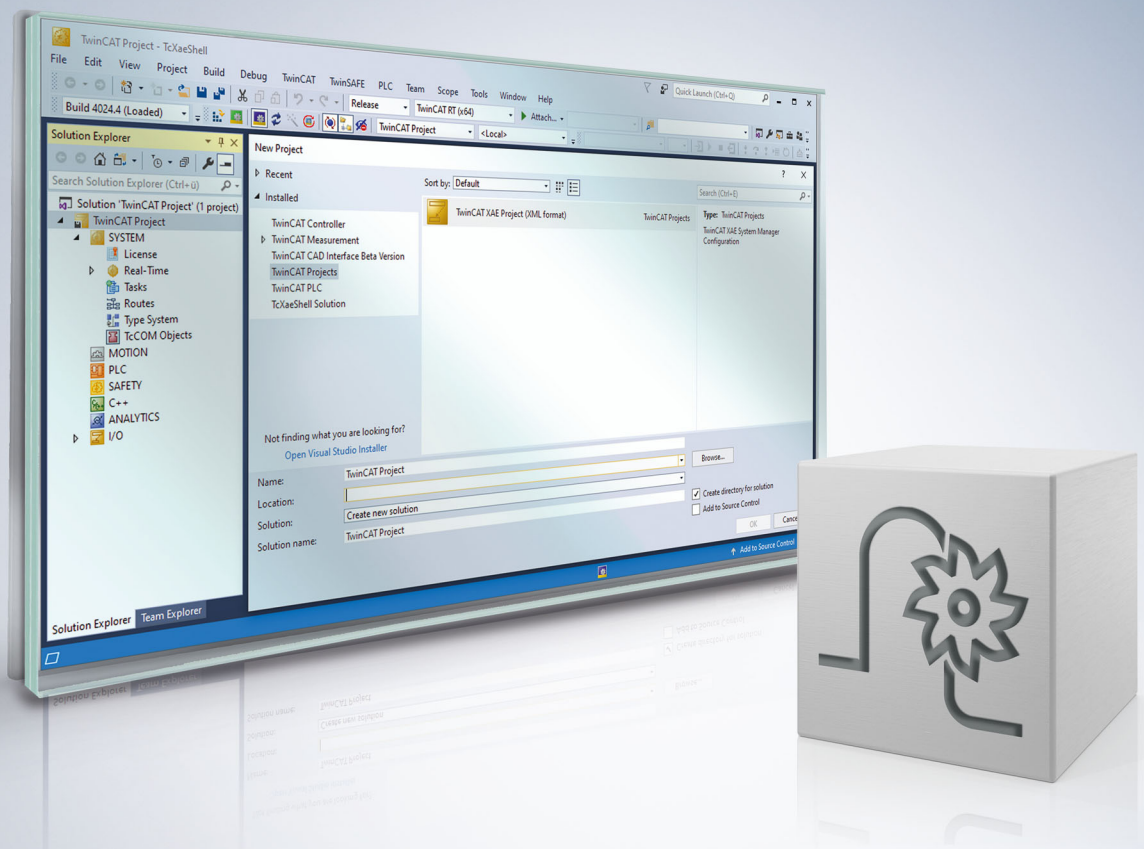
BECKHOFF New Automation Technology

Functional description | EN

TF5200 | TwinCAT 3 CNC

Axis compensation



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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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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.

⚠ DANGER

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.

⚠ CAUTION

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.

NOTICE

Restriction or error

This icon describes restrictions or warns of errors.

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

Axis compensations rectify inaccuracies in tool guidance caused by mechanical errors such as backlash, errors in spindle pitch or temperature fluctuations.

A distinction is made between 5 programming modes:

- Backlash compensation
- Temperature compensation
- Leadscrew error compensation
- Cross compensation
- Plane compensation

Properties

In general, each axis compensation can be activated for all:

- axis types
- drive types

The conditions required for their effectiveness are described in the related sections on compensation types.

Parametrisation

Specific parameters must be configured for each axis compensation in order to activate them. They are described for each compensation type in the section “Parameterisation”.

Programming

Axis compensations can be activated and deactivated in the NC program with the command X[COMP…].

Mandatory note on references 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.

The friction compensation functionality is described in FCT-C25.

2 Backlash compensation

2.1 Overview

Task

Backlash compensation has the purpose of compensating for the deviation between the real and calculated actual position of an axis caused by mechanical backlash.

Effectiveness

Backlash compensation can be activated for **all** axis types.

The effect of backlash can be compensated for **all** drive types.

Parameterisation

With regard to backlash compensation,

- the type of mechanical backlash P-AXIS-00021
- the amount of mechanical backlash P-AXIS-00103
- the distribution of mechanical backlash P-AXIS-00243

can be parameterised in the axis parameter record [AXIS].

2.2 Description

Mechanical backlash

The play between the

- the drive and a moving machine part or
- between a sensor and a moving machine part is referred to as mechanical backlash.

For a moving machine part, mechanical backlash results in a deviation between the commanded position and the actual position. This especially has an effect when the direction of motion is reversed.

A distinction is made between the following kinds of mechanical backlash:

- Positive backlash
- Negative backlash

Positive backlash

Positive backlash occurs in systems in which

- the measuring system is connected directly to the drive and
- the backlash occurs between the drive and the moving mechanical part.

When the direction of movement reverses, the measuring system will detect a position change although the machine part is not yet moving due to the backlash.
This leads to a situation in which the machine part does not reach the commanded position, but travels too short by the backlash amount because the sensor that indirectly measures the position of the machine part is **ahead** of the machine part's **actual position**.

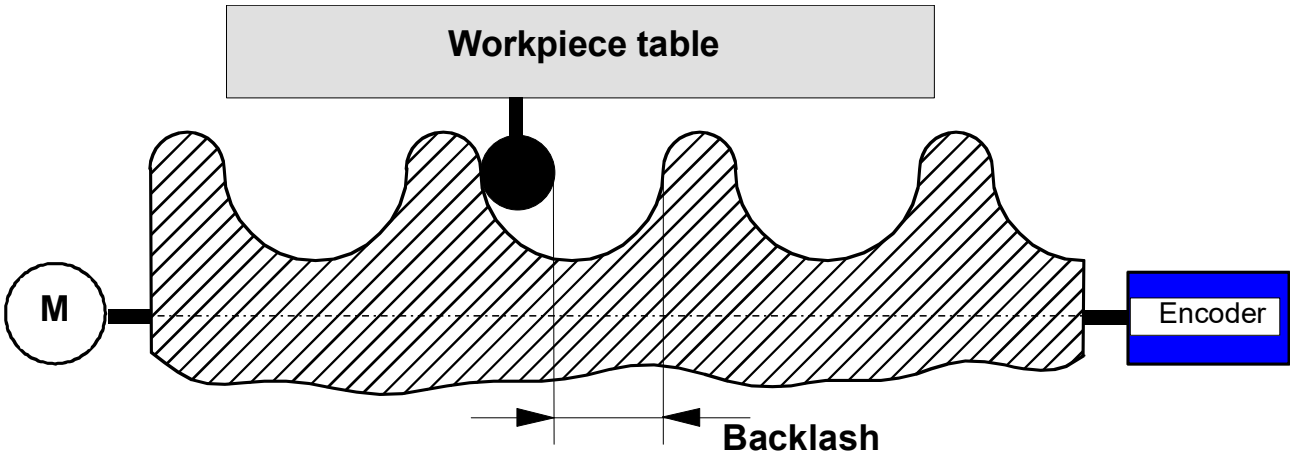


Fig. 1: Positive backlash

Negative backlash

Negative backlash is encountered in systems in which the backlash occurs between the moving machine part and the measuring system. When the direction is reversed, the machine part directly moves in the new direction without the measuring system detecting a position change.
In this case, the machine part moves further by the backlash amount than is required by the command because the sensor that directly measures the position of the machine part **lags behind** the position of the machine part.

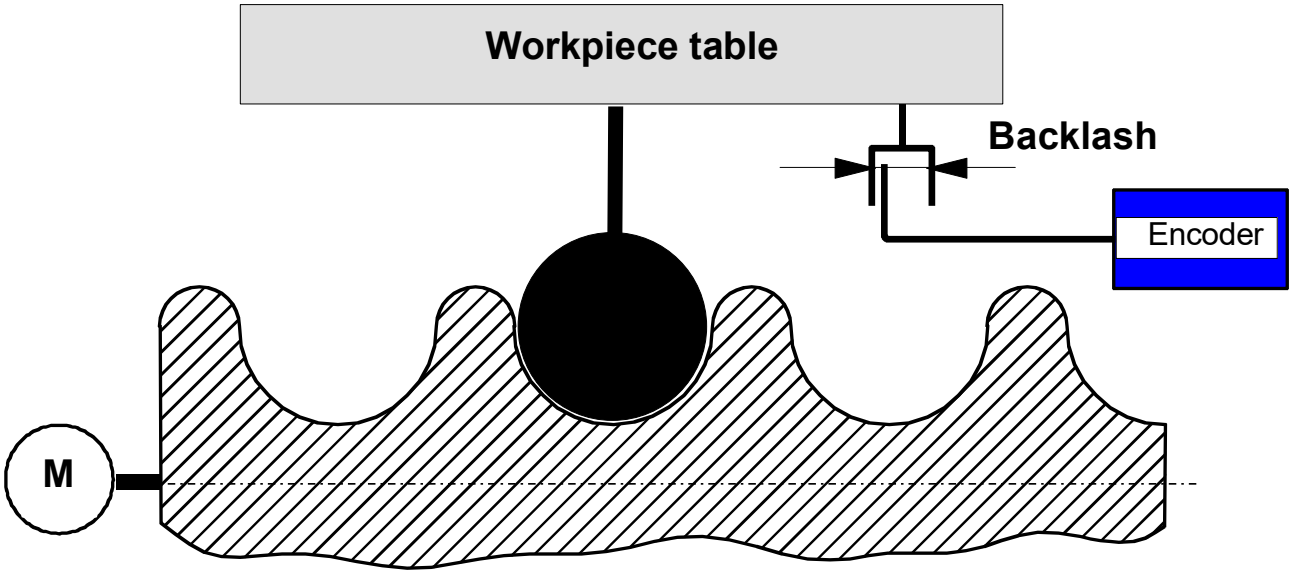


Fig. 2: Negative backlash

Backlash compensation

The size of the backlash P-AXIS-00103 during on position control is taken into consideration depending on the type of mechanical backlash P-AXIS-00021 and acts on the calculation of the command variables.

The display of the absolute command position or actual position of the moving machine part does **not** include the compensation values and therefore represents the position of an ideal machine.

Effectiveness

When backlash compensation is selected, it is active directly after controller start-up, regardless of whether homing has taken place [FCT-M1//Description].

The algorithm compensates for the backlash in the 1st cycle of the path motion. A large backlash can cause strong excitation in the machine. o prevent this, the backlash can be distributed over several position control cycles P-AXIS-00243.

2.3 Parameterisation

2.3.1 Overview

ID	Parameter	Description
P-AXIS-00021	anwahl_losekomp	Selection and type of mechanical backlash
P-AXIS-00103	lose	Size of mechanical backlash
P-AXIS-00243	n_backlash_cyc	Distribution of mechanical backlash

2.3.2 Description

P-AXIS-00021	**Selection of backlash compensation**	
Description	The selection of backlash compensation is done using this parameter. The type of backlash (the backlash between the table and the drive or the backlash between the drive and the measuring system) depends on the mathematical sign of P-AXIS-00103 (getriebe[i].lose).	
Parameter	lr_param.anwahl_losekomp	
Data type	UNS16	
Data range	0: No backlash compensation 1: Last axis motion occurred in pos. direction. 2: Last axis motion occurred in neg. direction.	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
drive types.	----	
Remarks		

P-AXIS-00103	**Size of backlash**	
Description	The parameter defines the size of backlash.	
Parameter	getriebe[i].lose	
Data type	SGN16	
Data range	SGN16 range 0 < backlash: backlash betw. drive and slide	
Axis types	T, R, S	
Dimension	T: 0.1µm	R,S: 0.0001 °
Default value	0	
drive types.	----	
Remarks		

2.3.3 CNC objects

Name	BC::actual backlash		
Description	This object reads the current effective compensation offset of backlash compensation		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0093
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	BC::conf. backlash		
Description	This object reads the configured value for backlash compensation. The parameter P-AXIS-00103 [▶ 11] defines this value.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>00AF
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	BC::delta backlash		
Description	This object reads the change in compensation value in the current backlash compensation cycle.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0095
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	BC::sum backlash		
Description	This object reads the compensation value of the backlash compensation at the current position without filters.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0094
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

2.4 Error messages

Errors in the configuration of batch compensation result in deactivation of the function for the axis affected and an error message (warning) is output:

P-ERR-110392

2.5 Parameterisation example

Excerpt from the axis parameter list

```
getriebe[0].lose           1000  #0,1 µm backlash
lr_param.anwahl_losekomp   1     #Positive direction
lr_param. n_backlash_cyc   10    #Number of filter cycles
```

3 Temperature compensation

3.1 Overview

Deformation and its effect

Temperature changes cause an expansion or contraction of machine parts.

Deformations cause offsets in the axis positions that are not detected by the machine's position measuring system and lead to inaccuracies in the finished workpiece.

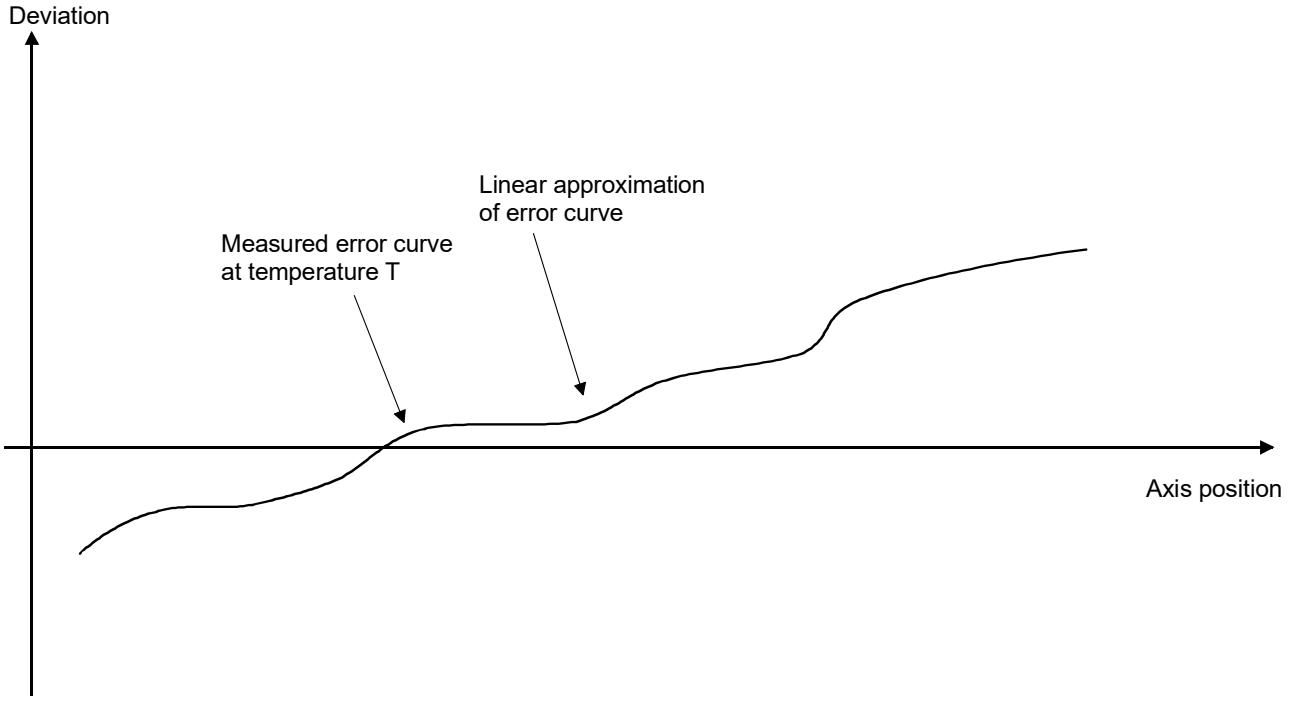


Fig. 3: Temperature-dependent falsification of the axis position

Compensation

Temperature compensation provides a function to correct the command variable of the axis depending on the current temperature and axis position.

The compensation values are determined according to the following equation:

$\Delta s\ (T,s) = offset_0(T) + coefficient(T) * [s-s_0]$

where:

s = current position of the axis

T = current reference temperature

S_0 = reference position of the axis

$Offset_0(T)$ = temperature-dependent deviation from reference position

Coefficient = temperature-dependent ratio of deviation to distance from reference position

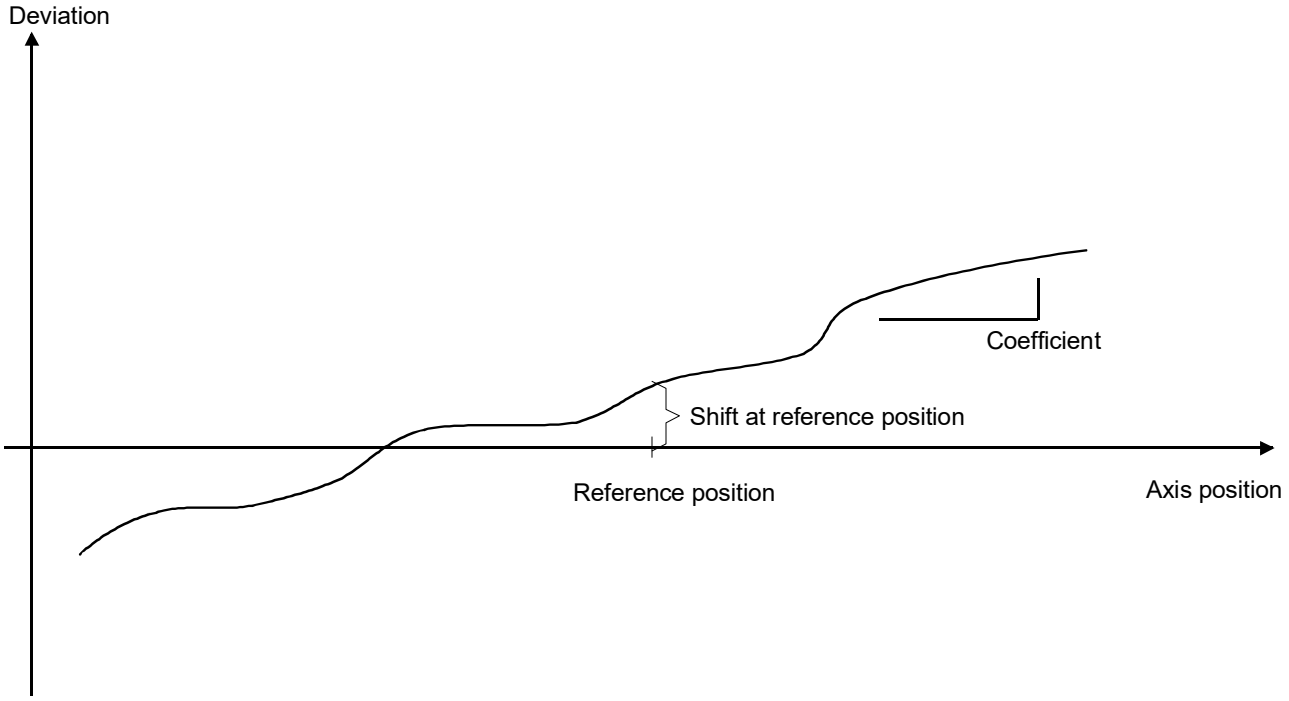


Fig. 4: Parameter of temperature compensation for a temperature T

Effectiveness

The temperature compensation is effective if:

- it was activated for the axis and
- the axis is homed.

3.2 Parameterisation

Activate

Temperature compensation is activated in the axis machine data record [AXIS] of the required axis using P-AXIS-00271:

```
kopf.achs_nr                                    1
#
# temperature compensation on/off
lr_param.temp_comp                1
```

Compensation can also be activated using a write access to the CNC object via the GEO task:

TEMPC::is_active Index group = 0x120300, Index offset = 0x10041

Reference measurement

Before specifying the parameters of temperature compensation, a reference measurement must first be carried out using an external position measuring system. It determines the deviations of the axis positions between the internal and external measuring system at different temperatures.

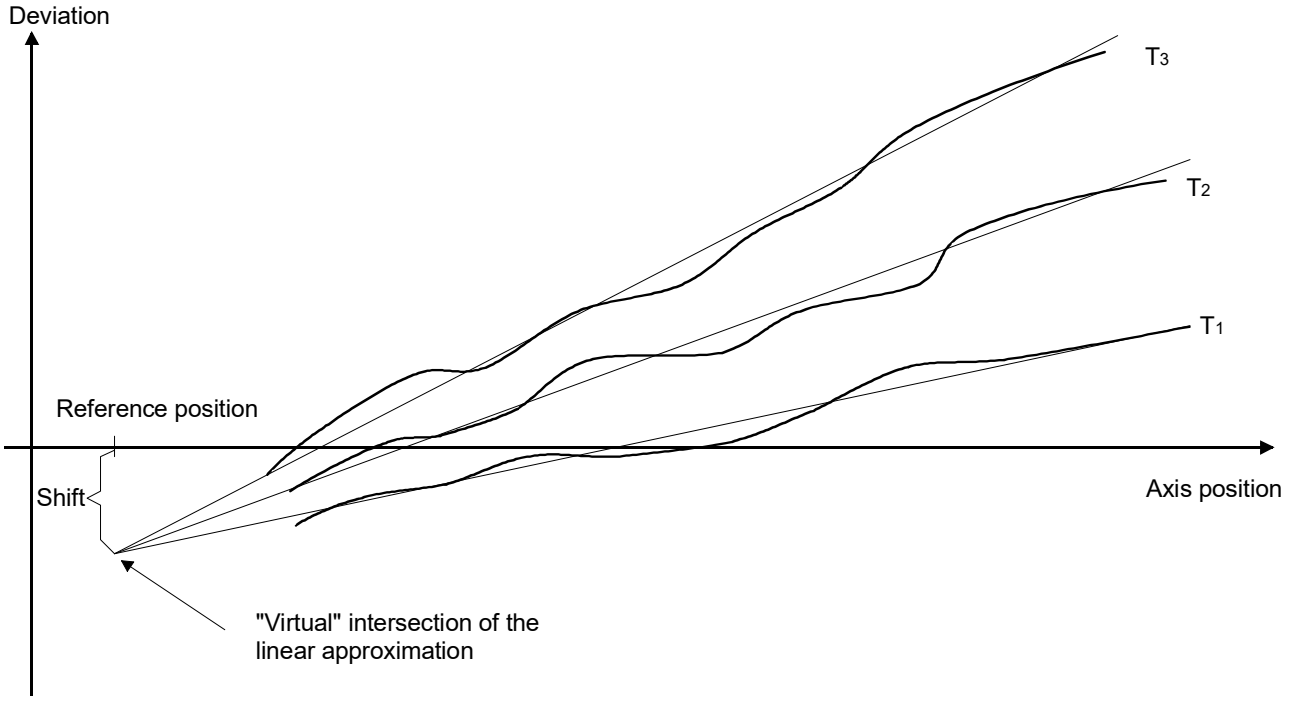


Fig. 5: Reference measurement at different temperatures

Determine parameters

The parameters reference position, offset and coefficient can be taken from the measurement curves. The values at a given temperature can be set later from the curves. Temperatures that are not measured can be interpolated or extrapolated from the measured temperature curves.

If the virtual intersection of the approximated linear curves is chosen as the reference position, the offset is independent of temperature. In this case, only the coefficient must be reset for different temperatures.

Influence of temperature

The individual parameters can be set by the PLC depending on the current temperature. To do this, a corresponding temperature signal (sensor) is transmitted to the PLC which then derives the parameters from it.

Explicit activation in NC program

```
lr_param.temp_comp_manual_activation          0
```

- 0 (default): The CNC activates temperature compensation automatically as soon as the required preconditions are met (e.g. the axis is homed).
- 1: Temperature compensation must be activated manually in the NC program using the COMP command (see Section “Selecting and deselecting axis compensations in the NC program [▶ 71]").

Compensation is deselected:

- at the end of the NC program
- at CNC reset and
- on release of the axis.

Change parameters

Each of the parameters can be changed by downloading the axis list:

```
kopf.achs_nr                                    1
#
# temperature compensation on/off
lr_param.temp_comp          1
# reference position
lr_param.temp_comp_position_0              100 [0.1µm]
# reference offset
lr_param.temp_comp_offset_0                 40 [0.1µm]
lr_param.temp_comp_coefficient            4000 [µm/m]
#
```

In addition to the download option, there is also the option of writing and reading the parameters via direct access to the GEO task via CNC objects. For example, the first axis can be addressed via the following index group and index offset:

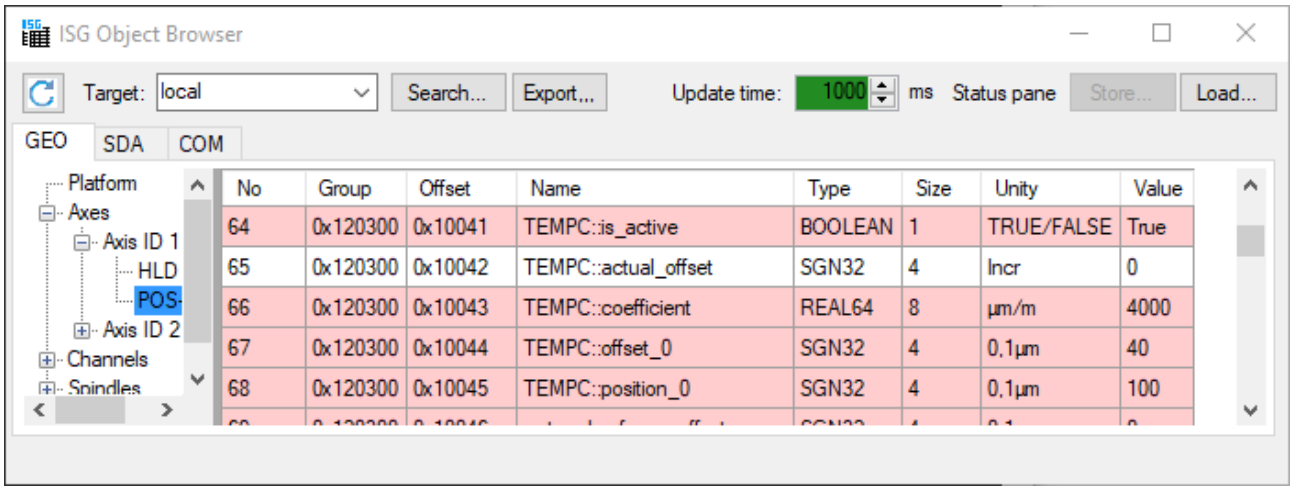


Fig. 6: Access to CNC objects of temperature compensation

Monitoring and coupling/decoupling

The compensation values are recalculated for each interpolation cycle. If the change per cycle exceeds the given maximum axis acceleration, this change can be output filtered over multiple cycles.

For this the number of cycles of the sin² filter can be defined in the axis parameter list. By default, this is set to one cycle.

```
kopf.achs_nr                          1
#
# Cycle of the sin² filter
lr_param.temp_comp_n_cycles          20
```

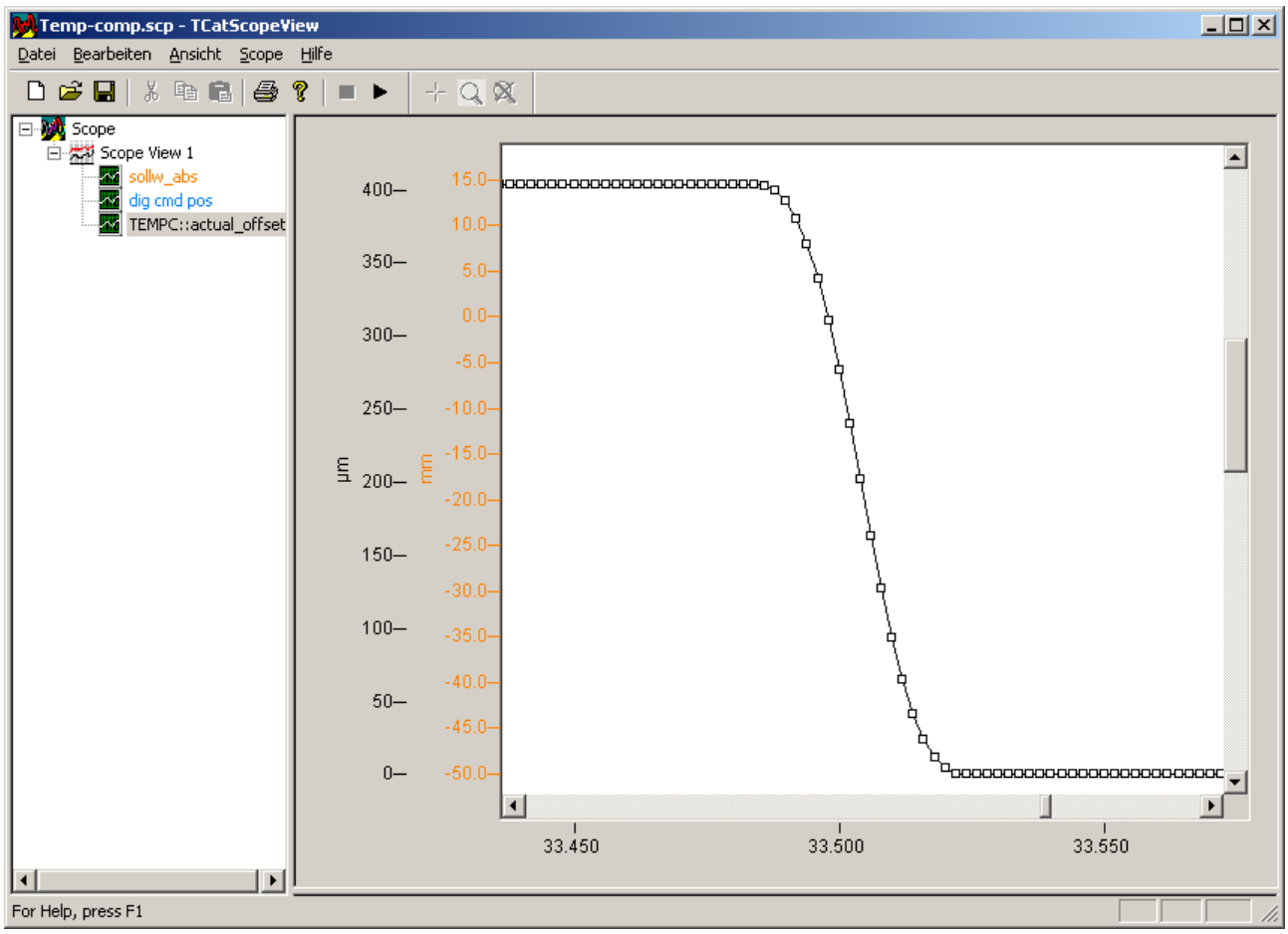


Fig. 7: Deactivating compensation values with a sin² filter over 20 cycles by deactivating temperature compensation temporarily

Display the compensation

In addition to the download option, there is also the option of writing and reading the parameters via direct access to the CNC objects of the GEO task. For example, the 1st axis can be addressed using the following index group and index offset:

TEMPC::is_active Index group = 0x120300, Index offset = 0x10041

TEMPC::is_active Index group = 0x120300, Index offset = 0x10042

Display the axis position

When temperature compensation is activated, the normal command and actual positions of the axis are displayed unchanged.

The corrections are only calculated and included before output to the drive bus and can therefore be viewed in the position values of the drive bus (dig_cmd_pos, dig_act_pos).

3.2.1 Overview

ID	Parameter	Description
P-AXIS-00789	lr_param.crosstalk	Activate crosstalk compensation

ID	Parameter	Description
P-COMP-00063	kw.crosstalk.master_ax_nr	Log. Axis number of the master axis
P-COMP-00064	kw.crosstalk.n_cycles	Number of cycles for ‘smooth switching’
P-COMP-00065	kw.crosstalk.last_index	Last index of compensation value table
P-COMP-00066	kw.crosstalk.acceleration	Accelerations of the master axis
P-COMP-00067	kw.crosstalk.correction	Compensation values for the slave axis
P-COMP-00073	kw.crosstalk.manual_activation	Manual activation

3.2.2 Description

P-AXIS-00271	**Selection of temperature compensation**	
Description	The parameter selects the temperature compensation.	
Parameter	lr_param.temp_comp	
Data type	BOOLEAN	
Data range	0/1	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Drive types	----	
Remarks		

P-AXIS-00272	**Parameterisation of temperature compensation (Basic position)**	
Description	The compensation values are approximated by a linear straight line. This straight line is defined by a basic position, an offset at this position and a geometrical pitch. Depending on the temperature, these parameters can be adjusted e.g. by the PLC.	
Parameter	lr_param.temp_comp_position_0	
Data type	SGN32	
Data range	MIN(SGN32) < temp_comp_position_0 < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm	R,S: 0.0001°
Default value	0	
Drive types	----	
Remarks		

P-AXIS-00273	**Parameterisation of temperature compensation (Offset)**	
Description	The compensation values are approximated by a linear straight line. This straight line is defined by a basic position, an offset at this position and a geometrical pitch. Depending on the temperature, these parameters can be adjusted e.g. by the PLC.	
Parameter	lr_param.temp_comp_offset_0	
Data type	SGN32	
Data range	MIN(SGN32) < temp_comp_offset_0 < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm	R,S: 0.0001°
Default value	0	
Drive types	----	

Remarks	

P-AXIS-00274	**Parameterisation of temperature compensation (Geometrical pitch)**	
Description	The compensation values are approximated by a straight line. This straight line is defined by a basic position, an offset at this position and a geometrical pitch. Depending on the temperature these parameters can be adjusted e.g. by the PLC.	
Parameter	lr_param.temp_comp_coefficient	
Data type	REAL64	
Data range	-10000 ≤ temp_comp_coefficient ≤ 10000	
Axis types	T, R, S	
Dimension	T: µm/m	R,S: ----
Default value	0	
Drive types	----	
Remarks		

P-AXIS-00275	**Distribution of the temperature compensation on several cycles**	
Description	The compensation values are recalculated for each interpolation cycle. If the change per cycle exceeds the given maximum axis acceleration, this change can be output filtered over multiple cycles. For this the number of cycles of the sin² filter can be defined in the axis parameter list.	
Parameter	lr_param.temp_comp_n_cycles	
Data type	UNS16	
Data range	0 < temp_comp_n_cycles < 20	
Axis types	T, R, S	
Dimension	T: Number of interpolation cycles	R,S: Number of interpolation cycles
Default value	0	
Drive types	----	
Remarks		

P-AXIS-00482	**Manual activation of the temperature compensation**	
Description	The CNC turns the temperature compensation on when it is selected in the axis parameter list (P-AXIS-00271) and the required preconditions are met (e.g. the axis is homed). If the parameter is set to 1, the temperature compensation must be manually turned on in the NC program via an NC command (see [PROG//Switching axis compensation on/off in the NC program]). In addition, the compensation is turned off at the end of the NC program, during CNC reset and axis release.	
Parameter	lr_param.temp_comp_manual_activation	
Data type	BOOLEAN	
Data range	0: Automatic activation (default). 1: Manual activation in NC program.	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Drive types	----	
Remarks		

3.2.3 CNC objects

Name	TEMPC:: activated

Description	This object reads whether temperature compensation is activated via P-AXIS-00271 [▶ 20].		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0041
Data type	BOOLEAN	**Length**	1
Attributes	read/ write	**Unit**	[-]
Remarks	TRUE/FALSE		

Name	TEMPC::f_is_active		
Description	This object reads whether temperature compensation is activated . This means that all preconditions, such as axis is referenced and all necessary enables are on, must be fulfilled.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01D8
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	TEMPC::actual_offset		
Description	This object reads the current offset of the temperature compensation.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0042
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	TEMPC::coefficient		
Description	This object reads and writes the required geometrical pitch for temperature compensation. See also P-AXIS-00274 [▶ 21] The temperature compensation values are approximated by a straight line. The straight line is defined by a basic position, an offset at this position and a geometrical pitch.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0043
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[µm/m]
Remarks			

Name	TEMPC::offset_0		
Description	This object reads and writes the required offset for temperature compensation. See also P-AXIS-00273 [▶ 20] The temperature compensation values are approximated by a straight line. The straight line is defined by a basic position, an offset at this position and a geometrical pitch.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0044
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[0.1 µm]
Remarks			

Name	TEMPC::position_0		
Description	This object reads and writes the required reference position for temperature compensation. See also P-AXIS-00272 [▶ 20] The temperature compensation values are approximated by a straight line. The straight line is defined by a basic position, an offset at this position and a geometrical pitch.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0045
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[0.1 µm]
Remarks			

3.3 Example

Initialisation

Compensation is activated in the X axis by the following settings:

```
lr_param.temp_comp                      1
lr_param.temp_comp_position_0         100 [0.1µm]
lr_param.temp_comp_offset_0            40 [0.1µm]
lr_param.temp_comp_coefficient       4000 [µm/m]
lr_param.temp_comp_n_cycles            20
```

NC program

The following NC program was used for the test:

```
N10: G90 G01 X0 F1000
G04 1
N10 X100
G04 1
N10 X80
G04 1
N10 X50
G04 1
N20 X-200
G04 1

$GOTO [N10]
M30
```

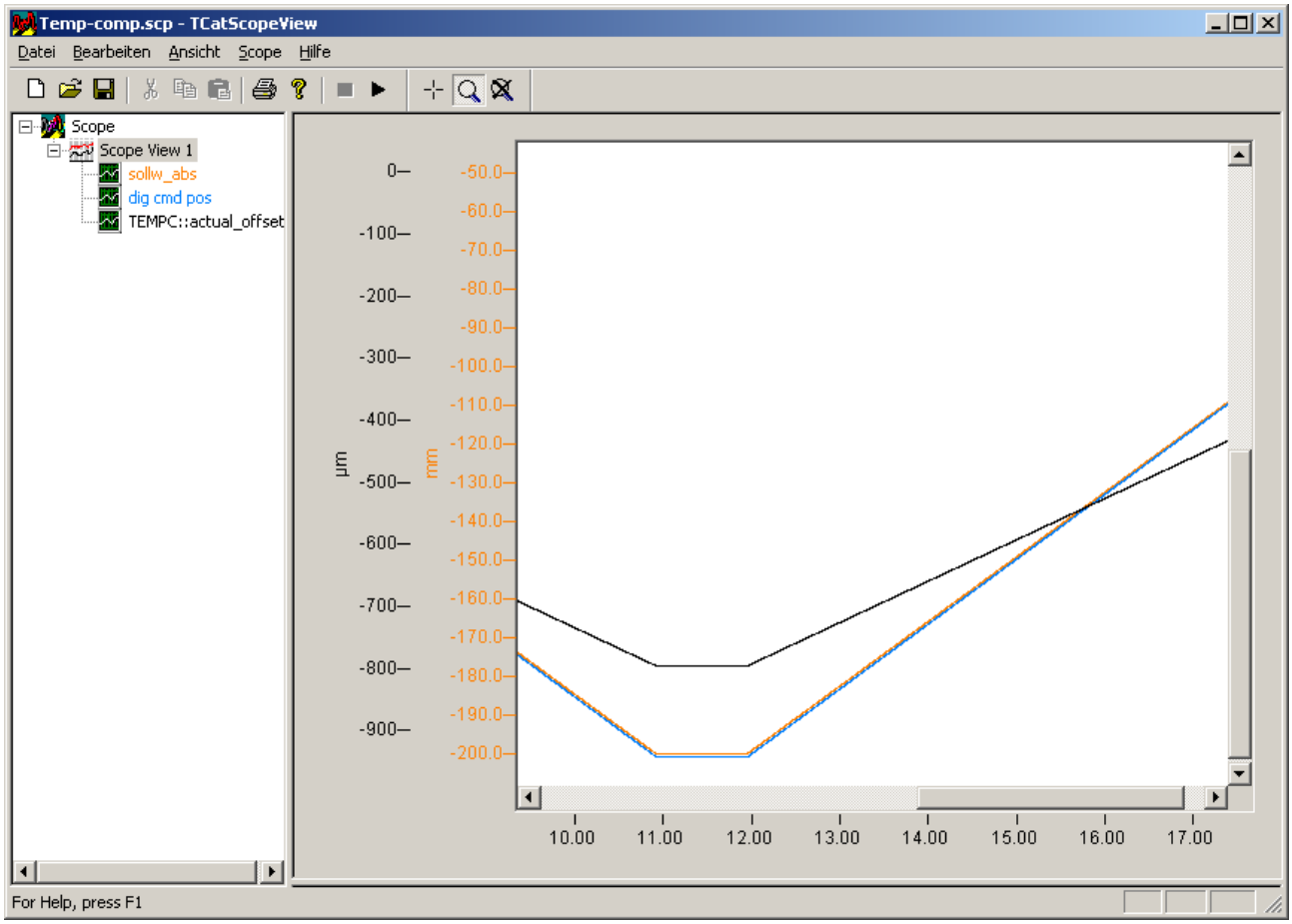


Fig. 8: Logged compensation values dependent on axis position.

4 Axis compensations with compensation value lists

4.1 Compensation value lists

Storing compensation values

Data for the compensation processes

- leadscrew error compensation
- cross compensation and
- plane compensation

are stored for each axis in so-called compensation value lists that are loaded when the controller starts up. It is also possible to update the lists at a later date.

It is possible to activate all the compensation processes (cross, plane, leadscrew error and temperature compensation) for an axis simultaneously.
When you use leadscrew error compensation, it is recommended to include a possible backlash directly in the compensation table of the leadscrew error compensation (double-sided compensation P-COMP-00021).

As of CNC Build V3.1.3079.06 you can adjust the size of the compensation value lists.

Providing the compensation value lists

The following entries must be present in the start-up description [STUP] in order to signal the compensation table to the controller:

Variable name	Type	Meaning
zahl_kw	UNS16	Number of offset value lists
achs_kw[i]	String	Name of datafile
achs_kw_log_ax_nr[i]	UNS16	Logical number of axis for which the compensation value list is valid.

NOTICE

If the compensation value list is configured by the TwinCAT System Manager, these entries are assigned automatically in the start-up description.

Excerpt from the start-up list *hochlauf.lis*:

```
:
zahl_kw                    3
#
achs_kw_log_ax_nr[0]       1
achs_kw[0]                 ..\listen\achskw1.lis
#
achs_kw_log_ax_nr[1]       2
achs_kw[1]                 ..\listen\achskw2.lis
#
achs_kw_log_ax_nr[2]       6
achs_kw[2]                 ..\listen\achskw6.lis
:
```

Structure of the compensation value list

The compensation value list consists of

- a list header containing general data and
- the body of the list where the compensation algorithms are configured and containing the actual compensation tables.

List header

The list header is identified in the list by the structure variable **kopf** . It contains the following elements:

Variable name	Type	Meaning
kopf.achs_nr	UNS16	Logical number of compensation value list
kopf.log_achs_name	String	Name of the axis, which is only used for diagnostic purposes

NOTICE

If the compensation value list is configured by the TwinCAT System Manager, these entries are made automatically in the compensation value list.

Body of the list

The list body contains general data and the compensation tables. The entries in the list body are identified by the structure variable **kw** . It contains the following substructures for the specific compensation processes:

Variable name	Meaning
kw.ssfk.	Data structure for leadscrew error compensation
kw.crosscomp.	Data structure for cross compensation
kw.crosscomp2	Data structure for plane compensation (2-dimensional cross compensation)

Updating the compensation table

The compensation table can be updated while the controller is running, provided the conditions for the effectiveness of a compensation are fulfilled.

NOTICE

After start-up, updating or re-initialisation, it is “almost” not permissible to command a rapid program start or exchange an axis without requesting axis positions.
First, the NC channel must be synchronised in relation to axis positions.

4.2 Leadscrew error compensation

Compensation process

Leadscrew error compensation (referred to below as LSEC) is an axial compensation.
The position setpoint of the compensated axis is changed by a compensation value in the position controller cycle in order to compensate for leadscrew errors, for instance.

This compensation is cancelled by computation for the measured actual position values so that the compensation performed does not appear in the display data of the controller.

Compensation table

The compensation values are taken from a table in which the profile of the compensation curve is stored as a function of the axis position. The axis positions entered in the table are called interpolation points and the corresponding values of the compensation curve are called compensation values.

The compensation value is linearly interpolated for axis positions that lie between interpolation points.

The table containing compensation values is referred to in the following as the compensation table.

Bilateral/unilateral LSEC

You can specify a separate compensation table for each direction of axis motion; this type of compensation is called bilateral compensation.

With bilateral leadscrew error compensation, any backlash that may be present can also be compensated for; additional backlash compensation (see Section "Backlash compensation [▶ 8]") is therefore not necessary.

With bilateral leadscrew error compensation, the parameter P-AXIS-00243 [▶ 33] specifies the number of cycles for distribution of the compensation offset in case of a reversal in direction.

If a table is used for both directions of axis motion, it is referred to as unilateral compensation.

- The compensation tables are stored to a file for each axis (compensation value list).
- Axis dynamics are not taken into account in the output of compensation values.

The graphic below shows an example of a compensation value curve. The meaning of the parameters used in the graphic will be explained later.

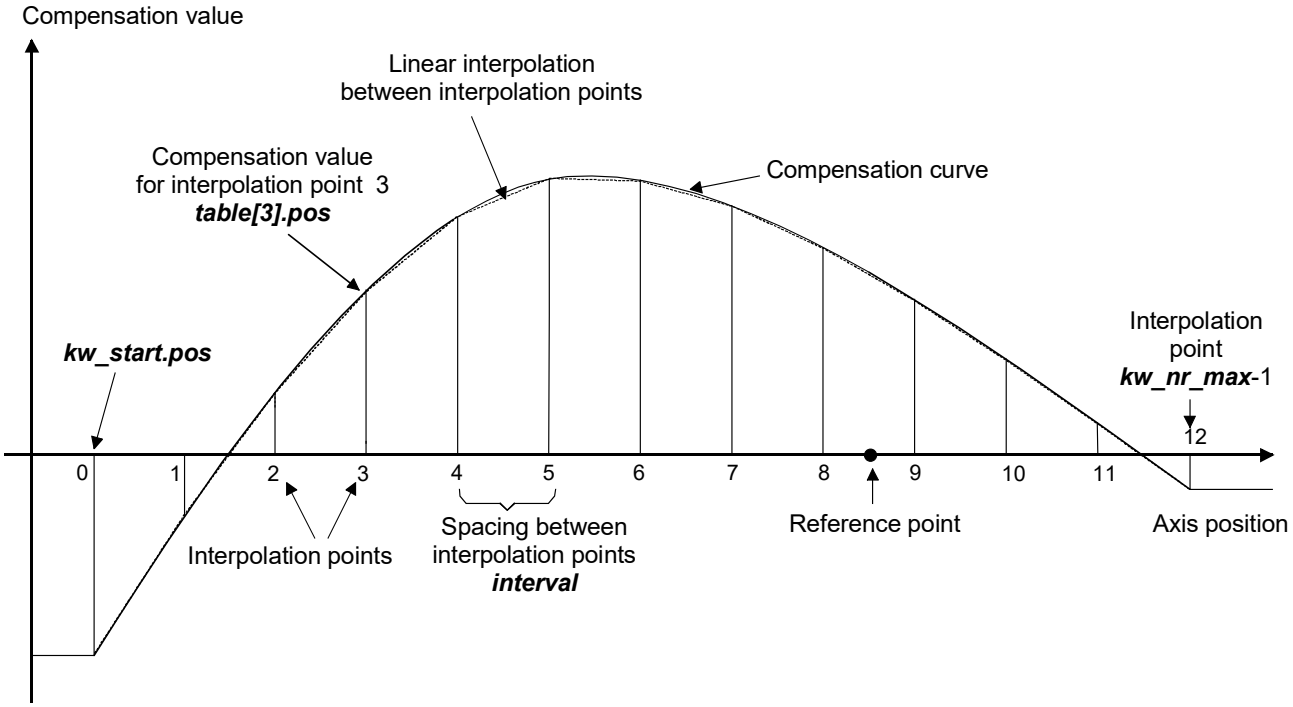


Fig. 9: Compensation table with equidistant interpolation point grid and unilateral compensation

Properties

Leadscrew error compensation (LSEC) has the following characteristics:

- When bilateral compensation is used, the same interpolation point positions must be used for both value tables.
- You can define a compensation table only for a partial motion range of an axis. For axis positions outside the compensation table, the value at either end of the table continues to be used.
- Any compensation value other than 0 can be present at the reference point.
- The distance between interpolation points in the value tables can be selected either equidistant or non-equidistant.
- As of CNC Build V3.1.3079.06 you can adjust the size of the compensation table. The parameter P-COMP-00059 [▶ 33] defines the maximum number of table entries. The actual number of entries used by P-COMP-00020 [▶ 34]

Effectiveness

The LSEC is effective under the following conditions:

- The LSEC was activated for the slave axis.
- A compensation table for the axis must be transferred to the controller.
- he axis was referenced or uses an absolute measuring system.

4.2.1 Parameter

4.2.1.1 Overview

Activation

Leadscrew error compensation (LSEC) is activated in the axis machine data record of the corresponding slave axis by P-AXIS-00175:

Variable name	Type	Meaning
lr_param.ssfk	BOOLEAN	0: no LSEC 1: LSEC active
P-AXIS-00243 [▶ 33] lr_param.n_backlash_cyc	UNS16	Number of cycles with bilateral leadscrew error compensation with reversal of direction

Excerpt from the axis parameter list:

```
:
lr_param.ssfk     1
:
```

Management data of the LSEC table

The general data of the list body parameterises the operation mode of the compensation, e.g. unilateral or bilateral. General data is entered in the structure **kw.ssfk.**.* and contains the following elements.

Management data elements

Variable name	Type	Meaning
unit	BOOLEAN	Unit of the length entries: 0: Encoder increments 1: metric (in 0.1 µm)
interval	SGN32	Distance between interpolation points of the compensation table for use if using equidistant interpolation points. If this parameter is = 0, the position of each interpolation point must be specified separately.
kw_startpos	SGN32	Start position of the compensation table (with equidistant interpolation points)
kw_nr_max	SGN32	Number of entries in the compensation table As of CNC Build V3.1.3079.06, the maximum possible number of entries can be defined in P-COMP-00059 [▶ 33] . In previous builds the default value is 1500.
bilateral	BOOLEAN	0: Unilateral compensation 1: Bilateral compensation
modulo	BOOLEAN	Compensation for a modulo axis take place
manual_activation	BOOLEAN	0 (default): The CNC activates leadscrew error compensation automatically as soon as the required conditions are met (e.g. the master axis is referenced) 1: Leadscrew error compensation must be activated explicitly in the NC program by the COMP command (see Section "Selecting/deselecting axis compensations in the NC program") [▶ 71] . Compensation is deactivated at the end of the NC program, when the CNC is reset or when the axis is released.
set_pos_without_comp	BOOLEAN	By default, leadscrew error compensation also considers the compensation values generated from other axis compensations, e.g. cross and plane compensation. Direction-dependent leadscrew error compensation (see P-COMP-00021 [▶ 30]) may result in undesired backlash cover. The parameter set_pos_without_comp can disable the inclusion of other compensation values in the calculation. 0: Compensation values of other compensations are considered in the leadscrew error compensation. 1: Compensation values of other compensations are not considered.

LSEC compensation values

The compensation values are specified in the table **kw.ssfk.table[i].***.

The field index i can then assume the value 0 *to* **kw.ssfk.kw_nr_max** –1. The maximum number of entries is specified in [SYSP//Number 2.23].

The compensation values are specified as absolute position errors in the unit specified in **kw.ssfk.unit** (metric in 0.1 µm or incremental). Where:

$[Delta]_{si}$ i-th compensation value

$s_{soll, i}$ i-th command value (interpolation point of the compensation table)

$s_{ist, i}$ i-th actual value (measured with reference measuring system)

Compensation value table

Variable name	Type	Meaning
pos	SGN16	Compensation value for motion in a positive direction (bilateral compensation) and compensation value for use with unilateral compensation.
neg	SGN16	Compensation value for motion in a negative direction. Not used with unilateral SSKF.
setpoint	SGN32	Interpolation point of the axis (programmed value). Only with non equidistant interpolation points.

For use with bilateral compensation, enter position errors for motion in a position direction in the **pos** entry, The interpolation points specified are valid for both directions.

For use with unilateral compensation, also enter position errors in the **pos** Entry. The **neg** entry is omitted.

As opposed to the entry of individual interpolation points for the compensation table, a grid structure can also be used. Entries for interpolation points can then be omitted in the **setpoint** variable in this case.

To use an interpolation point grid, enter the increment of the interpolation point grid in the **kw.ssfk.interval** variable. The interpolation points are then calculation internally from the start position (**kw.ssfk.kw_startpos**) and the increment.

Special features applicable to modulo axes

If a compensation table is configured for a modulo axis (**kw.ssfk.modulo** = 1), a modulo transition also occurs in the compensation table at the modulo transition of the axis position.

This can be used in order to compensate for position errors caused by gears or transmissions for instance.

The following special aspects must be noted:

- The position values of the first and last entries in the compensation list must be identical.
- The number of compensation values is also equal here to the number of entries in the compensation value table.

4.2.1.2 Description

P-AXIS-00175	**Activation of SSFK**	
Description	This parameter activates the lead screw error compensation.	
Parameter	lr_param.ssfk	
Data type	BOOLEAN	
Data range	0/1	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
Drive types	----	
Remarks		

P-AXIS-00243	**Distribution of the backlash on multiple cycles**	
Description	The parameter defines a number of position control cycles on which the backlash is distributed. The distribution is done according to a $\sin^2$ function. The parameter is also used for bi-directional lead screw error compensation if a change of direction is executed.	
Parameter	lr_param.n_backlash_cyc	
Data type	UNS16	
Data range	0 < n_backlash_cyc < 20	
Axis types	T, R, S	
Dimension	T: Number of interpolation cycles	R,S: Number of interpolation cycles
Default value	0	
Drive types	----	
Remarks	For the values 0 or 1 the output of the backlash to the drive is done abruptly within one cycle. A value larger than 1 creates a distribution according to the $\sin^2$function The use of this feature avoids increasing errors at the workpiece, because for large backlash the machine excitation is reduced.	

P-COMP-00059	**Maximum number of table entries for leadscrew error compensation**
Description	This leadscrew error compensation parameter (FCT-C5 [▶ 28]) sets the memory space required for a particular number of table entries. The size of the actually used compensation table is defined by `kw_nr_max` (P-COMP-00020) and `kw_nr_max` must be smaller than `max_points`.
Parameter	kw.ssfk.max_points
Data type	UNS32
Data range	0 <= P-COMP-00059
Axis types	T, R, S

Dimension	T: ----	R,S: ----
Default value	1500	
Remarks	The parameter value can no longer be changed after start-up or after lists are reloaded. Otherwise error ID 110638 is output. If P-COMP-00059 is not specified (or assigned the value 0), the default value is assigned to P-COMP-00059 for downward compatibility reasons. To avoid the default assignment, memory can be saved for an axis that does not use leadscrew error compensation [▶ 28] by assigning the value 1 to P-COMP-00059. This parameter is available as of CNC Build V3.3079.06	

P-COMP-00017	**Unit of the length entries**	
Description	This parameter defines the unit of the length / position entries.	
Parameter	kw.ssfk.unit	
Data type	BOOLEAN	
Data range	0: Encoder increments 1: Metric (in 0.1 µm)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00018	**Distance between interpolation points**	
Description	The parameter defines the distance between interpolation points of the compensation table when equidistant interpolation points are used. If this parameter is = 0, the position of each interpolation point must be specified separately.	
Parameter	kw.ssfk.interval	
Data type	SGN32	
Data range	0 ≤ interval < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00019	**Start position of compensation values**	
Description	This parameter determines the position of the axis at which the compensation table starts.	
Parameter	kw.ssfk.kw_startpos	
Data type	SGN32	
Data range	MIN(SGN32) ≤ kw_startpos < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00020	**Number of compensation values**
Description	This parameter defines the number of entries in the compensation table.
Parameter	kw.ssfk.kw_nr_max
Data type	SGN32

Data range	0 ≤ kw_nr_max < P-COMP-00059 [▶ 33]	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	P-COMP-00059 [▶ 33] is available as of Build V3.1.3079.06.	

P-COMP-00021	**Operation mode of compensation**	
Description	This parameter defines whether compensation is unilateral or bilateral.	
Parameter	kw.ssfk.bilateral	
Data type	BOOLEAN	
Data range	0: Unilateral compensation 1: Bilateral compensation	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00022	**Compensation of a modulo axis**	
Description	This parameter defines the compensation table for a modulo axis. A modulo transition also takes place in the compensation table on the modulo transition of the axis position. The number of compensation values must then be equal to the number of entries in the compensation value table.	
Parameter	kw.ssfk.modulo	
Data type	BOOLEAN	
Data range	0: Compensation without modulo handling 1: Compensation for a modulo axis	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00023	**Compensation value in positive direction**	
Description	This parameter defines a compensation value in case of movement in positive direction at interpolation point 'i'.	
Parameter	kw.ssfk.table[i].pos	
Data type	SGN32	
Data range	MIN(SGN32) ≤ pos < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00024	**Compensation value in negative direction**
Description	This parameter defines a compensation value in case of movement in negative direction at interpolation point 'i'.
Parameter	kw.ssfk.table[i].neg
Data type	SGN32
Data range	MIN(SGN32) ≤ neg < MAX(SGN32)
Axis types	T, R, S

Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00025	**Interpolation points of the axis**	
Description	This parameter determines the interpolation points of the axis for which the axis must be corrected.	
Parameter	kw.ssfk.table[i].setpoint	
Data type	SGN64	
Data range	MIN(SGN64) ≤ setpoint < MAX(SGN64)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks	In CNC Builds V2.11.20xx and higher, the data type is SGN32 and so is the related data range.	

P-COMP-00028	**Manual activation**	
Description	Leadscrew error compensation is automatically activated by the CNC if it selected in the axis parameters (P-AXIS-00175) and the required conditions are met (e.g. axis is homed). If the parameter is set to value 1, leadscrew error compensation must be explicitly activated by an NC command (see [PROG//Selecting/deselecting axis compensations in the NC program]. In addition, compensation is deselected at the end of the NC program, at CNC reset and on axis release.	
Parameter	kw.ssfk.manual_activation	
Data type	BOOLEAN	
Data range	0: Automatic activation 1: Manual activation in NC program	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00057	**Consideration of other axis compensations**	
Description	By default, leadscrew error compensation also considers the compensation values generated from other axis compensations, e.g. cross and plane compensation. With direction-dependent spindle leadscrew error compensation (see P-COMP-00021) this may result in the undesirable occurrence of backlash under certain circumstances. The parameter **set_pos_without_comp** can disable the inclusion of other compensation values in the calculation.	
Parameter	kw.ssfk.set_pos_without_comp	
Data type	BOOLEAN	
Data range	0: Compensation values of other compensations are considered in the leadscrew error compensation. 1: Compensation values of other compensations are not considered.	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

4.2.1.3 CNC objects

Name	ssfk activated		
Description	This object reads whether leadscrew error compensation (LSEC) is activated via P-AXIS-00175 [▶ 33].		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0038
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	LSEC::active		
Description	This object reads whether leadscrew error compensation is active. This means that all preconditions must be met, such as the axis is homed and all necessary enables are on. (leadscrew error compensation - LSEC)		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>00D0
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	LSEC::epsilon		
Description	This object reads the change in compensation value of leadscrew error compensation in the current cycle. (leadscrew error compensation - LSEC)		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>001C
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	LSEC::sum epsilon		
Description	This object reads the leadscrew error compensation of the current compensation value, i.e. the sum of all compensation values. (leadscrew error compensation - LSEC)		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>001D
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

4.2.2 Example - Non-equidistant bilateral SSFK

The diagram below shows a compensation value table with the properties:

- Non-equidistant interpolation points (kw.ssfk.interval = 0)
- Bilateral compensation table (kw.ssfk.bilateral = 1)
- Position specifications in metric system (kw.ssfk.unit = 1)
- Compensation value table with 140 entries (kw.ssfk.kw_nr_max = 140). The index of the position and setpoint entries goes from 0 to 139.

The following values were measured at the third gauged position (table[3]):

Programmed Position $s_{soll,i}$ ith setpoint	pos measurement value $s_{ist,i}$ ith actual value (pos direction)	neg measurement value $s_{ist,i}$ ith actual value (neg direction)	computed pos compensation value $\Delta s_i = s_{ist,i} - s_{soll,i}$	Computed neg compensation value $\Delta s_i = s_{ist,i} - s_{soll,i}$
19866.7 µm	19856.5 µm	19874.7 µm	-102 x 0.1 µm	80 x 0.1 µm

Non-equidistant bilateral SSFK

```
kopf.achs_nr                        2
kopf.log_achs_name                    Y AXIS
kw.ssfk.interval                    0
kw.ssfk.kw_startpos                 -200000
kw.ssfk.kw_nr_max                   140
kw.ssfk.unit                        1
kw.ssfk.bilateral                   1
kw.ssfk.table[0].setpoint           -200000
kw.ssfk.table[1].setpoint           -199306
kw.ssfk.table[2].setpoint           -198667
kw.ssfk.table[3].setpoint           -198001
...
kw.ssfk.table[138].setpoint         334488
kw.ssfk.table[139].setpoint         335591
kw.ssfk.table[0].pos                0
kw.ssfk.table[1].pos                24
kw.ssfk.table[2].pos                -102
...
kw.ssfk.table[139].pos              -55
kw.ssfk.table[0].neg                0
kw.ssfk.table[1].neg                67
kw.ssfk.table[2].neg                80
...
kw.ssfk.table[139].neg              114
```

4.2.3 Error messages

Errors in the configuration of leadscrew error compensation result in deactivation of the function for the affected axis and to the output of an error message (warning message).

The following error messages then appear:

- ID 110217
- ID 110218
- ID 110392
- ID 110474
- ID 110476
- ID 110477
- ID 110478
- ID 110479
- ID110480
- ID 110590
- ID 110638

4.3 Cross compensation

Cross compensation permits the compensation of rectangularity errors or errors that arise due to deflection of the axis.

Compensation process

Cross compensation (also called sag compensation) permits the compensation of an axis position depending on the command position of another axis.

The axis whose command positions influences the compensation value is called the master axis. The axis for which compensation is active is called the slave axis.

A master axis can also be the salve axis of another master axis.

Cross compensation data is specified in the compensation value list of the **slave axis** .

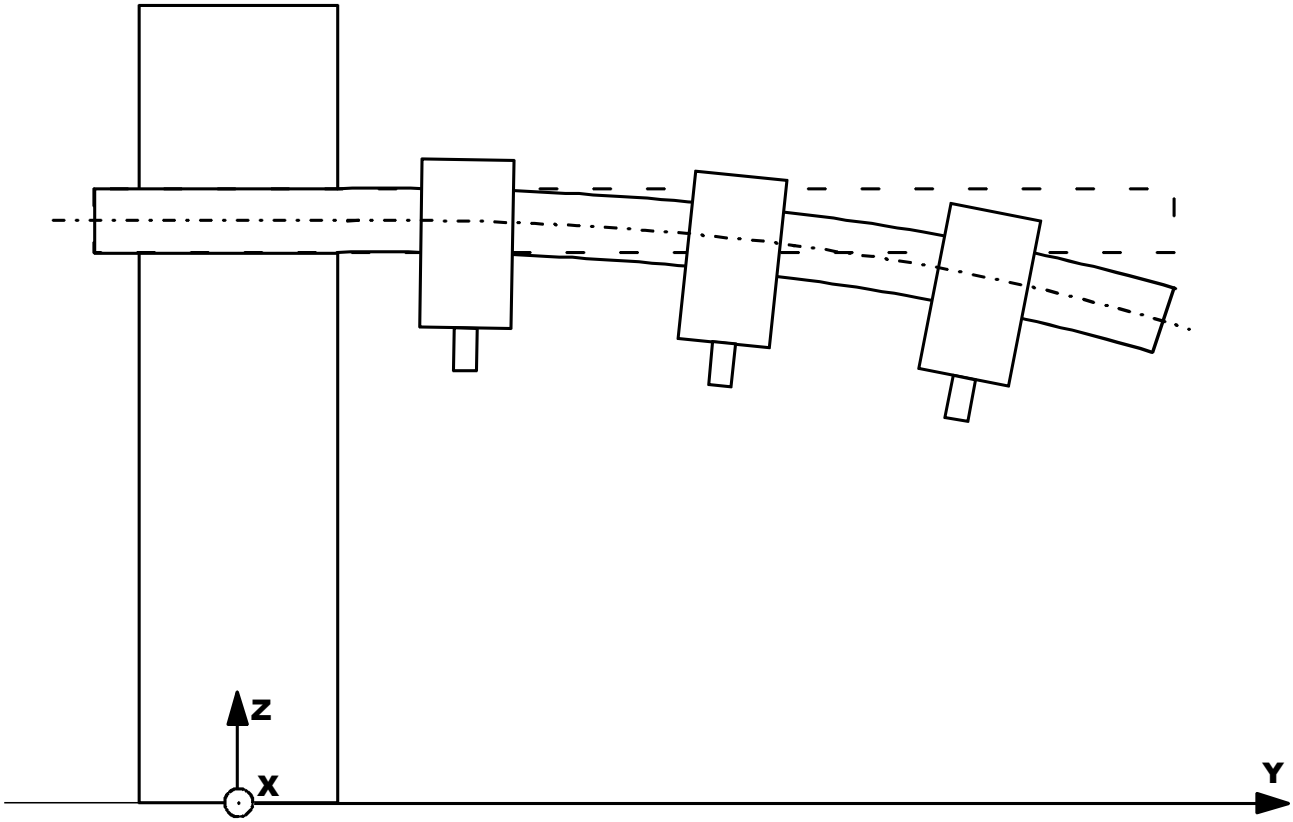


Fig. 10: Application example for cross compensation (Y: Master, Z: Slave).

Properties

- A master axis has one or several slave axes.
- A slave has only one master axis.
- Cross compensation can also be used for the master and slave axes of a gantry combination.
- A compensation value can be specified for each interpolation point.
- Interpolation between interpolation points is linear.
- Cross compensation is available for all drive types.
- Compensations can only be viewed in the positions directly output to the drive (not in the normal display data) since compensation takes place outside normal calculations.
- As of CNC Build V3.1.3079.06 you can adjust the size of the compensation table. The parameter P-COMP-00060 [▶ 44] defines the maximum number of table entries. The actual number of entries used by P-COMP-00004 [▶ 44]

Effectiveness

Cross compensation is only effective if all the following conditions are fulfilled:

- The function was activated for the slave axis.
- The compensation value table was provided.
- Master and slave axes are linear axes. As of CNC Build v263.1504, cross compensation can also be used for rotary axes or spindles.
- The master axis was referenced. Therefore there is no need to reference the slave axis.

4.3.1 Parameter

4.3.1.1 Overview

Activation

Cross compensation is activated in the axis machine data record of the slave axis by P-AXIS-00047:

Variable name	Type	Meaning
lr_param.crosscomp	BOOLEAN	0: no cross compensation 1: Cross compensation active

Excerpt from the axis parameter list:

```
:
lr_param.crosscomp     1
:
```

Cross compensation can also be used for a gantry axis group. A compensation value table must then be specified for each individual axis in the gantry combination (cross compensation slave).

Compensation value tables can therefore have different settings for each gantry axis.

Activating/deactivating

Cross compensation (ON if master axis is referenced and compensation is activated) can be switched on or off at any time when the slave axis is at standstill. The slave axis command positions displayed are offset with the offset values.

Filter:

When the master axis is referenced, inconsistencies may occur when compensation values are calculated for a moved slave axis. These inconsistencies can be smoothed by using a $\sin^2$ filter. The parameter P-COMP-00026 (n_cycles) switches the filter order to activate it.

Management data of the cross compensation table

General data of the list body is entered in the structure **kw.crosscomp.**.*. It contains the following elements.

Management data elements

Variable name	Type	Meaning
unit	BOOLEAN	Unit of the length entries: 0: Encoder increments 1: metric (in 0.1 µm)
last_index	SGN32	Last valid index in the slave axis table. As of CNC Build V3.1.3079.06 the maximum possible of table entries can be defined in P-COMP-00060 [▶ 44]. In previous Builds the default value is 1000. The table always starts with index 0
master_ax_nr	UNS16	Axis number of the master axis; its command position acts as the input variable of the compensation table.
n_cycles	UNS16	Number of cycles of $\sin^2$ filter.
manual_activation	BOOLEAN	0: (Default) The CNC activates cross compensation automatically as soon as the required conditions are met (e.g. the master axis is referenced). 1: Cross compensation must be activated explicitly in the NC program by the COMP command (see section "Selecting/deselecting axis compensations in the NC program") [▶ 71]. Compensation is deactivated at the end of the NC program, when the CNC is reset or when the axis is released.

Compensation values for cross compensation

The corresponding compensation value of the slave axis is entered in the table **kw.crosscomp.table[i].*** for every interpolation point. The compensation table is valid for positive and negative directions of motion.

Compensation value table

Variable name	Type	Meaning
table[i].setpoint	SGN32	Interpolation point of master axis for which the slave axis must be compensated.
table[j][i].correction	SGN32	Relative compensation value for the salve axis at interpolation point i

Special feature for rotary master axis

As of CNC Build v263.1504, cross compensation can also be used for rotary axes or spindles. A modulo calculation of the axis position is carried out in the position controller for these axis types.

If a cross compensation master axis is a modulo axis, a "modulo transition" also takes place in the compensation table in the modulo transition of the axis position of this master axis. To prevent a jump from occurring at this point of the compensation value process of the slave axis, the same compensation value must be specified in the compensation table at the modulo transition.

4.3.1.2 Description

P-AXIS-00047	Activation of cross compensation
Description	This parameter activates the cross compensation.
Parameter	lr_param.crosscomp
Data type	BOOLEAN

Data range	0/1	
Axis types	T	
Dimension	T: ----	
Default value	0	
Drive types	----	
Remarks		

P-COMP-00060	**Maximum number of table entries for cross compensation**	
Description	This cross compensation parameter (FCT-C5 [▶ 40]) saves the memory space required for a particular number of table entries. The size of the actually used compensation table is defined by `last_index` (P-COMP-00004) and `last_index` must be smaller than `max_points`.	
Parameter	kw.crosscomp.max_points	
Data type	UNS32	
Data range	0 <= P-COMP-00060	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	1001	
Remarks	The parameter value can no longer be changed after start-up or after lists are reloaded. Otherwise error ID 110639 is output. If P-COMP-00060 is not specified (or assigned the value 0), the default value is assigned to P-COMP-00060 for downward compatibility reasons. To avoid the default assignment, memory can be saved for an axis that does not use cross compensation [▶ 40] by assigning the value 1 to P-COMP-00060. This parameter is available as of CNC Build V3.3079.06	

P-COMP-00003	**Unit of the length entries**	
Description	The parameter defines the unit to be used for the length entries of compensation values.	
Parameter	kw.crosscomp.unit	
Data type	BOOLEAN	
Data range	0: Encoder increments 1: Metric (in 0.1 µm)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00004	**Last index of compensation value table**	
Description	This parameter determines the last valid index in the table of the master axis. The table always starts with index 0	
Parameter	kw.crosscomp.last_index	
Data type	SGN32	
Data range	0 ≤ last_index < P-COMP-00060 [▶ 44]	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	

Remarks	P-COMP-00060 [▶ 44] is available as of Build V3.1.3079.06. The upper limit in previous CNC versions is 1000.

P-COMP-00005	**Logical axis number of the master axis**	
Description	This parameter determines the logical number of the master axis whose command position is used to calculate the input variable of the compensation value table of the slave axis.	
Parameter	kw.crosscomp.master_ax_nr	
Data type	UNS16	
Data range	1 ≤ master_ax_nr ≤ MAX (UNS16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00026	**Number of cycles for 'smooth switching'**	
Description	This parameter determines the number of cycles for which cross compensation is activated/deactivated smoothly.	
Parameter	kw.crosscomp.n_cycles	
Data type	UNS16	
Data range	0 ≤ n_cycles ≤ 20 (maximum number of cycles for which cross compensation is activated/deactivated, application-specific)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00029	**Manual activation**	
Description	Cross compensation is automatically activated by the CNC if it selected in the axis parameters (P-AXIS-00047) and the required conditions are met (e.g. axis is homed). If the parameter is set to the value 1, cross compensation must be activated explicitly by an NC command (see [PROG//Selecting/deselecting axis compensations in the NC program]. In addition, compensation is deselected at the end of the NC program, at CNC reset and on axis release.	
Parameter	kw.crosscomp.manual_activation	
Data type	BOOLEAN	
Data range	0: Automatic activation 1: Manual activation in NC program	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00006	**Interpolation point of the master axis**
Description	This parameter determines the interpolation points of the master axis on which the slave axis has to be corrected.
Parameter	kw.crosscomp.table[i].setpoint
Data type	SGN32
Data range	MIN(SGN32) ≤ setpoint < MAX(SGN32)
Axis types	T, R, S

Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00007	**Compensation values for the slave axis**	
Description	This parameter determines the relative compensation values for the slave axis at interpolation points 'i'.	
Parameter	kw.crosscomp.table[i].correction	
Data type	SGN32	
Data range	MIN(SGN32) ≤ correction < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

4.3.1.3 CNC objects

Name	CROSSC::f_is_active		
Description	This object reads whether cross compensation is activated. This means that all preconditions, such as axis is referenced and all necessary enables are on, must be fulfilled.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>004F
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	CROSSC::activated		
Description	This object reads whether cross compensation is activated via P-AXIS-00047 [▶ 43].		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01D6
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	CROSSC::actual_offset		
Description	This object reads the current effective offset of cross compensation.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0035
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	CROSSC::delta_offset		
Description	This object reads the change in compensation value in the current cross compensation cycle.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0034
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

4.3.2 Example of a compensation value list

Example of a compensation value list for cross compensation

```
# ***************************************
#  Axis compensation data for Z-axis
# ***************************************

kopf.achs_nr                        3
kopf.log_achs_name                  Z
kw.crosscomp.last_index             99 /*Last valid index of the table*/
kw.crosscomp.master_ax_nr           1  /*Log. ax. number of the master axis*/
kw.crosscomp.unit                   1  /*0:Incr. 1:Metric in 0.1 µm*/
kw.crosscomp.n_cycles               20
#
kw.crosscomp.table[0].setpoint      10735
kw.crosscomp.table[0].correction    3
```

```
kw.crosscomp.table[1].setpoint        11523
kw.crosscomp.table[1].correction      5
:
:
kw.crosscomp.table[99].setpoint       10000000  /*at 1000 mm of axis 3*/
kw.crosscomp.table[99].correction     1000      /*corr. of 0.1 mm for axis 1*/
```

4.3.3 Error messages

Errors in the configuration of the cross compensation result in deactivation of the function for the affected axis and to the output of an error message (warning message).

The following error messages then appear:

- ID 110639
- ID 70242
- ID 70244
- ID 70245
- ID 70246
- ID 70247
- ID 70248
- ID 70249
- ID 70250
- ID 70432

4.4 Plane compensation

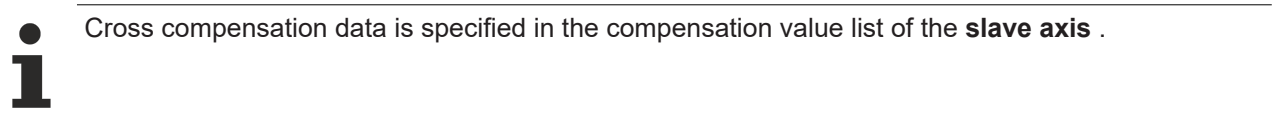
With plane compensation, axis misalignments can be compensated for as a function of the position of two master axes. One application case, for example, is the compensation of the Z axis depending on X and Y.

Compensation process

Plane compensation allows the compensation of an axis position depending on the command positions of two axes.

The two axes whose command positions influence the compensation value are called master axes. The axis for which compensation is active is called the slave axis.

One of the master axes can also be a slave axis itself.



Cross compensation data is specified in the compensation value list of the **slave axis** .

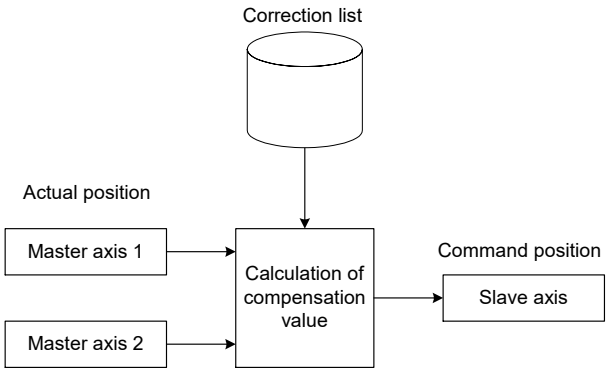


Fig. 11: Schematic of the compensation value calculation for plane compensation

Properties

- The two master axes form a 2-axis coordinate system; in the simplest case it is the X-Y plane (master axis 1 = X axis, master axis 2 = Y axis).
- This coordinate system is divided into squares or rectangles like a chessboard.
- The edge length of the squares or the edge lengths of the rectangles can be parameterised.
- The corners of the squares or rectangles form the interpolation points of the table (see figure below).
- A compensation value can be specified for each interpolation point.
- Interpolation between interpolation points is linear (see 2nd figure below).
- Outside the table, the compensation values at the edge of the table remain effective.
- As of CNC Build V3.1.3079.06 you can adjust the size of the compensation table. The maximum number of table entries can be set by P-COMP-00061 [▶ 56] and The actual number of entries used is specified by P-COMP-00010 [▶ 57] and P-COMP-00011 [▶ 57].

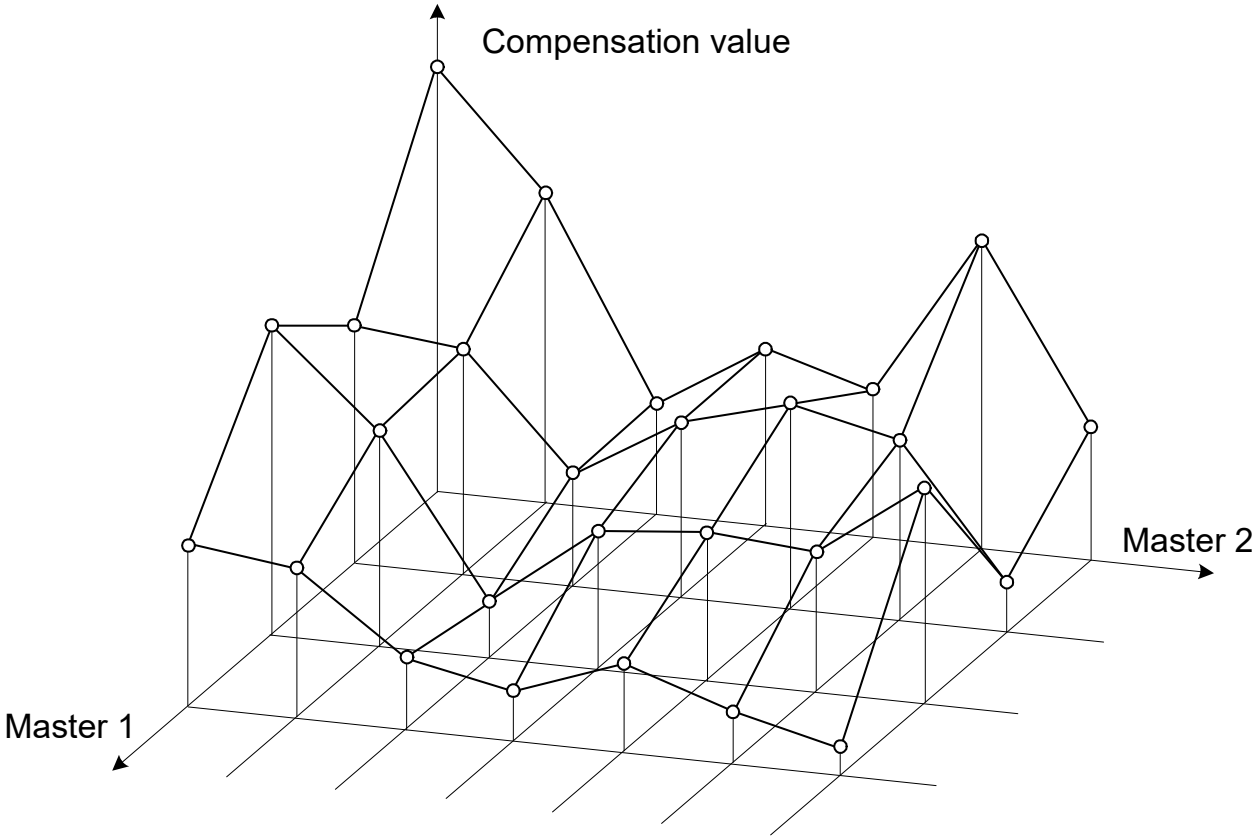


Fig. 12: Specify compensation values at the interpolation points

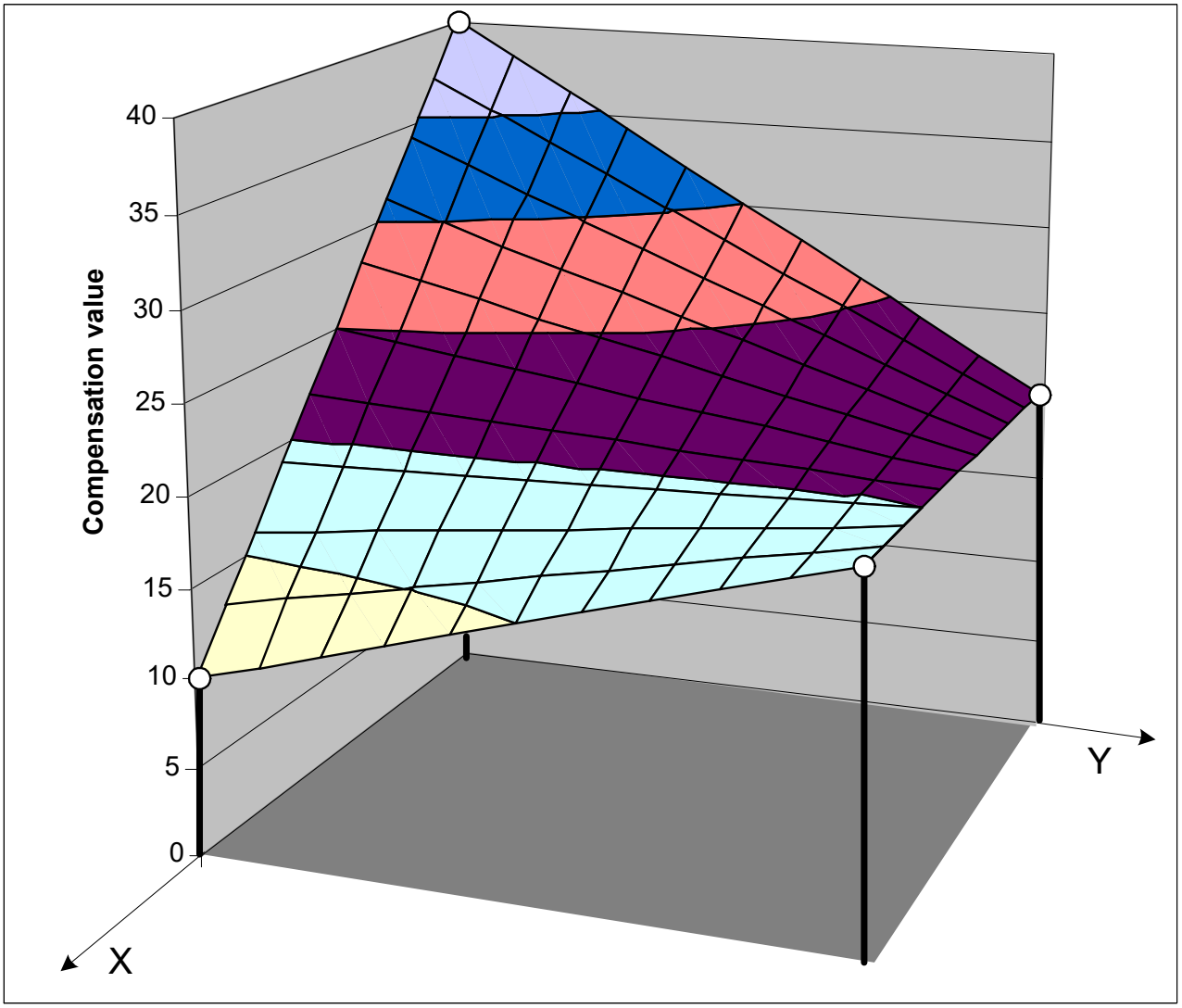


Fig. 13: Linear interpolation between the 4 interpolation points of a square

Effectiveness

- Plane compensation is only effective if all the following conditions are fulfilled:
- The function was activated for the slave axis.
- The compensation value table was provided.
- Master and slave axes are linear axes. As of CNC Build v263.1504, plane compensation can also be used for rotary axes or spindles.
- Master axes have an absolute measuring system or were referenced.

4.4.1 Parameter

4.4.1.1 Overview

Activation

Plane compensation is activated in the axis machine record of the slave axis by P-AXIS-00174:

Variable name	Type	Meaning
lr_param.crosscomp2	BOOLEAN	0: no plane compensation 1: Plane compensation active

Excerpt from the axis parameter list:

```
:
lr_param.crosscomp2     1
:
```

Activating/deactivating

Plane compensation (ON if master axes are referenced and compensation is activated) can be switched on or off at any time when the slave axis is at standstill. The slave axis command positions displayed are offset with the offset values.

Filter:

When master axes are referenced, inconsistencies may occur when compensation values are calculated for a moved slave axis. These inconsistencies can be smoothed by using a $\sin^2$ filter. The parameter P-COMP-00027 [▶ 59] (n_cycles) switches the filter order to activate it.

Special feature for rotary master axes

As of CNC Build v263.1504, plane compensation can also be used for rotary axes or spindles. A modulo calculation of the axis position is carried out in the position controller for these axis types.

If a plane compensation master axis is a modulo axis, a "modulo transition" also takes place in the compensation table in the modulo transition of the axis position of this master axis. To prevent a jump from occurring at this point of the compensation value process of the slave axis, the same compensation value must be specified in the compensation table at the modulo transition.

Management data of the plane compensation table

The general data of the list body parameterise the axes involved, the limits of the compensation range, etc. General data is entered in the structure **kw.crosscomp2**.*. It contains the following elements.

Management data elements

Variable name	Type	Meaning
unit	BOOLEAN	Unit of the length entries: 0: Encoder increments 1: metric (in 0.1 µm)
grid	STRING	Type of interpolation point sample grid: QUADRATIC: Identical grid structure, interval for both master axes RECTANGULAR: Different grid structure, interval1 and interval2 for both master axes
interval	UNS32	Interval between 2 interpolation points in 0.1 µm for the two master axes (grid = QUADRATIC)
interval1	UNS32	Interval of the first master axis between 2 interpolation points in 0.1 µm (grid = RECTANGULAR)
interval2	UNS32	Interval of 2nd master axis between 2 interpolation points in 0.1 µm (grid = RECTANGULAR)
last_index_master1	SGN32	Last valid index in the table for master axis 1 (see Limits of compensation table [▶ 54]). The table always starts with index 0
last_index_master2	SGN32	Last valid index in the table for master axis 2 (see Limits of compensation table [▶ 54]). The table always starts with index 0
start_position_master1	SGN32	Position of master axis 1 at which the compensation table starts
start_position_master2	SGN32	Position of master axis 2 at which the compensation table starts
master1_ax_nr	UNS16	Log. axis number of master axis 1
master2_ax_nr	UNS16	Log. axis number of master axis 2
n_cycles	UNS16	Number of cycles of $\sin^2$ filter.
manual_activation	BOOLEAN	0: Default: The CNC activates plane compensation automatically as soon as the required conditions are met (e.g. the master axes are referenced) 1: Plane compensation must be activated explicitly in the NC program by the COMP command (see section "Selecting/deselecting axis compensations in the NC program [▶ 71]"). Compensation is deactivated at the end of the NC program, when the CNC is reset or when the axis is released.

Limits of compensation table

As of CNC Build V3.1.3079.06 the maximum possible of table entries can be defined in P-COMP-00061 [▶ 56]. In previous builds, the entries "last_index_master1"(P-COMP-00010 [▶ 57]) and "last_index_master2" (P-COMP-00011 [▶ 57]) are limited to 100 entries.

This rigid limitation non longer applies. Note only that:

P-COMP-00010 [▶ 57] x P-COMP-00011 [▶ 57] <= P-COMP-00061 [▶ 56]

Compensation values of plane compensation

The corresponding compensation value of the slave axis is entered in the table **kw.crosscomp2.table[j][i].*** for every interpolation point.

Compensation value table

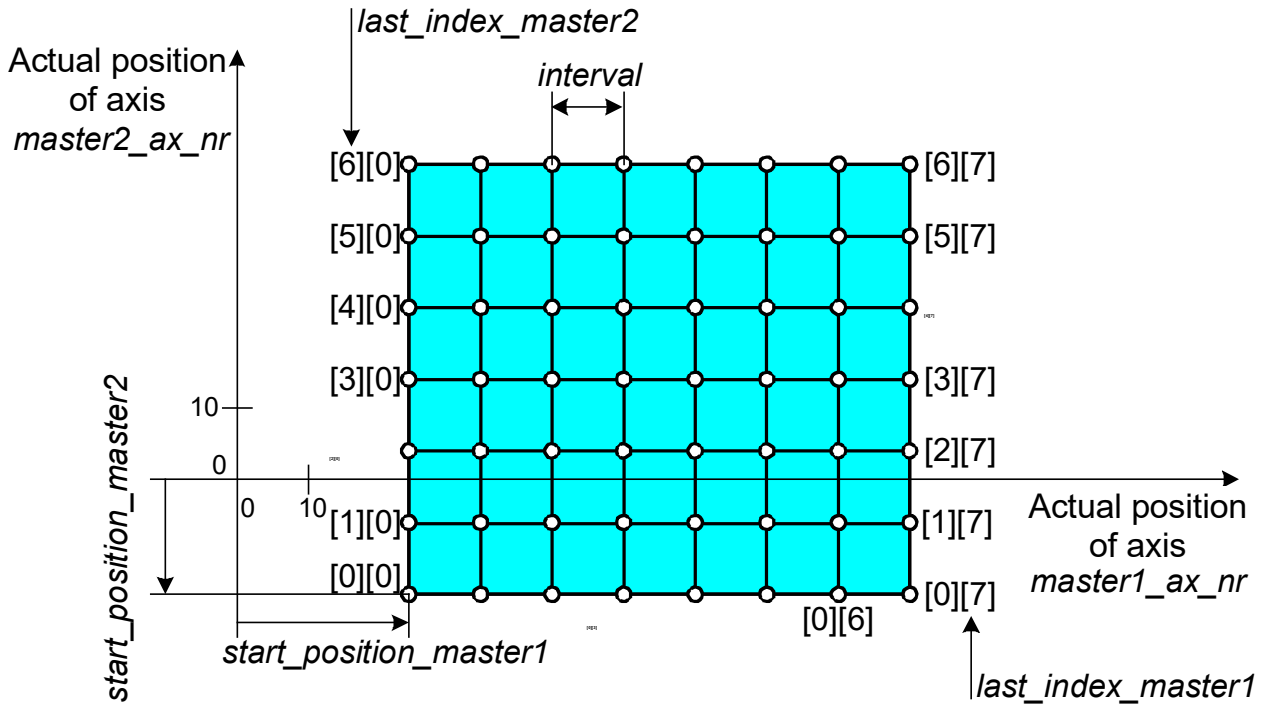
Variable name	Type	Meaning
table[j][i].correction	SGN32	Compensation value of slave axis at interpolation point [j][i], see figure below.

When interpolation points are indexed in the compensation value table, the **1.** index j always refers to the **2.** master axis (see figure below).

Index j -> master axis 2

Index i -> master axis 1

Unassigned interpolation points are assigned the value 0 in the compensation value table. This value is also used in the calculation.




```
kw.crosscomp2.interval                    100000
kw.crosscomp2.last_index_master1               7
kw.crosscomp2.last_index_master2               6
kw.crosscomp2.start_position_master1      220000
kw.crosscomp2.start_position_master2     -160000
kw.crosscomp2.unit                             1
kw.crosscomp2.master1_ax_nr                    1
kw.crosscomp2.master2_ax_nr                    2

kw.crosscomp2.table[0][0].correction           0
                          ...
kw.crosscomp2.table[6][7].correction         324
```

Fig. 14: Compensation value list parameters

4.4.1.2 Description

P-AXIS-00174	Activation of plane compensation
Description	This parameter activates the plane compensation (2-dimensional cross compensation).
Parameter	lr_param.crosscomp2
Data type	BOOLEAN
Data range	0/1
Axis types	T
Dimension	T: ----
Default value	0
Drive types	----
Remarks	

P-COMP-00061	Maximum number of table entries for plane compensation
Description	This plane compensation parameter (FCT-C5 [▶ 50]) saves the memory space required for a particular number of table entries. The size of the actually used compensation table is defined by `last_index:master1` (P-COMP-00010) and `last_index_master2` (P-COMP-00011) and the following must apply: (`last_index_master1` + 1) * (`last_index_master2` + 1) <= `max_points` If `max_points` is not specified (or assigned the value 0), the previous restrictions apply to `last_index_master1` and `last_index_master2`. • 0 <= `last_index_master1` <= 100 • 0 <= `last_index_master2` <= 100
Parameter	kw.crosscomp2.max_points
Data type	UNS32
Data range	0 <= P-COMP-00061
Axis types	T, R, S
Dimension	T: ---- R,S: ----
Default value	10201 (*)
Remarks	The parameter value can no longer be changed after start-up or after lists are reloaded. Otherwise error ID 110640 is output. If P-COMP-00061 is not specified (or assigned the value 0), the default value is assigned to P-COMP-00061 for downward compatibility reasons. To avoid the default assignment, memory can be saved for an axis that does not use plane compensation [▶ 50] by assigning the value 1 to P-COMP-00061. * composition of the default value: 101*101 =10201 This parameter is available as of CNC Build V3.3079.06

P-COMP-00008	Unit of the length entries
Description	This parameter defines the unit of the length / position entries.
Parameter	kw.crosscomp2.unit
Data type	BOOLEAN

Data range	0: Encoder increments 1: Metric (in 0.1 µm)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00009	**Distance between interpolation points**	
Description	This parameter defines the distance between two interpolation points if both axes use an identical grid (P-COMP-000031(grid) = QUADRATIC).	
Parameter	kw.crosscomp2.interval	
Data type	UNS32	
Data range	0 < interval < MAX(UNS32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00010	**Last index of master axis 1**	
Description	This parameter determines the last valid index in the table of master axis 1 (maximum value is 100). The table always starts with index 0.	
Parameter	kw.crosscomp2.last_index_master1	
Data type	SGN32	
Data range	0 ≤ P-COMP-00010 <= 100	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	As of Build V3.1.3079.06, P-COMP-00010 is freely assignable. There is no upper limit. However, the condition of P-COMP-00061 [▶ 56] must be complied with. P-COMP-00010 * P-COMP-00011 [▶ 57] <= P-COMP-00061 [▶ 56] **Attention**: If this parameter is re-interpreted, all the values in the compensation value table (P-COMP-00016 [▶ 58]) must be read in again.	

P-COMP-00011	**Last index of master axis 2**	
Description	This parameter determines the last valid index in the table of the two master axes (maximum 100 values). The table always starts with index 0.	
Parameter	kw.crosscomp2.last_index_master2	
Data type	SGN32	
Data range	0 ≤ P-COMP-00011 <= 100	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	As of Build V3.1.3079.06, P-COMP-00011 is freely assignable. There is no upper limit. However, the condition of P-COMP-00061 [▶ 56] must be complied with. P-COMP-00010 [▶ 57] * P-COMP-00011 <= P-COMP-00061 [▶ 56] **Attention**: If this parameter is re-interpreted, all the values in the compensation value table (P-COMP-00016 [▶ 58]) must be read in again.	

P-COMP-00012	Start position of master axis 1	
Description	This parameter determines the start position of master axis 1 in the compensation table.	
Parameter	kw.crosscomp2.start_position_master1	
Data type	SGN32	
Data range	MIN(SGN32) ≤ start_position_master1 < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00013	Start position of master axis 2	
Description	This parameter determines the start position of master axis 2 in the compensation table.	
Parameter	kw.crosscomp2.start_position_master2	
Data type	SGN32	
Data range	MIN(SGN32) ≤ start_position_master2 < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00014	Logical axis number of the master axis 1	
Description	This parameter defines the logical axis number of the first master axis.	
Parameter	kw.crosscomp2.master1_ax_nr	
Data type	UNS16	
Data range	1 ≤ master1_ax_nr ≤ MAX (UNS16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00015	Logical axis number of the master axis 2	
Description	This parameter defines the logical axis number of the second master axis.	
Parameter	kw.crosscomp2.master2_ax_nr	
Data type	UNS16	
Data range	1 ≤ master2_ax_nr ≤ MAX (UNS16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00016	Compensation values for the slave axis
Description	This parameter defines the relative compensation values of the slave axis at interpolation points [j][i]. When indexing the interpolation points in the compensation list, the first index j refers to the second master axis.
Parameter	kw.crosscomp2.table[j][i].correction
Data type	SGN32
Data range	MIN(SGN32) ≤ correction < MAX(SGN32)
Axis types	T, R, S

Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00027	Number of cycles for 'smooth switching'	
Description	This parameter determines the number of cycles for which plane compensation is activated/deactivated smoothly.	
Parameter	kw.crosscomp2.n_cycles	
Data type	UNS16	
Data range	0 ≤ n_cycles ≤ 20 (maximum number of cycles for which cross compensation is activated/deactivated, application-specific)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00030	Manual activation	
Description	Plane compensation is automatically activated by the CNC if it selected in the axis parameters (P-AXIS-00174) and the required conditions are met (e.g. axis is homed). If the parameter is set to value 1, plane compensation must be activated explicitly by an NC command (see [PROG//Selecting/deselecting axis compensations in the NC program]. In addition, compensation is deselected at the end of the NC program, at CNC reset and on axis release.	
Parameter	kw.crosscomp2.manual_activation	
Data type	BOOLEAN	
Data range	0: Automatic activation 1: Manual activation in NC program	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks		

P-COMP-00032	Distance between the interpolation points of the first master axis	
Description	The parameter defines the interval between two interpolation points for the first master axis if both master axes use a different grid (P-COMP-00031(grid) = RECTANGULAR).	
Parameter	kw.crosscomp2.interval1	
Data type	UNS32	
Data range	0 < interval1 < MAX(UNS32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

P-COMP-00033	Distance between the interpolation points on the second master axis
Description	The parameter defines the interval between two interpolation points for the first master axis if both master axes use a different grid (P-COMP-00031(grid) = RECTANGULAR).
Parameter	kw.crosscomp2.interval2
Data type	UNS32

Data range	0 < interval2 < MAX(UNS32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm or increments	R,S: 0.0001° or increments
Default value	0	
Remarks		

4.4.1.3 CNC objects

Name	CROSSC::f_is_active		
Description	This object reads whether cross compensation is activated. This means that all preconditions, such as axis is referenced and all necessary enables are on, must be fulfilled.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>004F
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	CROSSC::delta_offset		
Description	This object reads the change in compensation value in the current cross compensation cycle.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0034
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	CC2::correction		
Description	This object reads the current effective offset of plane compensation.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>0052
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	CC2::activated		
Description	This object reads whether plane compensation is activated via P-AXIS-00174 [▶ 56].		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01D7
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

4.4.2 Examples of compensation value lists

Compensation value list for plane compensation

Available as of Build V3.1.3079.06

The parameterisation example below reserved a maximum number of table entries of 50000 entries. The actual number of entries used is defined by the product of “last_index_master1” and “last_index_master2”.

```
# ***************************************
#  Axis compensation data X axis
# ***************************************

kopf.achs_nr                                  1
kopf.log_achs_name                            X

# Reserve maximum number of table entries
kw.crosscomp2.max_points                  50000
kw.crosscomp2.last_index_master1           1000
kw.crosscomp2.last_index_master2             20

kw.crosscomp2.table[  0][  0].correction      -3
kw.crosscomp2.table[  0][  1].correction      -1
```

…

```
kw.crosscomp2.table[ 20][ 999].correction      58
kw.crosscomp2.table[ 20][1000].correction      49
```

Compensation value list for plane compensation

```
# ***************************************
#  Axis compensation data X axis
# ***************************************

kopf.achs_nr                                  1
kopf.log_achs_name                            X
kw.crosscomp2.interval                   100000  /* 10 mm */
kw.crosscomp2.last_index_master1            100
kw.crosscomp2.last_index_master2            200
kw.crosscomp2.start_position_master1     -400000  /* -40 mm */
kw.crosscomp2.start_position_master2     -700000  /* -70 mm */
kw.crosscomp2.unit                            1  /* 0.1 my */
kw.crosscomp2.master1_ax_nr                   2
kw.crosscomp2.master2_ax_nr                   3
kw.crosscomp2.n_cycles                       20

kw.crosscomp2.table[  0][  0].correction      -3
kw.crosscomp2.table[  0][  1].correction      -1
kw.crosscomp2.table[  0][  2].correction       4
kw.crosscomp2.table[  0][  3].correction       9
kw.crosscomp2.table[  0][  4].correction      13
kw.crosscomp2.table[  0][  5].correction      17
kw.crosscomp2.table[  0][  6].correction      42
kw.crosscomp2.table[  0][  7].correction      53
kw.crosscomp2.table[  0][  8].correction      33
kw.crosscomp2.table[  0][  9].correction      42
kw.crosscomp2.table[  0][ 10].correction      19
kw.crosscomp2.table[  0][ 11].correction       7
kw.crosscomp2.table[  0][ 12].correction       2
kw.crosscomp2.table[  0][ 13].correction       0
kw.crosscomp2.table[  0][ 14].correction       5
kw.crosscomp2.table[  0][ 15].correction      -3
kw.crosscomp2.table[  0][ 16].correction      -7
kw.crosscomp2.table[  0][ 17].correction     -11
kw.crosscomp2.table[  0][ 18].correction     -13
kw.crosscomp2.table[  0][ 19].correction     -22
kw.crosscomp2.table[  0][ 20].correction     -34
kw.crosscomp2.table[  0][ 21].correction     -29
kw.crosscomp2.table[  0][ 22].correction     -99
…
kw.crosscomp2.table[200][ 71].correction      45
kw.crosscomp2.table[200][ 72].correction      68
kw.crosscomp2.table[200][ 73].correction      71
kw.crosscomp2.table[200][ 74].correction      90
kw.crosscomp2.table[200][ 75].correction     111
kw.crosscomp2.table[200][ 76].correction     123
kw.crosscomp2.table[200][ 77].correction     134
```

```
kw.crosscomp2.table[200][ 78].correction       147
kw.crosscomp2.table[200][ 79].correction       156
kw.crosscomp2.table[200][ 80].correction       176
kw.crosscomp2.table[200][ 81].correction       167
kw.crosscomp2.table[200][ 82].correction       148
kw.crosscomp2.table[200][ 83].correction       132
kw.crosscomp2.table[200][ 84].correction       123
kw.crosscomp2.table[200][ 85].correction       111
kw.crosscomp2.table[200][ 86].correction       101
kw.crosscomp2.table[200][ 87].correction        97
kw.crosscomp2.table[200][ 88].correction        88
kw.crosscomp2.table[200][ 89].correction        83
kw.crosscomp2.table[200][ 90].correction        82
kw.crosscomp2.table[200][ 91].correction        77
kw.crosscomp2.table[200][ 92].correction        68
kw.crosscomp2.table[200][ 93].correction        63
kw.crosscomp2.table[200][ 94].correction        61
kw.crosscomp2.table[200][ 95].correction        59
kw.crosscomp2.table[200][ 96].correction        57
kw.crosscomp2.table[200][ 97].correction        52
kw.crosscomp2.table[200][ 98].correction        56
kw.crosscomp2.table[200][ 99].correction        58
kw.crosscomp2.table[200][100].correction        49
#
End
```

4.4.3 Error messages

Errors in the configuration of the plane compensation result in deactivation of the function for the affected axis and to the output of an error message (warning message).

The following error messages then appear:

- ID 110640
- ID 70182
- ID 70183
- ID 70184
- ID 70185

4.5 Crosstalk compensation

Crosstalk compensation is used to compensate for position errors caused by an acceleration in another axis.

Compensation process

Crosstalk compensation is used to compensate an axis position depending on the acceleration of another axis.

The axis whose acceleration affects the compensation value is called the master axis. The axis for which compensation is active is called the slave axis.

A master axis can also be the salve axis of another master axis.

The data for crosstalk compensation is specified in the compensation value list of the slave axis.

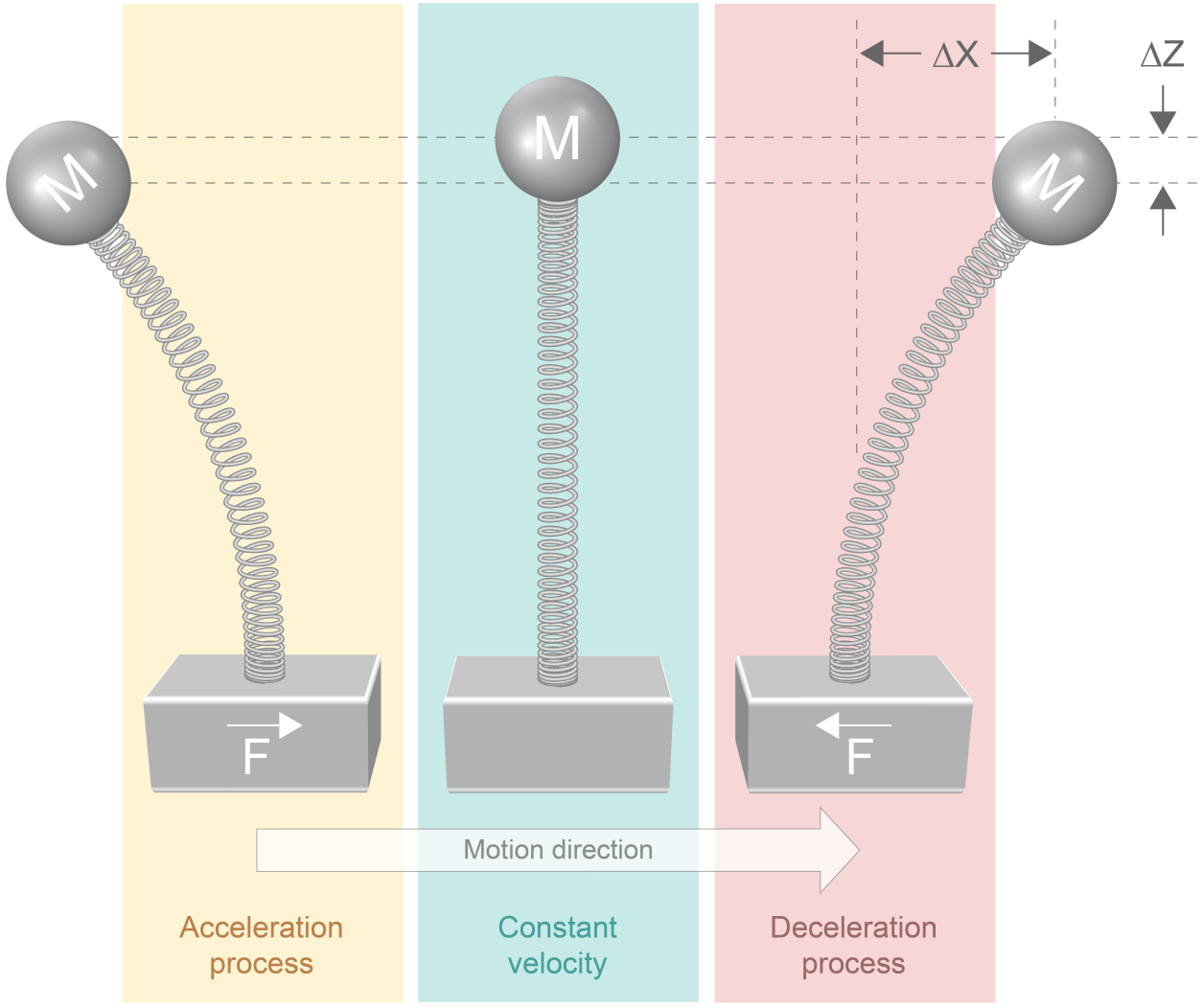


Fig. 15: Overview of crosstalk compensation

Properties

- A master axis has one or several slave axes.
- A slave has only one master axis.
- Crosstalk compensation can also be used for the master and slave axes of a gantry combination.
- A compensation value can be specified for each acceleration.
- Interpolation between accelerations is linear.
- Crosstalk compensation is available for all drive types.
- Compensations can only be viewed in the accelerations directly output to the drive (not in the normal display data) since compensation takes place outside normal calculations.

Effectiveness

Crosstalk compensation is only effective if all the following conditions are fulfilled:

- The function was activated for the slave axis.
- The compensation value table was provided.
- Master and slave axes include linear axes, rotary axes or spindles.

4.5.1 Overview

Activation

Crosstalk compensation is activated in the axis machine data record of the slave axis by P-AXIS-00789 [▶ 67] (lr_param.crosstalk)

Excerpt from the axis parameter list:

```
:
lr_param.crosstalk       1
:
```

Crosstalk compensation can also be used for a gantry axis group. A compensation value table must then be specified for each axis in the gantry combination (crosstalk compensation slave).

Compensation value tables can therefore have different settings for each gantry axis.

Activating/deactivating

Crosstalk compensation (ON if compensation is activated) can be switched on or off at any time when the slave axis is at standstill. The slave axis command positions displayed are offset with the offset values.

Filter:

These compensation values can be smoothed by using a sine-square filter. The parameter P-COMP-00064 [▶ 68] selects the filter order and its activation.(n_cycles).

Management data of the crosstalk compensation table

General data of the list body is entered in the structure kw.crosstalk.* It contains the following elements.

Management data elements

Variable name	Type	Meaning
last_index	SGN32	Last valid index in the slave axis table.

master_ax_nr	UNS16	Logical axis number of the master axis whose acceleration is used as the input variable of the compensation table.
n_cycles	UNS16	Number of cycles of the sine-square filter.
manual_activation	BOOLEAN	0: (Default) The CNC activates crosstalk compensation automatically as soon as the required preconditions are met.

Compensation values of crosstalk compensation

The corresponding compensation value of the slave axis is entered in the table **kw.crosstalk.table[i].*** for every acceleration The compensation table is valid for positive and negative directions of acceleration

Compensation value table

Variable name	Type	Meaning
table[i].acceleration	SGN32	Acceleration of the master axis for which the slave axis must be compensated.
table[j][i].correction	SGN32	Compensation value for the slave axis with acceleration i

4.5.2 Parameterisation

4.5.2.1 Overview

ID	Parameter	Description
P-AXIS-00789	lr_param. crosstalk	Activate crosstalk compensation

ID	Parameter	Description
P-COMP-00063	kw.crosstalk.master_ax_nr	Logical axis number of the master axis
P-COMP-00064	kw.crosstalk.n_cycles	Number of cycles for ‘smooth switching’
P-COMP-00065	kw.crosstalk.last_index	Last index of compensation value table
P-COMP-00066	kw.crosstalk.table[i].acceleration	Accelerations of the master axis
P-COMP-00067	kw.crosstalk.table[i].correction	Compensation values for the slave axis
P-COMP-00073	kw.crosstalk.manual_activation	Manual activation of the crosstalk compensation

4.5.2.2 Description

Axis parameters

P-AXIS-00789	**Activate crosstalk compensation**
Description	This parameter activates the crosstalk compensation function.
Parameter	lr_param.crosstalk
Data type	BOOLEAN
Data range	0/1
Axis types	T
Dimension	T: ----
Default value	0
Drive types	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher

Compensation parameters

P-COMP-00063	Logical axis number of the master axis	
Description	This parameter determines the logical number of the master axis whose acceleration is used as the input variable of the compensation value table of the slave axis.	
Parameter	kw.crosstalk.master_ax_nr	
Data type	UNS16	
Data range	1 ≤ P-COMP-00063 ≤ MAX (UNS16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher	

P-COMP-00064	Number of cycles for ‘smooth switching’	
Description	This parameter determines the number of cycles for which crosstalk compensation is coupled/decoupled softly.	
Parameter	kw.crosstalk.n_cycles	
Data type	UNS16	
Data range	0 ≤ P-COMP-00064 ≤ 20 (maximum number of cycles above which coupling or decoupling is to occur,	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher	

P-COMP-00065	Last index of compensation value table	
Description	This parameter determines the last valid index in the table of the master axis. The table always starts with index 0	
Parameter	kw.crosstalk.last_index	
Data type	SGN32	
Data range	0 ≤ P-COMP-00065 < 5	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher	

P-COMP-00066	Accelerations of the master axis	
Description	This parameter defines the accelerations of the master axis requiring a correction of the slave axis.	
Parameter	kw.crosstalk.table[i].acceleration	
Data type	SGN32	
Data range	MIN(SGN32) ≤ P-COMP-00066 < MAX(SGN32)	
Axis types	T	
Dimension	T: mm/s^2	R,S: ---
Default value	0	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher	

P-COMP-00067	Correction values for the slave axis
Description	This parameter determines the correction values for the slave axis at accelerations 'i'.
Parameter	kw.crosstalk.table[i].correction

Data type	SGN32	
Data range	MIN(SGN32) ≤ P-COMP-00067 < MAX(SGN32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm	R,S: ---
Default value	0	
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher	

P-COMP-00073	**Manual activation of crosstalk compensation**
Description	The CNC enables crosstalk compensation automatically if it is selected in the axis parameters (P-AXIS-00789 [▶ 67]) and if the necessary conditions are fulfilled. If parameter P-COMP-00073 is set to the value 1, crosstalk compensation must be explicitly activated by an NC command. [PROG// Selecting/deselecting axis compensations in the NC program (COMP)]. Compensation is deactivated at the end of the NC program, when the CNC is reset or when the compensating axis is released.
Parameter	kw.crosstalk.manual_activation
Data type	BOOLEAN
Data range	0: Automatic activation 1: Explicit activation in NC program
Axis types	
Dimension	T, R, S
Default value	0
Remarks	Parameter available as of CNC Build V3.1.3079.32 and higher

4.5.2.3 CNC objects

Name	CROSSTALK::activated		
Description	This object reads whether crosstalk compensation is activated by P-AXIS-00789 [▶ 67] .		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01F4
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks	Available as of CNC Build V3.1.3079.32		

Name	CROSSTALK::actual_offset		
Description	This object reads the current effective offset of crosstalk compensation.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01/7
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks	Available as of CNC Build V3.1.3079.32		

Name	CROSSTALK::delta_offset		
Description	This object reads the change in compensation value in the current crosstalk compensation cycle.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01F6
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]

Remarks	Available as of CNC Build V3.1.3079.32

Name	CROSSTALK::end_offset		
Description	This object reads the compensation value of crosstalk compensation at the current position without filters.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>01F8
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks	Available as of CNC Build V3.1.3079.32		

4.5.3 Example of a compensation value list

Parameterisation of a compensation value list for crosstalk compensation

```
# ************************************
# Axis compensation data for Z axis
# ************************************

kopf.achs_nr                                3
kopf.log_achs_name                          Z
kw.crosstalk.last_index                     2 /*Last valid index of the table*/
kw.crosstalk.master_ax_nr                   1  /*Log. ax. number of the master axis*/
kw.crosstalk.n_cycles                       20
#
kw.crosstalk.table[0].acceleration         -10000
kw.crosstalk.table[0].correction           -1000
kw.crosstalk.table[1].acceleration         10000
kw.crosstalk.table[1].correction            1000
```

4.5.4 Error messages

Errors in the configuration of crosstalk compensation result in deactivation of the function for the affected axis and to the output of an error message or warning message.

Overview of error messages:

- ID 70622
- ID 70625
- ID 70626
- ID 70627
- ID 70629
- ID 70630
- ID 70631
- ID 70632

5 Other configuration options for axis compensation

5.1 Selecting/deselecting axis compensation in the NC program

Axis compensations switched off by the COMP command has a global NC program effect, i.e. compensations are not automatically activated at program end. They must be switched back on explicitly using the COMP command in the subsequent NC program.

```
Syntax:
```

<axis_name> **[COMP** [[**ON** | **OFF** [**CROSS PLANE LEAD TEMP FRICT**]] | **OFF_ALL**] [**NO_MOVE**] { \ } **]**

<axis_name>	Name of the axis
COMP	Identifier to select/deselect axis-specific compensation. Must always be programmed as the first keyword.
ON	Activates programmed compensation(s)
OFF	Deactivates programmed compensation(s)
CROSS	Keyword for cross compensation
PLANE	Keyword for plane compensation
LEAD	Keyword for spindle leadscrew error compensation
TEMP	Keyword for temperature compensation
FRICT	Keyword for friction compensation [as of Build V2.11.2022.05]
CROSSTALK	Keyword for crosstalk compensation [as of Build V3.1.3079.32]
OFF_ALL	Switch off all active compensations. No further compensation keywords may be programmed after the keyword.

NO_MOVE	By default the position offset occurring when axis compensations are switched on/off is driven out before the NC program processing is continued. The keyword NO_MOVE suppresses this motion. The channel is initialised with the changed axis position. The position offset is only deactivated at the next axis motion programmed in the NC program.
\	Separator ("backslash") for clear programming of the command over multiple lines.

Axis-specific programming

```
;Deactivate cross and plane compensation in the X axis
N10 X[COMP OFF CROSS PLANE

;Compensation programming of multiple axes in an NC block
N50 X[COMP OFF CROSS] Y[COMP ON LEAD TEMP]

;Deactivate all compensations in the Z axis
N100 Z[COMP OFF_ALL]

;Deactivate all compensations of the Y axis without axis motion
N200 Y[COMP OFF_ALL NO_MOVE]
```

5.2 Checking the states of axis compensation in the NC program

V.A variables

The following V.A. variables can be used to check from the NC program whether a compensation programmable via the COMP command is initialised or already active for a specific axis.

Initialisation check

V.A.*Compensation name***_INIT[***Achsindex***]** *or*

V.A.*Compensation name***_INIT.***Achsname*

Activation check

V.A.*Compensation name***_ACTIVE[***Achsindex***]** *or*

V.A.*Compensation name***_ACTIVE.***Achsname*

The following identifiers are available for compensation name.

CROSS_COMP for cross compensation

PLANE_COMP for plane compensation

LEAD_COMP for leadscrew error compensation

TEMP_COMP for temperature compensation

Check the states of the axis compensation

```
N010 G74 X1 Y2 Z3
N020 $IF V.A.CROSS_COMP_INIT.X != TRUE
N030 #MSG ["Cross_Comp for X not init."]
N040 $ENDIF
N050 $IF V.A.TEMP_COMP_INIT.X != TRUE
N060 #MSG ["Temp_Comp for X not init."]
N070 $ENDIF
N080 X [ COMP ON CROSS TEMP ]
N090 $IF V.A.CROSS_COMP_ACTIVE[0] != TRUE
N100 #MSG ["Cross_Comp for X not active"]
N110 $ENDIF
N120 $IF V.A.TEMP_COMP_ACTIVE[0] != TRUE
N130 #MSG ["Temp_Comp for X not active"]
N140 $ENDIF
N150 ...
```

5.3 Monitoring of effectiveness of axis compensations in automatic mode

Some axis compensations must fulfil certain preconditions before they can be active. To ensure that the selected axis compensations are operative in automatic mode, the required compensations for processing the NC program can be specified bit-encoded in the parameter 'lr_param.prog_movement_requires_compensations' (see P-AXIS-00465).

The CNC then outputs the error message P-ERR-70435 if the axis is moved in automatic mode and the specified axis compensations are not active. However, in manual mode or during homing [FCT-M1// Description], the axis can be moved without compensations.

For example, this monitoring function may be practical to prevent the production of an inaccurate workpiece if there are errors in the compensation table.

Prerequisites

The following conditions exist for the effectiveness of axis compensations:

1. The compensation table may contain no errors, see [COMP].
2. The axis must be referenced for spindle leadscrew error compensation and temperature compensation.
3. The master axes must be referenced for cross and plane compensation..
4. The drive releases must be set for cross and plane compensation before NC program start.

Activating the monitoring function in the axis parameter list

Variable name	Type	Meaning
lr_param.prog_movement_requires_compensations	UNS32	Bit-encoded specification of the required compensations

The CNC only generates error messages for compensations which are also enabled in the axis parameter list.

Bit encoding

The table below contains the bit encoding for axis compensations. The bit identifier can also be used to specify the required compensations:

Bit	Identifier	Axis compensation
0x1	BACKLASH	Backlash compensation
0x2	LEAD	Leadscrew error compensation
0x4	TEMP	Temperature compensation
0x8	CROSS	Cross compensation
0x10	PLANE	Plane compensation

Monitoring the effectiveness of axis compensations in automatic mode

The following entry is required in the axis parameter list to monitor spindle leadscrew error compensation and cross compensation:

lr_param.prog_movement_requires_compensations LEAD | CROSS

The two compensations must be selected so that the CNC outputs an error message in automatic mode when the conditions are no longer met.

lr_param.ssfk 1

lr_param.crosscomp 1

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