Functional description | EN

TF5200 | TwinCAT 3 CNC

Coordinate systems and offsets
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.

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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.
   ⇨ Indicates an action statement.

<table>
<thead>
<tr>
<th>DANGER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute danger to life!</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>Personal injury and damage to machines!</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>Restriction or error</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.
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1 Overview

Task

By selecting a coordinate system (referred to as CS), the programming coordinate system (PCS) can be
offset and rotated relative to the machine coordinate system (MCS). This permits simple NC programming
even in slanted or twisted positions.

Offsets, e.g. zero offsets, can also be regarded as selecting a coordinate system.

Characteristics

Coordinate systems (CS) and offsets are always active from selection through to deselection or when offset
parameters are changed. The offsets additionally programmed while a coordinate system is active are only
valid until the coordinate system is deselected.

Programming and parameterisation

Some of the offsets can be defined in the NC program. They include the following:

- Offsets due to a coordinate system selection (#CS)
- Offsets due to a measurement run (G100)
- Offsets from position presets (#PSET)
- Reference point offsets (G92)
- Offsets due to manual mode in conjunction with parallel interpolation (/G202)

The following offsets are preset in configuration lists. They can be used directly in the NC program (G54..., D..). It is also possible to use the edit option during program runtime.

- Tool offsets: Parameterising using the tool parameter list [TOOL] or variable access (V.G.)
- Zero offsets: Parameterising using the zero point data list [ZERO] or variable access (V.G.)
- Clamping position offsets: Parameterisation by means of the clamp position offset data list [CLMP]

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 of the coordination system

The programming coordinate system (PCS) can be offset and rotated with respect to the machine coordinate system (MCS) by selecting a coordinate system (CS) (see figure below). This permits simple NC programming even in slanted or twisted positions.

The NC program coordinates refer to the PCS.

Offsets

Selecting a coordinate system generates an additional offset of the PCS. The following offsets are available in the CNC system:

- Offsets due to coordinate system selection
- Offsets due to a measurement run
- Offsets due to manual mode in conjunction with parallel interpolation
- Offsets due to position preset
- Reference point offsets
- Tool offsets
- Zero offsets
- Clamping offsets

Figure 1: PCS after selecting a coordinate system
2.1 Offset types

Overview of offsets that are selectable in parallel:

- Measurement offset
- Clamping position offset
- Manual operation offset
- Position preset
- Reference point offset
- Zero offset
- Position offset
- Tool offset
- CS-offset
- BKS
- Zero offset
- Measurement offset
- Clamping position offset
- Manual operation offset
- Position preset
- Reference point offset
- Zero offset
- Position offset
- Tool offset
- CS-offset
- BKS
- Zero offset

Figure 2: Overview of all offset types

**Special case in G91 mode:**

Newly selected offsets are only effective after the next absolute programmed position (G90) since the specified motion path may only be travelled in the case of relative programming (G91).

**Tool offset exception:** With appropriate parameterisation, tool offsets are travelled directly without programming a path movement when the D word (P-CHAN-00100) is selected.
Differences in definition and selection of individual offsets.

Offsets are selected or included in calculations by the following NC commands or parameters:

<table>
<thead>
<tr>
<th>NC command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#CS,</td>
<td>Select a coordinate system</td>
</tr>
<tr>
<td>#ACS,</td>
<td></td>
</tr>
<tr>
<td>#ECS,</td>
<td></td>
</tr>
<tr>
<td>#ROTATION</td>
<td>Rotate in the plane</td>
</tr>
<tr>
<td>G101</td>
<td>Include measurement offset in calculations</td>
</tr>
<tr>
<td>G201</td>
<td>Include manual mode offsets in calculations</td>
</tr>
<tr>
<td>#GET MANUAL OFFSETS</td>
<td></td>
</tr>
<tr>
<td>#PSET</td>
<td>Select position presets</td>
</tr>
<tr>
<td>G92</td>
<td>Reference point offset</td>
</tr>
<tr>
<td>G54, ... G59, G159</td>
<td>Deselect zero offsets</td>
</tr>
<tr>
<td>D</td>
<td>Tool geometry compensation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pzv_index</td>
<td>Index for selecting position offset. This must be specified along with the NC</td>
</tr>
<tr>
<td></td>
<td>program name when an NC program is commanded.</td>
</tr>
</tbody>
</table>
2.2 Coordinate systems

Coordinate systems are defined, selected and deselected by NC command. The section below deals briefly with programming. A detailed description of NC commands is contained in the Programming Manual (see PROG documentation).

2.2.1 Selecting a coordinate system (#CS)

Select: #CS ON

The PCS can be offset and rotated with respect to the MCS by selecting a CS. This permits simple NC programming even in slanted or twisted positions.

Use of this NC command depends on the axis configuration of the machine (see Channel parameters, Section: Configuration of the path axes).

Machining in a rotated PCS basically makes sense whenever existing rotary axes P-AXIS-00018 permit vertical orientation of the tool with respect to the machining surface (#TOOL ORI CS).

The axis designations P-CHAN-00006 remain unchanged in the CS.

![Diagram of selecting a CS with one offset and one rotation](image)

Figure 4: Selecting a CS with one offset and one rotation

- Offset vector $V$
- Rotation vector $\phi$

**Effectiveness**

- Active until cancelled or up to program end.
- Nesting/linking a CS is possible.

Zero offsets and reference point offsets may be programmed in the CS during machining. They are valid until the CS is deselected; they are not saved.
Deselect: #CS OFF

The NC command #ROTATION is provided for simple rotations in the plane.
2.2.2 Rotation in a plane (contour rotation)

Select: #ROTATION ON

The coordinate system can be rotated by contour rotation in the main plane. Rotation may also be applied within an already rotated coordinate system (CS, ACS).

Effectiveness

- Active until deselected or up to program end.
- Contour rotation acts in the main plane on the programmed axis coordinates before all other contour-influencing functionalities, i.e. all offsets and mirroring operations can continue to be used.

**NOTE**

A plane change with G17/18/19 automatically deselects an active contour rotation. The warning P-ERR-21143 is output.

Deselect: #ROTATION OFF
2.2.3 Coordinate system for fixture adaptation (#ACS)

Select: #ACS ON

The ACS compensates a sloping position of the workpiece or workpiece palette. ACS can be selected or deselected independently of a CS.

Figure 6: Selecting a coordinate system for fixture adaptation

**Effectiveness**

- Active until deselected or up to program end.
- Zero offsets and reference point offsets may be programmed in the ACS. However, they are only valid until the ACS is deselected and they are not stored.

Deselect: #ACS OFF
2.2.4 Linkage of coordinate systems

The combination of ACS and CS permits machining on an inclined plane with a slanted clamped workpiece.

Figure 7: Combining ACS and CS

Effectiveness

- Active until deselected or up to program end.
2.2.5  **Effector coordinate system (#ECS)**

**Select: #ECS ON**

The ECS is mainly used to execute a withdrawal strategy after

- a tool breakage,
- an NC reset or
- a program abort

for machining with a tool in any orientation. A machining plane perpendicular to the tool axis is determined automatically when the ECS is determined.

---

**Effectiveness**

- Active until deselected or up to program end.

> When the ECS is activated, no other coordinate system may be active, otherwise the error message P-ERR-20774 is output.

---

**Deselect: #ECS OFF**
2.2.6 Temporary transition to the machine axis coordinate system (#MCS)

Select: #MCS ON [ EX TOOL ]

With #MCS ON, active transformations and all offsets calculated in the axes can be temporarily deactivated so that machine axes can be directly positioned.

After leaving the MCS, the state before selection is restored.

Effectiveness

• Active until deselected or up to program end.

• With the ‘EX TOOL’ option, no tool offsets are included in the MCS calculation when the tool is changed so that machine axes can continue to be positioned directly. Only with #MCS OFF are tool offsets again included in the calculations.

• Default offsets (e.g. zero offsets) can be programmed in the MCS. However, they are only active until they are deselected and are not saved.

• It is not possible to select CS, ACS, ECS and TLC in the MCS.

Deselect: #MCS OFF
2.3 Measuring offset

Select: G101 <Achsnname> <Einrechnungsfaktor>

Measurement offset is the offset between the recorded measured values and the target position.

With G101, the measurement offset is included in the axis coordinates as an additional offset in accordance with the inclusion factor specified.

Figure 9: Measurement offset between measurement signal and target point

Effectiveness

• Active until deselected or up to program end.
• A new measurement offset has no effect until the next absolute programmed position (G90).

Deselect: G102 <axis_name><Dummyzahl>
2.4 Manual mode offset

Select: #GET MANUAL OFFSETS

Setpoints additionally generated in path axes while G201 is active result in an offset to the PCS plane. After manual mode is deselected with G202, these offset values can be requested from the interpolator with the #GET MANUAL OFFSETS commands and, in the NC program, can be included in the axis coordinates as an additional offset.

Figure 10: Manual mode offset

Effectiveness

- Active until deselected or up to program end.

Deselect: -
2.5 Position preset

Select: #PSET <axis_name> <Neue Istposition> ...

This NC command can assign a new actual value to the current axis position. The resulting offset is called the position preset.

\[
\begin{align*}
G01 \ X10 \ Y10 \\
#PSET \ X0 \ Y0
\end{align*}
\]

(Current position)

Figure 11: Position preset

Effectiveness

- Active until deselected or up to program end.
- Position reset is cancelled by a homing run (G74).
- A new offset has no effect until the next absolute programmed position (G90).

Deselect: #PRESET {<axis name><Dummywert>}

The position presets are cancelled in all axes if #PRESET is programmed without specifying an axis.
2.6 Reference point offset

Selection by G92 <Achsbezeichnung> <Verschiebung> ...

G92 permits a reference point offset by a freely programmable value in the specified axes. Depending on the settings of G90/G91, the currently programmed reference point offset is set absolutely or relatively.

![Diagram of reference point offset](image)

**Effectiveness**

- Active until the next reference point offset is programmed or up to program end.
- A new offset has no effect until the next absolute programmed position (G90).

**Deselect:** G92 <Achsbezeichnung> 0
2.7 Zero offset

Select: G54, ... G59, G159

The G54 - G59 or G159 commands select the corresponding zero offsets from the zero offset table [ZERO].

Figure 13: Zero offset

Effectiveness

- Active until deselected or up to program end.
- A new offset has no effect until the next absolute programmed position (G90).

Deselect: G53
2.8 Tool offset

Select: D <Nummer des Korrekturdatensatzes>

The D word selects the corresponding tool geometry compensation data from the tool list [TOOL].

![Diagram of tool offset](image)

Figure 14: Tool offset

Effectiveness

- Active until deselected or up to program end. In order to use kinematic transformations, special tool offset parameters may have to be assigned (wz[i].kinematic.param[j]).
- Depending on the parameterisation, a new offset becomes active either directly when the D word is selected or until the next absolute programmed position (G90) from (P-CHAN-00100).
- Depending on P-TOOL-00010 tool offsets act in the axis directions of the machining coordinate system or the machine coordinate system.

Deselect: D0

2.8.1 Tool length compensation (#TLC)

Select: #TLC ON [ <tool length compensation> ]

TLC permits the reuse of NC programs which were created by a programming system and which consider a specific tool length, even if the tool length was changed on the machine.

Effectiveness

- Active until deselected or up to program end.
- No new offsets or radii of the tool can be compensated, only the length.
- A new offset has no effect until the next absolute programmed position (G90).

Abwahl #TLC OFF
2.9 Clamp position offset

Select

When the NC program is commanded, the clamping position offset compensation data [CLMP] is selected together with the NC program name. In the NC program, the currently valid position offset index can be read via the V.G.AKT_PLATZ variable.

```
#PZV1
pzv_grp[1].achse[0].versatz  -10
pzv_grp[1].achse[1].versatz  88
pzv_grp[1].achse[2].versatz  0.32

#PZV2
pzv_grp[2].achse[0].versatz  13
pzv_grp[2].achse[1].versatz  153
pzv_grp[2].achse[2].versatz  -8.76
```

![Figure 15: Clamp position offset](image)

**Effectiveness**

- Effective up to program end.

**Deselect:** -
2.10 Suppressing offsets

Select: #SUPPRESS OFFSETS [ZERO PSET ...] <Achsname><position> ...

In combination with a motion block, this command causes an execution of the programmed axis positions without consideration of the active offsets.

All offsets in the NC block are suppressed if a particular offset type is not specified.

Effectiveness

- Valid only in the programmed NC block.

Deselect: -
3 Parameter

3.1 Overview

<table>
<thead>
<tr>
<th>ID</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-AXIS-00018</td>
<td>achs_typ</td>
<td>Axis type</td>
</tr>
<tr>
<td>P-CHAN-00006</td>
<td>bezeichnung</td>
<td>Axis designation</td>
</tr>
<tr>
<td>P-CHAN-00100</td>
<td>move_tool_offsets_directly</td>
<td>Effectiveness of tool compensations</td>
</tr>
</tbody>
</table>

3.2 Axis parameters

<table>
<thead>
<tr>
<th>P-AXIS-00018</th>
<th>Axis type (linear axis, rotary axes, spindle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>This parameter specifies the axis type of an axis.</td>
</tr>
<tr>
<td>Parameter</td>
<td>kenngr.achs_typ</td>
</tr>
<tr>
<td>Data type</td>
<td>STRING</td>
</tr>
<tr>
<td>Data range</td>
<td>Linear axis (ACHSTYP_TRANSLATOR) : 0x0001</td>
</tr>
<tr>
<td></td>
<td>Rotary axis (ACHSTYP_ROTATOR) : 0x0002</td>
</tr>
<tr>
<td></td>
<td>Spindle (ACHSTYP_SPINDEL): : 0x0004</td>
</tr>
<tr>
<td>Axis types</td>
<td>T, R, S</td>
</tr>
<tr>
<td>Dimension</td>
<td>T: ----</td>
</tr>
<tr>
<td></td>
<td>R,S: ----</td>
</tr>
<tr>
<td>Default value</td>
<td>ACHSTYP_TRANSLATOR</td>
</tr>
<tr>
<td>Drive types</td>
<td>----</td>
</tr>
<tr>
<td>Remarks</td>
<td>Depending on the axis type that is set, special functionalities are addressed in the NC kernel. Examples: - modulo calculation for rotary axes, - speed monitoring for spindles</td>
</tr>
</tbody>
</table>
### 3.3 Channel parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-CHAN-00006</td>
<td>Name of an axis in the NC channel</td>
</tr>
<tr>
<td>Description</td>
<td>This variable specifies the axis designations of all axes in the interpolator. The corresponding axis number is preset using the parameter P-CHAN-00035.</td>
</tr>
<tr>
<td>Parameter</td>
<td>gruppe[i].achse[j].bezeichnung</td>
</tr>
<tr>
<td>Data type</td>
<td>STRING</td>
</tr>
<tr>
<td>Data range</td>
<td>Maximum 16 characters (length of axis designation, application-specific)</td>
</tr>
<tr>
<td>Dimension</td>
<td>----</td>
</tr>
<tr>
<td>Default value</td>
<td>-</td>
</tr>
</tbody>
</table>
| Remarks            | The axis designations must begin with the letters A, B, C, U, V, W, X, Y, Z or Q. After that, all letters and digits are possible. The axis designations must be unique. Attention: The axle designations ‘A1’ to ‘A32’ may not be used if the parameter P-CHAN-00253 is active. In this case, these designators are explicitly only permitted as aliases in the axle lists (P-AXIS-00297). Parameterisation example: An axis group with 3 axes is to be configured. The first axis is addressed by ‘X_ACHSE1’ in the NC program. The second axis is designated ‘A’. The third axis is addressed by ‘W1’. **gruppe[0].achse[0].bezeichnung X_ACHSE1**  
**gruppe[0].achse[1].bezeichnung A**  
**gruppe[0].achse[2].bezeichnung W1** |

| P-CHAN-00100       | Time of effectiveness of tool compensation data                                                                                                                                                                                                                                                                                           |
| Description        | This parameter defines the time of the effectiveness of the tool compensation data (tool length compensation, tool position compensation) programmed by the D word.                                                                                                                                                                             |
| Parameter          | move_tool_offsets_directly                                                                                                                                                                                                                                                                                                             |
| Data type          | BOOLEAN                                                                                                                                                                                                                                                                                                                               |
| Data range         | 0: The compensation movement to include the new tool compensation data only takes place after the D word for an axis when the next traverse information absolute (G90) is programmed (default).  
1: The compensation movement in the corresponding axes is executed immediately with the D word without programming an absolute path condition (in compliance with DIN 66025). |
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