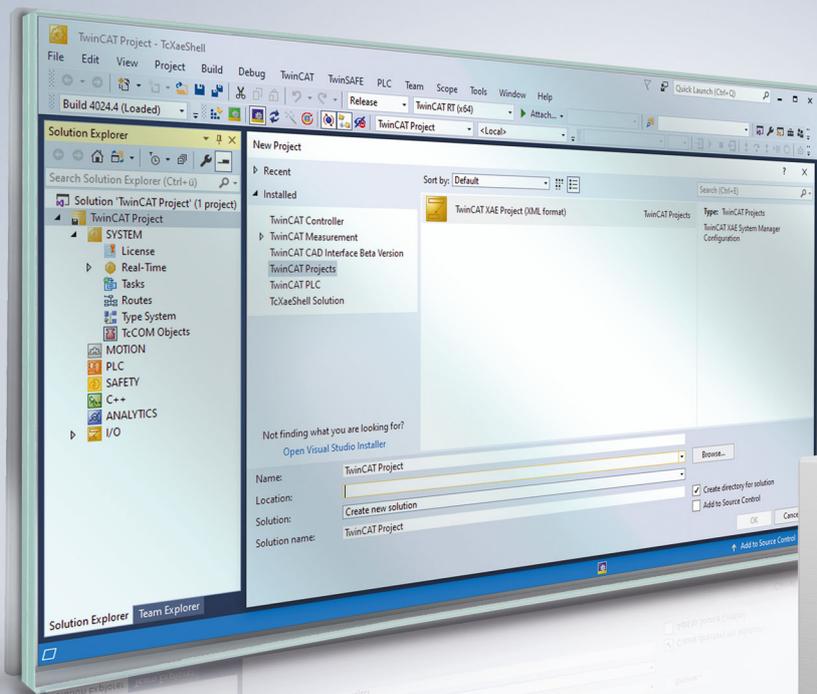


Functional description | EN

## TF5200 | TwinCAT 3 CNC

Axis coupling via HLI





## Notes on the documentation

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

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

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

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

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# General and safety instructions

## Icons used and their meanings

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

### Icons in explanatory text

1. Indicates an action.

⇒ Indicates an action statement.

#### **DANGER**

##### **Acute danger to life!**

If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.

#### **CAUTION**

##### **Personal injury and damage to machines!**

If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.

#### **NOTICE**

##### **Restriction or error**

This icon describes restrictions or warns of errors.

#### **Tips and other notes**



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

### General example

Example that clarifies the text.

### NC programming example

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

#### **Specific version information**



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

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# 1 Overview

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This description of functions is valid as of CNC Build V2.2800.

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## Task

Axis couplings are used to couple the movement of an axis to the movements of one or several other axis/axes.

Coupling is relative to the position of the axis when the coupling is activated. The dynamic limits of the target axis are not monitored.

## Properties

The axis couplings are active after the functionality has been activated via the HLI interface.

## Parametrisation

The coupling specifications are defined exclusively via the HLI interface. See the section [Parameters](#) [► 17].

## ***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

### Definitions

The definition of how movement of an axis influences another axis is referred to as a coupling specification.

Below, the axis whose position is influenced by other axes on the basis of the coupling specification is referred to as the **target axis**.

Axes that influence other axes via coupling specifications are referred to as **source axes**.

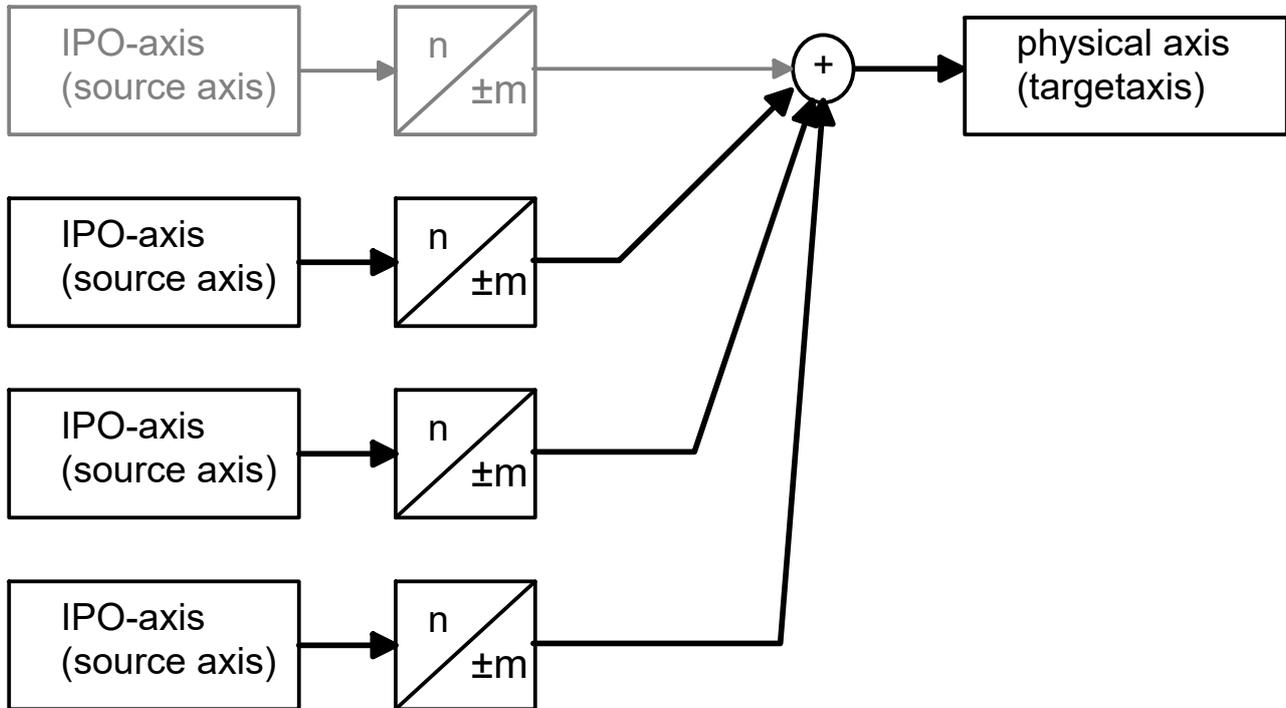


Fig. 1: View of the difference between source and target axis

In this example several source axes act on a physical target axis. The interpolator axis that normally moves the target axis need not necessarily belong to the source axes.

**i** **A change in axis coupling must take place when all the axes involved are at standstill.**

If this is not the case, the axis is stopped with error message ID 70200.

Standstill of all axes involved means that axis velocity must be 0. This affects both the target axis and all coupled source axes.

**i** **If a coupled axis is also programmed in the NC program, the target axis must be coupled to itself as source axis.**

The coupling specification stipulates: source axis = target axis with coupling factor 1

As an alternative to axis coupling via the HLI, the coupling can also be parameterised and enabled using the NC command #GEAR LINK in the NC program.

### Behaviour with command value request

Corresponding to the coupling instructions on drive level, an active gear coupling leads to an offset of the axis positions to the programmed command positions in NC channel. The axis positions and program coordinates are newly initialised at restart of program or by an explicitly programmed position request (#CHANNEL INIT [CMDPOS]). The ACS position (position on drive plane) is returned by default.

If the command value of the target axis is requested directly after activating an axis coupling, the returned value corresponds to the mechanical axis position.

The axis parameter P-AXIS-00436 defines the setting that the input coordinates of the gear coupling are recalculated by forward mapping when a command value request occurs.

If forward mapping of drive positions is activated with parameter P-AXIS-00436 the mapping is calculated by default relative to the activation position of the axis coupling..

The parameter P-AXIS-00460 can define the setting that the axis positions are regarded as absolute coordinates when a command value request occurs. In other words, it is assumed that the axis coupling is activated both for the master and for the slave axis at axis position 0.

### Restrictions when using P-AXIS-00436

If the axis parameter P-AXIS-00436 is set, the target axis may not be coupled to itself as source axis either directly or indirectly.

When the coupling is activated, a check is made for coupling loops such as these. If one is discovered, the error message ID 70410 is output and the coupling is not executed.

**i** When the parameters P-AXIS-00436 and P-AXIS-00460 are used, the channel must always be initialised.

### Schematic of a coupling

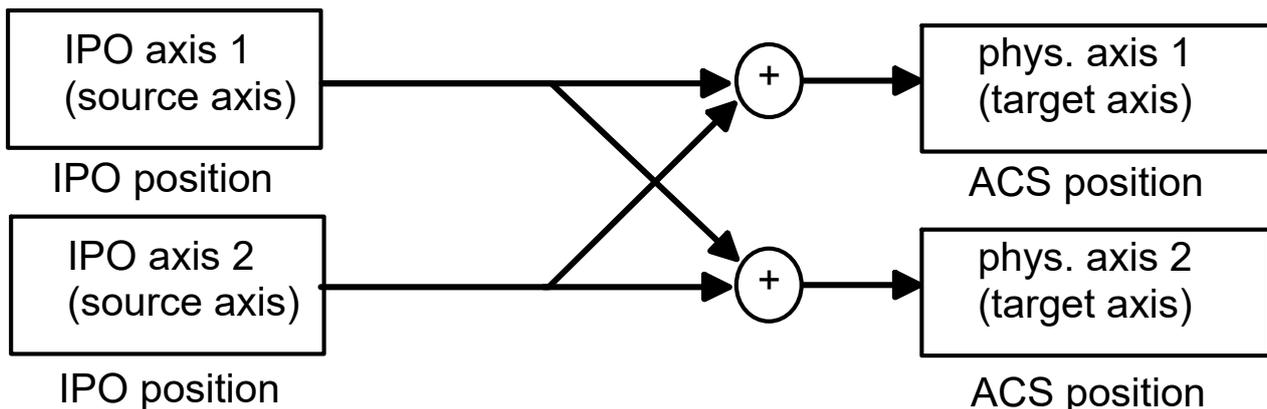


Fig. 2: Schematic of coupling specification

To calculate the IPO position of axis 2, the IPO position of axis 1 must already be known. The deadlock cannot be resolved and results in the output of error message ID 70410.

### General

The coupling specifications of a target axis are defined via an axis-specific control unit of the HLI.

In this control unit of the target axis, the coupling specifications are defined by specifying the logical axis number of the source axis and the coupling mode. If coupling mode HLI\_AXIS\_COUPLING\_FRACT is used, the coupling factor must also be specified as a fraction.

Several coupling specifications can be commanded. They are defined as an array in the commanded value of of the control unit. The indices of the array elements are within the interval [0 -HLI\_AX\_COUPLING\_MAXIDX]

The entered coupling specifications are activated by setting an HLI signal.

After evaluating the coupling specifications and checking for errors, the NC kernel resets the trigger signal.

**Activation**

Mit `axis_idx = [0..HLI_SYS_AX_MAXIDX]`

`coupl_idx = [0..HLI_AX_COUPLING_MAXIDX]`

**Axis-specific control unit of HLI:**

`gpAx[axis_idx]^lr_mc_control.axis_coupling`

**Defining the logical axis number of the source axis:**

`gpAx[axis_idx]^lr_mc_control.axis_coupling.command_w.desc[coupl_idx].ax_nr`

**Defining the coupling mode for this source axis:**

`gpAx[axis_idx]^lr_mc_control.axis_coupling.command_w.desc[coupl_idx].mode`

**Definition of coupling factor:**

`gpAx[axis_idx]^lr_mc_control.axis_coupling.command_w.desc[coupl_idx].fract_num`

`gpAx[axis_idx]^lr_mc_control.axis_coupling.command_w.desc[coupl_idx].fract_denom`

**Activating trigger signal**

`gpAx[axis_idx]^lr_mc_control.axis_coupling.command_w.semaphor_rw := TRUE`

## Programming of target axis

When axis couplings are used, all source axes acting on a target axis must be specified. If a target axis is also to be programmed in an NC program, a coupling specification must be defined for the logical axis number of the target axis on the HLI. For the programmed axis a coupling specification must be defined between its own source axis and its own target axis.

(See [example 2](#) [▶ 15])

## Coupling modes

The following coupling modes can be specified for a coupling specification:

Coupling identifier	Value	Meaning
HLI_AXIS_COUPLING_INACTIVE	0	The coupling specification is not active. All the following coupling specifications are also inactive. If the 1st coupling specification is defined as inactive, all coupling specifications are deactivated.
HLI_AXIS_COUPLING_ZERO	1	Coupling factor 0 This mode can be used to shut down an axis. A shut-down axis can nevertheless be used as a source axis for other axes.
HLI_AXIS_COUPLING_DIRECT	2	The coupling factor between the source and target axis is 1.
HLI_AXIS_COUPLING_MIRROR	3	The coupling factor between the source and target axis is -1.
HLI_AXIS_COUPLING_FRACT	4	The <a href="#">coupling factor</a> [▶ 9] K is a fraction and is defined by a nominator and a denominator.

## Coupling factor

The coupling factor K is defined as

$$K = \frac{\text{coupling factor nominator}}{\text{coupling factor denominator}}$$

## Defining the coupling factor:

Nominator: desc[coupl\_idx [▶ 11]].fract\_num

Denominator: desc[coupl\_idx [▶ 11]].fract\_denom

the permissible value range for the coupling factor nominator is: [-32768 ... 32767]. A value of 0 has the same effect as using coupling mode HLI\_AXIS\_COUPLING\_ZERO.

The permissible value range for the coupling factor denominator is [-32768 to 32767] excluding 0. A value of 0 causes the output of error message P-ERR-70396.

The absolute value of the coupling factor is limited to the value of HLI\_AXIS\_COUPLING\_FACT\_MAX. If the configured value for the coupling factor is greater than this value, the error message P-ERR-70397 is output.

**Software limit switches**

When the coupling mode HLI\_AXIS\_COUPLING\_FRACT is used, the target axis command position resulting from the active couplings is monitored to the configured software limit switches (P-AXIS-00177/P-AXIS-00178) provided the axis is referenced.

Here, a check is made whether the axis can be stopped from the current velocity using the emergency stop deceleration (P-AXIS-00003) in front of the configured software limit switches. If the software limit switch is exceeded, the error message P-ERR-70195 is output and the axis is stopped.

**Deactivation**

The axis couplings of an axis can be deactivated by setting the coupling mode of the first coupling entry in HLI\_AXIS\_COUPLING\_INACTIVE.

**Deactivating a coupling with several couplings on an axis**

Coupling no.	Source axis	Target axis	Coupling mode	Coupling active
1	X2	X2	2	yes
2	X	X2	2	yes
3	Y	X2	0	No
4	Z	X2	2	No

In the example the third coupling is deactivated. The consequence is that all subsequent couplings are deactivated.

**Status display**

In the control unit the status of the axis with regard to axis couplings is indicated in the

`gpAx[axis_idx [▶ 11]]^.lr_mc_control.axis_coupling.state_r`  
structure.

The active\_r structure element indicates whether an axis coupling is active for the axis. If a coupling is active, the element has the value TRUE.

When axis coupling is active, the couplings defined for this axis are indicated in the desc[] field.

An element of the desc[] field represents a coupling specification and consists of the following subelements.

- ax\_nr: logical axis number of the source axis
- mode: the coupling mode defined for the source axis

### Changing the axis coupling

Since it is only permitted to change an axis coupling if the target axis and all coupled source axes are at standstill, the PLC must first verify this when the coupling is changed.

In this case, for example, the current command velocity [ $10^{-3}$  mm/s or  $10^{-3}$  degree/s] of the axis can be checked before the coupling is activated.

```
gpAx[axis_idx [▶ 11]]^.lr_state.active_rev_r
```

### 3 Examples

Precondition for all examples below: Coupling specifications are to be defined for the axis with logical axis number 8 and axis designator Y2:

#### Example 1: Axis Y2 cannot be moved by the NC program.

```
desc[0].ax_nr:= 1
desc[0].mode:= HLI_AXIS_COUPLING_DIRECT

desc[1].ax_nr:= 0
desc[1].mode:= HLI_AXIS_COUPLING_INACTIVE
```

The axis moves in synchronicity with the axis with logical axis number 1. Since **no coupling specification is defined** for logical axis number 8, axis Y2 cannot be moved by the NC program.

Since coupling mode HLI\_AXIS\_COUPLING\_FRACT is not used, the elements `fract_num` and `fract_denom` need not be defined in the coupling specification `desc[0]`.

The coupling specification `desc[1]` indicates the end of the list of coupling specifications.

#### Example 2: Axis Y2 is moved by the NC program.

```
desc[0].ax_nr:= 1
desc[0].mode:= HLI_AXIS_COUPLING_DIRECT

desc[1].ax_nr:= 8
desc[1].mode:= HLI_AXIS_COUPLING_DIRECT

desc[2].ax_nr:= 0
desc[2].mode:= HLI_AXIS_COUPLING_INACTIVE
```

The **axis Y2 can now also be moved by the NC program when the coupling specification `desc[1]` is added.**

Since coupling mode HLI\_AXIS\_COUPLING\_FRACT is not used here, the elements `fract_num` and `fract_denom` need not be defined in the coupling specifications `desc[0]` and `desc[1]`.

The coupling specification `desc[2]` indicates the end of the list of coupling specifications.

**Example 3: Axis Y2 with coupling factor**

A coupling specification with coupling factor  $-5/9$  is to be defined for the axis with logical axis number 8 and axis designator Y2. Axis Y2 is also to be programmable in the NC program:

```
desc[0].ax_nr:= 8
desc[0].mode:= HLI_AXIS_COUPLING_DIRECT

desc[1].ax_nr:= 1
desc[1].mode:= HLI_AXIS_COUPLING_FRACT
desc[1].fract_num:= -5
desc[1].fract_denom:= 9

desc[2].ax_nr:= 0
desc[2].mode:= HLI_AXIS_COUPLING_INACTIVE
```

Since coupling mode HLI\_AXIS\_COUPLING\_FRACT is not used, the elements fract\_num and fract\_denom need not be defined in the coupling specification desc[0] .

The coupling specification desc[2] indicates the end of the list of coupling specifications.

## 4 Parameter

### 4.1 Overview

ID	Parameter	Description
P-AXIS-00003	getriebe[i].dynamik.a_emergency	Deceleration for an emergency stop
P-AXIS-00177	kenngr.swe_neg	Negative software limit switch
P-AXIS-00178	kenngr.swe_pos	Positive software limit switch
P-AXIS-00436	kenngr.recalc_link_main_input_position	Forward mapping of drive position
P-AXIS-00460	kenngr.recalc_input_position_absolute	Forward mapping of drive position with absolute coordinates

### 4.2 Description

<b>P-AXIS-00003</b>		<b>Deceleration for an emergency stop</b>	
Description	The parameter defines the used deceleration for an emergency stop. If errors of error reaction class 4 occur, the NC decelerates at the rate for specific axes. The path then leaves the trajectory.		
Parameter	getriebe[i].dynamik.a_emergency		
Data type	UNS32		
Data range	$1 \leq a\_emergency \leq 2 * P-AXIS-00008$		
Axis types	T, R, S		
Dimension	T: mm/s <sup>2</sup>	R,S: °/s <sup>2</sup>	
Default value	0		
drive types.	----		
Remarks	When the parameter has the value 0, the value of P-AXIS-00008 (a_max) is used.		

<b>P-AXIS-00177</b>		<b>Negative software limit switch</b>	
Description	The parameter defines the possible traverse range in the negative direction (negative software limit switch position). The programmed command positions are always checked on 'kenngr.swe_neg', the actual positions on 'kenngr.swe_neg - kengngr.swe_toleranz'.		
Parameter	kenngr.swe_neg		
Data type	SGN32		
Data range	$MIN(SGN32) < swe\_neg < P-AXIS-00178$		
Axis types	T, R		
Dimension	T: 0.1µm	R: 0.0001 °	
Default value	-100000000		
drive types.	----		
Remarks	The value of the parameter is adopted on reset, mode change and axis replacement from the axis record.		

<b>P-AXIS-00178</b>		<b>Positive software limit switch</b>	
Description	The parameter defines the possible traverse range in the positive direction (positive software limit switch position). The programmed command positions are always checked on 'kenngr.swe_pos', the actual positions on 'kenngr.swe_pos + kengngr.swe_toleranz'.		
Parameter	kenngr.swe_pos		
Data type	SGN32		
Data range	$P-AXIS-00177 < swe\_pos < MAX(SGN32)$		

Axis types	T, R	
Dimension	T: 0.1µm	R,S: 0.0001 °
Default value	100000000	
drive types.	----	
Remarks	The value of the parameter is adopted on reset, mode change and axis replacement from the axis record.	

<b>P-AXIS-00436</b>	<b>Forward mapping of drive position</b>	
Description	<p>Corresponding to the coupling instructions at drive level, an active gear coupling leads to an offset of the axis positions compared to the programmed command positions in NC channel.</p> <p>The gear coupling can be activated either by configuration in the axis parameters (see <code>multi_link[i]</code>) or via the HLI interface of the axis (see [FCT-A9 [► 8]]).</p> <p>In the event of a program restart or an explicitly programmed request of axis positions (<code>#CHANNEL INIT [CMDPOS]</code>), the axis positions and the channel program coordinates are re-initialised. The parameter must be set to 1 if the input coordinates of the gear coupling (e.g. absolute program coordinates) are to be recalculated by forward mapping. See also P-AXIS-00460.</p>	
Parameter	<code>kenngr.recalc_link_main_input_position</code>	
Data type	BOOLEAN	
Data range	0: No forward mapping of drive position (default). 1: Forward mapping is executed.	
Axis types	T, R	
Dimension	T: ----	R: ----
Default value	0	
Drive types	----	
Remarks	<p>Configuration example: Forward mapping is active during gear coupling</p> <pre>kenngr.multi_link[0].lead_axis           4 kenngr.multi_link[0].factor_numerator    1 kenngr.multi_link[0].factor_denominator  2 kenngr.recalc_link_main_input_position   1</pre> <p>Configuration example: Forward mapping with active gear coupling via the HLI</p> <pre>kenngr.recalc_link_main_input_position   1</pre>	

<b>P-AXIS-00460</b>	<b>Forward mapping of drive position with absolute coordinates</b>	
Description	<p>If forward mapping of drive positions is activated with parameter P-AXIS-00436, the mapping is calculated by default relative to the activation position of the axis coupling..</p> <p>This means that if immediately after the activation of an axis coupling the command positions are requested, the command position according to the mechanical axis position is returned.</p> <p>With parameter P-AXIS-00460 the axis positions are considered as absolute coordinates. This means the mapping is calculated as if the axes were coupled at position 0 for the master as well as for the slave axes.</p> <p><b>Example:</b></p> <p>At position X=40 mm and X1=50 mm the X1 axis is coupled each with a coupling factor of 1:1 to the X-axis and to itself.</p> <p>When P-AXIS-00460 is not set, the returned position for axis X1 is X1 = 50 mm on receipt of a command position request directly after activation of a coupling</p> <p>When P-AXIS-00460 is set, the returned axis position for the X1 axis is X1 = 10 mm.</p>	
Parameter	<code>kenngr.recalc_input_position_absolute</code>	
Data type	BOOLEAN	

Data range	0: Forward mapping relative to activation position (default). 1: Forward mapping with absolute positions.	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	0	
Drive types	----	
Remarks	This parameter is only effective for axis couplings that are activated via the HLI. This parameter is only practical for use with axes that deliver an absolute position.	

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### Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20  
33415 Verl  
Germany

Phone: +49 5246 963-0  
e-mail: [info@beckhoff.com](mailto:info@beckhoff.com)  
web: [www.beckhoff.com](http://www.beckhoff.com)

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More Information:  
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Beckhoff Automation GmbH & Co. KG  
Hülshorstweg 20  
33415 Verl  
Germany  
Phone: +49 5246 9630  
[info@beckhoff.com](mailto:info@beckhoff.com)  
[www.beckhoff.com](http://www.beckhoff.com)

