allow motion commands to external setpoint axis

FALSE: Before a PTP command can be triggered to the external setpoint axis, the external setpoint axis has to be set into PTP mode.

TRUE: To the external setpoint axis a PTP command can be triggered without having to set the axis into PTP mode before.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Dead Time Compensation (Delay Velo and Position)	0.0		F	s

Dead Time Compensation (Delay Velo and Position)

This parameter remains merely for compatibility issues. Do not use it within new projects.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Data Persistence	FALSE		B	

Data Persistence

The Data Persistence is used for special encoder issues.

FALSE: The Data Persistence is not activated.

TRUE: The Data Persistence is activated.

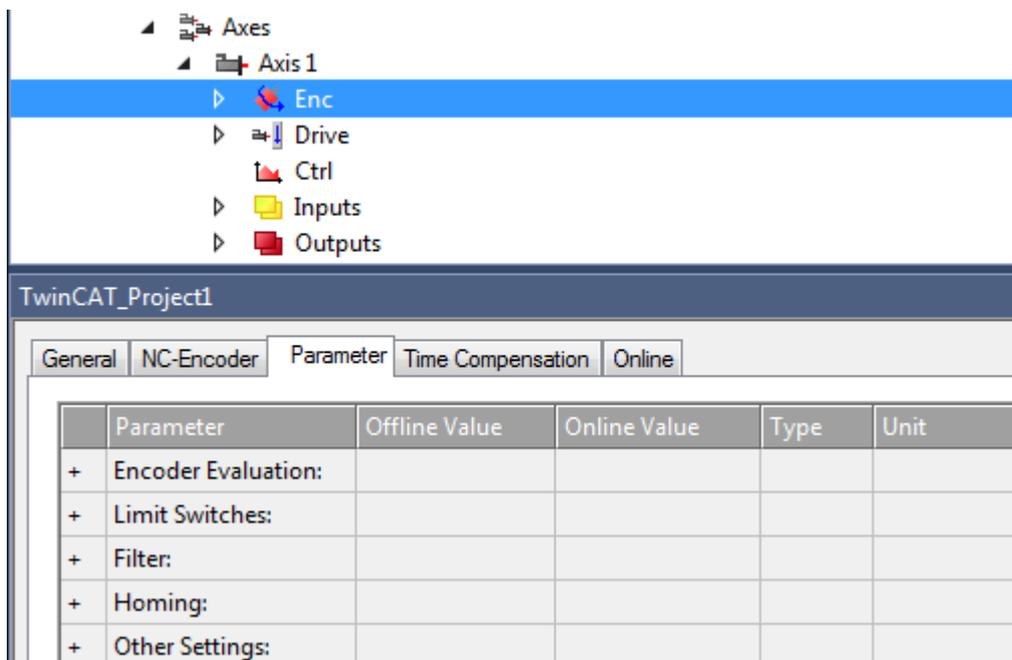
4.2 Axes | Axis 1 | Enc

Encoder

Depending on their operating modes encoders determine the actual position, actual velocity or actual acceleration or deceleration. Regularly, actual values fluctuate intemperately. So, for each mode a parameterizable filter is available to ensure a reasonable resolution.

A wide variety of encoder versions is supported. Available are absolute and incremental encoders. Furthermore, there are simulation encoders and there are special encoders for the determination of force.

The encoder parameters include scaling, zero offset shift and the modulo factor. There are encoder parameters for software end locations and for reference travel.



At “MOTION | NC-Task 1 SAF | Axes | Axis 1 | Enc” the file card Parameter displays the parameter groups

- Encoder Evaluation,
- Limit Switches,
- Filter,
- Homing,
- Other Settings.

4.2.1 Encoder Evaluation

Parameter	Offline Value	Online Value	Type	Unit
- Encoder Evaluation:				
Invert Encoder Counting Direction	FALSE		B	

Invert Encoder Counting Direction

If set `TRUE`, the parameter Invert Encoder Counting Direction inverts the counting direction of the encoder.

- `FALSE`: The polarity of the axis movement agrees with the counting direction of the acquisition hardware.
- `TRUE`: The polarity of the axis movement is opposite to the counting direction of the acquisition hardware.

⚠ WARNING

Risk of Unexpected Movements

If the encoder counting direction and the motor polarity do not match with each other, the axis will make unexpected movements.

Parameter	Offline Value	Online Value	Type	Unit
- Encoder Evaluation:				
Scaling Factor Numerator	0.0001		F	mm/INC
Scaling Factor Denominator (default: 1.0)	1.0		F	

Scaling Factor Numerator and Scaling Factor Denominator (default: 1.0)

The scaling factor is subdivided into a numerator and a denominator. It converts displacement increments into axis positions or calculates a user unit out of encoder increments.

Parameter	Offline Value	Online Value	Type	Unit
Encoder Evaluation:				
Position Bias	0.0		F	mm

Position Bias

The position bias is an offset used for absolute encoders to align their position within the machine coordinate system and thus to specify the machine-dependent zero point. Thereby, the position bias offset value is added to the encoder position to determine the axis position.

Parameter	Offline Value	Online Value	Type	Unit
Encoder Evaluation:				
Modulo Factor (e.g. 360.0°)	360.0		F	mm
Tolerance Window for Modulo Start	0.0		F	mm

Modulo Factor (e.g. 360.0°)

The value of the Modulo Factor (e.g. 360.0°) is the value to calculate modulo turns and modulo positions out of the absolute axis position. For rotating axes the Modulo Factor is the “distance” represented by one rotation. For instance, 360.0° should be entered here, if the actual rotational value is acquired in degrees.

Tolerance Window for Modulo Start

The Tolerance Window for Modulo Start should be big enough to allow backward movements, if a modulo forward command is running inside the window area. Vice versa, the Tolerance Window for Modulo Start should be big enough to allow forward movements, if a modulo backward command is running inside the window area.

Additional Information: Modulo Positioning

Following

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

you can find further Notes on Modulo Positioning.

Parameter	Offline Value	Online Value	Type	Unit
Encoder Evaluation:				
Encoder Mask (maximum encoder value)	0x0036EE7F		D	
Encoder Sub Mask (absolute range maximum value)	0x000FFFFF		D	

Encoder Mask (maximum encoder value)

The encoder mask defines the number of allowed increments until the feedback value flows over. Thereby, the increments are not the real encoder increments.

Encoder Sub Mask (absolute range maximum value)

The encoder submask defines the number of increments per motor turn.

Parameter	Offline Value	Online Value	Type	Unit
Encoder Evaluation:				
Noise level of simulation encoder	0.0		F	

Noise level of simulation encoder

Setting a level this parameter creates artificial noise for the simulation axis to make it appear more realistic.

Parameter	Offline Value	Online Value	Type	Unit
Encoder Evaluation:				
Reference System	'INCREMENTAL'		E	

Reference System

Use the Reference System parameter to select how the encoder values should be interpreted:

Mode	Physical feedback type	Feedback overflows	Adjustment of the position to a defined travel range when switching on
INCREMENTAL	Incremental or absolute value encoder	Overflows of the encoder position are also counted	The position is not initialized when switching on, and homing is required
INCREMENTAL (singleturn absolute)	Single-turn absolute value encoder	Overflows of the encoder position are also counted.	The position is not initialized when switching on, and homing is required.
ABSOLUTE	Multi-turn absolute value encoder	An overflow of the encoder count value leads to an error.	The position is accepted unchanged by the encoder system when it is switched on.
ABSOLUTE MULTITURN RANGE (with single overflow)	Multi-turn absolute value encoder	Only one overflow of the encoder count value may occur over the travel distance between the end positions, and the total travel distance must be smaller than the multi-turn count range of the encoder. This overflow is taken into account in the actual position. A further overflow leads to an error.	The position is initialized at power-on such that it is within the end positions.
ABSOLUTE SINGLETURN RANGE (with single overflow)	Single-turn absolute value encoder	Only one overflow of the encoder count value may occur over the travel distance between the end positions, and the total travel distance must be smaller than the single-turn count range of the encoder. This overflow is taken into account in the actual position. A further overflow leads to an error.	The position is initialized at power-on such that it is within the end positions.
ABSOLUTE (modulo) with retain data	Multi-turn absolute value encoder	Overflows of the encoder position are also counted. After switching on, the position is reset to the basic range of the absolute encoder (modulo).	If no end positions are defined, the initial position is reduced to the basic cycle of the absolute encoder. If both end positions are activated, the position is restored directly from the retain data.

Mode	Correction of a mechanical displacement in the switched-off state up to half the absolute value range	Software end positions	Persistent data
INCREMENTAL			
INCREMENTAL (singleturn absolute)	A shift of the encoder system in the switched-off state by a maximum of half the counting range can be compensated.		
ABSOLUTE	A shift of the encoder system in the switched-off state by a maximum of half the counting range can be compensated.		
ABSOLUTE MULTITURN RANGE (with single overflow)	A shift of the encoder system in the switched-off state by a maximum of half the counting range can be compensated.	For this operation mode, end positions must be selected in the parameters.	
ABSOLUTE SINGLETURN RANGE (with single overflow)	A shift of the encoder system in the switched-off state by a maximum of half the counting range can be compensated.	For this operation mode, end positions must be selected in the parameters. The maximum travel distance corresponds to one encoder revolution.	
ABSOLUTE (modulo) with retain data	A shift of the encoder system in the switched-off state by a maximum of half the counting range can be compensated.		For this operation mode, persistent NC data is a requirement. Therefore this data must be parameterized for the NC-SAF task and for the axis.

4.2.2 Limit Switches

Parameter	Offline Value	Online Value	Type	Unit
Limit Switches:				
Soft Position Limit Minimum Monitoring	FALSE	<input type="button" value="v"/>	B	
Minimum Position	0.0		F	mm
Soft Position Limit Maximum Monitoring	FALSE	<input type="button" value="v"/>	B	
Maximum Position	0.0		F	mm

Limit Switches

The Limit Switches parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Limit Switches parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Enc | Parameter.

Analogously, for different identifiers.

Soft Position Limit Minimum Monitoring

FALSE: Soft Position Limit Minimum Monitoring is not activated.

TRUE: Soft Position Limit Minimum Monitoring is activated.

Minimum Position

Lower position boundary for the axis not to be descended when the Soft Position Limit Minimum Monitoring is activated. Commands that violate this lower boundary are rejected.

Soft Position Limit Maximum Monitoring

FALSE: Soft Position Limit Maximum Monitoring is not activated.

TRUE: Soft Position Limit Maximum Monitoring is activated.

Maximum Position

Upper position boundary for the axis not to be exceeded when the Soft Position Limit Maximum Monitoring is activated. Commands that violate this upper boundary are rejected.

4.2.3 Filter

Parameter	Offline Value	Online Value	Type	Unit
Filter:				
Filter Time for Actual Position (P-T1)	0.0		F	s
Filter Time for Actual Velocity (P-T1)	0.01		F	s
Filter Time for Actual Acceleration (P-T1)	0.1		F	s

Filter Time for Actual Position (P-T1)

Filter time for PT1 filtering of the actual position.

Filter Time for Actual Velocity (P-T1)

Filter time for PT1 filtering of the actual velocity.

Filter Time for Actual Acceleration (P-T1)

Filter time for PT1 filtering of the actual acceleration.

Additional Information: PT1 Filter

Consult section [PT1 Filter](#) [▶ 81] for more information on a PT1 filter.

4.2.4 Homing

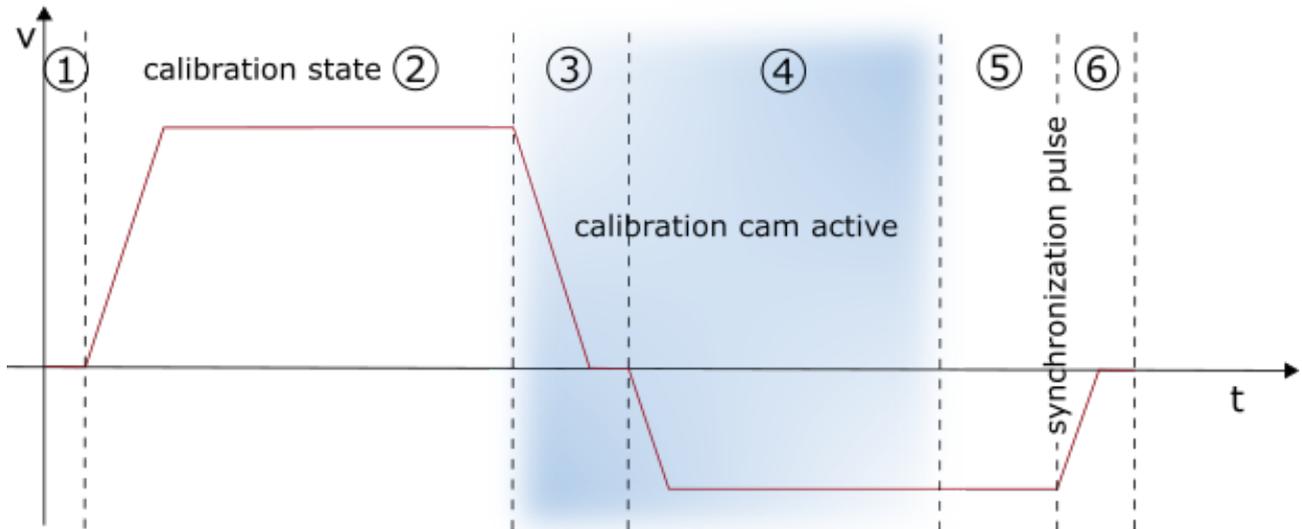
Homing refers to an axis initialization run during which the correct actual position is determined by means of a reference signal. This can be NC-guided, as described here.

Alternatively, there is also drive-guided homing, which is performed independently by a suitable drive without the influence of the control system. For details, please refer to the documentation of the drive system used.

Procedure

1. The axis is at a random position.

2. The axis moves in the parameterized direction and searches for the reference switch (referencing cam/calibration cam).
3. The axis reverses as soon as the referencing cam is detected.
4. The axis moves away from the referencing cam and detects the falling edge of the cam signal.
5. The axis continues to move and searches for the sync pulse (latch signal or zero pulse of the encoder).
6. The reference position is set and the axis stops. The standstill position of the axis deviates slightly from the reference position.



Parameterization

The parameterization is done via the following encoder parameters:

	Parameter	Offline Value	Online Val...	Type	Unit
+	Encoder Evaluation:				
+	Limit Switches:				
+	Filter:				
-	Homing:				
	Invert Direction for Homing Sensor Search	FALSE	▼	B	
	Invert Direction for Sync Impuls Search	TRUE	▼	B	
	Home Position (Calibration Value)	0.0		F	mm
	Reference Mode (Sync condition)	'Default'	▼	E	
	Homing Sensor Source	'Default: PLC Cam (MC_Home)'	▼	E	
+	Other Settings:				

Invert Direction for Calibration Cam Search

For the default homing sequence the direction for calibration cam search can be inverted.

- FALSE: cam is looked for in the direction of positive movement.
- TRUE: cam is looked for in the direction of negative movement.

Invert Direction for Sync Impuls Search

For the default homing sequence the direction for sync pulse search can be inverted.

- FALSE: sync pulse is looked for in the direction of positive movement.
- TRUE: sync pulse is looked for in the direction of negative movement.

Home Position (Calibration Value)

The Home Position is the position value that will be assigned to the axis when the sync pulse appears within the homing. This is done exactly with the sync pulse while in motion. Since the axis then stops, the standstill position deviates from the parameterized value. The referencing is nevertheless exact.

Reference Mode (Sync condition)

The parameter Reference Mode offers the opportunity to select which signal shall be used for sync impulse search:

- 'Default' / 'Homing Sensor Only (PLC cam or digital input 1..8)'
 - The simplest way of referencing an axis where only the cam signal is evaluated. Another sync signal is not used, so this setting should only be selected if the axis does not offer more extensive options.
- 'Hardware Sync (Feedback reference pulse)'
 - Some encoder systems provide a sync pulse per revolution (zero track) in addition to the count. The homing precision can be enhanced by selecting this mode, if the encoder evaluation logic is able to pick up the sync pulse. The precision is comparable with Software Sync. Hardware Sync mode may require parameterization or special wiring of the drive or encoder system.
- 'Hardware Latch 1 (pos. edge)', 'Hardware Latch 1 (neg. edge)'
 - Hardware latch responds to an external latch signal in addition to the cam signal. For this purpose, the latch mechanism must be configured in the drive and the latch input must be wired.
- 'Software Sync'
 - Software Sync mode enhances the homing precision by additionally detecting the encoder count overflow after an encoder or motor revolution, after the reference cam signal has been detected. This mode requires a part-absolute encoder (e.g. resolver) with constant overflow interval relative to the reference cam. Overflow detection is parameterized via the Reference Mask parameter.
- 'Application (PLC code)'
 - In this case, the entire homing procedure must be programmed in the PLC:
In this case, the NC sets bit 23 in the "NcApplicationRequest" status, which is polled by the PLC. Via MC_ReadApplicationRequest the request of the NC can be determined in the PLC. So far only 0 = NONE and 1 = HOMING is supported (see 0x33 at "[Index offset" specification for axis parameter](#)). In the case of homing, the PLC can perform the sequence itself by moving the axis.

Homing Sensor Source

- Default PLC Cam (MC_Home)
 - By default the homing sensor signal comes from the PLC with the function block MC_Home with the parameter bCalibrationCam, which is automatically linked to the PlcToNc.ControlWordD.7.
- Digital Input [1-8]
 - Alternatively, a digital input linked to the NC process can be used. For this purpose, a general Drive Status Byte with 8 digital inputs is defined in the process image (Drive->Inputs->nState8), which can serve as a signal source for the homing sensor. A digital input to be used must therefore be mapped manually to the desired position in this byte.
 - **Note** The digital inputs 1 and 2 may differ depending on the hardware used. For the MDP703/733 hardware (e.g. EL7031, EL7041, EL7201, EL7411) the direct digital inputs E1 and E2 of the terminal are used instead, which are located in the Drive.nState2 byte of the terminal at bit position 3 (E1) and 4 (E2). The lower two bits of Drive.nState8 are not assigned in this case.

Further information

- [Homing on the AX5000](#)
- [MC Home in the Tc2_MC2](#)

4.2.5 Other Settings

Parameter	Offline Value	Online Value	Type	Unit
-----------	---------------	--------------	------	------

- Other Settings:				
Encoder Mode	'POSVELO'	▼	E	

Encoder Mode

The parameter Encoder Mode offers the opportunity to select which values shall be calculated from the encoder position:

- 'POS': The actual position is determined.
- 'POSVELO': The actual position and the actual velocity are determined.
- 'POSVELOACC': The actual position, the actual velocity and the actual acceleration are determined.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Position Correction	FALSE	▼	B	
Filter Time Position Correction (P-T1)	0.0		F	s

Position Correction

The Position Correction can be activated at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Position Correction can be activated at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Enc | Parameter.

Analogously, for different identifiers.

FALSE: The Position Correction is disabled.

TRUE: The Position Correction is enabled.

The variable `axis.PlcToNc.PositionCorrection` is of data type LREAL and belongs to the structure `PLCTONC_AXIS_REF`. If Position Correction is enabled, this variable adds an additional offset onto the target position. Note, that this correction does not affect software limits.

Filter Time Position Correction (P-T1)

The filter time for the PT-1 filter that filters variations within the Actual Position Correction with the filter time set here. Consult section [PT1 Filter \[▶ 81\]](#) for more information on a PT1 filter.

See also:

MC_PositionCorrectionLimiter

- [TwinCAT 3 PLC Lib: Tc2_MC2](#)

The function block `MC_PositionCorrectionLimiter` adds the correction value `PositionCorrectionValue` to the actual position value of the axis. Depending on the `CorrectionMode` the position correction value is either written directly or filtered.



To use the `MC_PositionCorrectionLimiter` function block successfully the Position Correction has to be enabled by setting the parameter Position Correction TRUE.

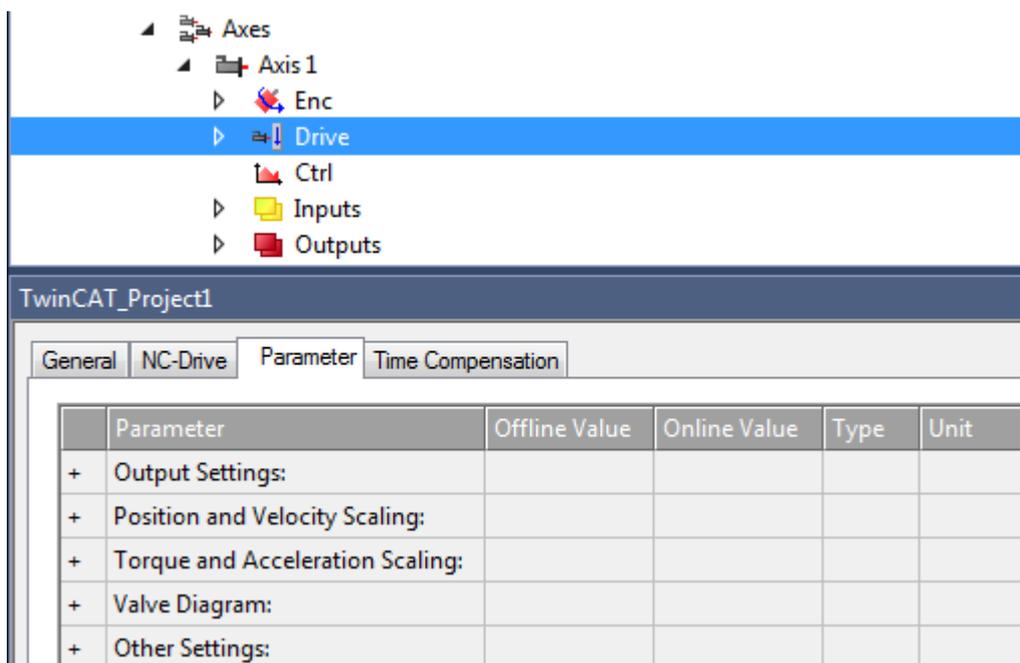
4.3 Axes | Axis 1 | Drive

Drive

The drive transfers the output voltage to the power section of the motor. A wide variety of drive versions is supported: E.g. servo drives, low speed drives, high speed drives, stepper motor drives. The drive parameters include the motor polarity and the reference speed.

Analog Drive

Within this context analog does not mean that the speed is represented by a voltage (e.g. ±10 V) or a current (e.g. ±20 mA), but rather that the axis can be adjusted over an effectively continuous range of values. This kind of adjustment is also possible for drives with digital interfaces such as the BISSI Terminals of type KL5051. Employing such a digital interface a speed can be adjusted like controlling an analog value, even though being transported in the form of digital information.



At “MOTION | NC-Task 1 SAF | Axes | Axis 1 | Drive” the file card Parameter displays the parameter groups

- Output Settings,
- Position and Velocity Scaling,
- Torque and Acceleration Scaling,
- Valve Diagram,
- Other Settings.

Furthermore, the parameter groups

- Optional Position Command Output Smoothing Filter,
- Sercos Behavior

may appear.

4.3.1 Output Settings

Parameter	Offline Value	Online Value	Type	Unit
- Output Settings:				
Invert Motor Polarity	FALSE		B	

Invert Motor Polarity

If set `TRUE`, the parameter Invert Motor Polarity inverts the polarity of the motor and thus inverts the direction of motor rotation.

- `FALSE`: In response to positive drive the axis moves in the direction of larger positions.
- `TRUE`: In response to positive drive the axis moves in the direction of smaller positions.

⚠ WARNING

Risk of Unexpected Movements

If the encoder counting direction and the motor polarity do not match with each other, the axis will make unexpected movements.

Parameter	Offline Value	Online Value	Type	Unit
Output Settings:				
Reference Velocity	2200.0		F	mm/s
at Output Ratio [0.0 ... 1.0]	1.0		F	

Reference Velocity at Output Ratio [0.0 ... 1.0]

Look at section [Reference Velocity](#) [▶ 38].

4.3.2 Position and Velocity Scaling

Parameter	Offline Value	Online Value	Type	Unit
Position and Velocity Scaling:				
Output Scaling Factor (Position)	1.0		F	
Output Scaling Factor (Velocity)	6.0		F	

Output Scaling Factor (Position)

Habitually, the drive parameter Output Scaling Factor (Position) does not evoke an effect. In principle, to avoid to infer its future use the user should not change the default value `1.0` of this parameter.

The positional output scaling is already set by the encoder input scaling. Regularly, the positional input scaling equals the positional output scaling for a drive. For this reason, the drive parameter Output Scaling Factor (Position) is currently not evaluated. Instead, solely the encoder parameters Scaling Factor Numerator and Scaling Factor Denominator do the scaling work and have to be adjusted for accurate scaling.

Output Scaling Factor (Velocity)

When a drive controller operates in velocity precontrol mode, the NC output value has to be scaled. To do this scaling there are two possibilities whose choice depends on the type of the employed drive controller.

1. Analog drive controllers, e.g. supplied by a $\pm 10V$ terminal:
 This type of drive controllers is scaled applying the Reference Velocity parameter.
2. Digital drive controllers to those an absolute digital velocity setpoint value is transferred, e.g. *CANopen DS402*:
 This type of drive controllers is scaled applying the Output Scaling Factor (Velocity) parameter.

Following, a tabular comparison shows, when the Reference Velocity parameter or the Output Scaling Factor (Velocity) parameter has to be applied.

Drive Type	Scaling with Reference Velocity	Scaling with Output Scaling Factor (Velocity)
M2400_DAC1	x	
M2400_DAC2	x	
M2400_DAC3	x	
M2400_DAC4	x	
KL4XXX	x	
KL4XXX_NONLINEAR	x	
TWOSPEED	x	
STEPPER	x	
SERCOS		x
KL5051	x	
AX2000_B200		x
SIMO611U		x
UNIVERSAL	x	
NCBACKPLANE	x	
CANOPEN_LENZE		x
DS402_MDP742		x
AX2000_B900	x	
AX2000_B310	x	
AX2000_B100	x	
KL2531		x
KL2532		x
TCOM_DRV		x
MDP_733		x
MDP_703	x	(x)*

*Also possible, but should be regularly left on the value 1.0.

Parameter	Offline Value	Online Value	Type	Unit
Position and Velocity Scaling:				
Output Delay (Velocity)	0.0		F	s

Output Delay (Velocity)

The output of the velocity value can be delayed by the Output Delay (Velocity) time.

Parameter	Offline Value	Online Value	Type	Unit
- Position and Velocity Scaling:				
Minimum Drive Output Limitation [-1.0 ... 1.0]	-1.0		F	
Maximum Drive Output Limitation [-1.0 ... 1.0]	1.0		F	

Minimum Drive Output Limitation [-1.0 ... 1.0]

To limit velocity and thus to protect hardware a lower output limit can be set for driving the axis. If just a part of the output data type is valid it is necessary to limit the minimum output value. The Minimum Drive Output Limitation is a directionally dependend limitation of the total output. The value 1.0 corresponds to unlimited output of 100%. Typically, using this parameter one refers to a velocity output signal for the drive in connection with position control. In exceptional cases the application of this parameter may refer to a torque value or a current value.

Maximum Drive Output Limitation [-1.0 ... 1.0]

To limit velocity and thus to protect hardware an upper output limit can be set for driving the axis. If just a part of the output data type is valid it is necessary to limit the maximum output value. The Maximum Drive Output Limitation is a directionally dependend limitation of the total output. The value 1.0 corresponds to unlimited output of 100%. Typically, using this parameter one refers to a velocity output signal for the drive in connection with position control. In exceptional cases the application of this parameter may refer to a torque value or a current value.

4.3.3 Torque and Acceleration Scaling

Parameter	Offline Value	Online Value	Type	Unit
- Torque and Acceleration Scaling:				
Input Scaling Factor (Actual Torque)	0.0		F	
Input P-T1 Filter Time (Actual Torque)	0.0		F	s
Input P-T1 Filter (Actual Torque Derivative)	0.0		F	s

This group of parameters creates an optional acceleration as a servo control that is supposed to act before a lag distance evolves. It may set e.g. a torque value.

Input Scaling Factor (Actual Torque)

The gain factor for the optional servo control.

Input P-T1 Filter Time (Actual Torque)

Time for the P-T1 filter. This time comes as an input to the P-T1 filter.

Input P-T1 Filter (Actual Torque Derivative)

Derivative of the actual torque to be scaled. This derivative comes as an input to the P-T1 filter.

Consult section [PT1 Filter](#) [▶ 81] for more information on a PT1 filter.

Parameter	Offline Value	Online Value	Type	Unit
- Torque and Acceleration Scaling:				
Output Scaling Factor (Torque)	0.0		F	
Output Delay (Torque)	0.0		F	s
Output Scaling Factor (Acceleration)	0.0		F	

Output Delay (Acceleration)	0.0		F	s
-----------------------------	-----	--	---	---

Output Scaling Factor (Torque)

Sometimes an optional output scaling for torque is needed.

Output Delay (Torque)

The output of the torque value can be delayed by the Output Delay (Torque) time.

Output Scaling Factor (Acceleration)

Sometimes an optional output scaling for acceleration is needed. (E.g. for NC acceleration feedforward. Consult section [Acceleration Feedforward](#) [▶ 77] for more information on acceleration feedforward.)

Output Delay (Acceleration)

The output of the acceleration value can be delayed by the Output Delay (Acceleration) time.

4.3.4 Valve Diagram

Parameter	Offline Value	Online Value	Type	Unit
Valve Diagram:				
Valve Diagram: Table Id	0		D	
Valve Diagram: Interpolation type	'LINEAR' ▼		E	
Valve Diagram: Output offset [-1.0 ... 1.0]	0.0		F	

Within this section cam tables are employed to construct linear position coupling. Thus, for numerical control e.g. a hydraulic axis may be treated similarly to a servo axis.

A cam plate is a relation R that describes non-linear position coupling between a master axis and a slave axis:

- $y = R(x)$,
- x -axis: master axis position,
- y -axis: slave axis position.

This relation is stored within a valve diagram table. Within this table the number pairs (x, y) are discrete.

Valve Diagram: Table Id

Each valve diagram table has its own identification number Id. It is assigned serially to each table. The table Id uniquely identifies the cam plate in the TwinCAT system.

Valve Diagram: Interpolation type

Two interpolation types

- 'LINEAR' or
- 'SPLINE'

can be selected to join the discrete number pairs (x, y) within the valve diagram table.

Valve Diagram: Output offset [-1.0 ... 1.0]

This parameter allows to adjust a zero transition of a position coupling curvature through the origin. Thus, e.g. a hysteresis branch can be adjusted to run through the origin.

TwinCAT PLC Hydraulics Library

Employing a cam plate relation some simple types of hydraulic axes can be controlled like servo axes. For more intricate types of hydraulic axes follow

- [TwinCAT PLC Hydraulics](https://infosys.beckhoff.com/content/1033/tcplclibhydraulics30/index.html) or <https://infosys.beckhoff.com/content/1033/tcplclibhydraulics30/index.html>

to find information on controlling them with the TwinCAT PLC Hydraulics Library.

4.3.5 Optional Position Command Output Smoothing Filter

Parameter	Offline Value	Online Value	Type	Unit
Optional Position Command Output Smoothing Filter:				
Smoothing Filter Type	'OFF (default)'		E	
Smoothing Filter Time	0.01		F	s
Smoothing Filter Order (P-Tn only)	2		D	

Smoothing Filter Type and Smoothing Filter Time

When

- 'OFF (default)'

is selected position command output smoothing is deactivated.

As filter types

- 'Moving Average' or
- 'P-Tn'

can be selected. Both modes refer to the position setpoint value.

'Moving Average': As an output the Moving Average Filter creates an average over a set of position setpoint values that comes as an input to the filter. Thereby, the Smoothing Filter Time prescribes the time interval over that the average spans. Values of the input set are created by position setpoint generation. Thus, the value generation frequency is determined by the cycle time of the task generating the setpoint values.

When a new value is generated e.g. each 1ms and the Smoothing Filter Time is set to e.g. 20ms an average is taken over 20 values. Thereby, the influence of a setpoint value is perceptible for 20ms.

'P-Tn': As an output the P-Tn Filter creates an average over a set of position setpoint values that comes as an input to the filter. Thereby, the Smoothing Filter Time prescribes the time constant of the P-Tn Filter. Values of the input set are created by position setpoint generation. Thus, the value generation frequency is determined by the cycle time of the task generating the setpoint values.

Smoothing Filter Order (P-Tn only)

The order of the employed P-Tn smoothing filter.

Smoothing Filter

In some applications position command output smoothing is used to reduce vibrations of machine parts. This smoothing forms an additional filter that should be handled with care. This filter cannot be compensated by a static dead time.

4.3.6 Sercos Behavior

Parameter	Offline Value	Online Value	Type	Unit
- Sercos Behavior:				
C1D Error Tolerance	'STANDARD' ▼		E	

C1D Error Tolerance

Some C1D errors of the hardware drive can be delayed by setting this parameter to 'IGNORE SELECTED ERRORS'.

4.3.7 Other Settings

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Drive Mode	'STANDARD' ▼		E	

Drive Mode

Currently, there is merely one drive mode, the 'STANDARD' drive mode. In principle, other modes are imaginable implementing a more open system.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Drift Compensation (DAC-Offset)	0.0		F	mm/s

Drift Compensation (DAC-Offset)

This value is added to the drive control level. In this way, a constant offset can be added to the output to compensate zero errors in analog drives, for instance.

Confer section [Automatic DAC Offset Adjustment](#) [▶ 77].

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Following Error Calculation	'Intern' ▼		E	

Following Error

The Following Error is equal to the Lag Distance, also called Position Lag Error.

Position Lag Error = Actual Position - Current Setpoint Position.

Following Error Calculation

Following error calculation can be done with the NC or inside the hardware drive. For all hardware drives working in position control mode the calculation should be done externally on the hardware drive.

'Intern': The Following Error Calculation is done within TwinCAT internally.

'Extern': The Following Error Calculation is done within the drive controller externally.

4.4 Axes | Axis 1 | Ctrl

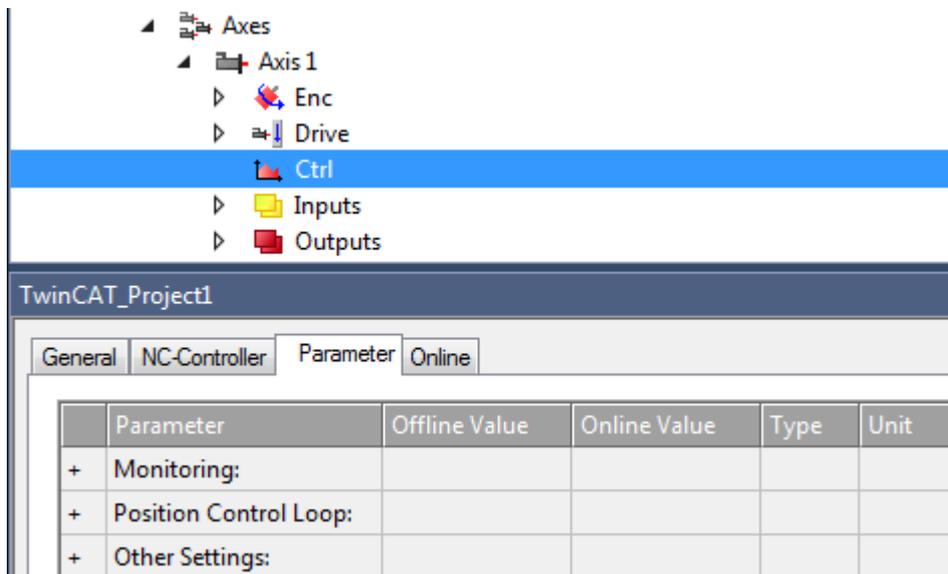
Controller

The purpose of the controller is to operate on the basis of setpoint velocities or other setpoint magnitudes (e.g. acceleration) and on the basis of setpoint magnitude differences as following errors. Controller operation is performed in a way to keep following errors as small as possible and to prevent any axis to undergo any overshoots in position or velocity.

Supported is a wide variety of controller versions: Servo position controllers and special controllers for particular axis types.

Controller Types

- *Position Controllers:* Control the actual position to follow the setpoint position as precisely as possible. Position controller P, following error proportional controller, position controller with two P constants, following error proportional controller with different constants for the stationary state and for movement, position PID-T1 controller with proportional acceleration feed forward.
- *Controllers for Axes:* Servo axes, stepper motors, low-speed axes, high-speed axes.



At "MOTION | NC-Task 1 SAF | Axes | Axis 1 | Ctrl" the file card Parameter displays the parameter groups

- Monitoring,
- Position Control Loop,
- Other Settings.

Furthermore, the parameter groups

- Velocity Control Loop,
- Observer

may appear.

Controller Types and their Parameters

The following table lists the available controller types and shows what parameters configure ("x") or do not configure ("-") each one of them.

	Position controller P	Position controller with two P constants (with Ka)	Position controller PID (with Ka)	Position P and velocity PID controller (Torque)	Position P and velocity PI controller with Observer (Torque)	Two speed controller	Stepper controller	SERCOS controller (Position by SERCOS)
Monitoring:	x	x	x	x	x	x	x	x
Position Lag Monitoring	x	x	x	x	x	x	x	x
Maximum Position Lag Value	x	x	x	x	x	x	x	x
Maximum Position Lag Filter Time	x	x	x	x	x	x	x	x
Position Control Loop:	x	x	x	x	x	x	x	x
Position control: Dead Band Position Deviation	-	x	x	-	x	-	-	-
Position control: Proportional Factor Kv	x	-	x	x	x	-	-	-
Position control: Proportional Factor Kv (standstill)	-	x	-	-	-	-	-	-
Position control: Proportional Factor Kv (moving)	-	x	-	-	-	-	-	-
Position control: Integral Action Time Tn	-	-	x	-	-	-	-	-
Position control: Derivative Action Time Tv	-	-	x	-	-	-	-	-
Position control: Damping Time Td	-	-	x	-	-	-	-	-
Position control: Min./max. limitation I-Part [0.0 ... 1.0]	-	-	x	-	-	-	-	-
Position control: Min./max. limitation D-Part [0.0 ... 1.0]	-	-	x	-	-	-	-	-
Disable I-Part during active positioning	-	-	x	-	-	-	-	-
Position control: Velocity threshold V dyn [0.0 ... 1.0]	-	x	-	-	-	-	-	-
Feedforward Acceleration: Proportional Factor Ka	-	x	x	x	x	-	-	-
Feedforward Velocity: Pre-Control Weighting [0.0 ... 1.0]	x	x	x	x	x	x	x	x
Velocity Control Loop:	-	-	-	x	x	-	-	-
Velocity control: Proportional Factor Kv	-	-	-	x	x	-	-	-
Velocity control: Integral Action Time Tn	-	-	-	x	x	-	-	-
Velocity control: Derivative Action Time Tv	-	-	-	x	-	-	-	-
Velocity control: Damping Time Td	-	-	-	x	-	-	-	-
Velocity control: Min./max. limitation D-Part [0.0 ... 1.0]	-	-	-	x	-	-	-	-
Velocity control: Min./max. limitation I-Part [0.0 ... 1.0]	-	-	-	x	x	-	-	-
Observer:	-	-	-	-	x	-	-	-
Velocity Filter: Time Constant T	-	-	-	-	x	-	-	-
Observer Mode	-	-	-	-	x	-	-	-
Motor: Torque Constant Kt	-	-	-	-	x	-	-	-
Motor: Moment of Inertia Jm	-	-	-	-	x	-	-	-
Bandwidth f0	-	-	-	-	x	-	-	-
Correction Factor Kc	-	-	-	-	x	-	-	-
Other Settings:	x	x	x	x	x	x	x	x
Controller Mode	x	x	x	x	x	x	x	x
Auto Offset	x	x	-	-	-	-	-	-
Offset Timer	x	x	-	-	-	-	-	-
Offset Limit (of Calibration Velocity)	x	x	-	-	-	-	-	-
Slave coupling control: Proportional Factor Kcp	x	x	x	-	-	-	-	-
Controller Outputlimit [0.0 ... 1.0]	x	x	x	x	x	-	-	-

4.4.1 Monitoring

Parameter	Offline Value	Online Value	Type	Unit
Monitoring:				
Position Lag Monitoring	TRUE <input type="checkbox"/>		B	
Maximum Position Lag Value	5.0		F	mm
Maximum Position Lag Filter Time	0.02		F	s

Position Lag Monitoring

When position lag monitoring is performed, the Position Lag Error is monitored, and if prescribed limits of position and time are exceeded, a runtime error is thrown.

Position Lag Error = Actual Position - Current Setpoint Position.

The Position Lag Monitoring parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Parameter.

Alternatively, the Position Lag Monitoring parameters can be set at MOTION | NC-Task 1 SAF | Axes | Axis 1 | Ctrl | Parameter.

Analogously, for different identifiers.

TRUE: Position Lag Monitoring is activated.

FALSE: Position Lag Monitoring is not activated.

Maximum Position Lag Value and Maximum Position Lag Filter Time

The Maximum Position Lag Value is the upper boundary for the permitted position lag error not to be exceeded for a time longer than the Maximum Position Lag Filter Time when the Position Lag Monitoring is activated. Otherwise, the NC axis will be stopped instantaneously by a zero voltage output and the NC axis will be placed into the logical "error" state throwing the error 0x4550.

4.4.2 Position Control Loop

Via fieldbus a setpoint velocity is transferred to the drive controller. Feeding back via fieldbus the actual axis position is transferred to TwinCAT thus forming a Position Control Loop. Employing this loop positional control can be carried out.

Parameter	Offline Value	Online Value	Type	Unit
Position Control Loop:				
Position control: Dead Band Position Deviation	0.0		F	mm

Position control: Dead Band Position Deviation

In contrast to position control in the drive device, in TwinCAT Dead Band Position Deviation is only effective for position control if, for example, the velocity interface to the drive is configured. It defines a range in which the controller is inactive. This parameter is a symmetrical window based on the assumption that the position lag error with respect to the position control (position control deviation) within this window is zero. Position control is therefore disabled within the window.

This functionality is required because certain axes and mechanical systems may cause a stationary oscillation around the target position. The parameter can be used to enforce "calm". The parameterizable deviation around the exact target position is accepted.

There are axes that are not capable of position control or have insufficient holding torque around standstill, so that a certain inaccuracy around the target position is accepted.

For other real effects, such as pronounced static friction (with tear-off torque) or pronounced slack, dead band position deviation can also be used to enforce "calm" for an accepted accuracy.

Parameter	Offline Value	Online Value	Type	Unit
Position Control Loop:				
Position control: Proportional Factor Kv	1.0		F	mm/s/mm

Parameter	Offline Value	Online Value	Type	Unit
Position Control Loop:				

	Position control: Proportional Factor Kv (standstill)	1.0		F	mm/s/mm
	Position control: Proportional Factor Kv (moving)	0.1		F	mm/s/mm

Position control: Proportional Factor Kv

The Proportional Factor Kv is the proportional gain factor of the P component of the P-controller. Output velocity = feed forward velocity + Kv * following error.

Position control: Proportional Factor Kv (standstill)

The Proportional Factor Kv (standstill) K_{vs} is the proportional gain factor of the P component of the P-controller, when the axis stands stationary still. Output velocity when stationary = feedforward velocity + K_{vs} * following error.

Position control: Proportional Factor Kv (moving)

The Proportional Factor Kv (moving) K_{vf} is the proportional gain factor of the P component of the P-controller, when the axis is moving. Output velocity when moving = feedforward velocity + K_{vf} * following error.

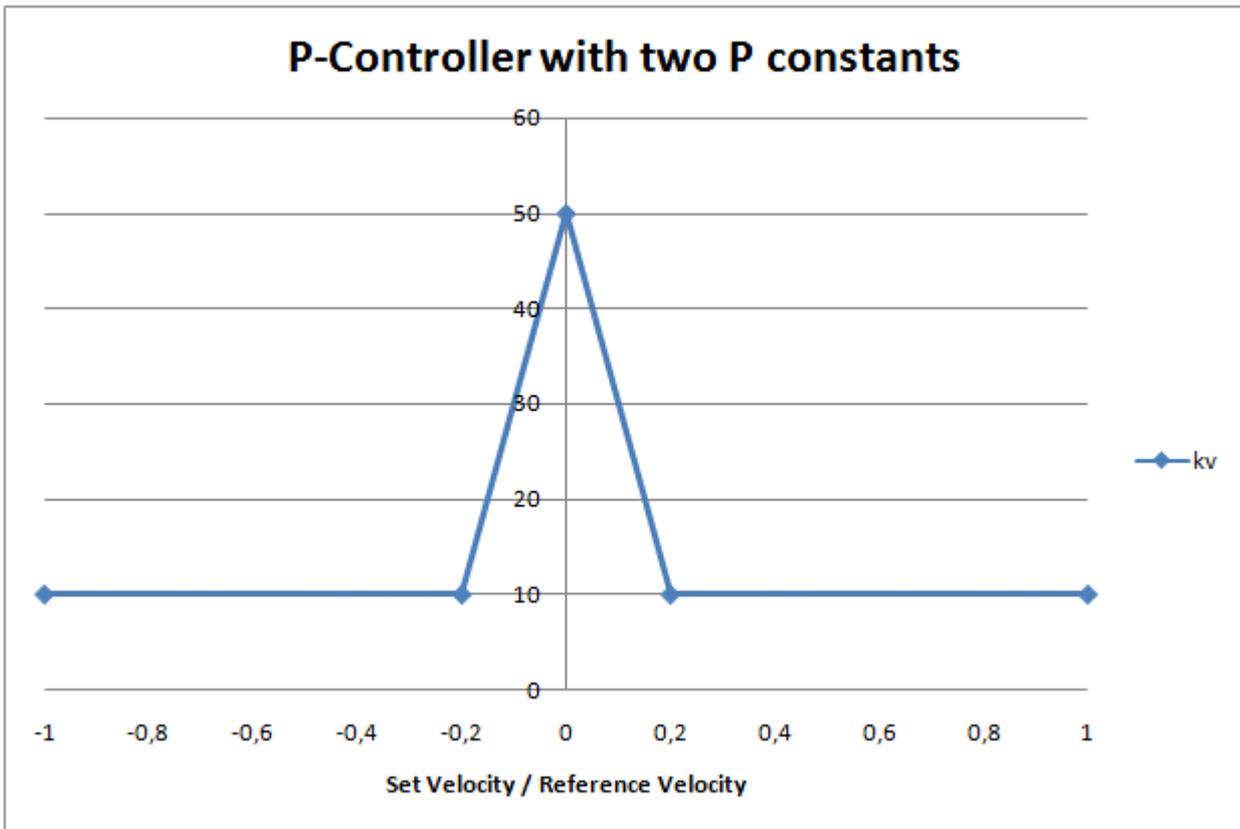
	Parameter	Offline Value	Online Value	Type	Unit
-	Position Control Loop:				
	Position control: Velocity threshold V dyn [0.0 ... 1.0]	0.5		F	

Position control: Velocity threshold V dyn [0.0 ... 1.0]

A PP controller uses two P constants

- Kv (standstill) K_{vs} and
- Kv (moving) K_{vf}

and a velocity threshold v_{dyn} to define a function for a velocity dependent k_v factor. When the value of the quotient "setpoint velocity / reference velocity" resides within the velocity threshold interval $[-v_{dyn} \dots +v_{dyn}]$ the gain factor of the P-controller is linearly interpolated from the proportional factor Kv (moving) K_{vf} towards the proportional factor Kv (standstill) K_{vs} at zero velocity. The diagram below illustrates the connections.



The sample is parameterized with $K_{vs} = 50$, $K_{vf} = 10$ and $v_{dyn} = 0.2$.

Parameter	Offline Value	Online Value	Type	Unit
Position Control Loop:				
Position control: Integral Action Time T_n	0.0		F	s
Position control: Derivative Action Time T_v	0.0		F	s
Position control: Damping Time T_d	0.0		F	s

Position control: Integral Action Time T_n

Integral Action Time T_n of the I component of the PID-controller. Integration time.

Position control: Derivative Action Time T_v

Rate time T_v of the real D component (D-T1 component) of the PID-controller.

Position control: Damping Time T_d

Damping time T_d of the real D component (D-T1 component) of the PID-controller.

Parameter	Offline Value	Online Value	Type	Unit
Position Control Loop:				
Position control: Min./max. limitation I-Part [0.0 ... 1.0]	0.1		F	
Position control: Min./max. limitation D-Part [0.0 ... 1.0]	0.1		F	

Position control: Min./max. limitation I-Part [0.0 ... 1.0]

I-part limitation of the PID-controller.

Position control: Min./max. limitation D-Part [0.0 ... 1.0]

D-part limitation of the PID-Controller.

Parameter	Offline Value	Online Value	Type	Unit
- Position Control Loop:				
Disable I-Part during active positioning	FALSE		B	

Disable I-Part during active positioning

The I-part of the PID-controller can be disabled during active positioning.

Parameter	Offline Value	Online Value	Type	Unit
- Position Control Loop:				
Feedforward Acceleration: Proportional Factor K_a	0.0		F	s
Feedforward Velocity: Pre-Control Weighting [0.0 ... 1.0]	1.0		F	

Feedforward Acceleration: Proportional Factor K_a

The acceleration feedforward proportional factor K_a is the gain factor when NC acceleration feedforward control is used. $\text{Output velocity component} = K_a * \text{setpoint acceleration}$.

Additional Information: Acceleration Feedforward

Consult section [Acceleration Feedforward \[► 77\]](#) for more information on Acceleration Feedforward.

Feedforward Velocity: Pre-Control Weighting [0.0 ... 1.0]

This parameter is a relative weighting of the feedforward. Thereby, the default parameter value 1.0 corresponds to 100% feedforward weighting. Velocity feedforward precontrol weighting can be reduced to avoid an overshoot in position.

4.4.3 Velocity Control Loop

Habitually, velocity control is performed within the drive controller by the velocity controller unit. This velocity controller is depicted within the controller overview of the Drive Manager. When velocity control is brought into the TwinCAT runtime this software velocity control unit has to be configured. The velocity control loop parameters configure the software velocity control within the TwinCAT runtime.

Parameter	Offline Value	Online Value	Type	Unit
- Velocity Control Loop:				
Velocity control: Proportional Factor K_v	0.1		F	

Velocity control: Proportional Factor K_v

The Proportional Factor K_v is the gain factor of the P-controller.

Parameter	Offline Value	Online Value	Type	Unit
- Velocity Control Loop:				
Velocity control: Integral Action Time T_n	0.0		F	s
Velocity control: Derivative Action Time T_v	0.0		F	s
Velocity control: Damping Time T_d	0.0		F	s

Velocity control: Integral Action Time T_n

Integral Action Time T_n of the I component of the PID-controller. Integration time.

Velocity control: Derivative Action Time T_v

Rate time T_v of the real D component (D-T1 component) of the PID-controller.

Velocity control: Damping Time T_d

Damping time T_d of the real D component (D-T1 component) of the PID-controller.

Parameter	Offline Value	Online Value	Type	Unit
Velocity Control Loop:				
Velocity control: Min./max. limitation D-Part [0.0 ... 1.0]	0.1		F	
Velocity control: Min./max. limitation I-Part [0.0 ... 1.0]	0.1		F	

Velocity control: Min./max. limitation D-Part [0.0 ... 1.0]

D-part limitation of the PID-controller.

Velocity control: Min./max. limitation I-Part [0.0 ... 1.0]

I-part limitation of the PID-controller.

4.4.4 Observer

Parameter	Offline Value	Online Value	Type	Unit
Observer:				
Velocity Filter: Time Constant T	0.001		F	s

Velocity Filter: Time Constant T

Part of the observer model for determining velocities.

Parameter	Offline Value	Online Value	Type	Unit
Observer:				
Observer Mode	'OFF' <input type="button" value="v"/>		E	
Motor: Torque Constant K_t	1.0		F	Nm/A
Motor: Moment of Inertia J_m	1.0		F	kg cm ²
Bandwidth f_0	20.0		F	Hz
Correction Factor K_c	1.0		F	

Observer Mode

As an Observer Mode

- 'OFF' or
- 'LUENBERGER'

can be selected. The Observer Mode implements an observer model for determining velocities.

Motor: Torque Constant κ_t

Part of the observer model.

Motor: Moment of Inertia J_m

Part of the observer model.

Bandwidth f_0

Part of the observer model.

Correction Factor κ_c

Part of the observer model.

4.4.5 Other Settings

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Controller Mode	'STANDARD'		E	

Controller Mode

Currently, only the 'STANDARD' controller mode can be selected.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Auto Offset	FALSE		B	
Offset Timer	1.0		F	s
Offset Limit (of Calibration Velocity)	0.01		F	

Auto Offset

The auto offset parameters merely influence the behavior of the P-controller and the PP-controller. To activate the

- Offset Timer

and the

- Offset Limit (of Calibration Velocity)

the parameter Auto Offset has to be set on `TRUE`.

The auto offset parameters are designed for an analog axis interface. A real axis may not be fully stopped at a zero velocity setpoint, but may drift slightly. This drift behavior may be due to offset problems, temperature problems or other reasons. The auto offset is supposed to act as an adaptive and automatic offset coordination to compensate slight drifts and thus to prevent the axis from drifting apart. On digital interfaces the auto offset has no effect.

The automatic offset adjustment calculates and activates a DAC offset that minimizes the following error in the position control.

Confer section [Automatic DAC Offset Adjustment](#) [▶ 77].

Offset Timer

For control the offset timer has a similar effect as an I-part.

Offset Limit (of Calibration Velocity)

For a P-controller or for a PP-controller within the interval [- Offset limit ... + Offset limit] the offset will automatically be adjusted. A relative control. At a limit the offset is kept constant not going beyond it.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Slave coupling control: Proportional Factor Kcp	0.0		F	mm/s/mm

Slave coupling control: Proportional Factor Kcp

This parameter influences merely the control loop in TwinCAT NC. The slave coupling control proportional factor Kcp is the gain factor for an additional P-controller. This P-controller is trying to minimize the difference of master and slave position lag to enhance the accuracy.

Parameter	Offline Value	Online Value	Type	Unit
- Other Settings:				
Controller Outputlimit [0.0 ... 1.0]	0.5		F	

Controller Outputlimit [0.0 ... 1.0]

Controller output limit can be set within the interval [0.0 ... 1.0].

4.5 Technical Terms

4.5.1 Acceleration Feedforward

In addition to proportional feedback of the following error nearly all position controllers contain a proportional acceleration feedforward: The K_a factor. This acceleration feedforward should normally only be used in association with the proportional component of the position controller: The K_v factor. Acceleration feedforward control requires to adjust the axis for strict symmetry:

- When stationary, the following error is symmetrical about 0 (DAC offset). Confer section [Automatic DAC Offset Adjustment \[▶ 77\]](#).
- When moving steadily, the following error is symmetrical about 0 (reference velocity).
- Set K_v .
- Measure the extreme value of the acceleration a_{+max} and the associated following error d_{+max} in the middle of the acceleration phase. Measure the extreme value of the deceleration a_{-max} and the associated following error d_{-max} in the middle of the braking phase.
- $K_{a+} = K_v * d_{+max} / a_{+max}$,
 $K_{a-} = K_v * d_{-max} / a_{-max}$,
 $K_a = (K_{a+} + K_{a-}) / 2$.

4.5.2 Automatic DAC Offset Adjustment

Any controller with no I component has automatic DAC offset adjustment as an option. This adjustment is only active when the velocity feedforward of the axis falls below a certain magnitude. This limited activity prevents the DAC offset adjustment from being affected by the dynamic behavior of the axis. If the axis is subject to position control or is moving at a suitably low velocity, an offset velocity is generated by integrating the control velocity. This offset velocity is added to the output. The negative feedback of the position control loop results in a PT1 behavior creating an exponential function.

Offset Adjustment Parameters

Offset filter time: Data type `Double`. Unit `sec`. Time constant for the offset adjustment.

Offset limit: Data type `Double`. A relative control. At a limit the offset is kept constant not going beyond it.

Quite possibly, the behavior of the offset adjustment could be affected at runtime. Suitably, a range of “switches” is available: For instance, at runtime the PLC or another ADS device can modify time constant parameters or feedforward limit parameters.

The offset adjustment could be switched off entirely. Doing so, it is not always possible to avoid a jump in the output voltage. Therefore, a soft deactivation can be achieved with the “fade out” mode. A fade out reduces the adjustment to zero over time while following its own curve. To keep the adjustment steady for a period of time the “hold” mode can be activated. E.g., the “hold” mode is suitable when stopping the power section of a drive temporarily. Performing such a stop it would be impossible for the offset not to run out of control if the offset adjustment was to remain active.

4.5.3 Axis Error

The variables `axis.Status.Error` and `axis.Status.ErrorID` belong to the `ST_AxisStatus` data structure.

The boolean variable `axis.Status.Error` displays the `StateDWord` bit 31 and refers to the axis error state. When the boolean variable `axis.Status.Error` is `TRUE`, it indicates that there is an error for the axis.

The variable `axis.Status.ErrorID` of data type `UDINT` refers to the error ID of the reported error and displays the axis error code.

4.5.4 AXIS_REF

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

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

MC axis variable



The PLC axis variable `MAIN.axis` has the data type `AXIS_REF`.

The data type `AXIS_REF`:

- contains information about an axis,
- is an interface between the PLC and the NC and
- is given to the MC function blocks as a reference to an axis.

● Refreshing the status data structure in `AXIS_REF`

I The status data structure `Status` of the type `ST_AxisStatus` contains additional or prepared status and diagnostic information about an axis. The structure is not cyclically refreshed, but has to be updated by the PLC program

Calling the `ReadStatus()` action from `AXIS_REF` updates the status data structure and should be done once at the beginning of each PLC cycle.

The status information does not change within a PLC cycle. After calling `ReadStatus()`, the current status information can be accessed in `AXIS_REF` within the entire PLC program.

The nature of the status data structure is purely informative. Therefore, its use is not mandatory.

4.5.5 NC

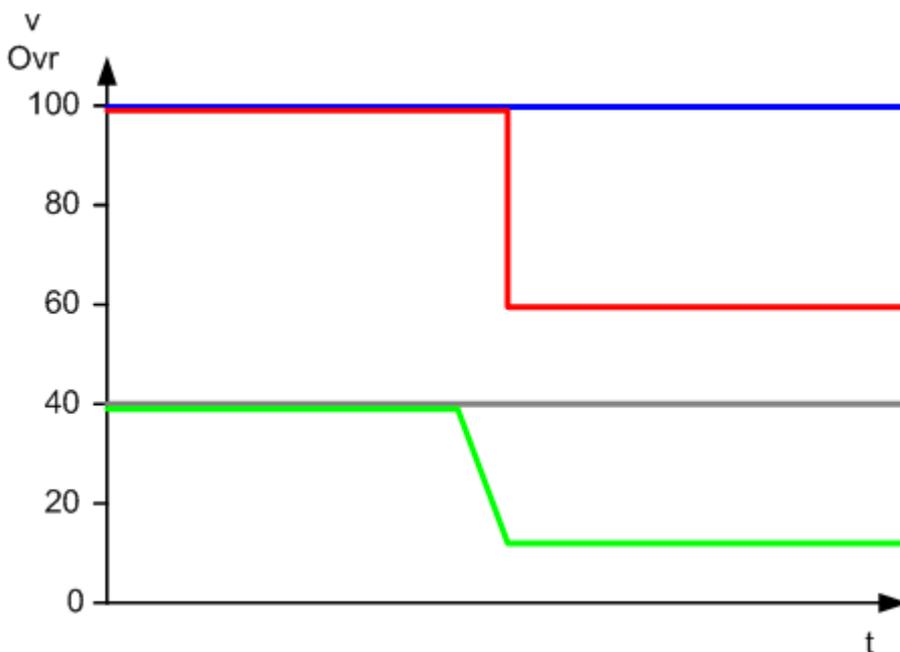
TwinCAT NC is an assembly of function groups used for the control and regulation of axes or of synchronized axis groups. An NC task consists of one or more channels of type PTP channel, FIFO channel or NCI channel, and their subsidiary parts. Generally, immediately after start-up the NC axes find themselves in one or more PTP channels. Particularly, they are moved to a different channel through a process of reconfiguration then, if necessary.

4.5.6 Path Override (Interpreter Override Types)

The path override is a velocity override. Consequently, changing the override creates a new velocity, but does not affect the ramps (acceleration or jerk). The applicable override types merely differ in terms of their underlying reference velocity.

The parameterization takes place in the interpolation channel under the group parameters.

Option "Reduced (iterated)"



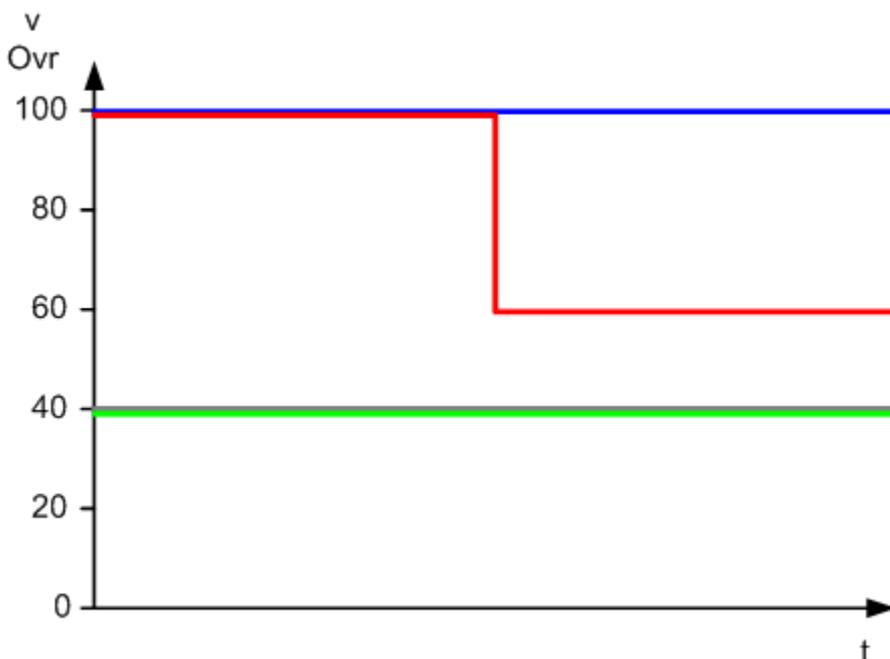
- █ resulting path velo
- █ max. velo of segment
- █ override
- █ programmed path velo

Based on the reduced velocity (default).

Because of the relevant dynamic parameters (braking distance, acceleration etc.) it is not possible for the programmed velocity, depicted by the blue line, to be achieved in every segment. For this reason, for each geometric segment a velocity, depicted by the red line, is calculated that may possibly be reduced compared to the programmed velocity. In the standard case, the override is made with reference to this possibly reduced segment velocity.

The advantage of this override type is that the machine operates with an approximately linear reduction in velocity when override values are small. Therefore, "Reduced (iterated)" is the correct setting for most applications:

$$v_{res} = v_{max} * \text{Override.}$$

Option "Original (iterated)"

- █ resulting path velo
- █ max. velo of segment
- █ override
- █ programmed path velo

Based on the programmed path velocity.

The override value is based on the velocity programmed by the user. The maximum segment velocity has merely a limiting effect.

Option "Reduced [0 ... >100%]"

Based on internally reduced velocity with the option to specify a value greater than 100%.

From TwinCAT V2.10, Build 1329.

Generally, the override type behaves like "Reduced (iterated)". More specifically, with this override type it is possible to travel along the path more quickly than programmed in the G-Code. There is no limitation to 120%, for example. The maximum possible path velocity is limited by the maximum velocities of the axis components (G0 velocity) and their dynamics.

If limitation to a particular value, e.g. 120%, is required, this limitation can be set within the PLC project.

4.5.7 PTP

PTP stands for point-to-point. PTP axis functionality is a control process for **one-dimensional positioning** of axes, in particular servo axes, but also other types of axes. One-dimensional does not necessarily mean linear. It simply means that one component is interpolated in some specified coordinate system (Cartesian coordinates, polar coordinates).

PTP is a licence level for basic axis numerical control. PTP forms the basis of the whole of TwinCAT NC, because at **system start-up** the axes are normally in PTP mode, and thus are position controlled. The extended TwinCAT NC functionalities are achieved on the basis of the PTP modes by reconfiguration (FIFO, NCI) or by coupling (all slave types).

4.5.8 PT1 Filter

A PT1 filter is a transfer function that performs convex interpolation between a new value x_n and an old value (from one cycle before) x_a . The filter time parameter, a nonnegative value in the unit of seconds, has to be entered into the calculation. If $I = \text{SAF cycle time} / (\text{SAF cycle time} + \text{filter time})$, then $x = I * x_n + (1-I) * x_a$. The filter time should be finite. For the filter time being a positive value I resides within the open interval from 0 to 1. If the filter time is close to 0.0, the new value has a high weighting. If the filter time is long, the older value has a relatively high weighting.

4.5.9 Rapid Traverse

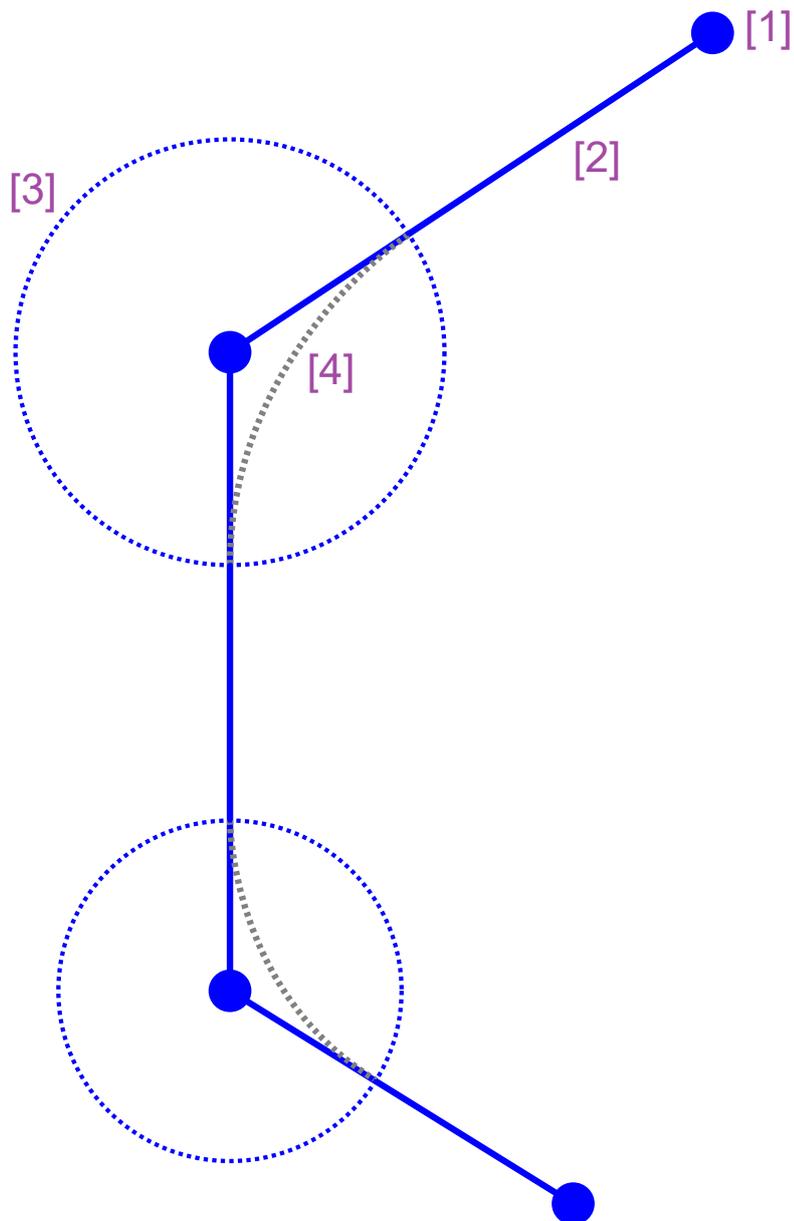
Command	G0
Cancellation	G1, G2 or G3

- Rapid traverse is used to position the tool quickly, and is not to be used for machining the workpiece. With G0 the axes are moved with linear interpolation as fast as possible. The velocity is calculated with MIN (Rapid Traverse Velocity (G0), Reference Velocity, Maximum Velocity).
- If a number of axes are to be driven in rapid traverse the velocity is determined by that axis that requires the most time for its movement.
- An accurate stop (G60) is cancelled with G0.
- The rapid traverse velocity is set for each axis individually at "MOTION | NC-Task 1 SAF | Axes | Axis 1 | NCI Parameter | Rapid Traverse Velocity (G0)".

4.5.10 ReadStatus()

See section [AXIS_REF \[▶ 78\]](#).

4.5.11 Tolerance Ball



- [1] Glue dot.
- [2] Segment, geometrical element, here: line.
- [3] Tolerance ball.
- [4] Transition, smooth path.

Motivation

- Dynamical-Steadiness*
- Segment transitions that are not two times steadily differentiable with respect to their spatial coordinate lead to dynamic-unsteadinesses, if at this transition the path velocity is not reduced to *zero* value.
 - Segment transitions can be smoothed out using Bézier-splines leading to the dynamics for the whole path to be steady at the segment transition, even though path velocity differs from *zero*.

- Smoothing*
- Tolerance balls are used to smooth out dynamic unsteadiness at segment transitions.

- Faster Dynamics*
- Smoothing permits faster dynamics.
 - The maximum segment transition velocity calculated by the system in advance has the value *VeloLink*.
 - The user can change the system parameter *C2* for *C2*-velocity reduction online.
 - The segment transition velocity has the value *C2 x VeloLink*.

Definition

- Segment Transition*
- For the smoothing a tolerance ball is placed around each segment transition.

- Permitted Path Deviation*
- Up to the extend that the path stays within the tolerance ball, this path may deviate from its predefined geometry within this tolerance ball.

Parameter

- Radius*
- The user adjusts the radius of the tolerance ball.

Range of Validity

- No Exact Halt, No Stop*
- The radius of the tolerance ball is valid modally for all segment transitions that at the segment transition do not imply an exact halt or a stop.

Algorithmic Behavior

- Adaptive*
- Automatically, the radii of the tolerance balls are set adaptively.

- Inhibit Overlap*
- Setting the radii adaptively prevents from overlap of the tolerance balls. Otherwise, especially for small segments an overlap of tolerance balls could occur.

- At the Segment Transition*
- Within the tolerance ball there is no override.
 - Entering the tolerance ball the path acceleration obtains *zero* value.
 - Entering the tolerance ball the path velocity obtains the value of the segment transition velocity.
 - Within the tolerance ball the path acceleration stays at *zero* value.
 - Within the tolerance ball the path velocity remains at the value of the segment transition velocity.
 - The override induced change of velocity level is interrupted within the tolerance ball and is continued after leaving the tolerance ball.

More Information:
www.beckhoff.com/tf5000

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