Functional description | EN

TF5200 | TwinCAT 3 CNC

Spindle operation mode
Notes on the documentation

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

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

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

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

Disclaimer

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

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

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

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General and safety instructions

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.
2. Indicates an action statement.

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="DANGER" /></td>
<td>Acute danger to life! If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.</td>
</tr>
<tr>
<td><img src="image" alt="CAUTION" /></td>
<td>Personal injury and damage to machines! 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>
<tr>
<td><img src="image" alt="NOTE" /></td>
<td>Restriction or error 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

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes on the documentation</td>
<td>3</td>
</tr>
<tr>
<td>General and safety instructions</td>
<td>4</td>
</tr>
<tr>
<td>1 Overview</td>
<td>8</td>
</tr>
<tr>
<td>2 Description</td>
<td>9</td>
</tr>
<tr>
<td>2.1 SERCOS drive with position control in the drive</td>
<td>10</td>
</tr>
<tr>
<td>2.2 Drives with position control in the CNC</td>
<td>11</td>
</tr>
<tr>
<td>2.3 Properties</td>
<td>12</td>
</tr>
<tr>
<td>3 Example</td>
<td>15</td>
</tr>
<tr>
<td>4 Parameter</td>
<td>16</td>
</tr>
<tr>
<td>4.1 Overview</td>
<td>16</td>
</tr>
<tr>
<td>4.1.1 Description</td>
<td>16</td>
</tr>
<tr>
<td>Index</td>
<td>18</td>
</tr>
</tbody>
</table>
List of figures

Figure 1  Positioning at specified speed and reversal ................................................................. 13
Figure 2  Positioning at 500 rpm despite changeover speed of 200 rpm..................................... 14
1 Overview

Task
When a spindle drive is operated at current limit, it may result in an excessive position lag at high speeds, causing error messages in the drive and/or the CNC. To avoid this, it is necessary at high speeds to change to controlled operation (no position control) and to only operate the spindles position-controlled for positioning movements.

Properties
Automatic changeover by the CNC for position control in the drive is only available for SERCOS drives.
A change between the two operation modes can take place automatically during the movement.

Parametrisation
Automatic changeover and switch-back can be specified by using the appropriate parameters. They are:

- P-AXIS-00264: antr.sercos.op_mode_for_velocity_control
- P-AXIS-00265: antr.velocity_position_control_on
- P-AXIS-00266: antr.velocity_position_control_off

The section Parameters [16] contains a detailed description of the commands.

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

Boundary condition

Basically a spindle can be operated position-controlled or speed-controlled. The operation mode is defined statically in most cases, whereby all the parameters required for each operation mode must be configured in the drive telegram for SERCOS drives.

In position-controlled mode (position control in the drive), the maximum speed is limited to 180° per tracing cycle for SERCOS spindles. Otherwise, the drive controller cannot determine the rotation direction from the specified path change. For example, for a tracing cycle of 2 ms, this results in a maximum speed of 15,000 rpm.

When a spindle drive is operated at current limit, it may result in an excessive position lag at high speeds, causing error messages in the drive and/or the CNC. This may make it necessary to change to controlled operation (no position control) at high speeds and to only operate the spindle position-controlled for positioning movements.

Functionality

To permit higher speeds, the spindle is operated

- speed-controlled with speed-only programming and
- position-controlled when a position is specified.

A change between the two operation modes can take place automatically during the movement.

- With CNC position-controlled drive, an operation mode changeover takes place internally in the controller.
- With speed-only programming, the position control loop is opened automatically and a speed command value is sent to the drive.

\[\text{If position control takes place in the drive, the changeover between position and speed control is always supported by the drive.}\]

Automatic changeover by the CNC for position control in the drive is only available for SERCOS drives.

The drive needs no special requirements for automatic changeover for drives with position control in the CNC.

Changeover of operation mode

```plaintext
N30   S200 M4  
N40   M19 S.POS=180 S1000 M4  
N50   S200 M3  
N60   M19 S.POS=180 S1000 M4  
N70   S200 M4  
N80   M19 S.POS=180 S1000 M3  
M30
```
2.1 SERCOS drive with position control in the drive

Parameterising the drive

Control with digital drives takes place in the drive itself. The CNC specifies a position/speed command value for the drive per tracing interval. The current actual value (position and speed) can be used in the CNC for display functions and monitoring.

In addition, the CNC sends the required operation mode cyclically to the drive.

SERCOS parameters

The following parameters are essential for a SERCOS drive for the position/speed control operation modes:

Main operation mode S-0-0032 = 3 (position actual value with encoder 1)
  • S-0-0051 position actual value (encoder 1) / S-0-0053 position actual value (encoder 2)
  • S-0-0047 position command value

Auxiliary operation mode 1 S-0-0033 = 2 (speed control)
  • S-0-0040 speed value
  • S-0-0036 speed command value

In addition to the auxiliary operation mode 1, other auxiliary operation modes 2 and 3 are provided.

What are also important are the scaling type settings. Weighting should always be set to rotary weighting for spindles.
  • S-0-0076 position scaling type (bit 2-0)
  • S-0-0044 speed scaling type (bit 2-0)
  • S-0-00160 acceleration scaling type (bit 2-0)

Parameter:

(000) unscaled
(001) translatory scaling
(010) rotary scaling
2.2 Drives with position control in the CNC

To change between position and speed control in CNC-controlled drives, the scaling of the manipulated variable (P-AXIS-00129, P-AXIS-00128) must be set correctly.

Parameterising the drive

For drives where position control is executed in the CNC, the drive must be in the ‘speed control’ operation mode. Otherwise, no special settings are required in the drive since a command speed is sent to the drive both in position-controlled and speed-controlled mode.

Settings in the CNC

For drives where position control can be executed both in the drive and in the CNC, e.g. with SERCOS, the operation mode “antr.operation_mode” CNC-position control “CNC_POSITION_CONTROL” must be selected for the spindle (P-AXIS-00320).

To change over to controlled mode, the scaling of the speed manipulated variable getriebe[i].multi_gain_z / getriebe[i].multi_gain_n (P-AXIS-00129, P-AXIS-00128, @@[CMS-A1]) must be set correctly. This can be checked by checking the displayed position lag at a constant endless motion M3 or M4 of the spindle and when feedforward control is inactive. When scaling is correct, the position lag value of the spindle speed caused by the proportional gain of the position control loop (see P-AXIS-00099) equals:

\[
\text{Position lag}[^{°}] = \frac{\text{speed}[^{°/s}]}{P-AXIS-00099} \times 0.01[^{1/s}] 
\]

The parameter antr.sercos.op_mode_for_velocity_control (P-AXIS-00264) for the ‘speed control’ operation mode has no meaning for CNC-controlled drives.
2.3 Properties

Changeover to speed control

If a speed (S word) is programmed with M3 or M4 and it is higher than the specified changeover parameter, the system changes over automatically to speed control.

Switch back to position control

A switch-back to position control takes place under the following conditions:

- Positioning was programmed with M19.
- A CNC reset was triggered.
- A spindle axis was issued from the spindle interpolator (NC command S[PUTAX]).
- Homing was started (G74).

If a previous speed programming was changed over to speed control, no switch-back to position control takes place if an additional speed below the switch-back speed is programmed.

Effect of switch-back speed

The command position is not considered during speed control. When a changeover occur to position control, the CNC determines the theoretical command position of the next cycle using:

- the current speed
- the Kv factor (of the drive or the controller position control) and
- the bus run time

The axis can then be switched back to position control without standstill.

The switch-back speed indicates the speed at which switch-back to position control may take place.

Since the actual speed may fluctuate slightly, especially at high speeds, a slight jerk may occur in the drive at high speeds on switch-back to position control.

For this reason, do not select a switch-back speed that is too high.

Effect of switch-back speed

```plaintext
%spindle-position
N10 M3 S1000
N20 M19 S.POS=180 M4 S50
M30
```
Figure 1: Positioning at specified speed and reversal
Special case
If the positioning speed is above the changeover speed with M19, positioning still takes place in position-controlled mode. Depending on the distance traversed, it is therefore possible to traverse above the changeover speed for a short time in position-controlled mode.

%spindle-position
(antr.velocity_position_control_on 1200000 -> 200 rpm
(antr.velocity_position_control_off 600000-> 100 rpm

N10 M4 S1000
N20 M19 S.POS=180 M4 S500
M30

Figure 2: Positioning at 500 rpm despite changeover speed of 200 rpm
3 Example

SERCOS drive with position control in the drive
As of a speed of 200 rpm, the system should change over to speed control. Switch-back may occur as of 50 rpm. The drive has a Kv factor of 4000/min. The following settings are required in the axis list in addition to the drive telegram:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>antr.sercos.op_mode_for_velocity_control</code></td>
<td>1</td>
</tr>
<tr>
<td><code>antr.velocity_position_control_on</code></td>
<td>1200000</td>
</tr>
<tr>
<td><code>antr.velocity_position_control_off</code></td>
<td>300000</td>
</tr>
<tr>
<td><code>antr.nbr_delay_cycles</code></td>
<td>4</td>
</tr>
</tbody>
</table>

SERCOS drive with position control in the CNC
As of a speed of 200 rpm, the system should change over to speed control. Switch-back may occur as of 50 rpm. A Kc factor of 100/s is set in the CNC: Scaling of the speed command value in the drive is $10^{-4}$ rpm. The following settings are required in the axis list in addition to the drive telegram:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>antr.operation_mode</code></td>
<td><code>CNC_POSITION_CONTROL</code></td>
</tr>
<tr>
<td><code>antr.velocity_position_control_on</code></td>
<td>1200000</td>
</tr>
<tr>
<td><code>antr.velocity_position_control_off</code></td>
<td>300000</td>
</tr>
<tr>
<td><code>getriebe[0].kv</code></td>
<td>10000</td>
</tr>
<tr>
<td><code>getriebe[0].multi_gain_z</code></td>
<td>10000000</td>
</tr>
<tr>
<td><code>getriebe[0].multi_gain_n</code></td>
<td>360</td>
</tr>
</tbody>
</table>
4 Parameter

4.1 Overview

<table>
<thead>
<tr>
<th>ID</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-AXIS-00264</td>
<td>antr.sercos.op_mode_for_velocity_control</td>
<td>Operation mode for velocity control</td>
</tr>
<tr>
<td>P-AXIS-00265</td>
<td>antr.velocity_position_control_on</td>
<td>Changeover speed</td>
</tr>
<tr>
<td>P-AXIS-00266</td>
<td>antr.velocity_position_control_off</td>
<td>Switch back speed</td>
</tr>
</tbody>
</table>

4.1.1 Description

P-AXIS-00264 Operation mode for velocity control (SERCOS)

| Description | This parameter defines the desired operation mode during switching to velocity control. |
| Parameter   | antr.sercos.op_mode_for_velocity_control      |
| Data type   | UNS16                                         |
| Data range  | 0 ≤ op_mode_for_velocity_control ≤ 3 where: |
|             | 0: Main operation mode S-0-0032               |
|             | 1: Auxiliary operation mode 1, S-0-0033       |
|             | 2: Auxiliary operation mode 2, S-0-0034       |
|             | 3: Auxiliary operation mode 3, S-0-0035       |
| Axis types  | S                                             |
| Dimension   | S: ----                                       |
| Default value | 0                                     |
| Drive types | SERCOS                                       |
| Remarks     | The main mode can also be used for speed control. |

P-AXIS-00265 Maximum velocity limit for switching to velocity controlled mode

| Description | If any spindle revolution higher than the given limit is commanded, the operation mode is switched to velocity control automatically. |
| Parameter   | antr.velocity_position_control_on             |
| Data type   | SGN32                                         |
| Data range  | 0 ≤ velocity_position_control_on ≤ MAX(SGN32) |
| Axis types  | S                                             |
| Dimension   | S: 0.001°/s                                   |
| Default value | 2000000000                                    |
| Drive types | SERCOS                                       |
| Remarks     | For a sensorless spindle only a velocity of 0 is useful. Therefore the command velocity of the interpolator is always output and not the setpoint velocity of the position controller. |

P-AXIS-00266 Maximum velocity limit for switching back to position control

<p>| Description | If the actual revolution during any positioning via M19 is higher than the given limit, the spindle is first decelerated to the limit. Afterwards the operation mode is switched back to position control. |
| Parameter   | antr.velocity_position_control_off            |
| Data type   | SGN32                                         |
| Data range  | 0 ≤ velocity_position_control_off ≤ MAX(SGN32) |
| Axis types  | S                                             |</p>
<table>
<thead>
<tr>
<th>Dimension</th>
<th>S: 0.001°/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>0</td>
</tr>
<tr>
<td>Drive types</td>
<td>SERCOS</td>
</tr>
<tr>
<td>Remarks</td>
<td>For a sensorless spindle only a velocity of 0 is useful. Therefore the command velocity of the interpolator is always output and not the setpoint velocity of the position controller.</td>
</tr>
</tbody>
</table>
Index

P
P-AXIS-00264 16
P-AXIS-00265 16
P-AXIS-00266 16