Functional description | EN

TF5200 | TwinCAT 3 CNC

Axis collision monitoring
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.
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Icons used and their meanings

This documentation uses the following icons next to the safety instruction and the associated text. Please read the (safety) instructions carefully and comply with them at all times.

Icons in explanatory text

1. Indicates an action.
   ➡ Indicate an action statement.

<table>
<thead>
<tr>
<th>DANGER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acute danger to life!</strong></td>
</tr>
<tr>
<td>If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal injury and damage to machines!</strong></td>
</tr>
<tr>
<td>If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Restriction or error</strong></td>
</tr>
<tr>
<td>This icon describes restrictions or warns of errors.</td>
</tr>
</tbody>
</table>

Tips and other notes

This icon indicates information to assist in general understanding or to provide additional information.

General example

Example that clarifies the text.

NC programming example

Programming example (complete NC program or program sequence) of the described function or NC command.

Specific version information

Optional or restricted function. The availability of this function depends on the configuration and the scope of the version.
Table of contents

Notes on the documentation ................................................................. 3
General and safety instructions .......................................................... 4
1 Overview ....................................................................................... 8
2 Description .................................................................................. 9
3 Parameter .................................................................................... 13
   3.1 Overview .............................................................................. 13
   3.2 Description .......................................................................... 13
4 Examples ..................................................................................... 16
5 Support and Service ....................................................................... 19
 Index ............................................................................................... 20
List of figures

Figure 1  Three slides on one linear drive................................................................. 9
Figure 2  6-axis parallel kinematic machine.............................................................. 10
Figure 3  Possible collision scenarios ........................................................................ 12
Figure 4  Minimum permitted distance between a collision pair ................................. 16
Figure 5  Collision pair with 2 channels and mechanically inverted motion directions ................................................................. 16
Figure 6  Collision pair with different zero positions .................................................. 17
Figure 7  Configuration of 2 collision pairs.................................................................. 18
1 Overview

Task

Mechanical collision of feed units whose motion ranges overlap is prevented by the axis collision monitoring function (collision monitoring). The motion ranges here run in parallel.

Characteristics

If a configurable limit is exceeded, the CNC generates an error message and the axes are stopped.

The collision monitoring function is used for gantry machines with linear drives with 2 or more slides or strut kinematic machines.

Parametrisation

The position monitor is configured for each individual axis in the axis parameter list. A complete list of parameters described in this document is contained in the chapter Parameters [\ref{parameters}].

Links to other documents

For the sake of clarity, links to other documents and parameters are abbreviated, e.g. [PROG] for the Programming Manual or P-AXIS-00001 for an axis parameter.

For technical reasons, these links only function in the Online Help (HTML5, CHM) but not in pdf files since pdfs do not support cross-linking.
2 Description

Task

When collision monitoring is used, the position command values of an axis pair generated in the CNC are monitored.

If the distance between two positions undershoots the minimum permitted value with regard to the deceleration distance required for stopping,

• the axes stop immediately depending on the specified dyn. data and
• the CNC outputs the message P-ERR-70092.

After CNC RESET, the two axes must be positioned apart from each other.

Two axes for which the distance is monitored are referred to as a collision pair.

Several collision pairs may be formed.

Figure 1: Three slides on one linear drive
Besides machines with linear drive, collision monitoring is also used for machine with strut kinematics to monitor column slides for collisions.

**NOTE**

If the axes are shut down when a collision is detected, the programmed contour is normally exited.

**Configuration**

In the parameter P-AXIS-00015 (achs_mode) the 0x8000 bit is set for the two axes in a collision pair. The collision monitor is then active.
Additional data must be set for collision monitoring in one of the two axes of a collision pair. Normally the following inputs are set in the second axis of a collision pair, referred to as the master axis:

- In P-AXIS-00043 (coll_check_ax_nr) the logical axis number of the collision partner.
- In P-AXIS-00045 (coll_offset) the minimum permitted distance between slide reference points.

This type of configuration is no longer recommended: Due to downwards compatibility, two axes can be configured as collision partners. In this case the two collision distances P-AXIS-00045 (coll_offset) have the same value.

If the collision axes are in different CNC channels, the parameter P-AXIS-00044 (coll_decelerate_chan) can force a stop in the two channels if a collision axis reports a drive error.

The corresponding axes must first be referenced. Only then is the collision monitor active.

**Axis deceleration for collision monitoring**

By default the value of P-AXIS-00008 (a_max) is used for collision monitoring to calculate deceleration distances and stop the axes if a collision is detected.

The parameter P-AXIS-00267 (coll_use_a_emergency) can be used to change this deceleration to the value defined in P-AXIS-00003 (a_emergency).

**Deceleration distance monitoring**

The current velocity of an axis results from:

\[ v_t = \frac{(sollw_n - sollw_{n-1})}{T_A} \]

where:
- \( v_t \) current velocity
- \( T_A \) interpolation cycle time
- \( sollw \) position setpoints in cycles n and n-1

The minimum deceleration distance results from the deceleration set for collision monitoring by:

- P-AXIS-00008 (a_max),
- P-AXIS-00267 (coll_use_a_emergency),
- P-AXIS-00003 (a_emergency)

and the current velocity at:

\[ s_{brems} = \frac{1}{2} \left( \frac{v_t^2}{a_{col}} \right) \]

where:
- \( s_{brems} \) Deceleration distance
- \( v_t \) current speed
- \( a_{col} \) Deceleration for collision monitoring
Figure 3: Possible collision scenarios
3 Parameter

3.1 Overview

<table>
<thead>
<tr>
<th>ID</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-AXIS-00015</td>
<td>kenngr.achs_mode</td>
<td>Axis mode</td>
</tr>
<tr>
<td>P-AXIS-00043</td>
<td>coll_check_ax_nr</td>
<td>Logical number of the associated axis pair</td>
</tr>
<tr>
<td>P-AXIS-00044</td>
<td>coll_decelerate_chan</td>
<td>Stop collision axes in different channels</td>
</tr>
<tr>
<td>P-AXIS-00045</td>
<td>coll_offset</td>
<td>Minimum permitted position distance of the collision axes</td>
</tr>
<tr>
<td>P-AXIS-00262</td>
<td>coll_moving_dir_inverted</td>
<td>Collision axes have different mechanical motion directions</td>
</tr>
<tr>
<td>P-AXIS-00263</td>
<td>coll_zero_position_offset</td>
<td>Offset between zero positions of collision axes</td>
</tr>
<tr>
<td>P-AXIS-00267</td>
<td>coll_use_a_emergency</td>
<td>Execute collision monitoring with P-AXIS-00003 (a_emergency).</td>
</tr>
</tbody>
</table>

3.2 Description

P-AXIS-00015 Operating mode of an axis

Description Axes can be traversed in different operating modes:

Parameter kenngr.achs_mode

Data type UNS32

Data range 0x00000001 - 0x10000000

Axis types T, R, S

Dimension T: ----  R,S: ----

Default value 0x00000001

Drive types ----

Remarks

P-AXIS-00043 Monitoring of axis collision: Logical axis identifier

Description Logical axis number of the monitored axis. For this axis, the 0x8000 bit must be set in the axis mode (P-AXIS-00015).

Parameter kenngr.coll_check_ax_nr

Data type UNS32

Data range 1 ≤ coll_check_ax_nr < MAX(UNS32)

Axis types T

Dimension T: ----

Default value 0

Drive types ----

Remarks

P-AXIS-00044 Monitoring of axis collision: Stopping in all channels in case of drive errors

Description If collision axes are assigned to different channels, a stop in all channels by this parameter can be forced if one collision axis reports a drive error. This ensures that an error in the measurement system of an axis does not result in an axis collision.

Parameter kenngr.coll_decelerate_chan

Data type BOOLEAN

Data range 0/1
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Data type</th>
<th>Data range</th>
<th>Axis types</th>
<th>Dimension</th>
<th>Default value</th>
<th>Drive types</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-AXIS-00045</td>
<td>Monitoring of axis collision: Security distance</td>
<td>kenngr.coll_offset</td>
<td>UNS32</td>
<td>1&lt; coll_offset &lt; MAX(UNS32)</td>
<td>T</td>
<td>0.1µm</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P-AXIS-00045</td>
<td>Monitoring of axis collision: Inverted of moving directions</td>
<td>kenngr.coll_moving_dir_inverted</td>
<td>BOOLEAN</td>
<td>0/1</td>
<td>T</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P-AXIS-00045</td>
<td>Monitoring of axis collision: Offset of zero positions</td>
<td>kenngr.coll_zero_position_offset</td>
<td>SGN32</td>
<td>MIN(SGN32)&lt;coll_zero_position_offset&lt;MAX(SGN32)</td>
<td>T</td>
<td>0.1µm</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P-AXIS-00045</td>
<td>Monitoring of axis collision: Valid deceleration</td>
<td>kenngr.coll_use_a_emergency</td>
<td>BOOLEAN</td>
<td>0/1</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension</td>
<td>T: ----</td>
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<tr>
<td>Default value</td>
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<td></td>
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<tr>
<td>Drive types</td>
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<tr>
<td>Remarks</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
4 Examples

Minimum permitted distance

Figure 4: Minimum permitted distance between a collision pair

Initialisation in the axis parameter list of axis X1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>kopf.achs_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
</tbody>
</table>

Initialisation in the axis parameter list of axis 1X2 (collision partner of X1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>kopf.achs_nr</td>
<td>2</td>
</tr>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
<tr>
<td>kenngr.coll_check_ax_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.coll_offset</td>
<td>200000</td>
</tr>
</tbody>
</table>

Axis motion direction

The collision monitor assumes that the axes affected move in the same direction. If a motion in positive direction was programmed for the two axes in a collision pair, the axes also move mechanically in the same direction.

If this precondition is not fulfilled, it must be indicated in P-AXIS-00262 (coll_moving_dir_inverted) of the master axis.

Figure 5: Collision pair with 2 channels and mechanically inverted motion directions

2-channel collision pair with mechanically inverted motion directions

Channel 1:

Initialisation in the axis parameter list of axis X1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>kopf.achs_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
</tbody>
</table>

Channel 2:
Initialisation in the axis parameter list of axis 1X2 (collision partner of X1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>kopf.achs_nr</td>
<td>6</td>
</tr>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
<tr>
<td>kenngr.coll_check_ax_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.coll_offset</td>
<td>200000</td>
</tr>
<tr>
<td>kenngr.coll_moving_dir_inverted</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.coll_decelerate_chan</td>
<td>1</td>
</tr>
</tbody>
</table>

Zero positions of the axes

If the collision axes do not have the same zero position, then enter the zero offset in P-AXIS-00263 (coll_zero_position_offset). The value of the P-AXIS-00263 is equal to the position of the zero position of the collision partner axis in the axis coordinate system of the master axis.

Figure 6: Collision pair with different zero positions
Collision pair with different zero positions

Initialisation in the axis parameter list of axis X1

<table>
<thead>
<tr>
<th>kopf.achs_nr</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
</tbody>
</table>

Initialisation in the axis parameter list of axis 1X2 (collision partner of X1)

<table>
<thead>
<tr>
<th>kopf.achs_nr</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
<tr>
<td>kenngr.coll_check_ax_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.coll_offset</td>
<td>200000</td>
</tr>
<tr>
<td>kenngr.coll_zero_position_offset</td>
<td>-1000000</td>
</tr>
</tbody>
</table>

Configuration of 2 collision pairs

![Diagram of 2 collision pairs]

X1 X2
\[P-AXIS-00045 \text{ (X1 - X2)}\]
X3
\[P-AXIS-00045 \text{ (X2 - X3)}\]

Figure 7: Configuration of 2 collision pairs

Configuration of 2 collision pairs

This example defines two collision pairs (X1-X2, X2-X3):

Initialisation in the axis parameter list of axis X1

<table>
<thead>
<tr>
<th>kopf.achs_nr</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
</tbody>
</table>

Initialisation in the axis parameter list of axis X2 (collision partner of X1)

<table>
<thead>
<tr>
<th>kopf.achs_nr</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>kenngr.achs_mode</td>
<td>0x8001</td>
</tr>
<tr>
<td>kenngr.coll_check_ax_nr</td>
<td>1</td>
</tr>
<tr>
<td>kenngr.coll_offset</td>
<td>200000</td>
</tr>
</tbody>
</table>

Initialisation in the axis parameter list of axis X3 (collision partner of X2)

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>kenngr.achs_mode</td>
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<tr>
<td>kenngr.coll_check_ax_nr</td>
<td>2</td>
</tr>
<tr>
<td>kenngr.coll_offset</td>
<td>300000</td>
</tr>
</tbody>
</table>
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### Index

#### P

| P-AXIS-00015 | 13  |
| P-AXIS-00043 | 13  |
| P-AXIS-00044 | 13  |
| P-AXIS-00045 | 14  |
| P-AXIS-00262 | 14  |
| P-AXIS-00263 | 14  |
| P-AXIS-00267 | 14  |