Manual

Parameters for Motion

TwinCAT 3
Contents

1 Notes on the documentation ............................................................................................................. 5

2 Safety instructions ............................................................................................................................ 6

3 Axes | Axis 1 ........................................................................................................................................ 7
  3.1 Reference Velocity .......................................................................................................................... 7
  3.2 Maximum Dynamics, Default Dynamics ......................................................................................... 9
  3.3 Manual Motion and Homing ........................................................................................................... 10
  3.4 Fast Axis Stop ................................................................................................................................ 12
  3.5 Limit Switches ............................................................................................................................... 14
  3.6 Monitoring ...................................................................................................................................... 15
  3.7 Setpoint Generator .......................................................................................................................... 18
  3.8 NCI Parameter ............................................................................................................................... 18
  3.9 Other Settings ............................................................................................................................... 20

4 Axes | Axis 1 | Enc ..................................................................................................................................... 23
  4.1 Encoder Evaluation ......................................................................................................................... 23
  4.2 Limit Switches ............................................................................................................................... 25
  4.3 Filter ............................................................................................................................................. 26
  4.4 Homing ......................................................................................................................................... 27
  4.5 Other Settings ............................................................................................................................... 27

5 Axes | Axis 1 | Drive .................................................................................................................................... 29
  5.1 Output Settings .............................................................................................................................. 29
  5.2 Position and Velocity Scaling ......................................................................................................... 30
  5.3 Torque and Acceleration Scaling ................................................................................................... 32
  5.4 Valve Diagram ................................................................................................................................ 33
  5.5 Optional Position Command Output Smoothing Filter ..................................................................... 34
  5.6 Sercos Behavior ............................................................................................................................. 34
  5.7 Other Settings ............................................................................................................................... 35

6 Axes | Axis 1 | Ctrl ...................................................................................................................................... 36
  6.1 Monitoring ...................................................................................................................................... 37
  6.2 Position Control Loop ..................................................................................................................... 38
  6.3 Velocity Control Loop .................................................................................................................... 41
  6.4 Observer ....................................................................................................................................... 42
  6.5 Other Settings ............................................................................................................................... 42

7 Technical Terms ............................................................................................................................... 44
  7.1 Acceleration Feedforward ............................................................................................................. 44
  7.2 Automatic DAC Offset Adjustment ............................................................................................... 44
  7.3 Axis Error ...................................................................................................................................... 44
  7.4 AXIS_REF ..................................................................................................................................... 45
  7.5 NC.................................................................................................................................................. 45
  7.6 Path Override (Interpreter Override Types) ................................................................................... 46
  7.7 PTP ................................................................................................................................................. 47
  7.8 PT1 Filter ....................................................................................................................................... 48
  7.9 Rapid Traverse .............................................................................................................................. 48
  7.10 ReadStatus() ............................................................................................................................. 48

Parameters for Motion Version: 1.0
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.11</td>
<td>Tolerance Ball</td>
<td>49</td>
</tr>
</tbody>
</table>
1 Notes on the documentation

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

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

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

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

Disclaimer

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

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Trademarks

Beckhoff®, TwinCAT®, EtherCAT®, Safety over EtherCAT®, TwinSAFE®, XFC® and XTS® are registered trademarks of and licensed by Beckhoff Automation GmbH.

Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

Patent Pending

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

EP1590927, EP1789857, DE102004044764, DE102007017835

with corresponding applications or registrations in various other countries.

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

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

EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

Copyright

© Beckhoff Automation GmbH & Co. KG, Germany.

The reproduction, distribution and utilization of this document as well as the communication of its contents to others without express authorization are prohibited.

Offenders will be held liable for the payment of damages. All rights reserved in the event of the grant of a patent, utility model or design.
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!

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>Serious risk of injury! Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.</td>
</tr>
<tr>
<td>!</td>
<td>Risk of injury! Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.</td>
</tr>
<tr>
<td>!</td>
<td>Personal injuries! Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.</td>
</tr>
<tr>
<td>!</td>
<td>Damage to the environment or devices Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.</td>
</tr>
<tr>
<td>!</td>
<td>Tip or pointer This symbol indicates information that contributes to better understanding.</td>
</tr>
</tbody>
</table>
3 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.

3.1 Reference Velocity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Settings;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference Velocity</td>
<td>2200.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
<tr>
<td>at Output Ratio [0.0 ... 1.0]</td>
<td>1.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Drive Output Limitation [-1.0 .. 1.0]</td>
<td>-1.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Maximum Drive Output Limitation [-1.0 .. 1.0]</td>
<td>1.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>
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 a physical velocity limit not to be exceeded by setpoint generation and positional control.

*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 exceed 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.
3.2 Maximum Dynamics, Default Dynamics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Dynamics:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Velocity</td>
<td>2000.0</td>
<td>F</td>
<td>mm/s</td>
<td></td>
</tr>
<tr>
<td>Maximum Acceleration</td>
<td>15000.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
<tr>
<td>Maximum Deceleration</td>
<td>15000.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Dynamics:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default Acceleration</td>
<td>1500.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
<tr>
<td>Default Deceleration</td>
<td>1500.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
<tr>
<td>Default Jerk</td>
<td>2250.0</td>
<td>F</td>
<td>mm/s³</td>
<td></td>
</tr>
</tbody>
</table>

Dynamic-Parameters
- Velocity $\text{Vel}$
- Acceleration $\text{Acc}$
- Deceleration $\text{Dec}$
- 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 for one of the dynamic-parameters “Acc, Dec, jerk” the input value “0.0” is assigned to a motion function block, for this parameter the value “0.0” is replaced by a default value.
- If for one of the dynamic-parameters “Acc, Dec, jerk” no input value is assigned to a motion function block, this dynamic-parameter is preset to the value “0.0” and for this parameter the value “0.0” will be replaced by a default value.
Tc2_NC2, Tc2_MC
Maximum Dynamics

- The maximum dynamics are regarded as a real physical limit for the corresponding axis.
- Values exceeding those limits prescribed by the maximum dynamics will not be accepted and lead to an error.

Tc2_NC2
"Online Transformation"

- At the “online transformation” from slave to master various measures are taken to prevent exceeding the maximum velocity or an inversion of moving direction.
- For instance, such measures are an increase in jerk or an increase in acceleration or deceleration up to the maximum value.
- From slave to master: Uncoupling a slave-axis within 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.

3.3 Manual Motion and Homing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Motion and Homing:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homing Velocity (towards plc cam)</td>
<td>30.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
<tr>
<td>Homing Velocity (off plc cam)</td>
<td>30.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
</tbody>
</table>
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.

**Additional Information: MC_HOME**

Following

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

you can find further information on MC_Home.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Motion and Homing:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual Velocity (Fast)</td>
<td>600.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
<tr>
<td>Manual Velocity (Slow)</td>
<td>100.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
</tbody>
</table>

**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.
Analogueously, 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Motion and Homing:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jog Increment (Forward)</td>
<td>5.0</td>
<td>F</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Jog Increment (Backward)</td>
<td>5.0</td>
<td>F</td>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>

**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 or
  https://infosys.beckhoff.com/content/1033/tcplclib_tc2_mc2/index.html

you can find further information on MC_Jog.

### 3.4 Fast Axis Stop

**Fast Axis Stop**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Axis Stop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Axis Stop Signal Type (optional)</td>
<td>'OFF (default)'</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Acceleration (optional)</td>
<td>0.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
<tr>
<td>Fast Deceleration (optional)</td>
<td>0.0</td>
<td>F</td>
<td>mm/s²</td>
<td></td>
</tr>
<tr>
<td>Fast Jerk (optional)</td>
<td>0.0</td>
<td>F</td>
<td>mm/s³</td>
<td></td>
</tr>
</tbody>
</table>

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)

you can find further information on MC_Stop.

### 3.5 Limit Switches

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Position Limit Minimum Monitoring</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Minimum Position</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Soft Position Limit Maximum Monitoring</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Maximum Position</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

**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.

**Additional Information: Basic Safety Settings**

Following
you can find information on basic safety settings that involve the limit switches parameters.

### 3.6 Monitoring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Lag Monitoring</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Maximum Position Lag Value</td>
<td>5.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Maximum Position Lag Filter Time</td>
<td>0.02</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

**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.


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.

**Additional Information: Basic Safety Settings**

Following

• TF5000 TC3 NC PTP 10 Axes or https://infosys.beckhoff.com/content/1031/tf5000_tc3_nc_ptp_10/index.html

you can find information on basic safety settings that involve the position lag monitoring parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Range Monitoring</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Position Range Window</td>
<td>5.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Target Position Monitoring</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Target Position Window</td>
<td>2.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Target Position Monitoring Time</td>
<td>0.02</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>
Position Range Monitoring

[1] • Nominal value of the target position.


  • 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.

**Note**


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.


[7]  • Target Position Window.

[8], [9] Target Position Monitoring
Target position:
• 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Monitoring:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Target Alarm</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>In-Target Timeout</td>
<td>5.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Monitoring:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motion Monitoring</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Motion Monitoring Window</td>
<td>0.1</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Motion Monitoring Time</td>
<td>0.5</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

Motion Monitoring
Basically, the Motion Monitoring reveals whether the axis is moving in fact.
FALSE: The Motion Monitoring is not activated.
TRUE: The Motion Monitoring is activated.
Motion Monitoring Window
A position range that is tracked by the Motion Monitoring.

Motion Monitoring Time
When the axis is performing a job and within the Motion Monitoring Time does not change its position beyond the Motion Monitoring Window, the NC axis throws the error 0x435D.

3.7 Setpoint Generator

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setpoint Generator Type</td>
<td>7 Phases (optimized)</td>
<td></td>
<td></td>
<td>E</td>
</tr>
</tbody>
</table>

Setpoint Generator Type
The only available option is "7 Phases (optimized).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity Override Type</td>
<td>Reduced (iterated)</td>
<td></td>
<td></td>
<td>E</td>
</tr>
</tbody>
</table>

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 [9].

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) [46] for more information on path override.

3.8 NCI Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Traverse Velocity (G0)</td>
<td>2000.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
</tbody>
</table>

Rapid Traverse Velocity (G0)
The Rapid Traverse Velocity is used, when a G0 interpreter command is running. Look at section Rapid Traverse [48] for a short description of the G0 interpreter command.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velo Jump Factor</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Tolerance ball auxiliary axis</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>
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 [49] for more information.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCI Parameter:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. position deviation, aux. axis</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Max. position deviation, aux. axis

Introduced for future enhancements.
### 3.9 Other Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Correction</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Filter Time Position Correction (P-T1)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

#### 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](#) for more information on a PT1 filter.

#### Additional Information: MC_PositionCorrectionLimiter

Following

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

you can find information on `MC_PositionCorrectionLimiter`.

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.

**Note!**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backlash Compensation</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Backlash</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

#### Backlash Compensation and Backlash

These parameters remain merely for compatibility issues. Do not use them within new projects.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couple slave to actual values if not enabled</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Velocity Window</td>
<td>1.0</td>
<td>F</td>
<td>mm/s</td>
<td></td>
</tr>
<tr>
<td>Filter Time for Velocity Window</td>
<td>0.01</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allow motion commands to slave axis</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Allow motion commands to external setpoint axis</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead Time Compensation (Delay Velo and Position)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

**Dead Time Compensation (Delay Velo and Position)**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Persistence</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

**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 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 intertemporally. 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.

4.1 Encoder Evaluation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invert Encoder Counting Direction</td>
<td>FALSE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaling Factor Numerator</td>
<td>0.0001</td>
<td></td>
<td>F</td>
<td>mm/INC</td>
</tr>
<tr>
<td>Scaling Factor Denominator (default: 1.0)</td>
<td>1.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Bias</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulo Factor (e.g. 360.0°)</td>
<td>360.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Tolerance Window for Modulo Start</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

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 or
  https://infosys.beckhoff.com/content/1033/tcplclib_tc2_mc2/index.html

you can find further Notes on Modulo Positioning.
**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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise level of simulation encoder</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

**Noise level of simulation encoder**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Evaluation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference System</td>
<td>'INCREMENTAL'</td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

**Reference System**

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

- 'INCREMENTAL',
- 'INCREMENTAL (singleturn absolute)',
- 'ABSOLUTE',
- 'ABSOLUTE (with single overflow)',
- 'ABSOLUTE (modulo)'.

### 4.2 Limit Switches

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit Switches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft Position Limit Minimum Monitoring</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Minimum Position</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
<tr>
<td>Soft Position Limit Maximum Monitoring</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Maximum Position</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

**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.

**Additional Information: Basic Safety Settings**

Following

- TF5000 TC3 NC PTP 10 Axes or
  https://infosys.beckhoff.com/content/1031/tf5000_tc3_nc_ptp_10/index.html

you can find information on basic safety settings that involve the limit switches parameters.

### 4.3 Filter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Filter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Time for Actual Position (P-T1)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
<tr>
<td>Filter Time for Actual Velocity (P-T1)</td>
<td>0.01</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
<tr>
<td>Filter Time for Actual Acceleration (P-T1)</td>
<td>0.1</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

**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](#48) for more information on a PT1 filter.
4.4 Homing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invert Direction for Calibration Cam Search</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Invert Direction for Sync Impuls Search</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Calibration Value</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm</td>
</tr>
</tbody>
</table>

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 impuls search can be inverted.

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

Calibration Value

The Calibration Value is the position value that will be assigned to the axis when the synchronization pulse appears within the reference travel. Thus, the detected position will be set to the Calibration Value. If the actual axis position is acquired in any unit differing from mm, the actually employed unit has to appear in the column "Unit" of this parameter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Mode</td>
<td>'Default'</td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

Reference Mode

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

- ‘Default’,
- ‘Plc CAM’,
- ‘Hardware Sync’,
- ‘Hardware Latch 1 (pos. edge)’,
- ‘Hardware Latch 1 (neg. edge)’,
- ‘Software Sync’,
- ‘Application (PLC code)’.

4.5 Other Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encoder Mode</td>
<td>'POSVELO'</td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Correction</td>
<td>FALSE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Filter Time Position Correction (P-T1)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

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 [48] for more information on a PT1 filter.

Additional Information: MC_PositionCorrectionLimiter

Following

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

you can find information on MC_PositionCorrectionLimiter.

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.

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

5.1 Output Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invert Motor Polarity</td>
<td>FALSE</td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
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.

### 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference Velocity</td>
<td>2200.0</td>
<td>F</td>
<td>mm/s</td>
<td></td>
</tr>
<tr>
<td>at Output Ratio [0.0 ... 1.0]</td>
<td>1.0</td>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Look at section Reference Velocity [7].

### 5.2 Position and Velocity Scaling

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position and Velocity Scaling:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Scaling Factor (Position)</td>
<td>1.0</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Scaling Factor (Velocity)</td>
<td>6.0</td>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 ±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.
### Parameters for Motion

**Version:** 1.0

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

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

---

**Output Delay (Velocity)**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Delay (Velocity)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

---
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.

5.3 Torque and Acceleration Scaling

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](#) for more information on a PT1 filter.
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 [44] for more information on acceleration feedforward.)

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

5.4 Valve Diagram

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve Diagram: Table Id</td>
<td>0</td>
<td></td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Valve Diagram: Interpolation type</td>
<td>LINEAR</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Valve Diagram: Output offset [-1.0 ... 1.0]</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

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** or
  https://infosys.beckhoff.com/content/1033/tcplclibhydraulics30/index.html

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

### 5.5 Optional Position Command Output Smoothing Filter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional Position Command Output Smoothing Filter:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoothing Filter Type</td>
<td>'OFF (default)'</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoothing Filter Time</td>
<td>0.01</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Smoothing Filter Order (P-Tn only)</td>
<td>2</td>
<td>D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Smoothing Filter Type and Smoothing Filter Time**

When

- ‘OFF (default)’

is selected position command output smoothing is deactivated.

As filter types

- ‘Moving Average’
- ‘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 which 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.

### 5.6 Sercos Behavior
C1D Error Tolerance

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

5.7 Other Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive Mode</td>
<td>‘STANDARD’</td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

Drive Mode

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

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 [44].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift Compensation (DAC-Offset)</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>mm/s</td>
</tr>
</tbody>
</table>

Following Error

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


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.
6 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 overshots 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.
## 6.1 Monitoring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Lag Monitoring</td>
<td>TRUE</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Maximum Position Lag Value</td>
<td>5.0</td>
<td>F</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Maximum Position Lag Filter Time</td>
<td>0.02</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Position Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Dead Band Position Deviation</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv (standstill)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv (moving)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Integral Action Time Tn</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Derivative Action Time Tv</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Damping Time Td</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Min./max. limitation I-Part [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Min./max. limitation D-Part [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Enable I-Part during active positioning</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Position control: Velocity threshold V dyn [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Feedforward Acceleration: Proportional Factor Ka</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Feedforward Velocity: Pre-Control Weighting [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity control: Proportional Factor Kv</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity control: Integral Action Time Tn</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity control: Derivative Action Time Tv</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity control: Damping Time Td</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity control: Min./max. limitation D-Part [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Velocity control: Min./max. limitation I-Part [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Observer:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observer Mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor: Torque Constant Kt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor: Moment of Inertia Jm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandwidth f0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correction Factor Kc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controller Mode</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Auto Offset</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Offset Timer</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Offset Limit (of Calibration Velocity)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Slave coupling control: Proportional Factor Kcp</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Controller Outputlimit [0.0 ... 1.0]</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Parameters for Motion  Version: 1.0  37
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.


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.

Additional Information: Basic Safety Settings

Following

- TF5000 TC3 NC PTP 10 Axes or https://infosys.beckhoff.com/content/1031/tf5000_tc3_nc_ptp_10/index.html

you can find information on basic safety settings that involve the position lag monitoring parameters.

6.2 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Dead Band Position Deviation</td>
<td>0.0</td>
<td>F</td>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>

Position control: Dead Band Position Deviation

The Dead Band Position Deviation defines an area where the controller is inactive.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv</td>
<td>1.0</td>
<td>F</td>
<td>mm/s/mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv (standstill)</td>
<td>1.0</td>
<td>F</td>
<td>mm/s/mm</td>
<td></td>
</tr>
<tr>
<td>Position control: Proportional Factor Kv (moving)</td>
<td>0.1</td>
<td>F</td>
<td>mm/s/mm</td>
<td></td>
</tr>
</tbody>
</table>
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 stationarily 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.

Position control: Velocity threshold $V_{dyn}$ [0.0 ... 1.0]

A PP controller uses two P constants

- $K_{v}$ (standstill) $K_{vs}$ and
- $K_{v}$ (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 $[- V_{dyn} ... + V_{dyn}]$ the gain factor of the P-controller is linearly interpolated from the proportional factor $K_{v}$ (moving) $K_{vf}$ towards the proportional factor $K_{v}$ (standstill) $K_{vs}$ at zero velocity. The diagram below illustrates the connections.
The sample is parameterized with \( K_{\text{vs}} = 50, K_{\text{vf}} = 10 \) and \( v_{\text{dyn}} = 0.2 \).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Integral Action Time ( T_n )</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
<tr>
<td>Position control: Derivative Action Time ( T_v )</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
<tr>
<td>Position control: Damping Time ( T_d )</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position control: Min./max. limitation I-Part ([0.0 \ldots 1.0])</td>
<td>0.1</td>
<td></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Position control: Min./max. limitation D-Part ([0.0 \ldots 1.0])</td>
<td>0.1</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

**Position control: Min./max. limitation I-Part \([0.0 \ldots 1.0]\)**

I-part limitation of the PID-controller.

**Position control: Min./max. limitation D-Part \([0.0 \ldots 1.0]\)**

D-part limitation of the PID-Controller.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disable I-Part during active positioning</td>
<td>FALSE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Disable I-Part during active positioning**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedforward Acceleration: Proportional Factor ( K_a )</td>
<td>0.0</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
<tr>
<td>Feedforward Velocity: Pre-Control Weighting ([0.0 \ldots 1.0])</td>
<td>1.0</td>
<td></td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

**Feedforward Acceleration: Proportional Factor \( K_a \)**

The acceleration feedforward proportional factor \( K_a \) is the gain factor when NC acceleration feedforward control is used. Output velocity component = \( K_a \) * setpoint acceleration.

**Additional Information: Acceleration Feedforward**

Consult section Acceleration Feedforward \([\ref{44}] \) 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.

### 6.3 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity control: Proportional Factor Kv</td>
<td>0.1</td>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Velocity control: Proportional Factor Kv

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity control: Integral Action Time Tn</td>
<td>0.0</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Velocity control: Derivative Action Time Tv</td>
<td>0.0</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Velocity control: Damping Time Td</td>
<td>0.0</td>
<td>F</td>
<td>s</td>
<td></td>
</tr>
</tbody>
</table>

#### Velocity control: Integral Action Time Tn

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

#### Velocity control: Derivative Action Time Tv

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

#### Velocity control: Damping Time Td

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity Control Loop:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity control: Min./max. limitation D-Part [0.0 ... 1.0]</td>
<td>0.1</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity control: Min./max. limitation I-Part [0.0 ... 1.0]</td>
<td>0.1</td>
<td>F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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.
6.4 Observer

### Velocity Filter: Time Constant T

Part of the observer model for determining velocities.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity Filter: Time Constant T</td>
<td>0.001</td>
<td></td>
<td>F</td>
<td>s</td>
</tr>
</tbody>
</table>

**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 Kt**

Part of the observer model.

**Motor: Moment of Inertia Jm**

Part of the observer model.

**Bandwidth f0**

Part of the observer model.

**Correction Factor Kc**

Part of the observer model.

6.5 Other Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Offline Value</th>
<th>Online Value</th>
<th>Type</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Settings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controller Mode</td>
<td>‘STANDARD’</td>
<td></td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

**Controller Mode**

Currently, only the ‘STANDARD’ controller mode can be selected.
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 [44].

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.

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.

Controller Outputlimit [0.0 … 1.0]

Controller output limit can be set within the interval [0.0 … 1.0].
7 Technical Terms

7.1 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 [44].
- When moving steadily, the following error is symmetrical about 0 (reference velocity).
- Set $K_v$.
- Measure the extreme value of the acceleration $a_{+\text{max}}$ and the associated following error $d_{+\text{max}}$ in the middle of the acceleration phase. Measure the extreme value of the deceleration $a_{-\text{max}}$ and the associated following error $d_{-\text{max}}$ in the middle of the braking phase.

$$
K_{a+} = K_v \times \frac{d_{+\text{max}}}{a_{+\text{max}}} \\
K_{a-} = K_v \times \frac{d_{-\text{max}}}{a_{-\text{max}}} \\
K_a = \frac{(K_{a+} + K_{a-})}{2}
$$

7.2 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.

7.3 Axis Error


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.
7.4 AXIS_REF

PROGRAM MAIN
VAR
axis: AXIS_REF;
END_VAR
axis.ReadStatus();

MC-Axis Variable

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

The data type AXIS_REF
- contains information of an axis,
- is an interface between PLC and NC,
- is passed to MC-function blocks as reference to an axis.

<table>
<thead>
<tr>
<th>PlcToNc</th>
<th>PLCTONC_AXIS_REF</th>
<th>NCTOPLC_AXIS_REF</th>
<th>NcToPlc</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST_AdsAddress</td>
<td>ADS</td>
<td>ST_AxisStatus</td>
<td>Status</td>
</tr>
</tbody>
</table>

- Refreshing the Status Data Structure in AXIS_REF

The status data structure Status of type ST_AxisStatus
- contains additional or prepared status information for an axis,
- contains diagnosis information for an axis,
- is not refreshed cyclically, but has to be refreshed by the PLC program.

Calling the action ReadStatus() of AXIS_REF
- refreshes the status data structure,
- should be done once at the beginning of each PLC cycle.

Within a PLC cycle
- the status information does not change,
- after calling ReadStatus() the actual status information in AXIS_REF can be accessed within the whole PLC program.

The character of the status data structure is purely informational. Thus, its usage is not mandatory. Still, not to be misleading the status data structure has to be used properly if used.

7.5 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.
7.6 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)”

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:

\[ v_{\text{res}} = v_{\text{max}} \times \text{Override} \]
Option “Original (iterated)"

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.

7.7 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).
7.8  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 $I = \frac{S A F \text{ cycle time}}{S A F \text{ cycle time} + \text{filter time}}$, then $x = I \cdot x_n + (1-I) \cdot x_a$. 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.

7.9  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. At rapid traverse the axes are driven at 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)”.

7.10  ReadStatus()

See section AXIS_REF [45].
7.11 Tolerance Ball


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.

**Smoothening**

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

**Faster Dynamics**

- Smoothening 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 $C2 \times VeloLink$.

**Definition**

**Segment Transition**

- For the smoothening 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.