DOCUMENTATION ISG-kernel

Functional description
Distance control

Short Description:
FCT-M3

Documentation version: 1.45
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Preface

Legal information

This documentation was produced with utmost care. The products and scope of functions described are under continuous development. We reserve the right to revise and amend the documentation at any time and without prior notice.

No claims may be made for products which have already been delivered if such claims are based on the specifications, figures and descriptions contained in this documentation.

Personnel qualifications

This description is solely intended for skilled technicians who were trained in control, automation and drive systems and who are familiar with the applicable standards, the relevant documentation and the machining application.

It is absolutely vital to refer to this documentation, the instructions below and the explanations to carry out installation and commissioning work. Skilled technicians are under the obligation to use the documentation duly published for every installation and commissioning operation.

Skilled technicians must ensure that the application or use of the products described fulfil all safety requirements including all applicable laws, regulations, provisions and standards.

Further information

Links below (DE)

https://www.isg-stuttgart.de/produkte/softwareprodukte/isg-kernel/dokumente-und-downloads

or (EN)

https://www.isg-stuttgart.de/en/products/softwareproducts/isg-kernel/documents-and-downloads

contains further information on messages generated in the NC kernel, online help, PLC libraries, tools, etc. in addition to the current documentation.

Disclaimer

It is forbidden to make any changes to the software configuration which are not contained in the options described in this documentation.

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General and safety instructions

Icons used and their meanings

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

Icons in explanatory text

➢ 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.

Attention

Restriction or error

This icon describes restrictions or warns of errors.

Notice

Tips and other notes

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

Example

General example

Example that clarifies the text.

Programing Example

NC programming example

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

Release Note

Specific version information

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

Table of contents

List of figures

1 Overview

Task

Distance control has the task of controlling the distance between tools and workpieces. This takes place by additional electronic probe systems or sensors which detect the actual distance and then send the measurement to the controller.

For example, distance control compensates for thickness tolerances in workpieces or prevents the tool from contacting the workpiece in the event of surface unevenness.

Characteristics

There are two types of distance control:

1. axis-specific variant, also height control, that is configured for an axis
2. channel-specific variant, also 3D distance control [▸ 90]

Parameterisation

The parameters for each variant are configured either:

- in the parameters of each axis list [▸ 57] for axis-specific variants
- or in the parameters in the channel [▸ 124] for 3D distance control

Programming

Each of the variants is programmed either:

- by the NC command <axis_name> [DIST_CTRL ...] [▸ 38] or by the PLC for axis-specific variants
- By the NC command #DIST CRL[…] [▸ 96] for channel-specific variants

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.

2 Description

Task

Motions are generated by electronic probe systems or sensors. These motions should superimpose the programmed positions of axes when an NC program is interpolated.

This control helps to implement

- distance control (e.g. contact with the curved surface of a plate) or
- height control (e.g. to compensate for workpiece thickness tolerances).

Fig. 1: Specifying the ideal workpiece surface for height control

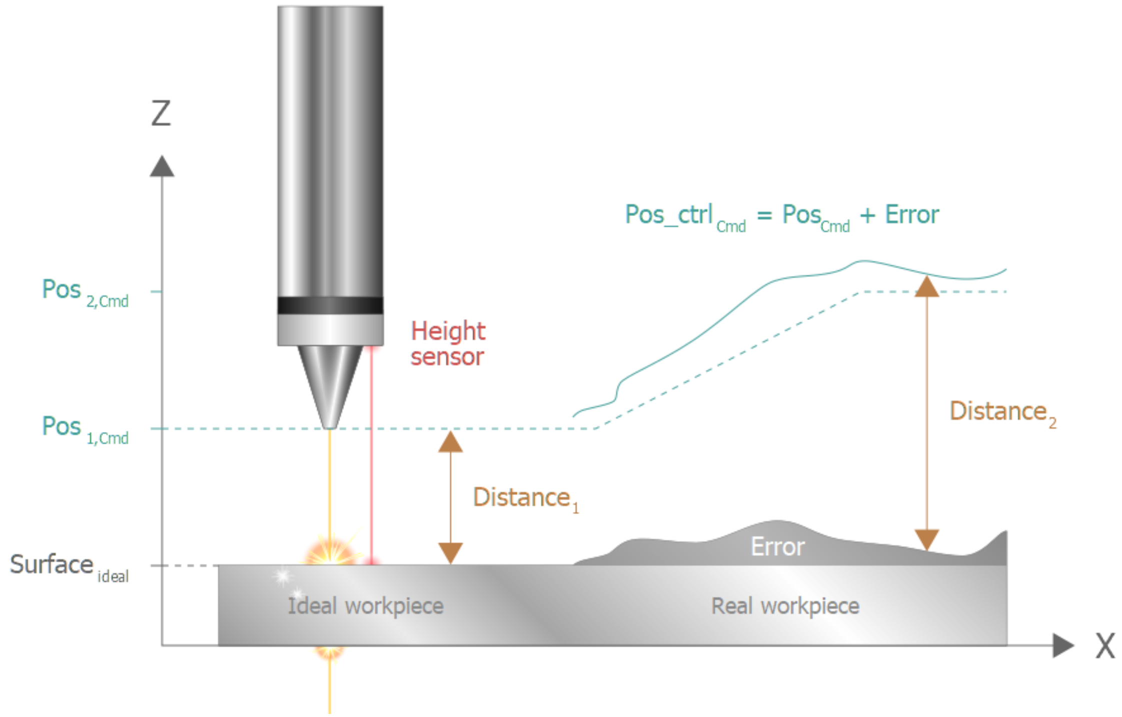


Fig. 2: Specifying the distance to workpiece for height control

Properties

A second measuring system is connected to the controller via a parameterisable sensor source. This measuring system can output axis-specific compensation values to an axis in addition to the interpolated command point to compensate the actual position of the axis.

Distance control is enabled and disabled in the

- NC program or
- via the PLC.

Variables relevant to distance control can be parameterised via the axis machine data.

Distance control operates in the interpolation cycle of the control system (GEO task).

Notice

Distance control is only available for SERCOS, PROFIdrive or CANopen drives.

Parameterisation overview

The motion generated by distance control can be influenced by machine data.

- Activate a smoothing filter
- Maximum permissible compensation value
- Maximum additive axis velocity
- Maximum permissible actual value jump of the probe system
- Maximum upper axis position
- Minimum lower axis position
- Tolerance value
- Dynamic weighting dependent on distance (as of CNC Build V2.11.2804.02)
- Dynamic weighting dependent on lowering movement (as of CNC Build V2.11.2807.13)

Enable/disable is executed either by the NC program or the PLC.

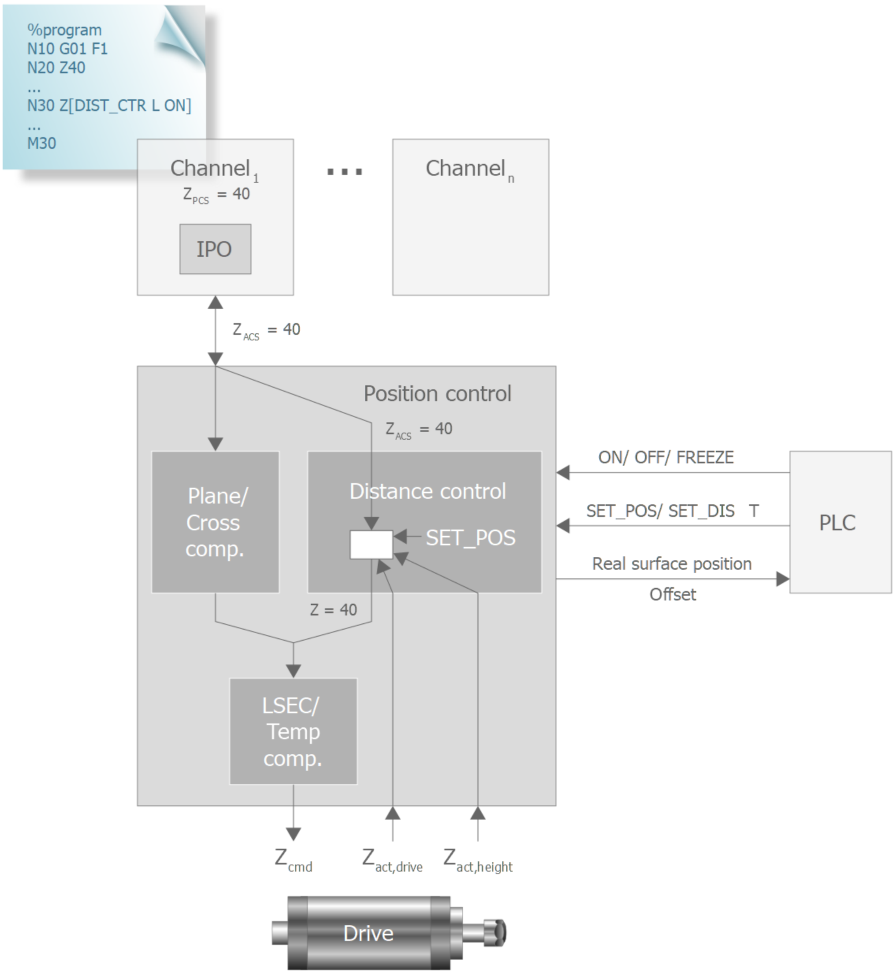


Fig. 3: Structure of distance control in conjunction with other compensations

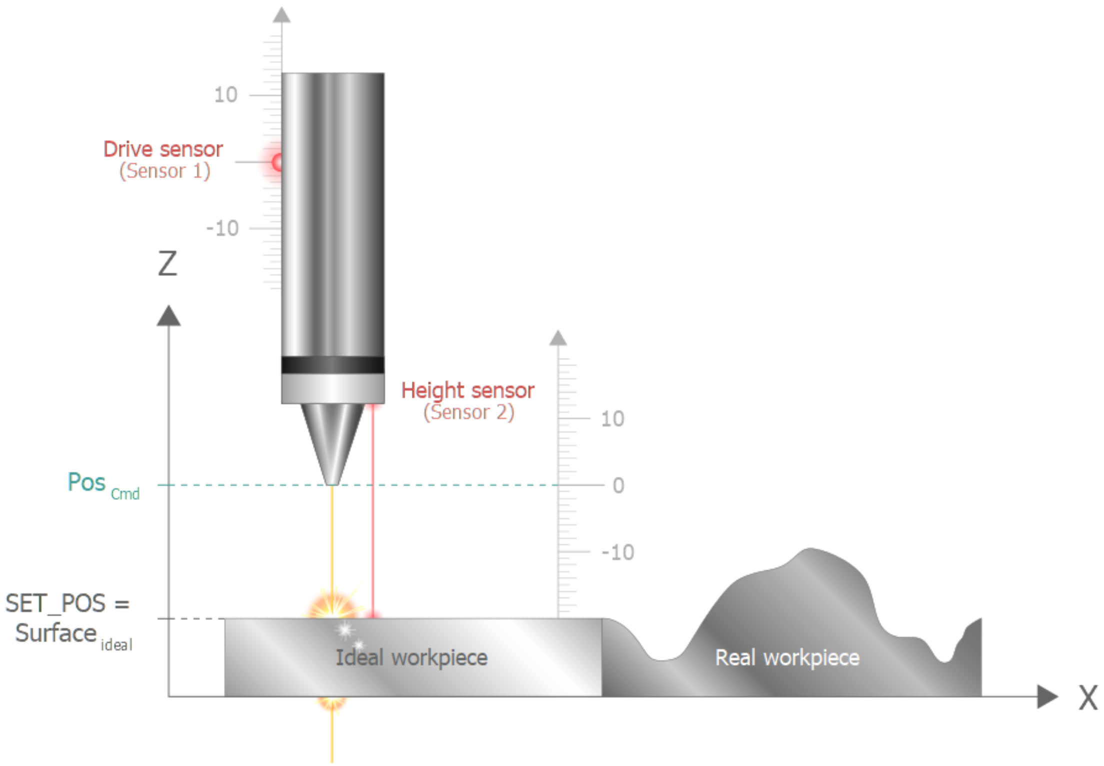


Fig. 4: Sensing the workpiece surface

Correction of set position

The actual workpiece surface produces a height offset:

$$Offset = Surface_{real} - Surface_{ideal}$$

where

$$Surface_{real} = Drivesensor + Heightsensor$$

$$Surface_{ideal} = Set_{pos}$$ ¶

This results in a correction of the programmed command position Pos_{Cmd} of the tool as follows:

$$Pos'_{cmd} = Pos_{cmd} + Offset$$

$$Pos'_{cmd} = Pos_{cmd} + Drivesensor + Heightsensor - Set_{pos}$$

Configuration overview

The encoder of the electronic probe system is connected to the controlled axis as actual value encoder 2. Make sure that the first configured encoder is used for axis position control and the second encoder for distance control. Encoder for distance control.

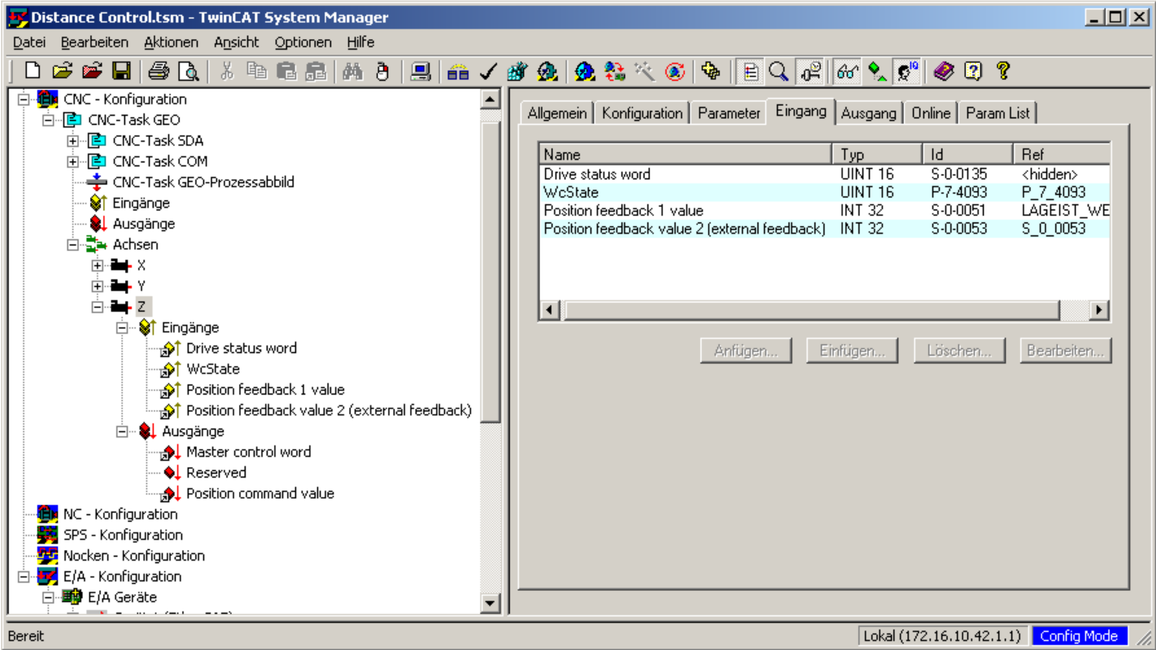


Fig. 5: TwinCAT configuration example for SERCOS (ID S-0-0053)

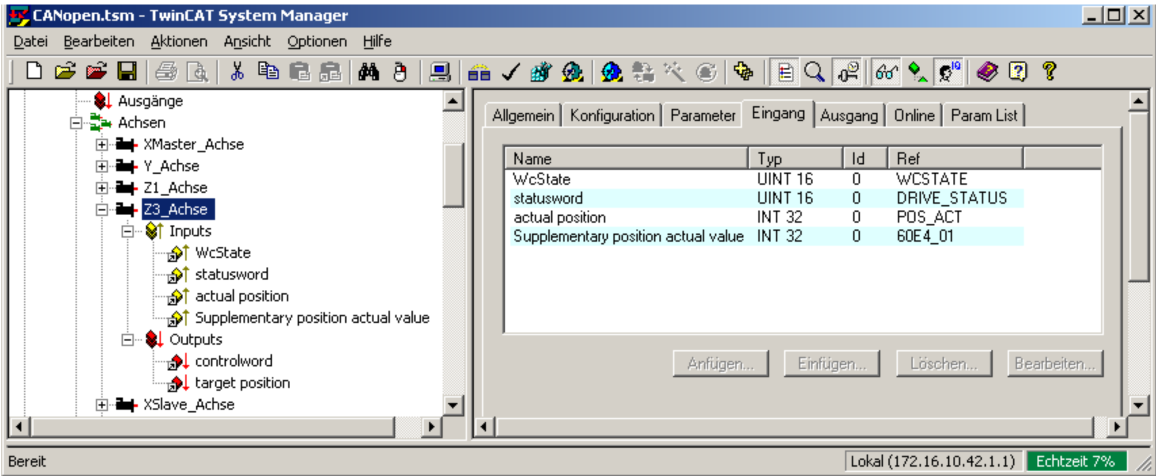


Fig. 6: TwinCAT configuration example for CANopen DS402 (PDO 0x60E4, Subindex 1)

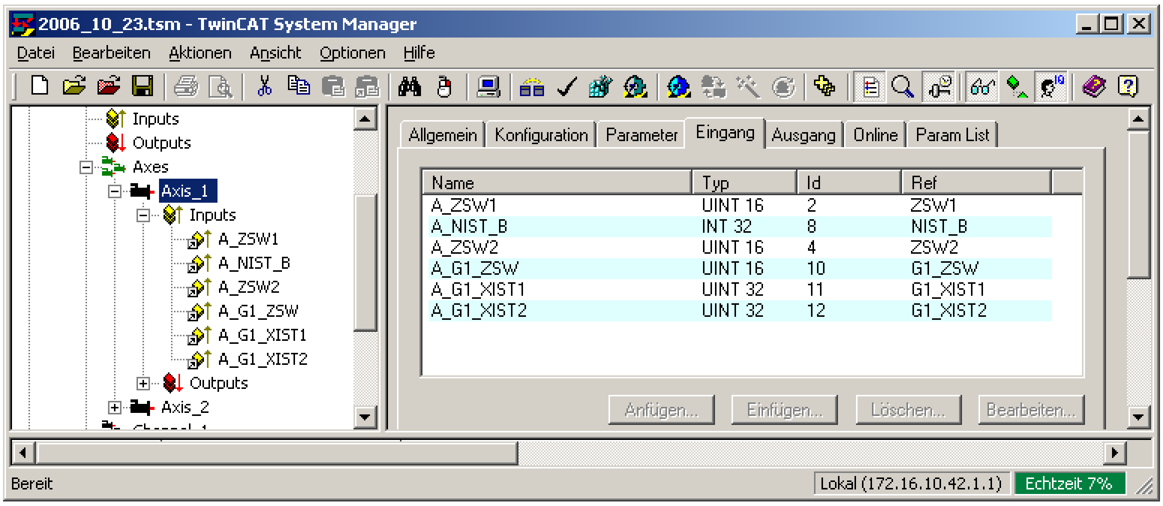


Fig. 7: TwinCAT configuration example for ProfiDrive (G1_XIST2)

Attention

The axis-specific feed override and the axis-specific feedhold enable act on distance control (see [HLI// Control commands of an axis]).

When override is 0 or when feedhold is set, distance control is no longer active and the current value is frozen.

3 Control

Distance control can be used optionally with P, PI, PD or PID controllers. This helps to combine the different advantages of the individual controllers. If distance control with a P-only controller does not work fast enough or problems occur with oscillation, we advise you to execute control as a PD controller. The I component should only be considered for permanent control deviations.

Characteristics of individual controllers for distance control:

P controller	Weights the output value and affects distance control dynamics. Can be set using P-AXIS-00759 [▸ 70].
I controller	Permanent control deviations are completely compensated after a certain time. If there is no permanent control deviation, we advise you to disable the I component using P-AXIS-00764 [▸ 70] = 0 to avoid a negative effect on distance control dynamics.
D controller	The faster the distance values change, the stronger the reaction of the D controller. This helps to reduce oscillations. Can be set using P-AXIS-00765 [▸ 71].

Step-by-step and iterative parameterisation of the controller:

1. Setting the proportional component using P-AXIS-00759 [▸ 70]:
   First set the controller as a P-only controller. This means disabling the I and D controllers by using P-AXIS-00764 [▸ 70]=0 and P-AXIS-00765 [▸ 71]=0, respectively. To avoid controller instability, start with a low Kp factor. Normally, a good start value is Kp=0.2. Then observe the response of the control loop at a defined input step, i.e. a change in distance. You can increase the Kp factor step by step until there is a recognisable but rapid drop in oscillation.
2. Setting the integral component using P-AXIS-00764 [▸ 70]:
   The integral component ensures that permanent control deviations are completely compensated after a certain time. If there are no permanent control deviations, you should disable the integral component.
3. The controller then operates as a PI controller. To avoid instability, start with a high integral action time value Tn. Normally, a good start value is Tn=5. In analogy to section 1, observe the response of the control loop at a defined change in distance and gradually reduce Tn. A good value for Tn is reached when the control deviation is compensated within the required time without causing any undesirable oscillations.
4. Setting the derivative component using P-AXIS-00765 [▸ 71]:
   The controller is then used as a PID or a PD controller. Again, start with a passive value for the derivative action time Tv. Normally, a good start value is Tv=0.01. As before, increase the derivative component step by step and observe the step response. The aim is to damp oscillations as much as possible without negatively affecting control loop dynamics.
5. Readjusting:
   To obtain the best controller response, you can even readjust the parameters again. For example, you can correct the P component upwards by using the D component.

4 Smoothing sensor data

Sensor values may be noisy. This can make the distance controller excite the system with oscillations. Filters can help to smooth the input signal and improve the performance of the distance controller.

The following sections describe the effect of the filters and the influence of the individual parameters on the filter effect in a single test. For this test, a millimetre high obstacle approx. 2.8mm high was crossed by a sensor. The distance controller is disabled for this test in order to demonstrate the effect of the filters without any feedback from the distance controller.

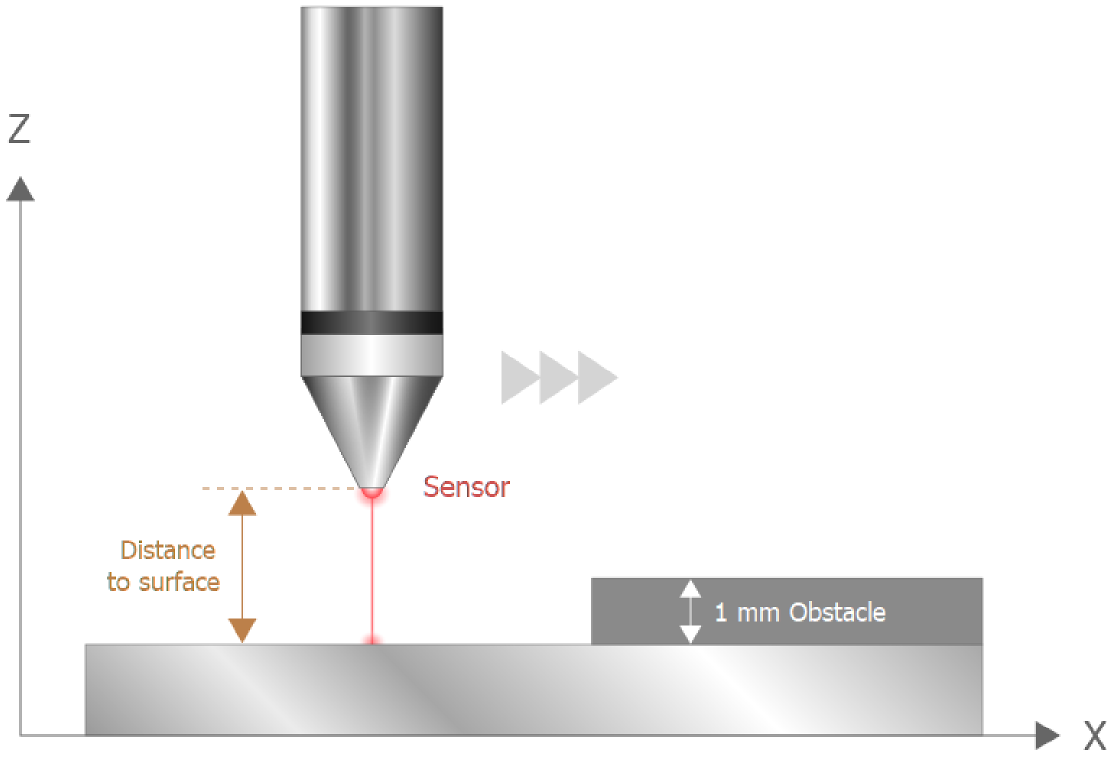


Fig. 8: Test set-up to determine the filter effect

The figure below shows the unfiltered sensor data recorded.

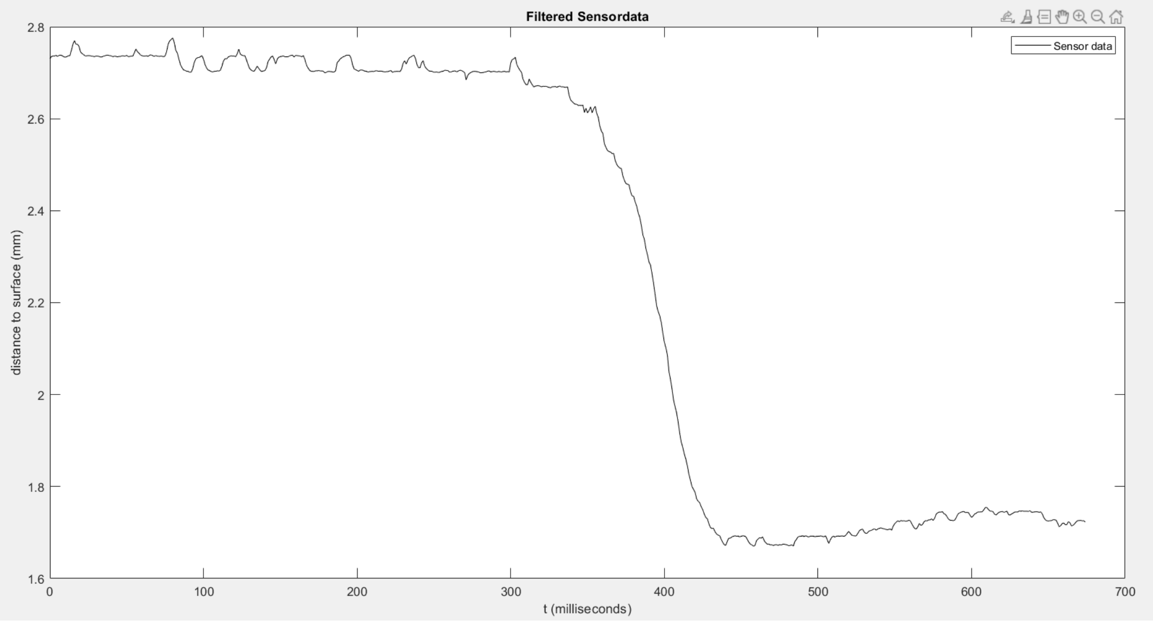


Fig. 9: Unfiltered sensor data when crossing over an obstacle

When you select a filter, remember that the filters introduce a dead time into the system. For the distance controller, this means a slower reaction to changes in distance. When you configure the filter, you must compromise between filter effect and filter delay.

The aim of configuring the filter is to achieve the best possible smoothing of the measured values when traversing the smooth plane and, at the same time, the lowest possible delay when reacting to an obstacle.

Notice

In order to optimise the performance of the distance control, you can also adjust the PID controller at the same time as you configure a suitable filter.

⚠ WARNING

When you configure filters, remember that an enabled distance controller automatically causes a feedback on the filter. This can lead to undesired behaviour of the distance controller and even result in oscillations on the axis.

4.1 Moving averaging filter

The moving average filter is the sequence of arithmetic averages over a number P-AXIS-00413 [▸ 59] of measured values

Influence of the parameter:

It is possible to achieve good smoothing of sensor data with a moving average filter. However, smoothing sensor data causes a relatively large delay in the system. The following conditions for the parameters are active: The more measured values are included in the filter via P-AXIS-00413 [▸ 59], the better the smoothing, but the greater the reaction delay involved.

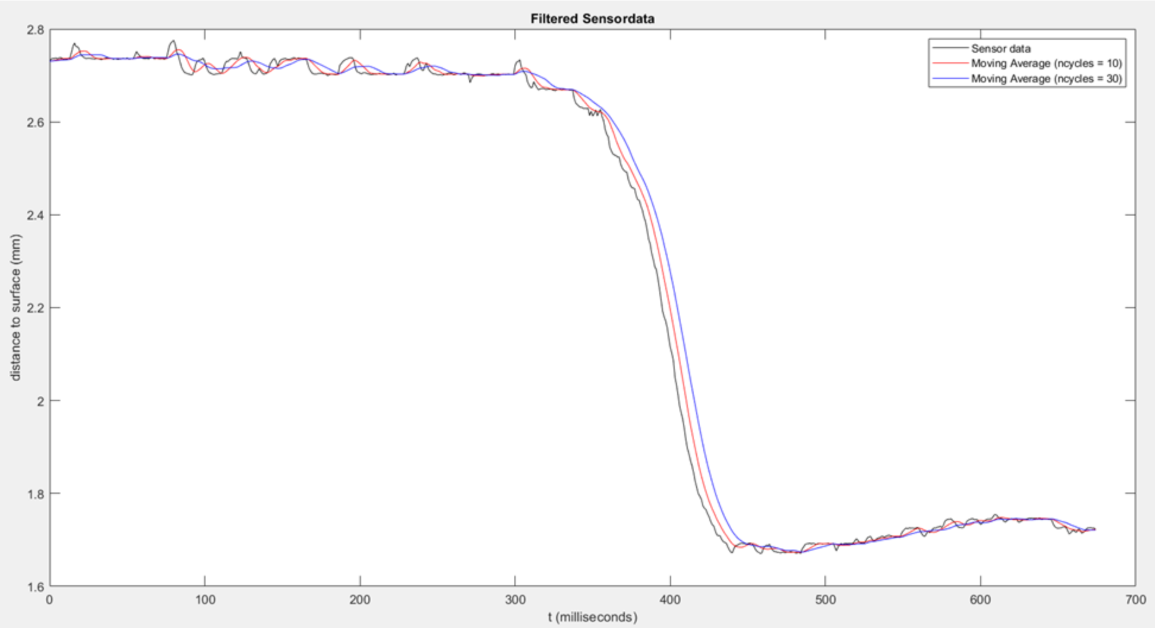


Fig. 10: Different filter effect with varying n_cycles

Example

Example parameters: Moving averaging filter

```
kenngr.distc.filter_type MOVING_AVERAGE  # Filter type
kenngr.distc.n_cycles      20          # Number of included measured val-
ues
```

4.2 Exponentially weighted averaging filter

The exponentially weighted averaging filter expands the moving averaging filter by an exponential weighting of the included sensor data. Current measured values are weighted more heavily than older measured values. The weighting of individual measured values is calculated based on a smoothing factor (P-AXIS-00784). The smoothing factor indicates the percentage weighting of the current measured value.

4.2.1 Influence of parameters

Smoothing factor (P-AXIS-00784):

The greater the weighting of the current measured value, the lower the filter effect but the faster the reaction to changes in the distance.

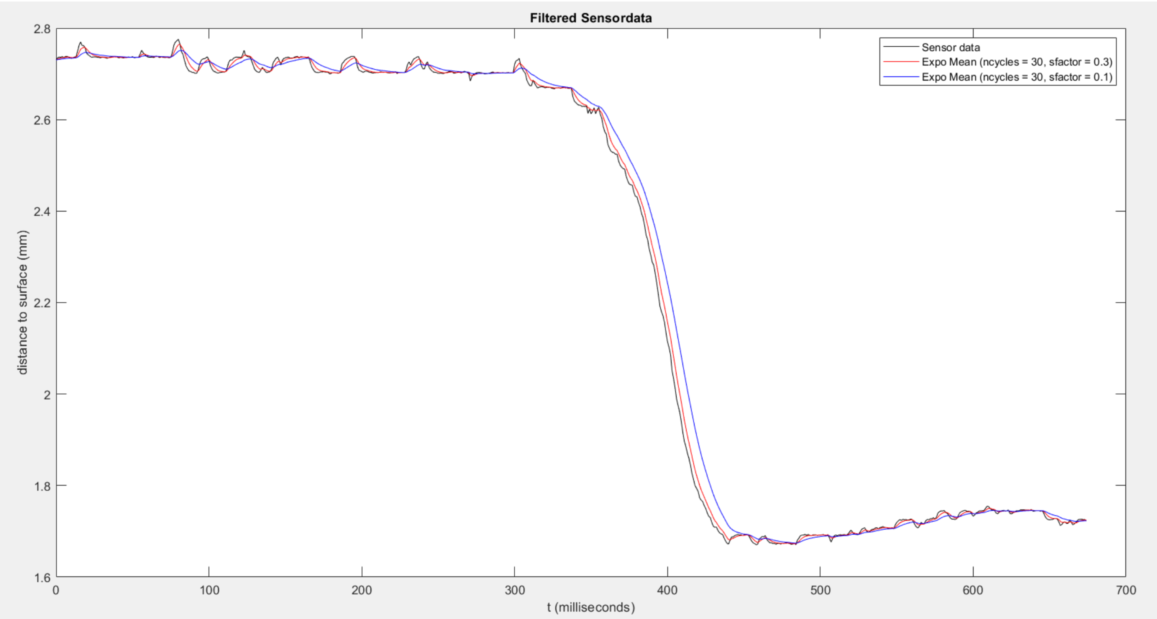


Fig. 11: Different filter effect due to smoothing factor

Number of measured values - n_cycles (P-AXIS-00413):

The more measured values are included in the filter via P-AXIS-00413 [▸ 59], the better the smoothing, but the greater the reaction delay involved. The greater the smoothing factor, the smaller the influence of P-AXIS-00413. Also, the influence of P-AXIS-00413 decreases steadily with increasing numbers due to the exponential weighting.

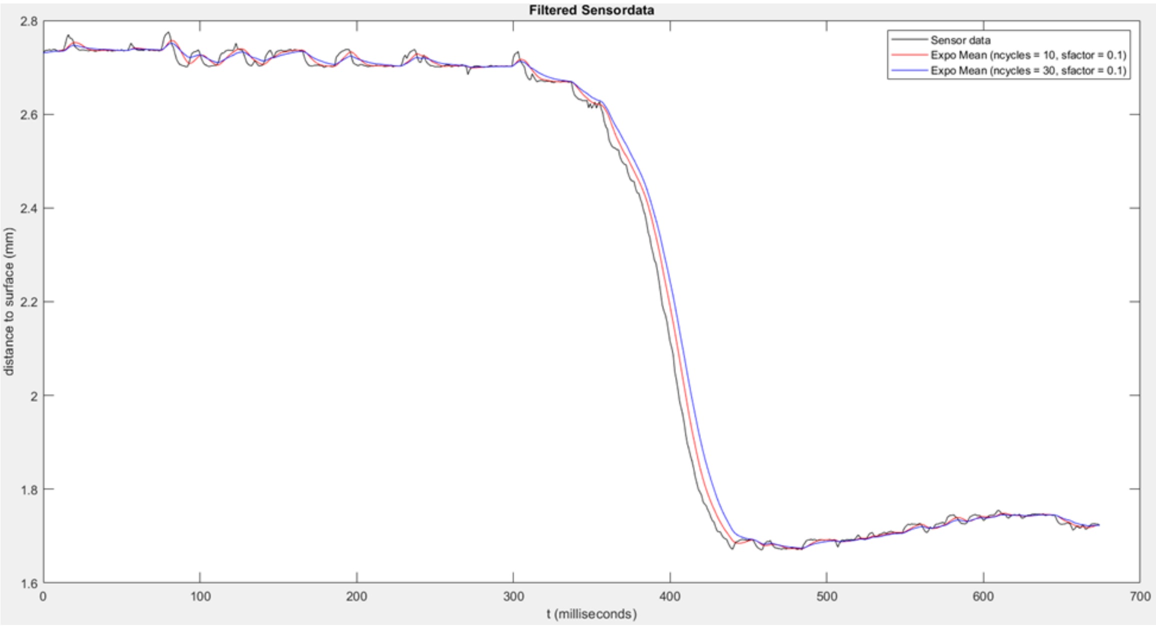


Fig. 12: Different filter effect with varying n_cycles

Example

Example parameters: Exponentially weighted averaging filter

```
kenngr.distc.filter_type      EXPO_MEAN # Filter type
kenngr.distc.n_cycles         30        # Number of included measured
values
kenngr.distc.smoothing_factor 0.3       # Smoothing factor
```

4.3 Low-pass filters

The oscillation tendency may be suppressed better by using a low-pass filter if the sensor signal is subject to heavy noise.

Example

Example parameters

```
kenngr.distc.filter_type            LOWPASS # Low-pass filter
kenngr.distc.low_pass_filter_order  2       # Low-pass filter
kenngr.distc.low_pass_filter_fg_f0  30      # Frequency 30 Hz
```

4.4 Kalman filter with averaging filter model

The Kalman filter tries to estimate the next measured values of the sensor based on a prediction model. The filter first builds the prediction and then refines it by the specified uncertainty of the measured values. The basis of the prediction is the moving averaging filter [▸ 19].

4.4.1 Influence of parameters:

Number of measured values - n_cycles (P-AXIS-00413):

The parameter P-AXIS-00413 [▸ 59] specifies the number of measured values that are included in the prediction model of the moving averaging filter. Accordingly, the larger the number of included measured values, the better the smoothing effect. The prediction characteristic of the Kalman filter reduces the dead time compared to a conventional moving averaging filter. However, it should be noted that the dead time of the prediction model leads to an oscillation at large changes in distance. The distance increases as the number of included measured values rises (P-AXIS-00413).

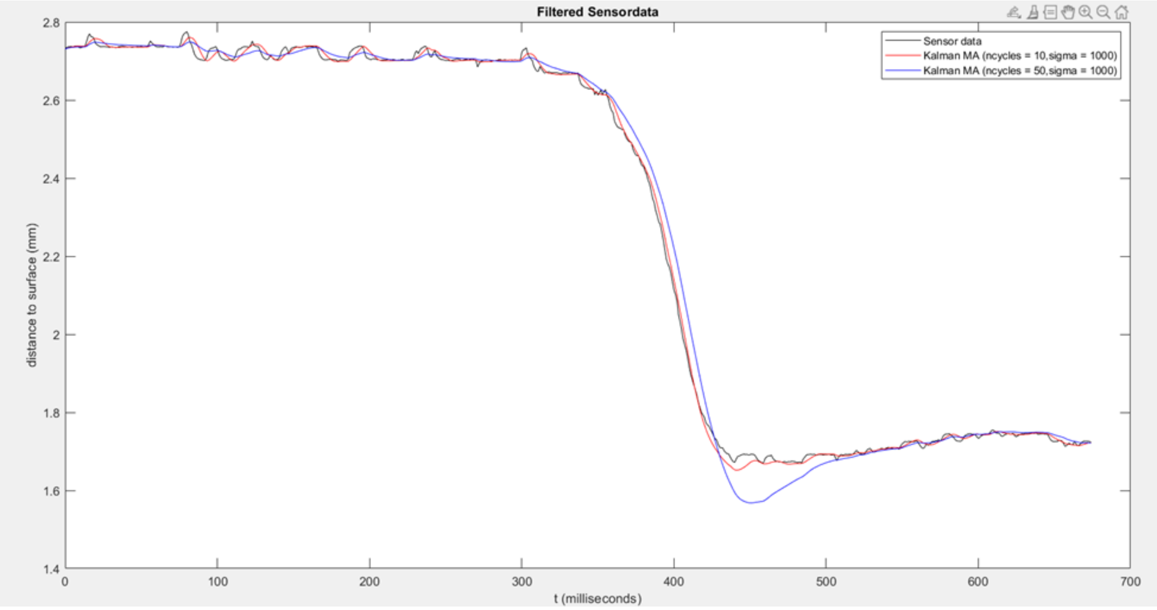


Fig. 13: Different filter effect with varying n_cycles

Degree of uncertainty - sigma (P-AXIS-00783):

The parameter P-AXIS-00783 [▸ 73] indicates the degree of uncertainty of the recorded measured values. The lower the specified uncertainty of the measured values, the more the prediction from the moving averaging filter is approximated to the actual measured values.

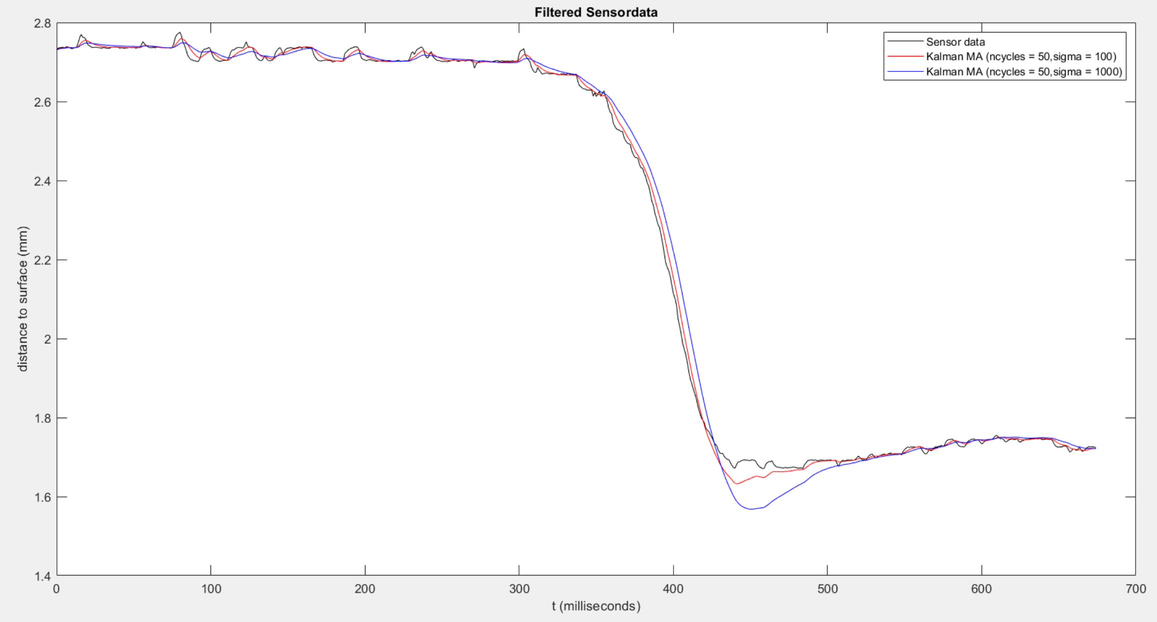


Fig. 14: Different filter effect with varying sigma

Example

Example parameters: Kalman filter with averaging filter model

```
kenngr.distc.filter_type    KALMAN_MA   #Filter type
kenngr.distc.n_cycles       30          #Number of included measured val-
ues
kenngr.distc.kalman_sigma   1000        #Uncertainty of measured values
```

4.5 Kalman filter with exponential model

The Kalman filter tries to estimate the next measured values of the sensor based on a prediction model. The filter first forms the prediction and then refines it using the uncertainty of the measured values. The basis of the prediction is the exponentially weighted averaging filter [▸ 20].

4.5.1 Influence of parameters:

Number of measured values - n_cycles (P-AXIS-00413):

The parameter P-AXIS-00413 specifies the number of measured values that are included in the prediction model of the exponentially weighted averaging filter. Accordingly, the larger the number of included measured values, the better the smoothing effect. The prediction characteristic of the Kalman filter reduces the dead time compared to a conventional exponential averaging filter. However, it should be noted that the dead time of the averaging filter leads to an oscillation with large changes in distance. The distance increases as the number of included measured values rises (P-AXIS-00413).

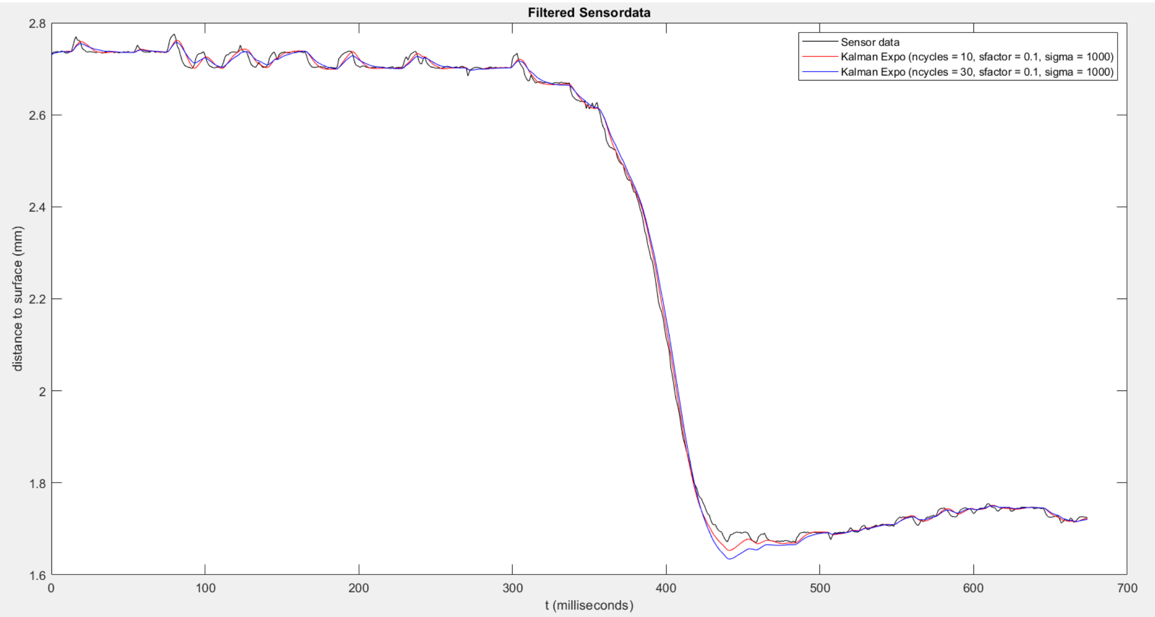


Fig. 15: Different filter effect with varying n_cycles

Smoothing factor (P-AXIS-00784)

The section Exponentially weighted averaging filter [▸ 20] explains the influence of the smoothing factor on the exponentially weighted averaging filter. The oscillation caused by the dead time of the filter can be improved by a higher weighting of the current measured value. At the same time, however, this reduces the smoothing effect.

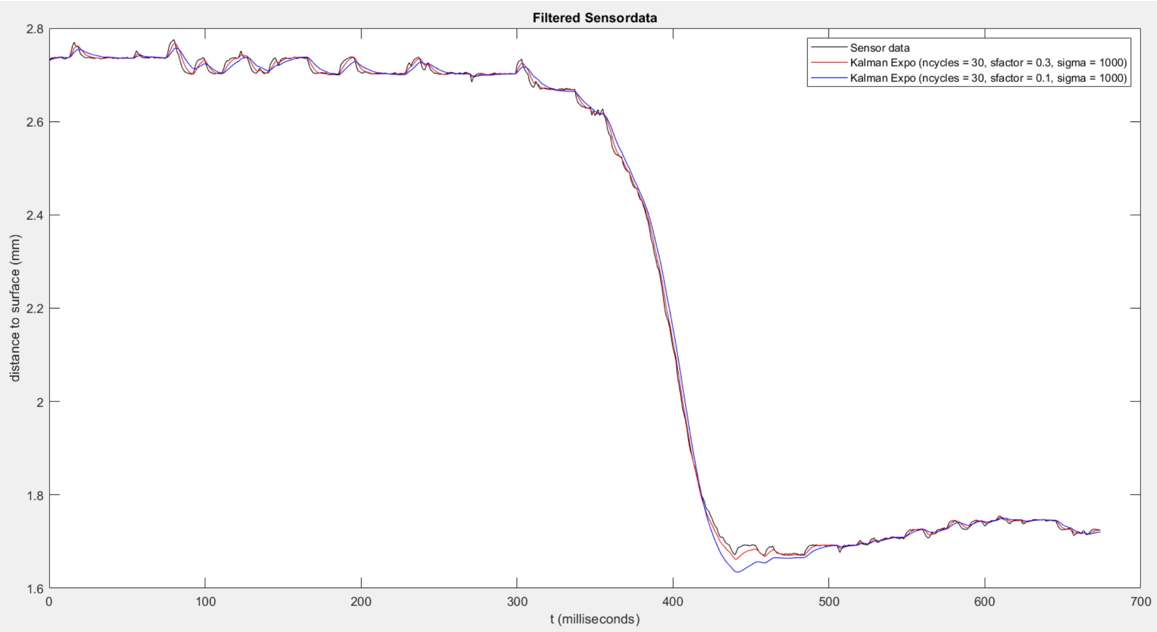


Fig. 16: Different filter effect with varying smoothing factor

Degree of uncertainty - sigma (P-AXIS-00783):

The parameter P-AXIS-00783 indicates the degree of uncertainty of the recorded measured values. The lower the specified uncertainty of the measured values, the more the prediction from the moving averaging filter is approximated to the actual measured values.

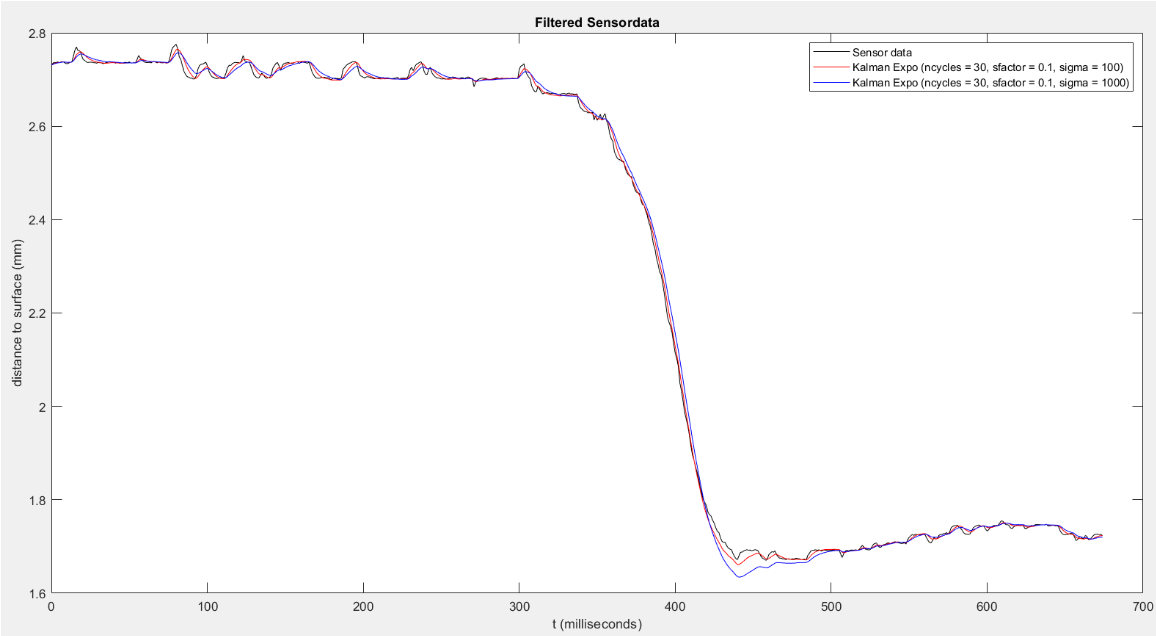


Fig. 17: Different filter effect with varying sigma

Example

Example parameters: Kalman filter with exponential model

```
kenngr.distc.filter_type      KALMAN_EXPO #Filter type
kenngr.distc.n_cycles         30          #Number of included measured
values
kenngr.distc.kalman_sigma     1000       #Uncertainty of measured values
kenngr.distc.smoothing_factor 0.3         #Smoothing factor
```

5 Operation mode of distance control

Distance control is integrated after interpolation and superimposes the programmed motion. Distance control acts independently of the current state of the interpolator, i.e. it is active even when it is waiting for acknowledgements (e.g. M functions).

Distance control determines the actual absolute position of the workpiece surface with the aid of the axis motor encoder and an additional encoder sensor. The two encoders are coupled to one another, i.e. the values of the two encoders always act in opposite directions when the axes move.

The axis-specific feed override and feedhold act on distance control (see [HLI//Control commands of an axis]). When override is 0 or when the axis-specific feedhold is set, the current value of distance control is frozen.

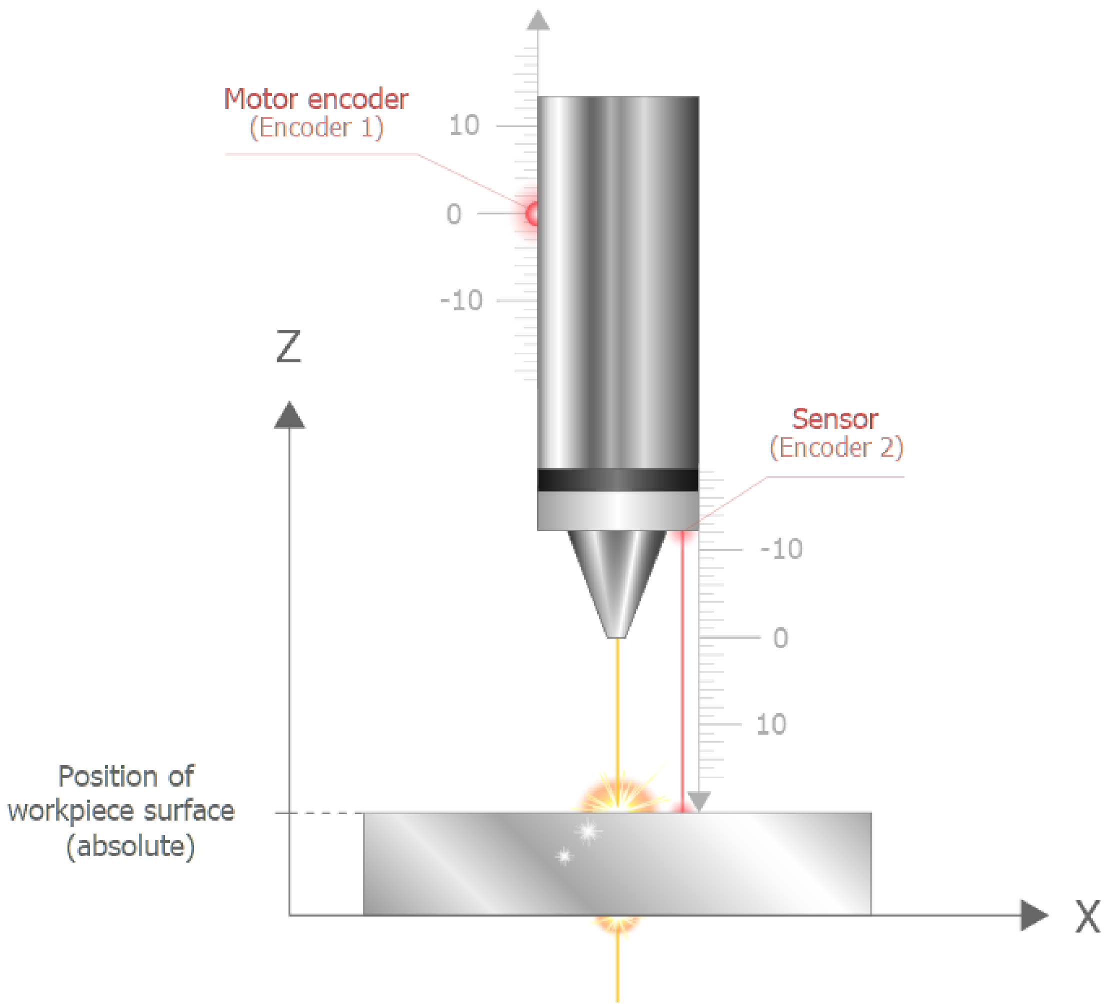


Fig. 18: Sensing the workpiece surface

Notice

The encoder position of the motor and the sensor position must act in opposite directions when the Z axis is lifted or lowered.

For example, if the Z axis is lifted and the encoder value of the motor increases, the encoder value of the sensor must be reduced. If required, the parameter P-AXIS-00230 can be used to invert the motion direction of the sensor.

5.1 Specifying the workpiece surface (SET_POS, surface)

Calculating deviation

The deviation of the real workpiece surface from the specified command position (SET_POS) is determined in each cycle by the electronic probe. Deviation results from:

Deviation = motor encoder + sensor encoder - set position (SET_POS)

= actual workpiece surface position - set position (SET_POS)

To compensate for the workpiece surface deviation, the drive position is additionally moved by the calculated offset of the distance control:

Drive setpoint = programmed setpoint (PCS) + distance control offset

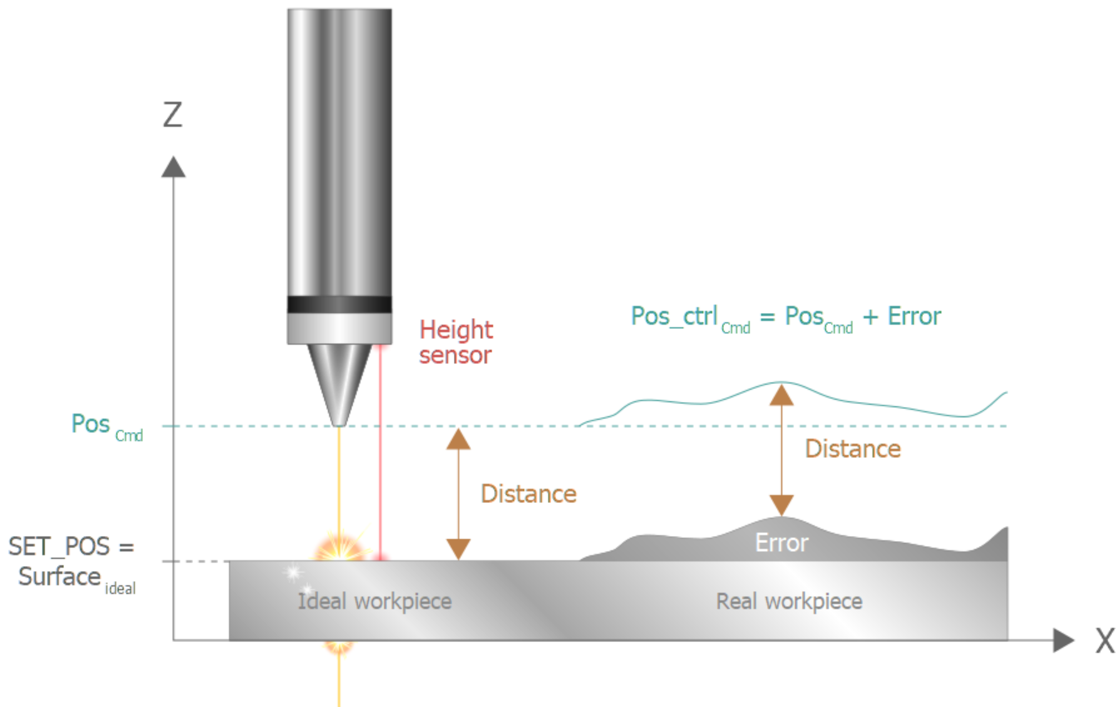


Fig. 19: Specifying the ideal workpiece surface for distance control

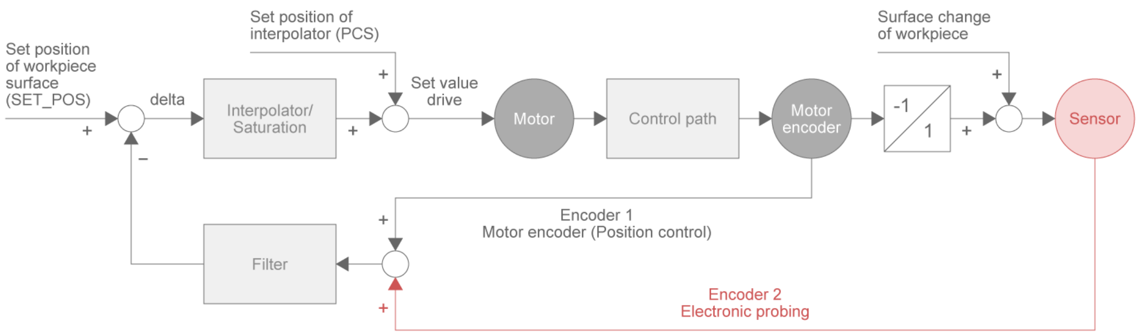


Fig. 20: Block diagram of distance control

Selecting and deselecting via the NC program

The NC program activates and deactivates distance control and also freezes the current correction value. Example:

```
N10 Z[DIST_CTRL SET_POS=30] Set the position
Nxx Z[DIST_CTRL ON] Select
…
Nxx Z[DIST_CTRL OFF] Deselect
N999 M30
```

The complete CNC syntax is described in the Programming [▸ 38] chapter.

Typical sequence

Typical sequence for activating distance control:

1. The tool is replaced.
2. X and Y axes move to machining position.
3. Distance control is activated and the workpiece set position is set. The Z axis must then be located within the detection range of the distance sensor.
4. Sensor or probe ring signals distance; distance control corrects height errors.
5. Z axis is lowered.
6. Distance control is active; thickness tolerances or position differences are compensated.

Deactivating distance control:

1. Distance control is deactivated via the NC program
2. Distance control is inactive; thickness tolerances or position differences are no longer compensated; and the current offset remains active until the next position request.

Operating principle

With distance control, deviations in the position of the workpiece surface (actual position) can be corrected with respect to a specified set position:

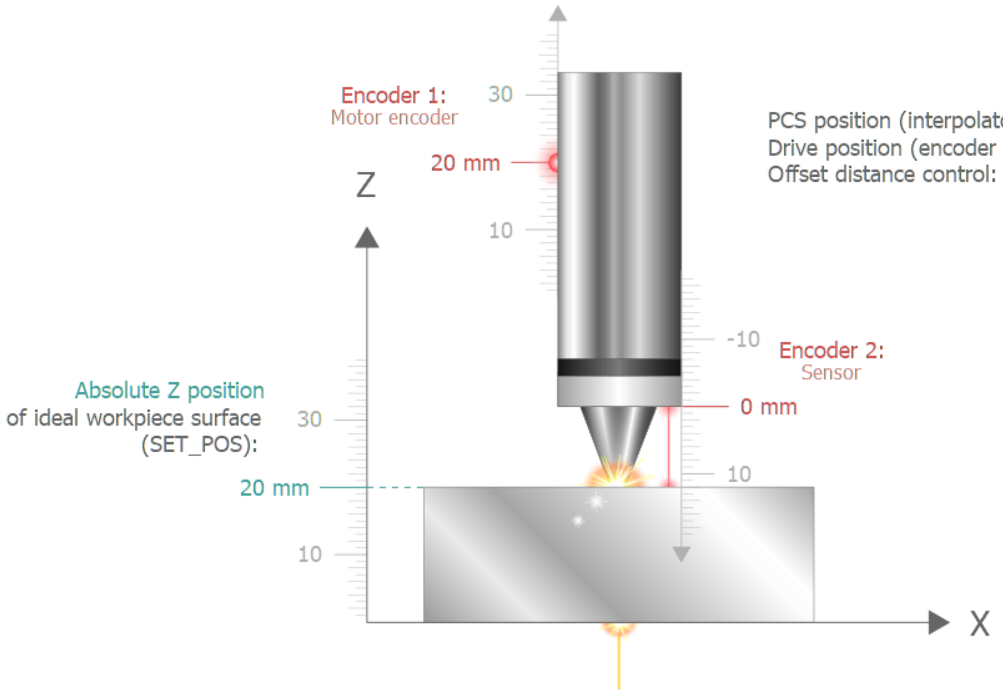


Fig. 21: Ideal workpiece

Deviation

A deviation from the ideal workpiece surface (e.g. with a thinner workpiece) is detected by the sensor (encoder 2):

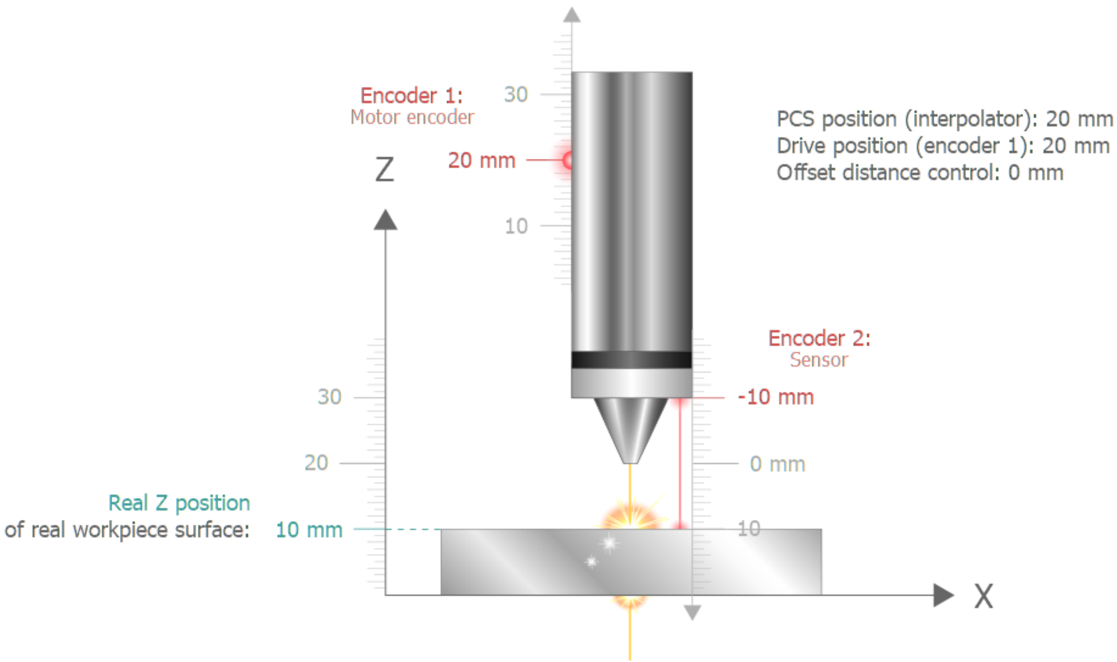


Fig. 22: Real workpiece without distance control

Offset compensation

After activation of distance control with SET_POS=20 mm (expected workpiece height), the offset is compensated by distance control. As a result, there is no need to adapt the NC program (PCS position). The NC program assumes a constant workpiece surface of Z=20 mm.

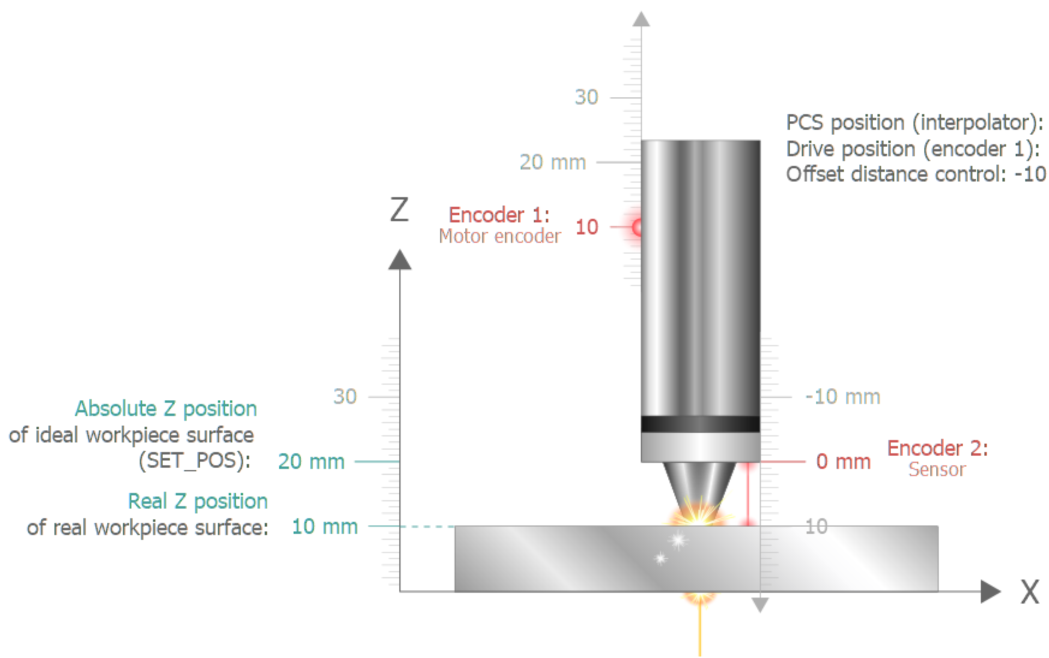


Fig. 23: Real workpiece with distance control

Notice

Distance control is automatically deactivated if an axis error or a CNC reset occurs.

At program end, distance control remains active.

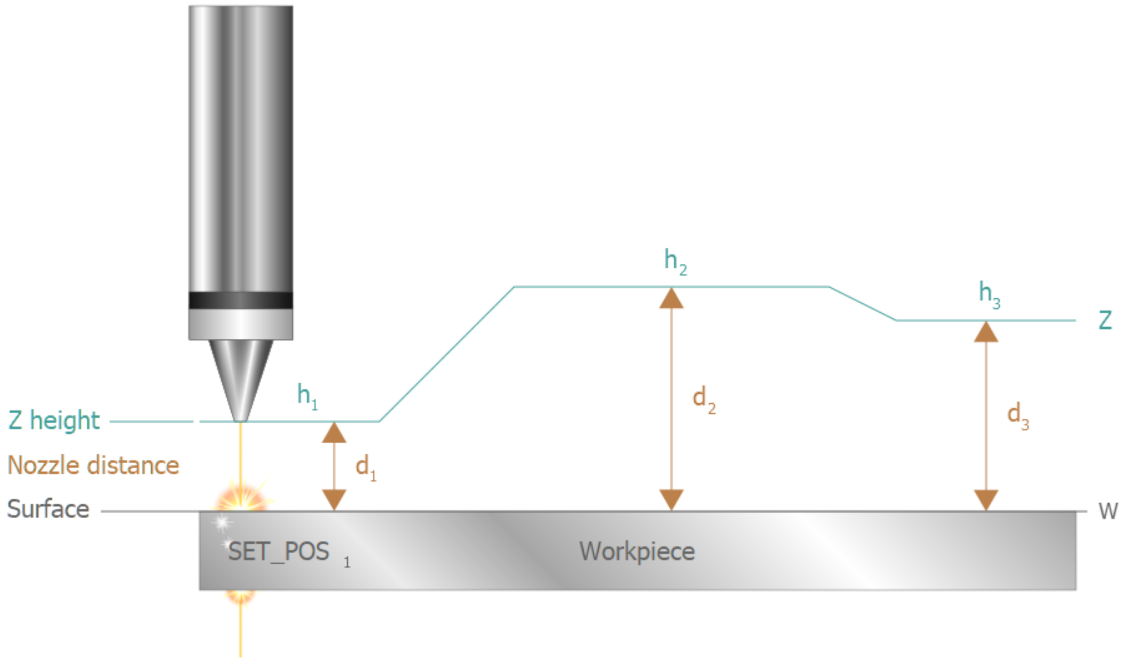


Fig. 24: Constant workpiece surface with changed tool distance

Height changes

Changes in the workpiece surface are compensated by distance control. The NC program therefore assumes a plane workpiece. Height changes in the workpiece surface can be defined by programming the axis. At Z=SET_POS the TCP tip touches the workpiece surface.

5.2 Specifying the distance (SET_DIST, distance)

Release Note

Specifying the set distance for distance control is only available as of CNC Build V2.11.2800.28.

Distance

In addition to specifying the workpiece surface for a given tool height (*see previous section*), the distance between the tool and the workpiece can also be specified directly in the NC program or via the PLC as of CNC Build V2.11.2800.28.

When distance is commanded via the PLC interface, the set distance can be respecified in every cycle.

In this case tool height is no longer changed by the NC program but is changed explicitly by distance control. This is especially of advantage when a constant distance needs to be maintained to a workpiece surface of any curvature.

For large changes, distance control is supported by additional programming of the Z axis.

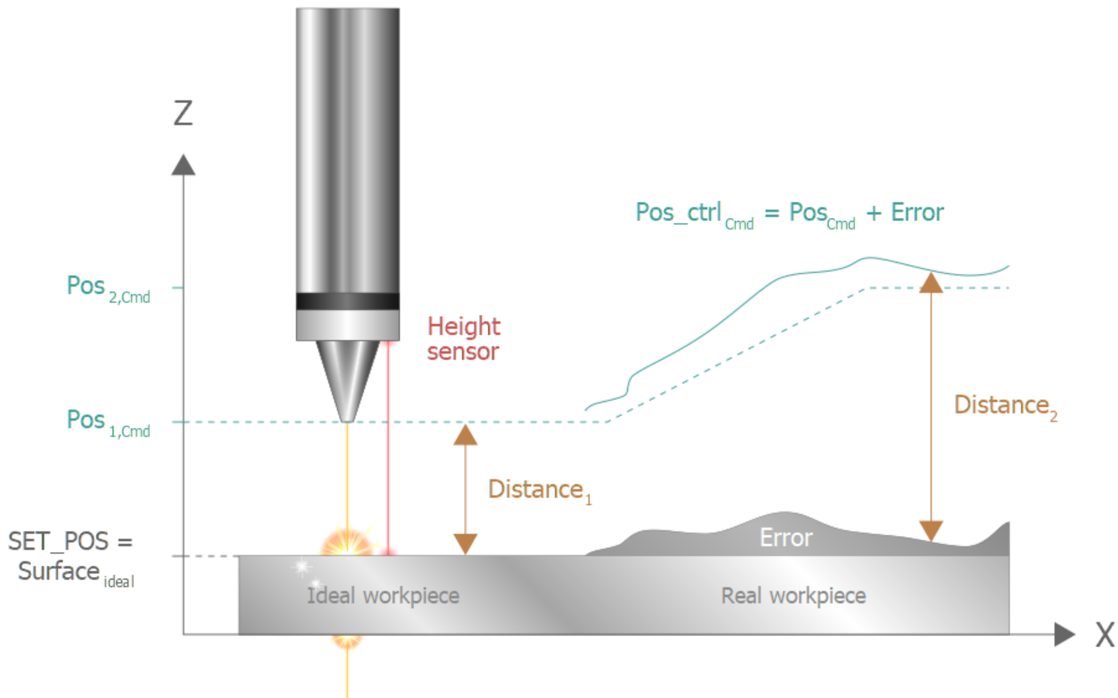


Fig. 25: Specifying the distance to workpiece for height control

Attention

If distance control is activated in "constant distance" mode, no further changes in distance to the workpiece can be specified for this axis in the NC program by explicit programming of the Z axis.

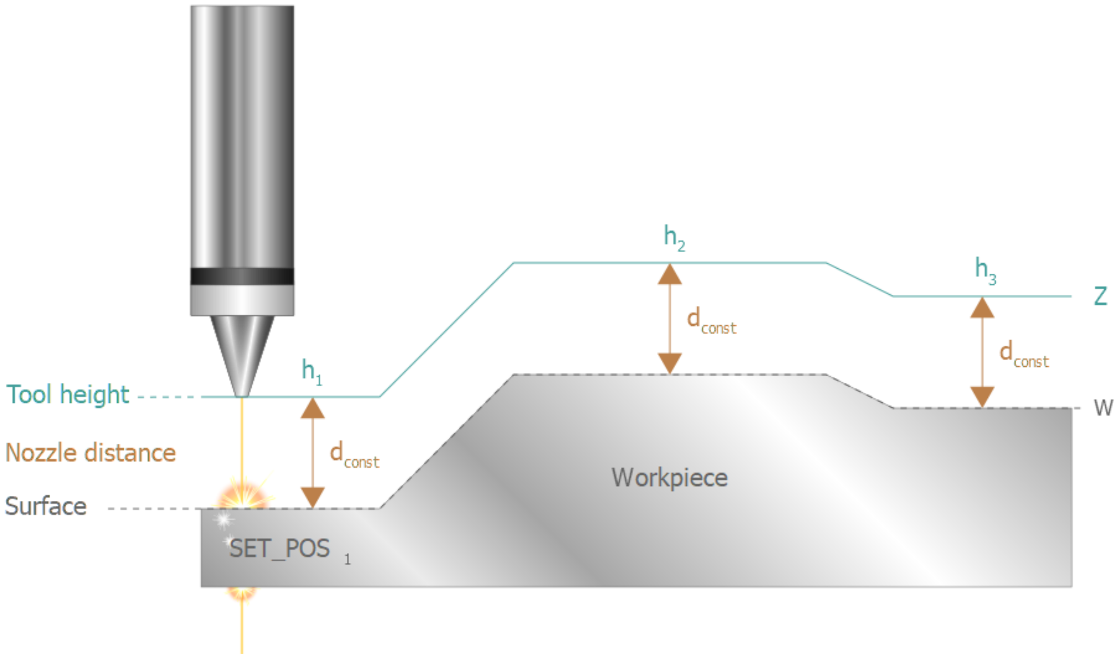


Fig. 26: Profiled workpiece surface with constant tool distance

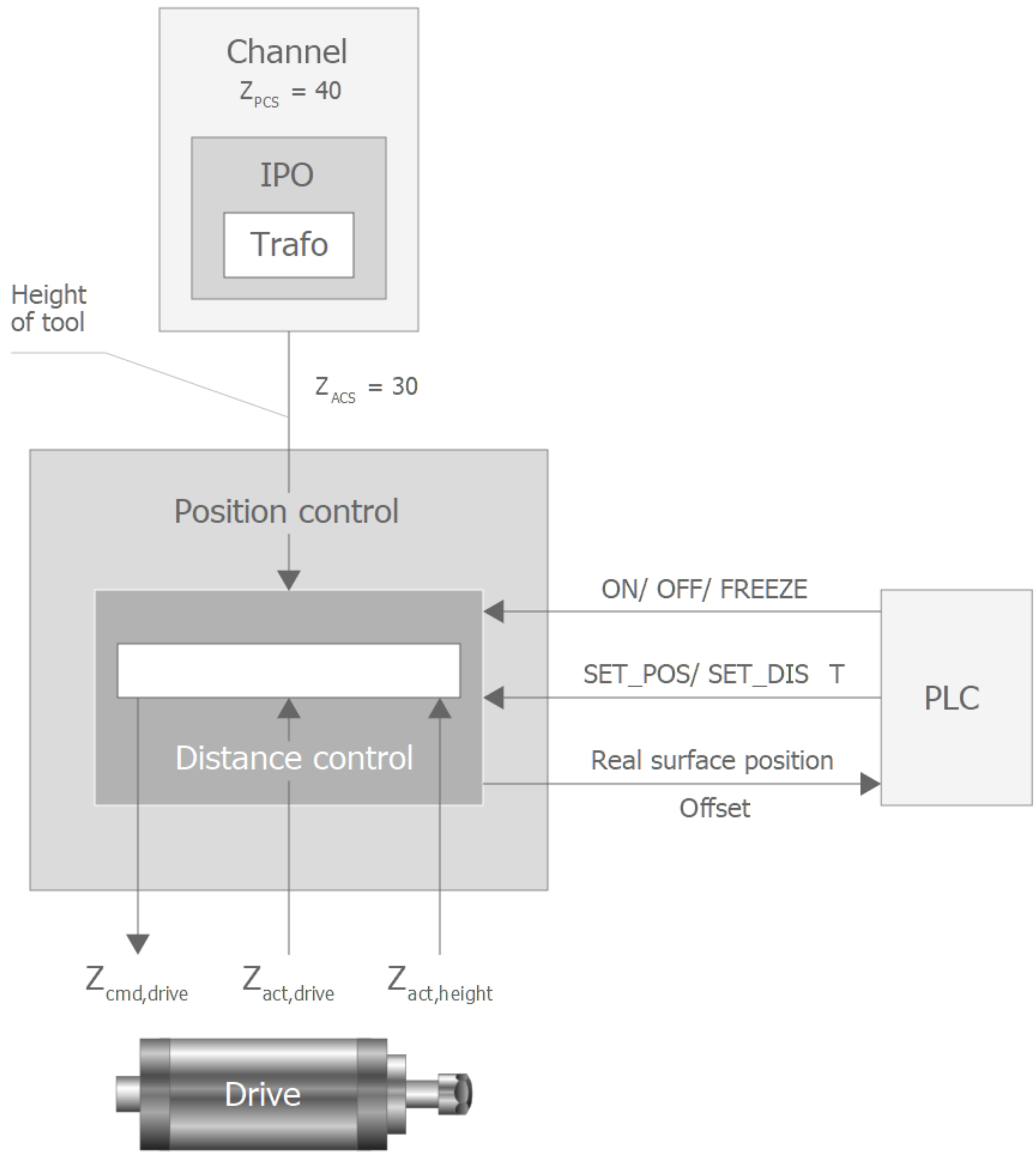


Fig. 27: Specifying the distance: distance

Notice

When the Z axis is lifted, distance control must be frozen (FREEZE) or deactivated (OFF), otherwise distance control prevents lifting/lowering.

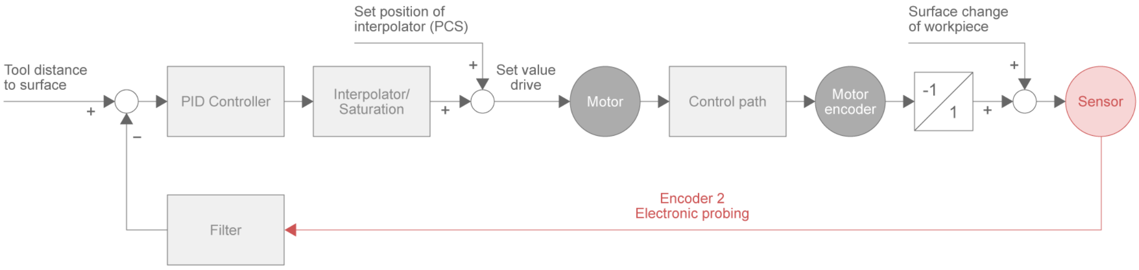


Fig. 28: Block diagram of distance control with distance specification

6 Programming

Syntax for Select by specifying the position of the workpiece surface:

<axis_name> **[DIST_CTRL ON | DRYRUN** [**SET_POS**=..] **]**

Syntax for Select by specifying a constant distance to the workpiece surface:

<axis_name> **[DIST_CTRL ON | DRYRUN CONST_DIST** [**SET_DIST**=..] **]**

Syntax for Deselect or Freeze offset

<axis_name> **[DIST_CTRL** [**OFF** [**NO_MOVE**]] | **FREEZE]**

Syntax for Test or reference sensor:

<axis_name> **[DIST_CTRL CHECK_POS** | **REF]**

Optionally, the following parameters can also be programmed in combination with select/deselect:

Syntax for additional sensor parameters:

<axis_name> **[DIST_CTRL** [**SENSOR_SOURCE**=*<ident>* **SENSOR_VAR**=..] [**VAL1**=.. - **VAL5**=..] { \ } **]**

Syntax for additional control parameters:

<axis_name> **[DIST_CTRL** [**KP**=..] [**I_TN**=..] [**D_TV**=..] { \ } **]**

Syntax for additional parameters for smoothing sensor signal:

<axis_name> **[DIST_CTRL** [**FILTER_TYPE**=..] [**N_CYCLES**=..] [**FG_F0**=..] [**ORDER**=..]
[**SMOOTH_FACT**=..] [**KALMAN_SIGMA**=..] { \ } **]**

<axis_name>	Name of the axis supporting the tool.
DIST_CTRL	Identifier for the "Sensed spindles" function. Must always be programmed as the first keyword.
ON	Activate distance control specifying the position of the workpiece surface. A set position at activation must be set with SET_POS.
SET_POS=..	Specify the position of the workpiece surface in [mm, inch] (absolute position). In the event of reset or program end, the parameter is reset, i.e. a new parameter must be specified before distance control is reactivated.
CONST_DIST	Activate distance control in combination with ON by specifying a constant distance to the workpiece surface. A distance must be set with SET_DIST at activation. **[as of V2.11.2804.03]**
SET_DIST=..	Specify the constant distance to the workpiece surface in [mm, inch]. In the event of reset or program end, the distance is reset, i.e. a new distance must be specified before distance control is reactivated.
DRYRUN	In combination with ON, the axis is not tracked in DRYRUN mode when there are changes in the workpiece surface. This allows data to be evaluated without feedback from the controller (e.g. filter effect). **[as of V3.1.3079.23]** When distance control is activated specifying the position of the workpiece surface, a set position must be set with SET_POS. When distance control is activated specifying a constant distance to the workpiece surface, a set distance must be set with SET_DIST.

OFF	Deactivate distance control.
NO_MOVE	By default, the resulting correction offset is executed when distance control is switched off. This motion can be suppressed by specifying NO_MOVE in combination with OFF. The channel is initialised with the changed axis position. The position offset is only executed at the next axis motion programmed in the NC program.
FREEZE	Freeze the compensated control distance across the workpiece. The axis position or the output compensation value is maintained. Axis tracking is interrupted.
CHECK_POS	Check whether position is within the tolerance window.
REF	Reference measuring system (sensor) (only if there is no absolute measuring system).
SENSOR_SOURCE=<*ident*>	Specify the source of the sensor signal **[as of V3.1.3080.12 or V3.1.3107.45]**. The following sources can be set for channel-specific distance control. Valid identifiers: DEFAULT: IF “DEFAULT” is selected as the sensor source, the CNC automatically sets to the “SECOND_ENCODER” sensor source internally. VARIABLE: The sensor signal is transferred to the CNC by a V.E. variable. In addition, the name of the V.E. variable must also be specified by the parameter “SENSOR_VAR”. SECOND_ENCODER: Make sure that the first configured encoder (P-AXIS-00823) is used for axis position control and the second encoder (P-AXIS-00824) for distance control.
SENSOR_VAR=..	Name of the V.E. variable which transfers the sensor signal to the CNC. **[as of V3.1.3080.12 or V3.1.3107.45]**
VAL1=..-VAL5=..	Five freely assignable values in real format.
KP=..	Weighting the distance control output values. Parameterisation can be executed analogous to P-AXIS-00759 [▸ 70]. The value range is limited to 0.0 < KP <= 2.0. For KP values less than 1.0, the distance control dynamics are reduced; for KP values greater than 1.0, the dynamics are increased. A KP factor less than 1 reduces a possible distance control oscillation and steadies control in the event of minor distance errors. **[as of V2.11.2809.06 or V3.1.3079.06]**
I_TN=..	Integral action time of the PID controller in [s]. The integral action time defines the time after which the P and I components of the manipulated variable are equal. Parameterisation can be executed analogous to P-AXIS-00764 [▸ 70]. The value range is limited to 0.0 <= I_TN <= 50.0. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. A short integral action time excites oscillations more strongly. **[as of V2.11.2809.06 or V3.1.3079.06]**
D_TV=..	Derivative action time of the PID controller in [s]. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. Parameterisation can be executed analogous to P-AXIS-00765 [▸ 71]. The value range is limited to 0.0 <= D_TV <= 2.0. The larger the derivative action time, the stronger the D component. **[as of V2.11.2809.06 or V3.1.3079.06]**
FILTER_TYPE=..	Filter type to filter sensor values according to P-AXIS-00782 [▸ 72]. **[as of V3.1.3079.23]**
N_CYCLES=..	Number the measured values used for filtering according to P-AXIS-00413 [▸ 59]. **[as of V3.1.3079.23]**
FG_F0=..	Cut-off frequency for the low-pass filter in [Hz] according to P-AXIS-00508. **[as of V3.1.3079.23]**
ORDER=..	Order of the low-pass filter according to P-AXIS-00507. **[as of V3.1.3079.23]**
SMOOTH_FACT=..	Smoothing factor of the exponential averaging filter according to P-AXIS-00784. Specifies the weighting of the current measured value.
KALMAN_SIGMA=..	Uncertainty of the included measured values according to P-AXIS-00783 [▸ 73]. **[as of V3.1.3079.23]**
\	Separator ("backslash") for clear programming of the command over multiple lines.

Notice

If distance control is still active at program end, it is not automatically deselected.
When a reset or axis error occurs, active distance control is always deselected automatically.

Notice

Parameters of the PID controller are not reset at program end.

Programing Example

Programming examples for distance control

```
%DIST_1
;Set expected position of the workpiece surface
N10 Z[DIST_CTRL SET_POS=30]
N20 Z[DIST_CTRL ON]          ;Select
; …
Nxx Z[DIST_CTRL OFF]         ;Deselect
N999 M30
```

```
%DIST_2
;Select + set expected position of the workpiece surface
N10 Z[DIST_CTRL ON SET_POS=30]
; …
Nxx Z[DIST_CTRL FREEZE]      ;Hold position
; …
Nxx Z[DIST_CTRL OFF]         ;Deselect
N999 M30
```

```
%DIST_3
;Select + set expected position of the workpiece surface
N10 Z[DIST_CTRL ON SET_POS=50]

;Deactivate distance control; Z axis does not move
Nxx Z[DIST_CTRL OFF NO_MOVE]
;The generated compensation offset is included for motion
;to the target point 100
Nxx G0 Z100
N999 M30
```

```
%DIST_4
;Set distance parameters
N10 Z[DIST_CTRL SET_POS=30]
;Select specifying the position of the workpiece surface (SET_POS)
N20 Z[DIST_CTRL ON]
; …
Nxx Z[DIST_CTRL OFF]         ;Deselect
```

```
; …
;Select specifying the workpiece surface (SET_DIST)
Nxx Z[DIST_CTRL SET_DIST=10]
Nxx Z[DIST_CTRL ON CONST_DIST]
; …
Nxx Z[DIST_CTRL OFF]         ;Deselect
N999 M30


%DIST_5
;Select filter type
N10Z[DIST_CTRL FILTER_TYPE=KALMAN_MA]
;Parametrise filter
N20 Z[DIST_CTRL N_CYCLES=30 KALMAN_SIGMA=1000]
;Check the filter effect on the sensor signal
N30 Z[DIST_CTRL DRYRUN]
;…
;Parameterise the PID controller
Nxx Z[DIST_CTRL KP=0.3 I_TN=0 D_TV=0.01]
;Activate distance control
Nxx Z[DIST_CTRL ON CONST_DIST SET_DIST=1]
; …
;Change filter
Nxx Z[DIST_CTRL FILTER_TYPE=KALMAN_EXPO SMOOTH_FACT=0.3]
; …
Nxx Z[DIST_CTRL OFF];        Deselect
N999 M30
```

7 Various distance control options

7.1 Option: Use of distance sensor and motor encoder

Release Note

This option is available starting at CNC Build V2.11.2804.02 and higher.

Distance sensor

Normally the distance is just measured by the distance sensor. The actual position of the Z axis is not included.

Deviation = Set distance - Sensor value

$\Delta d = d_{com} - d_{act}$ (controller$_{DistCtrl}$: $Z_{offset,i} = Z_{offset,i-1} + \Delta d$)

d_{act} = Filter (d'_{act})

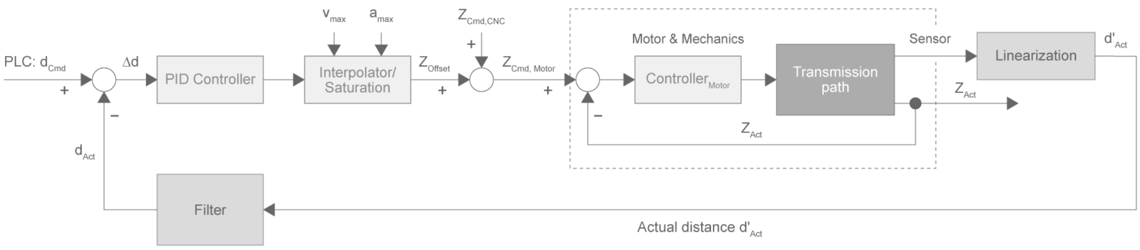


Fig. 29: Block diagram of distance control with distance sensor

Distance sensor and motor encoder

As an extension, both the distance sensor and the Z actual value sensor can be used. The inverse coupling of the two encoders (motor, distance) generally causes a reduction in oscillation tendency.

Deviation = Set distance - Sensor value

$\Delta d = d_{com} - d_{act}$ $(Z_{offset,i} = Z_{offset,i-1} + d\varepsilon)$

$d_{act} = \text{filter}(d'_{act} + Z_{act} - Z_{com}) = \text{filter}(d'_{act} - \Delta Z)$

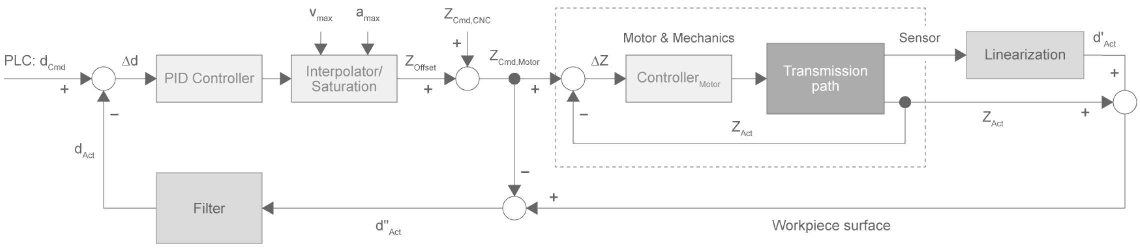


Fig. 30: Block diagram with distance sensor and motor encoder

Example

Example parameters

```
kenngr.distc.mode_dist_use_both_encoder 1 # Motor and distance encoder
active
```

7.2 Option: Weighting of acceleration dependent on distance deviation

Release Note

This option is available starting at CNC Build V2.11.2804.02 and higher.

Acceleration weighting

To reduce a possible oscillation the acceleration can be reduced for small deviations.

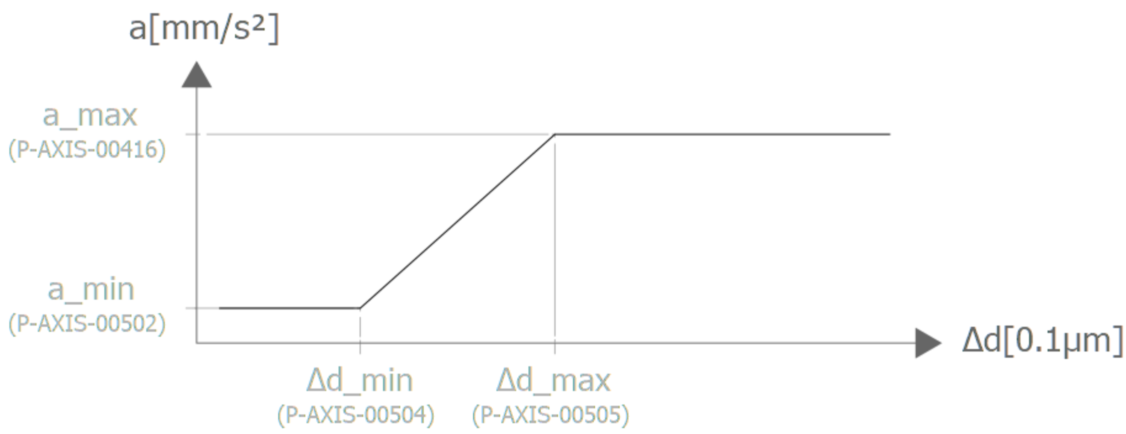


Fig. 31: Distance-dependent acceleration weighting

Example

Example parameters

```
kenngr.distc.use_adaptive_acceleration    1       # adaptive acceleration active
kenngr.distc.a_min                        1000    # [mm/s*s] Min. acceleration
kenngr.distc.a_max                        10000   # [mm/s*s] Max. acceleration
kenngr.distc.dist_error_a_min             250     # [0.1 µm] Min. distance error
kenngr.distc.dist_error_a_max             500     # [0.1 µm] Max. distance error
```

7.3 Option: Dead time reduction

Release Note

This option is available starting at CNC Build V2.11.2804.02 and higher.

Dead time reduction

The dead time of distance control can be reduced by an optimized schedule of the CNC. This setting is generally recommended.

Example

Example parameters

```
kenngr.distc.optimized_scheduling 1  # Scheduling active
```

7.4 Option: Dynamic weighting of the lowering movement

Release Note

This option is available starting at CNC Build V2.11.2807.13 and higher.

Dynamic weighting of the lowering movement

The “dynamic weighting of the lowering movement” option can be used to reduce the speed and acceleration of the lowering movement towards the workpiece. The lifting movement normally uses high dynamics in order to be able to avoid obstacles or protrusions quickly. The weighting can be used to reduce the dynamics of the lowering movement compared to the lifting movement in order to approach the workpiece more slowly.

This option can also be combined with the “acceleration weighting dependent on distance deviation” option.

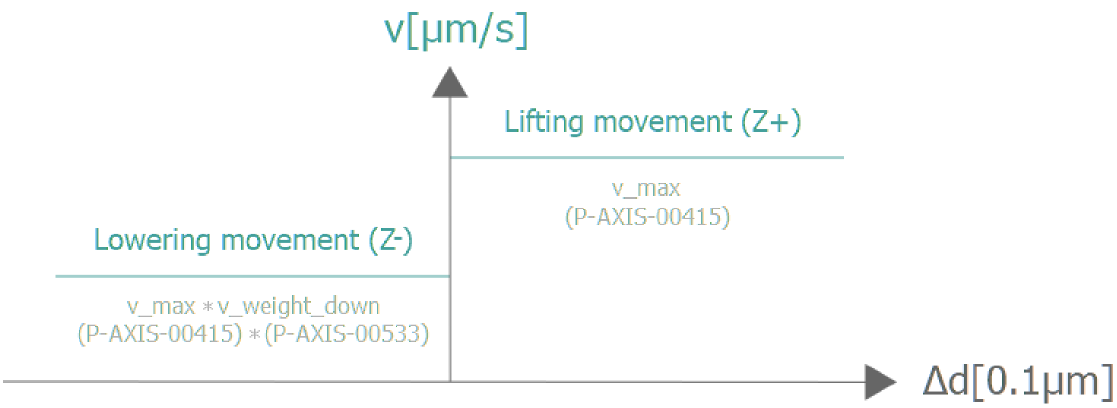


Fig. 32: Reduction in velocity by dynamic weighting of the lowering movement

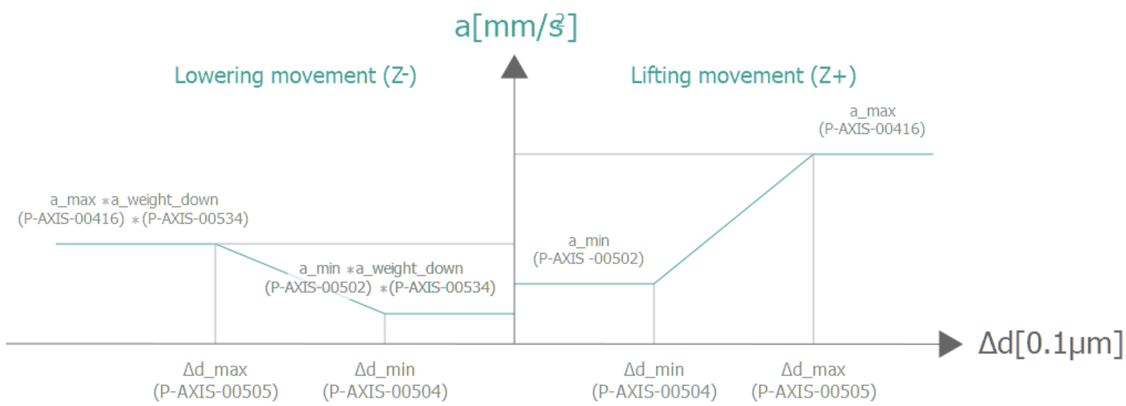


Fig. 33: Reduction in acceleration by dynamic weighting of the lowering movement

Example

Example parameters

```
kenngr.distc.v_weight_down          500       # Lowering movement at 50% velocity of
                                              P-AXIS-00415
kenngr.distc.a_weight_down          300       # Lowering movement at 30% acceleration
                                              of P-AXIS-00416
```

7.5 Parameter display

When you start up the distance control system, it is useful to record some values, e.g. using the ISG Object Browser.

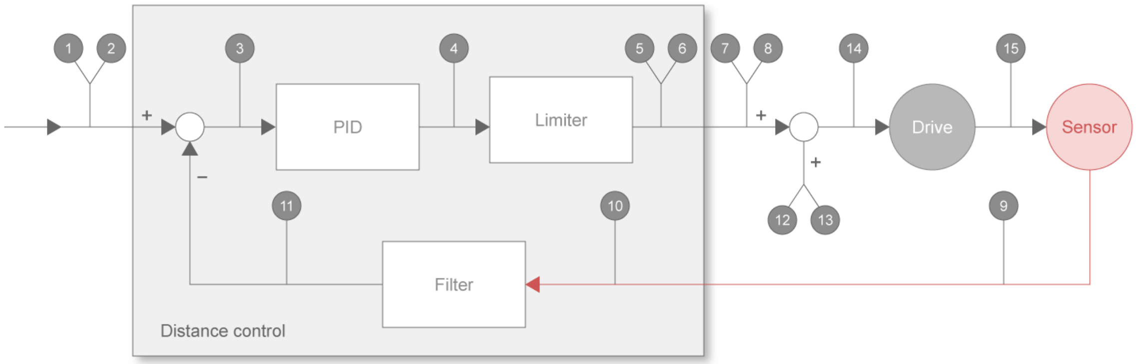


Fig. 34: Axis-specific CNC objects in the position control loop

Number	Name of the CNC object
1	DIST_CTRL::set_pos [▸ 76]
2	DIST_CTRL::set_distance [▸ 75]
3	DIST_CTRL::target_deviation [▸ 80]
4	DIST_CTRL::delta_deviation_pre_limiter [▸ 80]
5	DIST_CTRL::m_actual_offset [▸ 75]
6	DIST_CTRL_IFC::sloped_delta_deviation [▸ 75]
7	DIST_CTRL_IFC::actual_offset [▸ 81]
8	DIST_CTRL_IFC::delta_offset [▸ 82]
9	DIST_CTRL::sensor_value [▸ 80]
10	DIST_CTRL::feedback_value [▸ 79]
11	DIST_CTRL>::filtered_feedback [▸ 79]
12	m_sollw_absolut (axis-specific)
13	sollw_absolut (axis-specific)
14	dig cmd pos high_res (axis-specific)
15	dig act pos (axis-specific)

The previous axis-specific CNC objects remain available.

7.6 Changing parameters

Certain distance control parameters can be edited using CNC objects.

The objects provided are in the GEO task and are:

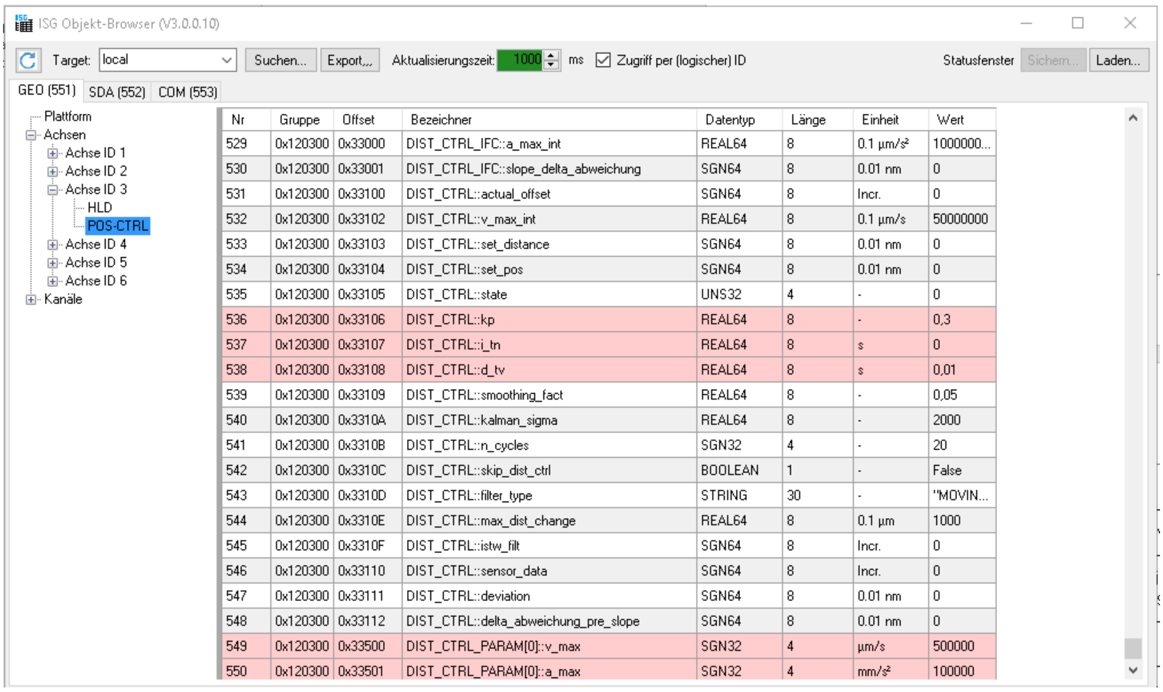
Name	Type	Unit	Index-Group	Index-Offset
DIST_CTRL_PARAM[0]::v_max [▸ 81]	SGN32	µm/s	0x120300	0x13500 (*)
DIST_CTRL_PARAM[0]::a_max [▸ 81]	SGN32	mm/s^2	0x120300	0x13501 (*)
DIST_CTRL::kp [▸ 76]	REAL64	-	0x120300	0x13106(*)
DIST_CTRL::i_tn [▸ 77]	REAL64	s	0x120300	0x13107(*)
DIST_CTRL::d_tv [▸ 77]	REAL64	s	0x20300	0x13108(*)

(*) for the first axis, otherwise + 0x10000 * axis_index (e.g. 0x30152 for the 3rd axis)

Notice

Take note that the new values are only adopted and active in the internal distance control work data for the following transitions for security reasons:
1. from INACTIVE state to ACTIVE or
2. from FREEZE state to ACTIVE

Parameters can be changed directly from the ISG object browser. All writable parameters are highlighted in colour



Nr	Gruppe	Offset	Bezeichner	Datentyp	Länge	Einheit	Wert
529	0x120300	0x33000	DIST_CTRL_IFC::a_max_int	REAL64	8	0.1 µm/s²	1000000...
530	0x120300	0x33001	DIST_CTRL_IFC::slope_delta_abweichung	SGN64	8	0.01 nm	0
531	0x120300	0x33100	DIST_CTRL::actual_offset	SGN64	8	Incr.	0
532	0x120300	0x33102	DIST_CTRL::v_max_int	REAL64	8	0.1 µm/s	50000000
533	0x120300	0x33103	DIST_CTRL::set_distance	SGN64	8	0.01 nm	0
534	0x120300	0x33104	DIST_CTRL::set_pos	SGN64	8	0.01 nm	0
535	0x120300	0x33105	DIST_CTRL::state	UNS32	4	-	0
536	0x120300	0x33106	DIST_CTRL::kp	REAL64	8	-	0,3
537	0x120300	0x33107	DIST_CTRL::i_tn	REAL64	8	s	0
538	0x120300	0x33108	DIST_CTRL::d_tv	REAL64	8	s	0,01
539	0x120300	0x33109	DIST_CTRL::smoothing_fact	REAL64	8	-	0,05
540	0x120300	0x3310A	DIST_CTRL::kalman_sigma	REAL64	8	-	2000
541	0x120300	0x3310B	DIST_CTRL::n_cycles	SGN32	4	-	20
542	0x120300	0x3310C	DIST_CTRL::skip_dist_ctrl	BOOLEAN	1	-	False
543	0x120300	0x3310D	DIST_CTRL::filter_type	STRING	30	-	"MOVIN...
544	0x120300	0x3310E	DIST_CTRL::max_dist_change	REAL64	8	0.1 µm	1000
545	0x120300	0x3310F	DIST_CTRL::istw_filt	SGN64	8	Incr.	0
546	0x120300	0x33110	DIST_CTRL::sensor_data	SGN64	8	Incr.	0
547	0x120300	0x33111	DIST_CTRL::deviation	SGN64	8	0.01 nm	0
548	0x120300	0x33112	DIST_CTRL::delta_abweichung_pre_slope	SGN64	8	0.01 nm	0
549	0x120300	0x33500	DIST_CTRL_PARAM[0]::v_max	SGN32	4	µm/s	500000
550	0x120300	0x33501	DIST_CTRL_PARAM[0]::a_max	SGN32	4	mm/s²	100000

8 PLC interface

8.1 Distance control states and transitions

Alternative commanding via SPS interface

Basic condition: Distance control is enabled for the axis (see P-AXIS-00328).

In addition to the NC program, distance control can also be commanded via the PLC interface (see [HLI//Distance control]) by specifying the required status transitions (e.g. activating or deactivating) and specifying command positions via the DistanceControl control unit.

The current state of the distance control unit can be viewed in the state of the DistanceControl control unit. The control unit state also includes the current actual position of the workpiece surface, the current distance, the active command source (0=NC program,1=PLC) and the current output position offset.

Explanation of figure:

Distance control has 6 internal states which are depicted in the figure below together with the permitted transitions. Transitions, such as a transition to error state, are displayed automatically and cannot be commanded.

A change in the “Active” and “Active constant Distance” states is only permitted in the “Freeze” or “Inactive” states.

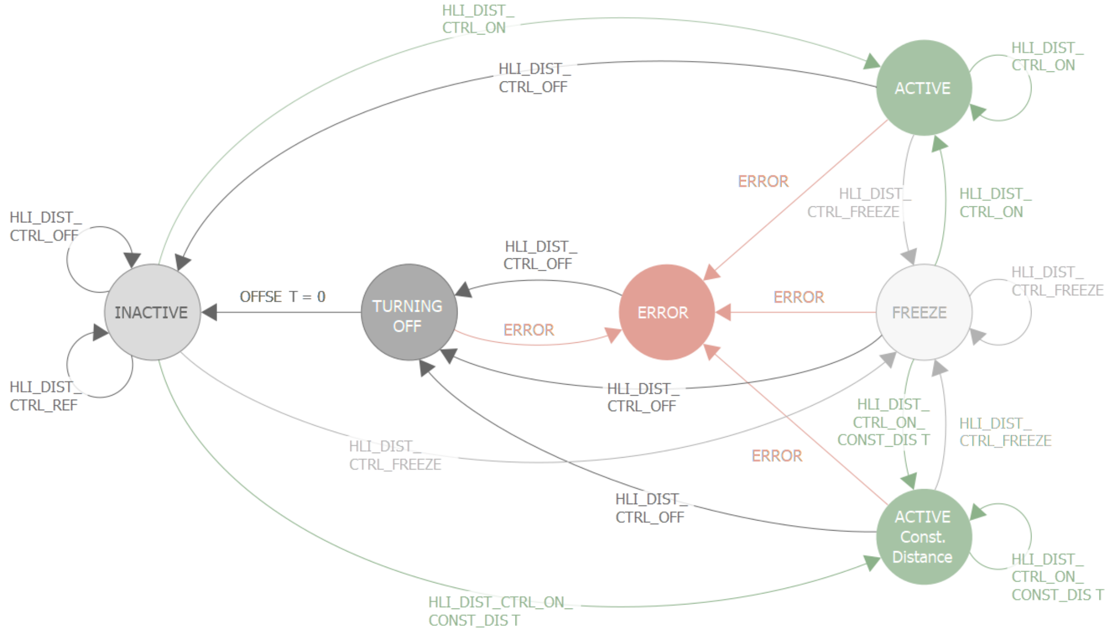


Fig. 35: Distance control state graph and transitions

Defined states of distance control

State	Value	Meaning
HLI_DIST_CTRL_STATE_INACTIVE	0	Distance control is deactivated. The specified offset ("actual_offset") is 0.
HLI_DIST_CTRL_STATE_ACTIVE	1	Distance control is active and adjusts the axis to the workpiece surface.
HLI_DIST_CTRL_STATE_FREEZE	2	Distance control is active. The offset ("actual_offset") is frozen, i.e. the axis is not adjusted to the workpiece surface.
HLI_DIST_CTRL_STATE_TURNING_OFF	3	Distance control was deactivated. The actual active offset ("actual_offset") is run out. As soon as the offset is 0, an automatic switch to INACTIVE state takes place.
HLI_DIST_CTRL_STATE_ACTIVE_CONST_DIST	4	Distance control is active and adjusts the axis to the workpiece surface. Continuous specification of the set distance of the tool to the workpiece surface.
HLI_DIST_CTRL_STATE_ERROR	5	Distance control is in error state, e.g. due to an incorrect state transition or due to an error in the position controller. Only a transition to TURNING OFF is possible to exit this state.
HLI_DIST_CTRL_STATE_DRYRUN_CONST_DIST	6	Distance control is active, however axis is not adjusted to workpiece surface. This allows the evaluation of data, for example filter effect without feedback from the control system. Continuous commanding of the set distance of the tool to the workpiece surface.
HLI_DIST_CTRL_STATE_DRYRUN_SETPOS	7	Distance control is active, however axis is not adjusted to workpiece surface. This allows the evaluation of data, for example filter effect without feedback from the control system.

Permissible transitions to command the distance control

Transition	Value	Meaning
HLI_DIST_CTRL_OFF	0	Distance control is deactivated. The program switches to the TURNING OFF state in which the position offset is run out. The state then switches automatically to the INACTIVE state.
HLI_DIST_CTRL_ON	1	Distance control is activated. When activated a command position for the workpiece surface must be transferred in the “position” datum. If no absolute encoder is used, distance control must first be referenced.
HLI_DIST_CTRL_FREEZE	2	The current position offset is frozen. Axis adjustment to the actual workpiece surface is ended.
HLI_DIST_CTRL_REF	3	Referencing distance control if no absolute encoder is used. Referencing is only permitted in the INACTIVE state. With this transition a reference position must additionally transferred in the “position” datum.
HLI_DIST_CTRL_ON_CONST_DIST	4	Activating distance control with continuous distance specification. On activation, a set position must be specified. If the distance sensor supplies no absolute values, distance control must be referenced in advance.
HLI_DIST_CTRL_DRYRUN	5	Activate distance control for pure evaluation of data. No axis tracking in case of changes to the workpiece surface. When activated a command position for the workpiece surface must be transferred in the “position” datum. If no absolute encoder is used, distance control must first be referenced.
HLI_DIST_CTRL_CONST_DIST	6	Activate distance control for pure evaluation of data. No axis tracking in case of changes to the workpiece surface. On activation, a set position must be specified. If the distance sensor supplies no absolute values, distance control must be referenced in advance.

8.2 Control commands for distance control

Commanding distance control	
Description	This control unit can influence the distance control of the axis. This is dependent on whether the distance control function is selected in the axis parameters (see P-AXIS-00328).
Data type	MC_CONTROL_DISTANCE_CONTROL, see description of Control unit with usage check
Access	PLC reads state_r and writes command_w + enable_w
ST path	gpAx[axis_idx]^.lr_mc_control.distance_control
Flow control of commanded values	
ST element	**.command_semaphor_rw**
Signal flow	PLC → CNC
Data type	BOOL
Peculiarities	**Consumption data item**
Access	CNC accepts the commanded values when this element has the value TRUE. After successful acceptance the CNC sets this value to FALSE. PLC sets this value to TRUE when the commanded value is enabled for acceptance by the CNC. The commanded values can only be updated by the PLC if this element has the value FALSE.
Commanded values	
ST element	**.command_w**
Signal flow	PLC → CNC
Data type	HLI_DISTANCE_CONTROL_COMMAND
Access	PLC writes
Distance control state	
ST element	**.state_r**
Signal flow	CNC → PLC
Data type	HLI_DISTANCE_CONTROL_STATE
Access	PLC is reading
Redirection	
ST element	**.enable_w**

Distance control state	
Description	This entry reads the distance control state.
Signal flow	PLC → CNC
Data type	HLI_DISTANCE_CONTROL_STATE
ST Path	gpAx[*axis_idx*]^.lr_mc_control.distance_control.**state_r**
Access	PLC is reading
Elements of the data type	
Element	**.actual_state**
Data type	UDINT
Access	PLC is reading
Value range/Description	See table: Distance control states and transitions [▸ 50]
Element	**.actual_position**
Data type	DINT
Unit	0.1 µm or 0.0001°
Access	PLC reads
Description	This data item indicates the current actual position of the workpiece surface detected by the sensing controller.
Characteristics	This data item is entered only if distance control is activated in the axis parameters (see P-AXIS-00328).
Element	**.actual_offset**
Data type	DINT
Unit	0.1 µm or 0.0001°
Access	PLC reads
Description	This data item indicates the current position offset of distance control by which the axis was moved due to deviations between the actual workpiece surface and the specified position (SET_POS). The following applies in stationary state (constant workpiece surface and position offset completely run out): Position offset = SET_POS – actual_position
Characteristics	This data item is entered only if distance control is activated in the axis parameters (see P-AXIS-00328).

Command for distance control	
Description	This entry commands distance control.
Signal flow	PLC → CNC
Data type	HLI_DISTANCE_CONTROL_COMMAND
ST Path	gpAx[*axis_idx*]^.lr_mc_control.distance_control.**command_w**
Access	PLC writes
Elements of the data type	
ST element	**.transition**
Data type	UDINT
Value range/De-scription	See Table - Permissible transitions to command distance control [▸ 52]
ST element	**.position**
Data type	DINT
Value range	[DINT_MIN, DINT_MAX]
Description	The meaning depends on the commanded transition: HLI_DIST_CTRL_ON: Command position of the workpiece surface (SET_POS) HLI_DIST_CTRL_REF: Reference position of the workpiece surface (REF_POS)

Cyclic command for distance control	
Description	This entry specifies cyclic set values are specified (position of workpiece surface or set distance).
Signal flow	PLC → CNC
Data type	HLIDistanceControlCyclicCommand
ST Path	pAC[*axis_idx*]^.addr^.McControlLr_Data.MCControl_DistanceControl.**CyclicCommand**
Access	PLC writes
Elements of the data type	
ST element	**.D_Position**
Data type	DINT
Value range	[DINT_MIN, DINT_MAX]
Description	The meaning depends on the commanded transition: HLI_DIST_CTRL_ON: Command position of the workpiece surface (SET_POS) HLI_DIST_CTRL_REF: Reference position of the workpiece surface (REF_POS)
ST element	**.D_Distance**
Data type	DINT
Value range	[DINT_MIN, DINT_MAX]
Description	Specification of the distance to workpiece surface after selection by transition HLI_DIST_CTRL_ON_CONST_DIST.

9 Parameter

9.1 Overview

ID	Parameter	Description
P-AXIS-00328	lr_param.distance_control_on	Enabling of distance control
P-AXIS-00414	kenngr.distc.max_deviation	Maximum position offset [0.1 µm]
P-AXIS-00415	kenngr.distc.v_max	Maximum velocity [µm/s]
P-AXIS-00416	kenngr.distc.a_max	Maximum acceleration [mm/s^2]
P-AXIS-00417	kenngr.distc.max_act_value_change	Maximum permissible change speed of measured distance [0.1 µm/cycle]
P-AXIS-00418	kenngr.distc.ref_offset	Reference point offset for control measuring system
P-AXIS-00419	kenngr.distc.max_pos	Upper limit for measuring system
P-AXIS-00420	kenngr.distc.min_pos	Lower limit for measuring system
P-AXIS-00421	kenngr.distc.tolerance	Tolerance band for limits
P-AXIS-00428	kenngr.distc.check_sw_limit_switch	Consideration of distance control in software limit switch monitoring
P-AXIS-00500	kenngr.distc.mode_dist_use_both_encoder	Option: Coupling of distance sensor and motor encoder
P-AXIS-00501	kenngr.distc.use_adaptive_acceleration	Option: Adaptive weighting of acceleration
P-AXIS-00502	kenngr.distc.a_min	
P-AXIS-00416	kenngr.distc.a_max	
P-AXIS-00504	kenngr.distc.dist_error_a_min	
P-AXIS-00505	kenngr.distc.dist_error_a_max	
P-AXIS-00509	kenngr.distc.optimized_scheduling	Option: Dead time reduction
P-AXIS-00533	kenngr.distc.v_weight_down	Velocity weighting for the lowering movement
P-AXIS-00534	kenngr.distc.a_weight_down	
P-AXIS-00422	lr_hw[1].encoder_resolution_num	Numerator distance resolution of the additive sensor measuring system [increments]
P-AXIS-00423	lr_hw[1].encoder_resolution_denom	Denominator distance resolution of the additive sensor measuring system [0.1 µm]

ID	Parameter	Description
P-AXIS-00230	lr_hw[1].vz_istw	Sign reversal of actual sensor values
P-AXIS-00424	lr_hw[1].mode_act_pos	Definition of the sensor value range: Linear scale or modulo handling of sensor values

P-AXIS-00759	kenngr.distc.kp	Weighting the distance control output values
P-AXIS-00764	kenngr.distc.i_tn	Integral action time of the PID controller
P-AXIS-00765	kenngr.distc.d_tv	Derivative action time of the PID controller
P-AXIS-00782	kenngr.distc.filter_type	Smoothing sensor data
P-AXIS-00507	kenngr.distc.low_pass_filter_order	
P-AXIS-00508	kenngr.distc.low_pass_filter_fg_f0	
P-AXIS-00413	kenngr.distc.n_cycles	
P-AXIS-00783	kenngr.distc.kalman_sigma	
P-AXIS-00784	kenngr.distc.smoothing_factor	

9.2 Description

P-AXIS-00328	**Enabling of distance control (spindle with touch probe)**	
Description	The distance control for a spindle with touch probe is enabled with this parameter. The activation is done by a special command in the NC program [PROG//section 'Distance controlled spindles'].	
Parameter	lr_param.distance_control_on	
Data type	BOOLEAN	
Data range	0/1	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00413	**Filtering of sensor values**	
Description	Sensor values may be noisy. To keep excitation of the machine low, the setpoints for distance control can be smoothed by a filter. The parameter specified the number of values that are used for filtering.	
Parameter	kenngr.distc.n_cycles	
Data type	SGN32	
Data range	0 ≤ n_cycles < 100	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	4	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00414	**Maximum position offset**	
Description	The correction value of the axis that was calculated via distance control may not exceed this machine data item. An error message is issued if this value is exceeded. The correction value is limited.	
Parameter	kenngr.distc.max_deviation	
Data type	SGN32	
Data range	0 ≤ max_deviation < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	50000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00415	**Maximum velocity**	
Description	The parameter defines the maximum speed at which a position offset is cleared. Distance compensation is dynamically limited to maximum speed to limit any resulting excitation.	
Parameter	kenngr.distc.v_max	
Data type	SGN32	
Data range	0 ≤ v_max < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.001 mm/s	R: 0,001°/s
Default value	5000	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00416	**Maximum acceleration**	
Description	The parameter defines the maximum acceleration with which a position offset is extended. Correction of the distance is limited dynamically with respect to the maximum acceleration to limit the resulting excitation. If no acceleration is specified, the maximum axis acceleration is used automatically (see P-AXIS-00008).	
Parameter	kenngr.distc.a_max	
Data type	SGN32	
Data range	0 ≤ a_max < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 1 mm/s²	R: 1°/s²
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	Then this parameter is 0, the maximum axis acceleration P-AXIS-00008 is used.	

P-AXIS-00417	Maximum permissible change speed of measured distance	
Description	The parameter defines the maximum permissible change in speed of the measured distance within one cycle. After activation of distance control, the sensor's actual values are monitored for change. When the maximum permissible change speed is exceeded, the error message ID 70329 is output. This detects problems with actual value detection.	
Parameter	kenngr.distc.max_act_value_change	
Data type	SGN32	
Data range	0 ≤ max_act_value_change < MAX(SGN32)	
Axis types	T, R	
Dimension	T: µm/s	R: 0.0001°/s
Default value	5000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00418	Reference point offset for measuring system	
Description	The value range of the sensor measuring system can be moved by an offset via this machine data item. This is necessary in the case of absolute position sensors, for example, to define the reference point, i.e. the sensor position that is adjusted if the spindle touches the ideal workpiece surface.	
Parameter	kenngr.distc.ref_offset	
Data type	SGN32	
Data range	MIN(SGN32) ≤ ref_offset < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	0 (No offset)	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00419	Upper limit for measuring system	
Description	The following parameter defines the upper limit of the sensor. An error message is generated if it is exceeded while distance control is active.	
Parameter	kenngr.distc.max_pos	
Data type	SGN32	
Data range	0 ≤ max_pos < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	50000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00420	Lower limit for measuring system	
Description	The following value defines the lower limit of the sensor. An error message is generated if it is exceeded while distance control is active.	
Parameter	kenngr.distc.min_pos	
Data type	SGN32	
Data range	0 ≤ min_pos < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	-50000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00421	Tolerance band for limits	
Description	This parameter defines a minimum distance from the minimum and maximum sensor positions. If this distance is undershot, the CNC generates the error messages ID 70330 or ID 70576. If the tolerance band is specified by zero, the limits of the minimum and maximum sensor positions from the axis parameters P-AXIS-00419 and P-AXIS-00420 have a direct effect.	
Parameter	kenngr.distc.tolerance	
Data type	SGN32	
Data range	0 ≤ tolerance < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00428	Consideration of distance control in software limit switch monitoring	
Description	This parameter defines whether the calculated distance control offset is included in the software limit switch monitor (see [FCT-A2]).	
Parameter	kenngr.distc.check_sw_limit_switch	
Data type	BOOLEAN	
Data range	0: Offset of distance control is not considered in software limit switch monitoring (Standard). 1: Offset of distance control is considered in software limit switch monitoring.	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00500	Option: Coupling of distance sensor and motor encoder	
Description	As an extension, both the distance sensor and the Z actual value sensor can be used. The inverse coupling of the two sensors can reduce an oscillation tendency.	
Parameter	kenngr.distc.mode_dist_use_both_encoder	
Data type	BOOLEAN	
Data range	0: No coupling 1: Coupling of motor encoder and distance sensor active	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00501	Option: Adaptive weighting of acceleration	
Description	To reduce a possible oscillation the acceleration can be reduced for small deviations.	
Parameter	kenngr.distc.use_adaptive_acceleration	
Data type	BOOLEAN	
Data range	0: No adaptive weighting of acceleration 1: Adaptive weighting of acceleration active	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	In addition the following limits for acceleration and distance error must be configured: P-AXIS-00502 or P-AXIS-00416 and P-AXIS-00504 or P-AXIS-00505	

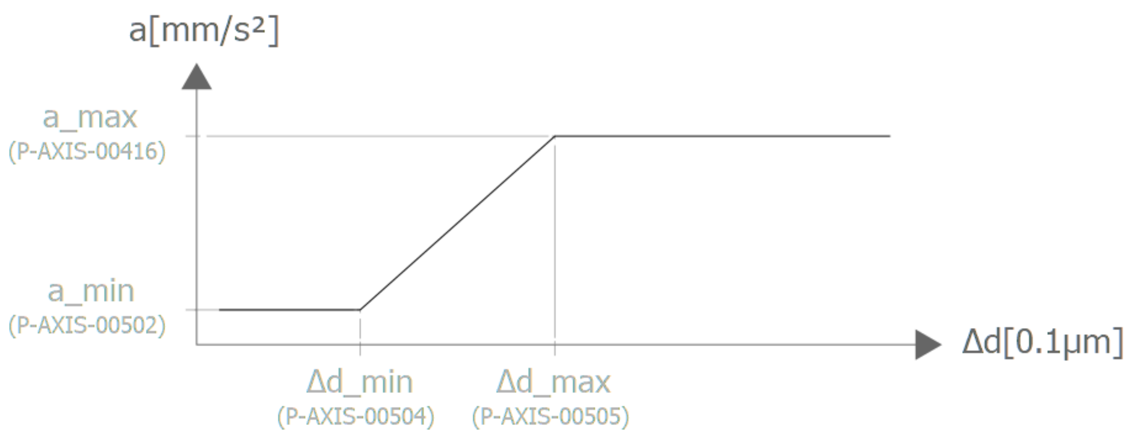


Fig. 36: View Option: Adaptive acceleration weighting

P-AXIS-00502	**Minimum acceleration**	
Description	The parameter defines the minimal acceleration of distance control.	
Parameter	kenngr.distc.a_min	
Data type	UNS32	
Data range	1 ... MAX (UNS32)	
Axis types	T, R	
Dimension	T: mm/s^2	R: mm/s^2
Default value	500	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	.	

P-AXIS-00504	**Minimum distance error**	
Description	The parameter defines the minimum distance error for distance control up to which minimum acceleration (P-AXIS-00502) is used.	
Parameter	kenngr.distc.dist_error_a_min	
Data type	UNS32	
Data range	0 ≤ P-AXIS-00504 < MAX(UNS32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	1000	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00505	**Maximum distance error**	
Description	The parameter defines the maximum distance error for distance control up to which maximum acceleration (P-AXIS-00416) is used.	
Parameter	kenngr.distc.dist_error_a_max	
Data type	UNS32	
Data range	0 ≤ P-AXIS-00505 < MAX(UNS32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	5000	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00507	Order of the filter	
Description	The filter's order describes its behaviour with regard to the drop in the frequency response. The following applies: Frequency drop = - P-AXIS-00507 * 20 dB/decade	
Parameter	kenngr.distc.low_pass_filter_order	
Data type	UNS32	
Data range	0 … 6	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	4	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00508	Characteristic frequency of a filter	
Description	The parameter defines the value of a filter's characteristic frequency.	
Parameter	kenngr.distc.low_pass_filter_fg_f0	
Data type	REAL64	
Data range	0 ≤ low_pass_filter_fg_f0 < MAX(REAL64)	
Axis types	T, R	
Dimension	T: Hz	R: Hz
Default value	25	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00509	Option: Dead time reduction	
Description	The dead time of distance control can be reduced by an optimized schedule of the CNC.	
Parameter	kenngr.distc.optimized_scheduling	
Data type	BOOLEAN	
Data range	0: Without optimized scheduling 1: Optimized scheduling active	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00533	**Weighting factor for velocity of lowering movement**	
Description	This parameter weights the velocity (see P-AXIS-00415) of the lowering movement (towards the workpiece). This can be useful since the lifting movement is normally highly dynamic in order to avoid an obstacle or elevation quickly. With the weighting factor it is possible to use a reduced velocity for the lowering movement towards the workpiece.	
Parameter	kenngr.distc.v_weight_down	
Data type	UNS32	
Data range	0 ≤ v_weight_down < 2000	
Axis types	T, R	
Dimension	T: 0.1%	R: 0.1%
Default value	0 *	
Drive types	SERCOS, Profidrive, CANopen	
Remarks	* The weighting is deactivated, lifting and lowering movement use the identical velocity P-AXIS-00415. This parameter is available from CNC version V2.11.2807.13 onwards.	

P-AXIS-00534	**Weighting factor for acceleration of lowering movement**	
Description	This parameter weights the velocity (see P-AXIS-00416) of the lowering movement (towards the workpiece). This can be useful since the lifting movement is normally highly dynamic in order to avoid an obstacle or elevation quickly. With the weighting factor it is possible to use a reduced acceleration for the lowering movement towards the workpiece.	
Parameter	kenngr.distc.a_weight_down	
Data type	UNS32	
Data range	0 ≤ a_weight_down < 2000	
Axis types	T, R	
Dimension	T: 0.1%	R: 0.1%
Default value	0 *	
Drive types	SERCOS, Profidrive, CANopen	
Remarks	* The weighting is deactivated, lifting and lowering movement use the identical acceleration P-AXIS-00416. This parameter is available from CNC version V2.11.2807.13 onwards.	

P-AXIS-00422	Numerator distance resolution of the additive sensor measuring system	
Description	The distance resolution of the sensor measuring system is specified as the quotient P-AXIS-00423 in the dimension [increments/0.1 µm] for translatory axes or [increments/10^-4°] for rotary axes. The number of sensor increments must be specified in P-AXIS-00422.	
Parameter	lr_hw[i].encoder_resolution_num	
Data type	UNS32	
Data range	0 < encoder_resolution_num < MAX(UNS32)	
Axis types	T, R, S	
Dimension	T: increments	R,S: increments
Default value	1	
Drive types	----	
Remarks	This entry is valid for 'lr_hw[i].*' with i ≥ 1! The resolution of the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00233 and P-AXIS-00234.	

P-AXIS-00423	Denominator distance resolution of the additive sensor measuring system	
Description	The distance resolution of the sensor measuring system is specified as the quotient P-AXIS-00422 / P-AXIS-00423 in the dimension [increments/0.1 µm] for translatory axes or [increments/10^-4°] for rotary axes. The amount of the travel range must be specified in this parameter.	
Parameter	lr_hw[i].encoder_resolution_denom	
Data type	UNS32	
Data range	0 ≤ encoder_resolution_denom < MAX(UNS32)	
Axis types	T, R, S	
Dimension	T: 0.1 µm	R,S: 0.0001°
Default value	1	
Drive types	----	
Remarks	This entry is valid for 'lr_hw[i].*' with i ≥ 1! The resolution of the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00233 and P-AXIS-00234.	

P-AXIS-00230	Sign reversal of actual value	
Description	This parameter defines the sign reversal of the actual value.	
Parameter	lr_hw[i].vz_istw	
Data type	BOOLEAN	
Data range	0/1	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Drive types	----	
Remarks	These entries are not taken over when the axis parameters list is updated. Updates only become effective when the controller is rebooted.	

P-AXIS-00424	Handling of the additive sensor values	
Description	This parameter defines whether the sensor positions are to be considered as linear or modulo values. By default, it can be handled according to the axis type or an individual default can be defined. When sensor values are handled according to the set axis type (see P-AXIS-00018), values are considered linear for the TRANSLATOR axis type, while modulo handling applies to the ROTATOR axis type.	
Parameter	lr_hw[i].mode_act_pos	
Data type	UNS16	
Data range	0, 1, 2 where: 0: depending on axis type (default) 1 : linear 2 : modulo	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
Drive types	----	
Remarks	This entry is valid for 'lr_hw[i].*' with i ≥ 1! The setting of the sensor value range for the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00122.	

P-AXIS-00759	**Weighting the distance control output values**	
Description	The parameter weights the cyclic output value of the distance control. This may affect the distance control dynamics. For kp values less than 1.0, the distance control dynamics are reduced; for kp value greater than 1.0, the dynamics are increased.	
Parameter	kenngr.distc.kp	
Data type	REAL64	
Data range	0.0 < kp <= 2.0	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	1.0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	A kp factor less than 1.0 reduces a possible distance control oscillation and steadies the control in the event of minor distance errors. This parameter is available as of CNC Build V2.11.2809.06 or V3.1.3079.06.	

P-AXIS-00764	**Integral (I) action time of the PID controller**	
Description	This parameter weights the I component of the PID controller. The integral action time defines the time after which the P and I components of the manipulated variable are equal. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. Disable the I component by i_tn = 0.	
Parameter	kenngr.distc.i_tn	
Data type	REAL64	
Data range	0.0 <= i_tn <= 50.0	
Axis types	T, R	
Dimension	T: s	R: s
Default value	0.0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	To begin with, it is advisable to select a high initial value for the integral action time setting (e.g. 5) to avoid instability in the control loop. You can then reduce the integral action time step by step to obtain the effect you require. If there are no permanent control deviations, do not use the I component at first. This parameter is available as from Build 2809.06 or 3079.06.	

P-AXIS-00765	**Derivative (D) action time of the PID controller**	
Description	This parameter weights the D component of the PID controller. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. The derivative action time stabilises controller behaviour and reduces oscillations. The larger the derivative action time, the stronger the D component. Disable the D component by d_tv=0.	
Parameter	kenngr.distc.d_tv	
Data type	REAL64	
Data range	0.0 <= d_tv <= 2.0	
Axis types	T, R	
Dimension	T: s	R: s
Default value	0.0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	To begin with, it is advisable to select a low initial value for the derivative action time setting to avoid instability in the control loop (e.g.: 0.01). You can then reduce the derivative action time step by step to obtain the effect you require. This parameter is available as from Build 2809.06 or 3079.06.	

<table>
<tr><th>P-AXIS-00782</th><th colspan="2">Filter type for smoothing sensor values</th></tr>
<tr><td>Description</td><td colspan="2">In some cases, the sensor values are noisy. The oscillation tendency can be possibly suppressed by using a suitable filter . The following filter types can be selected for distance control:
• DEFAULT: Moving average filter where P-AXIS-00413 [59] = 4
• MOVING_AVERAGE: Moving average filter
• LOWPASS Low-pass filter
• KALMAN_MA: Kalman filter with prediction from average filter
• EXPO_MEAN: Exponential weighted average filter
• KALMAN_EXPO: Kalman filter with prediction from exponentially weighted average filter</td></tr>
<tr><td>Parameter</td><td colspan="2">kenngr.distc.filter_type</td></tr>
<tr><td>Data type</td><td colspan="2">STRING</td></tr>
<tr><td>Data range</td><td colspan="2">DEFAULT
MOVING_AVERAGE
LOWPASS
KALMAN_MA
EXPO_MEAN
KALMAN_EXPO</td></tr>
<tr><td>Axis types</td><td colspan="2">T, R</td></tr>
<tr><td>Dimension</td><td>T: ----</td><td>R: ----</td></tr>
<tr><td>Default value</td><td colspan="2">DEFAULT</td></tr>
<tr><td>Drive types</td><td colspan="2">SERCOS, Profidrive, CANopen</td></tr>
<tr><td>Remarks</td><td colspan="2">The following filter parameters are still required for each of the filter types::
• MOVING_AVERAGE: P-AXIS-00413 [59]
• LOWPASS: P-AXIS-00507 [66], P-AXIS-00508 [66] (As of v3.1.3079.21 this setting replace the parameter P-AXIS-00506)
• KALMAN_MA: P-AXIS-00413 [59], P-AXIS-00783 [73]
• EXPO_MEAN: P-AXIS-00413 [59], P-AXIS-00784 [73]
• KALMAN_EXPO: P-AXIS-00413 [59], P-AXIS-00784 [73], P-AXIS-00783 [73]</td></tr>
</table>

P-AXIS-00783	Uncertainty of measurement values	
Description	The parameter indicates the degree of deviation of measurement values from actual values. The higher this value, the better the filter effect. However, any overshoots are amplified.	
Parameter	kenngr.distc.kalman_sigma	
Data type	REAL64	
Data range	1.0 ≤ P-AXIS-00783 ≤ 10000.0	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	4	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

P-AXIS-00784	Smoothing factor	
Description	The parameter indicates the weighting of the current measurement value. Example: At a smoothing factor of 0.5, 50% of the current value is included in the average value.	
Parameter	kenngr.distc.smoothing_factor	
Data type	REAL64	
Data range	0 < P-AXIS-00784 ≤ 1.0	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0.7	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

9.3 Example of distance axis

Example

Example parameters

```
# ------ Distance control --------
lr_param.distance_control_on        1          Enables the distance control function
kenngr.distc.max_abweichung         20000000   # [0.1µm] Max. permissible deviation
kenngr.distc.v_max                  50000      # [µm/s] Max. velocity of distance
                                               controller
kenngr.distc.a_max                  10000      # [mm/s*s] Max. acceleration
kenngr.distc.max_istw_sprung        100000000  # Max. actual value jump/cycle
kenngr.distc.ref_offset             0          # Reference point offset
kenngr.distc.max_pos                1500000    # [0.1µm] Max. position
kenngr.distc.min_pos                -1500000   # [0.1µm] Min. position
kenngr.distc.toleranz               50000      # [0.1µm] Tolerance value of probing
                                               depth
kenngr.distc.check_sw_limit_switch 1           # Distance control offset
                                               monitor
kenngr.distc.optimized_scheduling   1          # Opt. scheduling active
kenngr.distc.mode_dist_use_both_en-1           # Motor and distance encoder active
coder
#kenngr.distc.use_adaptive_accel-   1          Adaptive weighting of acceleration
eration                                        active
kenngr.distc.a_min                  1000       # [mm/s*s] Min. acceleration
kenngr.distc.a_max                  10000      # [mm/s*s] Max. acceleration
kenngr.distc.dist_error_a_min       250        # [0.1 µm] Min. distance
kenngr.distc.dist_error_a_max       500        # [0.1 µm] Max. distance
kenngr.distc.filter_type            KALMAN_MA  # Kalman filter active
kenngr.distc.n_cycles               20         # Number of measured values for fil-
                                               tering
kenngr.distc.sigma                  1000       # Uncertainty of measured values
```

9.4 CNC objects of axis-specific distance control

Available as of Build V3.1.3080.12 or V3.1.3107.44

Name	DIST_CTRL_IFC::a_max_int		
Description	Maximum acceleration of the linear slope.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3000
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 µm/s²]
Remarks			

Name	DIST_CTRL_IFC::sloped_delta_deviation		
Description	The deviation to be executed in this cycle after being influenced by the slope.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3001
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL::m_actual_offset		
Description	Current offset to the interpolated command position of the drive as specified by distance control.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3100
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL::v_max_int		
Description	Maximum permissible velocity of the axis.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3102
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 µm/s]
Remarks			

Name	DIST_CTRL::set_distance		
Description	Set command distance of the tool to the surface.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3103
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	Only effective in “SET_DIST” mode		

Name	DIST_CTRL::set_pos		
Description	Set command value of the workpiece surface.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3104
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	Only effective in “SET_POS” mode		

Name	DIST_CTRL::state		
Description	Current internal state of distance control 0: IDLE 2: ACTIVE 3: FREEZE 4: OFF 5: OFF_NO_MOVE 6-12: ERROR 15:DRYRUN		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3105
Data type	UNS32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::kp		
Description	Weighting the distance control output values. Parameterisation can be executed analogous to P-AXIS-00759 [▸ 70]. The value range is limited to 0.0 < KP <= 2.0. For KP values less than 1.0, the distance control dynamics are reduced; for KP values greater than 1.0, the dynamics are increased. A KP factor less than 1 reduces a possible distance control oscillation and steadies control in the event of minor distance errors. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3106
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[-]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL::i_tn		
Description	Integral action time of the PID controller in [s]. The integral action time defines the time after which the P and I components of the manipulated variable are equal. Parameterisation can be executed analogous to P-AXIS-00764 [▸ 70]. The value range is limited to 0.0 <= I_TN <= 50.0. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. A short integral action time excites oscillations more strongly. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A$_{ID}$>3107
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL::d_tv		
Description	Derivative action time of the PID controller in [s]. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. Parameterisation can be executed analogous to P-AXIS-00765 [▸ 71]. The value range is limited to 0.0 <= D_TV <= 2.0. The larger the derivative action time, the stronger the D component. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A$_{ID}$>3108
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL::smoothing_fact		
Description	Currently set smoothing factor of the exponential averaging filter analogous to P-AXIS-00784 [▸ 73]. Specifies the weighting of the current measured value.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A$_{ID}$>3109
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::kalman_sigma		
Description	Currently set uncertainty of the included measured values analogous to P-AXIS-00783 [▸ 73]. [as of V3.1.3079.23]		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310A
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::n_cycles		
Description	Currently set number of measured values used for filtering according to P-AXIS-00413 [▸ 59]. [as of V3.1.3079.23]		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310B
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::skip_dist_ctrl		
Description	Not in use - in preparation		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310C
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::filter_type		
Description	Active filter type to smooth sensor values. Filter types for smoothing sensor values, see P-AXIS-00782 [▸ 72].		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310D
Data type	STRING	**Length**	30
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL::max_dist_change		
Description	Maximum change in sensor values per cycle. Required for the “Kalman_DYN” filter.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310E
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 μm]
Remarks	Filter not yet available.		

Name	DIST_CTRL::filtered_feedback		
Description	Filtered feedback value.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>310F
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL::feedback_value		
Description	Calculated distance control feedback value. SET_DIST mode: Measured actual distance between the interpolated command position of the drive and the surface. SET_DIST (use_both_encoder) and SET_POS modes: Measured position of the real surface in the selected coordinate system.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3110
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL::target_deviation		
Description	SET_DIST mode: Current difference between the interpolated command position of the dive and the set command distance to the surface. SET_POS mode: Current difference between the measured real surface and the specified command surface.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3111
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm] I
Remarks	Filtered sensor values are included in this value.		

Name	DIST_CTRL::delta_deviation_pre_limiter		
Description	The distance to be executed in this cycle before being influenced by the limiter. Influenced by the PID controller.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3112
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	SET_DIST: For kp=1, this is the distance to go between the actual position of the tool and the set command distance to the surface. SET_POS: For kp=1, this is the distance to go to be executed in order to compensate for the difference between the actual position of the tool and the real surface.		

Name	DIST_CTRL::sensor_value		
Description	Return value of the sensor.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3113
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL_PARAM[0]::v_max		
Description	The maximum velocity set by P-AXIS-00415 [▸ 60] when a position offset is executed.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3500
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[µm/s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL_PARAM[0]::a_max		
Description	The maximum acceleration set by P-AXIS-00416 [▸ 60] when a position offset is executed.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3501
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[mm/s²]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL_IFC::actual_offset		
Description	Offset to the interpolated command position of the drive currently output by distance control to the drive.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3900
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks	The drive resolution and the gear ratio are included in this value.		

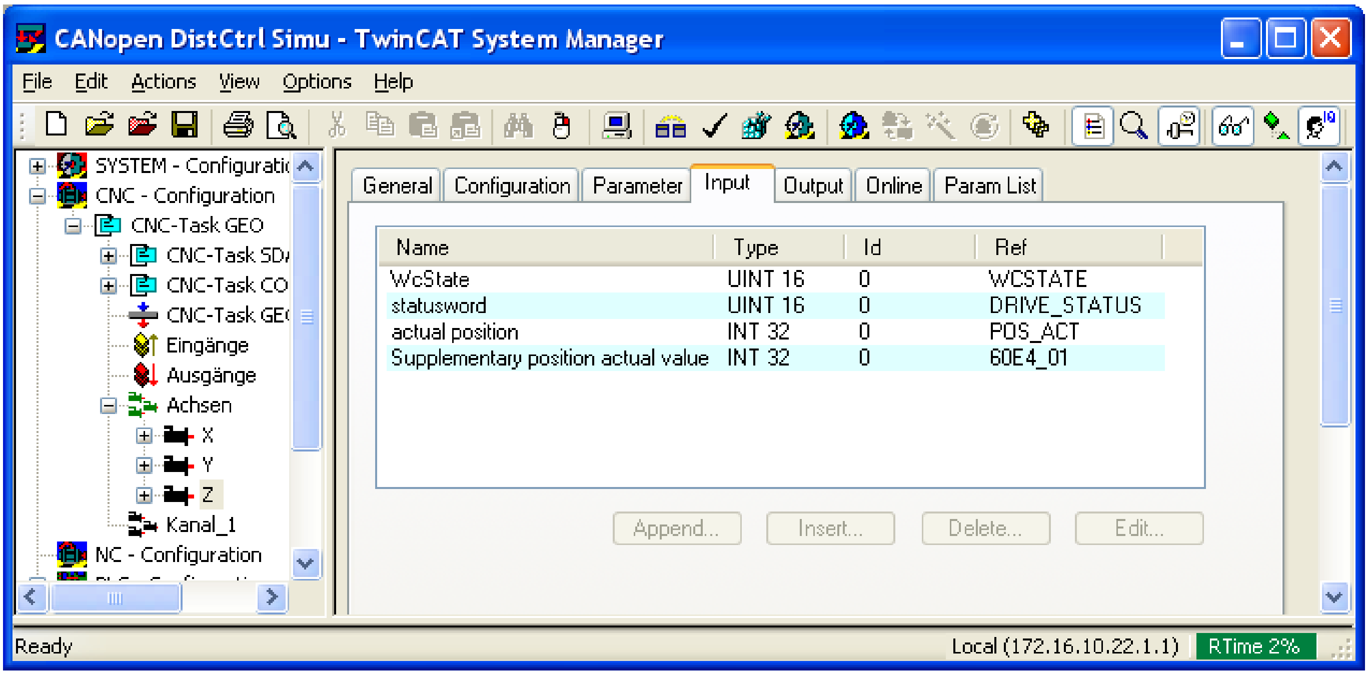
Name	DIST_CTRL_IFC::delta_offset		
Description	Delta currently output to the drive indicating that the cycle must be executed.		
Task	GEO (Port 551)		
Index group	0x120300	**Index offset**	0x<A_{ID}>3901
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks	The drive resolution and the gear ratio are included in this value.		

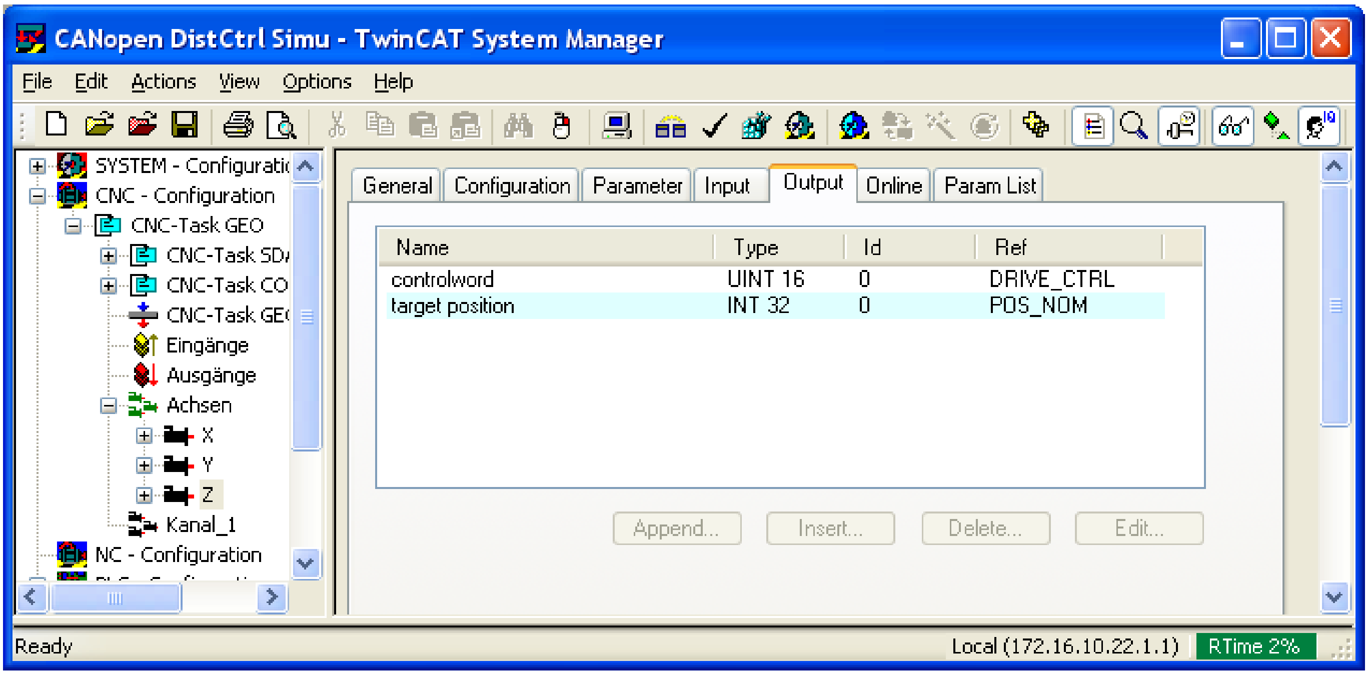
10 Test example with drive simulation

PLC test environment

Configuration of a Z axis according to CANopen DS402 drive with additional distance sensor (0x60E4_01).

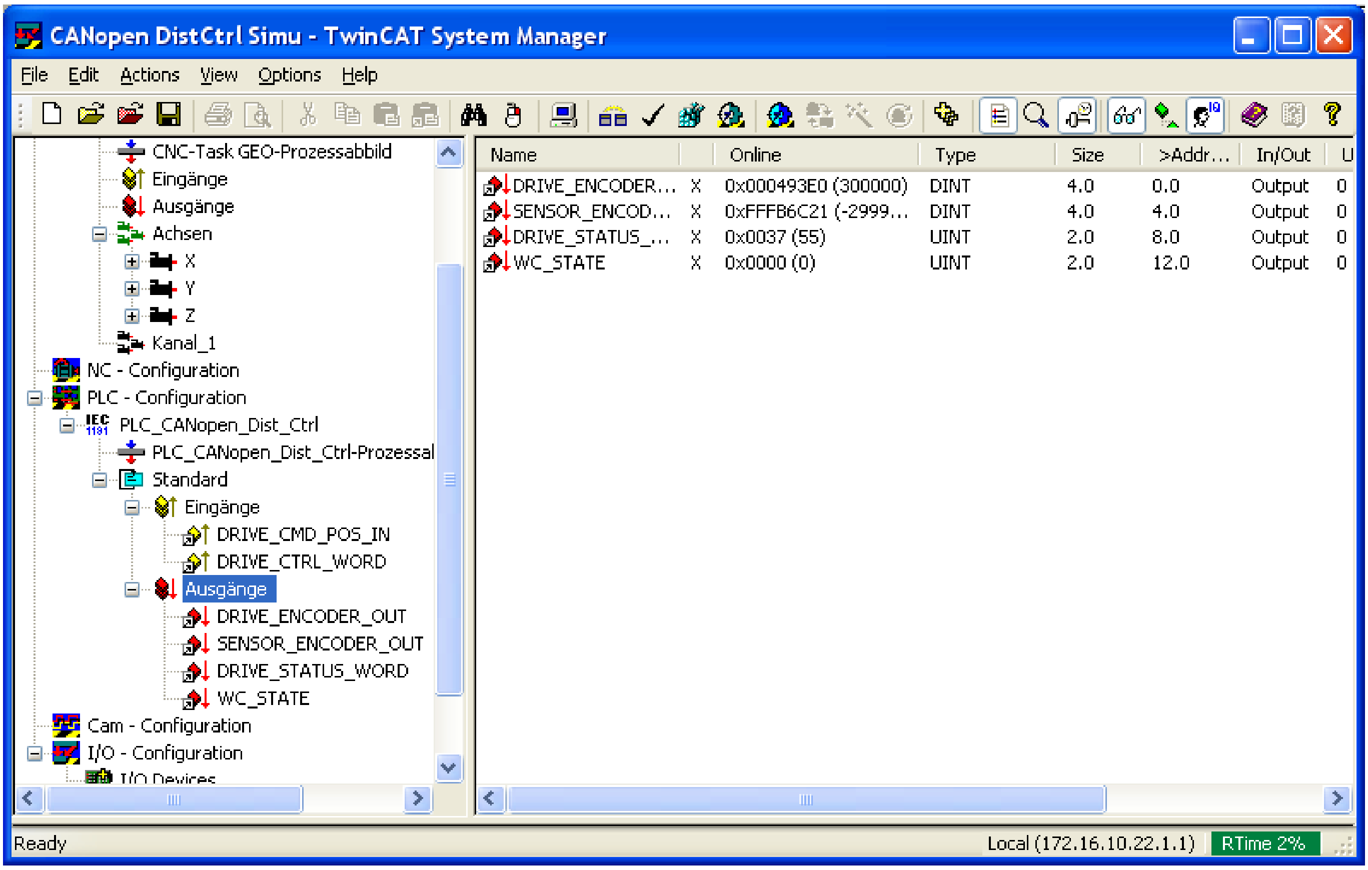
Configuration of CAN drive





Simulation in PLC

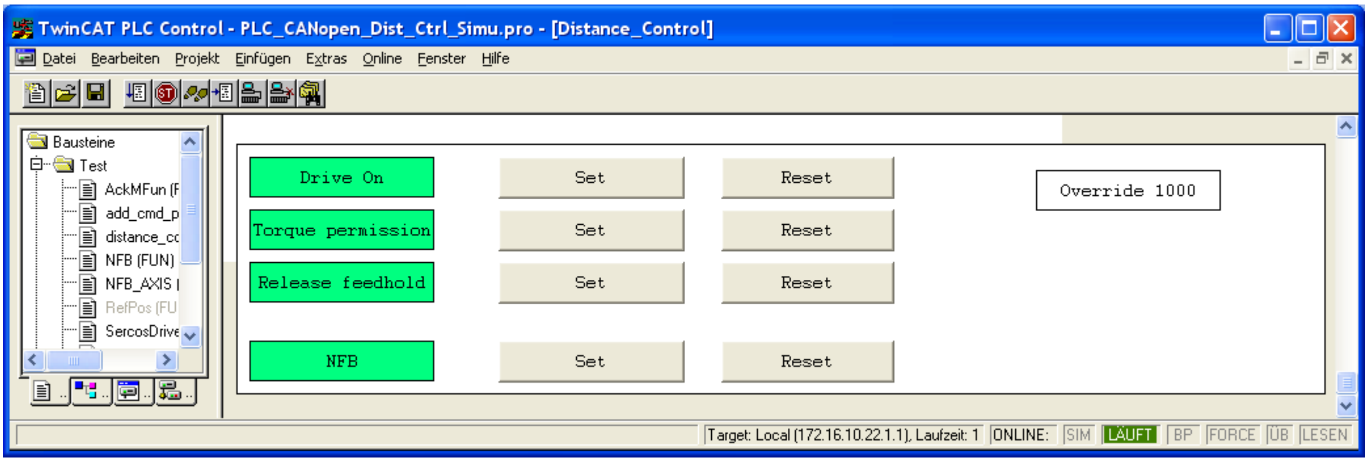
Simulation of CAN-PDO via PLC inputs/outputs



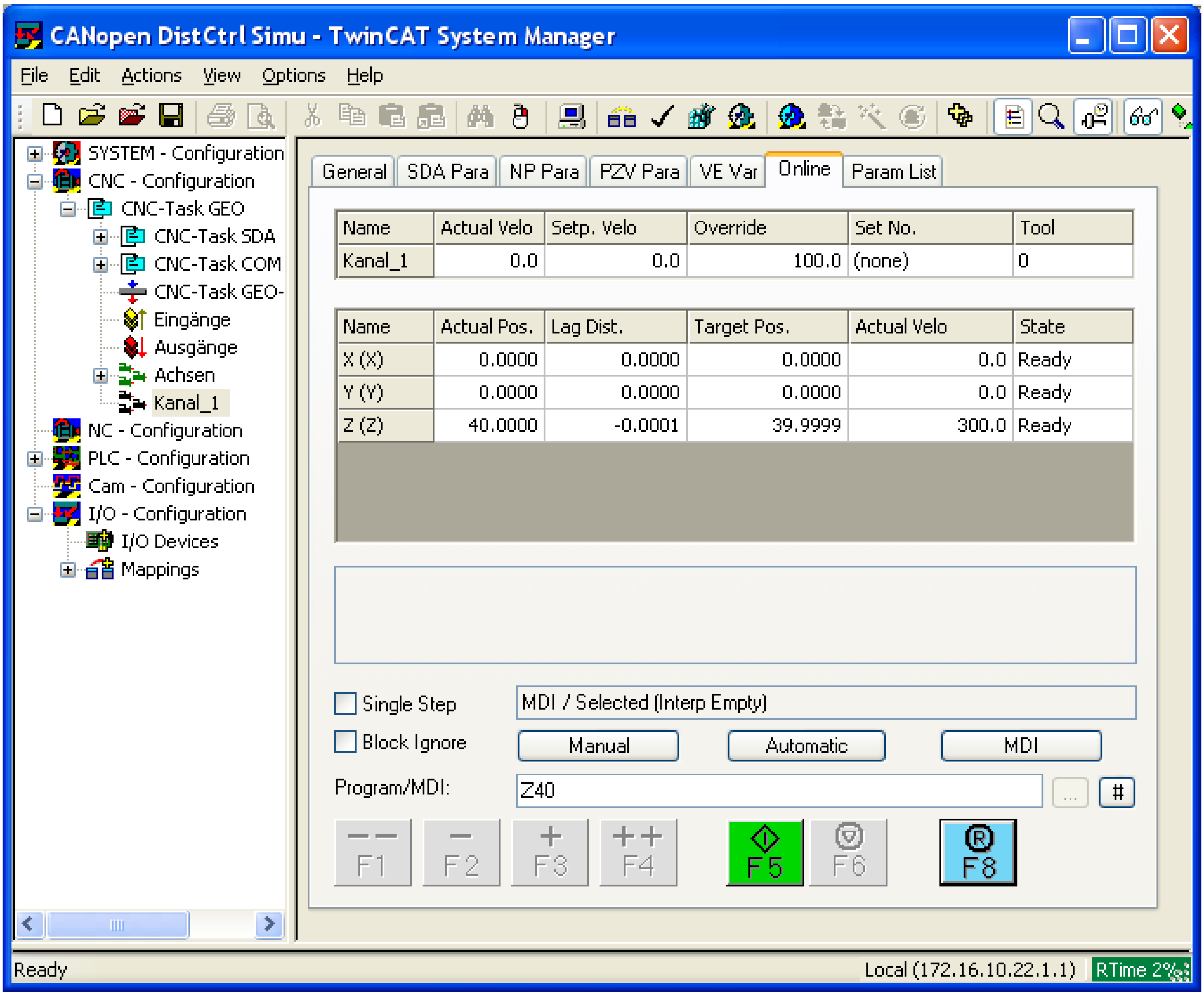
The drive encoder and the distance sensor are also subject to slight random noise.

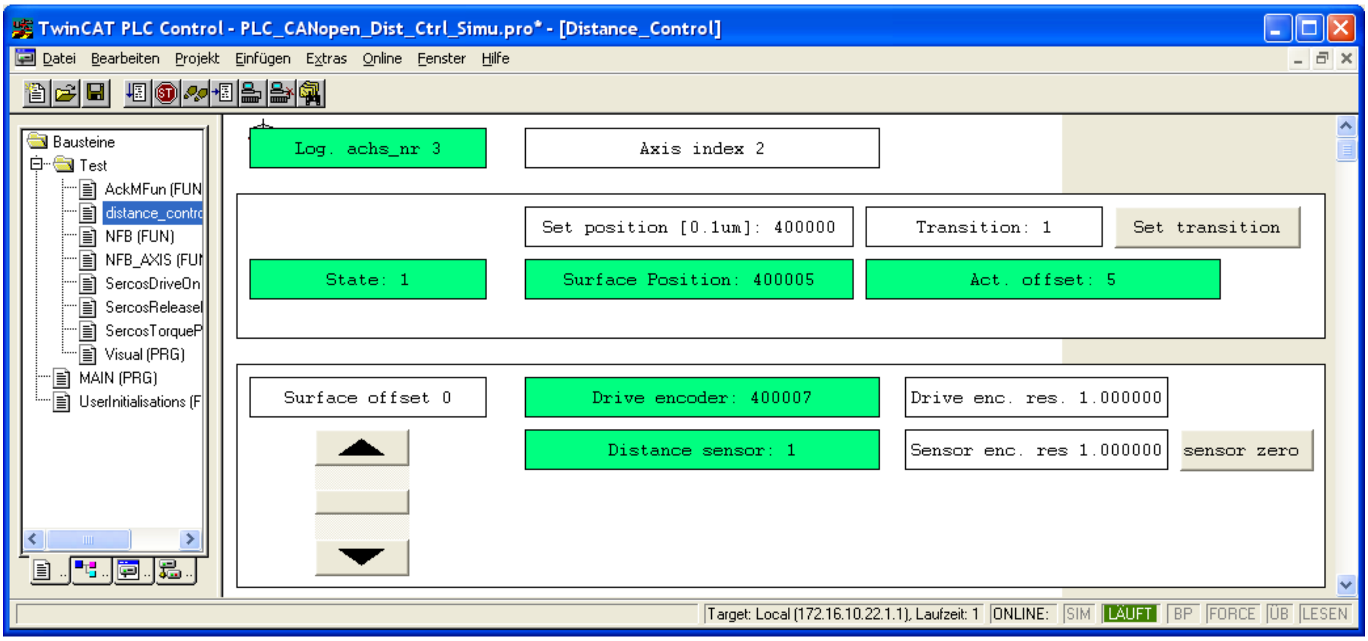
Turning on the drives

The drive can be run after setting the drive enables (drive on, torque, feedhold off).



Approaching a set position



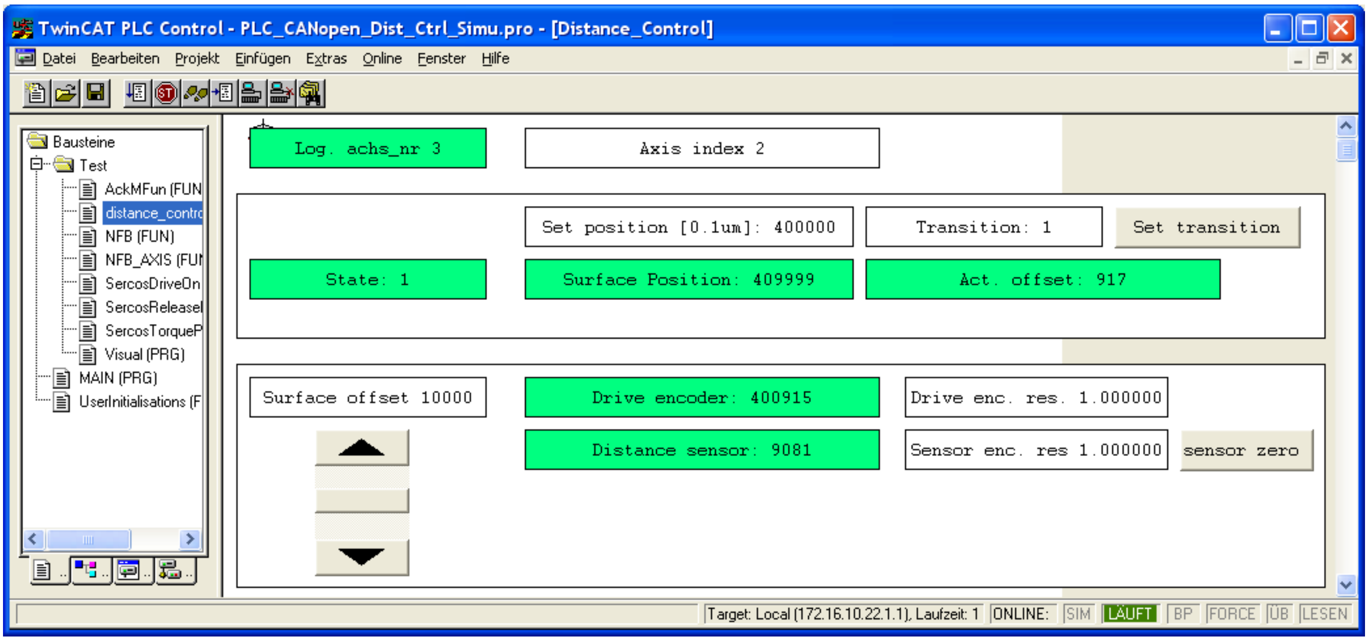


1. Referencing the sensor, “sensor zero”, 2. Entering the set position, 3. Position=400000, 4. Turning on distance control, 5. Transition=1 (ON)

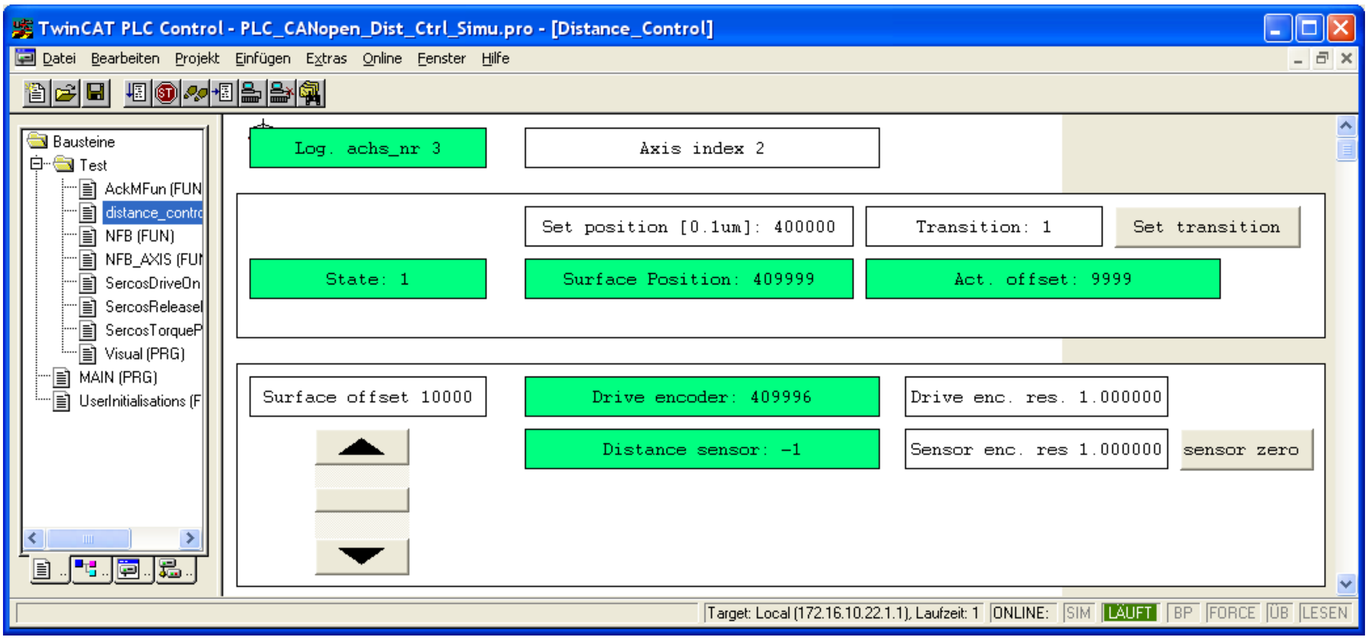
In the transmitted set position (SET_POS) the distance sensor supplies the value = 0.

Changing the surface position “Surface offset”

The changed surface position results in a change in the measured distance sensor.

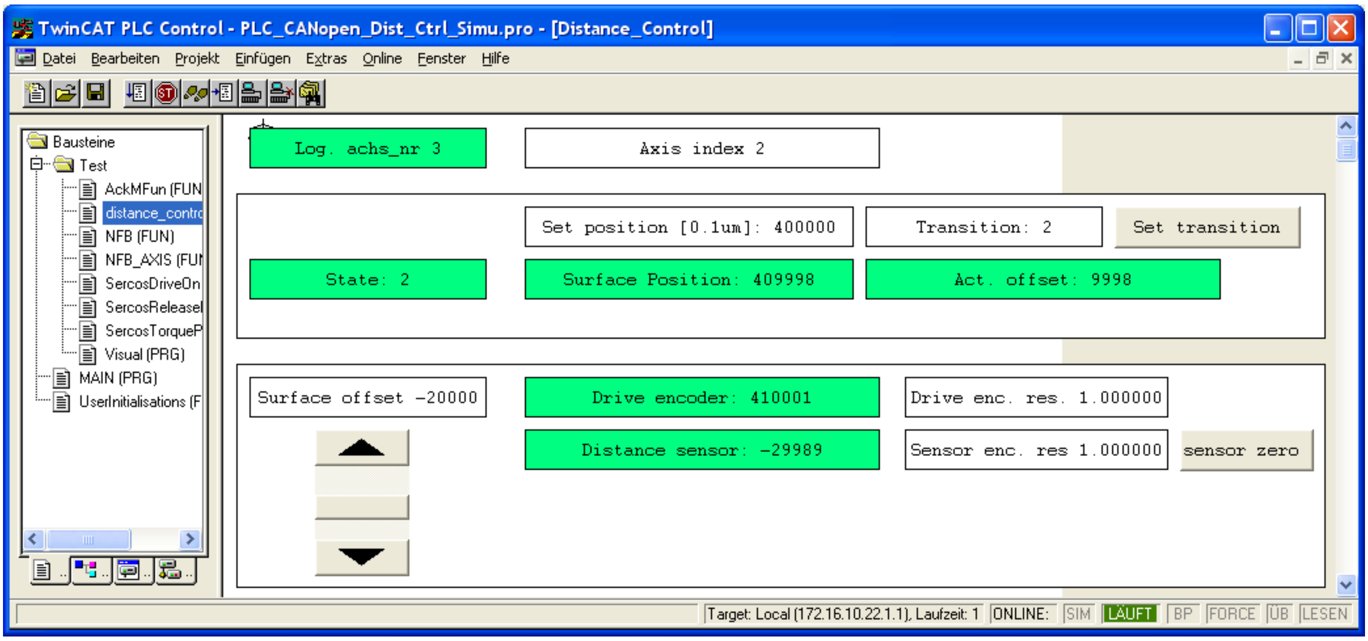


This causes a re-adjustment of the real axis position until the distance sensor supplies the value = 0 again. In other words the desired distance to surface is reached in this case.



“Freezing” of the current height, transition=2 (FREEZE)

If distance control is interrupted (transition = FREEZE = 2), a changed sensor value (–20000) has no influence on axis correction in this time.

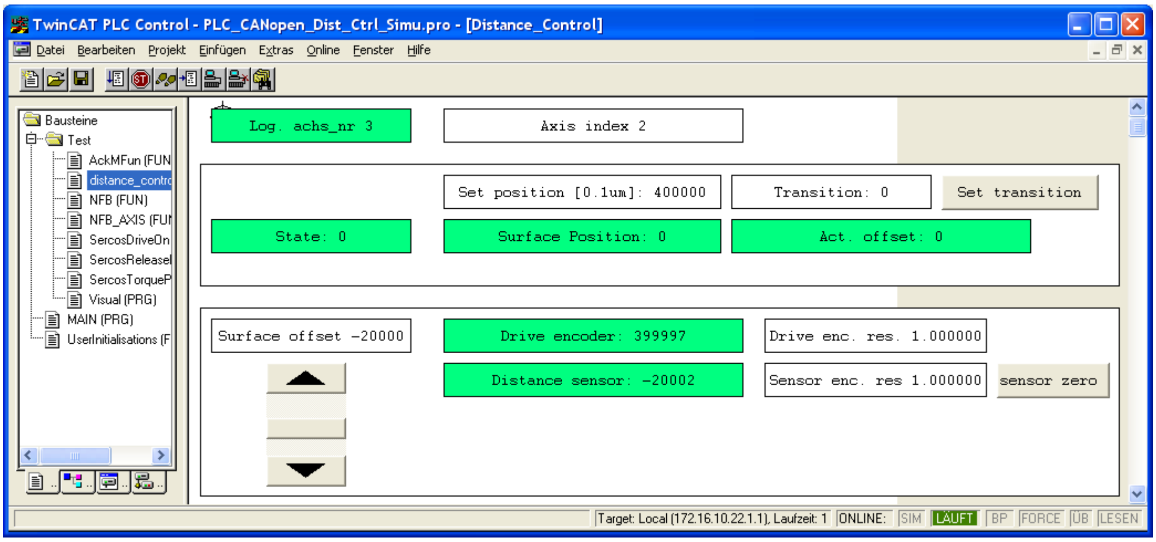


After re-activation of distance control the current sensor value is restored.

Turning off

Transition=0 (OFF)

After deselection of distance control (transition = OFF = 0) the position offset caused by the distance sensor is cancelled.



11 Error messages

The following error messages can occur when distance control is active:

ID 70329	Actual value change of sensor signal greater than limit
ID 70330	Sensor completely run out
ID 70331	Excessive sensing deviation
ID 70332	Distance control still active at program end
ID 70333	Distance control active for axis that is to be specified.
ID 70334	On repeat selection, deselection of distance control not yet complete
ID 70335	Distance control selected without programmed position
ID 70336	Function is not available

12 3D distance control

The license for “Cutting” is required in order to use 3D distance control.

Release Note

This function is available as of V3.1.3080.12 or V3.1.3107.44

Notice

This function is an additional option requiring a license.

If the NC command #DIST CTRL [▸ 96] is programmed for 3D distance control without a license, the NC program is aborted and Error ID 21837 is output.

In principle, kinematic transformation with the appropriate licence is assumed for tool orientation.

Notice

Transformations are additional options and subject to the purchase of a license.

Notice

The number of simultaneous 3D distance controls permitted in an NC channel is limited to one

12.1 Overview of functionality

Use of 3D distance control requires activation by using P-CHAN-00500 [▸ 127].

```
configuration.decoder.function FCT_3D_DIST_CTRL
```

In addition, the kinematic transformation ID98 is required to maintain the TCP constant when the tool is rotated, to monitor the minimum distance and to control the tool direction.
[KITRA// KIN_TYP_98- Transformation to monitor the minimum distance]

12.1.1 Minimum distance

Depending on the tool head geometry, the tool head may collide with the surface when the tool is inclined. As a result, it may be preferable for the tool head not to undershoot a minimum distance (maximum inclination). When the minimum distance is reached, the tool is virtually extended if it is inclined further so that the tool head remains at a constant height and the specified inclination angle can still be maintained.

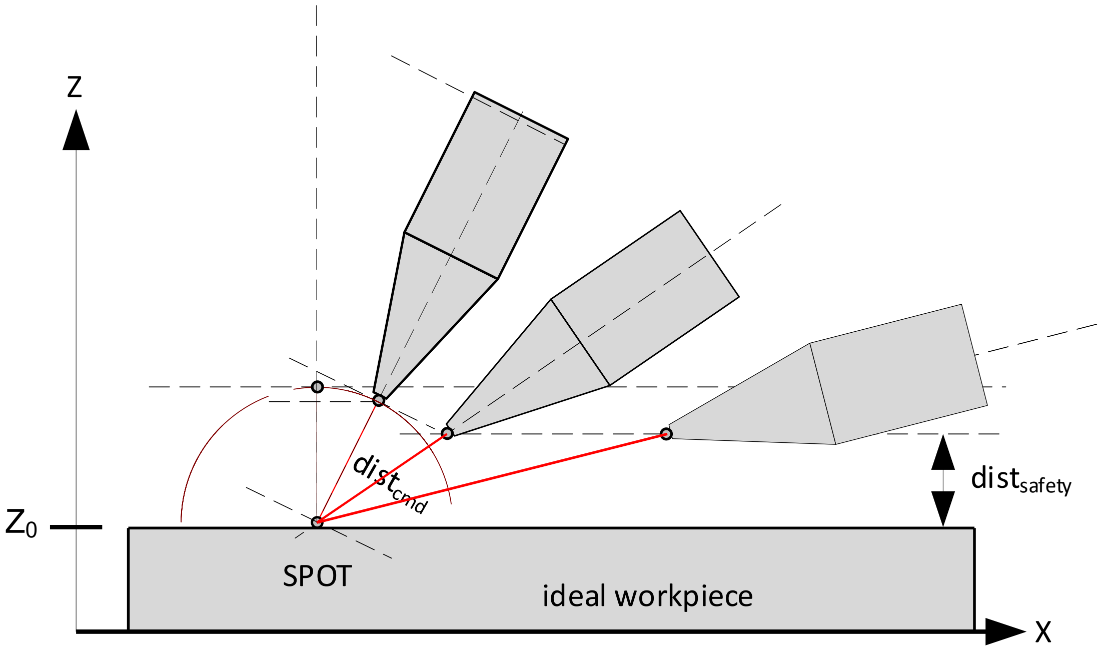


Fig. 37: Minimum tool distance

The tool is virtually extended automatically by monitoring the minimum distance. Therefore, this method is particularly suited for certain types of machining (laser, waterjet, plasma/autogenous cutting). The change in tool length is displayed on the PLC interface (Virtual tool length [▸ 114]) in order to adjust the process (e.g. laser focus point) as required.

12.1.2 Constant tool centre point

The programmed tool centre point (TCP) is kept constant by kinematic transformation when the tool is inclined. The resulting reduction in orthogonal distance to the tool surface is automatically included in 3D distance control.

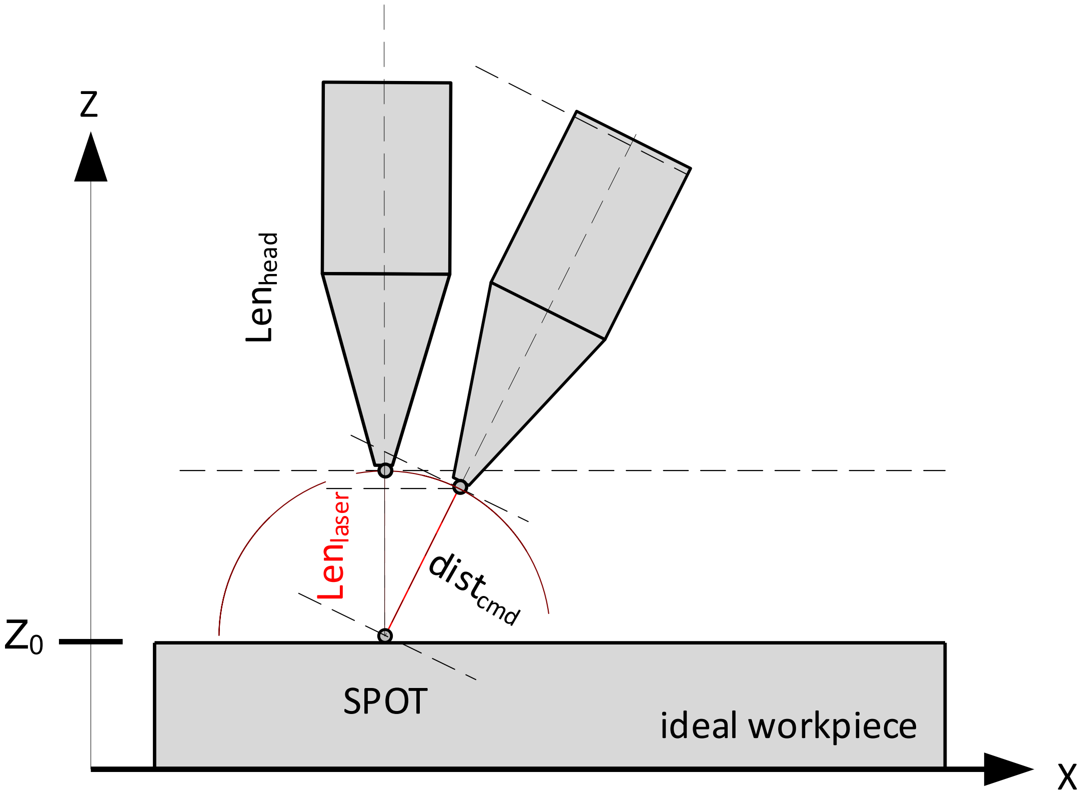


Fig. 38: Constant tool centre point

Distance control is activated and deactivated in the NC program.

Notice

The distance control set distance must be identical to the tool length for kinematic transformation.

Tool length = set distance

Therefore, kinematic transformation can plan all movements within the dynamic conditions. Any deviation from this, e.g. due to height adjustment, will result in additional dynamic stress. In general, distance control can be modified online via the PLC interface, but kinematic transformation can then no longer be taken into account.

12.1.3 Compensation for real workpiece surface

If the actual workpiece surface deviates from the assumed, theoretically ideal surface position, it is compensated for by distance control.

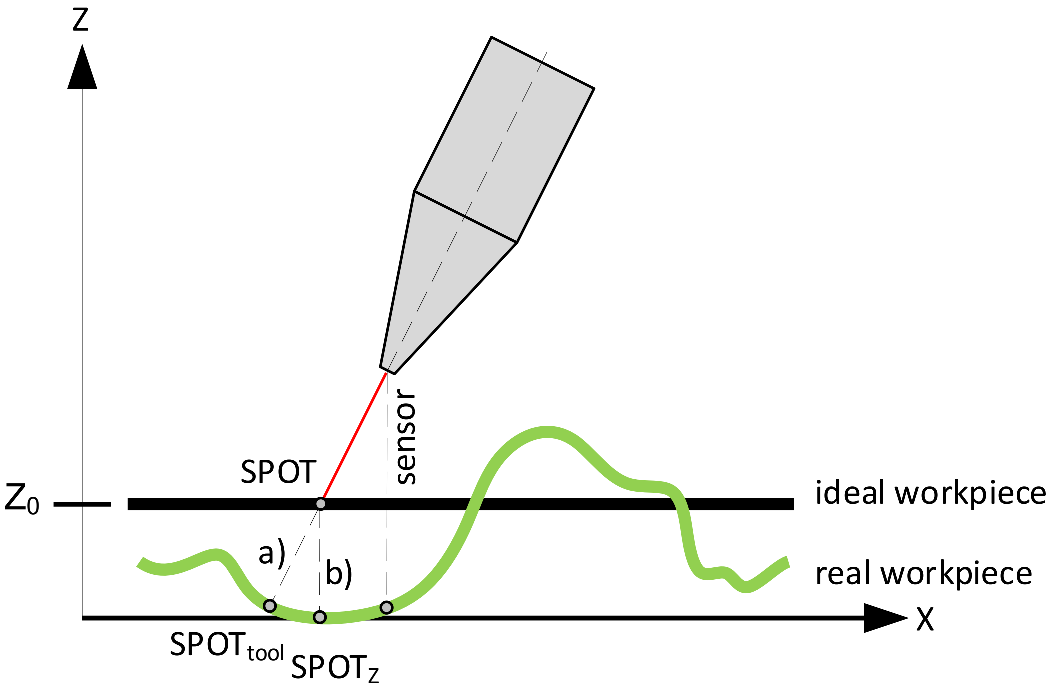


Fig. 39: Real workpiece surface

Compensation of the deviation can basically take place in two modes:

1. in the tool direction
2. orthogonal to the surface

Compensation in tool direction

In this mode, the cutting curve orientation is maintained despite the height offset. This is essential for a (pipe) feedthrough, for example.

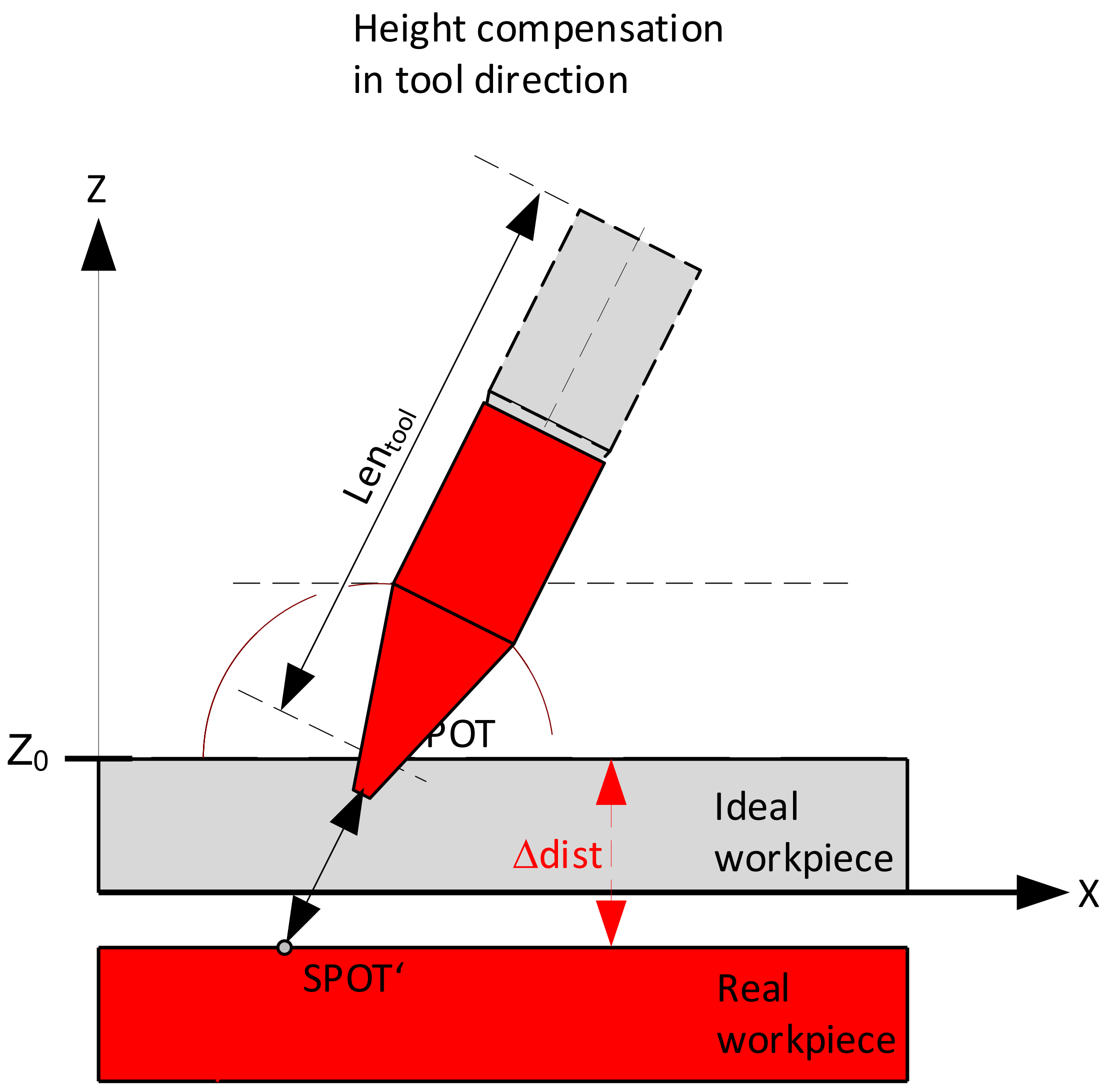


Fig. 40: Compensation for a deviation in tool direction

Compensation orthogonal to the surface

In this mode, the projection (top view) of the machining operation remains identical, i.e. the shape is not distorted but only offset in height. Projection in X/Y remains stationary despite compensation.

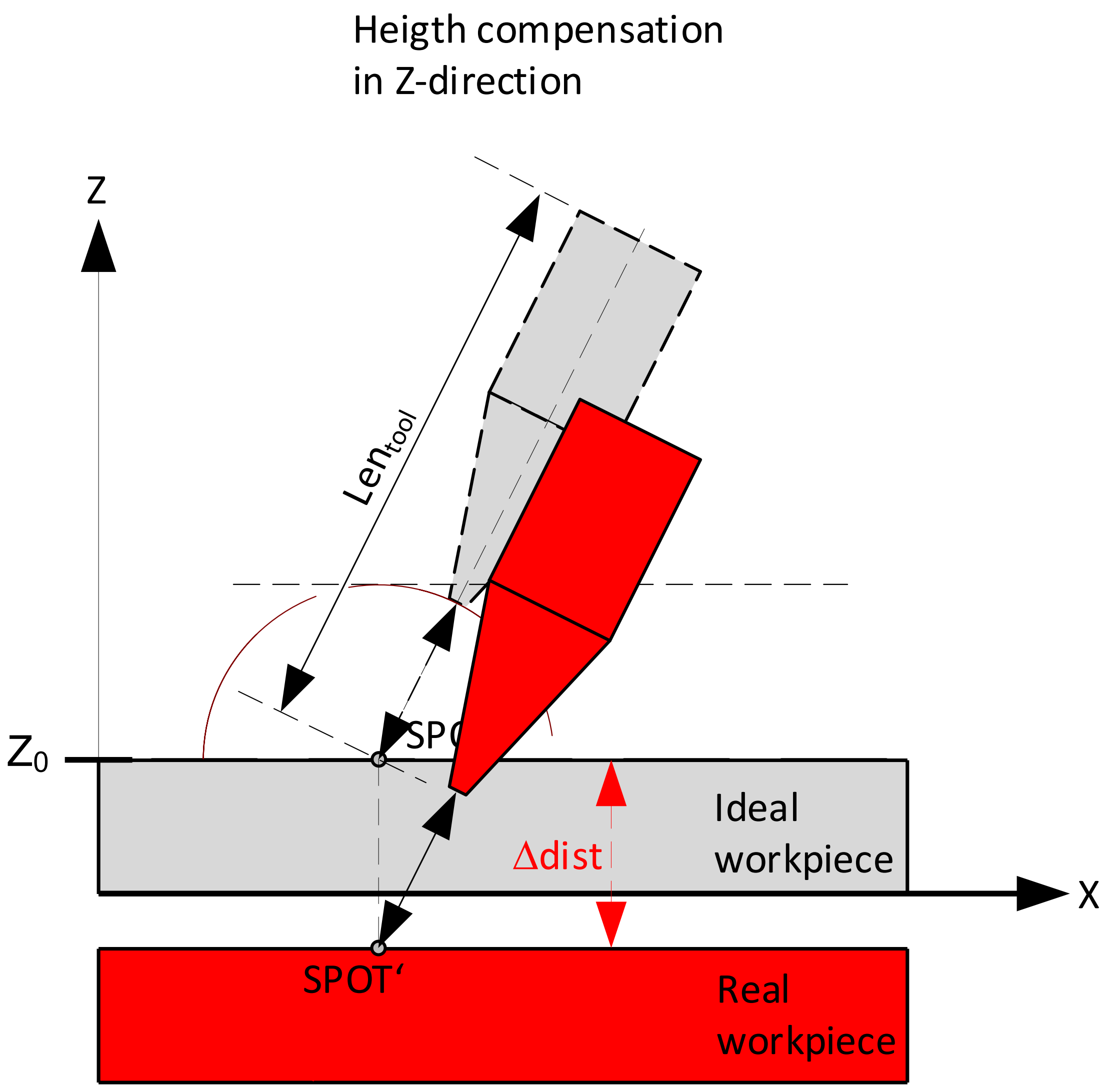


Fig. 41: Deviation compensation orthogonal to the surface

12.2 Programming

`Syntax for Select by specifying the position of the workpiece surface:`

#DIST CTRL [**WAIT**] **ON | DRYRUN [SURFACE** [**SET_POS**=..] **]**

`Syntax for Select by specifying a constant distance to the workpiece surface:`

#DIST CTRL [**WAIT**] **ON | DRYRUN [CONST_DIST** [**SET_DIST**=..] **]**

`Syntax for Deselect:`

#DIST CTRL [**WAIT**] **OFF** [**NO_MOVE**]

`Syntax for Freeze offset:`

#DIST CTRL [**WAIT**] **FREEZE**

`Syntax for Test or reference sensor:`

#DIST CTRL [**WAIT**] **CHECK_POS | REF**

`Syntax for additional parameterisation (optionally, can also be programmed in combination with select/deselect):`

#DIST CTRL [[**MODE=**<*ident*>] [**DIRECTION**=<*axis_name*>] [**KP**=..] [**I_TN**=..] [**D_TV**=..]
[**FILTER_TYPE**=.. **FILTER_TIME=..**] [**N_CYCLES**=..] [**FG_F0**=..] [**ORDER**=..]
[**SMOOTH_FACT**=..] [**KALMAN_SIGMA**=..] [**SENSOR_SOURCE**=<*ident*>]
[**SENSOR_VAR**=..] [**VAL1**=.. - **VAL5**=..] { \ } **]**

WAIT	In the WAIT option, a command waits before execution until distance control is completely activated or deactivated before the next NC command is executed
ON	Activate distance control
SURFACE	Activate distance control in combination with ON by specifying the position of the workpiece surface. A set position at activation must be set with SET_POS.
SET_POS=..	Specify the workpiece surface in [mm, inch] (absolute position). In the event of reset or program end, the set position is reset, i.e. a new set position must be specified before distance control is reactivated.
CONST_DIST	Activate distance control in combination with ON by specifying a constant distance to the workpiece surface. A distance must be set with SET_DIST at activation.
SET_DIST=..	Specify the constant distance to the workpiece surface in [mm, inch]. In the event of reset or program end, the distance is reset, i.e. a new distance must be specified before distance control is reactivated.
DRYRUN	In DRYRUN mode, the axis is not tracked when there are changes in the workpiece surface. This allows data to be evaluated without feedback from the controller (e.g. filter effect). **[as of V3.1.3079.23]** In combination with SURFACE, a set position must be set with SET_POS. In combination with CONST_DIST, a set position must be set with SET_DIST.
OFF	Deactivate distance control.

CHECK_POS	Check whether position is within the tolerance window.
FREEZE	Freeze the compensated control distance across the workpiece. The axis position or the output compensation value is maintained. Axis tracking is interrupted.
REF	Reference measuring system (sensor) (only if there is no absolute measuring system).
MODE=<*ident*>	The distance control offset is superimposed at the appropriate level. Valid identifiers: PCS : Programmed coordinates MCS : In the machine coordinate system (Cartesian basic system) ECS : In the tool direction ACS : At physical axis level OFF : No superposition (DEFAULT) **Note**: An active kinematic ID98 is required for a compensation motion in ECS. (#KIN ID[98], #TRAFO ON)
DIRECTION=<*axis_name*>	Name of the axis to which PCS/MCS/ACS compensation is applied. At present, DIRECTION = Z is supported (DIRECTION=X/Y are in preparation.)
KP=..	Weighting the distance control output values. Parameterisation can be executed analogous to P-CHAN-00821 [▸ 134]. The value range is limited to 0.0 < KP <= 2.0. For KP values less than 1.0, the distance control dynamics are reduced; for KP values greater than 1.0, the dynamics are increased. A KP factor less than 1 reduces a possible distance control oscillation and steadies control in the event of minor distance errors.
I_TN=..	Integral action time of the PID controller in [s]. The integral action time defines the time after which the P and I components of the manipulated variable are equal. Parameterisation can be executed analogous to P-CHAN-00822 [▸ 134]. The value range is limited to 0.0 <= I_TN <= 50.0. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. A short integral action time excites oscillations more strongly.
D_TV=..	Derivative action time of the PID controller in [s]. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. Parameterisation can be executed analogous to P-CHAN-00823 [▸ 135]. The value range is limited to 0.0 <= D_TV <= 2.0. The larger the derivative action time, the stronger the D component.
FILTER_TYPE=..	Filter type to filter sensor values according to P-CHAN-00825 [▸ 135].
FILTER_TIME=..	If a value > 0 is specified, distance control activation and deactivation are smoothed by a $\sin^2$ filter. The filter time is specified in interpolator cycles.
N_CYCLES=..	Number the measured values used for filtering according to P-CHAN-00800 [▸ 127].
FG_F0=..	Cut-off frequency for the low-pass filter in [Hz] according to P-CHAN-00817 [▸ 133].
ORDER=..	Order of the low-pass filter according to P-CHAN-00816 [▸ 132].
SMOOTH_FACT=..	Smoothing factor of the exponential averaging filter according to P-CHAN-00827 [▸ 136]. Specifies the weighting of the current measured value.
KALMAN_SIGMA=..	Uncertainty of the included measured values according to P-CHAN-00826 [▸ 136].
SENSOR_SOURCE=<*ident*>	Sensor signal source specified The following sources can be set for channel-specific distance control: DEFAULT : If “DEFAULT” is selected as the sensor source, the CNC automatically sets to the “VARIABLE” sensor source internally. VARIABLE : The sensor signal is transferred to the CNC by a V.E. variable. In addition, the name of the V.E. variable must also be specified by the parameter “SENSOR_VAR”.

SENSOR_VAR=..	Name of the V.E. variable which transfers the sensor signal to the CNC.
NO_MOVE	By default, the resulting correction offset is executed when distance control is switched off. This motion can be suppressed by specifying NO_MOVE in combination with OFF. The channel is initialised with the changed axis position. The position offset is only executed at the next axis motion programmed in the NC program.
VAL1=..-VAL5=..	Five freely assignable values in real format.
\	Separator ("backslash") for clear programming of the command over multiple lines.

Programing Example

Use of axis-specific distance control with inclined tool

Example 1 - Behaviour as for axis-specific distance control

```
N010 G0 Z10
;Set the sensor input source
N020 #DIST CTRL [SENSOR_SOURCE=VARIABLE SENSOR_VAR=V.E.SENSOR]
;Activate distance control
N030 #DIST CTRL ON [CONST_DIST SET_DIST=1 MODE=ACS DIRECTION=Z]
;...
;Deactivate distance control with no wait Next block is executed immedi-
ately.
N900 #DIST CTRL OFF
N910 G0 Z0
N999 M30
```

Example 2 - Distance control with inclined tool and kinematic ID 98

```
; Parameterising the kinematic 98
: ---------------------------------
; HD1: Tool offset (100mm)
; HD2: Start limit angle (inclination to the perpendicular) Start of
tool extension (30°)
; HD3: End limit angle (inclination to the perpendicular) End of tool
extension (60°)
; HD4: maximum inclination -> error message (91°)
N010 V.G.KIN_STEP[1].ID[98].PARAM[0] = 1000000
N020 V.G.KIN_STEP[1].ID[98].PARAM[1] = 300000
N030 V.G.KIN_STEP[1].ID[98].PARAM[2] = 600000
N040 V.G.KIN_STEP[1].ID[98].PARAM[3] = 910000
; tool length (80mm)
N050 V.G.WZ_AKT.L = 80

; activate kinematic transformations ID9 and ID98.
N060 #KIN ID[9.98]
N070 #TRAFO ON
N080 G0 Z10
N090 G90 A=-45
; Set the sensor input source
N100 #DIST CTRL [SENSOR_SOURCE=VARIABLE SEN-SOR_VAR=V.E.SENSOR]
; Activate distance control in tool direction (surface 1mm)
N110 #DIST CTRL ON [SURFACE SET_POS=1 MODE=ECS DIRECTION=Z]
;...
; Deactivate distance control and wait until the deactivation process is
completed.
N120 #DIST CTRL WAIT OFF
N130 G0 Z0
```

```
N140 M30
```

12.3 CNC and PLC tasks

The various functions are activated and deactivated in the NC program

- kinematic transformation
- Monitoring the minimum distance for collision avoidance
- Activate/deactivate distance control at the set distance $dist_{beam}$

The PLC assumes the supply of the idealised sensor value. The actual sensor value is normalised accordingly.

The PLC must remove non-linear dependencies from the sensor value. Example: dependencies

- on the inclination angle
- of tool head geometry
- Temperature
- or material dependencies

The PLC supplies the actual orthogonal distance of the tool clamping point (laser exit point) from the surface as a sensor value.

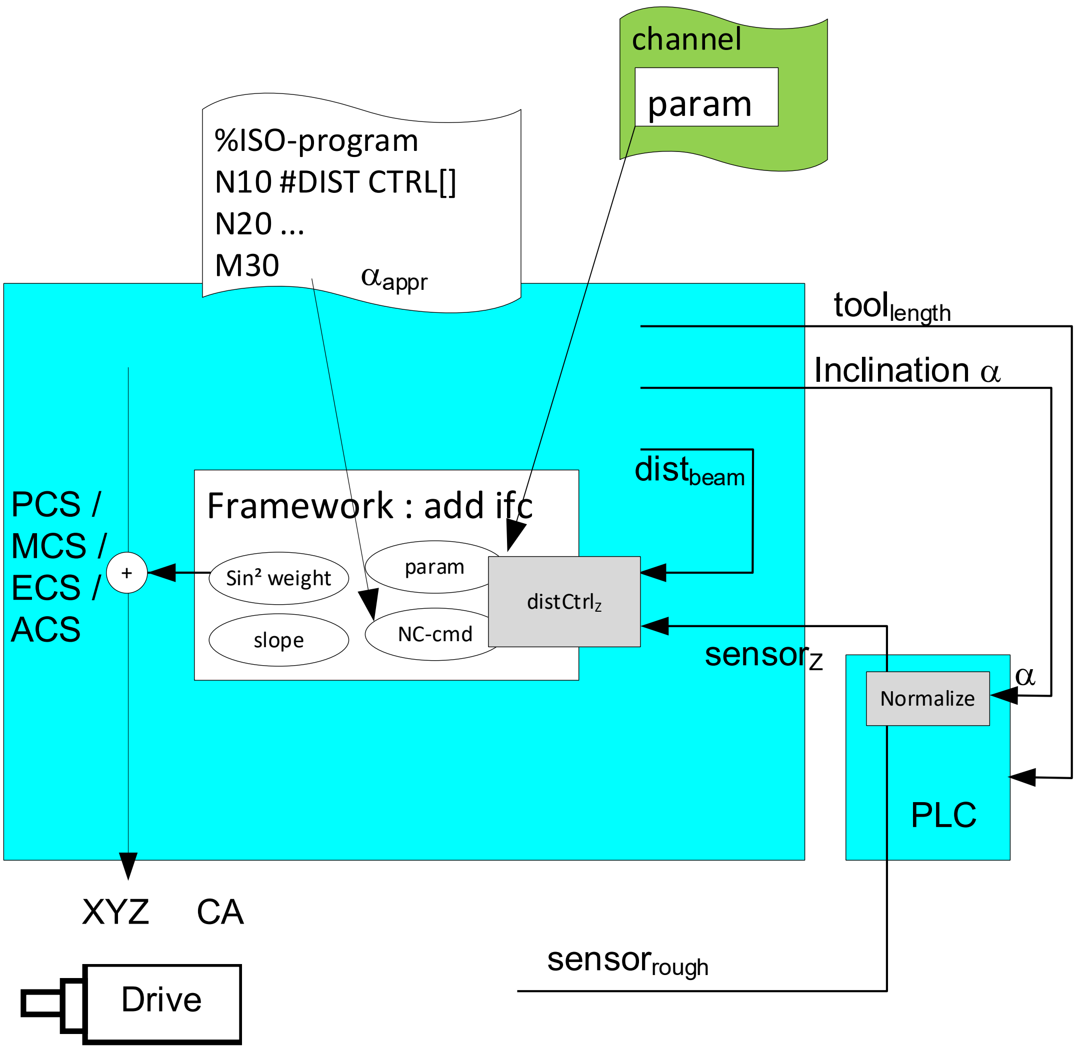


Fig. 42: CNC and PLC tasks

12.4 Properties, function

12.4.1 Tool centre point and compensation motion

The kinematic transformation holds the tool centre point constant in relation to the surface when the tool is inclined. The CNC executes any necessary compensation motions automatically. The dynamic axis limits are taken into account.

The following applies to a tool that is not initially inclined:

tool length = laser length = tool distance

Distance control takes into account a reduction in the orthogonal distance of the tool head due to inclination. The capacitive sensor specifies the orthogonal distance of the tool head (tool clamping point) from the surface.

Depending on the tool head geometry and if the tool is inclined, another point may be closer to the workpiece instead of the tool clamping point. However, the PLC specifies the distance of the tool clamping point (laser exit) as the idealised sensor value.

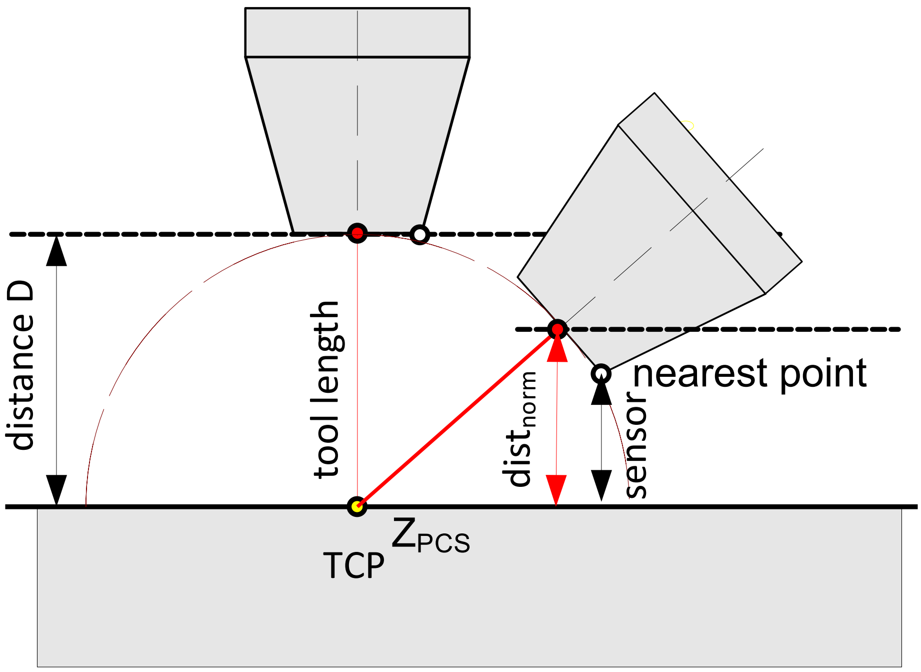


Fig. 43: Distance to the workpiece surface

12.4.2 Monitoring the minimum distance using kinematic ID 98

Depending on the tool head geometry and if the tool is inclined, the tool head may undershoot the minimum distance or even collide with the surface.

As a result, it may be preferable for the tool head not to undershoot a minimum security distance. If the minimum distance is reached and if the tool continues to be inclined, it is virtually extended for kinematic transformation so that the tool head remains at a constant height (Phase 2). Monitoring the minimum distance is then executed by a preceding kinematic transformation ID 98 (see also Documentation of multi-step kinematic transformations). The required limit angles can be specified in the kinematic transformation parameters.

Phase 1: As long as the minimum distance is not reached, the tool length (tool clamping point = tool centre point = laser beam length) remains constant when the tool is inclined.

Phase 2: When the minimum security distance is reached, the height of the tool clamping point is maintained constant. This corresponds to an extension of the tool, which is normally only possible automatically with laser beam machining. The actual effective tool length is displayed on the PLC interface to adjust the process (e.g. laser focus point).

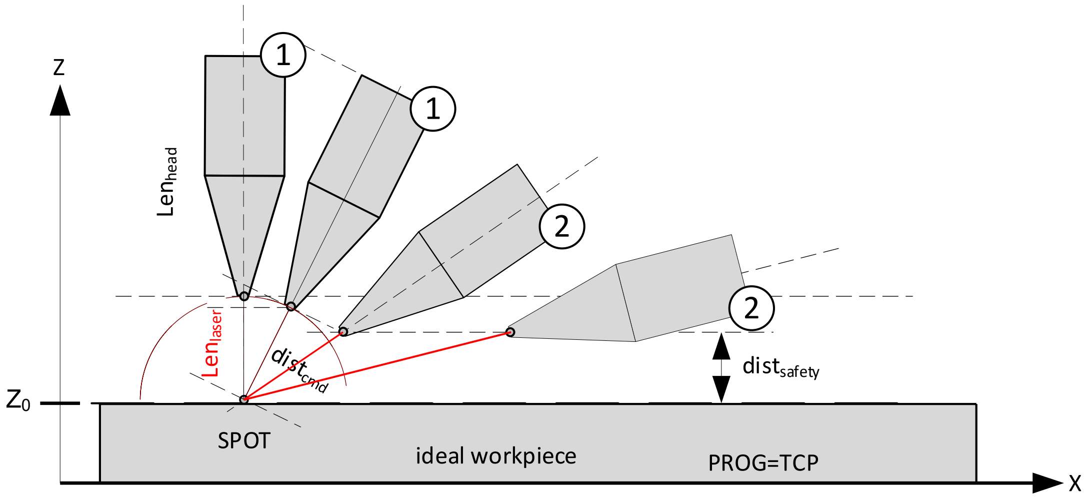


Fig. 44: Monitoring the minimum distance

When inclination compensation is activated in the NC program, a number of different angles can be defined. These parameters are set as Kinematic 98 parameters.

- Maximum inclination angle starting at which the tool is virtually extended.
- Angle at which tool extension deactivated.
- Maximum inclination angle. Further inclination results in an error message with program abort.

Offset data of kinematics

HD offset	param[i]	Description	Unit
HD1	0	Tool clamping point offset up to tool head reference point	1.0 E-4 mm
HD2	1	Inclination angle starting at which the distance of the tool head to the surface is kept constant.	1.0 E-4°
HD3	2	Maximum inclination angle starting at which the distance of the tool head to the surface is kept constant.	1.0 E-4°
HD4	3	Maximum inclination angle. When exceeded, an error message is output with process abort.	1.0 E-4°

12.4.2.1 Example: Inclination of tool via CA kinematic

The example below shows the effect of height monitoring at a tool head inclination of 90°. The red area visualises the original “penetration of the laser beam” into the workpiece. The blue line describes the height of the tool head (laser exit point) when the tool is inclined.

No compensation: No tool head height compensation here.

With compensation: starting at the specified angle, the tool head is maintained at a constant height.

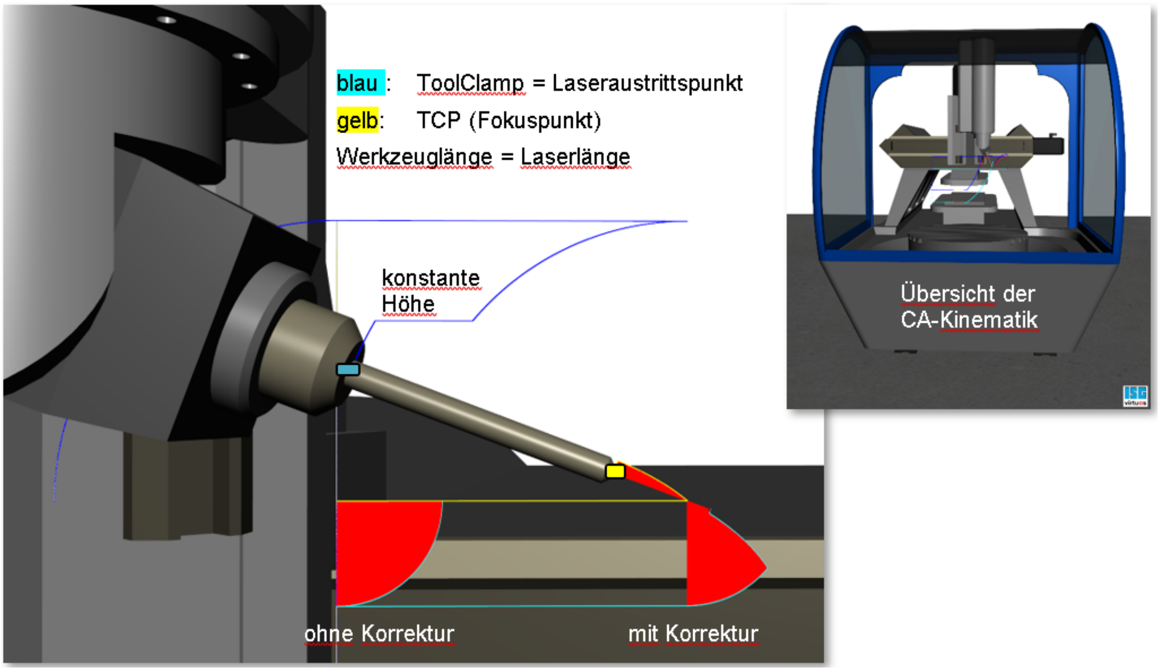


Fig. 45: Inclination of tool via CA kinematic

The required distance monitoring parameters (Kinematic ID 98) are entered in the NC program:

```
;DistCtrl-OnOff.nc
; 80 mm tool length
N100 V.G.WZ_AKT.L = 80

; HD1 geometric tool head offset
N200 V.G.KIN_STEP[1].ID[98].PARAM[0] = 1000000
; inclination angle starting at which tool head is maintained constant
N210 V.G.KIN_STEP[1].ID[98].PARAM[1] = 500000
; max. inclination angle up to which the distance is maintained
; constant
N210 V.G.KIN_STEP[1].ID[98].PARAM[2] = 700000
; max. inclination angle starting at which an error is output
N210 V.G.KIN_STEP[1].ID[98].PARAM[3] = 910000

N220 #TRAFO [ 9, 98]
N240 G01 A90 F10
```

12.4.2.2 Example: Monitoring the minimum distance with different orientations in the plane

In this case, minimum distance monitoring is not dependent on orientation in the plane (C axis orientation). This is shown in the example below by various rotations in the plane with the subsequent tool inclinations.

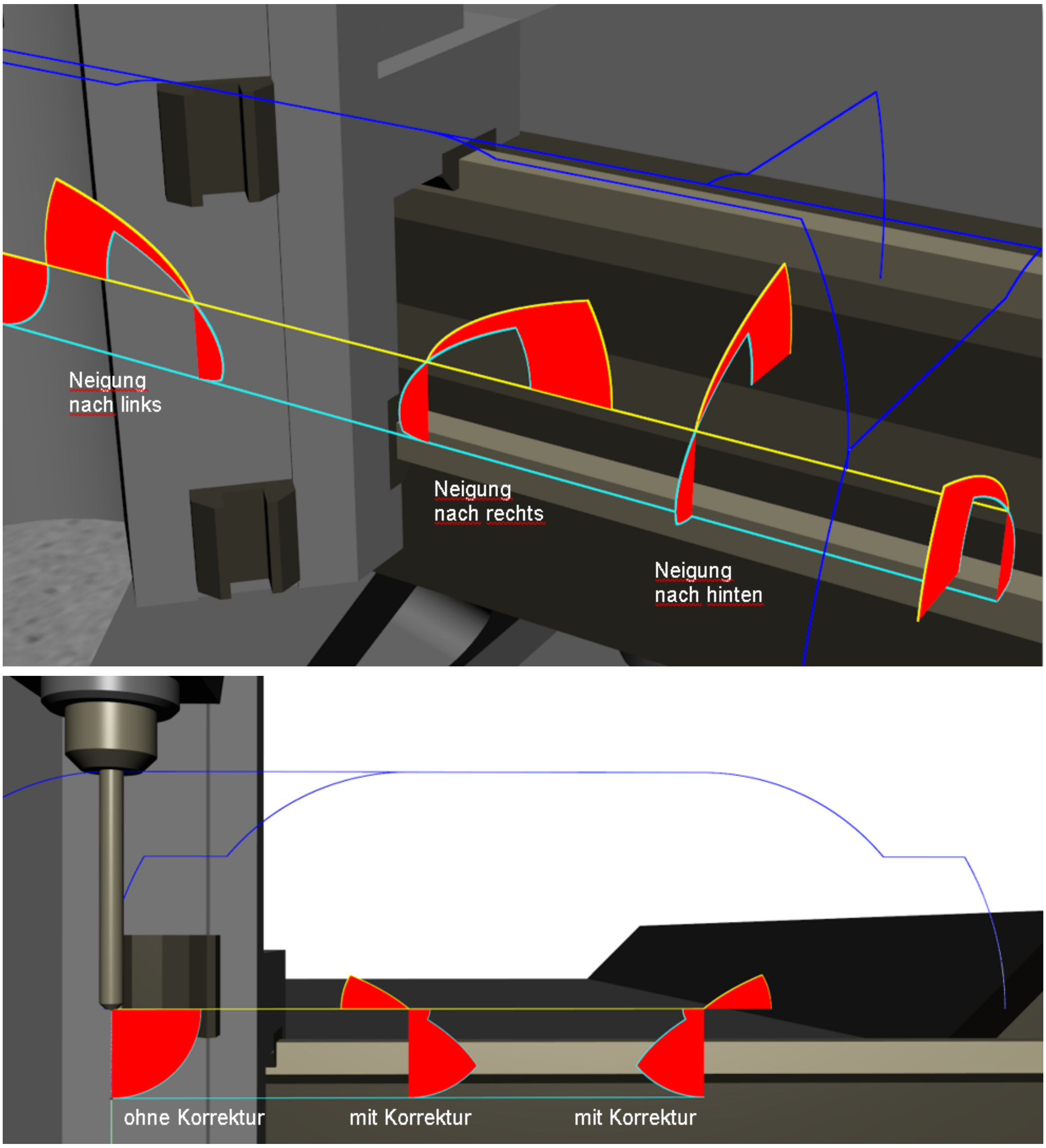


Fig. 46: Minimum distance monitoring

12.4.3 Compensation for real workpiece surface

Distance control compensates for deviations between the actual workpiece surface and the theoretically assumed surface.

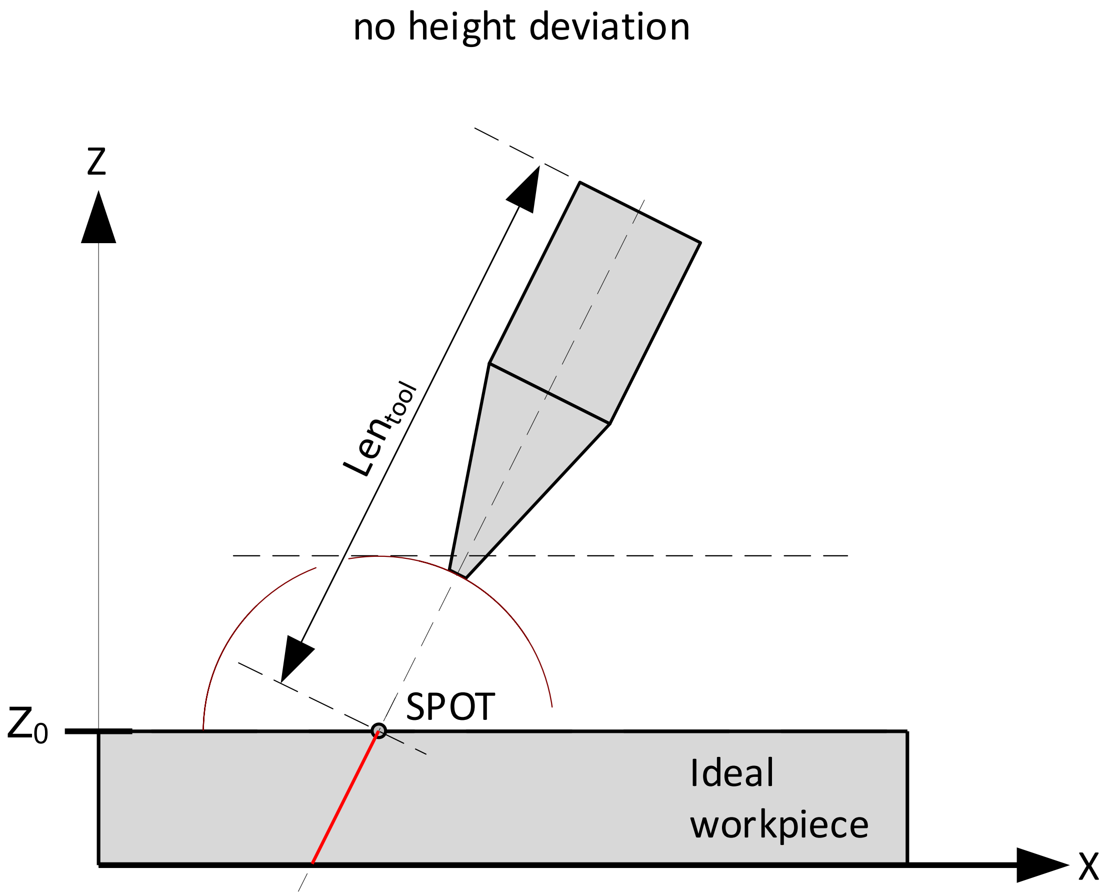
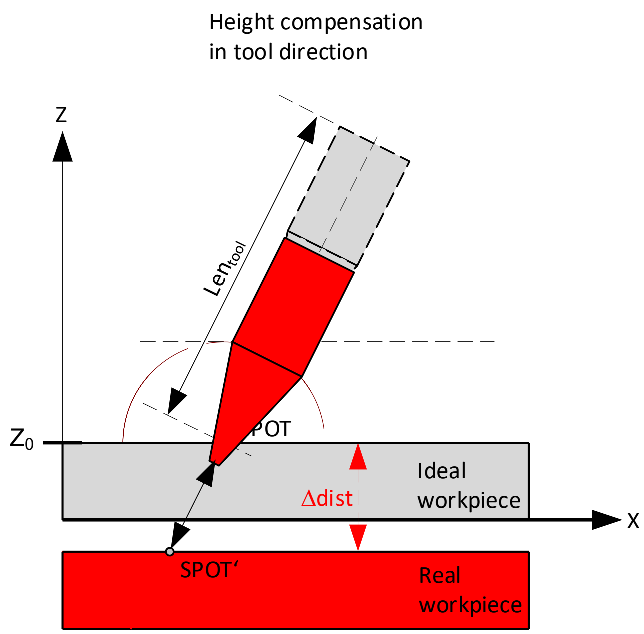


Fig. 47: Compensation for ideal workpiece surface

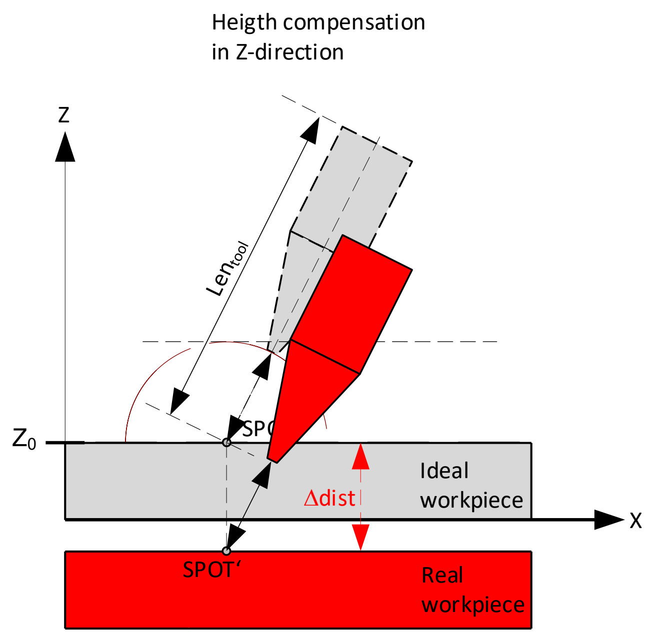
There are two different options for compensation. Depending on the application, they are selectable in the NC program when distance control is activated.

1. In tool direction (mode = ECS): Height deviation is compensated by tracking the tool head in the tool direction. In this mode, the cutting curve orientation is maintained despite the height offset. This is essential for a (pipe) feedthrough, for example.
2. Orthogonal to tool surface (mode = MCS): A height deviation is compensated by tracking the tool head orthogonally to the surface. In this mode, the projection (top view) of the machining operation remains identical, i.e. the shape is not distorted but only offset in height.

Tool direction



Orthogonal to tool surface



12.4.3.1 Example: Compensation in tool direction

In the example below, a static offset is applied to the original contour by 3D distance control and compensates for this in the tool direction. The area shown shows the penetration of the laser beam into the workpiece.

- Grün : programmierte Kontur
- Rot : Kontur mit Offset

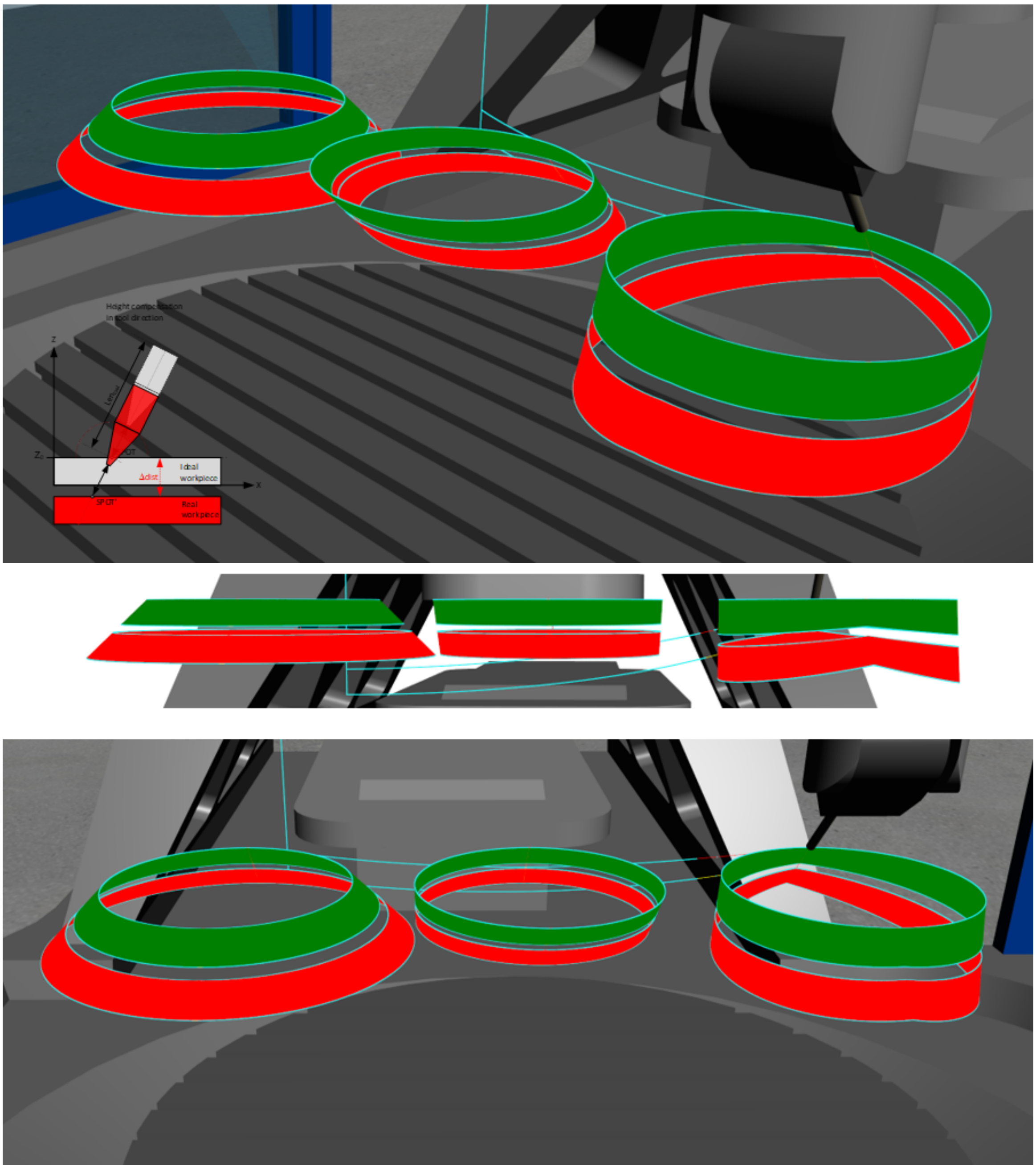


Fig. 48: Compensation in tool direction

12.4.3.2 Example: Compensation orthogonal to the surface

The example shows compensation of the height offset orthogonally to the workpiece surface, i.e. in Z direction.

- Grün : programmierte Kontur
- Rot : Kontur mit Offset

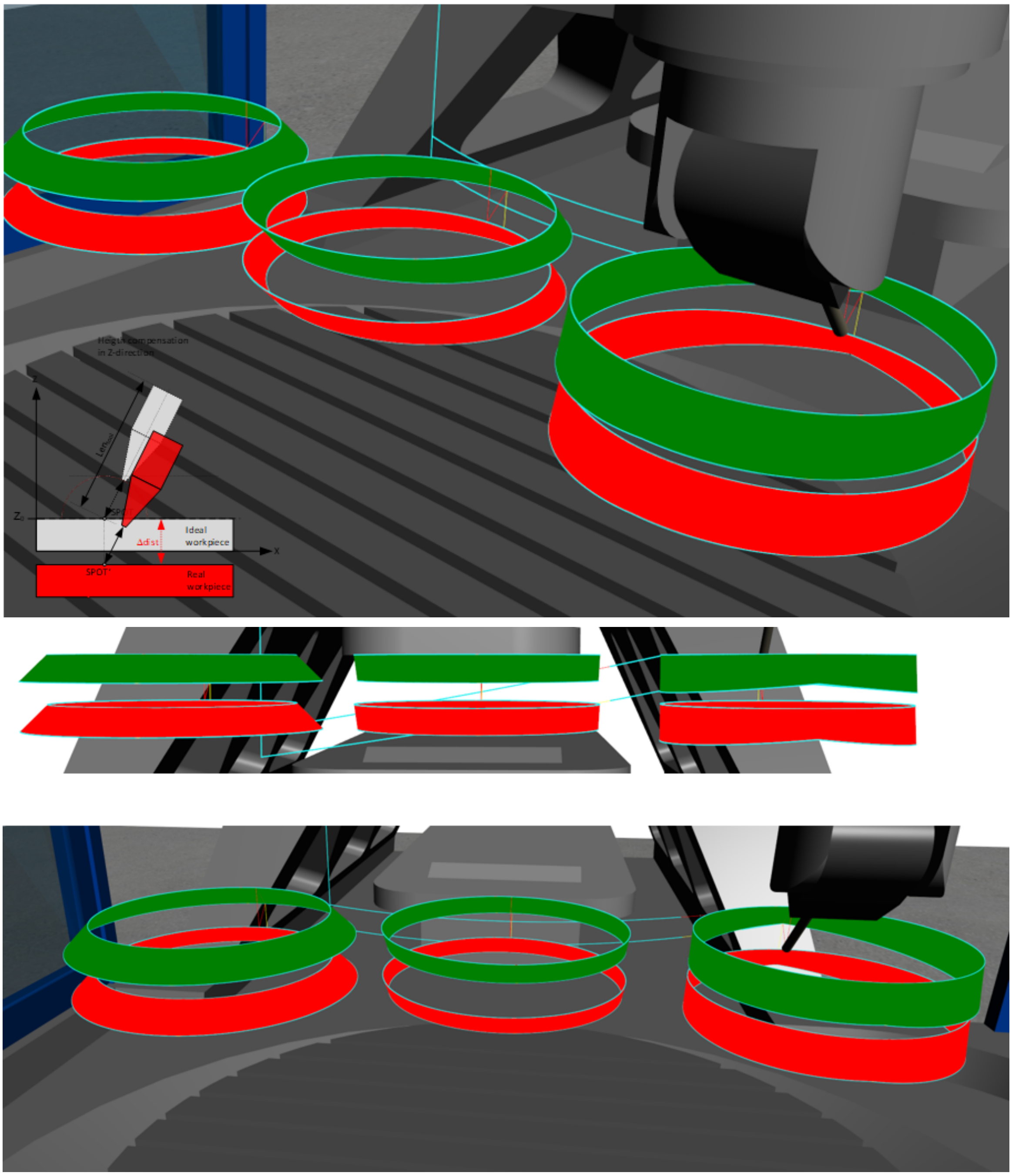


Fig. 49: Compensation orthogonal to the surface

12.4.3.3 Example: Robot

Distance control can be used with different kinematics (see also the “Introduction” chapter, Kinematics 5 to 10, Robot 45, Universal 91, Coupling 210, 96)

These kinematics are used for tool orientation.

Below, distance control is used with a robot kinematic (Kinematic ID 45).

In this application example, the workpiece was inclined by 30° (PCS system). The orientation/programming of the tool was executed by the robot kinematic (Kin 45) The sensor deviation was simulated by a sinusoidal oscillation and the tool described a circle with phase advance. A short waiting time was added at the quadrant transitions to illustrate the effect of compensation more clearly. The various colours show the different compensation orientations.

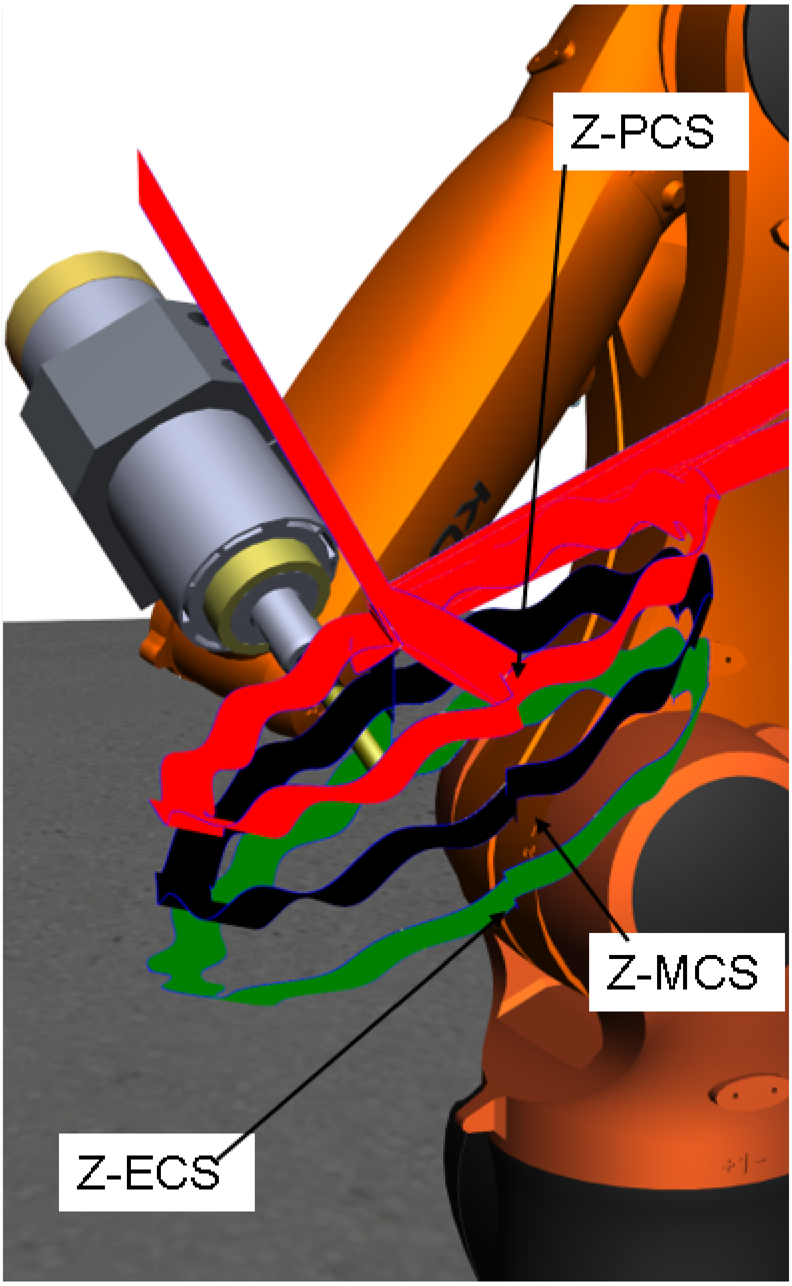


Fig. 50: Robot example

12.4.4 Activating/deactivating, behaviour at reset, program end

If offset values are still present when distance control is deactivated, you can define how to proceed with them:

- The values remain as a static offset. The next path motion starts from this changed position.
- The offset values are first reset to ZERO. The next path motion starts from the original unchanged position. Before continuing, you can wait to see whether the offset values are completely reset (option = WAIT) or whether the offset values are removed "on the fly" when continuing.

When the controller is reset, the program stops within the dynamic limits. The previous offset due to distance control is retained, i.e. no further sensor changes are carried out.

The previous offset is also retained at program end, analogous to a reset, Further sensor changes have no effect after program end.

You can specify whether the current offset is retained (NO_MOVE) or reset to zero (default) by deactivating the #DIST CTRL [OFF] command in the NC program.

Example

Activating/deactivating distance control

```
;DistCtrl-OnOff.nc
;------------------- NO_MOVE
N200 Y40
…
N220 #DIST CTRL WAIT [ON SET_POS=10]
N230 Y60
#TIME 71
N240 #DIST CTRL WAIT [OFF NO_MOVE]
N250 Y70
…
;------------------- MOVE
N420 #DIST CTRL WAIT [ON SET_POS=10]
N430 Y160
#TIME 71
N440 #DIST CTRL WAIT [OFF]
```

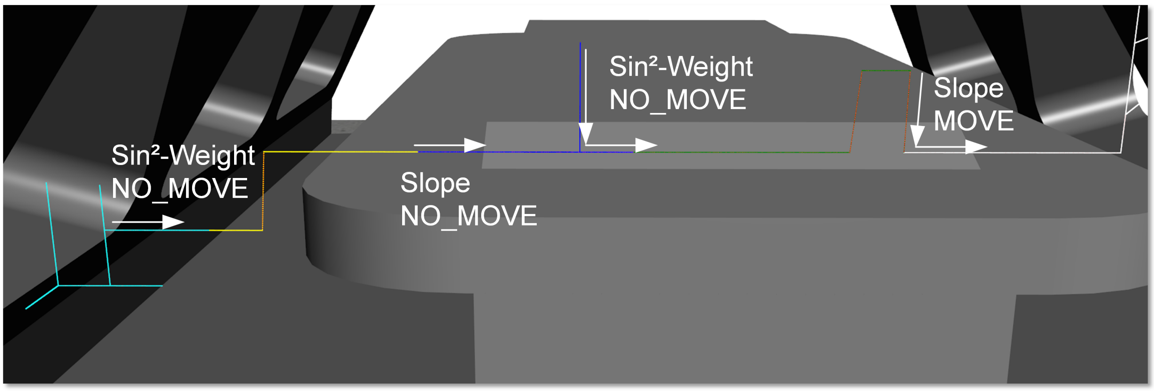


Fig. 51: Different deactivation options

12.4.5 Restrictions - compatibility with other functions

You can only re-initialise the channel position when 3D distance control is deactivated. This means that, before using functions that cause an update in the channel position, you must deactivate 3D distance control.

Example of the functions affected:

- #CS - change Cartesian transformation
- #TRAFO – change kinematic transformation
- #CHANNEL INIT - explicit position synchronisation

If this is ignored, Error ID 51062 is output and NC program processing is aborted.

12.5 PLC interface (status information of a channel)

At present, there is no channel-specific control unit for 3D distance control since the NC program currently handles control:

The following value are displayed on the HLI (PLC interface) so that the PLC can adapt the focus point or normalise the sensor:

- tool inclination angle α
- current (virtually extended) tool length; this means the distance between the laser exit point and laser focus point

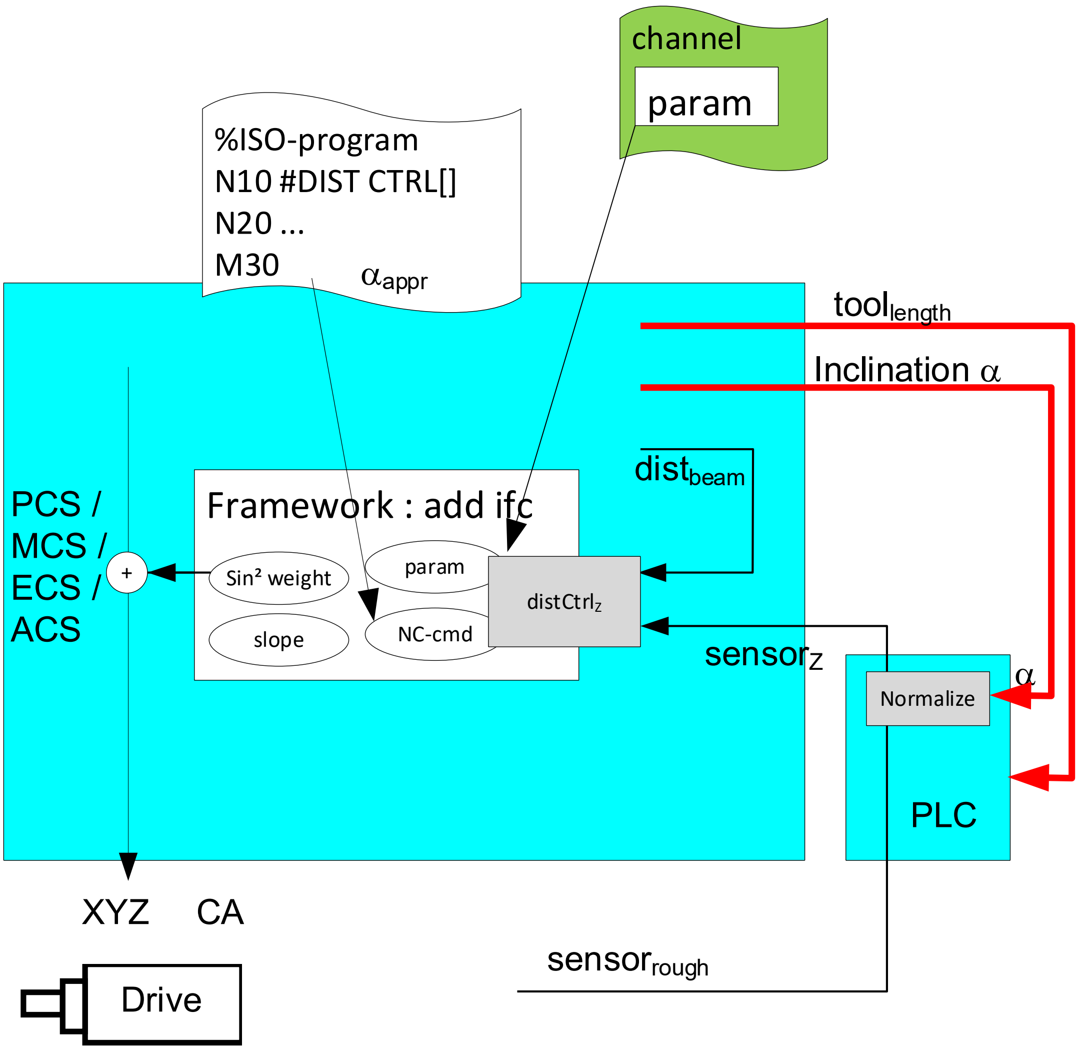


Fig. 52: Link to PLC

Virtual tool length	
Description	Virtual too length This length consists of the actual length of the tool and the extension caused by monitoring the inclination angle.
Signal flow	CNC → PLC
ST path	gpCh[*channel_idx*]^.bahn_state.**virt_tool_length_r**
Data type	DINT
Unit	0.1 µm
Access	PLC reads
Special feature	If, in addition to kinematic transformation, collision avoidance is activated by the 2nd kinematic step 98, the adapted tool length (virtual tool length) is displayed. This avoids the tool head from approaching any closer to the workpiece. This length corresponds to the actual distance between the laser exit and the laser focus point on the workpiece.

Tool inclination angle	
Description	Current inclination angle of the tool.
Signal flow	CNC → PLC
ST path	gpCh[*channel_idx*]^.bahn_state.**inclination_r**
Data type	DINT
Unit	0.0001 °
Access	PLC reads
Special feature	If, in addition to kinematic transformation, collision avoidance is activated by the 2nd kinematic step 98, the current inclination angle is displayed.

12.6 CNC objects 3D distance control

When you start up 3D distance control, it is useful to record some values, e.g. using the ISG Object Browser.

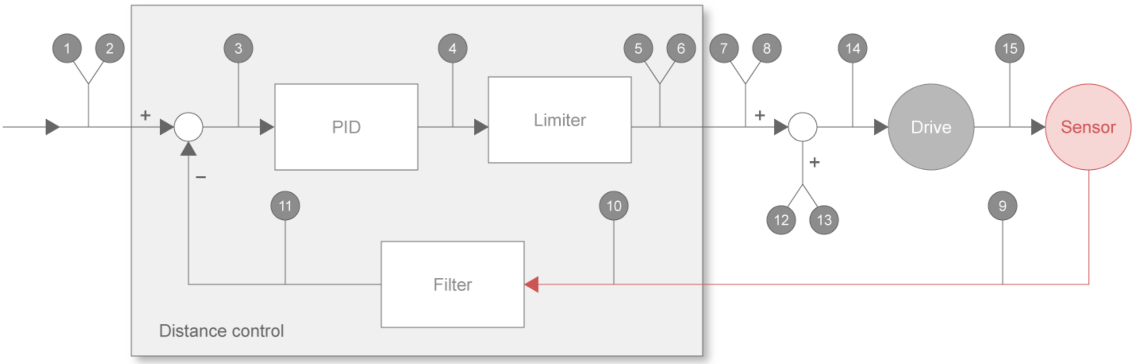


Fig. 53: CNC objects in position control loop for 3D distance control

Number	Name of the CNC object
1	DIST_CTRL[0]::set_pos [▸ 117]
2	DIST_CTRL[0]::set_distance [▸ 117]
3	DIST_CTRL[0]::target_deviation [▸ 121]
4	DIST_CTRL[0]::delta_deviation_pre_limiter [▸ 122]
5	DIST_CTRL[0]::m_actual_offset [▸ 116]
6	DIST_CTRL_IFC[0]::sloped_delta_deviation [▸ 116]
7	DIST_CTRL_IFC[0]::actual_offset [▸ 123]
8	DIST_CTRL_IFC[0]::delta_offset [▸ 123]
9	DIST_CTRL[0]::sensor_value [▸ 122]
10	DIST_CTRL[0]::feedback_value [▸ 121]
11	DIST_CTRL[0]::filtered_feedback [▸ 121]
12	m_sollw_absolut (axis-specific for all axes)
13	sollw_absolut (axis-specific for all axes)
14	dig cmd pos high_res (axis-specific for all axes)
15	dig act pos (axis-specific for all axes)

Channel-specific distance control, also 3D distance control

The number of possible 3D distance control operations in the NC channel is limited to one distance control operation. Therefore, only one access is possible to the objects with DSTCTRL[0].

This function is available as of CNC Build V3.1.3080.12 or V3.1.3107.44.

The channel-specific CNC objects for distance control below are only available if they are configured by Description [▸ 127].

```
configuration.decoder.function FCT_3D_DIST_CTRL
```

Name	DIST_CTRL_IFC[0]::a_max_int		
Description	Maximum acceleration of the linear slope.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3000
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 µm/s²]
Remarks			

Name	DIST_CTRL_IFC[0]::sloped_delta_deviation		
Description	The deviation to be executed in this cycle after being influenced by the slope.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3001
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL[0]::m_actual_offset		
Description	Current offset to the interpolated command position of the drive as specified by distance control.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3100
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL[0]::v_max_int		
Description	Maximum permissible velocity.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3102
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 µm/s]
Remarks			

Name	DIST_CTRL[0]::set_distance		
Description	Set command distance of the tool to the surface.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3103
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	Only effective in “SET_DIST” mode		

Name	DIST_CTRL[0]::set_pos		
Description	Set command value of the workpiece surface.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3104
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	Only effective in “SET_POS” mode		

Name	DIST_CTRL[0]::state		
Description	Current internal state of 3D distance control. 0: IDLE 2: ACTIVE 3: FREEZE 4: OFF 5: OFF_NO_MOVE 6-12: ERROR 15: DRYRUN		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x<3105
Data type	UNS32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::kp		
Description	Weighting the distance control output values. Parameterisation can be executed analogous to P-CHAN-00821 [▸ 134]. The value range is limited to 0.0 < KP <= 2.0. For KP values less than 1.0, the distance control dynamics are reduced; for KP values greater than 1.0, the dynamics are increased. A KP factor less than 1 reduces a possible distance control oscillation and steadies control in the event of minor distance errors. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3106
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[-]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL[0]::i_tn		
Description	Integral action time of the PID controller in [s]. The integral action time defines the time after which the P and I components of the manipulated variable are equal. Parameterisation can be executed analogous to P-CHAN-00822 [▸ 134]. The value range is limited to 0.0 <= I_TN <= 50.0. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. A short integral action time excites oscillations more strongly. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3107
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL[0]::d_tv		
Description	Derivative action time of the PID controller in [s]. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. Parameterisation can be executed analogous to P-CHAN-00823 [▸ 135]. The value range is limited to 0.0 <= D_TV <= 2.0. The larger the derivative action time, the stronger the D component. [as of V2.11.2809.06 or V3.1.3079.06]		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3108
Data type	REAL64	**Length**	8
Attributes	read/ write	**Unit**	[s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL[0]::smoothing_fact		
Description	Currently set smoothing factor of the exponential averaging filter analogous to P-CHAN-00827. Specifies the weighting of the current measured value.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3109
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::kalman_sigma		
Description	Currently set uncertainty of the included measured values analogous to P-CHAN-00826 [▸ 136]. [as of V3.1.3079.23]		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310A
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::n_cycles		
Description	Currently set number of measured values used for filtering analogous to P-CHAN-00800 [▸ 127]. [as of V3.1.3079.23]		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310B
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::skip_dist_ctrl		
Description	Not in use - in preparation		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310C
Data type	BOOLEAN	**Length**	1
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::filter_type		
Description	Active filter type to smooth sensor values. Filter types for smoothing sensor values, see P-CHAN-00825 [▸ 135].		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310D
Data type	STRING	**Length**	30
Attributes	read	**Unit**	[-]
Remarks			

Name	DIST_CTRL[0]::max_dist_change		
Description	Maximum change in sensor values per cycle. Required for the “Kalman_DYN” filter.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310E
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[0.1 µm]
Remarks	Filter not yet available.		

Name	DIST_CTRL[0]::filtered_feedback		
Description	Filtered feedback value.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x310F
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL[0]::feedback_value		
Description	Calculated distance control feedback value. SET_DIST mode: Measured actual distance between the interpolated command position of the drive and the surface. SET_DIST (use_both_encoder) and SET_POS modes: Measured position of the real surface in the selected coordinate system.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3110
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL[0]::target_deviation		
Description	SET_DIST mode: Current difference between the interpolated command position of the dive and the set command distance to the surface. SET_POS mode: Current difference between the measured real surface and the specified command surface.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3111
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	Filtered sensor values are included in this value.		

Name	DIST_CTRL[0]::delta_deviation_pre_limiter		
Description	The distance to be executed in this cycle before being influenced by the limiter. Influenced by the PID controller.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3112
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks	SET_DIST: For kp=1, this is the distance to go between the actual position of the tool and the set command distance to the surface. SET_POS: For kp=1, this is the distance to go to be executed in order to compensate for the difference between the actual position of the tool and the real surface.		

Name	DIST_CTRL[0]::sensor_value		
Description	Return value of the sensor.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3113
Data type	SGN64	**Length**	8
Attributes	read	**Unit**	[0.01 nm]
Remarks			

Name	DIST_CTRL_PARAM[0]::v_max		
Description	The maximum velocity set by P-CHAN-00802 [▸ 128] when a position offset is executed.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3500
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[µm/s]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL_PARAM[0]::a_max		
Description	The maximum acceleration set by P-CHAN-00803 [▸ 128] when a position offset is executed.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3501
Data type	SGN32	**Length**	4
Attributes	read/ write	**Unit**	[mm/s²]
Remarks	The new values only become effective with the following transitions for safety reasons 1. From INACTIVE to ACTIVE state 2. From FREEZE to ACTIVE state		

Name	DIST_CTRL_IFC[0]::actual_offset		
Description	Offset to the interpolated command position of the drive currently output by distance control to the drive.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3900
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

Name	DIST_CTRL_IFC[0]::delta_offset		
Description	Delta currently output to the drive indicating that the cycle must be executed.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x3901
Data type	SGN32	**Length**	4
Attributes	read	**Unit**	[Incr.]
Remarks			

12.7 Error messages

In principle, the same error messages occur with channel-specific distance control and with axis-specific control. They are:

Error ID	Error text
ID 70329 / ID 310018	Actual value change of sensor signal greater than limit
ID 70330 / ID 310019	Sensor completely run out
ID 70331 / ID 310017	Excessive sensing deviation
ID 70332 / ID 310021	Distance control still active at program end
ID 70333 / ID 310022	Distance control active for axis that is to be specified.
ID 70334 / ID 310023	On repeat selection, deselection of distance control not yet complete
ID 70335 / ID 310026	Distance control selected without programmed position
ID 70336 / ID 310015	Function is not available
ID 310027	Distance control turned on without valid sensor variable
ID 310028	Change of sensor source while distance control is active not allowed

The following errors may also occur with channel-specific distance control:

Error ID	Error text
ID 51061	3D distance control not configured
ID 51062	Initialization of axis positions during active distance control not allowed.
ID 51064	Mode setting only allowed when 3D distance control is inactive.

Notice

If the NC command #DIST CTRL [] is programmed without enabling the 3D distance control functionality, Error ID 20209 (Unknown Nc-command) is output.

12.8 Parameter

12.8.1 Overview

ID	Parameter	Description
P-CHAN-00500	configuration.decoder.function	Decoder function enable
P-CHAN-00801	dist_ctrl[i].max_deviation	Maximum position offset [0.1 µm]
P-CHAN-00802	dist_ctrl[i].v_max	Maximum velocity for distance control [µm/s]
P-CHAN-00803	dist_ctrl[i].a_max	Maximum permissible acceleration for distance control [mm/s^2]
P-CHAN-00804	dist_ctrl[i].max_act_value_change	Maximum permissible change speed of measured distance [0.1 µm/cycle]
P-CHAN-00805	dist_ctrl[i]. ref_offset	Reference point offset for control measuring system
P-CHAN-00806	dist_ctrl[i].max_pos	Upper limit for measuring system
P-CHAN-00807	dist_ctrl[i].min_pos	Lower limit for measuring system
P-CHAN-00808	dist_ctrl[i].tolerance	Tolerance band for limits
P-CHAN-00810	dist_ctrl[i]. mode_dist_use_both_encoder	Option: Coupling of distance sensor and motor encoder
P-CHAN-00811	dist_ctrl[i]. use_adaptive_acceleration	Option: Adaptive weighting of acceleration
P-CHAN-00812	dist_ctrl[i].a_min	
P-CHAN-00803	dist_ctrl[i].a_max	
P-CHAN-00813	dist_ctrl[i].dist_error_a_min	
P-CHAN-00814	dist_ctrl[i].dist_error_a_max	
P-CHAN-00819	dist_ctrl[i].v_weight_down	Velocity weighting for the lowering movement
P-CHAN-00820	dist_ctrl[i].a_weight_down	

P-CHAN-00821	dist_ctrl[i].kp	Weighting the distance control output values
P-CHAN-00822	dist_ctrl[i].i_tn	Integral action time of the PID controller
P-CHAN-00823	dist_ctrl[i].d_tv	Derivative action time of the PID controller
P-CHAN-00825	dist_ctrl[i].filter_type	Smoothing sensor data
P-CHAN-00816	dist_ctrl[i].low_pass_filter_order	
P- CHAN-00817	dist_ctrl[i].low_pass_filter_fg_f0	
P-CHAN-00800	dist_ctrl[i].n_cycles	
P-CHAN-00826	dist_ctrl[i].kalman_sigma	
P-CHAN-00827	dist_ctrl[i].smoothing_factor	Smoothing factor

The number of possible 3D distance control operations in the NC channel is limited to one distance control. Therefore, i can only have the value 0.

12.8.2 Description

Channel parameters

P-CHAN-00500	Definition of decoder functions
Description	The parameter defines specific functionalities for decoding. This disables specific functions for testing or for performance reasons.
Parameter	configuration.decoder.function
Data type	STRING
Data range	FCT_USE_CACHED_FILES: Enabling file caching FCT_VOL_COMP_COMPUTATION: Calculations for machine calibration FCT_3D_DIST_CTRL: Enable 3D distance control (as of V3.1.3080.12 or V3.1.3107.44) -: No functionalities defined.
Dimension	----
Default value	*
Remarks	Parameter is available as of the following Builds: V2.11.2040.04 ; V2.11.2810.02 ; V3.1.3079.17 ; V3.1.3107.10 Parameterisation example: Caching of maximal 4 files of maximum 4096 bytes each. *configuration.decoder.function FCT_USE_CACHED_FILES* *configuration.decoder.max_cache_number 4* *configuration.decoder.max_cache_size 4096* * Note: The default value of variables is a blank string. The parameters P-CHAN-00507 and P-CHAN-00508 can be used to define functions depending on the machining mode.

P-CHAN-00800	Filtering of sensor values
Description	Sensor values may be noisy. To keep excitation of the machine low, the setpoints for distance control can be smoothed by a filter. The parameter specified the number of values that are used for filtering.
Parameter	dist_ctrl[i].n_cycles (where i=0)
Data type	SGN32
Data range	0 ≤ n_cycles < 100
Dimension	[-]
Default value	4
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00801	**Maximum position offset**
Description	The compensation value that was calculated via distance control may not exceed this machine data item. An error message is issued if this value is exceeded. The correction value is limited.
Parameter	dist_ctrl[i].max_deviation (where i=0)
Data type	SGN32
Data range	0 <= max_deviation < MAX(SGN32)
Dimension	[0.1 10^-3 mm or ø]
Default value	50000
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00802	**Maximum velocity**
Description	The parameter defines the maximum speed at which a position offset is cleared. Distance compensation is dynamically limited to maximum velocity to limit any resulting excitation.
Parameter	dist_ctrl[i]. v_max (where i=0)
Data type	SGN32
Data range	0 <= v_max < MAX(SGN32)
Dimension	[1µm/s or 0.001°/s]
Default value	5000
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00803	**Maximum acceleration**
Description	The parameter defines the maximum acceleration at which a position offset is cleared. Correction of the distance is limited dynamically with respect to maximum acceleration to limit the resulting excitation. This parameter must be specified. If this is not the case, Error ID 315001 is output.
Parameter	dist_ctrl[i].a_max (where i=0)
Data type	SGN32
Data range	0 < a_max < MAX(SGN32)
Dimension	[mm/s^2 bzw. °/s^2]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00804	**Maximum permissible change in velocity of the measured distance**
Description	The parameter defines the maximum permissible change in velocity of the measured distance. When distance control is activated, the sensor actual values are monitored with respect to their change velocity. If the maximum permissible change in velocity is exceeded, the error message or ID 70329 is output. This detects problems with actual value detection.
Parameter	dist_ctrl[i].max_act_value_change (where i=0)
Data type	SGN32
Data range	0 <= max_act_value_change < MAX(SGN32)
Dimension	[1µm/s or 0.001°/s]
Default value	5000
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00805	**Reference point offset for measuring system**
Description	The value range of the sensor measuring system can be moved by an offset using this machine data item. This is necessary in the case of absolute sensors, for example, to define the reference point, i.e. the sensor position that is adjusted if the spindle touches the ideal workpiece surface.
Parameter	dist_ctrl[i]. ref_offset (where i=0)
Data type	SGN32
Data range	MIN(SGN32) <=ref_offset < MAX(SGN32)
Dimension	[0.1 10^-3 mm or ø]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00806	**Upper limit for measuring system**
Description	The parameter defines the upper limit of the sensor. An error message is output if this limit is exceeded when distance control is active.
Parameter	dist_ctrl[i].max_pos (where i=0)
Data type	SGN32
Data range	0 <= max_pos < MAX(SGN32)
Dimension	[0.1 10^-3 mm or ø]
Default value	50000
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00807	Lower limit for measuring system
Description	The following value defines the lower limit of the sensor. An error message is output if this limit is exceeded when distance control is active.
Parameter	dist_ctrl[i].min_pos (where i=0)
Data type	SGN32
Data range	0 <= min_pos < MAX(SGN32)
Dimension	[0.1 10^-3 mm or ø]
Default value	-50000
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00808	Tolerance band for limits
Description	This parameter defines a minimum distance from the minimum and maximum sensor positions. If there is a deviation from the valid distance, the CNC outputs the error messages or (or ID 70330 or ID 70576) . If the tolerance band is specified by zero, the limits of the minimum and maximum sensor positions in axis parameters P-CHAN-00806 [▸ 129] and P-CHAN-00807 [▸ 130] have a direct effect.
Parameter	dist_ctrl[i].tolerance (where i=0)
Data type	SGN32
Data range	0 <= P-CHAN-00808 < MAX(SGN32)
Dimension	[0.1 10^-3 mm or ø]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00810	Option: Coupling of distance sensor and motor encoder.
Description	As an extension, both the distance sensor and the Z actual value sensor can be used. The inverse coupling of the two sensors can reduce an oscillation tendency.
Parameter	dist_ctrl[i].mode_dist_use_both_encoder (where i=0)
Data type	BOOLEAN
Data range	0: No coupling 1: Coupling of motor encoder and distance sensor active
Dimension	[-]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00811	Option: Adaptive weighting of acceleration
Description	To reduce a possible oscillation the acceleration can be reduced for small deviations.
Parameter	dist_ctrl[i].use_adaptive_acceleration (where i=0)
Data type	BOOLEAN
Data range	0: No adaptive weighting of acceleration 1: Adaptive weighting of acceleration active
Dimension	[-]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 In addition the following limits for acceleration and distance error must be configured: P-CHAN-00812 or P-CHAN-00803 and P-CHAN-00813 or P-CHAN-00814

P-CHAN-00812	Minimum acceleration
Description	The parameter defines the minimal acceleration of distance control.
Parameter	dist_ctrl[i].a_min (where i=0)
Data type	UNS32
Data range	1 ... MAX (UNS32)
Dimension	[mm/s²]
Default value	500
Remarks	Available as of v3.1.3107.44

P-CHAN-00813	Minimum distance error
Description	The parameter defines the minimum distance error for distance control up to which minimum acceleration (P-CHAN-00812) is used.
Parameter	dist_ctrl[i].dist_error_a_min (where i=0)
Data type	UNS32
Data range	0 ≤ dist_error_a_min < MAX(UNS32)
Dimension	[0.1 μm or 0.0001°]
Default value	1000
Remarks	Available as of v3.1.3107.44

P-CHAN-00814	Maximum distance error
Description	The parameter defines the maximum distance error for distance control up to which maximum acceleration (P-CHAN-00803) is used.
Parameter	dist_ctrl[i].dist_error_a_max (where i=0)
Data type	UNS32
Data range	0 ≤ dist_error_a_max < MAX(UNS32)
Dimension	[0.1 µm or 0.0001°]
Default value	5000
Remarks	Available as of v3.1.3107.44

P-CHAN-00815	Low-pass filter
Description	The tendency for oscillation can be better suppressed by using a low-pass filter. For more information on the low-pass filter, see [FCT-A7].
Parameter	dist_ctrl[i].low_pass_filter_enable (where i=0)
Data type	BOOLEAN
Data range	0: Without low pass filter 1: Low pass filter active
Dimension	[-]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 In addition the following filter parameters for order and limit frequency must be configured: P-CHAN-00816 and P-CHAN-00817

P-CHAN-00816	Order of the filter
Description	The filter order describes its behaviour in the event of a drop in frequency response. The following applies: Frequency drop = - P-CHAN-00816 * 20 dB/decade
Parameter	dist_ctrl[i].low_pass_filter_order (where i=0)
Data type	UNS32
Data range	0 … 6
Dimension	[-]
Default value	4
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00817	**Filter cut-off frequency**
Description	The parameter defines the value of a filter's characteristic frequency.
Parameter	dist_ctrl[i].low_pass_filter_fg_f0 (where i=0)
Data type	REAL64
Data range	0 ≤ low_pass_filter_fg_f0 < MAX(REAL64)
Dimension	[Hz]
Default value	25
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00819	**Weighting factor for velocity of lowering movement**
Description	This parameter weights the velocity (see P-CHAN-00802) of the lowering movement (towards the workpiece) This can be useful since the lifting movement is normally highly dynamic in order to avoid an obstacle or elevation quickly. With the weighting factor it is possible to use a reduced velocity for the lowering movement towards the workpiece.
Parameter	dist_ctrl[i].v_weight_down (where i=0)
Data type	UNS32
Data range	0 ≤ v_weight_down < 2000
Dimension	[0.1%]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 * Weighting is deactivated, i.e. lifting and lowering movements use the identical velocity P-CHAN-00802 .

P-CHAN-00820	**Weighting factor for acceleration of lowering movement**
Description	This parameter weights the velocity (see P-CHAN-00803) of the lowering movement (towards the workpiece) This can be useful since the lifting movement is normally highly dynamic in order to avoid an obstacle or elevation quickly. With the weighting factor it is possible to use a reduced acceleration for the lowering movement towards the workpiece.
Parameter	dist_ctrl[i].a_weight_down (where i=0)
Data type	UNS32
Data range	0 ≤ a_weight_down < 2000
Dimension	[0.1%]
Default value	0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 * Weighting is deactivated, i.e. lifting and lowering movements use the identical acceleration P-CHAN-00803 .

P-CHAN-00821	Weighting the distance control output values
Description	The parameter weights the cyclic output value of the distance control. This may affect the distance control dynamics. For kp values less than 1.0, the distance control dynamics are reduced; for kp value greater than 1.0, the dynamics are increased.
Parameter	dist_ctrl[i].kp (where i=0)
Data type	REAL64
Data range	0.0 < kp <= 2.0
Dimension	[-]
Default value	1.0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 A kp factor less than 1 reduces a possible distance control oscillation and steadies the control in the event of minor distance errors.

P-CHAN-00822	Integral (I) action time of the PID controller
Description	This parameter weights the I component of the PID controller. The integral action time defines the time after which the P and I components of the manipulated variable are equal. A large integral action time produces greater control stability. The shorter the integration action time, the greater the I component and the faster the control. Disable the I component by i_tn = 0.
Parameter	dist_ctrl[i].i_tn (where i=0)
Data type	REAL64
Data range	0.0 <= i_tn <= 50.0
Dimension	[s]
Default value	0.0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 To begin with, it is advisable to select a high initial value for the integral action time setting (e.g. 5) to avoid instability in the control loop. You can then reduce the integral action time step by step to obtain the effect you require. If there are no permanent control deviations, do not use the I component at first.

P-CHAN-00823	Derivative (D) action time of the PID controller
Description	This parameter weights the D component of the PID controller. The derivative action time defines the time after which the P and D components of the manipulated variable are equal. The derivative action time stabilises controller behaviour and reduces oscillations. The larger the derivative action time, the stronger the D component. Disable the D component by d_tv=0.
Parameter	dist_ctrl[i].d_tv (where i=0)
Data type	REAL64
Data range	0.0 <= d_tv <= 2.0
Dimension	[s]
Default value	0.0
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 To begin with, it is advisable to select a low initial value for the derivative action time setting to avoid instability in the control loop (e.g.: 0.01). You can then reduce the derivative action time step by step to obtain the effect you require.

P-CHAN-00825	Filter type for smoothing sensor data
Description	Sensor values may be noisy. The oscillation tendency can better be suppressed by using a suitable filter . You can select the following filter types for distance control: • DEFAULT: Moving averaging filter where P-CHAN-00800 = 4 • MOVING_AVERAGE: Moving averaging filter • LOWPASS: Low-pass filter • KALMAN_MA: Kalman filter with prediction from averaging filter • EXPO_MEAN: Exponentially weighted averaging filter • KALMAN_EXPO: Kalman filter with prediction from exponentially weighted averaging filter
Parameter	dist_ctrl[i].filter_type (where i=0)
Data type	STRING
Data range	DEFAULT MOVING_AVERAGE LOWPASS KALMAN_MA EXPO_MEAN KALMAN_EXPO
Dimension	[-]
Default value	DEFAULT
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44 In addition, the following filter parameters are required for each of the filter types:: • MOVING_AVERAGE: P-CHAN-00800 • LOWPASS: P-CHAN-00816, P-CHAN-00817 • KALMAN_MA: P-CHAN-00800, P-CHAN-00826 • EXPO_MEAN: P-CHAN-00800, P-CHAN-00827 • KALMAN_EXPO: P-CHAN-00800, P-CHAN-00827, P-CHAN-00826

P-CHAN-00826	Uncertainty of measured values
Description	The parameter specifies the degree of deviation of the measured value from the actual values. The higher this value, the better the filter effect. However, possible overshoots are amplified.
Parameter	dist_ctrl[i].kalman_sigma (where i=0)
Data type	REAL64
Data range	1.0 ≤ P-CHAN-00826 ≤ 10000.0
Dimension	[-]
Default value	4
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

P-CHAN-00827	Smoothing factor
Description	The parameter specifies the weighting of the current measured value. Example: With a smoothing factor of 0.5, the current value is applied to the average value at a rate of 50%.
Parameter	dist_ctrl[i].smoothing_factor (where i=0)
Data type	REAL64
Data range	0 < P-CHAN-00827 ≤ 1.0
Dimension	[-]
Default value	0.7
Remarks	Available as of Build V3.1.3080.12 or V3.1.3107.44

start-up parameters

P-STUP-00175	32-bit compatibility mode for CNC display data
Description	As of CNC Build 2807 and CNC Build 3039.06 and higher, the CNC position controller uses 64-bit integer variables with a finer resolution for command and actual positions. To ensure downward compatibility, this data is downscaled for display data in CNC objects and continue to be supplied as 32-bit values. Conversion can be deactivated by setting the ads_32_bit_comp_mode parameter to the value 0. High-resolution position controller variables are then transferred via CNC objects as 64-bit integer values.
Parameter	ads_32_bit_comp_mode
Data type	BOOLEAN
Data range	0: No conversion; high-resolution 64-bit variable. 1: Downward compatibility, conversion and supply of 32-bit integer variables
Dimension	----
Default value	1
Remarks	This parameter is available as of CNC Builds 2.11.2027.01 and V3.1.3039.06 or higher.

12.8.3 Parameterisation example

Examples of parameters in a channel list:

```
# P-CHAN-00500: Activate functionality
configuration.decoder.function         FCT_3D_DIST_CTRL
## Dynamic parameters
# P-CHAN-00801: Max. permissible deviation [0.1um]
dist_ctrl[0].max_deviation             10000000
# P-CHAN-00802: Max. velocity [um/s]
dist_ctrl[0].v_max                     10000
# P-CHAN-00803: Max. acceleration [mm/s*s]
dist_ctrl[0].a_max                     100
# P-CHAN-00804: Max. speed of sensor values change per cycle [um/s]
dist_ctrl[0].max_act_value_change      10000000
# P-CHAN-00819: Lowering movement at 0.1% velocity
# of P-CHAN-00802 v_max
dist_ctrl[0].v_weight_down             0
# P-CHAN-00820: Lowering movement at 0.1% acceleration
# of P-CHAN-00804 a_max
dist_ctrl[0].a_weight_down              0

# P-CHAN-00805: Offset reference of sensor [0.1um]
dist_ctrl[0].ref_offset                0
# P-CHAN-00806: Upper limit of sensor [0.1um]
dist_ctrl[0].max_pos                   1500000
# P-CHAN-00807: Lower limit of sensor [0.1um]
dist_ctrl[0].min_pos                   -1500000
# P-CHAN-00808: Tolerance to sensor limits P-CHAN-00806/00807 [0.1um]
dist_ctrl[0].tolerance                 0

## PID controller
# P-CHAN-00821: weighting of output values
dist_ctrl[0].kp                        0.3
# P-CHAN-00822: integral time
dist_ctrl[0].i_tn                      0.0
# P-CHAN-00823: derivative time
dist_ctrl[0].d_tv                      0.01

## Filter
# P-CHAN-00800: Number of cycles used for filter calculation
dist_ctrl[0].n_cycles                  20
# P-CHAN-00825: Filter type to smooth sensor values
dist_ctrl[0].filter_type               MOVING_AVERAGE
# P-CHAN-00827: Weighting of the actual sensor value (Expo filters)
dist_ctrl[0].smoothing_factor          0.05
# P-CHAN-00826: uncertainty of measured values (Kalman filters)
dist_ctrl[0].kalman_sigma              2000
# P-CHAN-00816: Order of low-pass filter
dist_ctrl[0].low_pass_filter_order     3
# P-CHAN-00817: Frequency of low-pass filter [Hz]
dist_ctrl[0].low_pass_filter_fg_f0     50
```

```
## Adaptive acceleration
# P-CHAN-00811: Adaptive acceleration active
dist_ctrl[0].use_adaptive_acceleration  0
# P-CHAN-00812: Min. acceleration [mm/s*s]
dist_ctrl[0].a_min                      1
# P-CHAN-00813: Min. distance [0.1 um] to use a_min for
# adaptive acceleration
dist_ctrl[0].dist_error_a_min           400
# P-CHAN-00814: Max. distance [0.1 um] to use a_max for
# adaptive acceleration
dist_ctrl[0].dist_error_a_max           2500
```

12.8.4 Example configuration of sensor variables

The sensor signal for 3D distance control should be specified by the PLC using an external variable (V.E.). (see [EXTV].

Example

Configuration and use of sensor variables.

Configuration of a sensor variable in the configuration list of external variables

```
number_used_variables        1
#
var[0].name                  SENSOR
var[0].type                  REAL64
var[0].scope                 CHANNEL
var[0].synchronisation       TRUE
var[0].access_rights         READ_ONLY
```

Activating the sensor input for 3D distance control in the NC program:

```
#DIST CTRL [SENSOR_SOURCE=VARIABLE  SENSOR_VAR=V.E.SENSOR]
```

When axis-specific distance control is used, the NC command is:

```
<axis_name> [DIST_CTRL  SENSOR_SOURCE=VARIABLE  SENSOR_VAR=V.E.SENSOR]
```

The V.E.SENSOR variable can be linked analogously to the example in (FCT-C22// Example of distance control).

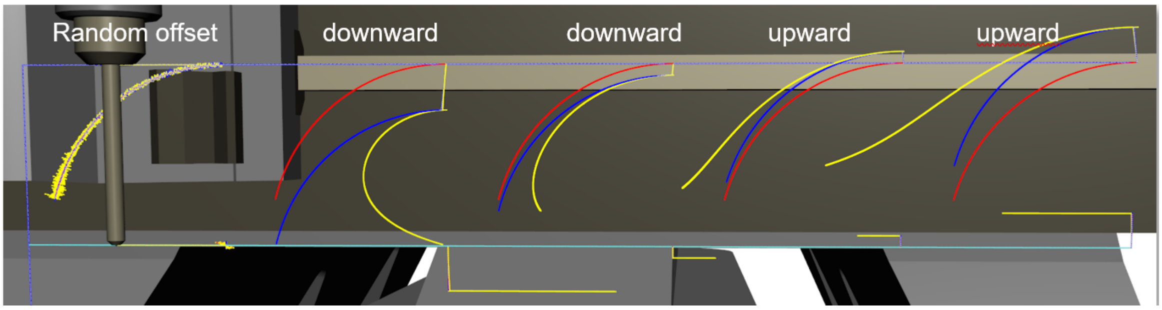
12.9 Application examples

The examples below intend to visualise the operating principle of distance control and height monitoring when the tool head is inclined.

- (red) Path oft tool head with original contour (tool clamping point = laser exit)
- (blue) With specified hight offset and compensation perpendicular to surface
- (yellow) With specified hight offset and compensation in tool direction

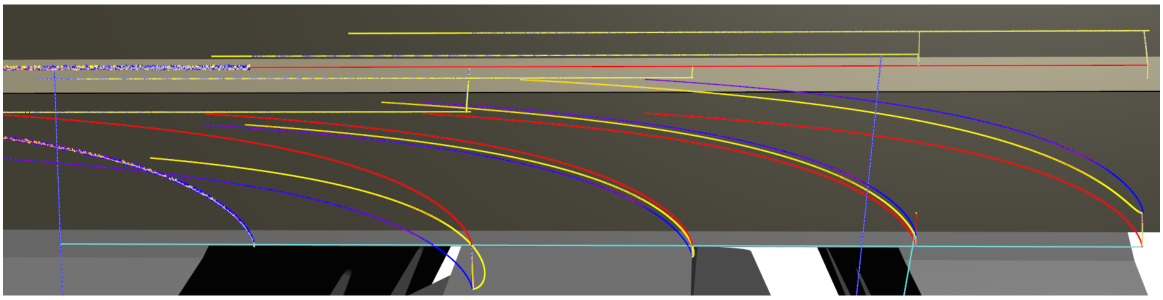
Example 1: Monitoring minimum height in the range [90°; -]

No height monitoring is executed during the entire inclination from 0° to 90°.



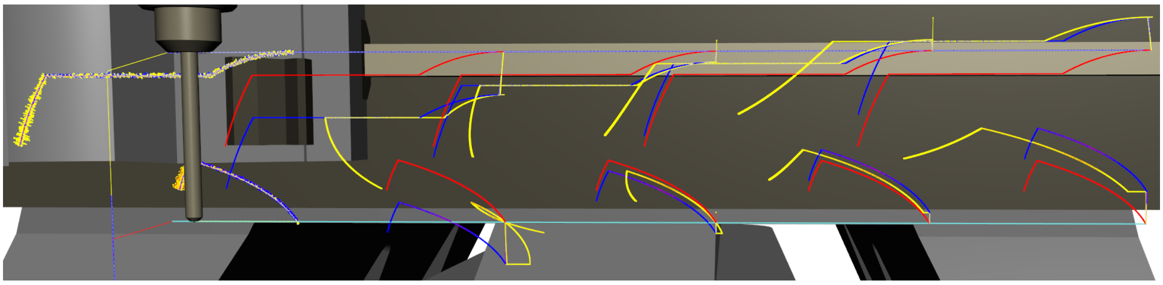
Example 2: Monitoring minimum height in the range [0°; -]

The height of the tool head is kept constant immediately at the start of the inclination.



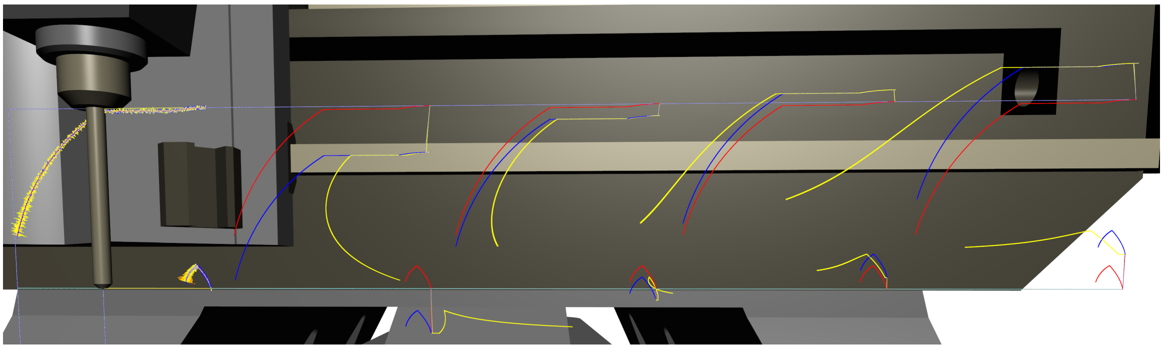
Example 3: Monitoring minimum height in the range [30°; 60°]

The height of the tool head is kept constant at an inclination between 30° and 60°.



Example 4: Monitoring minimum height in [10°; 31°]

In this application example, the height of the tool head is is kept constant at an inclination between 10° and 31°.



12.10 Diagnosis

Additions to diagnosis data for channel-specific distance control.

Information on creating and reading diagnosis data, see [FCT-M9// Diagnosis upload].

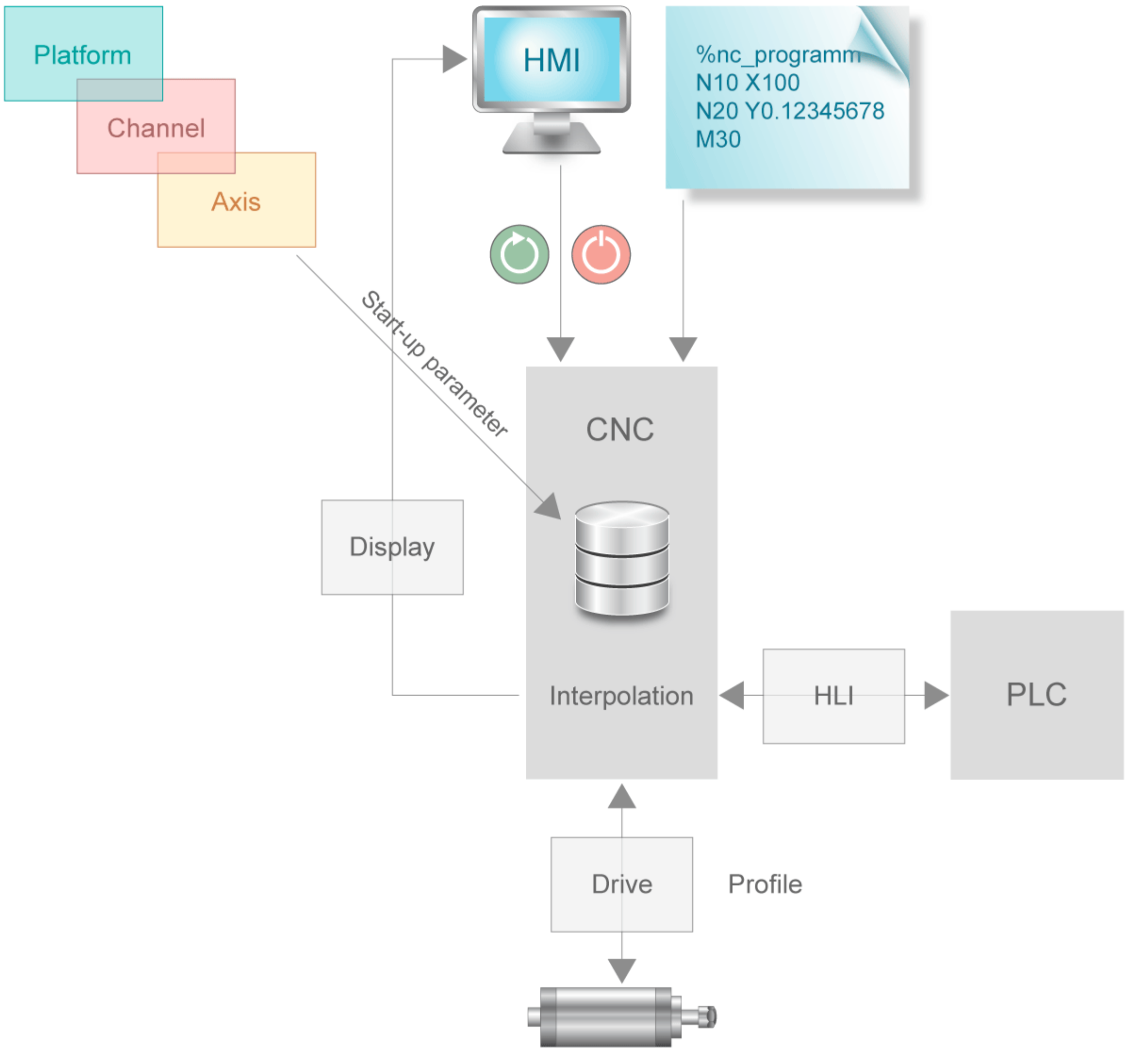


Fig. 54: Overview of diagnosis

Activating 3D distance control can be verified as shown in the figure below.

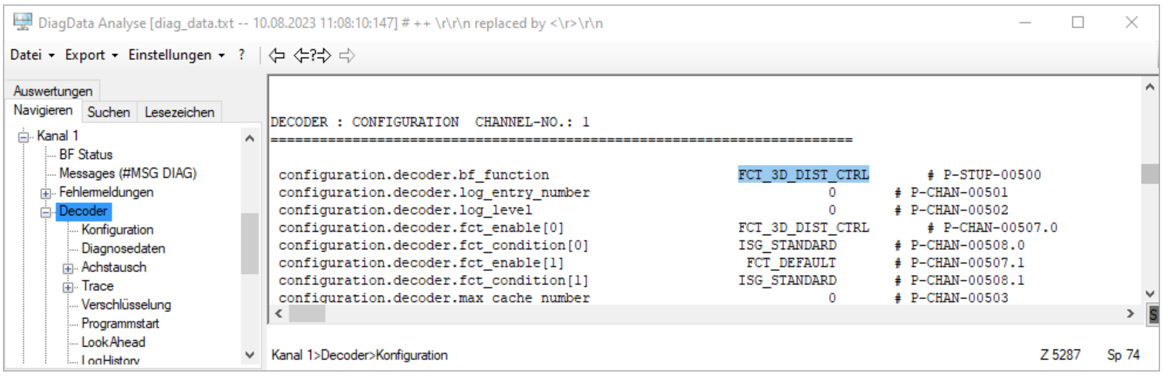


Fig. 55: Diagnosis data - Verification of activation

Further diagnosis data for 3D distance control can be found as follows.

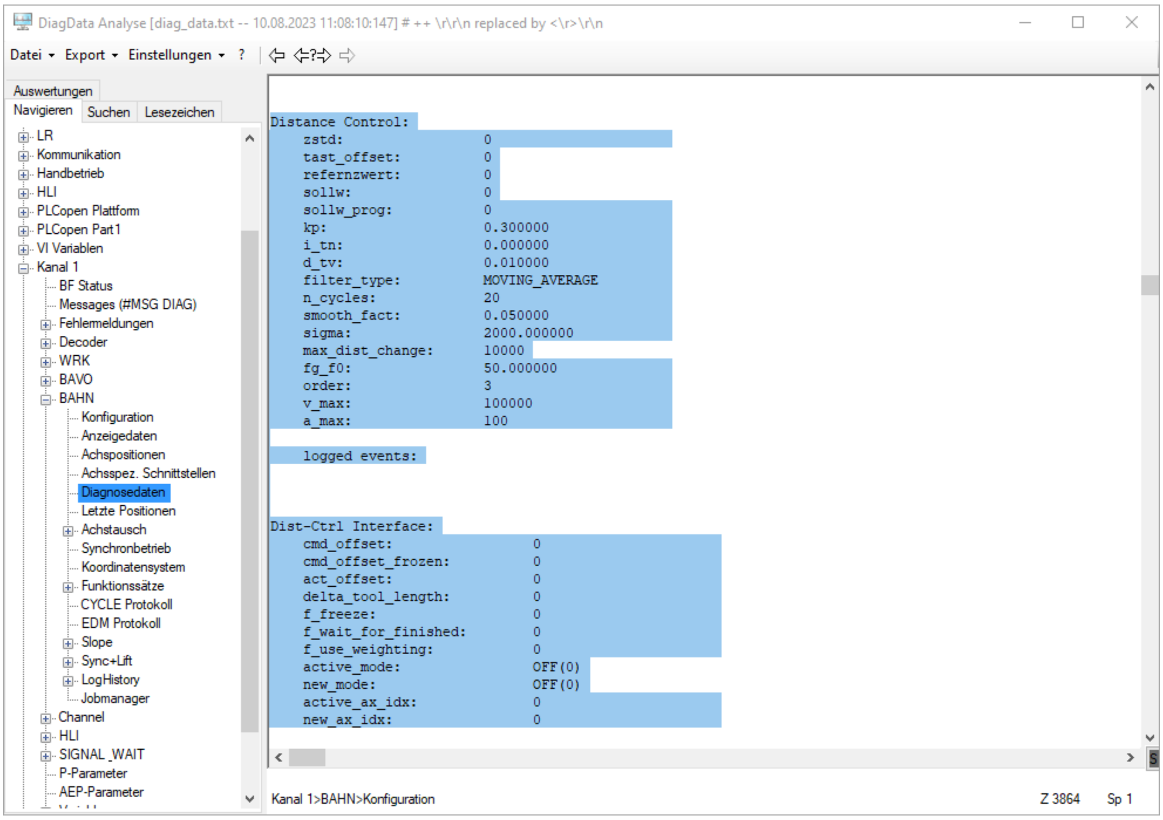


Fig. 56: Diagnosis data for 3D distance control

13 Appendix

13.1 Suggestions, corrections and the latest documentation

Did you find any errors? Do you have any suggestions or constructive criticism? Then please contact us at documentation@isg-stuttgart.de. The latest documentation is posted in our Online Help (DE/EN):

QR code link: https://www.isg-stuttgart.de/documentation-kernel/

The link above forwards you to:

https://www.isg-stuttgart.de/fileadmin/kernel/kernel-html/index.html

Notice

Change options for favourite links in your browser;

Technical changes to the website layout concerning folder paths or a change in the HTML framework and therefore the link structure cannot be excluded.

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Keyword index