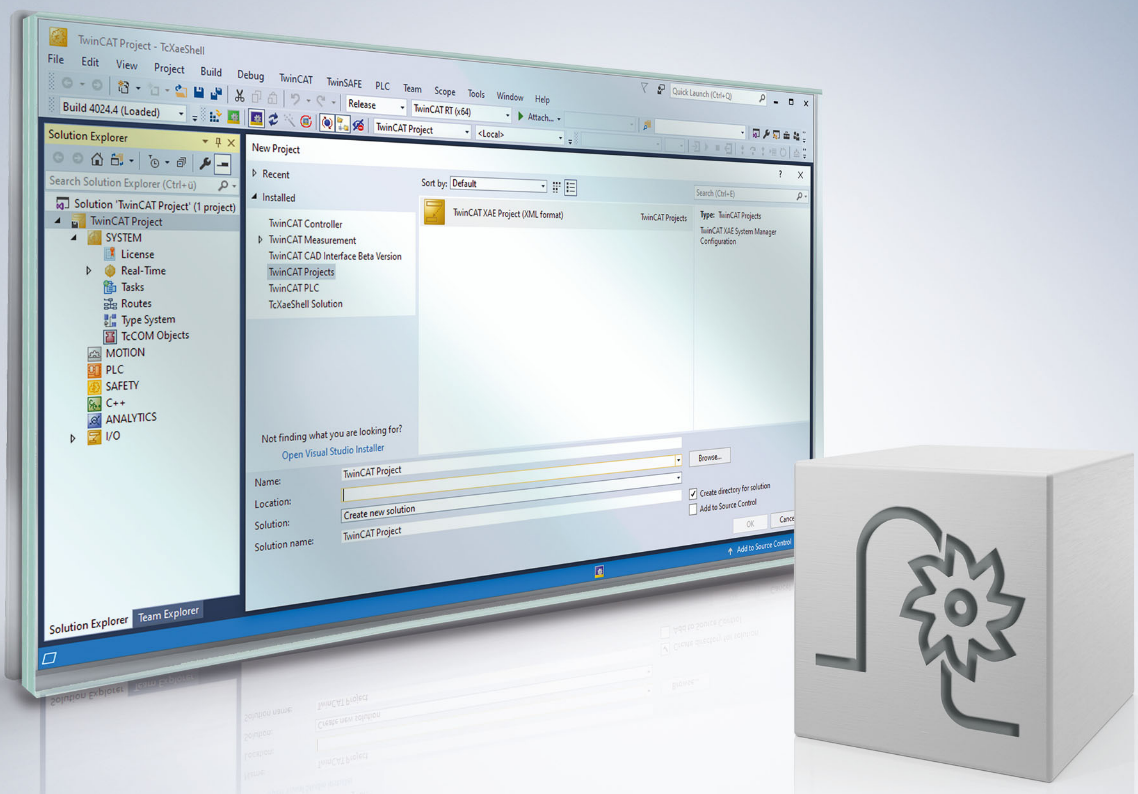
BECKHOFF New Automation Technology

Functional description | EN

TF5200 | TwinCAT 3 CNC

Dynamic coordinate system



12/18/2023 | Version: 1.04

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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The documentation has been prepared with care. The products described are, however, constantly under development.
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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.

Table of contents

List of figures

1 Overview

Task

The dynamic coordinate system compensates for and executes a superimposed motion. If a **machine** or a **workpiece** is additionally moved by an external source (master) during the machining process, this can be compensated by the processing NC channel (slave).

The additional movement is signalled to the processing NC channel (slave) **as dynamic coordinate system** (online offset and rotation).

This function is available as of CNC Build V3.1.3054.

Possible applications

A distinction is made between 2 basic applications:

1. Manufacture a moved workpiece.
2. Move the machine during machining (e.g. compensation for fluctuations in the kinematic base).

Programming and parameterisation

The TRACK CS ON/OFF command enables and disables the compensation function. The #TRACK CS ABS command is provided for implicit axis-specific calculation; the variable V.G.TRACK_CS.X is provided for explicit calculation.

The command #CHANNEL INTERFACE ON/OFF [DYN_CS] is used to define a CNC channel as master.

The PLC can also define the coordinate system.

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

A distinction is made between 2 application scenarios:

1. Manufacture a moved workpiece.
2. Move the machine during machining (e.g. compensating for fluctuations in the kinematics base).

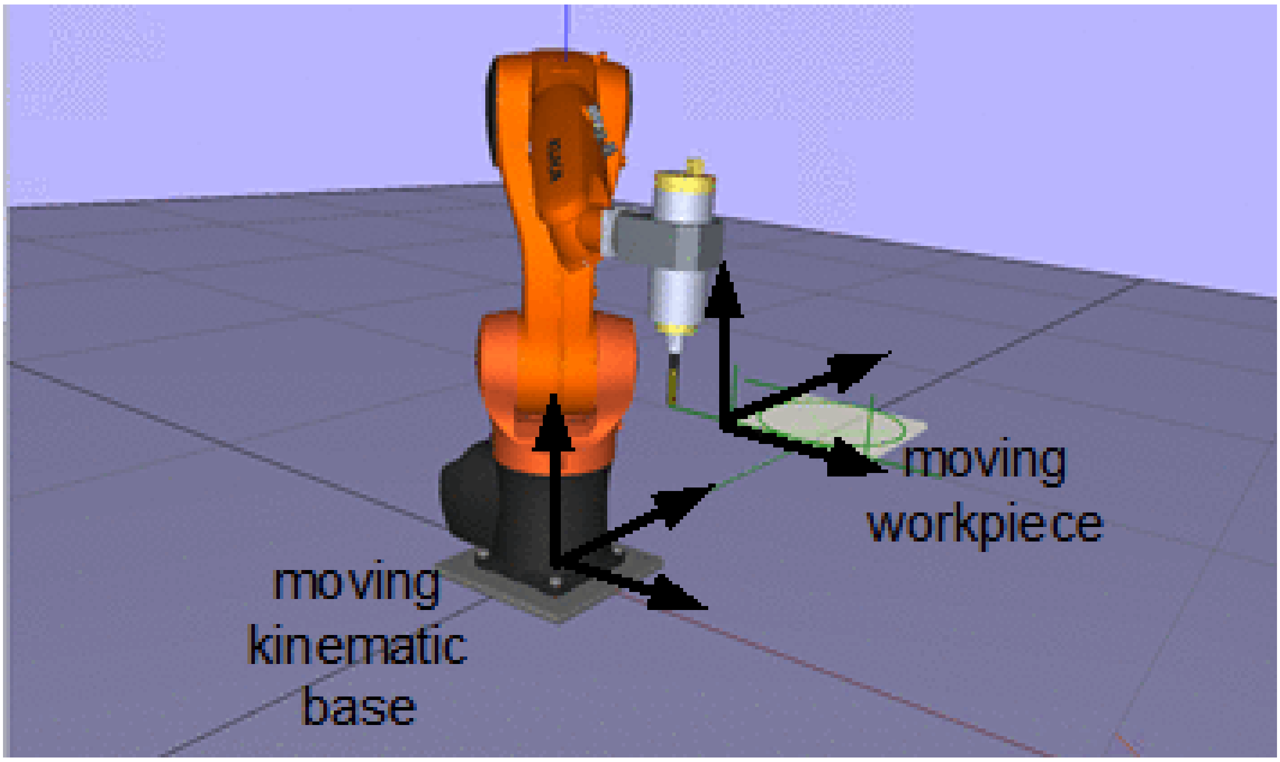


Fig. 1: Depiction of the two application fields of a Dynamic Coordinate System

2.1 Dynamic coordinate system

NOTICE

The processing slave channel attempts to follow the movements (offset, rotation) of the dynamic coordinate system. This additional movement is superimposed on the processing of the programmed channel.

The additional movement may lead to unplanned dynamic forces of the axes. This may give rise in particular to unplanned positions (kinematic singularities) being approached.

Application 1:

Manufacture a moved workpiece.

The moving coordinate system informs the processing NC channel (slave) when a moved workpiece is tracked and activates the compensation function.

#TRACK CS ON/OFF [ID<*id*>]

The workpiece can be moved by an NC channel (Masters, ID > 0) or by the PLC (ID = 0).

- NC channel: #CHANNEL INTERFACE ON/OFF [DYN_CS]
- PLC: Enable the control units on the HLI

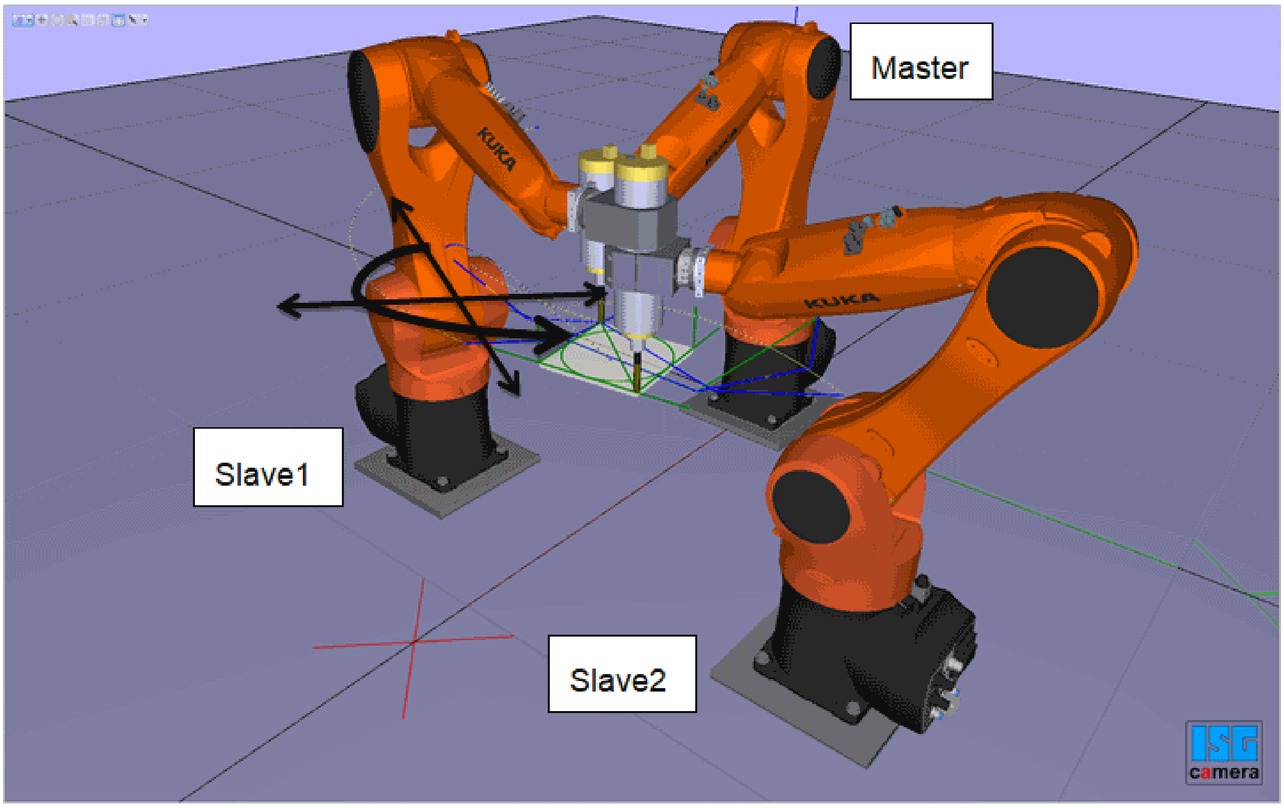


Fig. 2: Manufacture a moved workpiece.

Application 2:

Compensate the moved machine (kinematics base)

The controller compensates for fluctuations (offset, rotation) in a kinematics base. In this mode the programmed position is approached as if there was no base fluctuation. Fluctuations are detected by an external measuring system and signalled to the CNC channel by the dynamic coordinate system.

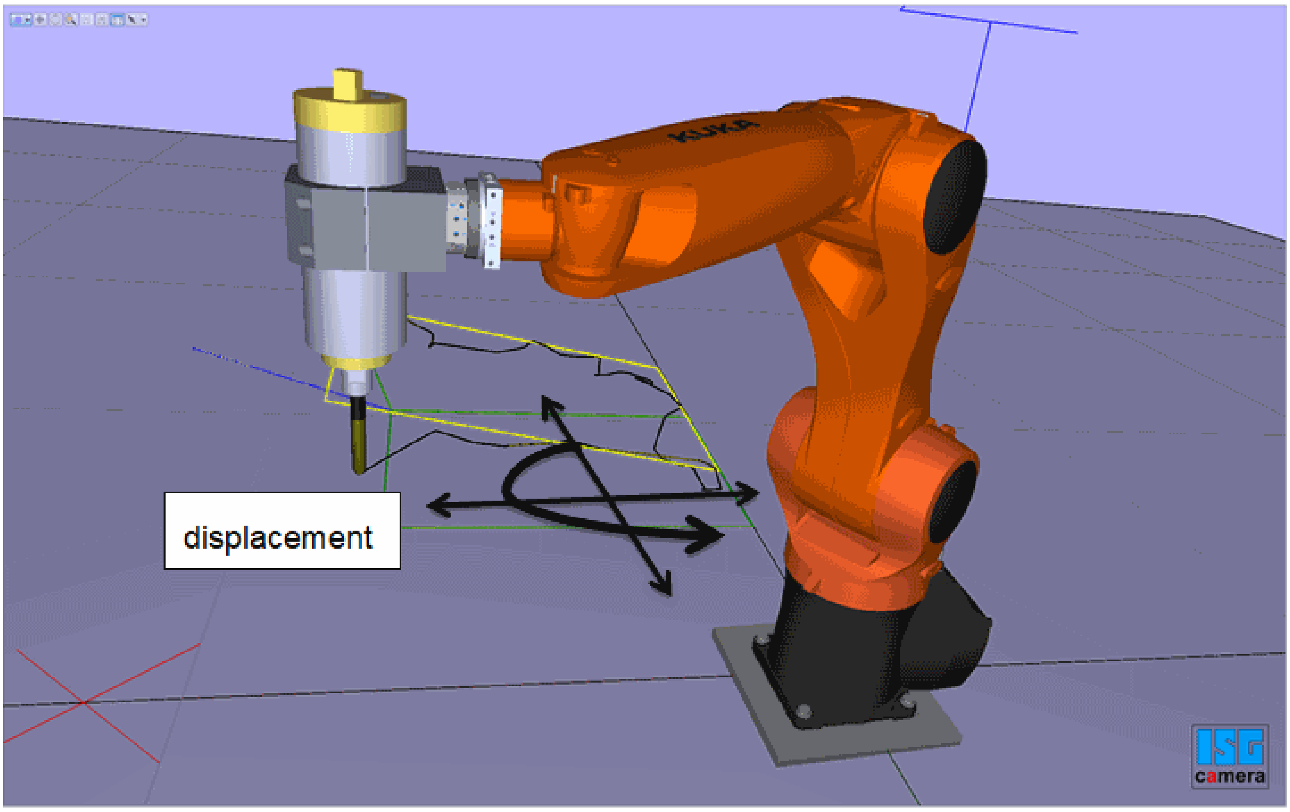


Fig. 3: Compensate the moved machine

Architecture and interfaces

The subsequent NC channel (slave) can be supplied by another NC channel (master) or by the PLC.

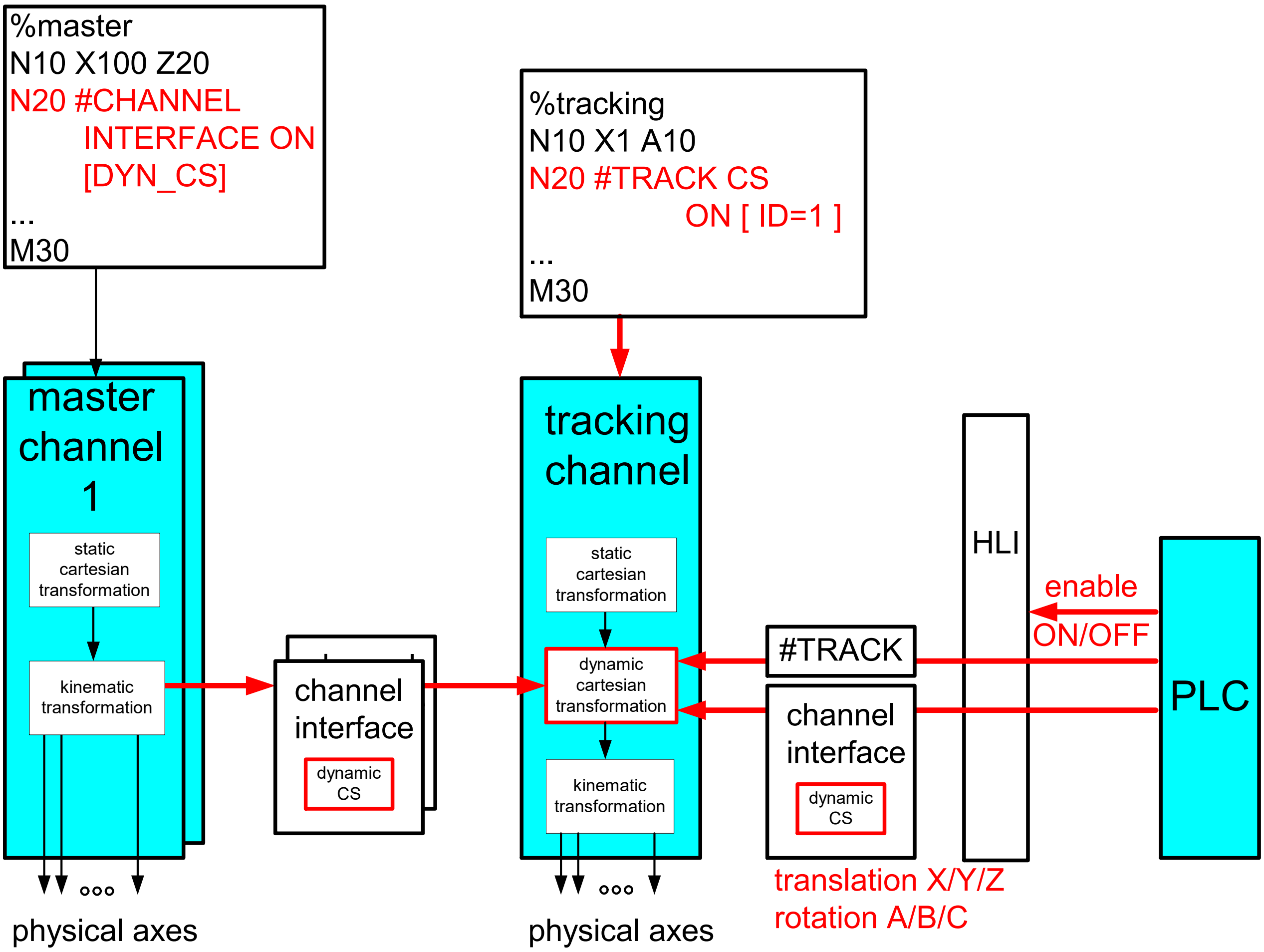


Fig. 4: Structure for coupling by a dynamic coordinate system

Slave channel tracking can be controlled by the NC program command or by PLC commands.

2.2 Specify the coordinate system by master

2.2.1 CNC channel as master (#CHANNEL INTERFACE)

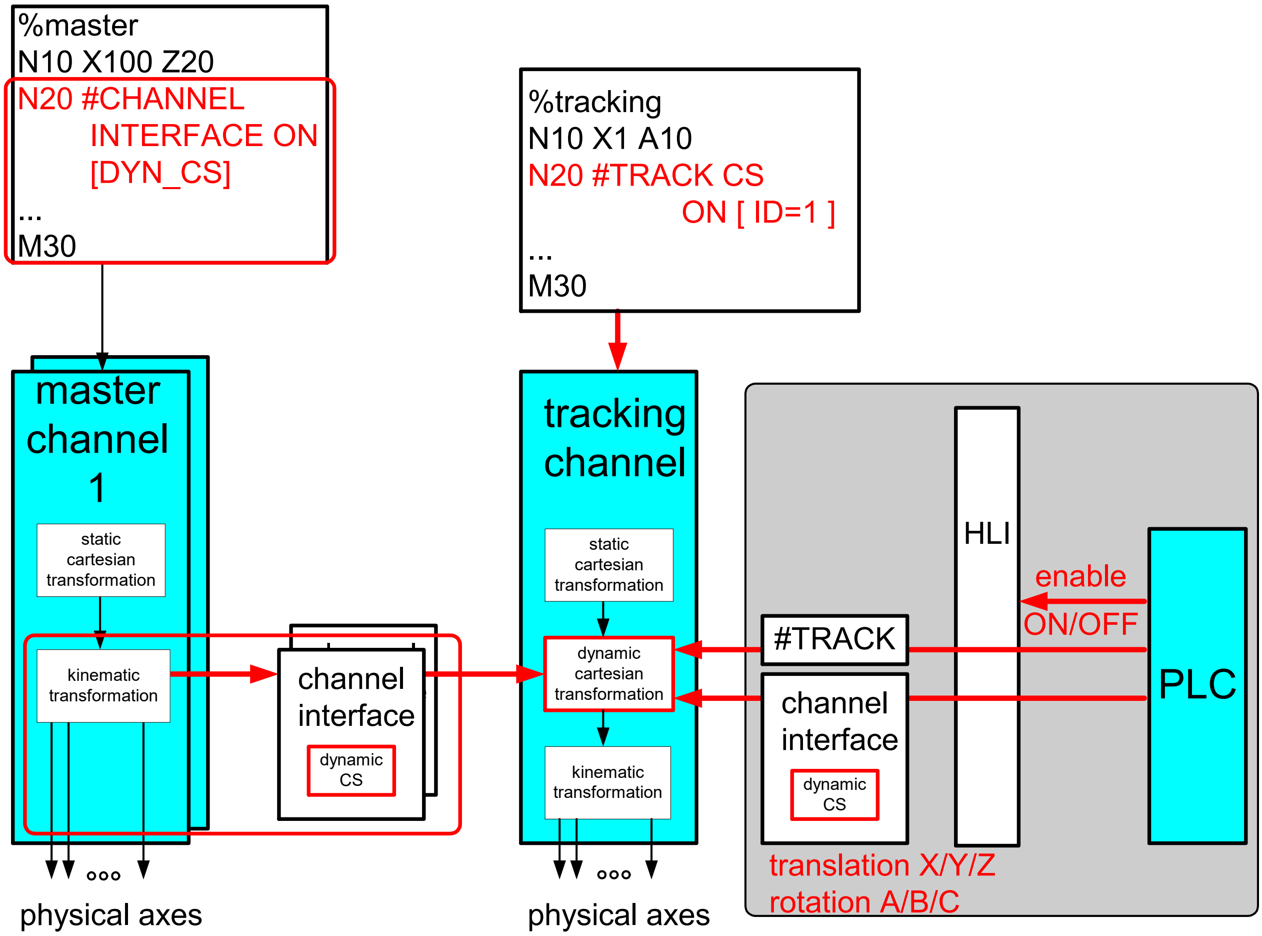


Fig. 5: Dynamic coordinate system by master CNC channel

Programmed enable

The master indicates a coordinate system at the channel interface. The coordinate is then defined by kinematic transformation (currently kinematic = 45 / 201). In other words, position and orientation are handled for each specific kinematic. The command consists of the following syntax elements:

#CHANNEL INTERFACE ON | OFF [DYN_CS]

DYN_CS / TRACK_CS There is no current option to activate the output of a dynamic coordinate system at the channel interface.

The master indicates whether it updates the dynamic coordinate system and whether the values are valid. When the interface is enabled or the when tracking is executed for the first time, the tracking slave is itself responsible for adopting the values “softly”.

The master can interrupt supply to the interface for a short time (FREEZE). When the function is continued, the slave must also adopt the values “softly”:

Automatic enable

Alternatively, dynCS channel interfaces can be automatically enabled by setting the channel parameter P-CHAN-00399 at program start.

2.2.2 PLC as Master

A dynamic coordinate system can be defined by a CNC channel or by the PLC. The HLI has a control unit for this.

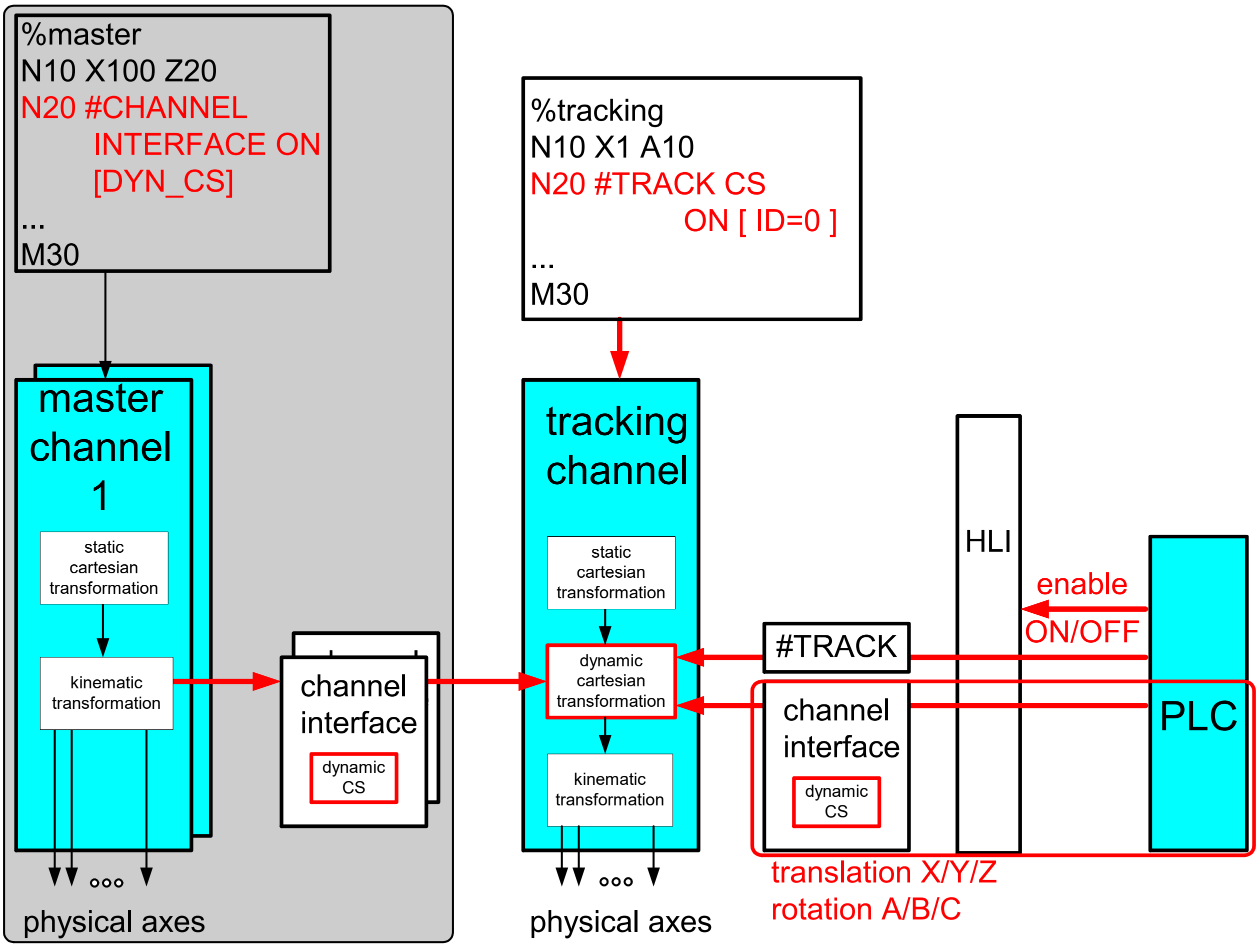


Fig. 6: Dynamic coordinate system by PLC

States of the tracking slave

INACTIVE	The slave does not track the dynamic coordinate system.
ACTIVATING	The first time the tracking function is activated, the salve adopts the changes “softly” via a filter.
ACTIVE	The slave tracks the dynamic coordinate system.
DEACTIVATING	The slave “softly” decouples dynamic coordinate system tracking.
ERROR	An error occurred in the slave. The slave is unable to track the dynamic coordinate system.

2.2.2.1 Control unit

Dynamic CS		
Description	Control unit to switch over dynamic CS tracking.	
Data type	MC_CONTROL_DYN_CS_UNIT [▶ 15]	
ST path	gpCh[*channel_idx*]^.channel_mc_control.**dyn_cs**	
Commanded, requested data		
ST element	**.command_w** **.request_r**	
Data type	HLI_COORDINATE_SYSTEM_INT translation: ARRAY [0..HLI_CS_AXES_MAXIDX] OF DINT;	
		X/Y/Z translation in [0.1 µm]
	rotation : ARRAY [0..HLI_CS_AXES_MAXIDX] OF DINT;	
		A/B/C rotation in [0.0001 degree]
Access	PLC writes command and reads request	
Return data		
ST element	**.state_r**	
Data type	HLI_DYN_CS_STATE actual_state : DINT;	HLI_DYN_CS_INACTIVE = 0
		HLI_DYN_CS_ACTIVATING = 1,
		HLI_DYN_CS_ACTIVE = 2,
		HLI_DYN_CS_DEACTIVATING = 3,
		HLI_DYN_CS_ERROR = -1
Access	PLC is reading	
Flow control of commanded value		
ST element	**.command_semaphor_rw**	
Data type	BOOL	
Value range	[TRUE, FALSE]	
Special features	**Consumption data item**	
Access	CNC accepts the commanded data if this element has the value TRUE and sets this element to the value FALSE after complete acceptance of the data. PLC can write data for commanding if this element has the value FALSE. The PLC sets this element to the value TRUE if all data to be commanded is written.	
Flow control of requested data		
ST element	**.request_semaphor_rw**	
Data type	BOOL	
Value range	[TRUE, FALSE]	
Special features	**Consumption data item**	
Access	CNC writes the data requested by the GUI if this element is FALSE and then sets this element to TRUE. PLC reads the data requested by the GUI if this value is TRUE. After the PLC fully accepts the data, the PLC sets this element to FALSE.	
Redirection		
ST path	gpCh[*channel_idx*]^.channel_mc_control.dyn_cs.**enable_w**	

Transition			
ST path	gpCh[*channel_idx*]^.channel_mc_control.dyn_cs.**transition_w**		
Data type	HLI_DYN_CS_TRANSITION		
	command	: DINT;	(* -1:DEACTIVATE, 1:ACTIVATE *)

	filter_max_ticks	: UDINT;	(* filter for turning ON/OFF, compare #TRACK CS ON [ID=<i> ...FILTER... *)
	option	: UDINT;	(* additional option, compare #TRACK CS ON [ID=<i> ...OPTION... *)
	f_wait	: BOOL;	(* #TRACK CS ON [...WAIT... *)
	f_set_zero	: BOOL;	(*#TRACK CS ON [...SET_ZERO... *)
	f_kin_base	: BOOL;	(* #TRACK CS ON [...KIN_BASE... *)
	f_rot_trans	: BOOL;	(* #TRACK CS ON [...ROT_TRANS... *)
	kinematic_base_cs	: HLI_COORDINATE_SYSTEM_INT;	
		(* add. shift between error and kinematic base, #TRACK CS ON [ID=<i> X=. Y=. *)	
Access	PLC writes the transition in analogy to the NC command #TRACK CS [ID=0 …] and CNC reads the transition. Correct NC/PLC handshake: First assign all parameters and then set command to +/-1.		

Control unit

```
TYPE HLI_COORDINATE_SYSTEM_INT :
STRUCT
  translation : ARRAY [0..HLI_CS_AXES_MAXIDX] OF DINT;
  fill_up_2 : DINT;
  rotation       : ARRAY [0..HLI_CS_AXES_MAXIDX] OF DINT;
  fill_up_1 : DINT;
END_STRUCT
END_TYPE

TYPE HLI_DYN_CS_STATE :
STRUCT
  actual_state : UDINT;
  fill_up_1    : DINT;
END_STRUCT
END_TYPE

TYPE HLI_DYN_CS_TRANSITION :
STRUCT
  command            : DINT;
  filter_max_ticks   : UDINT;
  option             : UDINT;
  f_wait             : BOOL;
  f_set_zero         : BOOL;
  f_kin_base         : BOOL;
  f_rot_trans        : BOOL;
  kinematic_base_cs : HLI_COORDINATE_SYSTEM_INT;
END_STRUCT
END_TYPE

TYPE MC_CONTROL_DYN_CS_UNIT :
STRUCT
  enable_w             : BOOL;  (* MC <-- PLC takes care *)
  request_semaphor_rw : BOOL;  (* Valid semaphore *)
  command_semaphor_rw : BOOL;  (* Valid semaphore *)
  fill_up_1            : BOOL;
  fill_up_2            : DINT;
  request_r            : HLI_COORDINATE_SYSTEM_INT;
  command_w            : HLI_COORDINATE_SYSTEM_INT;
  transition_w         : HLI_DYN_CS_TRANSITION;
  state_r              : HLI_DYN_CS_STATE;
END_STRUCT
END_TYPE
```

2.3 Tracking slave

2.3.1 Switch via NC command

The slave can track the dynamic coordinate system of any master. It can be controlled by an NC command.

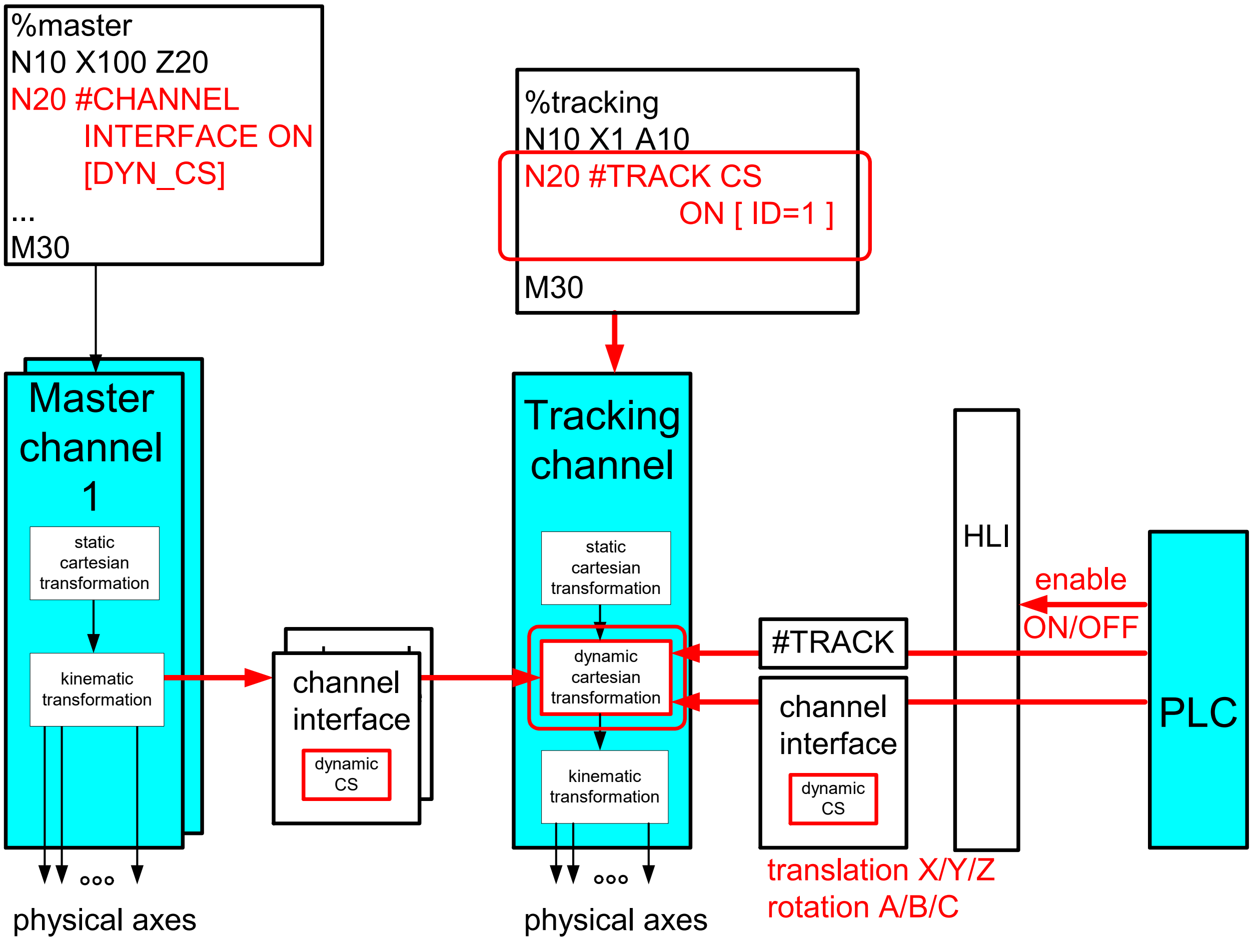


Fig. 7: Dynamic coordinate system by PLC

The enable command has the following syntax:

#TRACK CS ON	**[CH=.. | ID=.. [SET_ZERO | ABSOLUTE]** [**OPTION**=..] [**KIN_BASE**] [**FILTER**=..] [**WAIT**] [**ROT_TRANS**] [**RELATIVE**] [**X**=..] [**Y**=..] [**Z**=..] [**A**=..] [**B**=..] [**C**=..] **]** [**SIMU**] [**LOG_FILE**=..] **]**

CH=..	Source of the dynamic coordinate system which is to be tracked. [1;12]: CNC channel number which the dynCS indicates.
ID=..	Source of the dynamic coordinate system which is to be tracked. 0: PLC Interface [1;12]: CNC master channel number which the dynamic CS indicates.
SET_ZERO / ABSOLUTE	The current positions of the master are signalled to the decoder and can be calculated in the NC program as follows. This can occur implicitly by #TRACK CS ABS or explicitly by the channel variable V.G. TRACK_CS.X/Y/Z/A/B/C.
OPTION=..	Options which must be tracked: 0: translation and rotation are considered. (default) 1: only translation is tracked.
KIN_BASE	Fluctuations (red in the figure) in the kinematic based are compensated so that the slave TCP can be maintained at a stationary position. First specify the erroneous X/Y/Z offset and then the rotation C-B-A of the kinematic base.

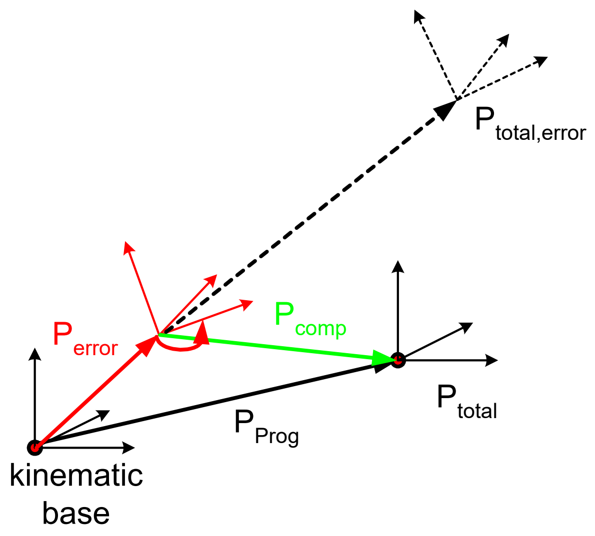


Fig. 8: Dynamic Coordinate System offsets

FILTER=..	If the input parameters are not 0 when the function is activated/deactivated, this would lead of a position jump in the programmed path contour. To prevent this, the specified translation/rotation can be coupled/decoupled softly by a filter and smoothed over the specified cycles. == 0, Filter is off. > 1, Filter is activated with explicitly specified filter time. If not specified, the filter is activated at default filter time = 200.
WAIT	When the filter is active, the program waits until the coupling is completely activated to execute the next NC row. If this mode is not specified (default), coupling is executed “on the fly”.
X | Y | Z | A | B | C	Additional static offset / rotation of error coupling point referred to kinematic base (KIN_BASE=1). Regarding the rotation, the default rotation sequence of the CNC applies: rotation about Z, rotation about Y, rotation about X. The rotation sequence cannot be changed even with the parameter settings of P-CHAN-00394. Static offset between master and slave (KIN_BASE=0).
ROT_TRANS	The error is specified by an offset and a rotation. First measure the offset and then the rotation. If the offset is measured in the coordinate system which is already rotated, this can be specified by the following setting.

Offset / rotation X | Y | Z | A | B | C

Specify an additional offset / rotation has different meanings depending on the application:

Application: Moved workpiece

This parameter specifies the static position offset of the slave to the master. In the example below this would be:

#TRACK CS […**X=400 Y=700 C= - 90**…]

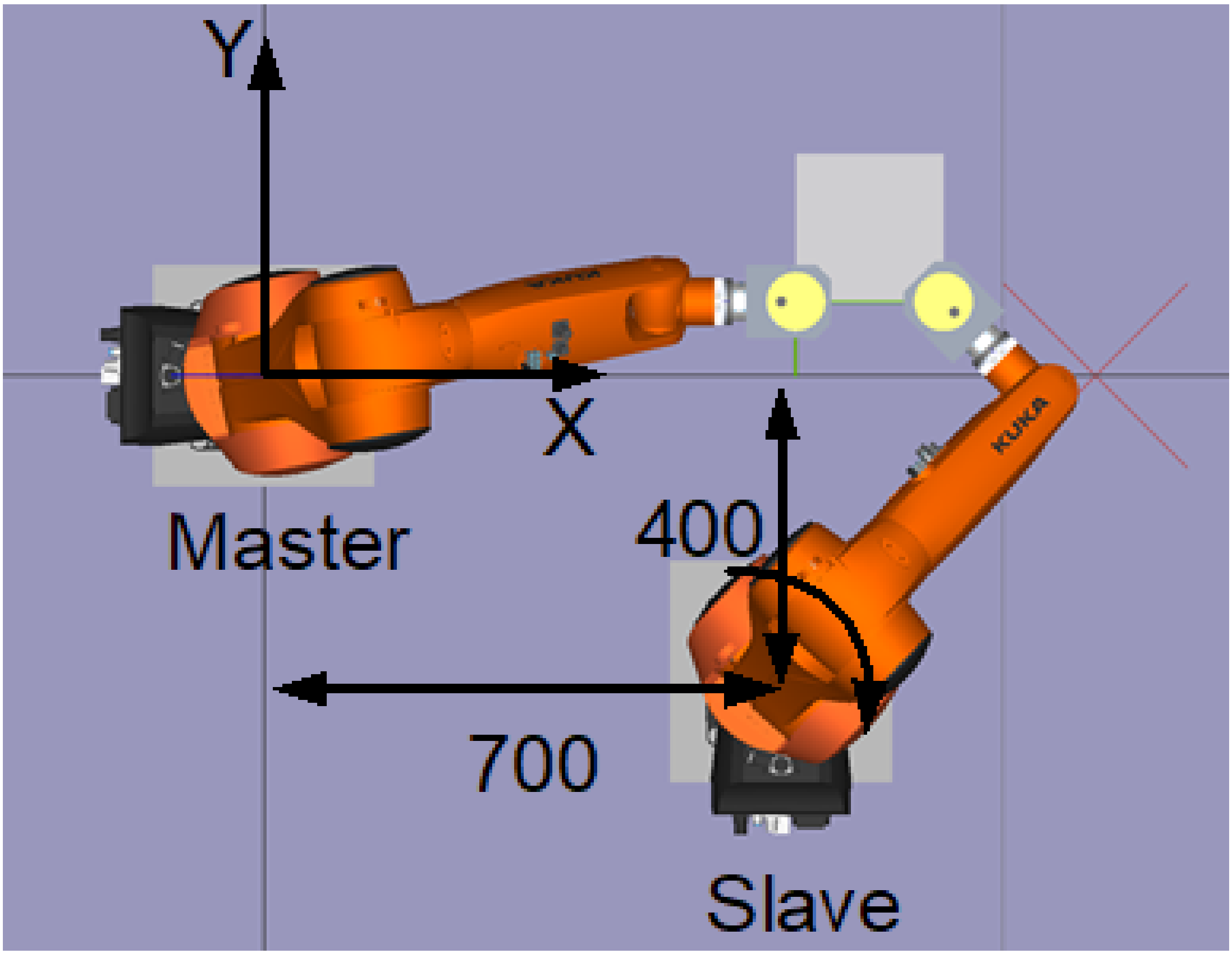


Fig. 9: Two robots machine a moved workpiece

Application: Fluctuations in kinematics base

These parameters specify additional static offsets / rotations (blue in the figure) between the error angle of attack and the kinematic base.

#TRACK CS […**KIN_BASE …X=200** …]

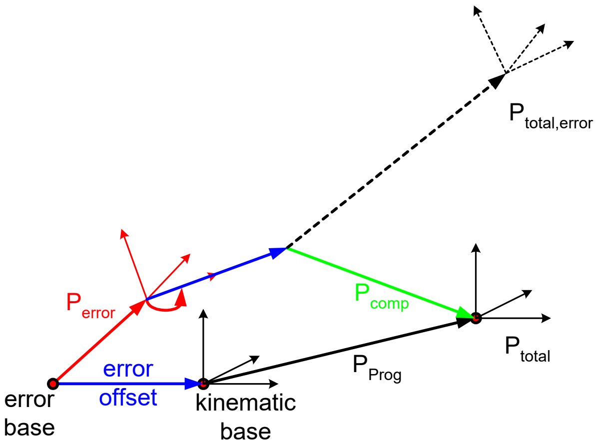


Fig. 10: Schematic of #TRACK CS command

The disable command has the following syntax elements:

#TRACK CS OFF [WAIT]

WAIT	When the filter is active, the program waits until the coupling is completely deactivated to execute the next NC row. If this mode is not specified (default), coupling is executed “on the fly”.

Switch via NC command

```
%TrackCS
; Dynamic CS received by PLC

N6076 #TRACK CS ON [ID=0 OPTION=1 FILTER=1000]

N6085 G01 X0 C0
N6080 X0 Y0 Z0 A0 B0 C0

N6077 #TRACK CS OFF [WAIT]; Wait until coupling is fully off
M30
```

2.3.1.1 Consider the master position in the slave

Calculate the current master position at activation

The current position of the master can be considered in the tracking function in the slave. When the tracking function is activated, you can specify whether the current master position is transferred to the slave channel decoder (option SET_ZERO). If this option is selected, the master positions are saved in channel-specific variables. This can only be done when the slave channel is at standstill, i.e. not on the fly.

V.G.TRACK_CS.X/Y/Z/A/B/C

The master position in the slave can then be calculated individually by various NC commands (#TRACK CS ABS, G92, #CS, etc.).

2.3.1.1.1 Implicit axis-specific calculation (#TRACK CS ABS)

#TRACK CS ABS

The zero point of the tracking channel is placed at the centre of the dynamic coordinated system.

In other words, if X0 Y0 Z0 are then programmed in the tracking channel, this channel executes a movement towards the centre of the dynamic coordinate system.

If the slave is not in the master TCP, a position offset is not considered when the master is rotated.

Implicit axis-specific calculation

```
%TrackCS

N6000 #TRACK CS ON[ ID=2 SET_ZERO FILTER=1000 ]

N7000 #TRACK CS ABS       ;Implicit calculation

;Equivalent explicit calculation by G92
N7010 G92 X=V.G.TRACK_CS.X Y=V.G.TRACK_CS.Y \
          Z=V.G.TRACK_CS.Z A=V.G.TRACK_CS.A \
          B=V.G.TRACK_CS.B C=V.G.TRACK_CS.C

N8000 X0 Y0 Z0 A0 B0 C0   ;Move slave to master centre
…
M30
```

2.3.1.1.2 Explicit calculation

V.G.TRACK_CS.X, etc.

These channel-specific variables can be used to calculate the current master position. For example, if this position is defined as 0 by an offset, the zero point of the tracking channel is located at the centre of the dynamic coordinate system. Position and orientation are considered. This means that if the master is rotated tracked, the slave tracks the rotation about the TCP of the master.

Explicit calculation

```
%TrackCS

N6000 #TRACK CS ON[ ID=2 SET_ZERO FILTER=1000 ]

; Yaw-Pitch-Roll : negative B axis
N7000 #CS ON[TRCK_CS] [V.G.TRACK_CS.X, V.G.TRACK_CS.Y,
                       V.G.TRACK_CS.Z, V.G.TRACK_CS.A,
                      -V.G.TRACK_CS.B, V.G.TRACK_CS.C]

N8000 X0 Y0 Z0 A0 B0 C0 ; Move slave to master centre

;…
M30
```

2.3.2 Switch via PLC command

Besides control of the tracking slave by an NC command, the equivalent command can also be sent by the PLC.

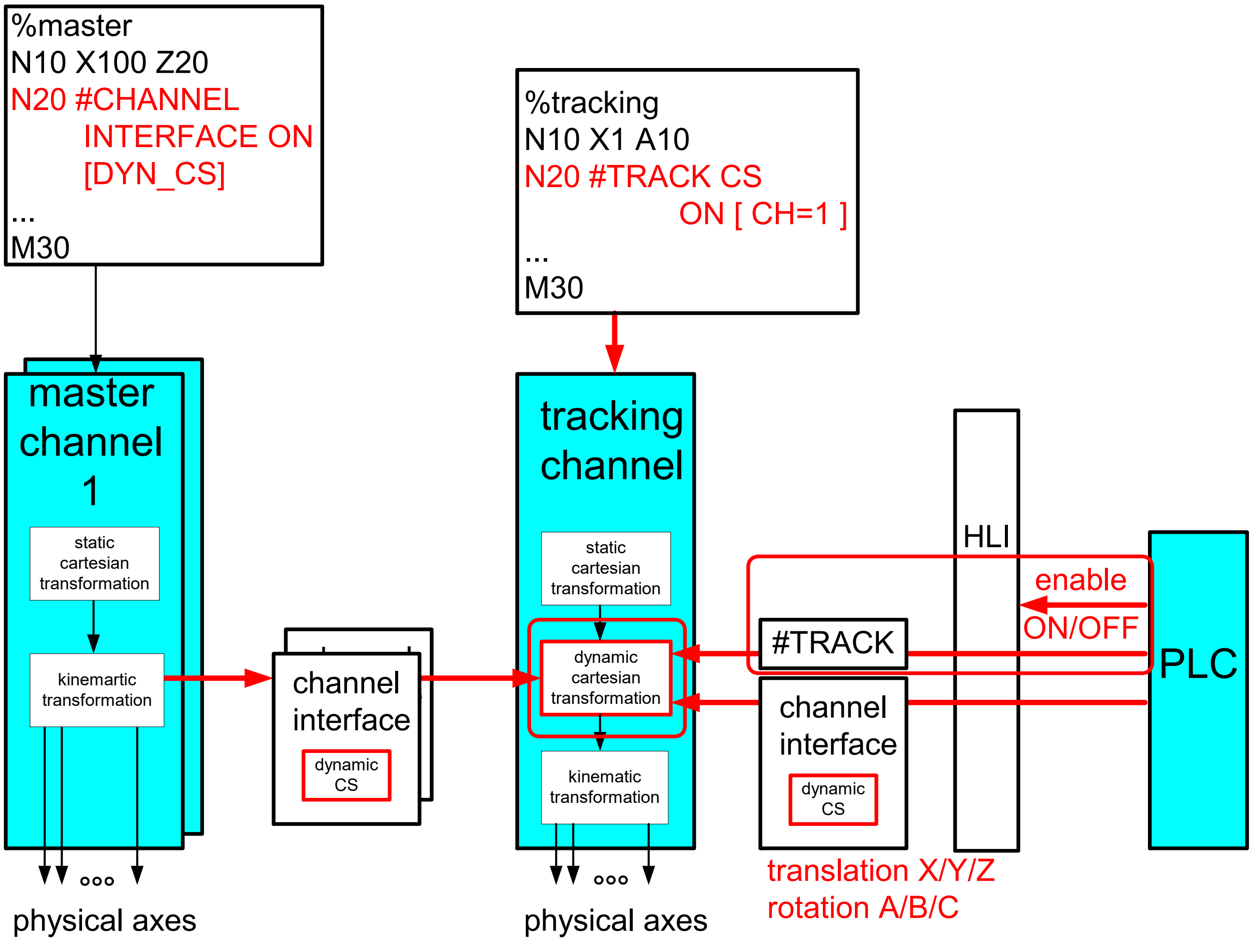


Fig. 11: Dynamic coordinate system by PLC

PLC switching options (cf. #TRACK CS ON/OFF)

ON / OFF	
Required filter time	(see FILTER…)
Reference to kinematic base	(see …KIN_BASE…)
Rotation sequence	(see.…ROT_TRANS…)
other options	(see …OPTION…)
Offset dimensions	(see …X/YZ… A/B/C…)
Relative as of activate/ deactivate.	(see …RELATIVE…)

The PLC can explicitly control a wait to continue until slave tracking has been completely activated or terminated. In other words, the PLC only releases feed in the master channel after an activate/ deactivate command, and after the status = INACTIVE / ACTIVE.

2.3.3 Display on the HLI

The input and output values of the dynamic coordinate system can be displayed on the HLI.

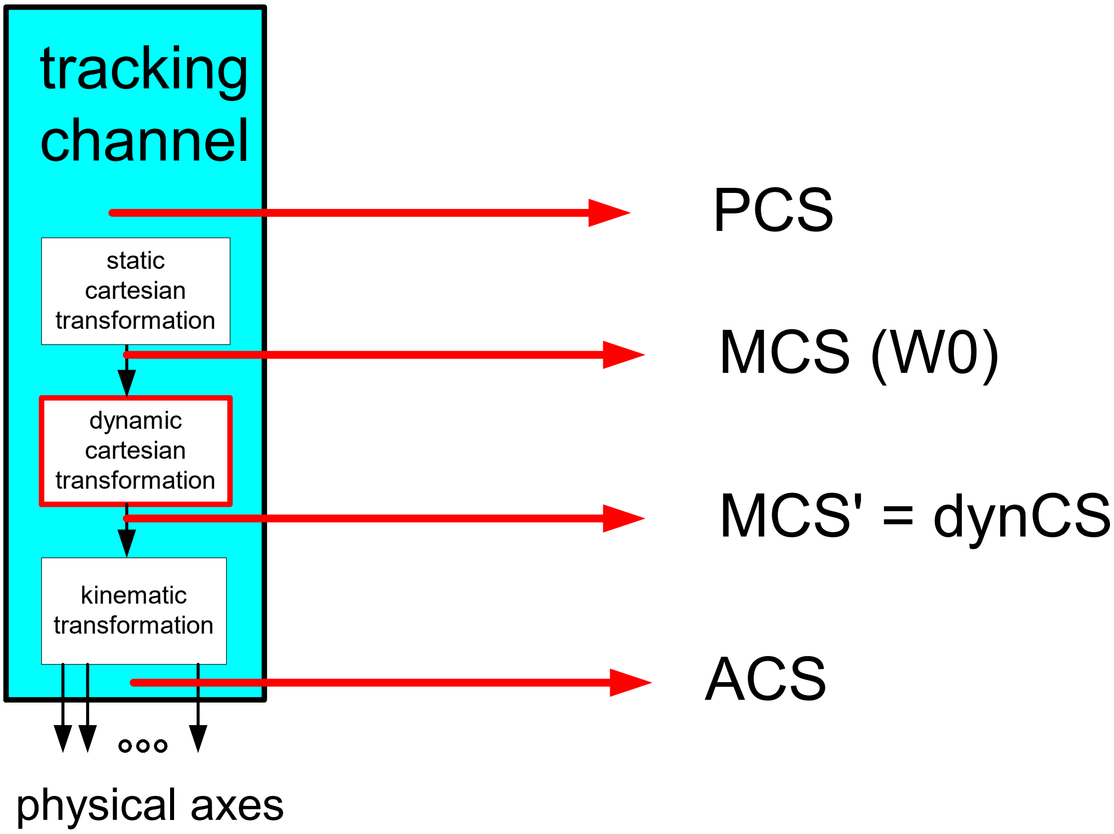


Fig. 12: Display of coordinate system positions to the PLC

Tool centre point position (MCS)	
Description	Command position of tool centre point in machine coordinate system MCS. The value is refreshed in each interpolation cycle.
Signal flow	CNC → PLC
Unit	0.1 µm
ST path	gpCh[*channel_idx*]^.bahn_state.coord_r[*axis_idx*].**w0_position_r**
Data type	DINT
Access	PLC is reading

For the purpose of compatibility, display of the **w0_position_r** must be activated in the channel list by P-CHAN-00145 (kin_trafo_display = 1).

Dynamic CS position (MCS)	
Description	Command position of tool centre point in machine coordinate system MCS. The value is refreshed in each interpolation cycle.
Signal flow	CNC → PLC
Unit	0.1 µm
ST path	gpCh[*channel_idx*]^.bahn_state.coord_r[*axis_idx*].**position_dyncs_r**
Data type	DINT
Access	PLC is reading

2.3.4 Diagnosis

Activate logging

When the dynamic coordinate system is calculated, the input and output values and the current dynCS can also be logged for diagnostic purposes. Logged data is loaded from the controller when diagnostic data is uploaded and written to a file. Logging is activated in the start-up list by P-STUP-00074:

Example:

configuration.channel[0].interpolator.dyn_cs_history_max 1000

Diagnosis

```
PATH : DYNAMIC CS, CHANNEL NO.:  1
=======================================================================
dynCs : max entries per PDU 15
TIME  STATE POSITION_IN CS_TRANSLATION  CS_ROTATION  POSITION_OUT
288943  1) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
944  2) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
945  3) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
946  4) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
947  5) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
948  6) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
949  7) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
950  8) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
951  9) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
952  10) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
953  11) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
954  12) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
955  13) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
956  14) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
957  15) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)

958  16) 2 (3200,0,0,0,0,0) (1000,-1000,0) (0,0,0) (4200,-1000,0,0,0,0)
```

```
PATH LOGGING CHANNEL NO.: 1
=======================================================================
BF 8 logging : 16/40, level ffffffff, index 16

    time level  message
-----------------------------------------------------------------------
  260482 00000001 BAHN restart... start
  260486 00000001 BAHN restart...finished
  279043 00000010 dynCS: cmd=ON PLC=1 N0 FILTER=1000 WAIT=1
  279044 00000010 dynCS: ON, axis positions
  279044 00000010   a[0..2](3200, 0, 0)
  279044 00000010   a[3..5](0, 0, 0)
  279044 00000010 dynCS: ON, VALUE
  279044 00000010   T(0, 0, 0)
  279044 00000010   R(0, 0, 0)
  280043 00000010 dynCS: is on = DYN_CS_SYNC_ACTIVE

  288777 00000010 dynCS: cmd=OFF PLC=1 N0 FILTER=1000
  288777 00000010   a[0..2](3200, 0, 0)
  288777 00000010   a[3..5](0, 0, 0)
  288777 00000010 dynCS: VALUE
  288777 00000010   T(1000, -1000, 0)
  288777 00000010   R(0, 0, 0)
```

2.4 Applications

2.4.1 Example 1: Slave tracks master axis-specific

Slave tracks master axis-specific

```
%TrackCS-Master
#TRAFO ON

G1 G90 AB=90 F200 ;Approach magazine position
AB=30
N20 #CHANNEL INTERFACE ON [TRACK_CS]

$WHILE 1
#SIGNAL SYN [ID3 COUNT1]
#WAIT SYN [ID1]
N20 #CHANNEL INTERFACE ON [TRACK_CS]
M0    ;Wait for bending robot in magazine position
AB=127.7213 F200  ;Working position


#SIGNAL SYN [ID2 COUNT1]  ;Set pipe in working position

N20 #CHANNEL INTERFACE OFF [TRACK_CS]

AB=30 ;Magazine

$ENDWHILE
```

Slave tracks master axis-specific 2

```
%TrackCS-Slave
$WHILE 1
#FLUSH WAIT
;Ensure that master and slave are at position
N20 #SIGNAL SYN [ID1 COUNT1]
#WAIT SYN [ID3]

;Query interface & allow master to lead
N10 #TRACK CS ON [ID=2 SET_ZERO]
#TRACK CS ABS

AM=0 AH=0  AA=25.44  ;Approach transfer gripper
#PSET AA=0

N30 #FLUSH CONTINUE
N40 #WAIT SYN [ID2] ;Wait for pipe in working position
#TRACK CS OFF [ID=2]

N00860  ;Execute initial movement to pipe
N00940  ;Vary angle of attack
N00950  AA=60
N00950  AA=-60
N00950  AA=60
N00950  AA=-60
N00950  AA=0
$ENDWHILE
```

2.4.2 Example 2: Fluctuations in a kinematics base

Pure offsets in the base can also be compensated in the PCK tool centre point by an inverse offset. However, if rotations are added, compensation is no longer possible.

The CNC can compensate this by correcting the target position (green). In this case, the programmed target point is approached as if there were no errors in the base.

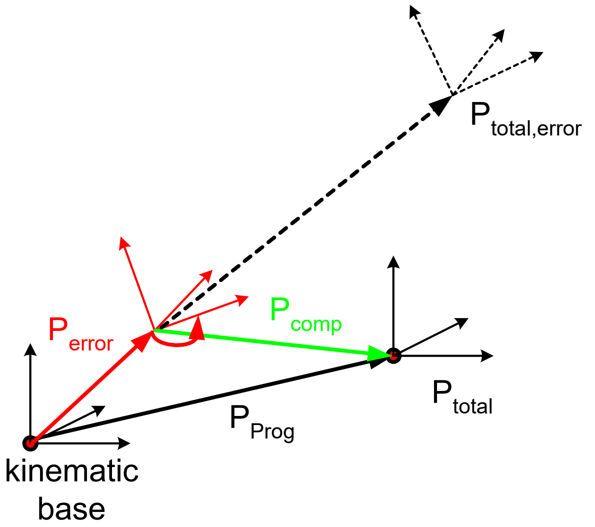


Fig. 13: Fluctuations in a kinematics base

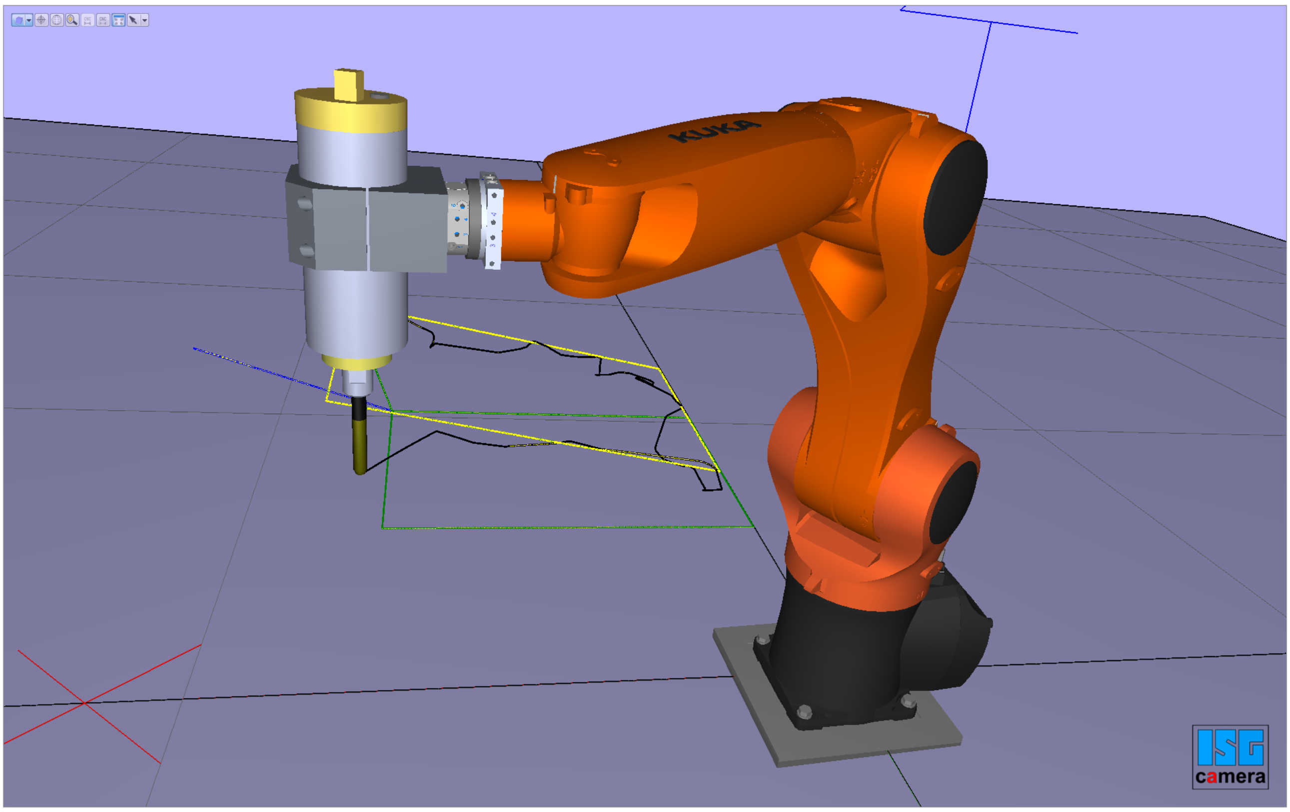


Fig. 14: Fluctuations in a kinematics base

Structure with error compensation

The deviation of a kinematic base is measured. This is then considered by the dynamic coordinate system when the kinematic TCP is positioned to compensate for errors.

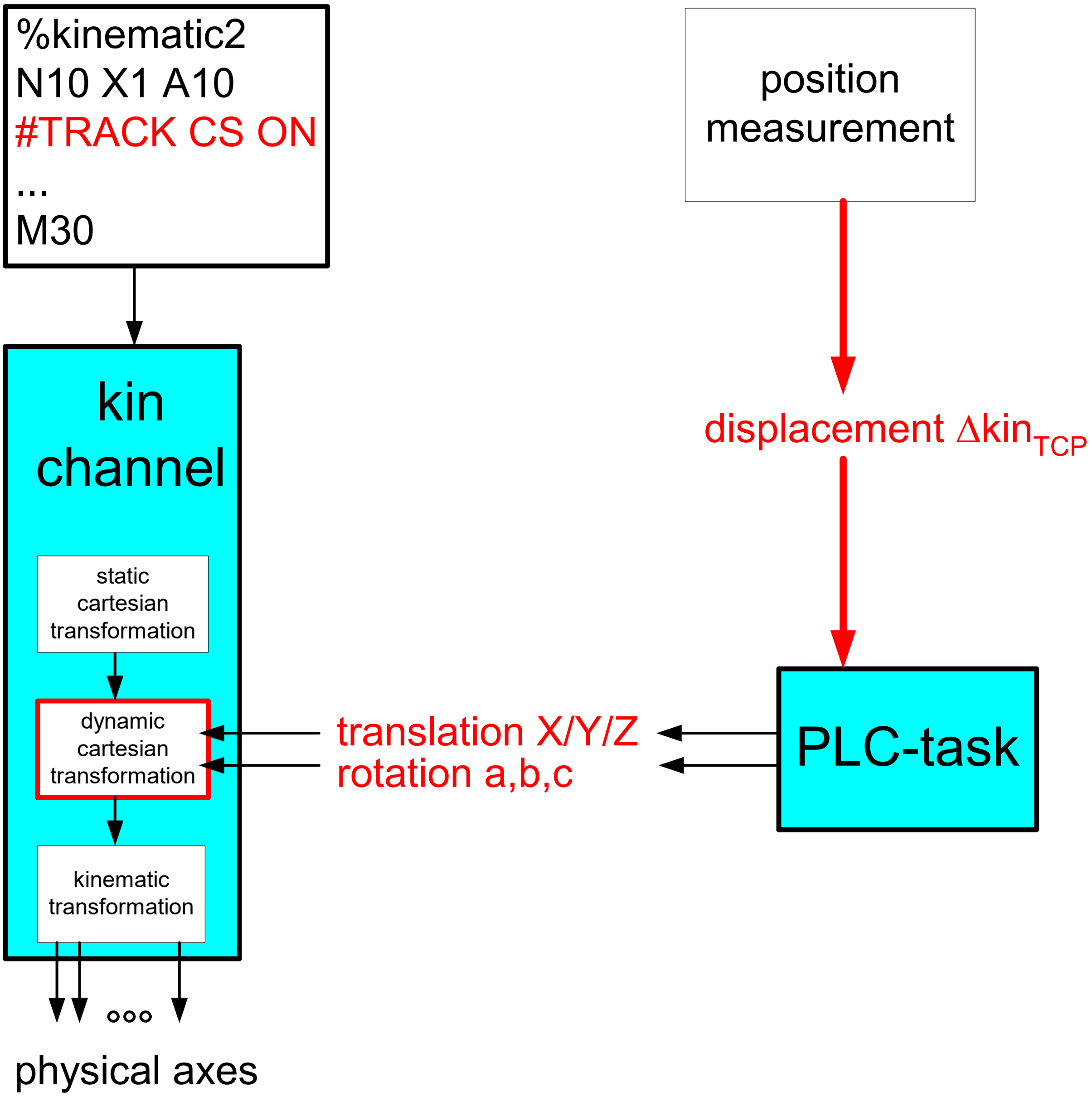


Fig. 15: Determine fluctuations

Fluctuations in a kinematics base

```
%dynCS-agilus
…

;Move to safe position to deselect compensation
N1000 Z200
;Compensate for error in base; error compensation by PLC
N1010 #TRACK CS ON [ID=0 KIN_BASE OPTION=0 FILTER=1000]

N2000 Z100
;Move with error compensation
N2010 G01 X100 F100
…
;Move to safe position to deselect compensation
N9000 Z200
N9010 #TRACK CS OFF [WAIT]

;Move without error compensation
N2000 G01 X100 F100
…

M30
```

2.4.3 Example 3: Slave tracks the moved workpiece

In this example, the slave tracks the master with position and orientation. The master signals its position to the interface of the dynamic coordinate system. The static offset between slave and master is also specified when the tracking function is activated.

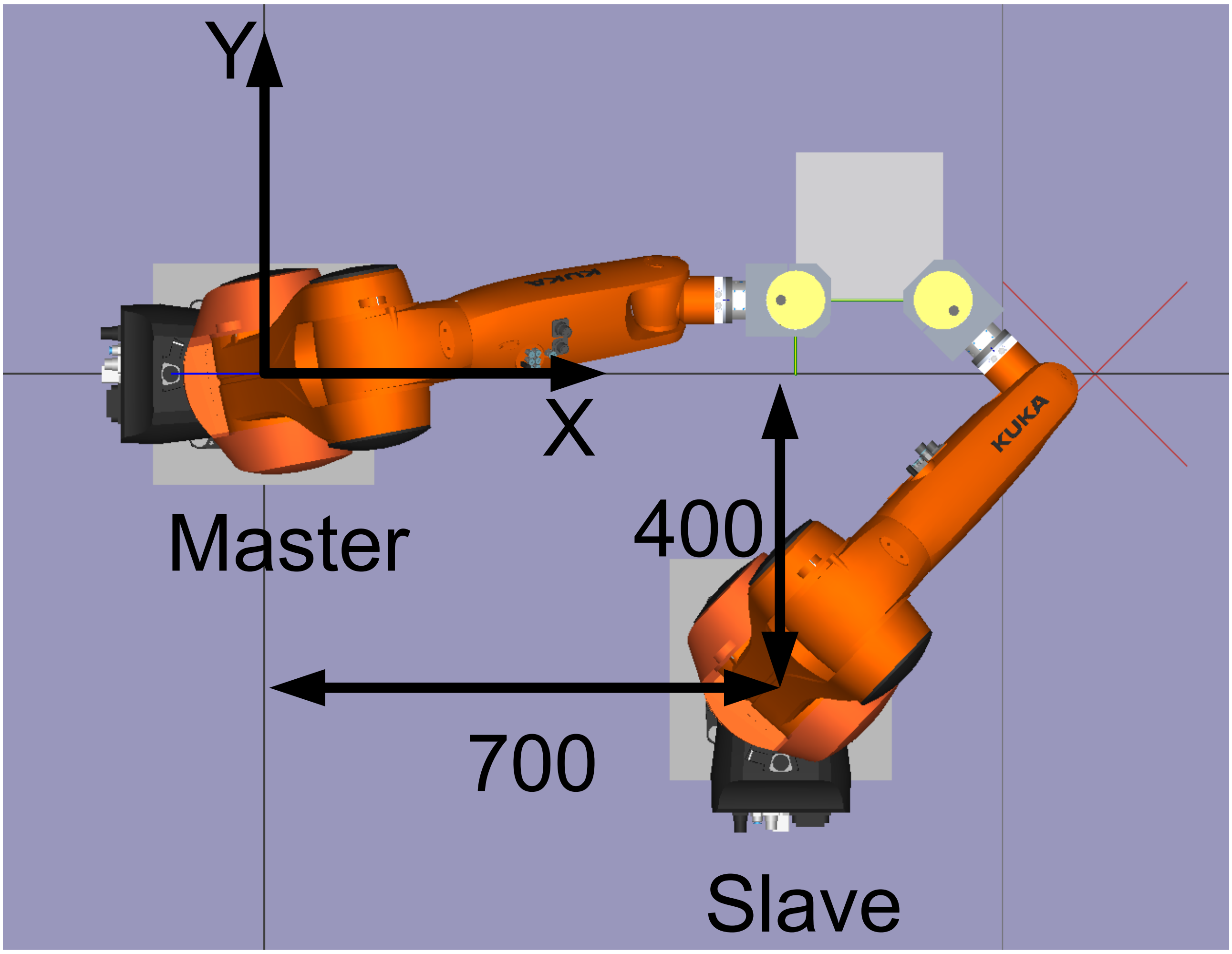


Fig. 16: Static offset between master and slave

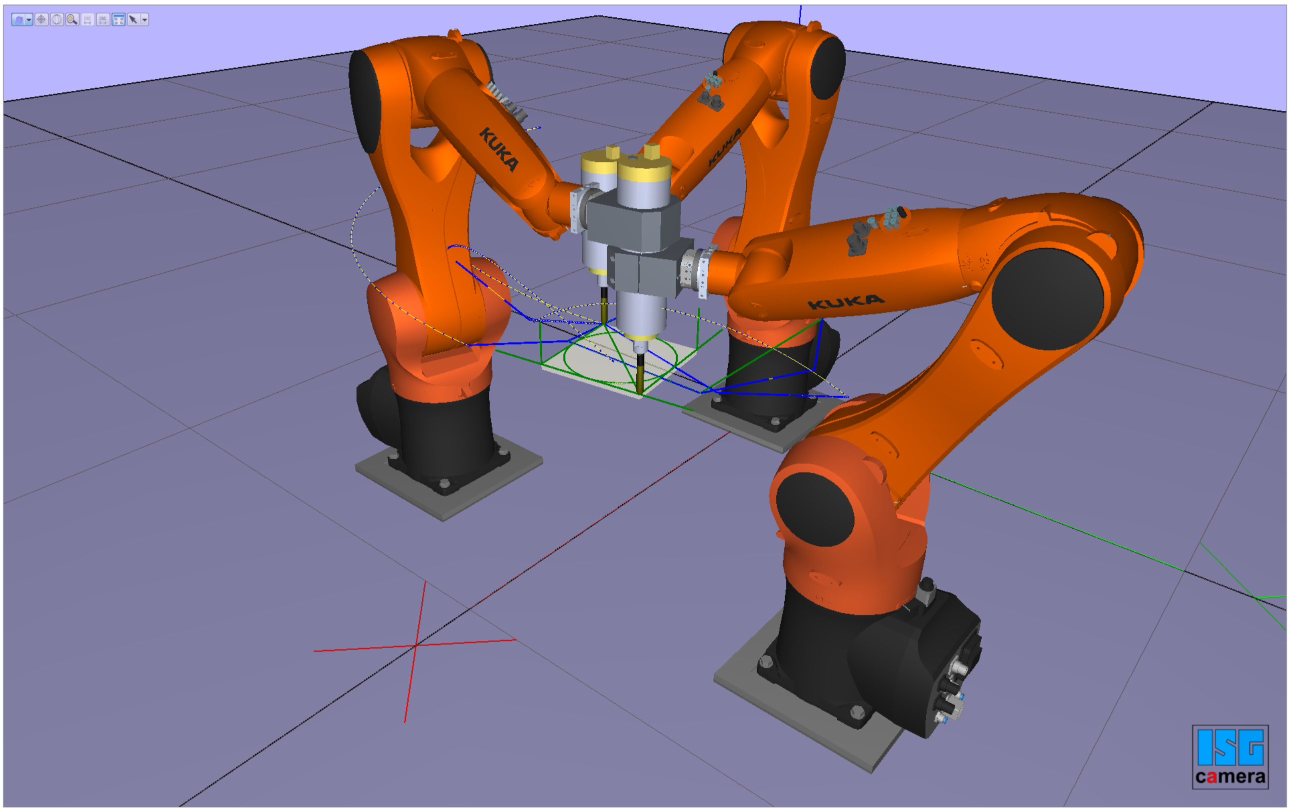


Fig. 17: Process two slave robots on a workpiece moved by the master robot

Master = channel 1

```
%dynCS-Master
;…
N100 G01 X100 Y-45 Z45 A0 B0 C0 F5000
N200 G01 X0 Y-45 Z45 A0 B0 C0 F5000

N1000 #TRAFO[45]
N1010 X720 Y0 Z450 A0 B0 C45 F1500

N2000 #CHANNEL INTERFACE ON [DYN_CS]
;…
N2020 B0
…
N9000 #CHANNEL INTERFACE OFF [DYN_CS]
N9010 #TRAFO OFF
N9020 M30
```

Slave tracks the moved workpiece

```
%dynCS-Slave
;…
N3000 G01 X0 Y-45 Z45 A0 B0 C0 F5000 ;Slave ACS
N3010 #TRAFO [45]
N3020 X720 Y0 Z450 F5000 ;Slave MCS
;Slave offset to master MCS
N3030 #CS ON [OFFS] [400,700,0,0,0,-90]

N3040 X620 Y0 Z450 A0 B15 C0 F5000 ; Moved slave in master MCS

; offset is transferred SLAVE to MASTER
N2010 #TRACK CS ON [ID=1 SET_ZERO X=400 Y=700 C=-90 FILTER=0 WAIT]

; Set slave zero point in master centre
; Yaw-Pitch-Roll: Negative B axis
N2020 #CS ON [V.G.TRACK_CS.X, V.G.TRACK_CS.Y, V.G.TRACK_CS.Z,
              V.G.TRACK_CS.A, -V.G.TRACK_CS.B, V.G.TRACK_CS.C]
; Move slave to master centre
N2200 X0 Y0 Z0 A0 B0 C0 F500
;…
N2900 #TRACK CS OFF [FILTER=0]
N2910 #CS OFF
;…
N3000 M30
```

2.4.4 Example 4: Slave tracks workpiece on rotary table

In the examples below, the PLC acts as master. Here, the start parameters are transferred by the NC program as described in the section "Hybrid implementation from PLC and NC program" [▸ 37]. The section "Implementation by PLC" [▸ 37] only describes working with the PLC.

The aim is to machine a workpiece on a rotary table while it is rotating. The rotary table is modelled here as a seventh axis (X1) in the system.

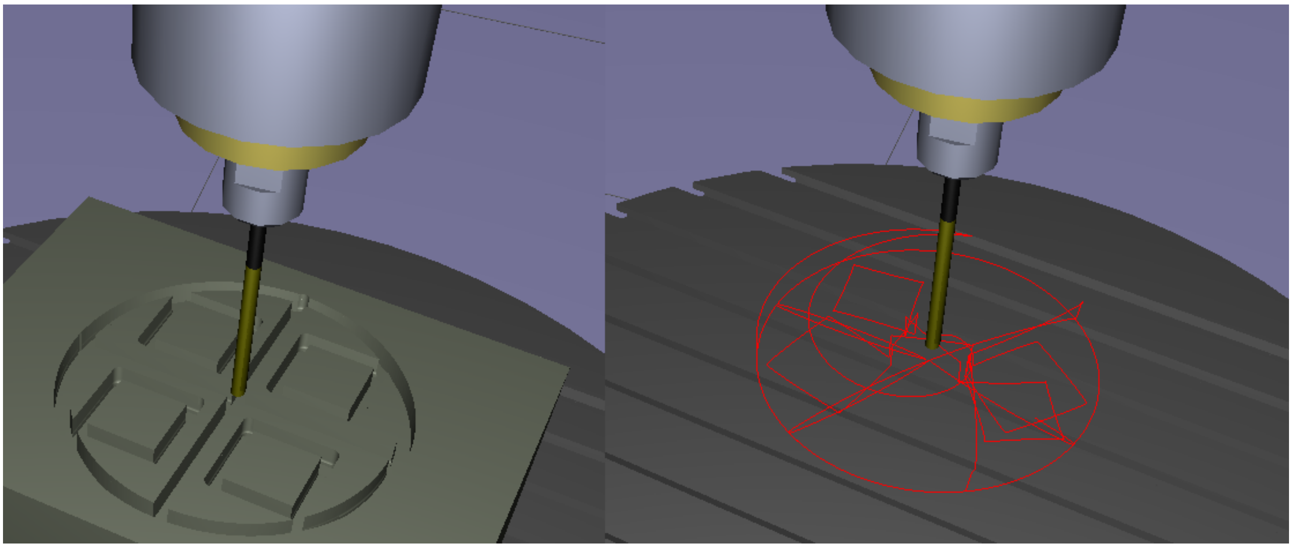


Fig. 18: Machined workpiece (left) during a rotation; the trace view on the right

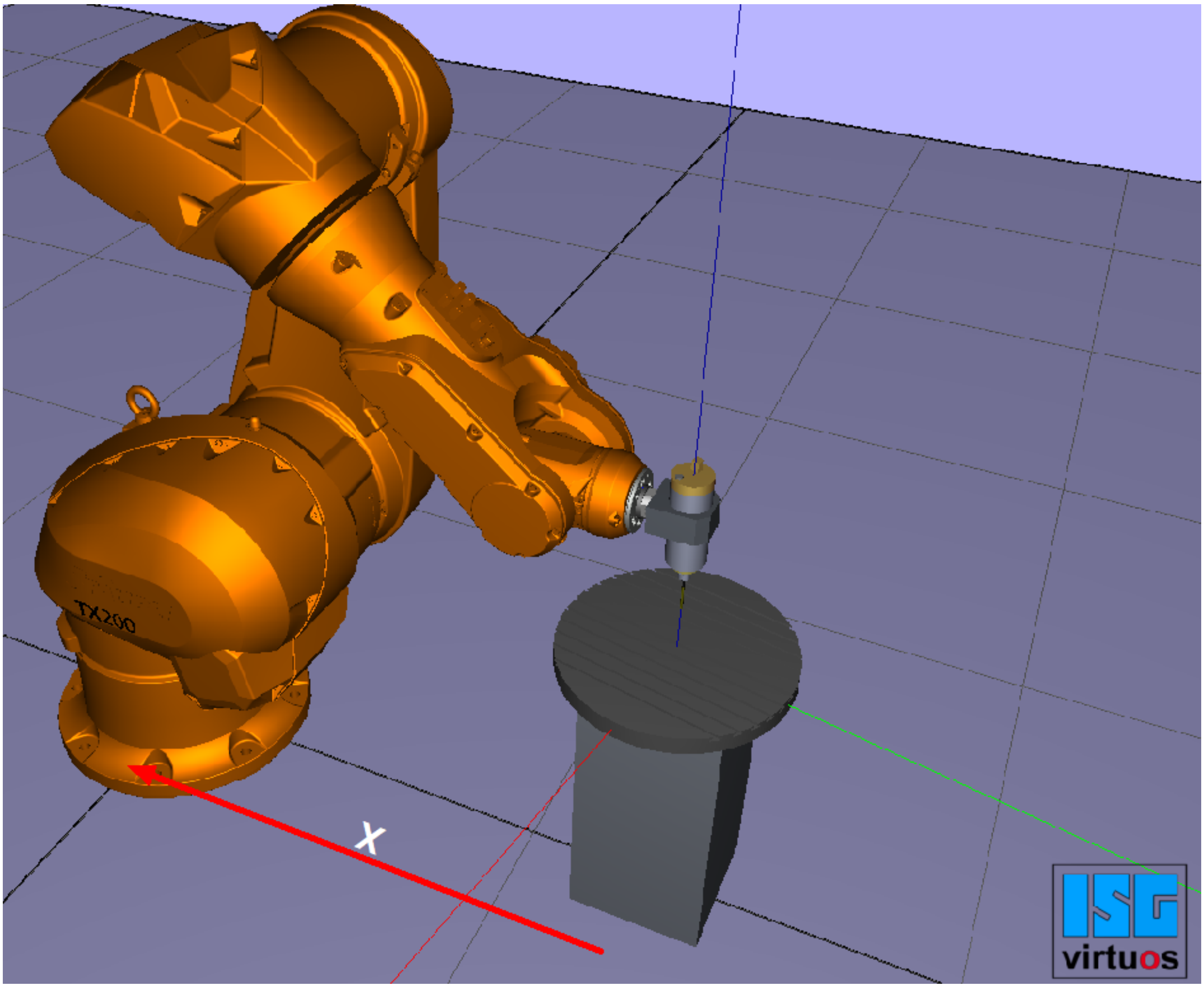


Fig. 19: Kin_Base offset from the master’s perspective (rotary table)

2.4.4.1 Hybrid implementation from PLC and NC program

The configuration parameters are transferred in the NC code by **#TRACK CS ON [ID=0 …]** Whereas the PLC only defines the correction and passed it on.

Slave

```
…
N200 X1305.92 Y0
N210 #TRACK CS ON [ID=0 OPTION=1 FILTER=0 WAIT KIN_BASE X=-1305.92]
N230 G92 X1305.92
N240 Z90
; robot on rotary axis positioned by jumps
; to prevent
; rotary table (X1) is rotated independently of robot
N250 X0 Y0 X1[INDP_ASYN POS=-90 G01 F500 G90]
N260 Z80
N270 X-60
N280 X60
N290 X0
N300 Y-60
N310 Y60
N320 Z90
…
N480 #WAIT INDP ALL
; robot to rotary table centre point by jumps
; to prevent
N490 G01 X0 Y0
N500 #TRACK CS OFF [FILTER=0 WAIT]
…
```

PLC

```
PROGRAM DynCsPLC_Activate
VAR
  pDynCs : POINTER TO MC_CONTROL_DYN_CS_UNIT;
END_VAR

(*Enable DynCS*)
pDynCs := ADR(gpCh[0]^.channel_mc_control.dyn_cs);
pDynCs[0]^.enable_w   := TRUE;


IF    pDynCs^.state_r.actual_state = UDINT#2 AND   pDynCs^.command_semaphor_rw  = FALSE
THEN
  pDynCs^.command_w.rotation[2]:=
-pAx[6]^.lr_state.current_position_acs_r;

  pDynCs^.command_semaphor_rw  := TRUE;
END_IF;
```

2.4.4.2 Implementation via PLC

The Dynamic Coordinate System (dynCS) is activated in the PLC as soon as **transition_w.command** := 1 is set. Here, the state of the dynCS changes from 0 to 1 and then to 2 (see Fig. “State of the dynamic coordinate system” in the section “PLC as Master [▶ 14]“). Accordingly, the required parameters must be set beforehand.

NOTICE
To activate the dynCS, an M function (M100) can be used here since activation by #TRACK CS ON activates the dynCS a second time and may lead to abnormal behaviour.

PLC

```
PROGRAM DynCsPLC_M
VAR
  Init : BOOL;
  KbCs : HLI_COORDINATE_SYSTEM_INT;
  pDynCs : POINTER TO MC_CONTROL_DYN_CS_UNIT;
END_VAR
…
IF NOT      Init
THEN
  pDynCs^.enable_w   := TRUE;
(*Offset to rotary table centre point*)
  kb_cs.translation[0]                := DINT#-13059200;
  kb_cs.translation[1]                := DINT#0;
  kb_cs.translation[2]                := DINT#800000;
  kb_cs.rotation[0]                   := DINT#0;
  kb_cs.rotation[1]                   := DINT#0;
  kb_cs.rotation[2]                   := DINT#0;
(*Set the config. parameters*)
  pDynCs^.transition_w.f_kin_base         := TRUE;
  pDynCs^.transition_w.f_set_zero         := FALSE;
  pDynCs^.transition_w.f_rot_trans        := FALSE;
  pDynCs^.transition_w.filter_max_ticks   := UDINT#0;
  pDynCs^.transition_w.option             := UDINT#1;
  pDynCs^.transition_w.kinematic_base_cs  := kb_cs;
  pDynCs^.transition_w.f_wait             := TRUE;
  Init := TRUE;
END_IF;

(* If DK was enabled by M100*)
(*IF M100.ACTIVE THEN *)
  pDynCs^.transition_w.command := DINT#1;
   (*M100.ACTIVE := FALSE     Reset trigger *)
(* END_IF *)

(* If DK was disabled by M101*)
(*IF M101.ACTIVE THEN *)
  pDynCs^.transition_w.command := DINT#-1;
   (*M101.ACTIVE := FALSE      Reset trigger *)
(* END_IF *)


(* Rotation about zero point set KbCs, *)
(* about Z axis at angle of rotary axis of table*)
IF pDynCs^.state_r.actual_state = UDINT#2 AND
   pDynCs^.command_semaphor_rw = FALSE
THEN
  pDynCs^.command_w.rotation[2]:=     gpAx[6]^.lr_state.current_position_acs_r;
  pDynCs^.command_semaphor_rw := TRUE;
END_IF;
```

Slave

```
…
N200 X1305.92 Y0
N210 M100
N230 G92 X1305.92
N240 Z90
; robot on rotary axis positioned by jumps
; to prevent
; rotary table (X1) is rotated independently of robot
N250 X0 Y0 X1[INDP_ASYN POS=-90 G01 F500 G90]
N260 Z80
N270 X-60
N280 X60
N290 X0
N300 Y-60
N310 Y60
N320 Z90
…
N480 #WAIT INDP ALL
; robot to rotary table centre point by jumps
; to prevent
N490 G01 X0 Y0
N500 M101
…
```

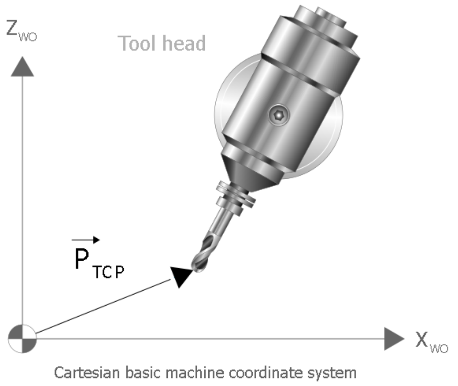
SDA

```
…
m_synch[100]        MVS_SVS     ( Activate dynamic CS)
m_synch[101]        MVS_SVS     ( Deactivate dynamic CS)
…
```

3 Parameter

ID	Parameter	Description
P-CHAN-00145	kin_trafo_display	Activation of TCP display data
P-CHAN-00399	provide_channel_interface.track_cs	Automatic enable of channel interface for synchronous dynamic CS operations
P-STUP-00074	configuration.channel[i].interpolator.dyn_cs_history_max	Number of logged input and output values of the dynamic CS

3.1 Channel parameters

P-CHAN-00145	**Activation of TCP display data**
Description	This parameter is used to activate W0 display data (TCP position referred to the Cartesian basic coordinate system of the machine - MCS). The TCP position is calculated dependent on the active kinematic ID based on the current command axis coordinates, the selected tool (length) and the kinematic offset parameters. The calculation also takes place when transformation is inactive. All axes in the kinematic structure must exist in the channel. 
Parameter	kin_trafo_display
Data type	UNS16
Data range	0: MCS display function inactive (default) 1: MCS display function active 2: MCS display function active (only for multistep transformation, see Addendum)
Dimension	----
Default value	0
Remarks	The axes must be homed to obtain the correct display. Programmed tool offsets (V.G.WZ_AKT.V.*) are only considered if they are followed by the programming of #KIN ID[<kinematic-ID>]. **Note:** As of CNC Build V3.1.3105 the data type of the parameter changed from BOOLEAN to UNS16.

P-CHAN-00399	**Automatic enable of channel interface for synchronous dynamic CS operations**
Description	This parameter automatically activates the supply of data to the dynCS channel interface at program start. This corresponds to programming the command #CHANNEL INTERFACE ON/OFF [DYN_CS] see [FCT-C30 [▶ 8]] in the NC program.
Parameter	provide_channel_interface.track_cs

Data type	BOOLEAN
Data range	0/1
Dimension	----
Default value	0
Remarks	

3.2 Start-up parameters

P-STUP-00074	**Number of logged input and output values of the dynamic CS**
Description	When the dynamic coordinate system is calculated, the input and output values and the current dynCS can also be logged for diagnostic purposes. Logged data is loaded from the controller when diagnostic data is uploaded and written to a file.
Parameter	configuration.channel[i].interpolator.dyn_cs_history_max
Data type	UNS32
Data range	0 ... MAX(UNS32)
Dimension	----
Default value	20
Remarks	

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