



# DOCUMENTATION ISG-kernel

## **Functional description** **Distance control**

Short Description:  
FCT-M3

# Preface

## Legal information

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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

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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

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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

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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.

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# 1 Overview

## Task

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

## Characteristics

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Distance control is used for example:

- to compensate for workpiece thickness tolerances
- to prevent the tool from contacting the workpiece in the event of surface unevenness

## Parametrisation

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Extensive settings must be configured in the axis list for distance control. The section Parameter [► 54] contains a complete list.

## Programming

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Distance control is activated and deactivated either by the NC program by the axis-specific NC command <axisname> [ DIST\_CTRL ...] [► 36] or by the PLC.

## ***Mandatory note on references to other documents***

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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

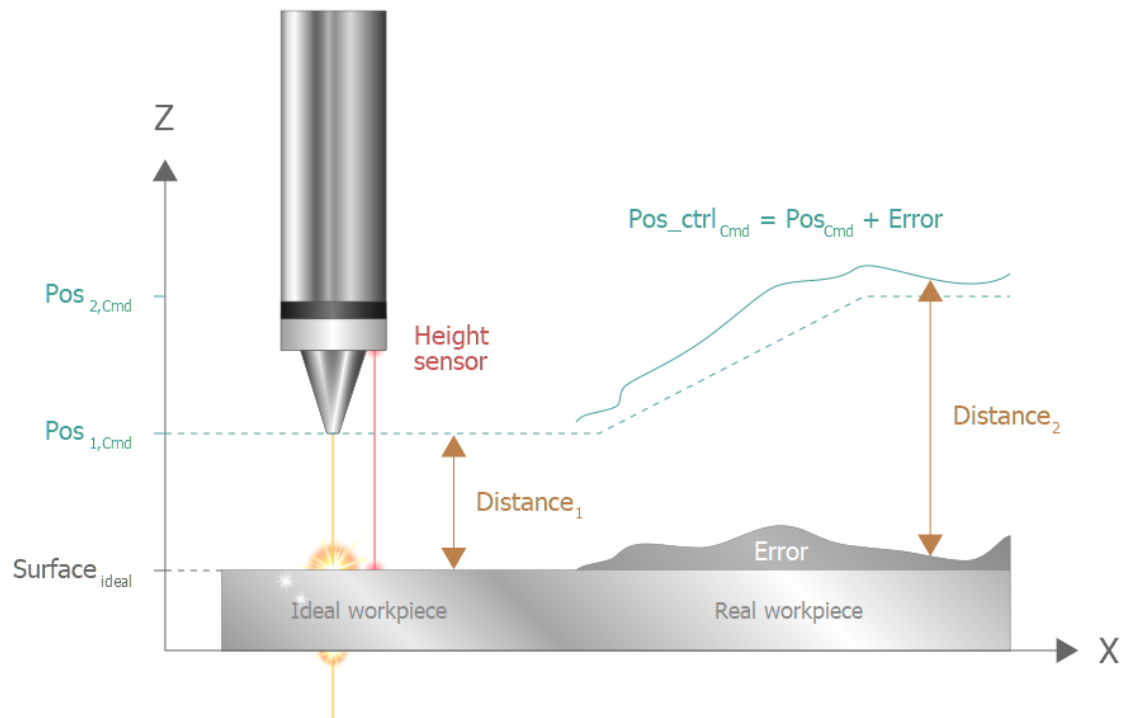
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Motions are generated by electronic probe systems or sensors. These motions should superimpose the programmed positions of axes when an NC program is interpolated.

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**



## Characteristics

A second measuring system is connected to the control system via an encoder. This measuring system can output axis-specific compensation values to an axis in addition to the interpolated command point to correct the actual position of the axis.

Distance control is enabled and disabled in the

- NC program or
- via the SPS.

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

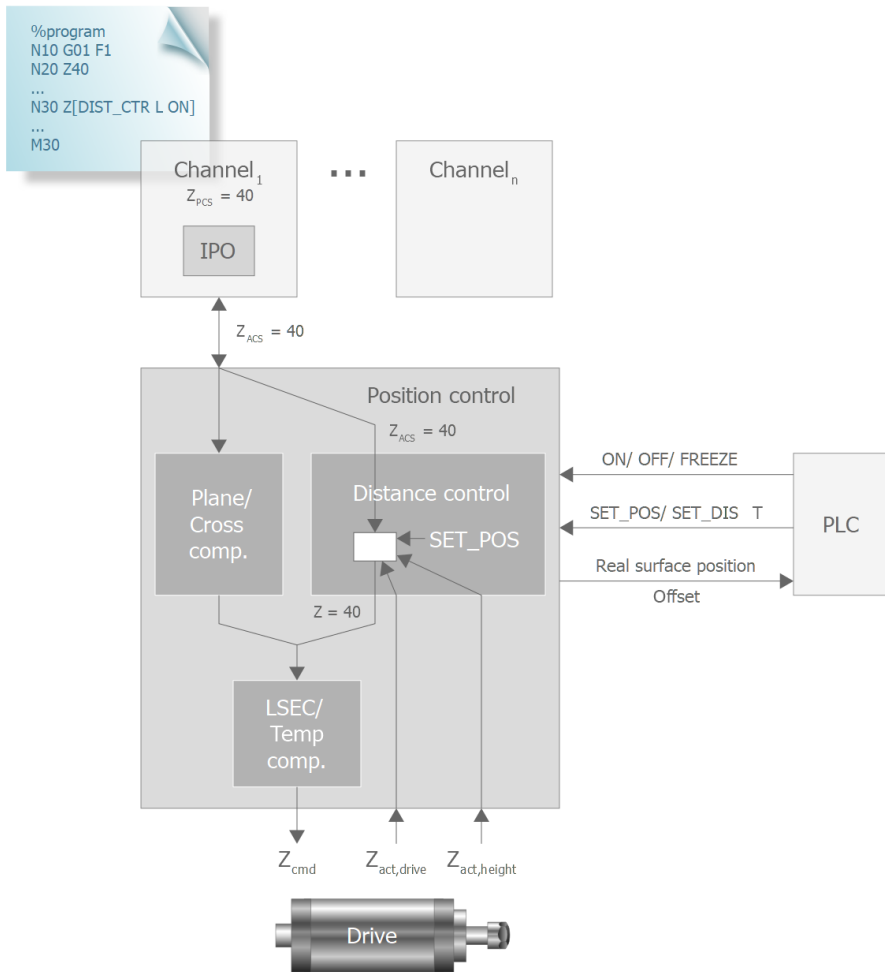
Distance control is only available for SERCOS, PROFIdrive or CANopen drives.

## Parameterisation overview

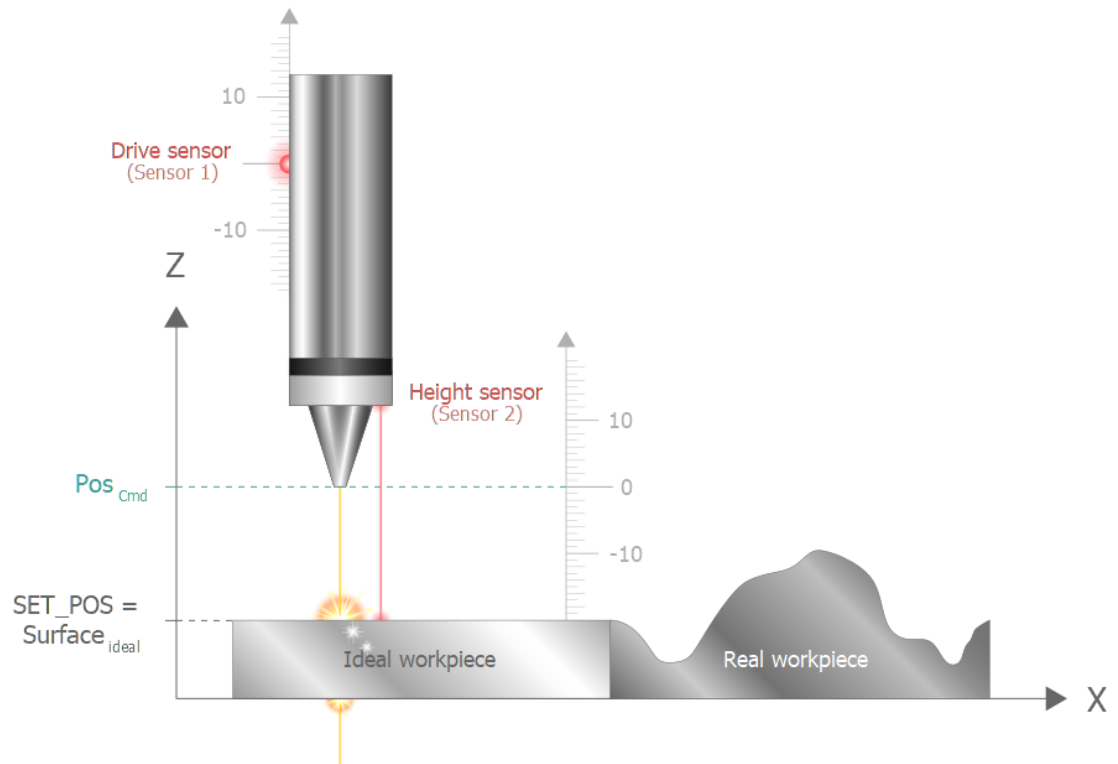
The motion generated by distance control can be influenced by machine data.

- Activating a mean value or a low pass filter
- Maximum permissible correction 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:

$$\text{Offset} = \text{Surface}_{\text{real}} - \text{Surface}_{\text{ideal}}$$

where

$$\text{Surface}_{\text{real}} = \text{Drivesensor} + \text{Heightsensor}$$

$$\text{Surface}_{\text{ideal}} = \text{Set}_{\text{pos}}$$

This results in a correction of the programmed command position  $\text{Pos}_{\text{Cmd}}$  of the tool as follows:

$$\text{Pos}'_{\text{cmd}} = \text{Pos}_{\text{cmd}} + \text{Offset}$$

$$\text{Pos}'_{\text{cmd}} = \text{Pos}_{\text{cmd}} + \text{Drivesensor} + \text{Heightsensor} - \text{Set}_{\text{pos}}$$

## 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.

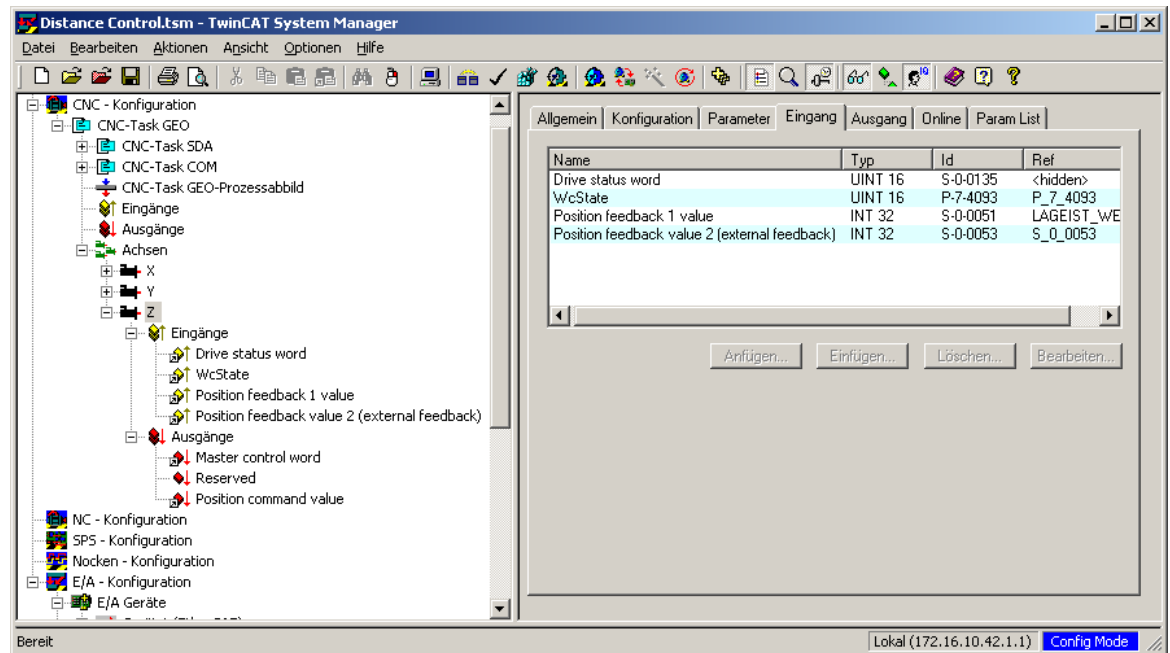


Fig. 5: TwinCAT configuration example for SERCOS (ID S-0-0053)

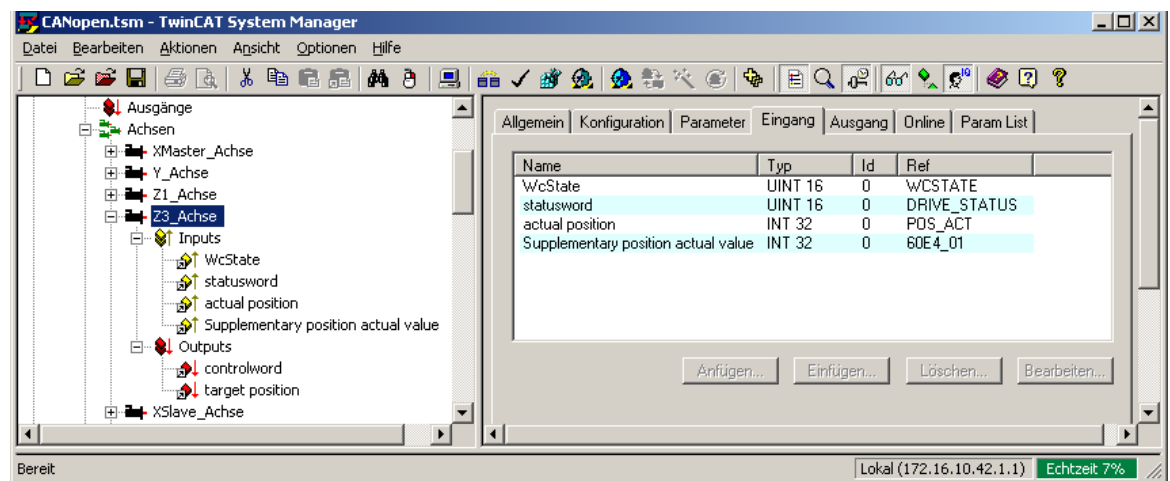


Fig. 6: TwinCAT configuration example for CANopen DS402 (PDO 0x60E4, Subindex 1)

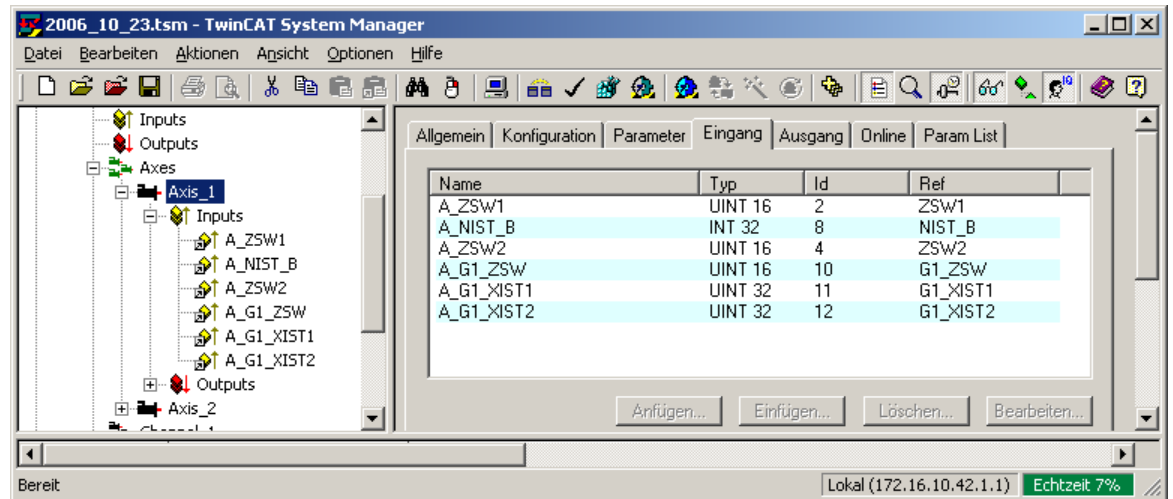


Fig. 7: TwinCAT configuration example for ProfiDrive (G1\_XIST2)



### 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 [▶ 67].
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 [▶ 67] = 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 [▶ 68].

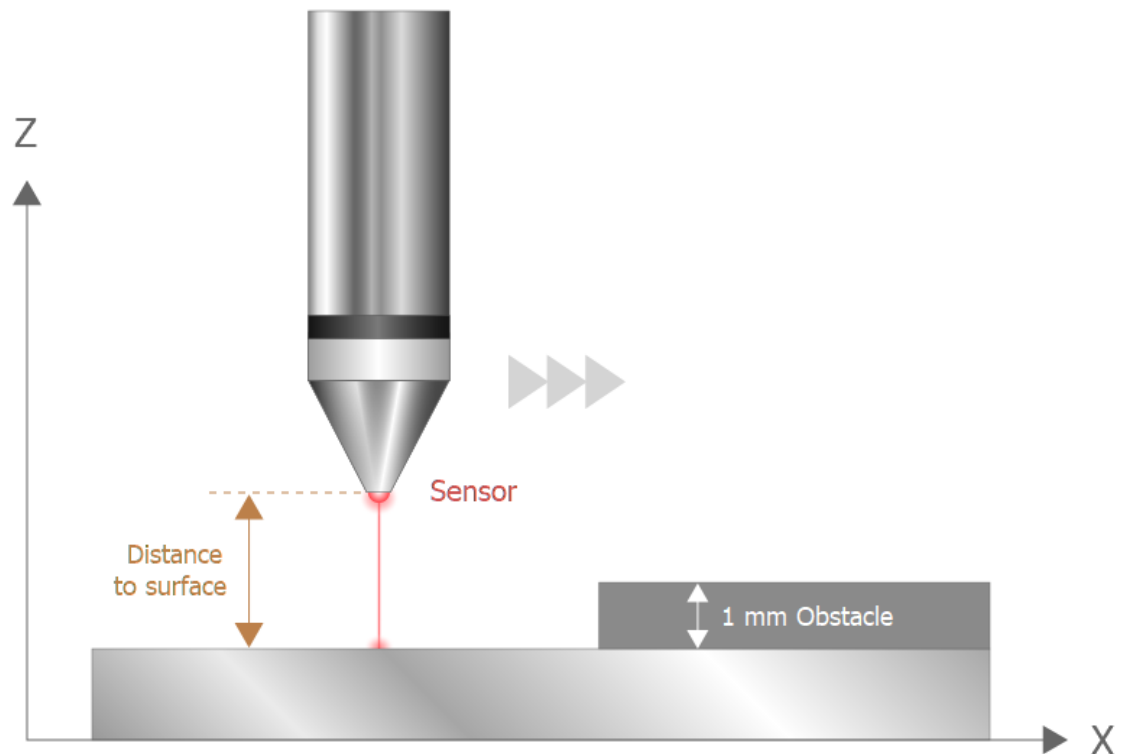
#### Step-by-step and iterative parameterisation of the controller:

1. Setting the proportional component using P-AXIS-00759 [▶ 67]:  
First set the controller as a P-only controller. This means disabling the I and D controllers by using P-AXIS-00764 [▶ 67]=0 and P-AXIS-00765 [▶ 68]=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 [▶ 67]:  
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 [▶ 68]:  
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

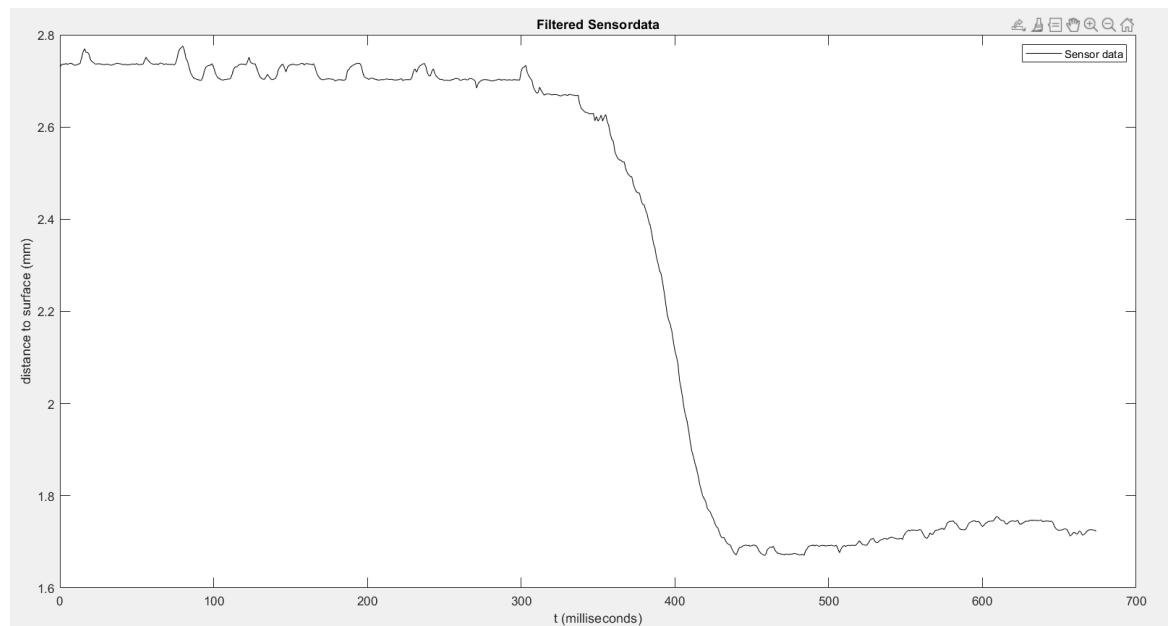
Sensor values may be noisy. This can make the distance controller excite the system with oscillations. Filters can help to smooth the input signal and improve the performance of the distance controller.

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 [► 56] 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 [► 56], the better the smoothing, but the greater the reaction delay involved.

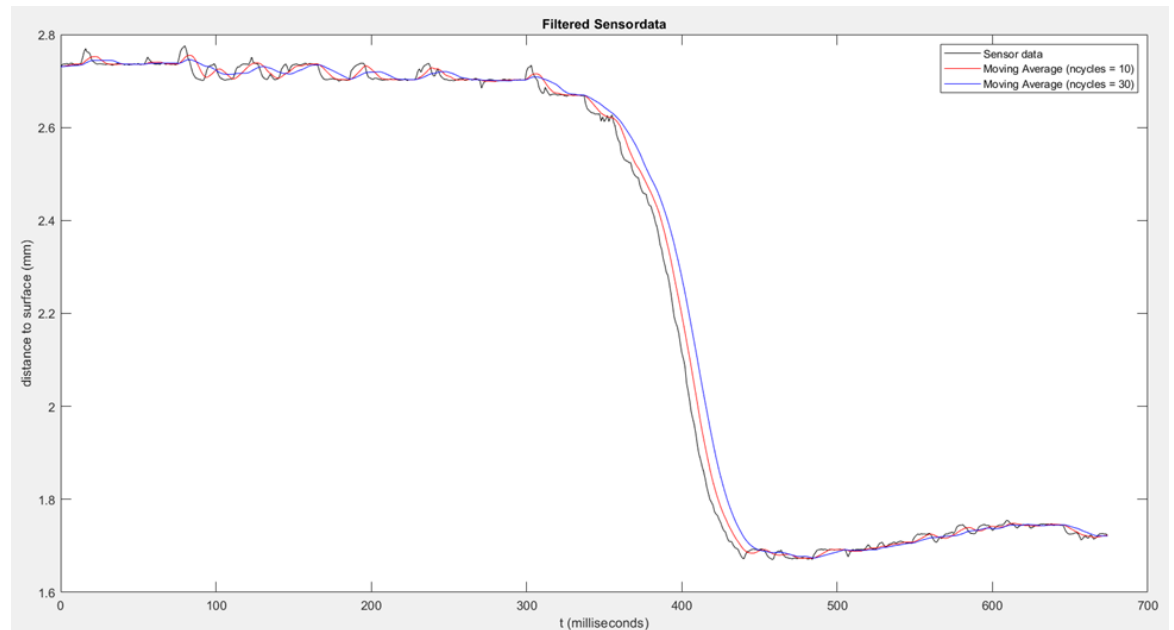


Fig. 10: Different filter effect with varying n\_cycles



### Example

Example parameters: Moving averaging filter

```
kenngr.distc.filter_type MOVING_AVERAGE #Filter type
#                                     Number of included measured values
kenngr.distc.n_cycles 20
```

## 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.

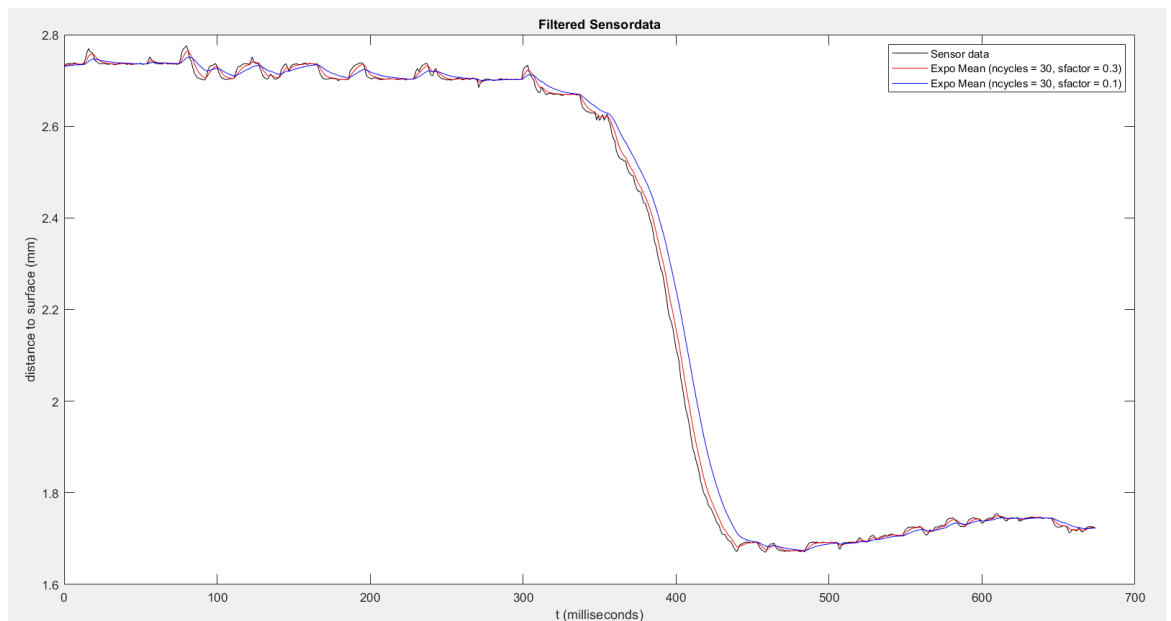


Fig. 11: Different filter effect due to smoothing factor

## Number of measured values - n\_cycles (P-AXIS-00413):

The more measured values are included in the filter via P-AXIS-00413, 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.

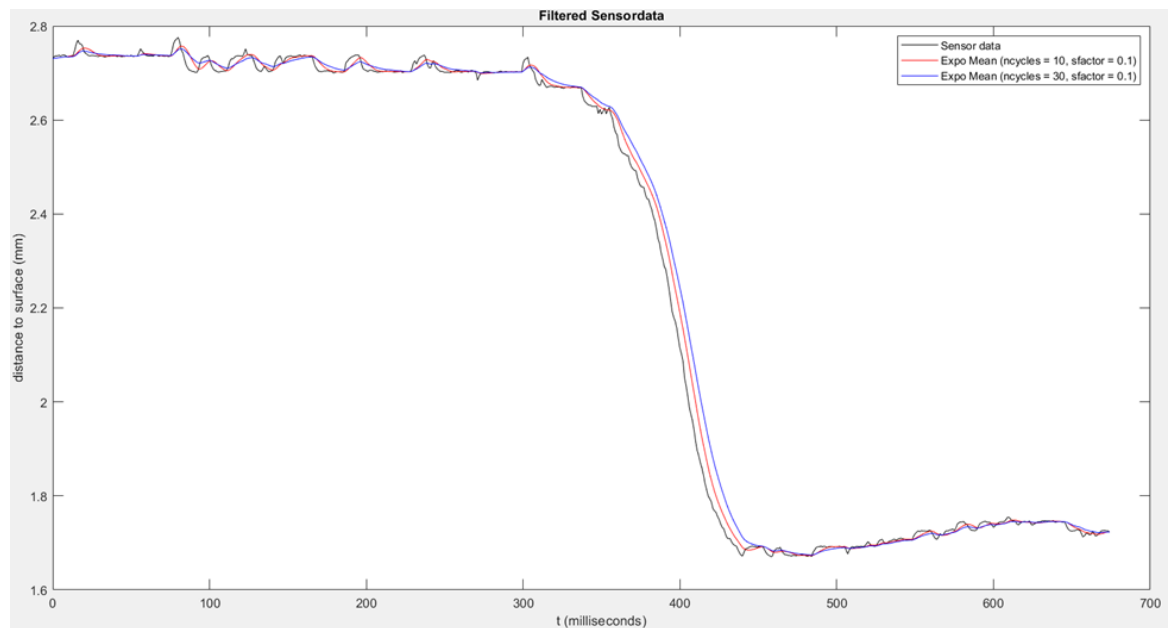


Fig. 12: Different filter effect with varying n\_cycles



### 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 # Low-pass filter freq 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 [► 17].

### 4.4.1 Influence of parameters:

#### Number of measured values - n\_cycles (P-AXIS-00413):

The parameter P-AXIS-00413 [► 56] 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).

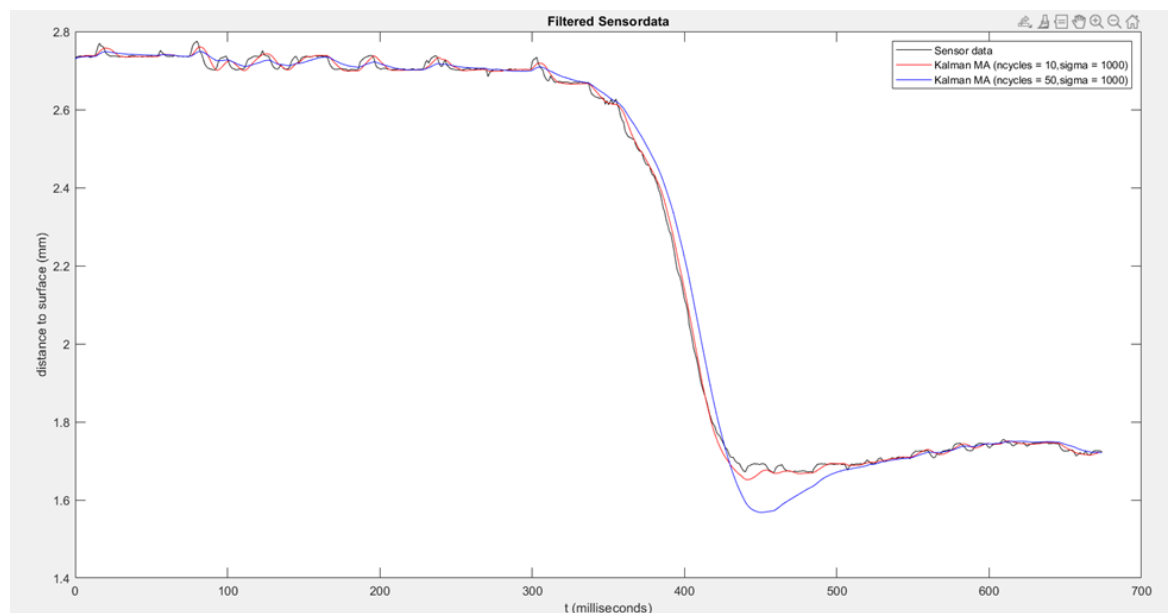


Fig. 13: Different filter effect with varying n\_cycles

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

The parameter P-AXIS-00783 [► 70] 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.

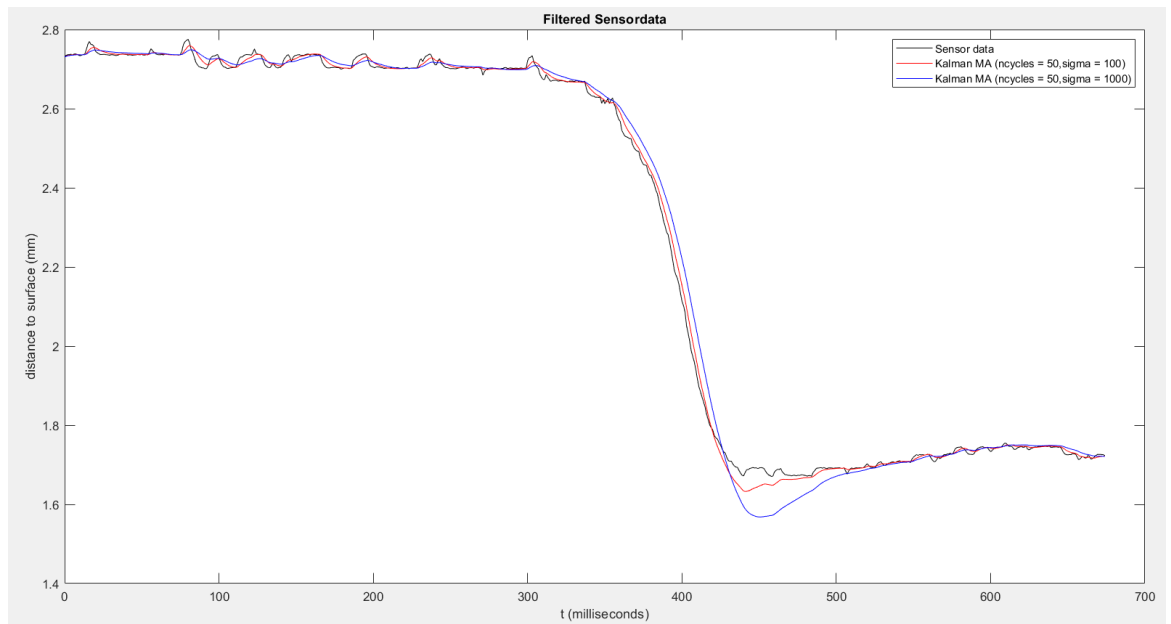


Fig. 14: Different filter effect with varying sigma



### 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 builds the prediction and then refines it by the uncertainty of the measured values. The basis of the prediction is the exponentially weighted averaging filter [► 18].

### 4.5.1 Influence of parameters:

#### Number of measured values - $n_{\text{cycles}}$ (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).

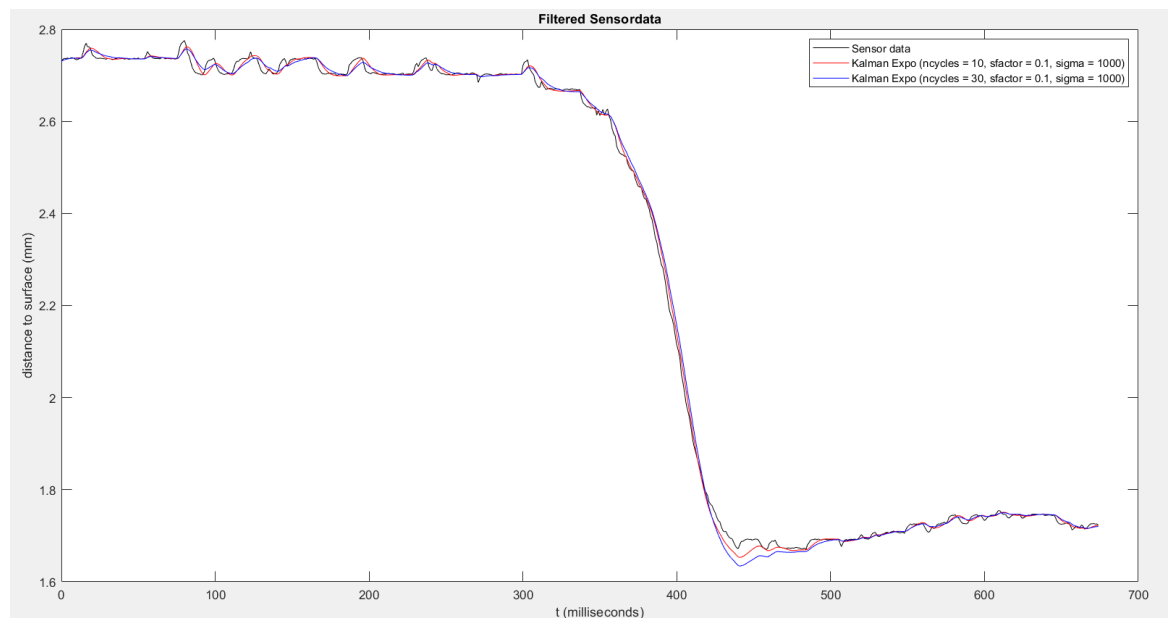


Fig. 15: Different filter effect with varying  $n_{\text{cycles}}$

## Smoothing factor (P-AXIS-00784)

The section Exponentially weighted averaging filter [► 18] explains the influence of the smoothing factor on the exponentially weight 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.

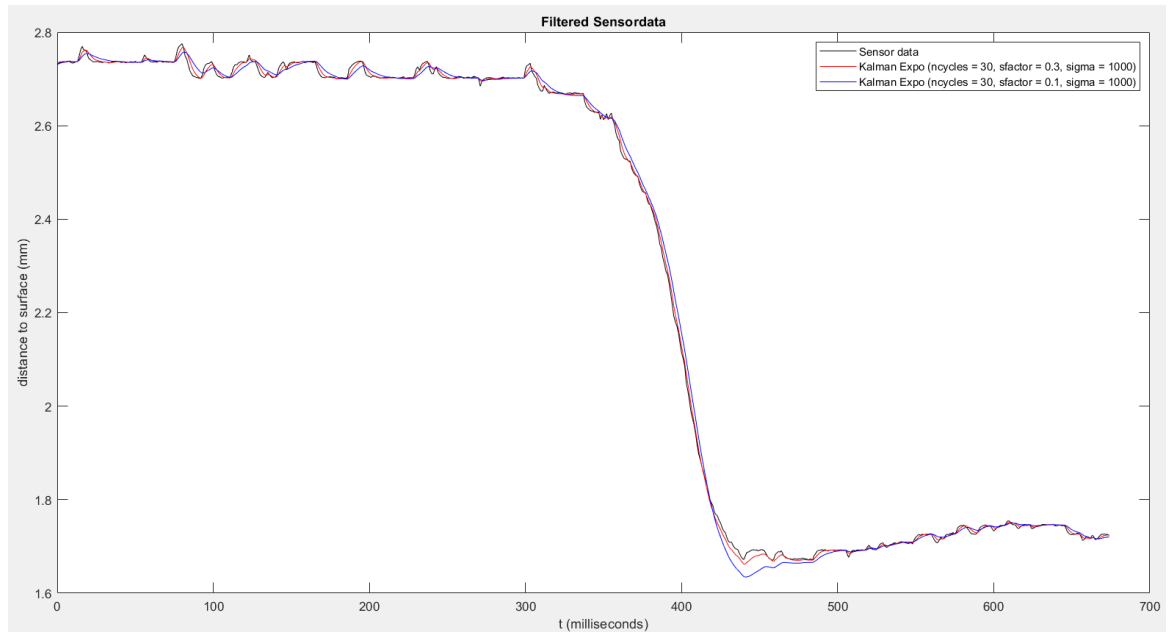


Fig. 16: Different filter effect with varying smoothing factor

## 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.

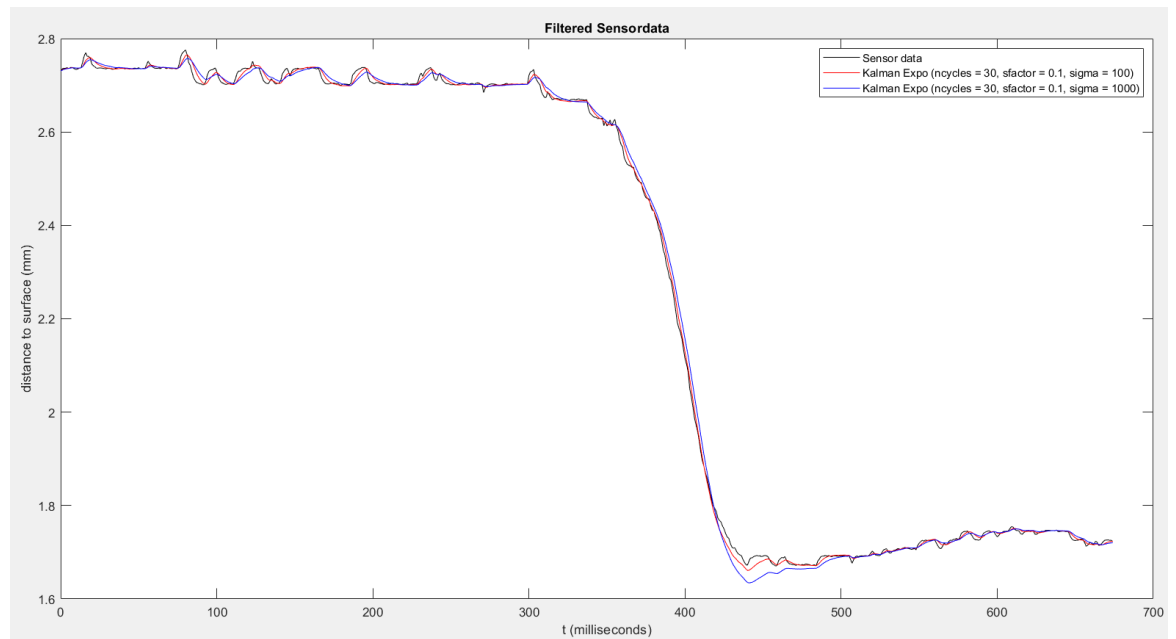


Fig. 17: Different filter effect with varying sigma



### 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 val-
ues
kenngr.distc.kalman_sigma 1000            #Uncertainty of measured values
kenngr.distc.smoothing_factor 0.3         #Smoothing factor
```

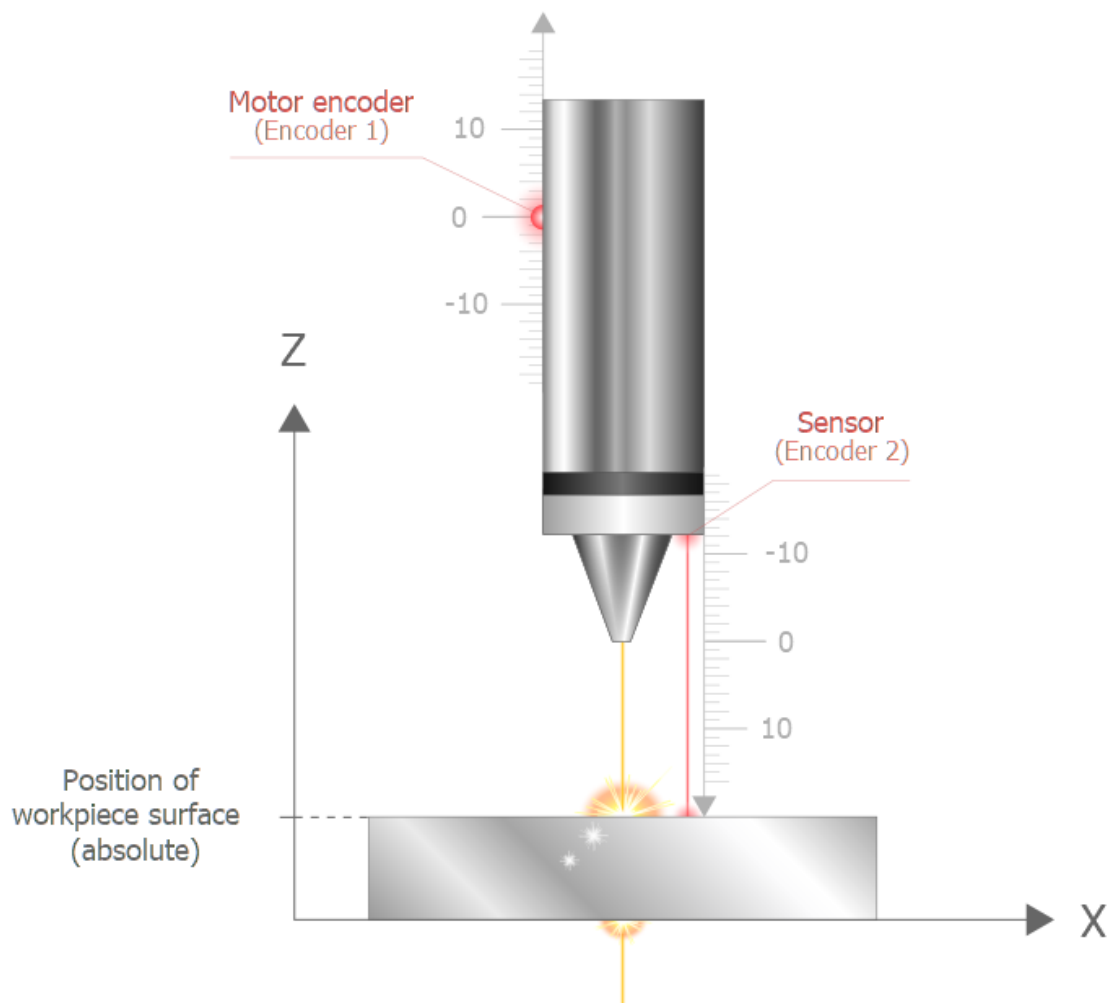


## 5 Operation mode of distance control

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:

$$\begin{aligned} \text{Deviation} &= \text{motor encoder} + \text{sensor encoder} - \text{set position (SET\_POS)} \\ &= \text{actual workpiece surface position} - \text{set position (SET\_POS)} \end{aligned}$$

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

$$\text{Drive setpoint} = \text{programmed setpoint (PCS)} + \text{distance control offset}$$

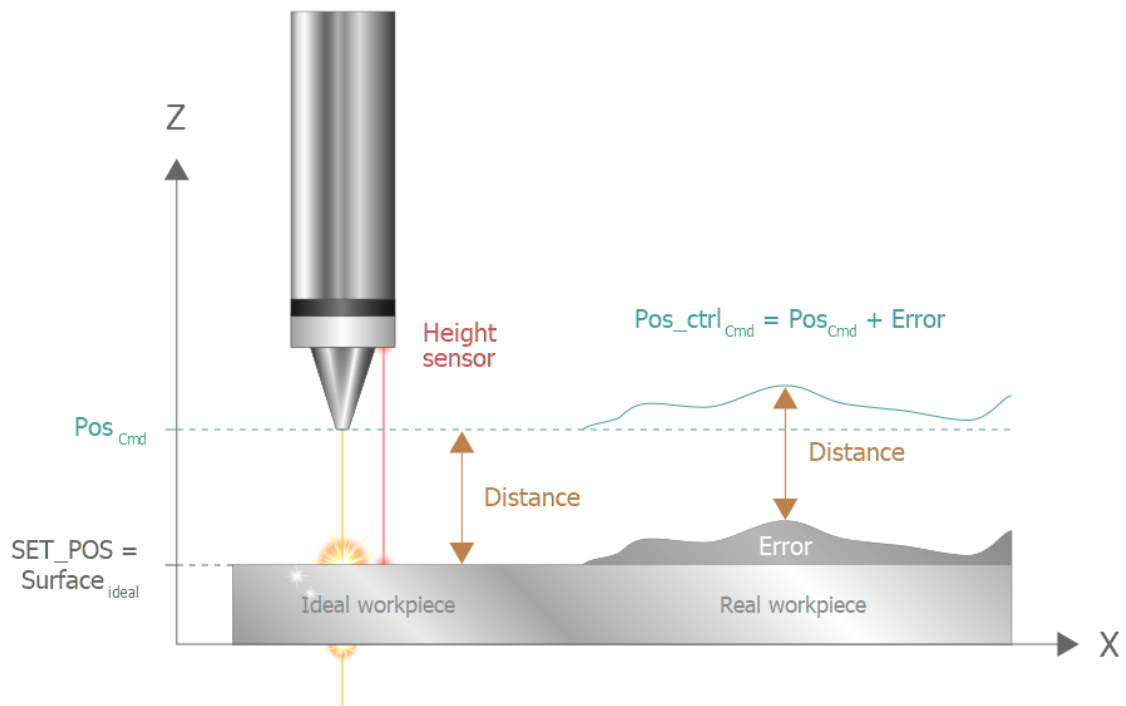


Fig. 19: Specifying the ideal workpiece surface for distance control

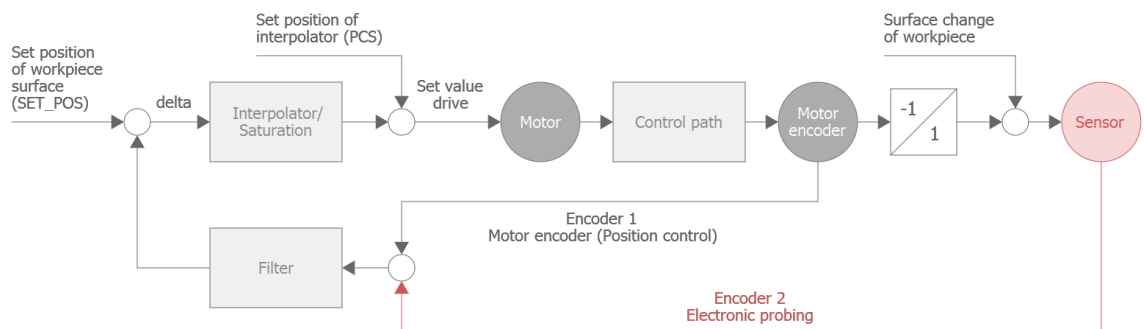


Fig. 20: Block diagram of distance control

## 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 [► 36] 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:

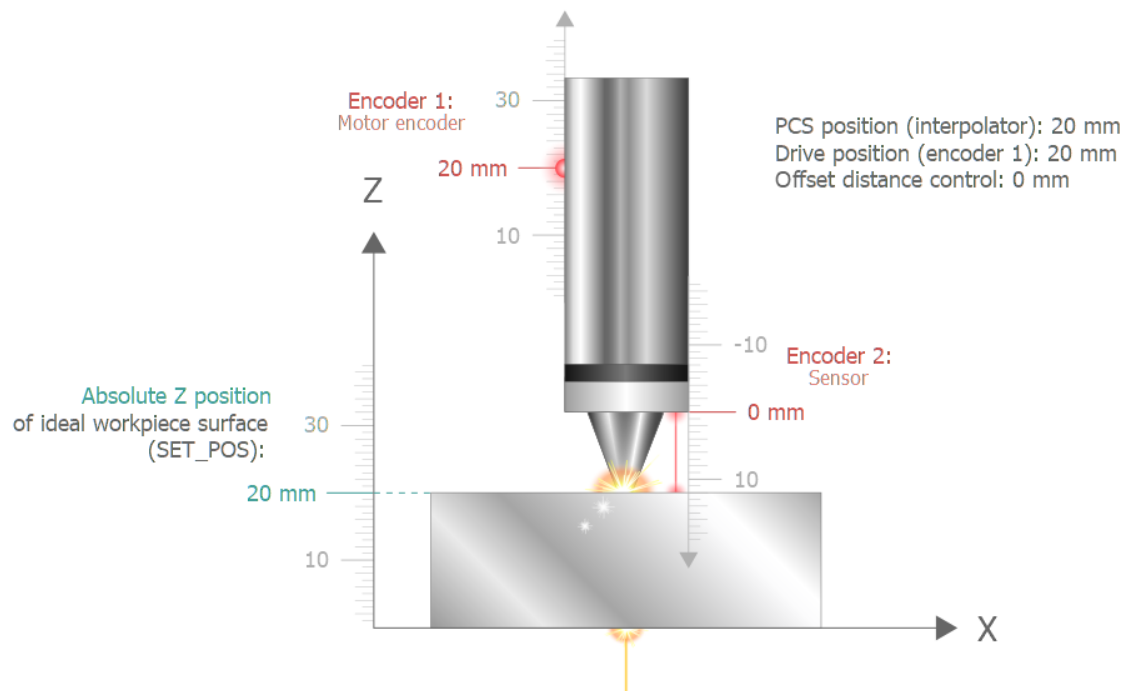
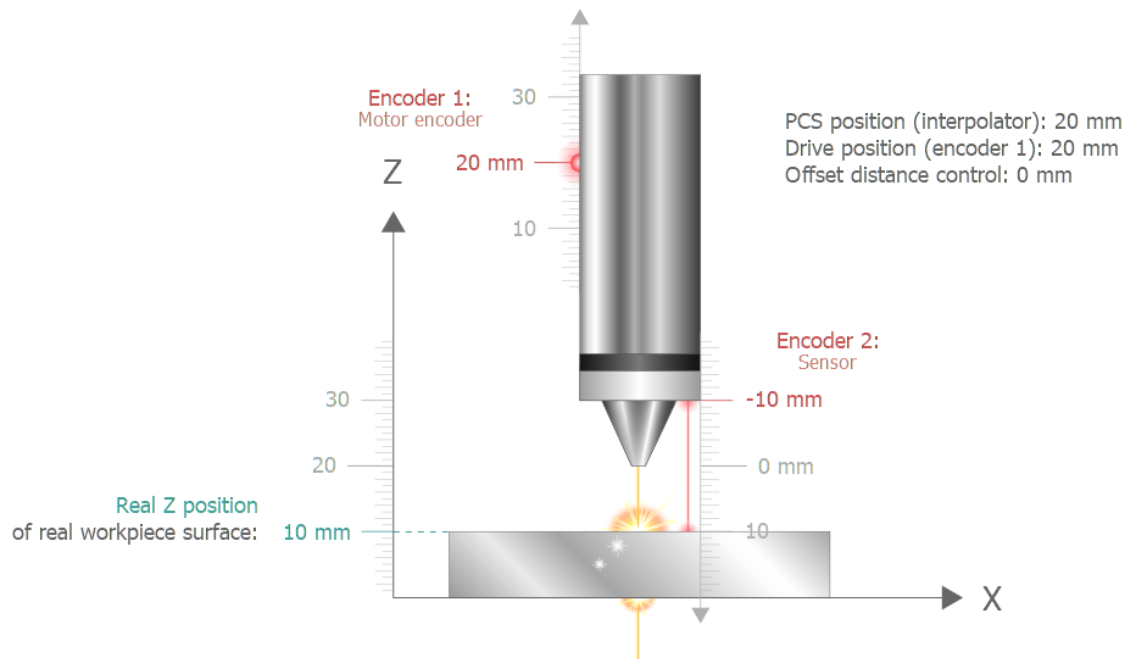


Fig. 21: Ideal workpiece

## Deviation

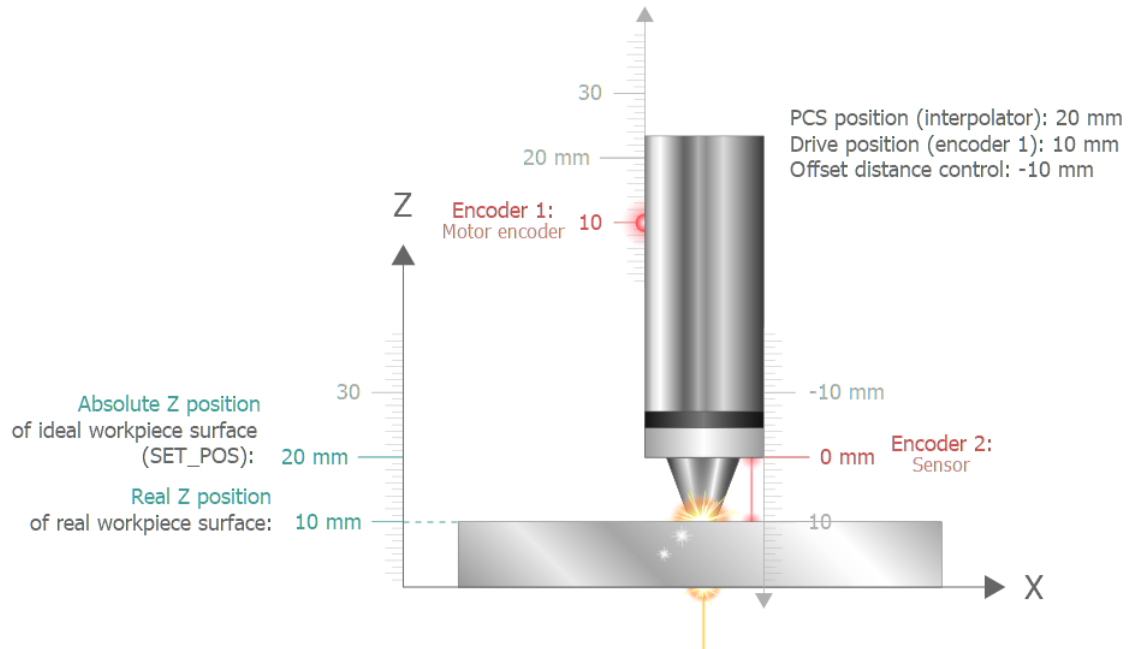
A deviation from the ideal workpiece surface (e.g. with a thinner workpiece) is detected by the sensor (encoder 2):



**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.

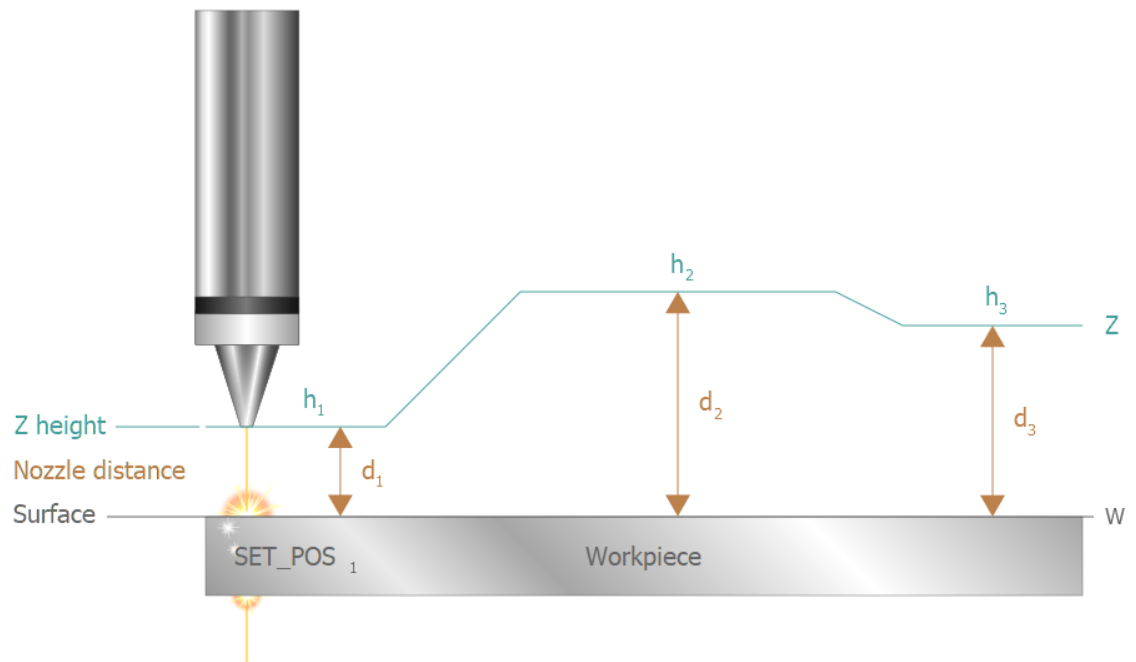


**Fig. 23: Real workpiece with distance control**



### 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  $Z=\text{SET\_POS}$  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.

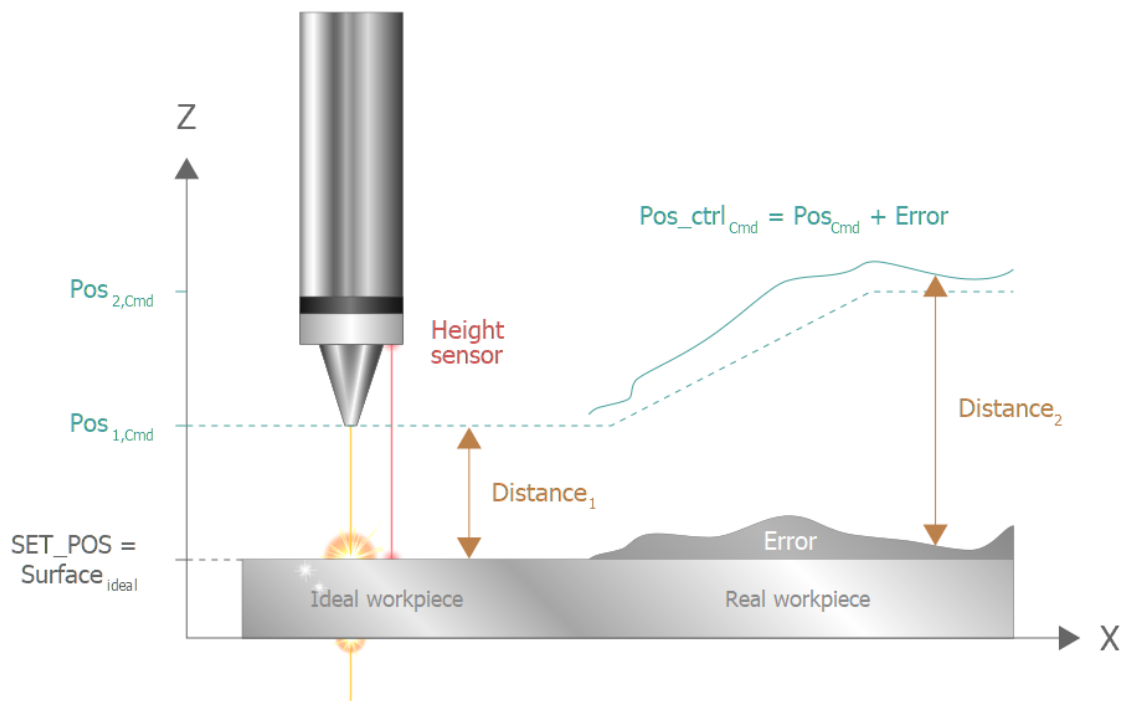


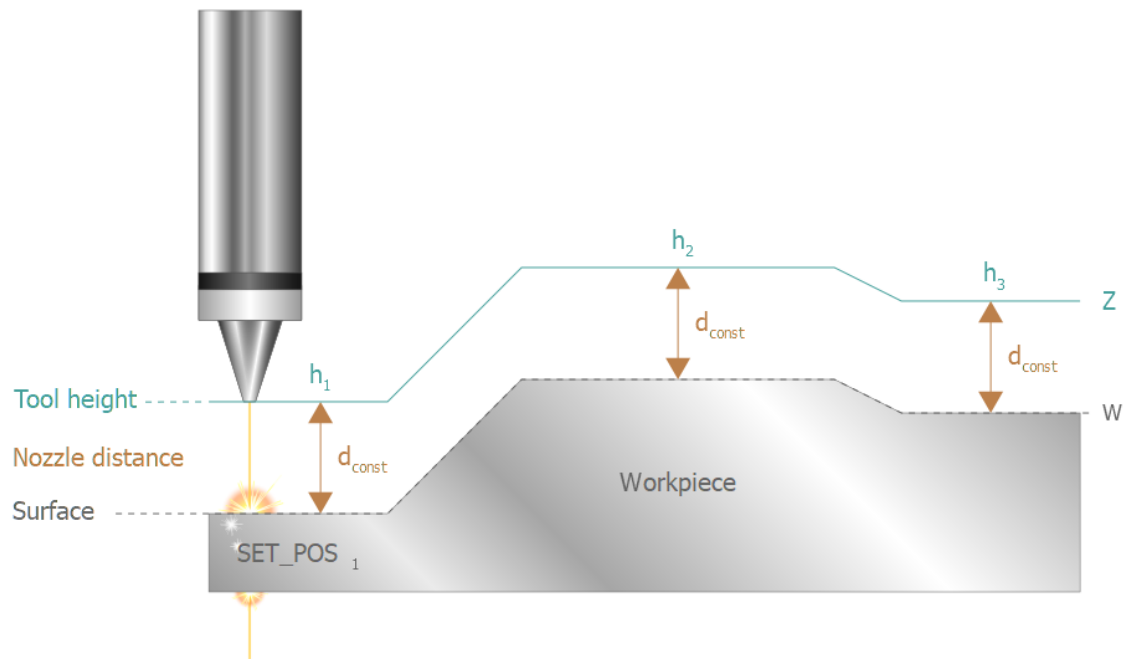
Fig. 25: Specifying the distance to workpiece for height control



### 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**

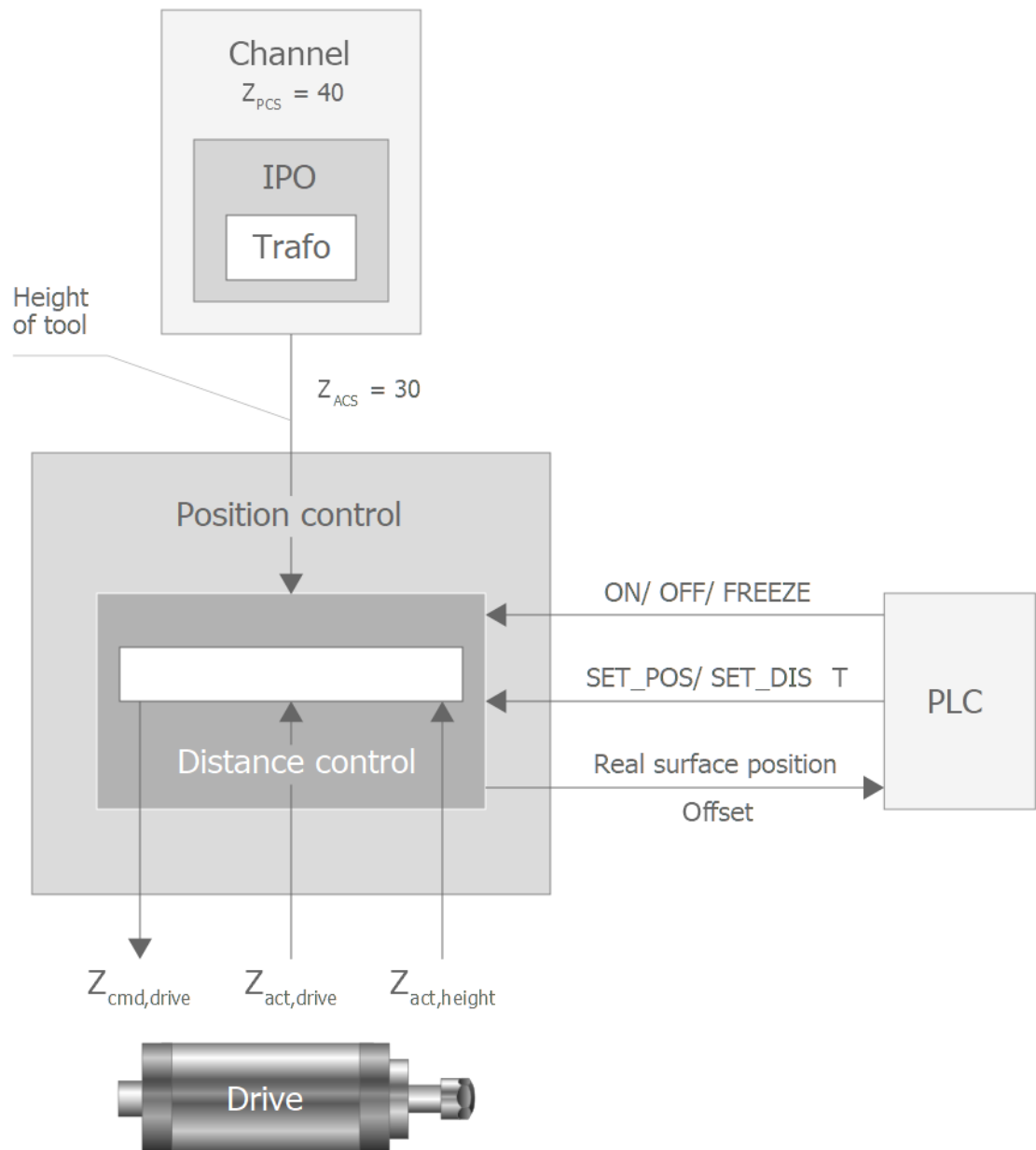
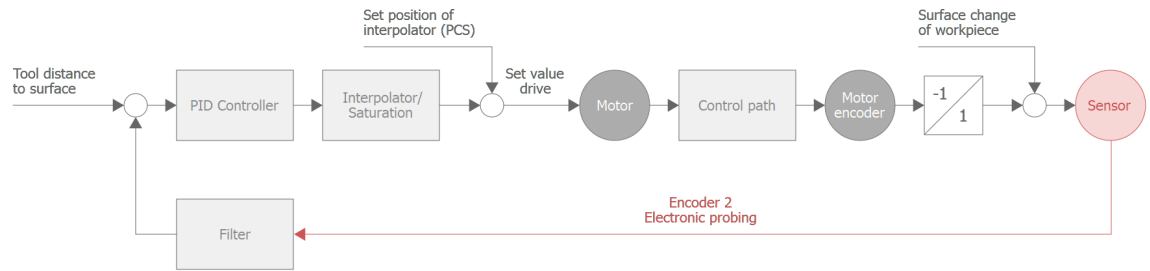


Fig. 27: Specifying the distance: distance



### 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:

```
<axis_name> [DIST_CTRL [ON [ DRYRUN ] [ CONST_DIST ]] | [OFF | CHECK_POS | FREEZE | REF]
SET_POS=.. SET_DIST=.. [ KP=.. ] [ I_TN=.. ] [ D_TV=.. ] [ FILTER_TYPE=.. ]
[ N_CYCLES=.. ] [ FG_F0=.. ] [ ORDER=.. ] [ SMOOTH_FACT=.. ] [ KALMAN_SIGMA=.. ]
[ NO_MOVE ] [ VAL1=.. - VAL5=.. ] { \ }
```

<axis_name>	Name of the axis supporting the tool.
DIST_CTRL	Identifier for the "Sensed spindles" function. Must always be programmed as the <u>first</u> keyword.
ON	Distance control on when workpiece surface is specified. A set position (SET_POS) must be set at switch-on.
CONST_DIST	Activate distance control (ON) when a constant distance to the workpiece surface is specified. A distance must be set with SET_DIST at switch-on. [as of Build V2.11.2804.03]
OFF	Deactivate distance control.
CHECK_POS	Check whether position is within the tolerance window.
FREEZE	Freeze the control distance across the workpiece. The axis position or the output correction value is maintained. Axis tracking is interrupted.
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). <b>[as of V3.1.3079.23]</b>  When distance control is activated, a set position must be set with SET_POS if the workpiece surface is specified.  When distance control is activated, a set distance must be set with SET_DIST if a constant distance from the workpiece surface is specified.
REF	Reference measuring system (sensor) (only if there is no absolute measuring system).

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.
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.
KP=..	Weighting the distance control output values. Parameterisation can be executed analogous to P-AXIS-00759 [► 67]. The value range is limited to $0.0 < KP \leq 2.0$ . 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 1.0 reduces 1 possible distance control oscillation and steadies control in the event of minor distance errors. <b>[as of V2.11.2809.06 or V3.1.3079.06]</b>
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 [► 67]. The value range is limited to $0.0 \leq I\_TN \leq 50.0$ . 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. <b>[as of V2.11.2809.06 or V3.1.3079.06]</b>
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 [► 68]. The value range is limited to $0.0 \leq D\_TV \leq 2.0$ . The larger the derivative action time, the stronger the D component. <b>[as of V2.11.2809.06 or V3.1.3079.06]</b>
FILTER_TYPE=..	Filter type to filter sensor values according to P-AXIS-00782 [► 69]. <b>[as of V3.1.3079.23]</b>
N_CYCLES=..	Number the measured values used for filtering according to P-AXIS-00413 [► 56]. <b>[as of V3.1.3079.23]</b>
FG_F0=..	Cut-off frequency for the low-pass filter in [Hz] according to P-AXIS-00508. <b>[as of V3.1.3079.23]</b>
ORDER=..	Order of the low-pass filter according to P-AXIS-00507. <b>[as of V3.1.3079.23]</b>
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 [► 70]. <b>[as of V3.1.3079.23]</b>
NO_MOVE	By default, the resulting correction offset is deactivated 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 deactivated 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.

The keywords ON/OFF, FREEZE, DRYRUN, CHECK\_POS and REF in the same command sequence mutually cancel each other out.

The keywords SET\_POS, SET\_DIST and VAL1-VAL5 can always be programmed in combination with each other.



## 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 SET_DIST=10]  
; Select with specified workpiece surface (SET_POS)  
N20 Z[DIST_CTRL ON]  
; ...  
Nxx Z[DIST_CTRL OFF]         ;Deselect  
; ...  
; Select with specified workpiece surface (SET_DIST)  
Nxx Z[DIST_CTRL ON CONST_DIST]  
; ...  
Nxx Z[DIST_CTRL OFF]         ;Deselect
```

N999 M30

**%DIST\_5**

```
N10 Z[DIST_CTRL FILTER_TYPE=KALMAN_MA] ;Select filter type
; Parametrise filter
N20 Z[DIST_CTRL N_CYCLES=30 KALMAN_SIGMA=1000]
; Activate distance control
N30 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

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

$$d_{\text{act}} = \text{Filter}(d'_{\text{act}})$$

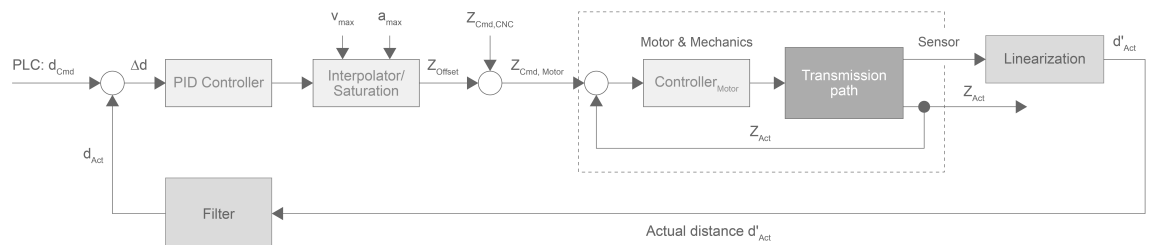


Fig. 29: Block diagram of distance control with distance sensor



## 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

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

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

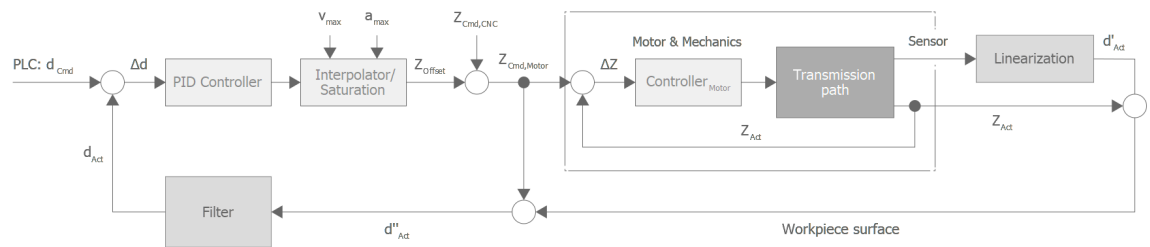


Fig. 30: Block diagram with distance sensor and motor encoder



### 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.

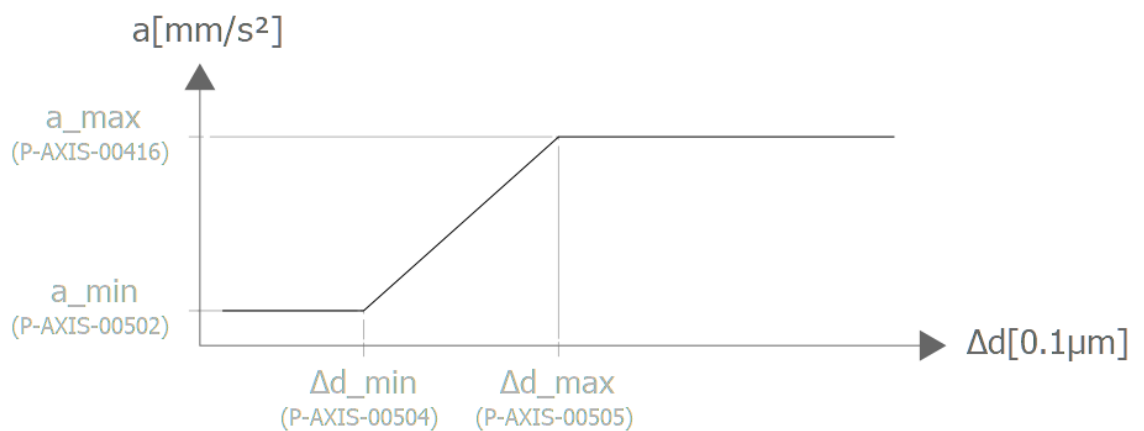


Fig. 31: Distance-dependent acceleration weighting



### 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.

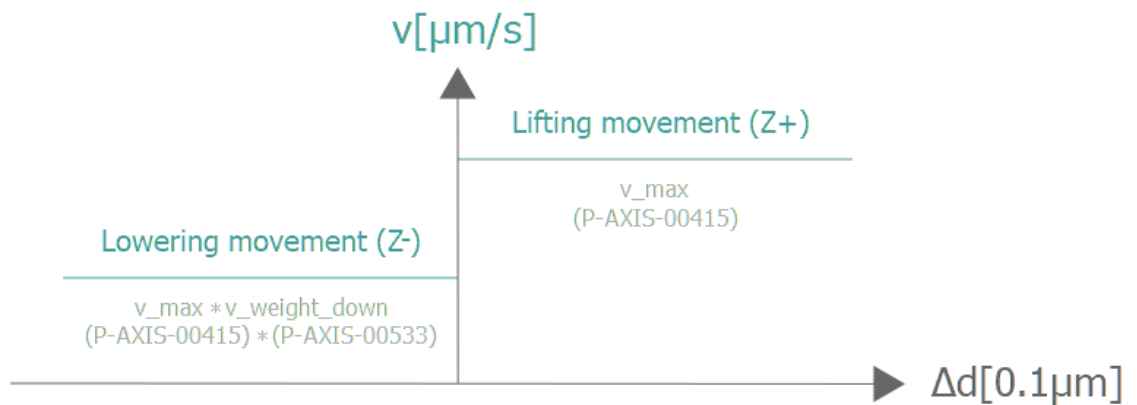


Fig. 32: Reduction in velocity by dynamic weighting of the lowering movement

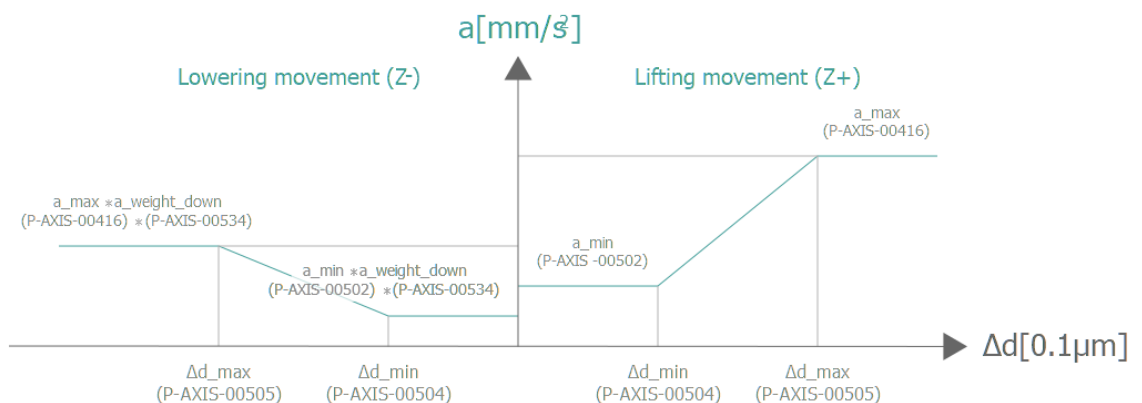


Fig. 33: Reduction in acceleration by dynamic weighting of the lowering movement



## 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 Changing parameters

The parameters `kenngnr.distc.v_max` (P-AXIS-00415) and `kenngnr.distc.a_max` (P-AXIS-00416) for speed and acceleration which distance control uses to correct deviations by constance control can be changed using ISG Objects.

The objects provided are in the GEO task and are:

Name	Type	Unit	Index-Group	Index-Offset
DISTCTRL::v_max	SGN32	µm/s	0x20300	0x10152 (*)
DISTCTRL::a_max	SGN32	mm/s^2	0x20300	0x10153 (*)

(\*) for the first axis, otherwise + 0x10000 \* axis\_index (e.g. 0x30152 for the third axis)

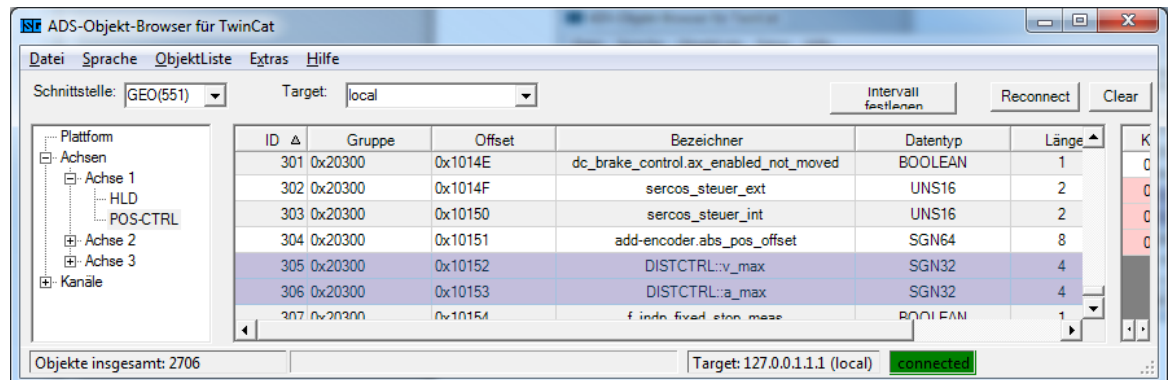


### Notice

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 to ACTIVE state or
2. from FREEZE to ACTIVE state

Parameters can be changed directly from the ISG object browser.



## 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).

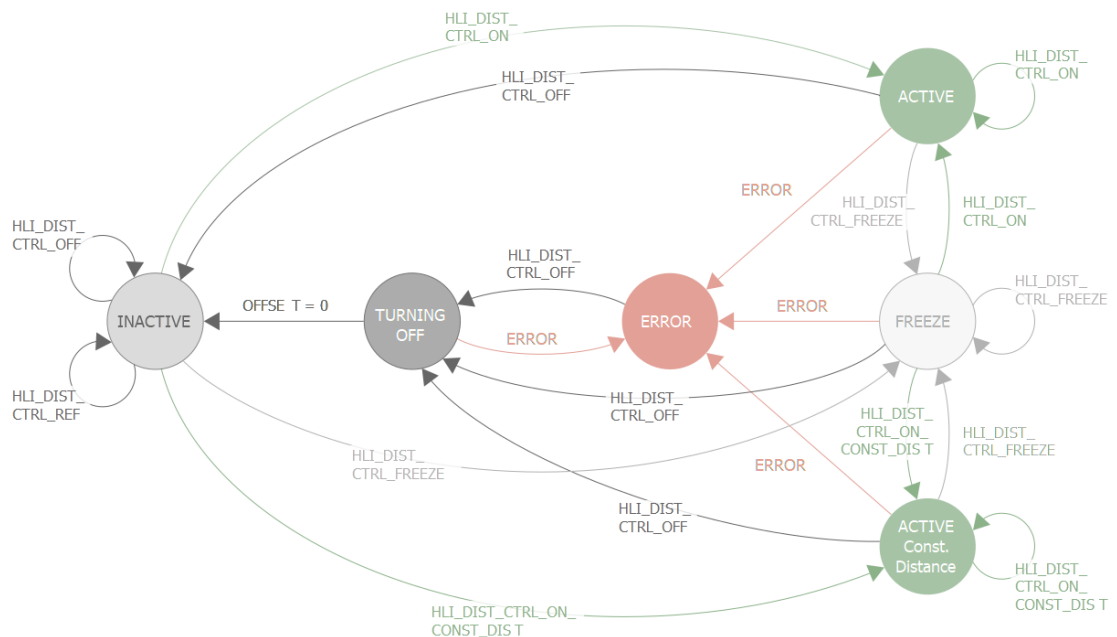
In addition to the NC program, distance control can also be commanded via the PLC interface (see [HLI//Distance control]) by specifying the required status transitions (e.g. activating or deactivating) and specifying command positions via the DistanceControl control unit.

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. 34: 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_CONS T_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_DI ST	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	<b>.command_semaphore_rw</b>
Signal flow	PLC → CNC
Data type	BOOL
Peculiarities	<b>Consumption data item</b>
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	<b>.command_w</b>
Signal flow	PLC → CNC
Data type	HLI_DISTANCE_CONTROL_COMMAND
Access	PLC writes
Distance control state	
ST element	<b>.state_r</b>
Signal flow	CNC → PLC
Data type	HLI_DISTANCE_CONTROL_STATE
Access	PLC is reading
Redirection	
ST element	<b>.enable_w</b>

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	<b>.actual_state</b>
Data type	UDINT
Access	PLC is reading
Value range/Description	See table: Distance control states and transitions [► 47]
Element	<b>.actual_position</b>
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	<b>.actual_offset</b>
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. <b>command_w</b>
Access	PLC writes
Elements of the data type	
ST element	<b>.transition</b>
Data type	UDINT
Value range/De- scription	See Table - Permissible transitions to command distance control [► 49]
ST element	<b>.position</b>
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. <b>CyclicCommand</b>
Access	PLC writes
Elements of the data type	
ST element	<b>.D_Position</b>
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	<b>.D_Distance</b>
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 <sup>2</sup> ]
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
<b>P-AXIS-00230</b>	lr_hw[1].vz_istw	Sign reversal of actual sensor values
<b>P-AXIS-00424</b>	lr_hw[1].mode_act_pos	Definition of the sensor value range: Linear scale or modulo handling of sensor values

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

## 9.2 Description

<b>P-AXIS-00328</b>	<b>Enabling of distance control (spindle with touch probe)</b>	
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		

<b>P-AXIS-00413</b>	<b>Filtering of sensor values</b>	
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	$0 \leq n\_cycles < 100$	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	4	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

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



<b>P-AXIS-00415</b>	<b>Maximum velocity</b>	
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	kenngr.distc.v_max	
Data type	SGN32	
Data range	$0 \leq v\_max < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: 0.001 mm/s	R: 0.001°/s
Default value	5000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00416</b>	<b>Maximum acceleration</b>	
Description	The parameter defines the maximum acceleration at which a position offset is cleared. 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	$0 \leq a\_max < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: 1 mm/s <sup>2</sup>	R: 1°/s <sup>2</sup>
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	Then this parameter is 0, the maximum axis acceleration P-AXIS-00008 is used.	

<b>P-AXIS-00417</b>	<b>Maximum permissible change speed of measured distance</b>	
Description	<p>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.</p> <p>When the maximum permissible change speed is exceeded, the error message ID 70329 is output. This detects problems with actual value detection.</p>	
Parameter	kenngr.distc.max_act_value_change	
Data type	SGN32	
Data range	$0 \leq \text{max\_act\_value\_change} < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: $\mu\text{m/s}$	R: $0.0001^\circ/\text{s}$
Default value	5000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00418</b>	<b>Reference point offset for measuring system</b>	
Description	<p>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.</p>	
Parameter	kenngr.distc.ref_offset	
Data type	SGN32	
Data range	$\text{MIN}(\text{SGN32}) \leq \text{ref\_offset} < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: $0.1\mu\text{m}$	R: $0.0001^\circ$
Default value	0 (No offset)	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00419</b>	<b>Upper limit for measuring system</b>	
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	$0 \leq \text{max\_pos} < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	50000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

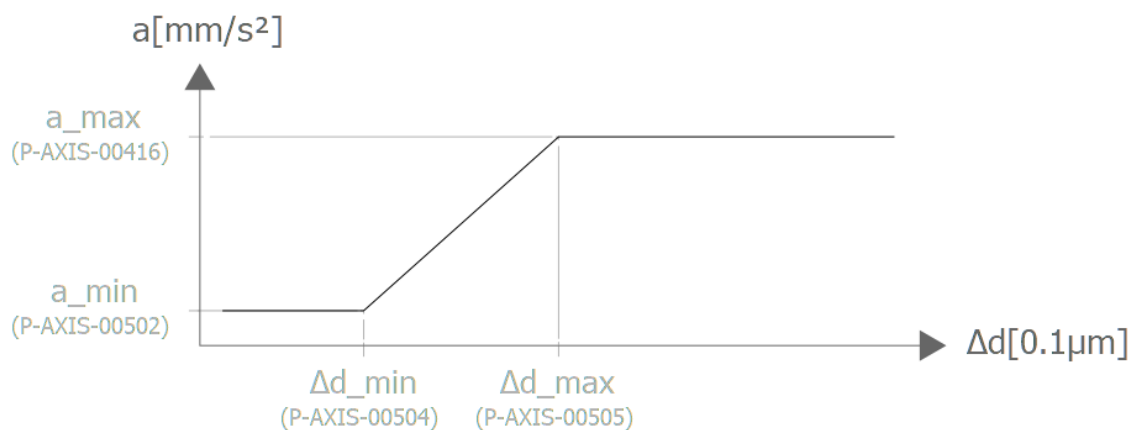
<b>P-AXIS-00420</b>	<b>Lower limit for measuring system</b>	
Description	The following value defines the lower limit of the sensor. An error message is generated if it is exceeded while distance control is active.	
Parameter	kenngr.distc.min_pos	
Data type	SGN32	
Data range	$0 \leq \text{min\_pos} <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

<b>P-AXIS-00421</b>	<b>Tolerance band for limits</b>	
Description	<p>This parameter defines a minimum distance from the minimum and maximum sensor positions.</p> <p>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.</p>	
Parameter	kenngr.distc.tolerance	
Data type	SGN32	
Data range	$0 \leq \text{tolerance} < \text{MAX}(\text{SGN32})$	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	0	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

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

<b>P-AXIS-00500</b>	<b>Option: Coupling of distance sensor and motor encoder</b>	
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		

<b>P-AXIS-00501</b>	<b>Option: Adaptive weighting of acceleration</b>	
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. 35: View Option: Adaptive acceleration weighting**

<b>P-AXIS-00502</b>	<b>Minimum acceleration</b>	
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 <sup>2</sup>	R: mm/s <sup>2</sup>
Default value	500	
drive types.	SERCOS, Profidrive, CANopen	
Remarks	.	

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

<b>P-AXIS-00505</b>	<b>Maximum distance error</b>	
Description	The parameter defines the maximum distance error of distance control from which a_max (P-AXIS-00416) is used.	
Parameter	kenngr.distc.dist_error_a_max	
Data type	UNS32	
Data range	0 ≤ dist_error_a_max < MAX(UNS32)	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	5000	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00507</b>	<b>Order of the filter</b>	
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		

<b>P-AXIS-00508</b>	<b>Characteristic frequency of a filter</b>	
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	$0 \leq \text{low\_pass\_filter\_fg\_f0} < \text{MAX}(\text{REAL64})$	
Axis types	T, R	
Dimension	T: Hz	R: Hz
Default value	25	
drive types.	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00509</b>	<b>Option: Dead time reduction</b>	
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		

<b>P-AXIS-00533</b>	<b>Weighting factor for velocity of lowering movement</b>	
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	$0 \leq v\_weight\_down < 2000$	
Axis types	T, R	
Dimension	T: 0.1%	R: 0.1%
Default value	0 *	
Drive types	SERCOS, Profidrive, CANopen	
Remarks	<p>* The weighting is deactivated, lifting and lowering movement use the identical velocity P-AXIS-00415.</p> <p>This parameter is available from CNC version V2.11.2807.13 onwards.</p>	

<b>P-AXIS-00534</b>	<b>Weighting factor for acceleration of lowering movement</b>	
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	$0 \leq a\_weight\_down < 2000$	
Axis types	T, R	
Dimension	T: 0.1%	R: 0.1%
Default value	0 *	
Drive types	SERCOS, Profidrive, CANopen	
Remarks	<p>* The weighting is deactivated, lifting and lowering movement use the identical acceleration P-AXIS-00416.</p> <p>This parameter is available from CNC version V2.11.2807.13 onwards.</p>	



<b>P-AXIS-00422</b>	<b>Numerator distance resolution of the additive sensor measuring system</b>	
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 <sup>-4</sup> °] 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	<p>This entry is valid for 'lr_hw[i].*' with i ≥ 1!</p> <p>The resolution of the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00233 and P-AXIS-00234.</p>	

<b>P-AXIS-00423</b>	<b>Denominator distance resolution of the additive sensor measuring system</b>	
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 <sup>-4</sup> °] 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	<p>This entry is valid for 'lr_hw[i].*' with i ≥ 1!</p> <p>The resolution of the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00233 and P-AXIS-00234.</p>	

<b>P-AXIS-00230</b>	<b>Sign reversal of actual value</b>	
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.	

<b>P-AXIS-00424</b>	<b>Handling of the additive sensor values</b>	
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 $i \geq 1$ ! The setting of the sensor value range for the motor sensor 'lr_hw[0].*' is defined by P-AXIS-00122.	

<b>P-AXIS-00759</b>	<b>Weighting the distance control output values</b>	
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.	

<b>P-AXIS-00764</b>	<b>Integral (I) action time of the PID controller</b>	
Description	<p>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.</p> <p>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.</p> <p>Disable the I component by i_tn = 0.</p>	
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	<p>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> <p>This parameter is available as from Build 2809.06 or 3079.06.</p>	

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	<p>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> <p>This parameter is available as from Build 2809.06 or 3079.06.</p>	

P-AXIS-00782	Filter type for smoothing sensor values	
Description	<p>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:</p> <ul style="list-style-type: none"> <li>• DEFAULT: Moving average filter where P-AXIS-00413 [▶ 56] = 4</li> <li>• MOVING_AVERAGE: Moving average filter</li> <li>• LOWPASS Low-pass filter</li> <li>• KALMAN_MA: Kalman filter with prediction from average filter</li> <li>• EXPO_MEAN: Exponential weighted average filter</li> <li>• KALMAN_EXPO: Kalman filter with prediction from exponentially weighted average filter</li> </ul>	
Parameter	kenngr.distc.filter_type	
Data type	STRING	
Data range	DEFAULT MOVING_AVERAGE LOWPASS KALMAN_MA EXPO_MEAN KALMAN_EXPO	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	DEFAULT	
Drive types	SERCOS, Profidrive, CANopen	
Remarks	<p>The following filter parameters are still required for each of the filter types::</p> <ul style="list-style-type: none"> <li>• MOVING_AVERAGE: P-AXIS-00413 [▶ 56]</li> <li>• LOWPASS: P-AXIS-00507 [▶ 63], P-AXIS-00508 [▶ 63] (As of v3.1.3079.21 this setting replace the parameter P-AXIS-00506)</li> <li>• KALMAN_MA: P-AXIS-00413 [▶ 56], P-AXIS-00783 [▶ 70]</li> <li>• EXPO_MEAN: P-AXIS-00413 [▶ 56], P-AXIS-00784 [▶ 70]</li> <li>• KALMAN_EXPO: P-AXIS-00413 [▶ 56], P-AXIS-00784 [▶ 70], P-AXIS-00783 [▶ 70]</li> </ul>	

<b>P-AXIS-00783</b>	<b>Uncertainty of measurement values</b>	
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	$1.0 \leq \text{P-AXIS-00783} \leq 10000.0$	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	4	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

<b>P-AXIS-00784</b>	<b>Smoothing factor</b>	
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	$0 < \text{P-AXIS-00784} \leq 1.0$	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0.7	
Drive types	SERCOS, Profidrive, CANopen	
Remarks		

## 9.3 Example of distance axis



### Programing Example

#### Distance axis

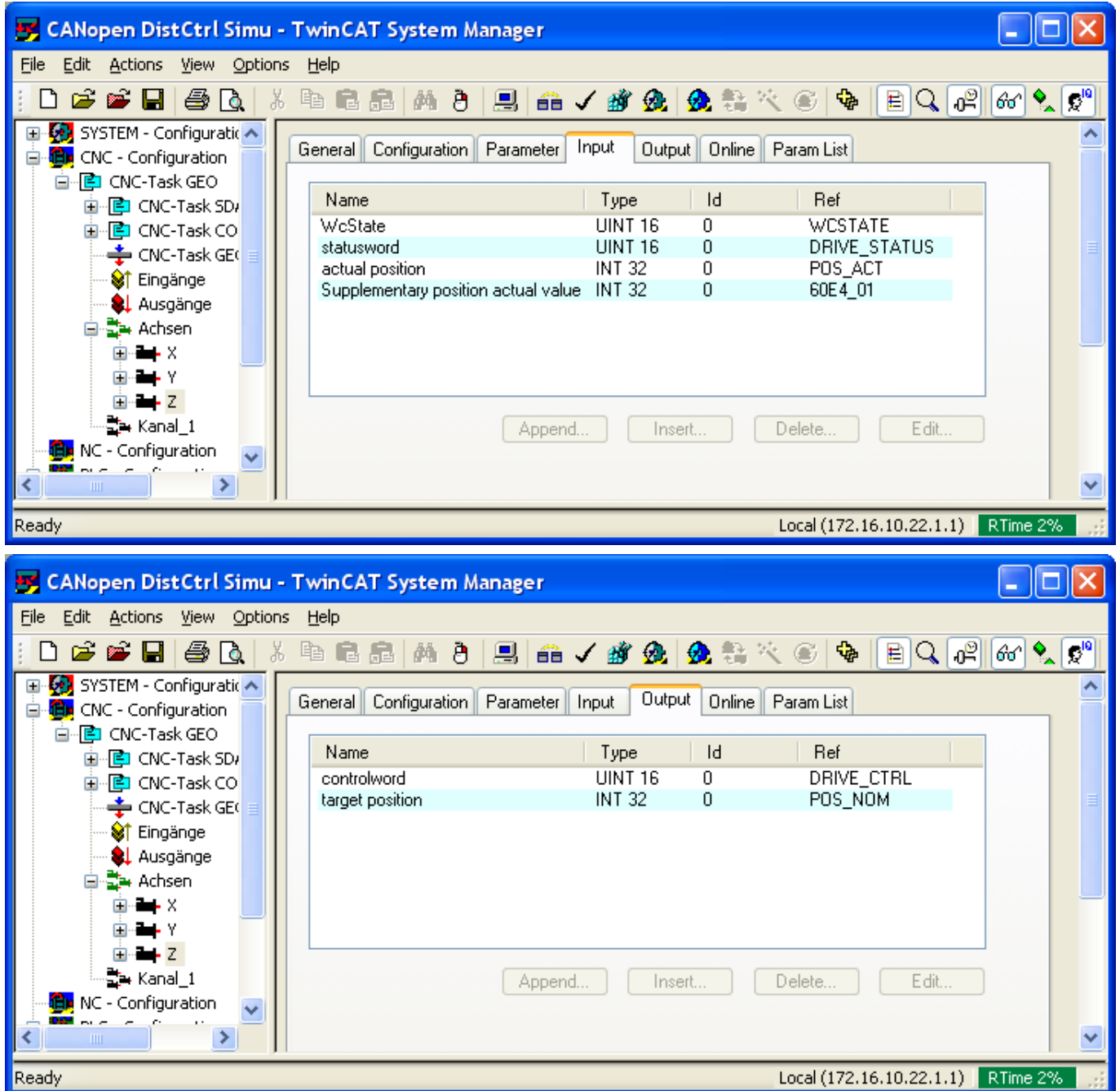
```
# ----- Distance control -----
lr_param.distance_control_on      1          Enables the distance control function
kenngr.distc.max_abweichung      20000000    # [0.1µm] Max. permissible deviation
kenngr.distc.v_max               50000       # [µm/s] Max. velocity of distance
                                              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_encoder 1    # Motor and distance encoder active
#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
```

## 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



The image displays two screenshots of the 'CANopen DistCtrl Simu - TwinCAT System Manager' software interface, showing the configuration of a Z axis drive.

**Top Screenshot: Input Configuration**

The 'Input' tab is selected. The table shows the following configuration:

Name	Type	Id	Ref
WcState	UINT 16	0	WCSTATE
statusword	UINT 16	0	DRIVE_STATUS
actual position	INT 32	0	POS_ACT
Supplementary position actual value	INT 32	0	60E4_01

**Bottom Screenshot: Output Configuration**

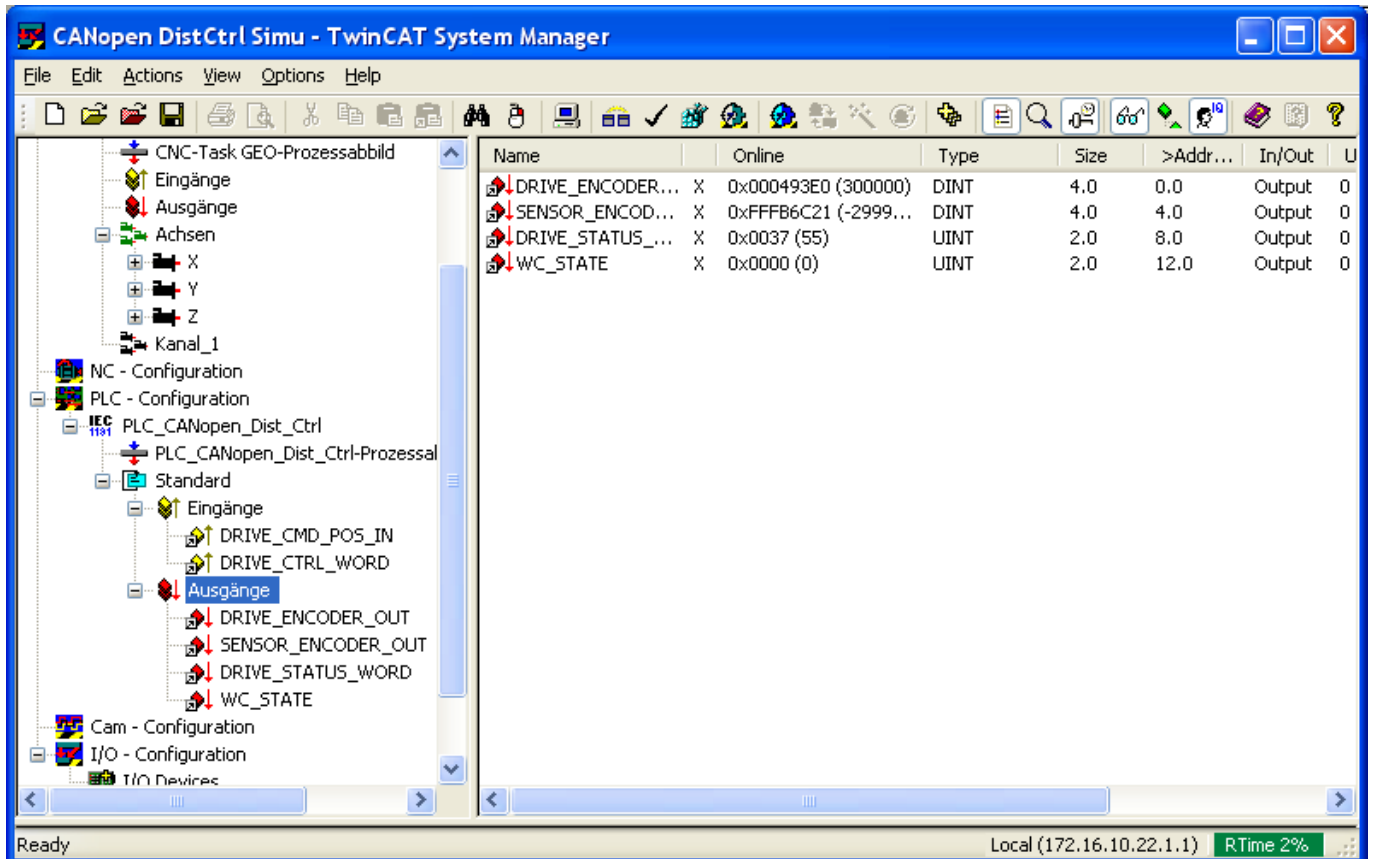
The 'Output' tab is selected. The table shows the following configuration:

Name	Type	Id	Ref
controlword	UINT 16	0	DRIVE_CTRL
target position	INT 32	0	POS_NOM



## Simulation in PLC

Simulation of CAN-PDO via PLC inputs/outputs



The screenshot shows the 'CANopen DistCtrl Simu - TwinCAT System Manager' interface. The left pane displays a hierarchical tree of the PLC configuration, including 'CNC-Task GEO-Prozessabbild', 'Eingänge', 'Ausgänge', 'Achsen', 'Kanal\_1', 'NC - Configuration', 'PLC - Configuration', 'PLC\_CANopen\_Dist\_Ctrl', 'Standard', 'Eingänge', 'Ausgänge', 'DRIVE\_CMD\_POS\_IN', 'DRIVE\_CTRL\_WORD', 'DRIVE\_ENCODER\_OUT', 'SENSOR\_ENCODER\_OUT', 'DRIVE\_STATUS\_WORD', 'WC\_STATE', 'Cam - Configuration', 'I/O - Configuration', and 'I/O Devices'. The right pane shows a table of I/O variables:

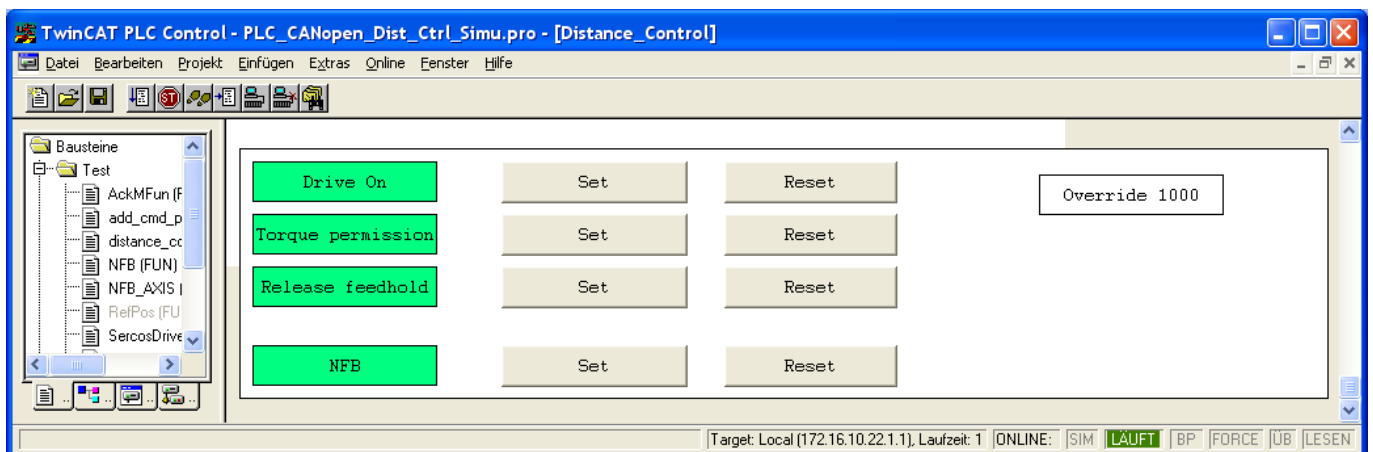
Name	Online	Type	Size	>Addr...	In/Out	U
DRIVE_ENCODER...	X 0x000493E0 (300000)	DINT	4.0	0.0	Output	0
SENSOR_ENCOD...	X 0xFFFFB6C21 (-2999...)	DINT	4.0	4.0	Output	0
DRIVE_STATUS...	X 0x0037 (55)	UINT	2.0	8.0	Output	0
WC_STATE	X 0x0000 (0)	UINT	2.0	12.0	Output	0

The status bar at the bottom indicates 'Ready' and 'Local (172.16.10.22.1.1) RTime 2%'.

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).



The screenshot shows the 'TwinCAT PLC Control - PLC\_CANopen\_Dist\_Ctrl\_Simu.pro - [Distance\_Control]' interface. The left pane displays a tree of 'Bausteine' (components) including 'Test', 'AckMFun (F)', 'add\_cmd\_p', 'distance\_cc', 'NFB (FUN)', 'NFB\_AXIS I', 'RefPos (FU)', and 'SercosDrive'. The main area contains a control panel with the following buttons:

- Drive On (green button)
- Torque permission (green button)
- Release feedhold (green button)
- NFB (green button)
- Set (yellow button)
- Reset (yellow button)
- Override 1000 (text box)

The status bar at the bottom indicates 'Target: Local (172.16.10.22.1.1), Laufzeit: 1', 'ONLINE: SIM', 'LÄUFT', 'BP', 'FORCE', 'UB', and 'LESEN'.

## Approaching a set position

**CANopen DistCtrl Simu - TwinCAT System Manager**

File Edit Actions View Options Help

SYSTEM - Configuration  
 CNC - Configuration  
 CNC-Task GEO  
 CNC-Task SDA  
 CNC-Task COM  
 CNC-Task GEO-  
 Eingänge  
 Ausgänge  
 Achsen  
 Kanal\_1  
 NC - Configuration  
 PLC - Configuration  
 Cam - Configuration  
 I/O - Configuration  
 I/O Devices  
 Mappings

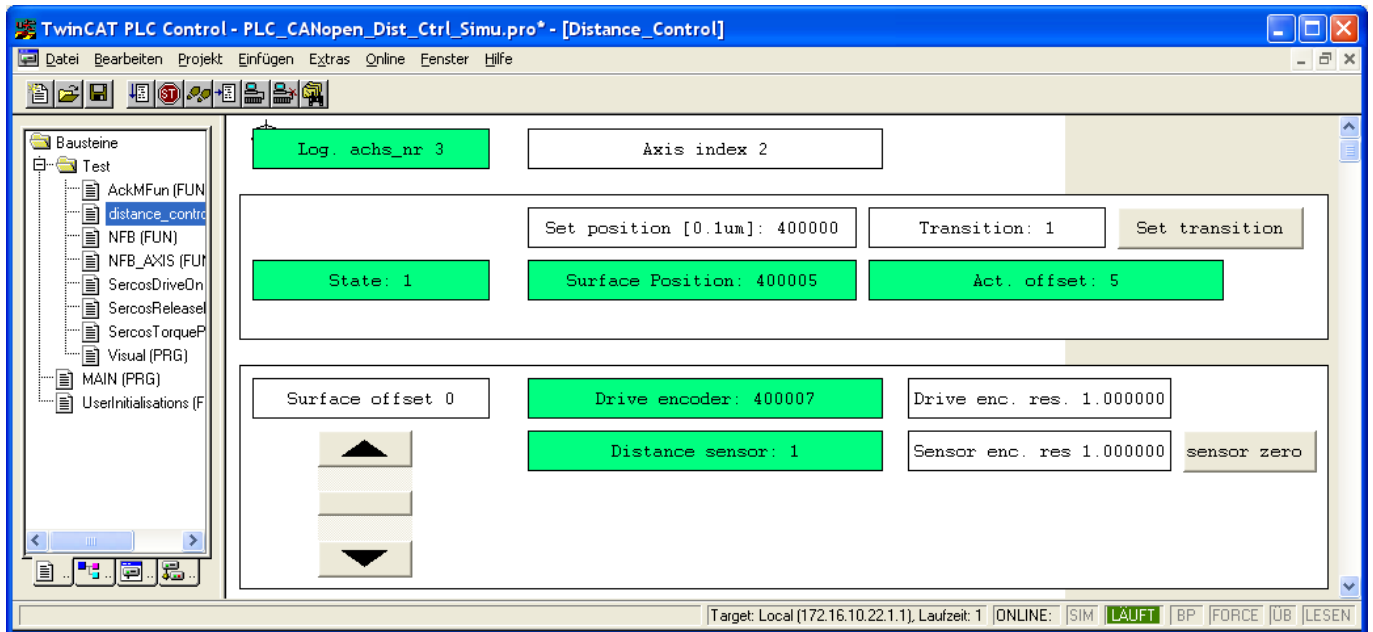
General SDA Para NP Para PZV Para VE Var Online Param List

Name	Actual Velo	Setp. Velo	Override	Set No.	Tool
Kanal_1	0.0	0.0	100.0	(none)	0

Name	Actual Pos.	Lag Dist.	Target Pos.	Actual Velo	State
X (X)	0.0000	0.0000	0.0000	0.0	Ready
Y (Y)	0.0000	0.0000	0.0000	0.0	Ready
Z (Z)	40.0000	-0.0001	39.9999	300.0	Ready

☐ Single Step MDI / Selected (Interp Empty)  
☐ Block Ignore Manual Automatic MDI  
 Program/MDI: Z40 #  
 F1 F2 F3 F4 F5 F6 F8

Ready Local (172.16.10.22.1.1) RTime 2%

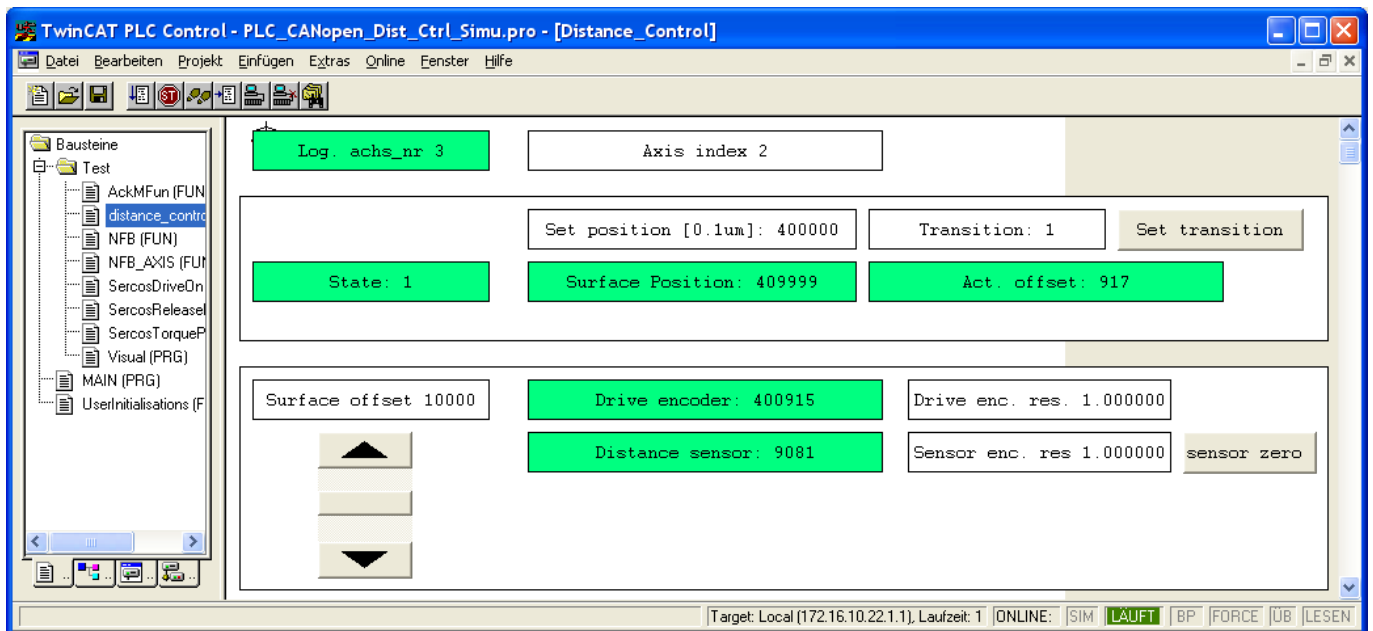


1. Referencing the sensor, "sensor zero", 2. Entering the set position, 3. Position=400000,
4. Turning on distance control, 5. Transition=1 (ON)

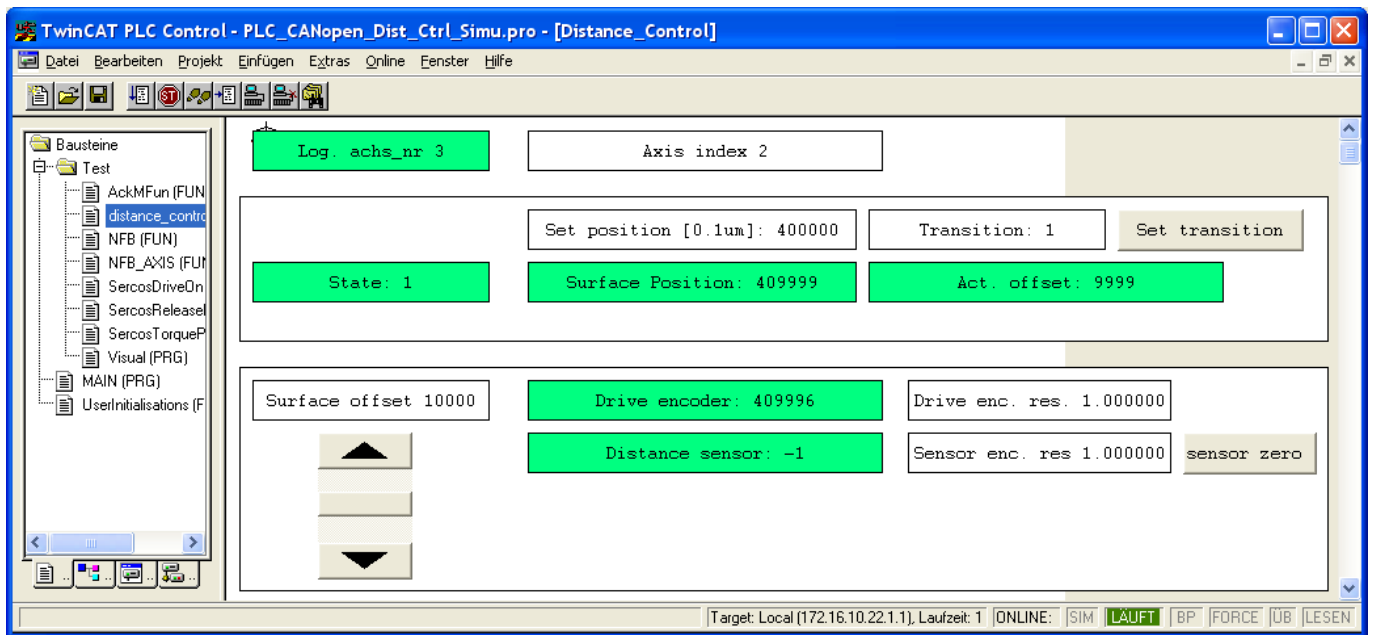
In the transmitted set position (SET\_POS) the distance sensor supplies the value = 0.

## Changing the surface position "Surface offset"

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

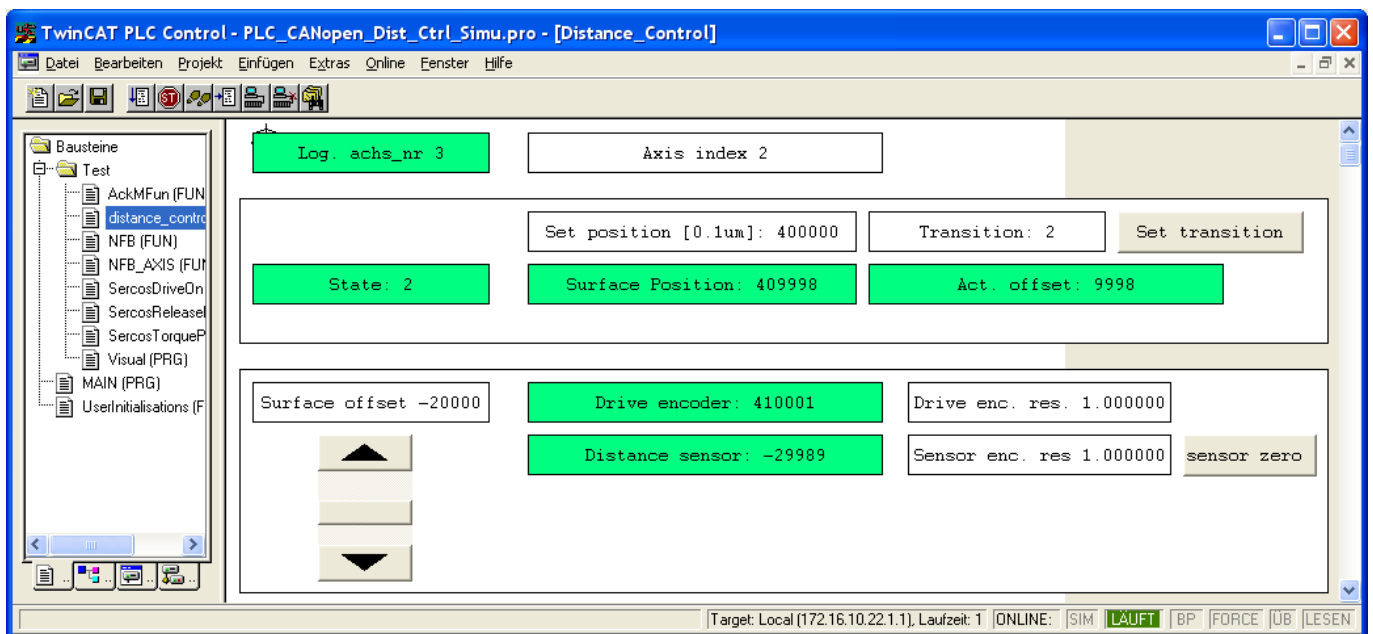


This causes a re-adjustment of the real axis position until the distance sensor supplies the value = 0 again. In other words the desired distance to surface is reached in this case.



### “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.

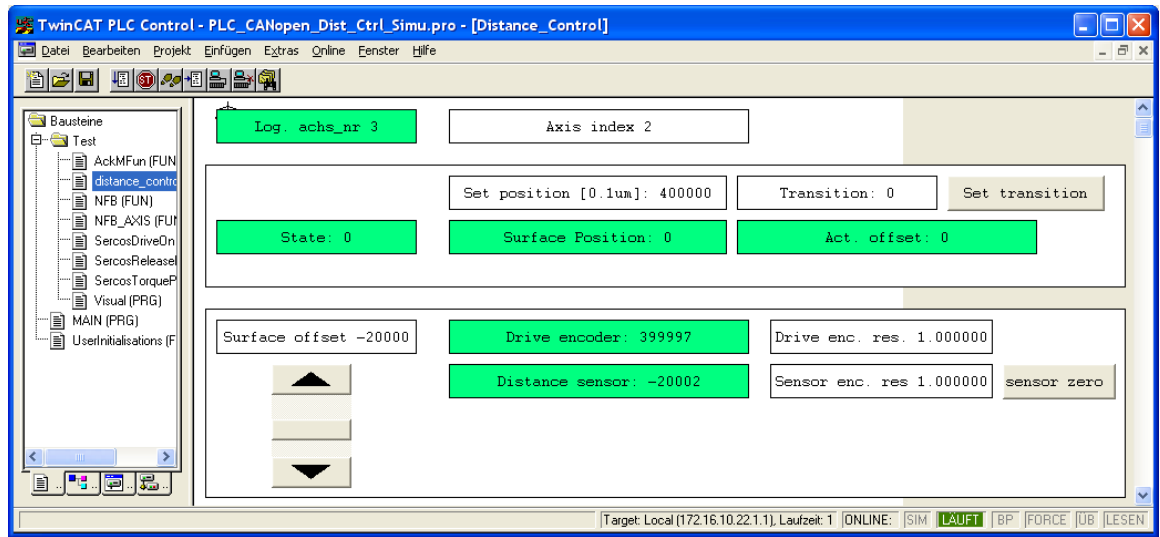


After re-activation of distance control the current sensor value is restored.

## 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:**

---

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

## 12 Appendix

### 12.1 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](mailto: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>



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##### 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.

We recommend you to save the above "QR code link" as your primary favourite link.

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DE:

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

EN:

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**E-Mail:** [documentation@isg-stuttgart.de](mailto:documentation@isg-stuttgart.de)

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### Distance control

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