SIEMENS

SINUMERIK

SINUMERIK 840D sl
SINUMERIK Run MyRobot /Direct Control

Programming Manual

Valid for

Control
SINUMERIK 840D sl
Software version
NCU system software for 840D sl 4.8 SP3

12/2018
A5E45237742B AB

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
indicates that minor personal injury can result if proper precautions are not taken.

NOTICE
indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Preface

SINUMERIK documentation

The SINUMERIK documentation is organized into the following categories:

- General documentation/catalogs
- User documentation
- Manufacturer/service documentation

Additional information

You can find information on the following topics at the following address (https://support.industry.siemens.com/cs/de/en/view/108464614):

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

If you have any questions regarding the technical documentation (e.g. suggestions, corrections), please send an e-mail to the following address (mailto:docu.motioncontrol@siemens.com).

mySupport/Documentation

At the following address (https://support.industry.siemens.com/My/ww/en/documentation), you can find information on how to create your own individual documentation based on Siemens' content, and adapt it for your own machine documentation.

Training

At the following address (http://www.siemens.com/sitrain), you can find information about SITRAIN (Siemens training on products, systems and solutions for automation and drives).

FAQs

You can find Frequently Asked Questions in the Service&Support pages under Product Support (https://support.industry.siemens.com/cs/de/en/ps/faq).

SINUMERIK

You can find information about SINUMERIK at the following address (http://www.siemens.com/sinumerik).

Target group

This document is intended for:

- Programmers
- Project engineers

Benefits

With the programming manual, the target group can develop, write, test, and debug programs and software user interfaces.

Standard scope

This documentation only describes the functionality of the standard version. Additions or revisions made by the machine manufacturer are documented by the machine manufacturer.

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

For the sake of simplicity, this documentation does not contain all detailed information about all types of the product and cannot cover every conceivable case of installation, operation, or maintenance.

Note regarding the General Data Protection Regulation

Siemens observes standard data protection principles, in particular the principle of privacy by design. That means that

this product does not process / store any personal data, only technical functional data (e.g. time stamps). If a user links this data with other data (e.g. a shift schedule) or stores personal data on the same storage medium (e.g. hard drive) and thus establishes a link to a person or persons, then the user is responsible for ensuring compliance with the relevant data protection regulations.

Technical Support

Country-specific telephone numbers for technical support are provided in the Internet at the following address (https://support.industry.siemens.com/sc/ww/en/sc/2090) in the "Contact" area.

Table of contents

Fundamental safety instructions

1

1.1 General safety instructions

⚠ **WARNING**

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following six steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

⚠ **WARNING**

Electric shock due to connection to an unsuitable power supply

When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage that might result in serious injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

⚠ WARNING

Electric shock due to equipment damage

Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

⚠ WARNING

Electric shock due to unconnected cable shields

Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the cores of cables that are not used at one end at the grounded housing potential.

⚠ WARNING

Electric shock if there is no ground connection

For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

⚠ WARNING

Spread of fire from built-in devices

In the event of fire outbreak, the enclosures of built-in devices cannot prevent the escape of fire and smoke. This can result in serious personal injury or property damage.

- Install built-in units in a suitable metal cabinet in such a way that personnel are protected against fire and smoke, or take other appropriate measures to protect personnel.
- Ensure that smoke can only escape via controlled and monitored paths.

WARNING

Unexpected movement of machines caused by radio devices or mobile phones

When radio devices or mobile phones with a transmission power > 1 W are used in the immediate vicinity of components, they may cause the equipment to malfunction. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- If you come closer than around 2 m to such components, switch off any radios or mobile phones.
- Use the "SIEMENS Industry Online Support app" only on equipment that has already been switched off.

WARNING

Fire due to inadequate ventilation clearances

Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

WARNING

Unexpected movement of machines caused by inactive safety functions

Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

Note

Important safety notices for Safety Integrated functions

If you want to use Safety Integrated functions, you must observe the safety notices in the Safety Integrated manuals.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization (parameter assignments) against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

1.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge

Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

1.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment or any eventuality which may arise. Application examples do not represent specific customer solutions, but are only intended to provide support for typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

1.4 Industrial security

Note

Industrial security

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the Internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit:

Industrial security (http://www.siemens.com/industrialsecurity)

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed at:

Industrial security (http://www.siemens.com/industrialsecurity)

Further information is provided on the Internet:

Industrial Security Configuration Manual (https://support.industry.siemens.com/cs/ww/en/view/108862708)

WARNING

Unsafe operating states resulting from software manipulation

Software manipulations (e.g. viruses, trojans, malware or worms) can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a holistic, state-of-the-art industrial security concept for the installation or machine.
- Make sure that you include all installed products into the holistic industrial security concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Protect the drive against unauthorized changes by activating the "know-how protection" drive function.

1.5 Residual risks of power drive systems

When assessing the machine- or system-related risk in accordance with the respective local regulations (e.g., EC Machinery Directive), the machine manufacturer or system installer must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware and/or software errors in the sensors, control system, actuators, and cables and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation
2. Unusually high temperatures, including open flames, as well as emissions of light, noise, particles, gases, etc., can occur inside and outside the components under fault conditions caused by, for example:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected communication systems, e.g. ripple-control transmitters or data communication via the network

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Introduction 2

2.1 Programming 6-axis robots

This manual supports you when programming a 6-axis robot with a SINUMERIK 840D sl. Specific know-how is required when it comes to programming 6-axis robots. This know-how is summarized in this manual.

This manual does not discuss any general know-how regarding programming with SINUMERIK 840 sl. You can find additional notes relating to references in Chapter Overview of the manuals for SINUMERIK 840D sl and Run MyRobot /Direct Control (Page 18).

2.2 Overview of the manuals for SINUMERIK 840D sl and Run MyRobot / Direct Control

You can find additional information in the following manuals.

References

- Function description of the ROBX transformation (included in folder…/rmrdc/robx_ar/doc)
- Function description of AXCO (included in folder axco/doc)
- Programming Manual SINUMERIK 840D sl / 828D Fundamentals
- Programming Manual SINUMERIK 840D sl / 828D Job Planning
- Programming Manual SINUMERIK 840D sl / 828D Measuring Cycles
- Programming Manual SINUMERIK 840D sl / 828D ISO Milling
- Function Manual SINUMERIK 840D sl / 828D Expansion Functions

3 Coordinate systems

3.1 Overview

The term frame in the context of ROBX transformation will be explained in this chapter.

Frame

One coordinate system can be transitioned into another one using a frame. In so doing, a distinction is made between translation and rotation. Whereas the translation causes only an offset, the rotation turns the coordinate system with regard to the reference system. The X, Y and Z coordinates are used to describe the translation. They are defined to produce a right-hand coordinate system. In this case, the translation is performed prior to the rotation.

Translation

Translation always refers to the coordinate directions of the initial system. The directions are assigned to machine data as follows:

- X direction: …_POS[0]
- Y direction: …_POS[1]
- Z direction: …_POS[2]

Rotation

The RPY angles A, B and C (RPY = Roll Pitch Yaw) are used for rotation. The positive direction of rotation is defined using the right-hand rule. When the thumb on the right hand is pointing in the direction of the axis of rotation, then the remaining fingers are pointing in the positive angular direction. In this respect, please note that A and C are defined at intervals [-180; +180] and B at intervals [-90; +90]. The RPY angles are specified as follows:

- Angle A: 1. Rotation around the Z axis of the initial system
- Angle B: 2. Rotation around the rotated Y' axis
- Angle C: 3. Rotation around the X'' axis that has been rotated twice

The RPY angles are assigned to machine data as follows:

- Angle A: ..._RPY[0]
- Angle B: ..._RPY[1]
- Angle C: ..._RPY[2]

Example

The initial coordinate system X1, Y1, Z1 is rotated around the RPY angles as follows:

- Through angle A around the Z_1 axis
- Through angle B around the Y_2' axis
- Through angle C around the X_3'' axis

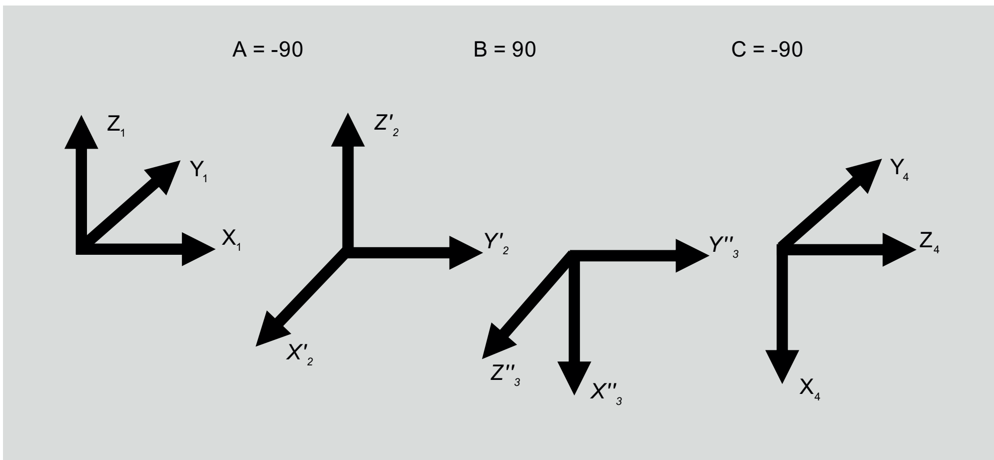


Figure 3-1 Example of rotation through the RPY angles

3.2 Basic coordinate system

In the default setting, the basic coordinate system lies at the foot point of the robot (dark red coordinate system in the following diagram). Consequently, this produces an offset in the Z axis compared with the internal robot coordinate system. The data is an example for a 6-axis industrial robot.

Depending on the system specification, using the following machine data, you can shift and rotate the basic coordinate system with respect to the internal robot coordinate system as required. The basic coordinate system does not need to lie at the foot point of the robot.

Note

The internal robot coordinate system (yellow coordinate system in the following diagram) is fixed.

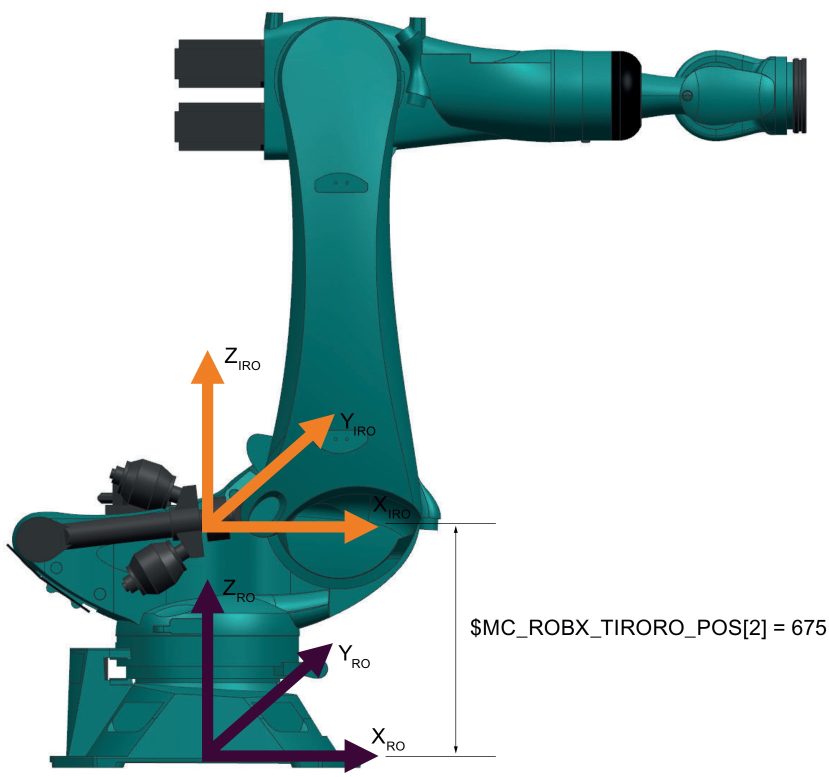


Figure 3-2 Basic coordinate system

Machine data	Value	Dimension
N62912 $MC_ROBX_TIRORO_POS[0]	0	mm
N62912 $MC_ROBX_TIRORO_POS[1]	0	mm
N62912 $MC_ROBX_TIRORO_POS[2]	675	mm
N62913 $MC_ROBX_TIRORO_RPY[0]	0	Degrees
N62913 $MC_ROBX_TIRORO_RPY[1]	0	Degrees
N62913 $MC_ROBX_TIRORO_RPY[2]	0	Degrees

References

A detailed description of the ROBX robot transformation is available in the separate "ROBX transformation function description" documentation.

3.3 Flange coordinate system

3.3.1 Flange coordinate system

In the default setting, the orientation of the flange coordinate system is aligned in N62911 $MC_ROBX_TFLWP_RPY[0-2].

The offset between the manual axis and the flange is set using machine data $MC_ROBX_TFLWP_POS[0-2].

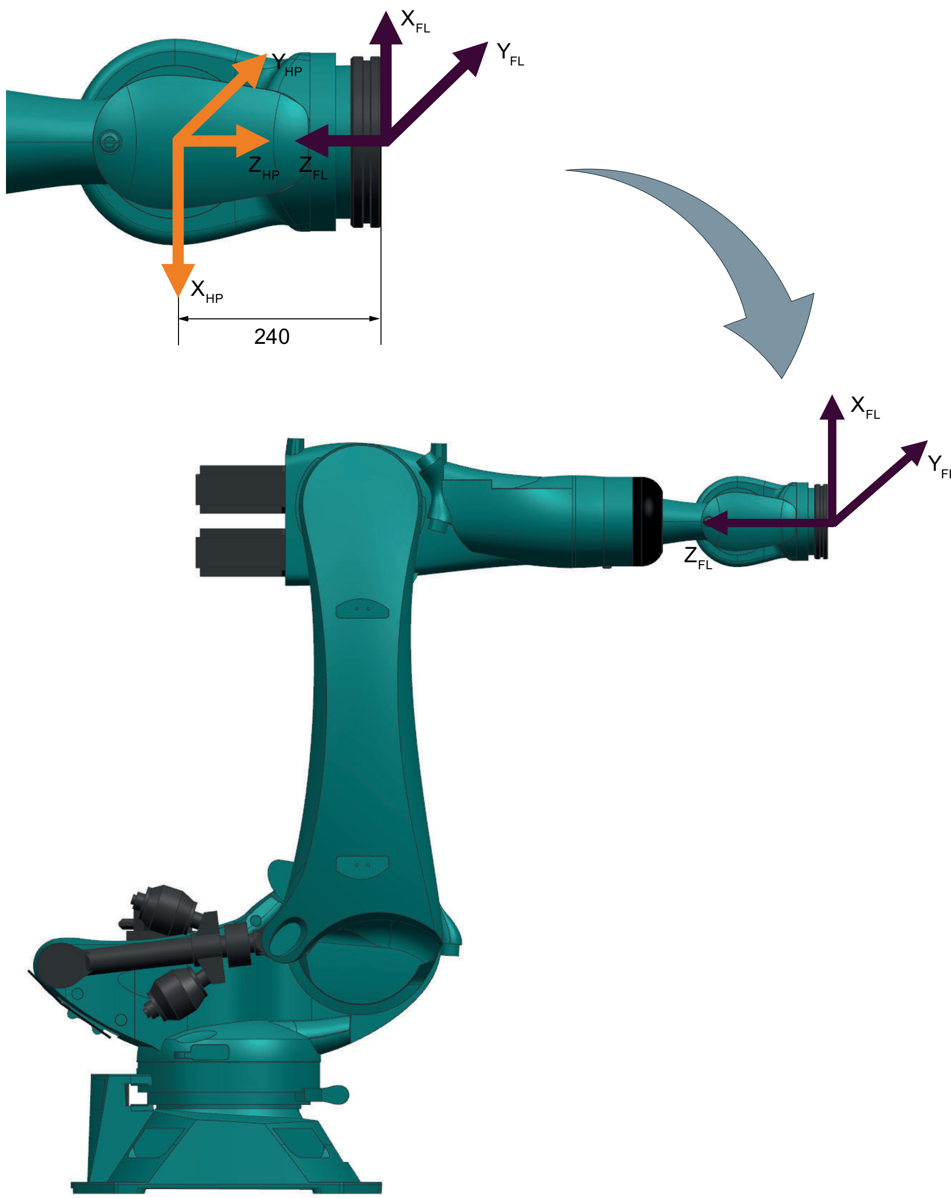


Figure 3-3 Flange coordinate system

Machine data	Value	Dimension
N62910 $MC_ROBX_TFLWP_POS[0]	0	mm
N62910 $MC_ROBX_TFLWP_POS[1]	0	mm
N62910 $MC_ROBX_TFLWP_POS[2]	240	mm
N62911 $MC_ROBX_TFLWP_RPY[0]	180	Degrees
N62911 $MC_ROBX_TFLWP_RPY[1]	0	Degrees
N62911 $MC_ROBX_TFLWP_RPY[2]	180	Degrees

See also

Single part tools according to the NC convention (Page 24)

Single part tools according to the Robot convention (Page 25)

Multipart tools according to the NC convention (Page 27)

Multipart tools according to the Robot convention (Page 28)

3.3.2 Flange coordinate system for single part tools

For single part tools, the reference point for the tool lengths (L1, L2, L3) and the tool rotations of the flange coordinate system are defined as in Chapter Flange coordinate system (Page 23) .

The parameterization for a gripper tool is explained in the following as example. A distinction is made between single part tools according to the NC convention and the Robot convention.

3.3.2.1 Single part tools according to the NC convention

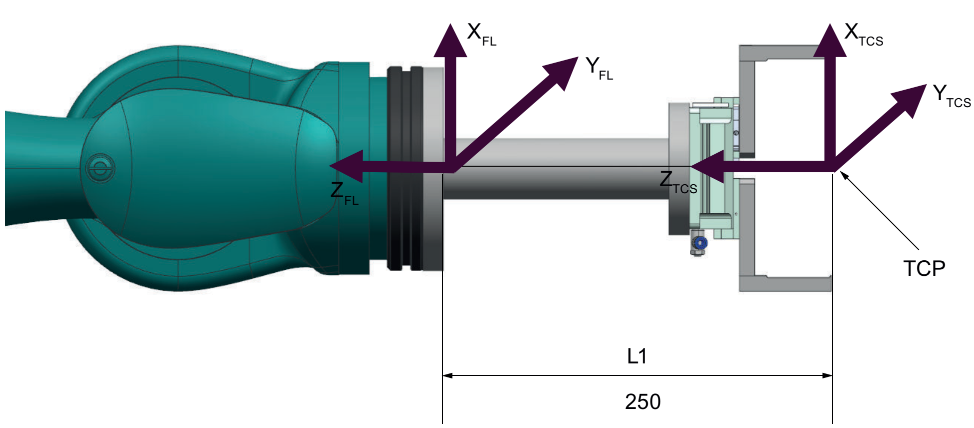


Figure 3-4 Parameterization of a single part tool using a gripper tool as example

Machine data	Value	Dimension
N62965 $MC_ROBX_TTCFL_POS[0]	0	mm
N62965 $MC_ROBX_TTCFL_POS[1]	0	mm
N62965 $MC_ROBX_TTCFL_POS[2]	0	mm
N62966 $MC_ROBX_TTCFL_RPY[0]	0	Degrees
N62966 $MC_ROBX_TTCFL_RPY[1]	0	Degrees
N62966 $MC_ROBX_TTCFL_RPY[2]	0	Degrees
N62949 ROBX_TOOL_DIR	1	
$TC_DP3[1,1] (Z) length L1 (for G17)	250	mm
$TC_DP4[1,1] (Y) length L2 (for G17)	0	mm
$TC_DP5[1,1] (X) length L3 (for G17)	0	mm
$TC_DPC1[1,1] 1st angle (rotation around Z)	0	°
$TC_DPC2[1,1] 2nd angle (rotation around Y)	0	°
$TC_DPC3[1,1] 3rd angle (rotation around X)	0	°

Note

With the setting ROBX_TOOL_DIR = 1, you define the tool direction according to the NC convention, this means positive tool lengths are taken into account in the negative X, Y, Z axes.

See also

Flange coordinate system (Page 23)

Flange coordinate system (Page 23)

3.3.2.2 Single part tools according to the Robot convention

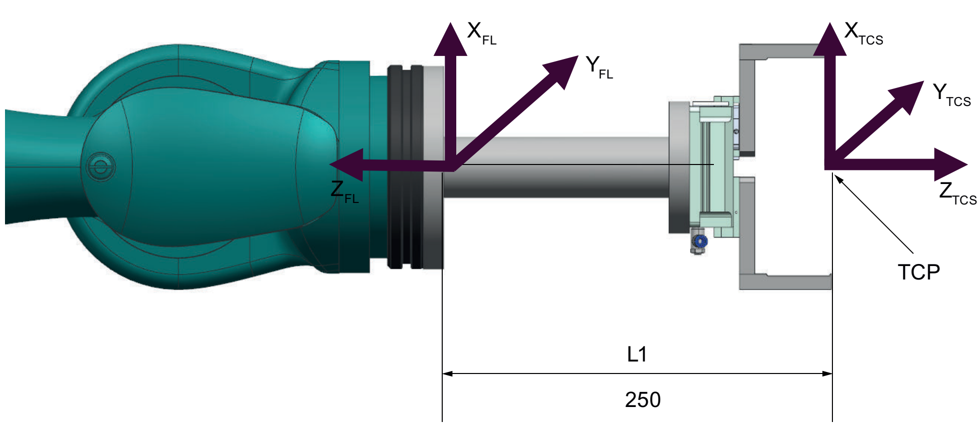


Figure 3-5 Parameterization of a single part tool using a gripper tool as example

Machine data	Value	Dimension
N62965 $MC_ROBX_TTCFL_POS[0]	0	mm
N62965 $MC_ROBX_TTCFL_POS[1]	0	mm
N62965 $MC_ROBX_TTCFL_POS[2]	0	mm
N62966 $MC_ROBX_TTCFL_RPY[0]	0	Degrees
N62966 $MC_ROBX_TTCFL_RPY[1]	180	Degrees
N62966 $MC_ROBX_TTCFL_RPY[2]	0	Degrees
N62949 $MC_ROBX_TOOL_DIR	0	
$TC_DP3[1,1] (Z) length L1 (for G17)	250	mm
$TC_DP4[1,1] (Y) length L2 (for G17)	0	mm
$TC_DP5[1,1] (X) length L3 (for G17)	0	mm
$TC_DPC1[1,1] 1st angle (rotation around Z)	0	°
$TC_DPC2[1,1] 2nd angle (rotation around Y)	0	°
$TC_DPC3[1,1] 3rd angle (rotation around X)	0	°

Note

With the setting ROBX_TOOL_DIR = 0, you define the tool direction according to the robot convention, this means positive tool lengths are taken into account in the positive X, Y, Z axes.

See also

Flange coordinate system (Page 23)

3.3.3 Flange coordinate systems for multipart tools

For multipart tools, the tool carrier (e.g. milling spindle) must be parameterized separately in the ROBX robot transformation. Using corresponding machine data, you can shift or rotate the tool acceptance point with respect to the flange coordinate system. You can thus define the end effector with reference to the flange coordinate system.

The rotation of the tool carrier coordinate system with respect to the flange coordinate system is entered in N62966 $MC_ROBX_TCLWP_RPY[0-2].

The reference point for programming the milling tool is the tool acceptance point.

The tool is defined with the tool lengths L1, L2 and L3.

A tool rotation can be programmed using $TC_DPC1-3[1,1].

The values correspond to RPY angles A, B and C, through which the tool is rotated with respect to the flange coordinate system. In this case, the shift is first realized across the tool lengths, and then the rotation in the TCP.

With the setting ROBX_TOOL_DIR = 1, you define the tool direction ($TC_DP[x,x] variables) according to the NC convention, this means positive tool lengths are taken into account in the negative X, Y, Z axes.

The following shows the parametrization of a multipart tool using the example of a milling spindle. A distinction is made between multipart tools according to the NC convention and the Robot convention.

See also

Multipart tools according to the NC convention (Page 27)

Multipart tools according to the Robot convention (Page 28)

3.3.3.1 Multipart tools according to the NC convention

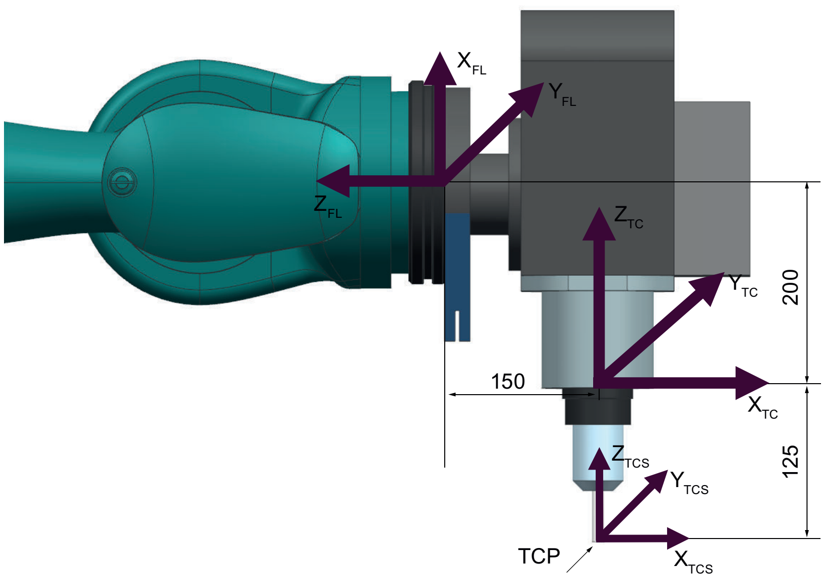


Figure 3-6 Parameterizing a multipart tool using a milling spindle as example

Machine data	Value	Dimension
N62965 $MC_ROBX_TTCFL_POS[0]	-200	mm
N62965 $MC_ROBX_TTCFL_POS[1]	0	mm
N62965 $MC_ROBX_TTCFL_POS[2]	-150	mm
N62966 $MC_ROBX_TTCFL_RPY[0]	0	Degrees
N62966 $MC_ROBX_TTCFL_RPY[1]	90	Degrees
N62966 $MC_ROBX_TTCFL_RPY[2]	0	Degrees
N62949 $MC_ROBX_TOOL_DIR	1	
$TC_DP3[1,1] (Z) length L1 (for G17)	125	mm
$TC_DP4[1,1] (Y) length L2 (for G17)	0	mm
$TC_DP5[1,1] (X) length L3 (for G17)	0	mm
$TC_DPC1[1,1] 1st angle (rotation around Z)	0	°

Machine data	Value	Dimension
$TC_DPC2[1,1] 2nd angle (rotation around Y)	0	°
$TC_DPC3[1,1] 3rd angle (rotation around X)	0	°

Note

With the setting ROBX_TOOL_DIR = 1, you define the tool direction according to the NC convention, this means positive tool lengths are taken into account in the negative X, Y, Z axes.

This setting requires the following sequence of axis rotations, which is activated with the programming command ORIVIRT1:

$MA_ORIAX_TURN_TAB_1[0]=1

$MA_ORIAX_TURN_TAB_1[1]=2

$MA_ORIAX_TURN_TAB_1[2]=3

References

Additional information on orientation tool orientation data is provided in the function description of the ROBX transformation.

3.3.3.2 Multipart tools according to the Robot convention

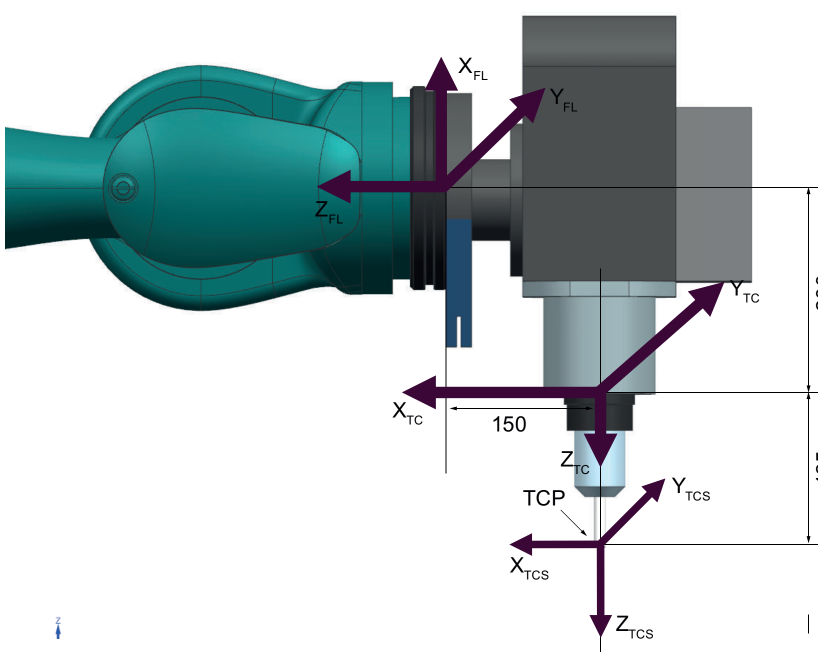


Figure 3-7 Parameterizing a multipart tool using a milling spindle as example

Machine data	Value	Dimension
N62965 $MC_ROBX_TTCFL_POS[0]	-200	mm
N62965 $MC_ROBX_TTCFL_POS[1]	0	mm
N62965 $MC_ROBX_TTCFL_POS[2]	-150	mm
N62966 $MC_ROBX_TTCFL_RPY[0]	0	Degrees
N62966 $MC_ROBX_TTCFL_RPY[1]	-90	Degrees
N62966 $MC_ROBX_TTCFL_RPY[2]	0	Degrees
N62949 $MC_ROBX_TOOL_DIR	0	
$TC_DP3[1,1] (Z) length L1 (for G17)	125	mm
$TC_DP4[1,1] (Y) length L2 (for G17)	0	mm
$TC_DP5[1,1] (X) length L3 (for G17)	0	mm
$TC_DPC1[1,1] 1st angle (rotation around Z)	0	°
$TC_DPC2[1,1] 2nd angle (rotation around Y)	0	°
$TC_DPC3[1,1] 3rd angle (rotation around X)	0	°

Note

With the setting ROBX_TOOL_DIR = 0, you define the tool direction according to the robot convention, this means positive tool lengths are taken into account in the positive X, Y, Z axes.

This setting requires the following sequence of axis rotations, which is activated with the programming command ORIVIRT1:

$MA_ORIAX_TURN_TAB_1[0]=3

$MA_ORIAX_TURN_TAB_1[1]=2

$MA_ORIAX_TURN_TAB_1[2]=1

References

Additional information on orientation tool orientation data is provided in the function description of the ROBX transformation.

4 Programming

The most common methods for programming robots are described in the following.

References

Additional programming information, such as orientation programming with the A3, B3 and C3 vectors, are described in the SINUMERIK 840D sl / 828D Fundamentals programming manual.

4.1 Axial programming

For axial programming, you must deactivate transformation using the modal TRAFOOF programming command. Then enter an axial position. The axial position refers to the machine axes in the channel.

Example

```
N15 TRAFOOF

;N16 HOME ;HOME position

N17 G0 RA1=0.0000 RA2=-90.0000 RA3=110.0000 RA4=0.0000 RA5=-20.0000
RA6=0.0000
```

Figure 4-1 HOME position

4.2 Cartesian programming with virtual rotary axis angles

For Cartesian programming, you must activate transformation using the modal TRAAORI programming command. Then enter a Cartesian position X, Y, Z - and an orientation A, B, C.

Example

```
N15 TRAORI

N16 G0 X1336.4283 Y1016.1269 Z426.6311 A=136.0484 B=-32.2151
C=160.9643
```

4.3 Orientation programming

4.3.1 Overview

The orientation is programmed via virtual rotary axis angles A, B, C. When doing this, the tool coordinate system (TCS) is rotated with respect to the reference coordinate system. The reference coordinate system can be either the machine coordinate system (MCS) or the workpiece coordinate system (WCS).

4.3.2 ORIMKS/ORIWKS

You define which reference system is active for the orientation programming using the programming commands ORIMKS and ORIWKS.

- ORIMKS: The reference system is the basic coordinate system
- ORIWKS: The workpiece coordinate system is the reference system

4.3.3 ORIVIRT1

You define the rotation sequence for interpreting orientation angles A, B, C in machine data $MC_ORIAX_TURN_TAB_1[0-2]. The following table shows the "KARDAN" setting.

Machine data	Value	Unit
N21120 $MC_ORIAX_TURN_TAB_1[0]	1	First rotation around X (A turns around X)
N21120 $MC_ORIAX_TURN_TAB_1[1]	2	Second rotation around Y (B turns around Y')
N21120 $MC_ORIAX_TURN_TAB_1[2]	3	Third rotation around Z (C turns around Z'')

Using programming command ORIVIRT1, you activate the rotation sequence set in machine data $MC_ORIAX_TURN_TAB_1[0-2].

Example, orientation programming (ORIMKS) without active tool

The following programming example shows the orientation programming in the machine coordinate system (ORIMKS) without active tool.

```
N12 G500
N13 ORIMKS
N14 ORIVIRT1
N15 TRAORI
N16 G1 X1590 Y0 Z1784 A=0 B=-90 C=0 F2000
```

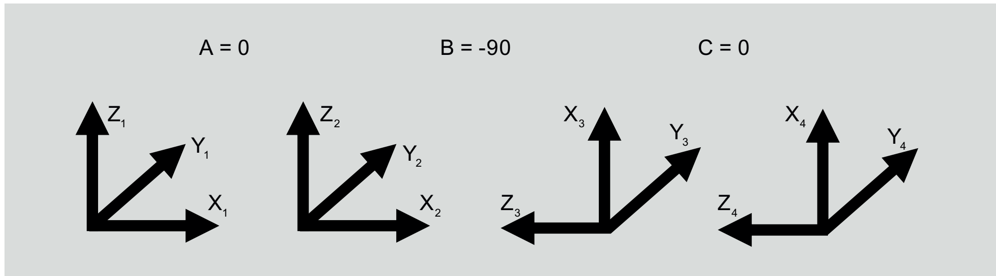


Figure 4-2 Example for programmed rotation A=0 B=-90 C=0 with ORIVIRT1

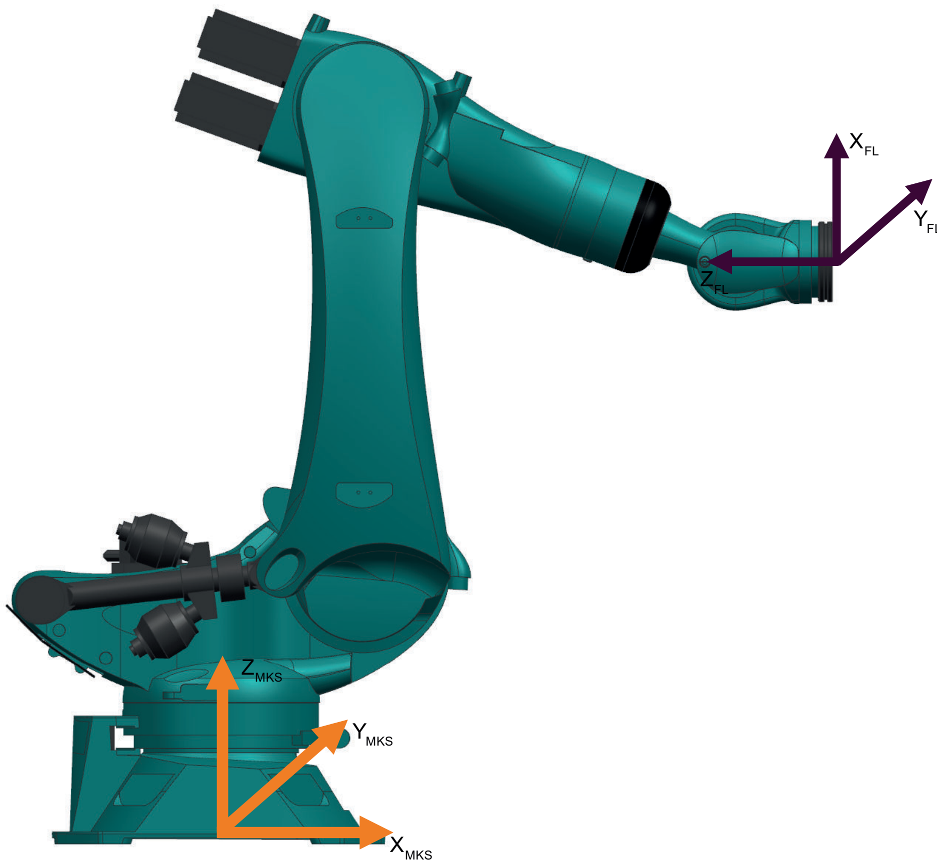
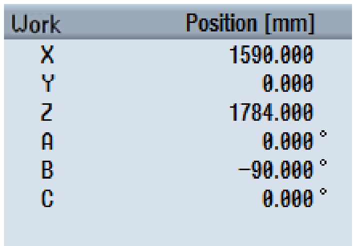
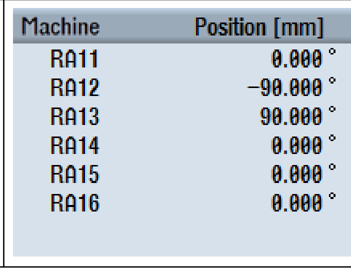


Figure 4-3 Orientation programming (ORIMKS) without tool

Actual value display in SINUMERIK Operate:

WCS actual value	MCS actual value
	

Example, orientation programming (ORIMKS) with active tool

The following programming example shows orientation programming in the workpiece coordinate system (ORIWKS) with active tool (configuration see Chapter Multipart tools according to the Robot convention (Page 28)).

```
;$P_UIFR[1]=CTRANS(X,1669,Y,0,Z,490):CROT(X,0,Y,0,Z,90)
N12 T="T8MILLD20" D1 ; $TC_DP3[1,1]=135
N13 ORIWKS
N14 ORIVIRT1
N15 TRAORI
N16 G54
N17 G1 X0 Y-71 Z959 A=0 B=0 C=-90 F2000
```

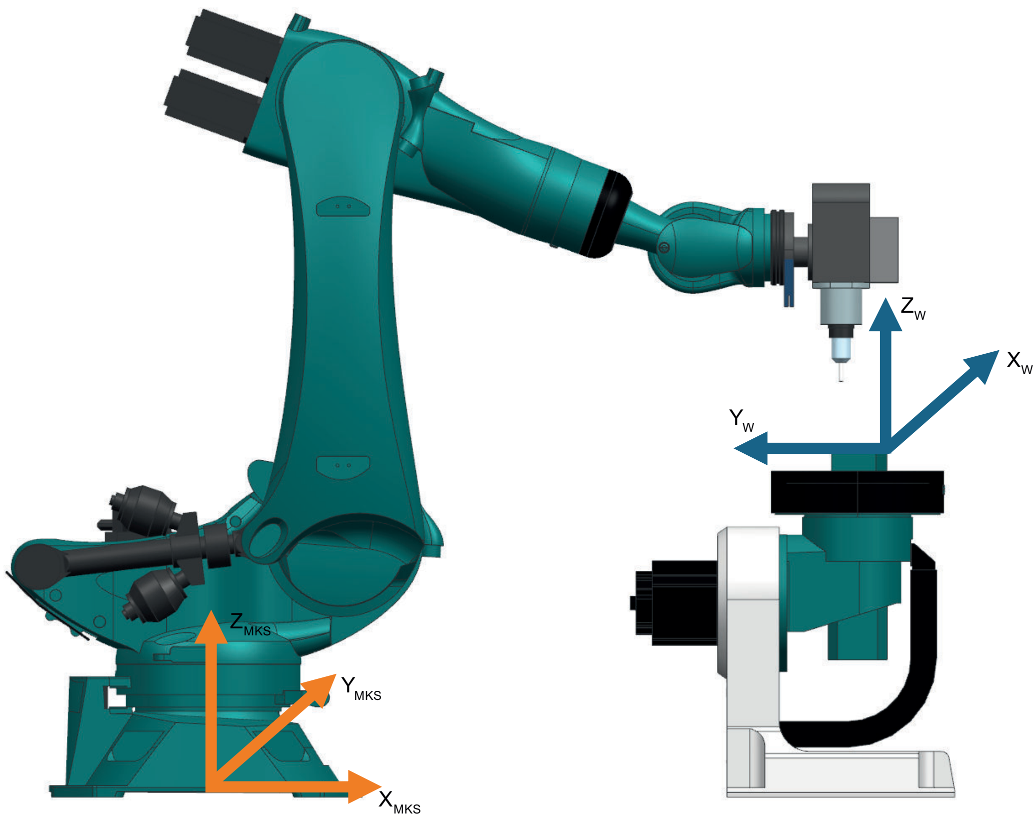


Figure 4-4 Orientation programming (ORIWKS)

Actual value display in SINUMERIK Operate:

WCS actual value		MCS actual value	
Work	Position [mm]	Machine	Position [mm]
X	0.000	RA11	0.000 °
Y	-71.000	RA12	-90.000 °
Z	959.000	RA13	90.000 °
A	0.000 °	RA14	0.000 °
B	0.000 °	RA15	0.000 °
C	-90.000 °	RA16	0.000 °
SP	0.000 °	SP1	0.000 °
G54 Z		G54 Z	

References

Further types of orientation programming are included in the "SINUMERIK 840D sl / 828D Fundamentals" and "SINUMERIK 840D sl / 828D Job Planning" programming manuals.

4.4 Cartesian PTP travel

4.4.1 Function

Using this function, you can approach a Cartesian position with synchronous axis motion. When an axis passes through a singularity, the feed velocity can either be reduced or the axis is overloaded. Using the "PTP travel" function, you can bypass these problems by approaching a Cartesian position with synchronous axis motion. You also have the possibility of changing the joint position.

References

General Information about Cartesian PTP travel is included in the "SINUMERIK 840D sl / 828D Expansion Functions" manual, Chapter "Cartesian PTP travel".

4.4.2 Activation

You activate this function using the PTP programming command. You deactivate this function using the CP command. Both commands are contained in G group 49.

- PTP command: The programmed Cartesian position is approached with a synchronized axis motion (PTP = point to point).
- CP command: The programmed Cartesian point is approached with a path motion (CP = continuous path) - default setting
- PTPG0 command: The programmed Cartesian PTP motion is automatically executed with each G0 block. Afterwards, CP is activated again.

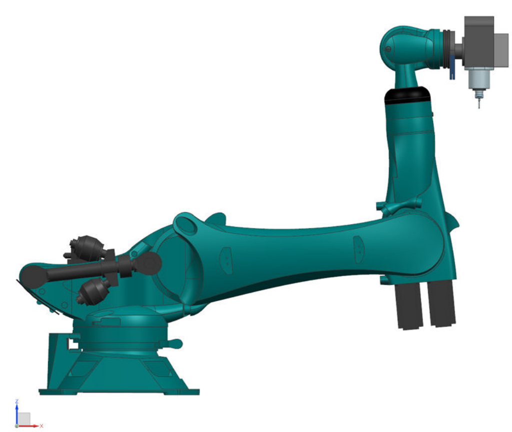
4.5 Robot position STAT (status)

A Cartesian position must be able to be converted uniquely into an axis angle. Enter the position of the joints under the STAT address. The STAT address contains a bit for every possible setting as a binary value. The following 3 positions are available for the ROBX robot transformation:

- Bit 0: Shoulder left/right
- Bit 1: Elbow Up/Down
- Bit 2: Handflip/no Handflip

The following programming examples illustrate the use of the STAT command. The basis is the configuration from Chapter Multipart tools according to the Robot convention (Page 28).

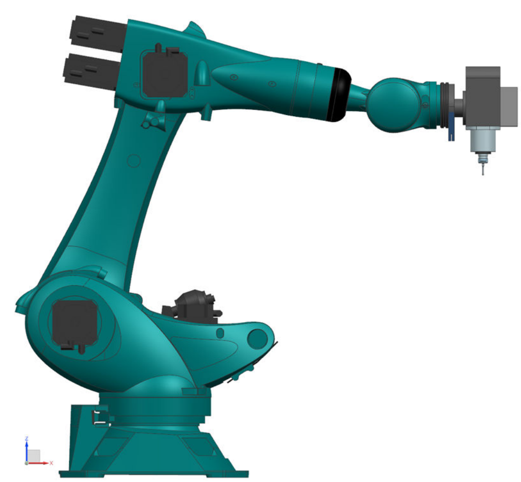
STAT = 0 ('B000')

Programming	Graphic
STAT = 0 ('B000') Bit 0: 0 Shoulder right Bit 1: 0 Elbow Down, A3 < 0° Bit 2: 0 no Handflip, A5 > 0°	

Example:

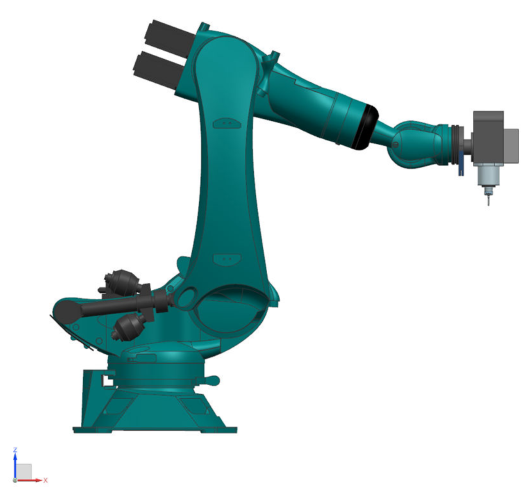
```
N14 T="T8MILLD20" D1  ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B000' F2000
```

STAT = 1 ('B001')

Programming	Graphic
STAT = 1 ('B001') Bit 0: 1 Shoulder left Bit 1: 0 Elbow Down, A3 < 0° Bit 2: 0 no Handflip, A5 > 0°	

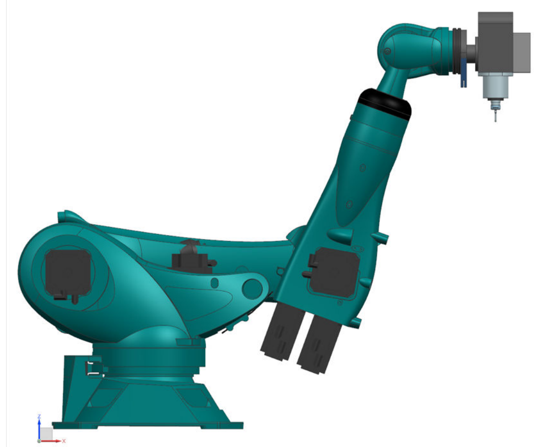
Example:
```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B001' F2000
```

STAT = 2 ('B010')

Programming	Graphic
STAT = 2 ('B010') Bit 0: 0 Shoulder right Bit 1: 1 Elbow Up, A3 ≥ 0° Bit 2: 0 no Handflip, A5 > 0°	

Example:
```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B010' F2000
```

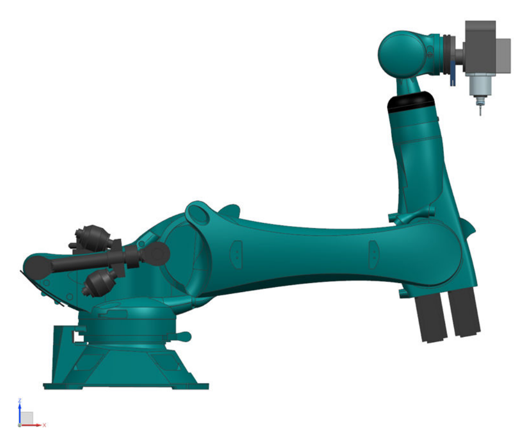
STAT = 3 ('B011')

Programming	Graphic
STAT = 3 ('B011') Bit 0: 1 Shoulder left Bit 1: 1 Elbow Up, A3 ≥ 0° Bit 2: 0 no Handflip, A5 > 0°	

Example:

```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B011' F2000
```

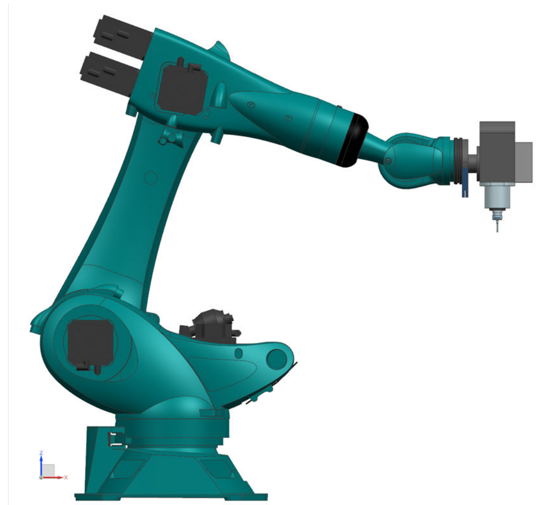
STAT = 4 ('B100')

Programming	Graphic
STAT = 4 ('B100') Bit 0: 0 Shoulder right Bit 1: 0 Elbow Down, A3 < 0° Bit 2: 1 Handflip, A5 ≤ 0°	

Example:

```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B100' F2000
```

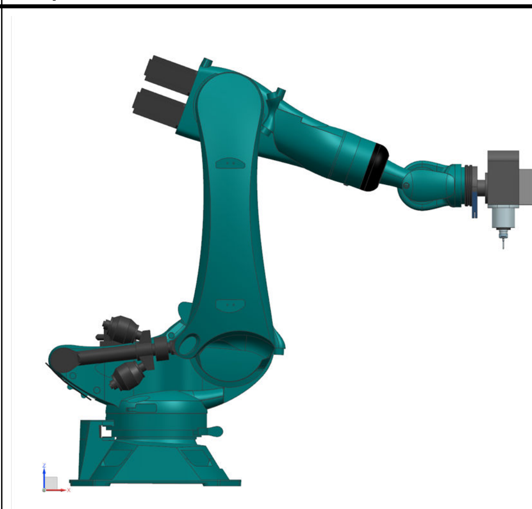
STAT = 5 ('B101')

Programming	Graphic
STAT = 5 ('B101') Bit 0: 1 Shoulder left Bit 1: 0 Elbow Down, A3 < 0° Bit 2: 1 Handflip, A5 ≤ 0°	

Example:

```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B101' F2000
```

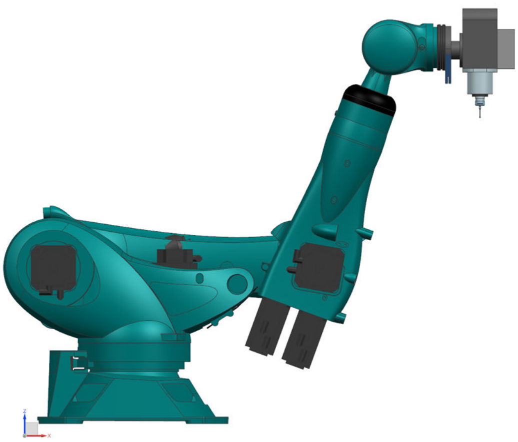
STAT = 6 ('B110')

Programming	Graphic
STAT = 6 ('B110') Bit 0: 0 Shoulder right Bit 1: 1 Elbow Up, A3 ≥ 0° Bit 2: 1 Handflip, A5 ≤ 0°	

Example:

```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B110' F2000
```

STAT = 7 ('B111')

Programming	Graphic
STAT = 7 ('B111') Bit 0: 1 Shoulder left Bit 1: 1 Elbow Up, A3 ≥ 0° Bit 2: 1 Handflip, A5 ≤ 0°	

Example:

```
N14 T="T8MILLD20" D1 ; $TC_DP3[1,1 ]=132.95
N16 ORIMKS
N17 G1 PTP X1665.67 Y0 Z1377.405 A=0 B=0 C=0 STAT='B111' F2000
```

4.6 Axis angular position TU (turn)

In order that you can uniquely approach an axis angle that is greater than ±180°, then you must program this information under address TU (turn). Address TU represents the sign of the axis angle. This allows an axis angle of |θ| < 360° to be uniquely approached without any ambiguity.

For each axis that is involved in the transformation, there is a bit in the TU variable. The particular bit indicates the traversing direction.

- TU bit=0: 0° ≤ θ < 360°
- TU bit=1: -360° < θ < 0°

For linear axes, set the TU bit to 0. For axes with a traversing range >±360°, the axis always moves along the shortest path as the axis position cannot be specified uniquely by the TU information. If you do not program TU for a position, then the axis always moves along the shortest path. In the following example, the shortest path is in the negative direction.

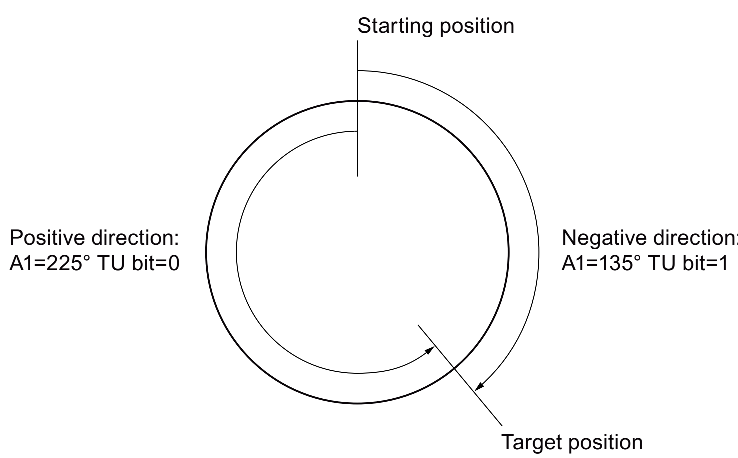


Figure 4-5 Example - axis angular position TU

Measuring cycles 5

5.1 Information about the measuring cycles

- Use the measuring cycles in conjunction with standard industrial robots with SINUMERIK 840Dsl - as described in the Programming Manual Measuring Cycles.
- It is essential that you calibrate a robot in order to improve the accuracy of the measurement results. This increases the absolute precision of the robot. Carefully note that kinematic robot errors flow into the measurement result. As a consequence, this can result in increased form and position tolerances/deviations of the programmed features. You must recalibrate the probe each time that a robot has been recalibrated. Remeasure reference point Z0 when calibrating the probe length.
- Carefully note the specific secondary conditions for the kinematics:
  - Before calling the measuring cycle, activate the robot transformation (TRAORI).
  - If you are using a probe, calibrate this at the robot kinematics being used (radius of the probe sphere/ball and probe length). Recalibrate the probe after each robot calibration.
  - For all measurements that you perform, you must always align the probe orthogonally to the workpiece. To do this use the "Align plane" measuring cycle or define your own values.

    Note

    The correction values are not automatically traversed through, but added as offset to the actual orientation angles (A, B, C). You must then manually traverse the axes through the correction values (A=0 B=0 C=0). Ensure that you avoid any collisions.

  - CYCLE800 is not available in combination with ROBX. Inclined planes in WCS, which cannot be emulated using the standard G17, G18, G19 planes, must be programmed using TOROT.
  - The basic robot configuration that you use when making measurements (Shoulder left / Shoulder right ; Elbow Up / Elbow Down; Handflip – programmable with PTP and STAT/ TU) should be identical for the subsequent technology-specific tasks. This is how you avoid kinematic-specific inaccuracies.

References

You can find additional information about the measuring cycles in the Programming Manual, Measuring Cycles:

Examples 6

6.1 Program example - programming commands

The following part program illustrates the commands explained in Chapter Programming (Page 31) as example:

```
N1 G90 ; activation of an absolute position
N2 T="T8MILLD20" D1 M6 ; activation of a tool
N3 TRAORI ; activation of ROBX transformation for Cartesian traversing
;$P_UIFR[1]=CTRANS(X,1500,Y,0,Z,400):CROT(X,0,Y,0,Z,-90); actual value of the work offset
G54
N4 G54 ; activation of the work offset
N5 M3 S20000 ; programming the main spindle
N6 ORIWKS ; activation of the orientation reference WCS
N7 ORIVIRT1 ; activation of the turning sequence from $MC_ORIAX_TURN_TAB_1[0-2]
N8 CYCLE832(0.01,_FINISH,1) ; activation of high-speed settings
;HOME ; defines the start position
N9 TRAFOOF ; deactivates the transformation
; traverse robot axes/channel axes with rapid traverse
N10 G0 RA1=0.0000 RA2=-90.0000 RA3=110.0000 RA4=0.0000 RA5=-20.0000 RA6=0.0000
N11 TRAORI
N12 G54
; traverse PTP block with explicit STAT/TU data. STAT and TU are only taken into account
when PTP travel is active.
N13 G0 PTP X1369.2426 Y956.7528 Z502.5517 A=135.5761 B=-33.2223 C=161.1435 STAT='B010'
TU='B001011'
N14 G0 X1355.1242 Y1014.9394 Z424.9695 A=135.8491 B=-33.1439 C=160.9941 STAT='B010'
TU='B001011'
; traverse CP block (linear motion)
N15 G1 CP X1354.8361 Y1016.1269 Z423.3862 A=136.0635 B=-33.0819 C=160.8770 F1000
N16 G1 X1336.4283 Y1016.1269 Z426.6311 A=136.0484 B=-32.2151 C=160.9643 F2000
N17 G1 X1317.9831 Y1016.1269 Z429.6730 A=136.0175 B=-31.3394 C=161.0655
;HOME
N18 TRAFOOF
N19 G0 RA1=0.0000 RA2=-90.0000 RA3=110.0000 RA4=0.0000 RA5=-20.0000 RA6=0.0000
N20 M30; end of program
```

6.2 Program example - measuring cycles

The program example shows how to use measuring cycles corresponding to the scene shown in the diagram.

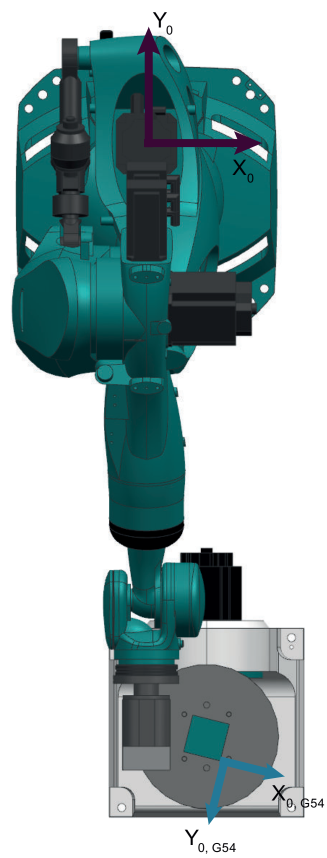


Figure 6-1 Robot scene for program example - measuring cycles

Program example

```
; home ;defined start position
N1 G0 RA1=0 RA2=-90 RA3=110 RA4=0 RA5=-20 RA6=0

N2 TRAORI ;activation of ROBX transformation for Cartesian traversing

; $P_UIFR[1]=CTRANS(X,(1767),Y,(197),Z,907):CROT(X,0,Y,0,Z,-52)
; actual value of the work offset G54 (X0,G54 ; Y0,G54)

N3 G54 ;activation of the work offset

N4 G0 A0 B0 C0
; alignment of the orientation axes orthogonally to the X,Y,Z axes of the work offset
activated in G54

N5 G0 X20 Y20 ; starting point in X,Y (pole) for measuring cycle 961

N6 G0 Z-10 ; starting point in Z for measuring cycle 961

N7 CYCLE961(30106,10001,1,134,28,-28,10,20,20,,,0,0,-52.131723,,1,10,100,1,,1,)
; determination of the zero in X,Y and the rotation of the workpiece around the Z axis

N8 G0 Z50 ; safety clearance for repositioning

N9 G0 A0 B0 C0
; alignment of the orientation axes orthogonally to the X,Y,Z axes of the work offset
activated in G54

N10 G0 X-70 Y60 ; starting point in X,Y (pole) for measuring cycle 978

N11 G0 Z20 ; starting point in Z for measuring cycle 978

N12 CYCLE978(100,10001,,1,0,30,100,3,2,1,"",,0,1.01,1.01,-1.01,0.34,1,0,,1,1)
; determination of the zero in Z

N13 G0 Z50 ; safety clearance for repositioning

N14 G0 A0 B0 C0
; alignment of the orientation axes orthogonally to the X,Y,Z axes of the work offset
activated in G54

N15 G0 X-107 Y-117 ; starting point in X,Y (pole) for measuring cycle 998

N16 G0 Z20 ; starting point in Z for measuring cycle 998

N17 CYCLE998(100106,1,,1,1,0,0,30,100,,,,103,,40,115,1,,1,)
;determination of the rotation around the X,Y axis of the workpiece with reference to MCS

N18 G0 Z50 ; safety clearance for repositioning

N19 G0 A0 B0 C0
; alignment of the orientation axes orthogonally to the X,Y,Z axes of the work offset
activated in G54

N20 G0 X-70 Y-60 ; starting point in X,Y (pole) for measuring cycle 978
```

```
N21 G0 Z20 ; starting point in Z for measuring cycle 978

N22 CYCLE978(100,10001,,1,0,30,100,3,2,1,"",,0,1.01,1.01,-1.01,0.34,1,0,,1,1)
; determination of the zero in Z

N23 G0 Z50 ; safety clearance for repositioning

N24 G0 A0 B0 C0
; alignment of the orientation axes orthogonally to the X,Y,Z axes of the work offset
activated in G54

N25 G0 X20 Y20 ; starting point in X,Y (pole) for measuring cycle 961

N26 G0 Z-10 ; starting point in Z for measuring cycle 961

N27 CYCLE961(30106,10001,1,134,28,-28,10,20,20,,,0,0,-52.131723,,1,10,100,1,,1,)
; determination of the zero in X,Y and the rotation of the workpiece around the Z axis

N28 G0 Z50 ; safety clearance for repositioning

; home ;defined start position
N29 G0 RA1=0 RA2=-90 RA3=110 RA4=0 RA5=-20 RA6=0

N30 M30; end of program
```

Notes relating to the program example

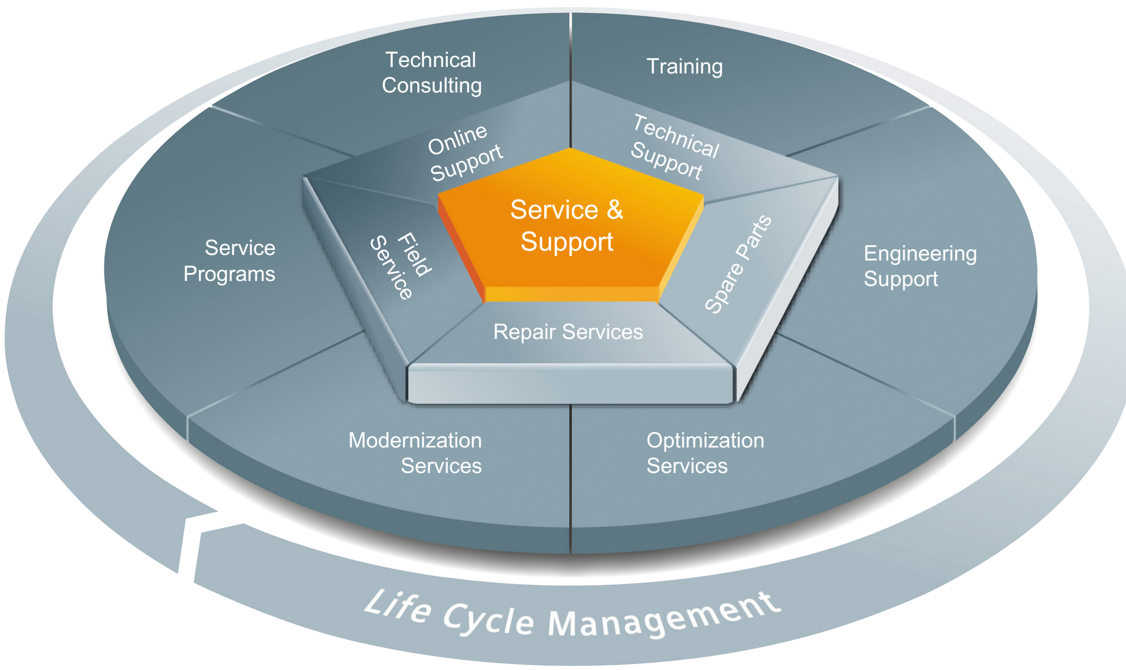
- Block number N4 – N13: These are used to measure the workpiece the first time. You can omit these, if the workpiece position is known.
- Block number N17: You must use measuring cycle 998 "Align plane" in order to avoid measurement inaccuracies. With this cycle, the probe measuring ball is aligned orthogonally to the workpiece. You can only correctly measure the zeros in the X, Y, Z axes of the workpiece once the plane has been aligned.

See also

Measuring cycles (Page 45)

Service & support

A



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- Comprehensive service from a single source, fewer interfaces and improved know-how

Contact persons

For you on-site, worldwide: Partner for consulting, sales, training, service, support, spare parts, etc. for the complete offering from Industry Automation and Drive Technologies. You can find your personal contact in our contact database in the Internet.