



Title	MTX 15VRS Measuring Functions
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1 About this documentation

Editions of this documentation

Edition	Release date	Note
01	2019-03	First edition
02	2021-09	New: G628, G629 (PBI 307916)

Tab. 1-1: Change record

1.1 Validity of the documentation

Purpose of the documentation

This documentation describes the MTX measuring cycles.

Overview on target groups and product phases

In the following illustration, the framed activities, product phases and target groups refer to the present documentation.

Example: The target group "Programmer" can "parameterize", "program", "configure" and "simulate" in the product phase "Engineering" using this documentation.

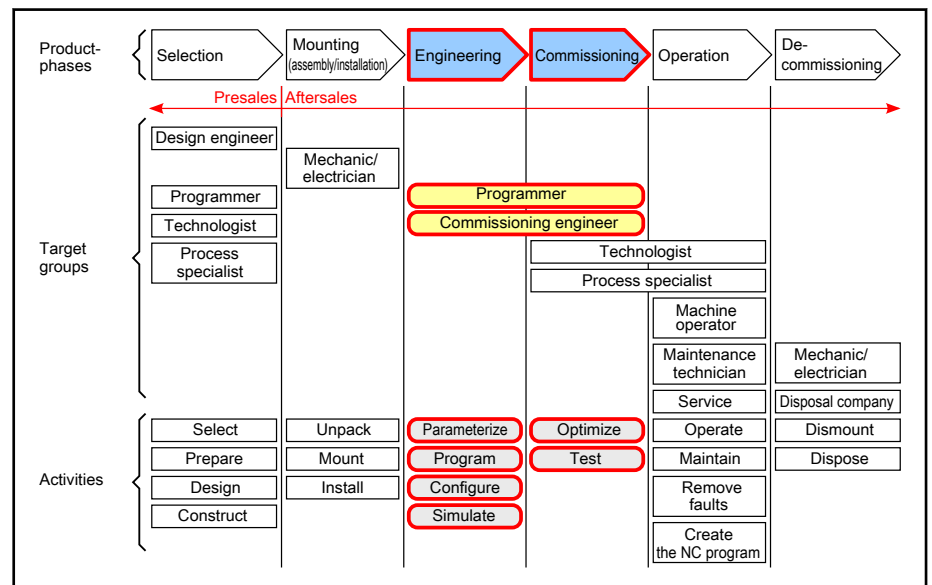


Fig. 1-1: Assigning this documentation to the target groups, product phases and target group activities

1.2 General information

The present manual supports you during the application/activation of various control functions.

It focuses on the procedures required for the parameterization.

This requires that the hardware of CNC, drives, PLC and voltage supply units are already integrated and checked according to your application documentation including wiring and accuracy. This refers especially to all safety-relevant features such as E-STOP circuits, release contacts, limit switches.

Ideally, the software of all Sercos drives is already commissioned. However, this is not imperative, since the control is able to configure any drives connected at startup via a parameter download. Thus, the fitting initialization files have to be available on the control.

To adjust the initialization files, have the corresponding documents available (such as lists with the necessary sercos parameter settings for all drives and drive documentation).

For a better overview, all functions are assigned to different superordinate topics (see "Table of Contents").

For each function, the following information is provided:

- Purpose or area of application
- Prerequisites/restrictions on use
- Interference options.

Numerous functions affect several domains at the same time (machine parameters, NC functions for programming, interface signals, etc.). Thus, many functions can also be described completely or partially in other manuals of this product.



Refer to the respective manual.

The following manuals supplement this manual:

- Machine parameters: "Rexroth IndraMotion MTX Machine Parameters"
- NC and CPL functions: "Rexroth IndraMotion MTX Programming Manual"
- Interface signals: "Rexroth IndraMotion MTX PLC Interface"

Furthermore, have the drive documentation at hand.

You require good knowledge of the

- standard user interface of the control
- Windows user interface of the PC control panel
- tools for the machine parameter configuration.

These tools can modify the control configuration. Therefore, you have to be familiar with all required tools!

CAUTION

Due to an incorrect or unintended use caused by insufficiently trained or untrained staff, serious damage to the machine, loss of data and even personal injury can result!

Thus, only qualified staff that is sufficiently trained may start and operate the system and set or modify configuration parameters!

The personnel also has to be able to detect the risks resulting from changing parameters and the inherent general risks of mechanical, electrical or electronic equipment.

Incorrect or unintended use by insufficiently trained or untrained staff can cause serious damage to the equipment! Bosch Rexroth is not liable for any of those damages and consequential damages caused.

1.3 Required and supplementing documentation MTX

1.3.1 Selection/compilation

Documentation titles with type codes and part numbers

MTX 15VRS System Description DOK-MTX***-SYS*DES*V15-PRRS-EN-P, R911397742 This documentation describes the MTX control. It includes the designs, technical data, interfaces as well as the configuration of the control components.
MTX 15VRS SafeLogic System Overview DOK-MTX***-SL**SYS*V15-PRRS-EN-P, R911398637 This documentation describes the use of the safety control SafeLogic in the MTX.
IndraControl XM42 Controls DOK-CTRL-XM4X*CTRL**-ITRS-EN-P, R911345566 This documentation describes the IndraControl XM42 controls.

RS Corresponding edition
Tab. 1-2: MTX documentation overview - Selecting/composing

1.3.2 Configuration

Documentation titles with type codes and part numbers

MTX 15VRS Machine Parameters DOK-MTX***-MA*PAR**V15-RERS-EN-P, R911400176 This documentation describes structure and the adjustment of available parameters of the MTX. It also includes the functions of the NC configurator and its operation.
MTX 15VRS PLC Interface DOK-MTX***-PLC*INT*V15-PRRS-EN-P, R911400172 This documentation describes the interface signals and the program function blocks for the integrated PLC.
MTX 15VRS Functional Description - Basics DOK-MTX***-NC*F*BA*V15-RERS-EN-P, R911401401 This documentation describes the basic functions of the MTX. The basic commissioning steps and the control functions are provided as description and handling instruction.
MTX 15VRS Functional Description - Extension DOK-MTX***-NC*F*EX*V15-RERS-EN-P, R911393316 This documentation describes the extended functions of the MTX. The basic commissioning steps and the control functions are provided as description and handling instruction.
MTX 15VRS Functional Description - Special Functions DOK-MTX***-NC*F*SP*V15-RERS-EN-P, R911393309 This documentation describes the special functions of the MTX. The basic commissioning steps and the control functions are provided as description and handling instruction.

MTX Free Form Surface Milling

DOK-MTX***-FREEFORM***-APRS-EN-P, R911341435

This documentation describes the free form surface milling process with the MTX control. CNC programs generated by a CAD/CAM system are used as basis for the entire process. Overview over the following topics: Description of the MTX or CNC function for freeform surface milling, strategy during the NC parameterization process, boundary conditions when generating CNC programs with CAM software.

MTX Conversion of MTX Projects

DOK-MTX***-PROCONV****-PRRS-EN-P, R911342484

This documentation provides support during the conversion of MTX 1.x projects to MTX 2G. This project planning manual provides information on how to convert a project and identifies potential difficulties during the conversion.

RS

Corresponding edition

Tab. 1-3:

MTX documentation overview - Configuring

1.3.3 Commissioning

Documentation titles with type codes and part numbers**MTX 15VRS Commissioning**

DOK-MTX***-STARTUP*V15-CORS-EN-P, R911393281

This documentation describes the commissioning of the MTX control. Apart from a complete overview, commissioning and configuration of the axes and the user interface as well as the PLC data are described.

IndraWorks 15VRS Basic Libraries, IndraLogic 2G

DOK-IL*2G*-BASLIB**V15-LIRS-EN-P, R911398633

This documentation describes the system-comprehensive PLC libraries.

IndraWorks 15VRS Field Buses

DOK-IWORKS-FB*****V15-APRS-EN-P, R911393284

This documentation describes the field bus and local periphery connections supported by the MLC and MTX systems. The focus of this documentation lies in the configuration, parameterization, commissioning and diagnostics of different periphery connections. It is the basis for the online help.

IndraWorks 14VRS WinStudio 7.4

DOK-IWORKS-WINSTUD*V14-APRS-EN-P, R911341585

This "User Manual and Technical Reference Book" supports the user in achieving the best results with the "Rexroth WinStudio"™ software. The document provides technical information and step-by-step instructions to create web-enabled HMI/SCADA programs.

IndraWorks 15VRS Software Installation

DOK-IWORKS-SOFTINS*V15-CORS-EN-P, R911393450

This documentation describes the IndraWorks installation.

IndraWorks 15VRS Engineering

DOK-IWORKS-ENGINEE*V15-APRS-EN-P, R911393303

This documentation describes the use of IndraWorks in which the Rexroth Engineering tools are integrated. It includes instructions on how to work with IndraWorks and how to operate the oscilloscope function.

IndraWorks 15VRS PLC Programming System IndraLogic 2G

DOK-IWORKS-IL2GPRO*V15-APRS-EN-P, R911396137

This documentation describes the PLC programming tool IndraLogic 2G and its use. The documentation includes the basic use, first steps, visualization, menu items and editors.

IndraWorks 15VRS HMI DOK-MLC***-HMI****V15-APRS-EN-P, R911399270 This documentation describes the functions, configuration and operation of the user interfaces IndraWorks HMI Engineering and IndraWorks HMI Operation.
MTX 15VRS Shape Cutting Technology DOK-MTX***-TEHCUT*V15-CORS-EN-P, R911399147 This documentation describes the shape cutting technology used by the machines to cut materials using an NC-controlled tool head.
MTX-integrated CAD/CAM System for Shape Cutting DOK-MTX***-CAD*TEHCUT-CO01-EN-P, R911393320 This documentation describes the mode of operation and the area of application of the CAD/CAM nesting software Lantek Expert Inside.

RS Corresponding edition
Tab. 1-4: MTX documentation overview - Commissioning

1.3.4 Operation

Documentation titles with type codes and part numbers

MTX 12VRS Block Pre-Run DOK-MTX***-BLK*RUN*V12-APRS-EN-P, R911334379 This documentation explains to the machine manufacturer how to setup the "Block pre-run" function at the machine for the end user.
MTX 15VRS Programming Manual DOK-MTX***-NC**PRO*V15-RERS-EN-P, R911393318 This documentation describes the standard programming of the MTX control. Apart from the basics of NC programming, the use of NC functions according to DIN 66025 as well as the NC functions with high-level language syntax and CPL functions are described.
MTX 15VRS Standard NC Operation DOK-MTX***-NC*OP***V15-APRS-EN-P, R911393314 This documentation describes the operation of the standard user interface of the NC control of the MTX. It includes the operation of the interface, the NC program development as well as the tool management.
MTX 15VRS Multitouch DOK-MTX***-MULTI***V15-APRS-EN-P, R911393311 The Multitouch user interface of the NC control MTX is described in this documentation.
MTX 15VRS Standard NC Cycles DOK-MTX***-NC*CYC**V15-PRRS-EN-P, R911394940 This documentation describes the application of the standard cycles of the different technologies for the MTX control.
MTX 15VRS NC Simulation DOK-MTX***-NC*SIM**V15-APRS-EN-P, R911393273 This documentation describes the NC simulation for the MTX control.
MTX 15VRS Measuring Functions DOK-MTX***-MES*FUN*V15-APRS-EN-P, R91194938 This documentation describes the measuring cycles of the MTX control.

RS Corresponding edition
Tab. 1-5: MTX documentation overview - Operating

1.3.5 OEM Engineering

Documentation titles with type codes and part numbers

MTX 13VRS Automation Interface DOK-MTX***-AUT*INT*V13-APRS-EN-P, R911337274 This documentation describes the script-based access to IndraWorks project data via the interface of the Automation Interface. Different objects including code examples are described. The Automation Builder is also described in this manual.
MTX 15VRS OPC Communication DOK-MTX***-OPC*COM*V15-PRRS-EN-P, R911399272 This documentation describes the syntax and the structure of the items for the communication with Bosch Rexroth devices.
IndraWorks OPC UA Communication DOK-IWORKS-OPC*UA*****-APRS-EN-P, R911379309 This documentation describes the OPC UA communication of the MLC and MTX control systems.

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Tab. 1-6: MTX documentation overview - OEM engineering

1.3.6 AddOns

Documentation titles with type codes and part numbers

MTX 11VRS Action Recorder DOK-MTX***-ACR*****V11-APxx-EN-P, R911329943 This documentation describes the MTX action recorder. It includes the installation and commissioning as well as interface signals, application and operation.
MTX 15VRS Efficiency Workbench MTX cta, MTX ega DOK-MTX***-EWB*****V15-APRS-EN-P, R911400178 This documentation describes the mode of operation and the area of application of the analysis tool MTX cta and MTX ega.
MTX Remote Condition Monitoring DOK-MTX***-RCM*****V01-APRS-EN-P, R911334383 This documentation describes the operation of the Remote Condition Monitoring System.
MTX visIREC User Documentation DOK-MTX***-VISIREC*V01-APRS-EN-P, R911344242 This documentation describes the analysis tool visIREC used to optimize the free form surface milling process. 2D or 4D display of path-related data. 2D or 4D display of coordinate-related data. Analysis of critical areas (path and orientation deviation). Comparing the programmed NC blocks to the interpolated NC blocks.

xx / RS Corresponding edition
Tab. 1-7: MTX documentation overview - AddOns

1.4 Using safety instructions

1.4.1 Structure of the safety instructions

The safety instructions are structured as follows:

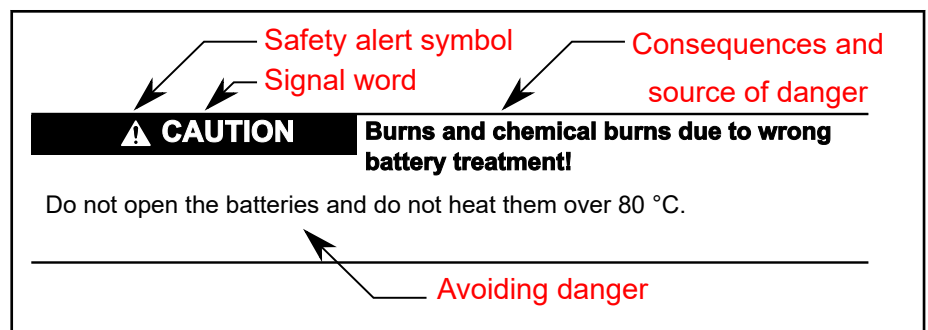


Fig. 1-2: Structure of the safety instructions

1.4.2 Explaining signal words and safety alert symbol

The safety instructions in this documentation contain specific signal words (danger, warning, caution, notice) and, if necessary, a safety alert symbol (according to ANSI Z535.6-2006).

The signal word draws attention to the safety instruction and indicates the risk potential.

The safety alert symbol (triangular safety reflector with exclamation marks), preceding the signal words Danger, Warning, Caution indicates hazards for persons.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **can** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury can occur.

NOTICE

In case of non-compliance with this safety instruction, material damage can occur.

1.4.3 Symbols used

Pointers are displayed as follows:



This is a note.

Tips are displayed as follows:



This is a tip.

1.4.4 Explaining the signal alert symbol on the device



If this symbol is on your device, you have to observe the documentation on the device. The respective documentation informs on the type of hazard as well as the steps required to avoid this hazard.

1.5 Names and abbreviations

Term	Explanation
IWE	IndraWorks Engineering
IWO	IndraWorks Operation
OWG	Optical waveguide
NC	Numerical Control
OEM	Original Equipment Manufacturer
Profibus	Communication connection
Sercos	Communication connection
MTB	Machine tool builder

Tab. 1-8: Terms and abbreviations

1.6 Customer feedback

Customer requests, comments or suggestions for improvement are of great importance to us. Please email your feedback on the documentations to Feedback.Documentation@boschrexroth.de. Directly insert comments in the electronic PDF document and send the PDF file to Bosch Rexroth.

2 Important instructions on use

2.1 Intended use

2.1.1 Introduction

Bosch Rexroth products are developed and manufactured according to the state-of-the-art. The products are tested prior to delivery to ensure operating safety and reliability.

The products may only be used as intended. If they are not used as intended, situations occur that result in damage to property or injury to persons.



Bosch Rexroth shall not assume any warranty, liability or payment of damages in case of damage resulting from a non-intended use of the products; the user shall solely bear all risks from unintended use of the products.

Before using Bosch Rexroth products, the following requirements have to be met to guarantee the intended use of the products:

- Anyone handling Bosch Rexroth products in any way is obliged to read and consent to the relevant safety instructions and the intended use.
- Hardware products may not be altered and have to remain in their original state; i.e. no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Do not install damaged or defective products or use them in operation.
- It has to be ensured that the products have been installed as described in the relevant documentation.



Ensure that the data present in the control or entered or read in by the user is correct before applying it to exclude unwanted axis motion. It can be the following invalid or old data:

- Part programs
- ZO tables
- Compensation tables
- Tool tables
- Permanent CPL variables
- Remanent PLC data
- Permanent system data

2.1.2 Areas of use and application

The MTX control is used to

- program contour and machining technology (path feed, spindle speed, tool change) of a workpiece.
- guide a machining tool along a programmed path.

Feed drives, spindles and auxiliary axes of a machine tool are activated via Sercos interface.



This additionally requires I/O components for the integrated PLC which - together with the actual CNC - control the machining process as a whole and also monitors this process with regard to technical safety.

It may only be operated with the explicitly specified hardware component configurations and combinations and only with the software and firmware specified in the appropriate documents and functional descriptions.

The CNC system MTX provides the perfect CNC system solution for cutting and forming for the following technologies:

- Rotate
- Milling
- Drilling
- Grinding
- Bending
- Nibbling
- Punching
- Contour cutting
- Handling

2.2 Unintended use

Using the CNC system MTX outside the previously specified areas of application or under operating conditions other than the conditions described in the documentation and the specified technical data, is defined as "unintended use".

The CNC system MTX must not be used if...

- it is subjected to operating conditions not corresponding to the specified ambient conditions. Operation under water, under extreme temperature fluctuations or under extreme maximum temperatures is prohibited.
- Furthermore, the CNC system MTX shall not be used for applications not expressly approved of by Bosch Rexroth. Therefore, please read the information given in the general safety instructions!
- The CNC system MTX may not be used in systems or machines connected to the internet via an unsecure network connection. Otherwise, malfunctions or a control failure can result due to unauthorized access.

3 Introduction

- Prerequisites**
- IndraDrive control units CSB, CDB, CSH
 - IndraDrive Firmware from MPx07, MPx17
 - Functional package Servo enabled for each measuring axis



No axis transformation must be active at the point of action AT2.

Working with this description

This description is divided into 4 chapters:

- [chapter 4 "Measuring cycle automatic" on page 15](#)
- [chapter 5 "Developing an individual measuring cycle automatic" on page 99](#)
- [chapter 6 "Manual probing" on page 119](#)
- [chapter 7 "Commissioning" on page 191](#)

Measuring task steps

Four consecutive steps have to be following to use the measuring cycles:

1. Calibrating the probe
2. Recording measured values at measured positions Providing measured results, e.g. boring center point and boring diameter
3. *Evaluating the measurement results and correction values:*
 - Monitoring the allowance and tolerance ranges with appropriate reaction in the process, outputting messages via the NC program
 - Determining the correction values depending on the dimensional deviation
4. *Processing the determined correction values in the NC user program:*
 - Assigning the correction values to programmed zero point offsets
 - Detecting rejected parts or rework

Additionally measured to control the status:

Protection of the probe against collision and monitoring of probe malfunctions.



To use the described measuring cycles, the MT_AxProbeMon function block has to be integrated in the PLC user program or a function has to be provided by the user. MT_AxProbeMon generates signals to be evaluated in the PLC user program. The PLC user program has to ensure monitoring of the probe and facilitate post-triggering at the radio probe.

Structure of the measuring cycles

The described measuring cycles are not based on parameterizable NC sub-routines. Call a so-called basic measuring cycle STP_PRBASE as NC sub-routine for the different measuring task steps.

The measuring cycles use SD variables in IndraMotion MTX to record and evaluate the measured values.

The SD variables defined for the measuring cycles are described in [chapter 7.5 "SD variables" on page 206](#).

Input mask tables

Input masks facilitate programming and operation of the measuring tasks. Each of the cycles has an individual input mask. Within the mask, the cycle parameters are explained with comments and graphics.

For the measuring cycles of the manual operation mode, the masks in OP2 Prepare F3 Zero point measurement are available.

For the measuring cycles of the automatic operation mode, the masks in the NC-Editor are available with <F5> "Input assistance", <F2>, "NC cycle".

A mask facilitates tabular input of the required and optional parameters and transmits the syntax and the parameters from the table to the NC-Editor. The cycle call is inserted at the current cursor position in the NC-Editor.

Change parameters of an already programmed cycle using the same input mask.

In [chapter 4 "Measuring cycle automatic" on page 15](#), the same steps of the measuring task steps are executed. Initially, the probe calibration is explained. Subsequently, the measurement, followed by the evaluation and processing of the information is described.

The measuring cycles are the standard solution for recurring measuring tasks. To solve special measuring tasks, individual user-defined measuring cycles can be developed or a compatible standard solution in the standard NC-Editor can be adjusted to the special measuring task, see [chapter 5 "Developing an individual measuring cycle automatic" on page 99](#).

To commission the measuring cycles or individual measuring cycles, a PLC function block is available as standard solution. Furthermore, certain parameters have to be adjusted in drive and control. A detailed description can be found in [chapter 7 "Commissioning" on page 191](#).

The individual measuring cycles are explained using the following specifications:

- Overview display (one or several figures):
The figures show the overview screens in an operating interface
- Syntax:
Syntax explanation, especially the mandatory and optional parameters in the cycle call. The parameters are identified by a maximum of a 3-digit code. Mandatory parameters are put in squared brackets (e.g. measuring distance <PRD>) in the syntax explanation. Optional parameters are additionally put in curly brackets (e.g. safety distance {<SDI>}). In the actual call, the parameters are not put in brackets individually but are only separated by semicolons. Mandatory parameters have to be assigned with a value in each measuring cycle call. No values have to be assigned to optional parameters.
- Input variables:
Transfer parameters to the measuring cycles
- Runtime variables:
Depending on the measuring cycle, local valid runtime parameters are created. The parameters can be read for diagnostics during commissioning.
- Output variables:
List of SD variables written with values within the measuring cycles or within the basic measuring cycle STP_PRBASE.
- Sequence:
Measuring cycle sequence description, partially with graphics.
- Programming example:
Compact, conclusive programming example with abstracted dimensioned drawing.

See also [chapter 4 "Measuring cycle automatic" on page 15](#).

Probe geometry The foot offsets for the lengths are always read out from the SD variables.

If the SD variable TOOL has the value TRUE, the geometry data "Length" and "Radius" are taken from the tool database. These values have to be enabled using G47.

If the SD variable TOOL has the value FALSE, the geometry data "Length" and "Radius" are taken from the SD variable. These values are automatically calculated by the cycle.

Specify the probe sphere center as tool length of the probe.

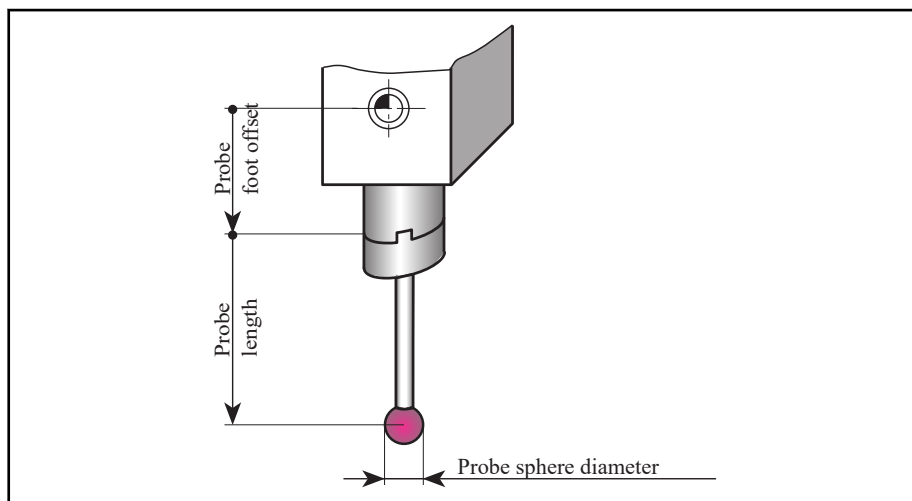


Fig. 3-1: Measuring the probe length

4 Measuring cycle automatic

4.1 General information

Functions	<i>The following functions are provided:</i>
	• <i>Calibrate tool probe</i> – G311 Tool length – G315 Tool radius • <i>Probe tool</i> – G301 Tool length – G303 Tool radius • <i>Calibrate workpiece probe</i> – G317 at a known point – G318 in an adjusting ring – G319 at a spigot • <i>Probe workpiece</i> – G321 Point – G323 Check workpiece availability – G324 Boring – G327 Spigot – G328 Ball – G329 Land – G331 Groove – G333 Angle – G628 Calculating the orientation of a plane – G629 Determining the center point of a calibrated ball • <i>Measuring value evaluation</i> – G541 Tolerance monitoring – G542 Averaging – G543 Percentage compensation

4.2 General notes

4.2.1 General information

Spindle orientation	For spindles with servo functionality, a spindle orientation is to be programmed before calling a measuring cycle. For measuring, the spindle is to be oriented to the same position that has already been used for calibrating (e.g. M19 S0). Thus, a higher measuring accuracy can be achieved. The value orientation value of the spindle can also be read out from the variable SD.SysPrbase.PROBE[n].ANGLE if it was stored there after calibration. As for spindles without servo functionality, no spindle orientation is available, after switching in the probe, the respective calibration cycle is to be called to ensure proper calibration.
SD variable RUNS	The variable specifies the number of measurements after calibration. The part programmer has the possibility to recalibrate automatically after a specif-

Measuring cycle automatic

Measuring position and measuring distance

ic number of measurements. This can also take place according to the time passed as the calibration time is also saved.

In the cycle call, a measuring position and the length of the measuring distance are entered. Starting point and end point of the measuring distance are calculated within the described measuring cycles. The signed starting point lies half the measuring distance in front of the programmed (expected) measuring position. The signed end point half the measuring distance behind the programmed measuring position. The following figure illustrates this relation.

The described measuring cycles expect triggering of the probe within the measuring distance. However, if the probe is triggered in front of the starting point or not triggered up to the end point, an error message is usually returned.

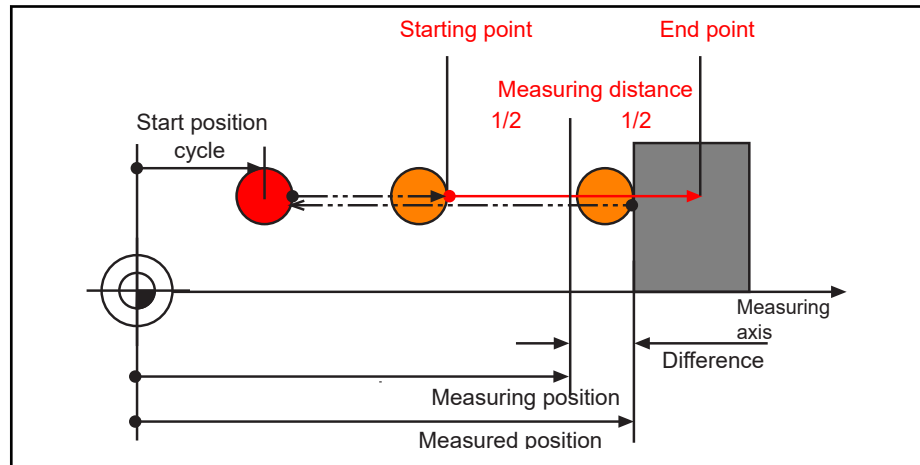


Fig. 4-1: Basic cycle sequence

Infeed and retraction

For the calibration of workpiece probes as well as for measuring workpieces, a standard motion sequence for infeed and retraction is implemented. This sequence can be adjusted by entering safety distance, retraction height, in-feed feed and retraction feed for each measuring task.

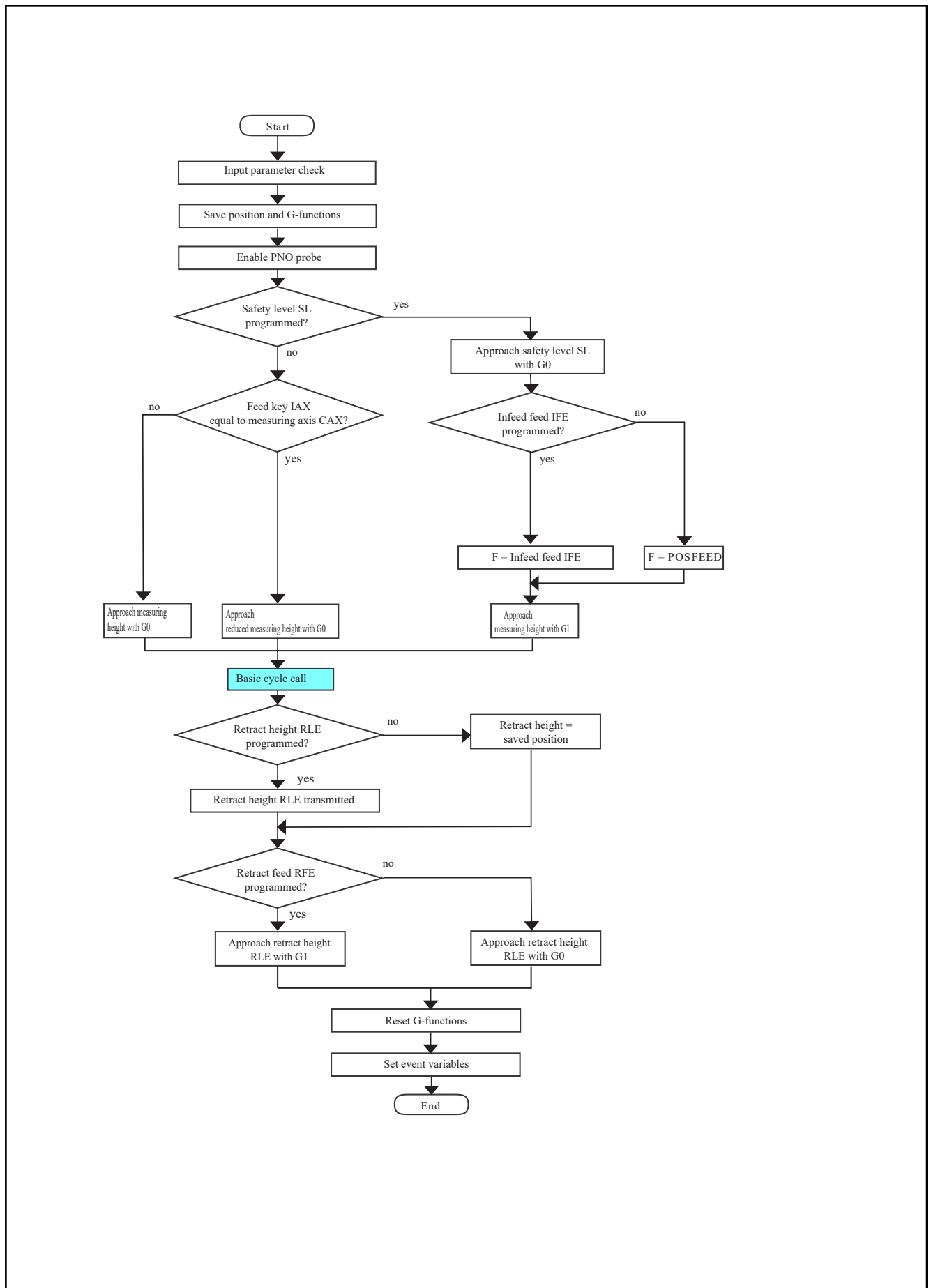


Fig. 4-2: Infeed and retraction sequence

Measuring cycle automatic

- NC axes** The measuring cycles use the channel axes X, Y and Z for measuring and auxiliary motions. If required, several axes can be added. However, please note that the system data structure has to be adjusted.
- Returns** The measuring cycles return the measurement result with double precision on system data structures. The system data structures should be used primarily during subsequent evaluations. Additionally, global variables with single precision are returned for compatibility reasons in previous versions (validity until the end of the program). Some, particularly calibration cycles, save their results in the form of permanent system data.

4.2.2 Meaning of abbreviations

Abbreviation	Description
ADI	Actual dimension
ANG	Set angle
BDI	Boring diameter
CA1	Center point of first measuring axis
CA2	Center point of second measuring axis
CA3	Center point of third measuring axis
CAX	Calibration axis
CDI	Calibration distance
CFE	Calibration feed
CLE	Calibration height
COB	Compensation limit
CPO	Calibrating position
CX1	Calibration axis 1
CX2	Calibration axis 2
DIA	Diameter
DIF	Differential dimension
DIS	Distance
EXV	Empirical value
GCE	Groove center
GWI	Groove width
IAX	Infeed axis number
IFE	Infeed feed
LMV	Average value of the last measurement
LOL	Lower limit
LTO	Lower deviation
MC	Remeasure center?
NCE	Land center
NDI	Nominal dimension

Abbreviation	Description
NWI	Land width
PA1	Name of the first measuring axis
PA2	Name of the second measuring axis
PA3	Name of the third measuring axis
PAX	Name of the measuring axis
PCL	Partial compensation limit
PCV	Percentage compensation value
PDI	Measuring distance
PFE	Measuring feed
PLE	Measuring height
PNO	Probe number
PP1	Main axis position
PP2	Secondary axis position
PPO	Measuring position
R	Ball radius
RDI	Ring diameter
RFE	Retraction feed
RLE	Retraction height
SCE	Spigot center
SCF	Scaling factor
SL	Safety level
SO	Spindle orientation command
SP	Spindle identifier
SST	Spindle stop command
TOC	Tolerance center
UPL	Upper limit
UTO	Upper deviation

Tab. 4-1: Abbreviations

4.3 Probe calibration

4.3.1 General information

Prior to actual measurements, a probe has to be calibrated for the axis and the direction of the measuring task at any known point of a measuring standard (zero tool) or a workpiece. The switching offset of the probe is determined. The determined switching offset can be used in the measuring cycles for calculative compensation of a measured value to achieve a precise measuring result.

A probe has to be recalibrated after:

- Initial commissioning

- Changing the stylus
- Changing the measuring feed
- Temperature range at the machine

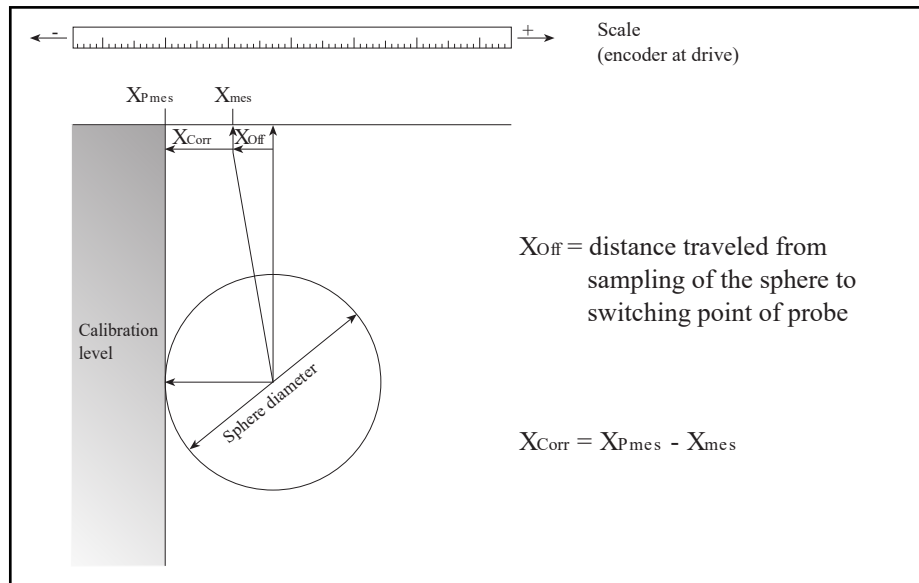


Fig. 4-3: Switching offset calibration

4.3.2 Probe calibration for workpiece measuring

G317 Calibrate probe - Point

Syntax G317 (PNO<pno>, IAX=<iax>, CDI<cdi>, CFE<cfe>, CLE<cle>, CAX<cax>, CPO<cpo>{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>})

Brief description The "Calibrate probe - Point" (G317) cycle defines the switching offset of a workpiece probe. The probe is calibrated for an axis and a direction. The calibration can also be carried out at any known point of a measuring standard (zero tool) or a workpiece.

Overview figure

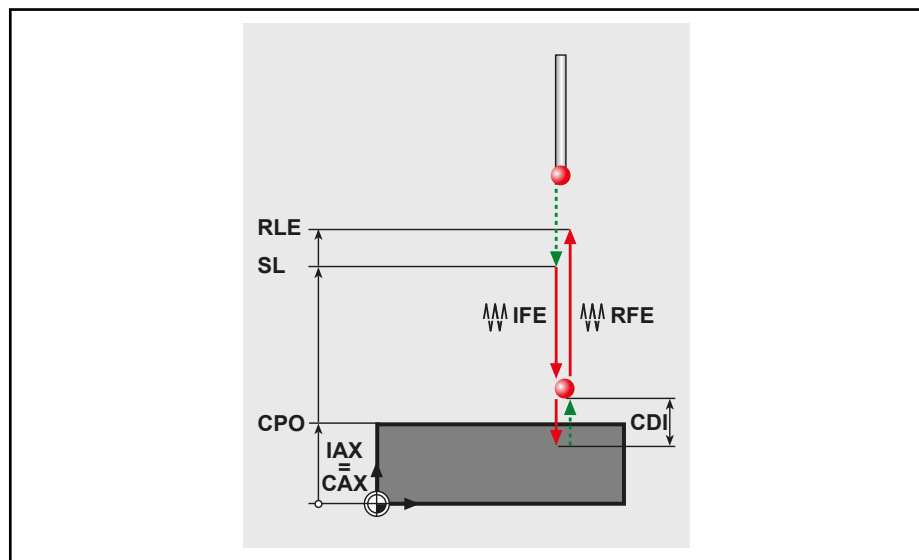


Fig. 4-4: Overview: Calibrate probe - Point with calibration axis equal to infeed axis

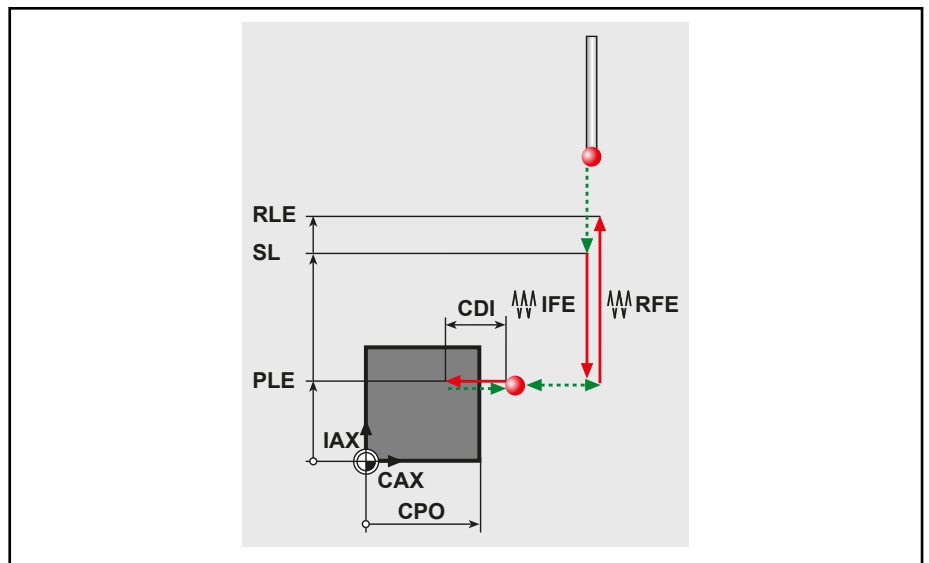


Fig. 4-5: Overview: Calibrate probe - Point with calibration axis unequal to in-feed axis

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety level	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	mm/min
CLE	Calibration height	Mandatory	REAL	Absolute
		optional	If infeed axis equal to calibration axis	
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
CDI	Calibration distance	Mandatory	REAL	Relative
CFE	Calibration feed	Mandatory	REAL	mm/min
CAX	Calibration axis	Mandatory	STRING	8
CPO	Calibrating position	Mandatory	REAL	Absolute

Tab. 4-2: Parameter call

Result variables

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
CALI	Calibrated	BOOL	TRUE..FALSE
VAL	Switching offset	REAL	
FEED	Calibration feed	REAL	
PRPOS	Switching position MCS	REAL	
YEAR	Year: YYYY	STRING	4
DATE	Day and month: DD:MM	STRING	5
TIME	Time: HH.MM.SS	STRING	8
RUNS	Number of measurements	INTEGER	

Tab. 4-3: Output values

Description

If no safety level is specified, the infeed takes place with rapid traverse on the calibration height or, if infeed axis and calibration axis are equal, directly to the starting point of the calibration distance. If a safety level is specified, the probe is first positioned in the safety level in rapid traverse. Afterwards, the probe moves to calibration height with G1 and the infeed feed to enable plunging at reduced velocity.

The measuring process is now traveled by the basic cycle. Afterwards, the probe is repositioned at the initial position. Afterwards, the output variables are stored in the permanent system variables and the "Number of measurements" (RUNS) variable is set to the value 0 in the SysPrResult structure.

Finally, the infeed axis is retracted. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

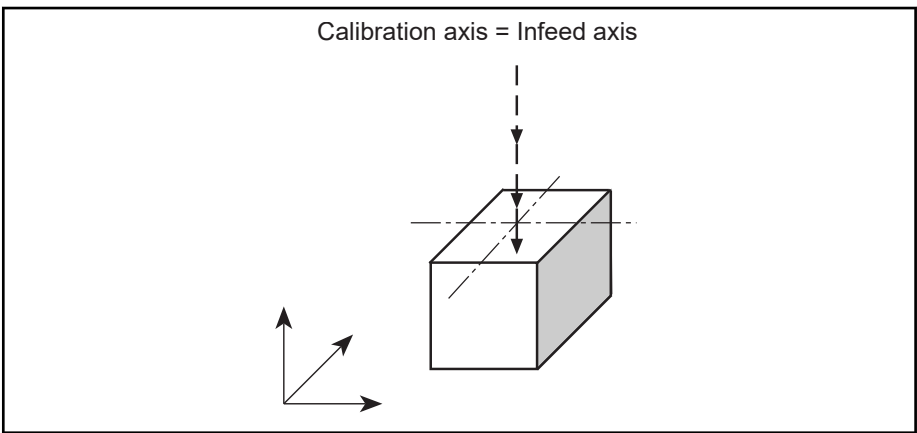


Fig. 4-6: Traversing motion: Calibrate probe - Point

Example

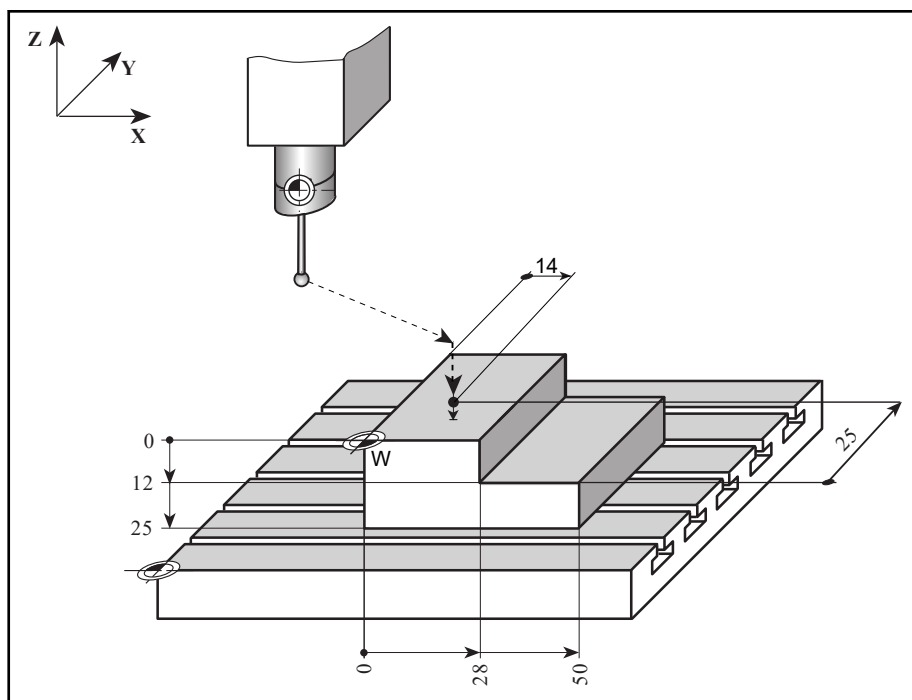


Fig. 4-7: Example: Calibrate probe - Point
Calibrate - Point

```

;----- Calibration at known point on the workpiece -----
;
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load Probel
N30 ED1 M97              ;Probel ON and enable edge
N40 G47 G54 G0 X14 Y25 Z100 M19 S0 ;enable tool length and ZPO
                               ;call cycle
N50 G317(PNO1, IAX Z, SL20,IFE3000, CDI-10, CFE500, CAX Z, CPO0)
N60 G0 Z100              ;retracting
N70 M30

```

G318 Calibrate probe - Adjusting ring

Syntax G318 (PNO<pno>, IAX <iax>, CDI<cdi>, CFE<cfe>, CLE<cle>,
CX1 <cx1>, CX2 <cx2>, CA1<ca1>, CA2<ca2>, RDI<rdi>
{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, MC<mc>}
{, SP <sp>, SO <so>})

Brief description With the "Calibrate probe - Adjusting ring" (G318) cycle, the probe is calibrated in an adjusting ring for the main and secondary axis respectively for positive and negative direction.

Overview figure

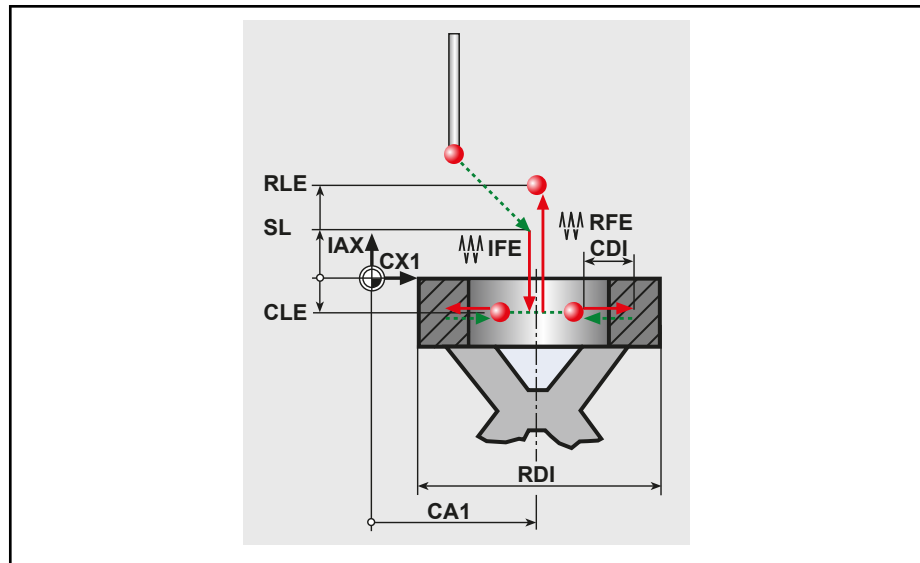


Fig. 4-8: Overview 1: Calibrate probe - Adjusting ring

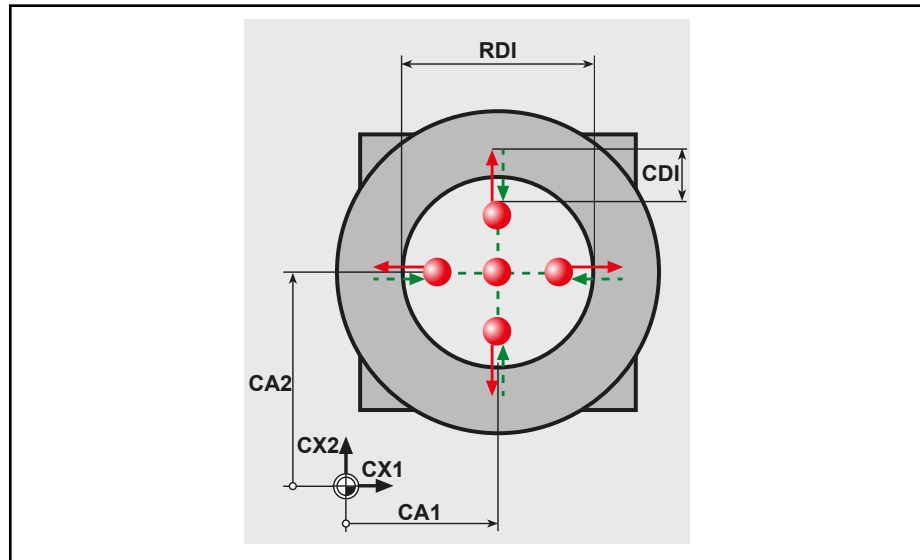


Fig. 4-9: Overview 2: Calibrate probe - Adjusting ring

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety distance	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
CLE	Calibration height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute

Parameter	Name	Properties		Values	Pre-assignment/Range
RFE	Retraction feed	optional		REAL	mm/min
CDI	Calibration distance	Mandatory		REAL	Relative
CFE	Calibration feed	optional		REAL	mm/min
CX1	Calibration axis 1 (main axis)	Mandatory		STRING	8
CX2	Calibration axis 2 (secondary axis)	Mandatory		STRING	8
CA1	Center of calibration axis 1	Mandatory		REAL	Absolute
CA2	Center of calibration axis 2	Mandatory		REAL	Absolute
RDI	Diameter	Mandatory		REAL	
MC	Remeasure center?	optional		INTEGER	1 Yes (pre-assigned) 2 No
SP	Spindle identifier	optional	Specify together with SO	STRING	8, pre-assigned "no reversal measurement on remeasure center"
SO	Command for spindle orientation	optional	Specify together with SP	STRING	8

Tab. 4-4: Parameter call

Result variables

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
CALI	Calibrated	BOOL	TRUE..FALSE
VAL	Switching offset	REAL	
FEED	Calibration feed	REAL	

Measuring cycle automatic

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
PRPOS	Switching position MCS	REAL	
YEAR	Year: YYYY	STRING	4
DATE	Day and month: DD:MM	STRING	5
TIME	Time: HH.MM.SS	STRING	8
RUNS	Number of measurements	INTEGER	
SD.SysPrResult.RESULT[1]	Center in axis 1	REAL	double precision
SD.SysPrResult.RESULT[2]	Center point in axis 2	REAL	double precision
#RESULT1	Center in axis 1	REAL	single precision
#RESULT2	Center point in axis 2	REAL	single precision

Tab. 4-5: Output values

Description

If the safety level is not specified, infeed takes place first to the ring center and then in rapid traverse to calibration height. If the safety level is specified, the probe positions in the safety level in rapid traverse. Afterwards, the probe moves to calibration height with G1 and the infeed feed to enable plunging at reduced velocity.

If the position of the ring center is not exactly known, MC2 is to be programmed. In this case, the exact position of the ring center is measured first. To prevent measuring errors due to uncalibrated probes, SP and SO are to be programmed. With these specifications, measuring errors are minimized by turning the spindle in measuring direction (reversal measurement). The center is determined by four measuring steps.

Now, the switching offsets are determined in four axis directions (without spindle orientation) and afterwards positioned to the center of the adjusting ring. Afterwards, the output variables are stored in the permanent system variables and the "Number of measurements" (RUNS) variable is set to the value 0 in the SysPrResult structure.

Finally, the infeed axis is retracted. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

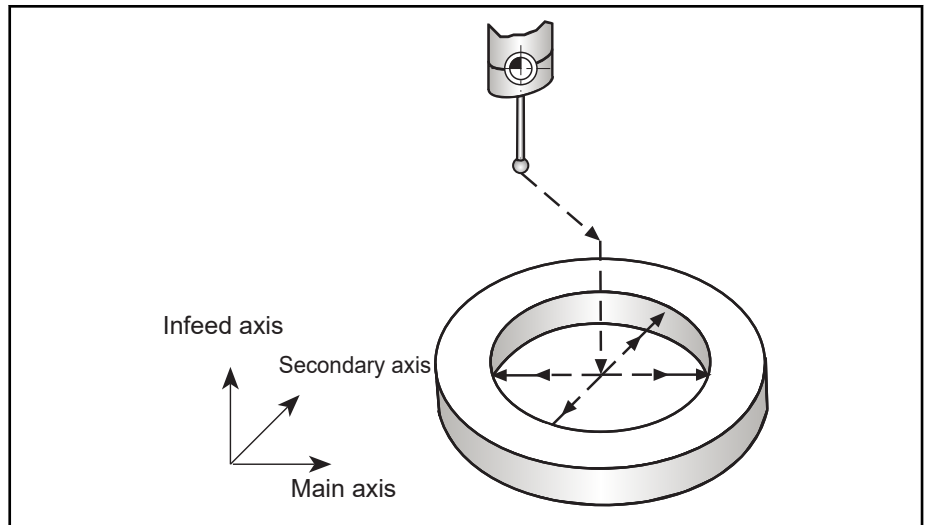


Fig. 4-10: Traversing motion: Calibrate probe - Adjusting ring

Example

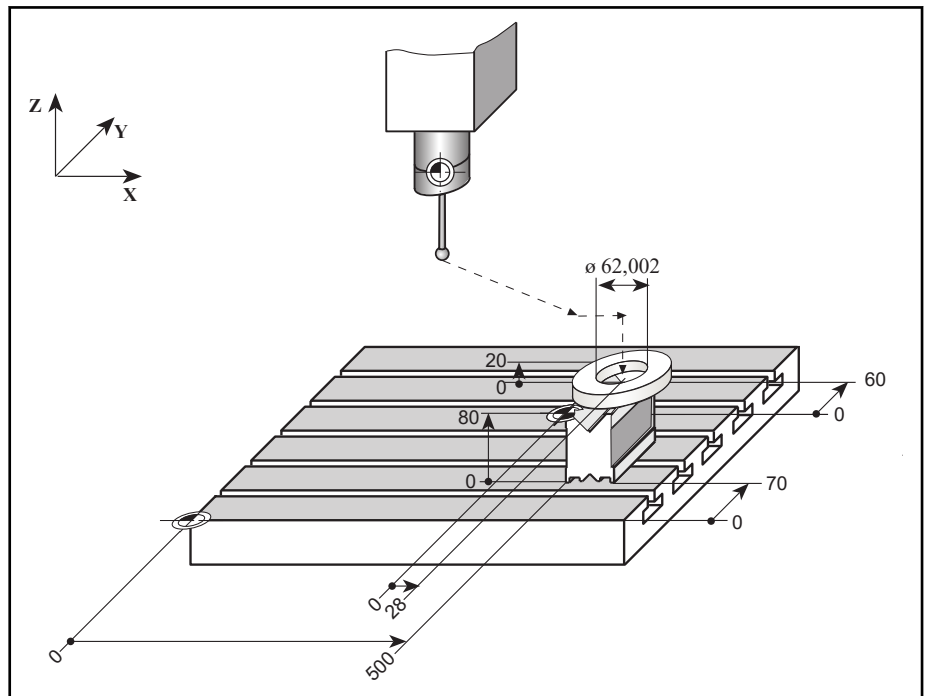


Fig. 4-11: *Example: Calibrate probe - Adjusting ring*

Calibration - Adjusting ring

```

;----- Calibrating X and Y in an adjusting ring -----
;
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load Probel
N30 ED1 M97             ;Probel ON and enable edge
N40 G47 G55             ;enable tool length and ZPO
N50 G0 X0 Y0 Z160 M19 S=0 ;approaching
;call cycle
N60 G318 (PNO1,IAX Z, SL20, IFE3000, CLE-31, RLE0, RFE1000,
  CDI6, CFE500, CX1 X, CX2 Y, CA1 28, CA2 80, RDI62.005)
N60 G0 Z100             ;retracting
N70 M30

```

G319 Calibrate probe - Spigot

Syntax G319 (PNO<pno>, IAX <iax>, CDI<cdi>, CFE<cfe>, CLE<cle> ,

Measuring cycle automatic

CX1 <cx1>, CX2 <cx2>, CA1<ca1>, CA2<ca2>, DIA<dia>
 {, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{,MC<mc>}
 {, SP <sp>, SO <so>}}

Brief description With the "Calibrate probe - Spigot" (G319) cycle, the probe is calibrated at a spigot with exactly known diameter for the main and secondary axis respectively for positive and negative direction.

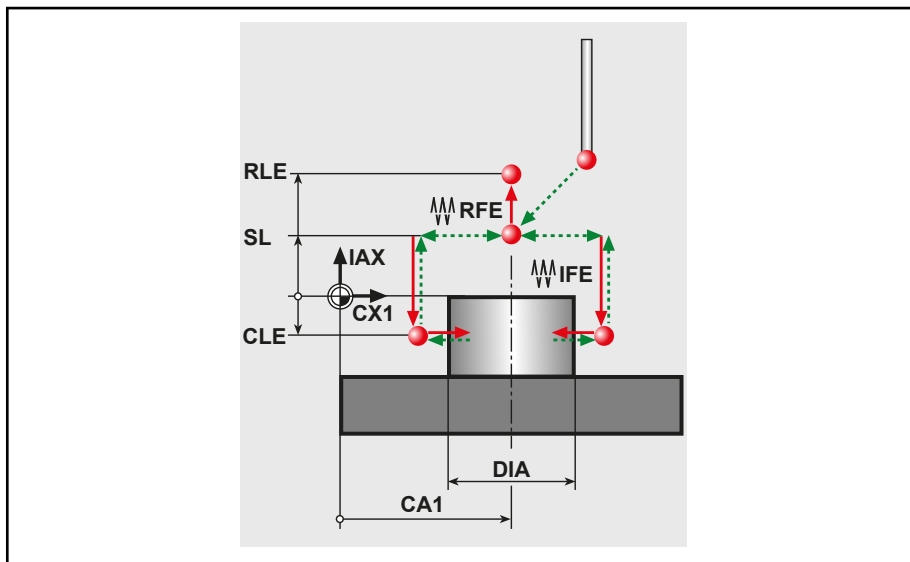
Overview figure

Fig. 4-12: Overview 1: Calibrate - Spigot

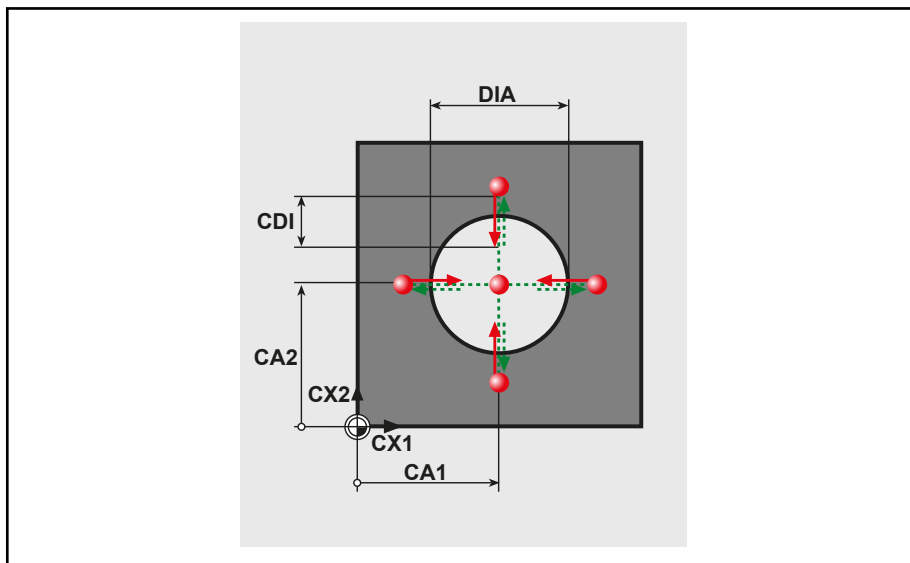


Fig. 4-13: Overview 2: Calibrate - Spigot

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety distance	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute

Parameter	Name	Properties		Values	Pre-assignment/Range
CLE	Calibration height	Mandatory		REAL	Absolute
RLE	Retraction height	optional		REAL	Absolute
RFE	Retraction feed	optional		REAL	mm/min
CDI	Calibration distance	Mandatory		REAL	Relative
CFE	Calibration feed	optional		REAL	mm/min
CX1	Calibration axis 1 (main axis)	Mandatory		STRING	8
CX2	Calibration axis 2 (secondary axis)	Mandatory		STRING	8
CA1	Center of calibration axis 1	Mandatory		REAL	Absolute
CA2	Center of calibration axis 2	Mandatory		REAL	Absolute
DIA	Diameter	Mandatory		REAL	
MC	Remeasure center?	optional		INTEGER	1 Yes (pre-assigned) 2 No
SP	Spindle identifier	optional	Specify together with SO	STRING	8, pre-assigned "no reversal measurement on remeasure center"
SO	Command for spindle orientation	optional	Specify together with SP	STRING	8

Tab. 4-6: Parameter call

Result variables

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
CALI	Calibrated	BOOL	TRUE..FALSE

Measuring cycle automatic

SD.SysPrResult.CAL[n].AXIS[j].DIR[j].Parameter			
VAL	Switching offset	REAL	
FEED	Calibration feed	REAL	
PRPOS	Switching position MCS	REAL	
YEAR	Year: YYYY	STRING	4
DATE	Day and month: DD:MM	STRING	5
TIME	Time: HH.MM.SS	STRING	8
RUNS	Number of measurements	INTEGER	
SD.SysPrResult.RESULT[1]	Center in axis 1	REAL	double precision
SD.SysPrResult.RESULT[2]	Center point in axis 2	REAL	double precision
#RESULT1	Center in axis 1	REAL	single precision
#RESULT2	Center point in axis 2	REAL	single precision

Tab. 4-7: Output values

Description At the beginning of the cycle, positioning takes place in rapid traverse by means of the spigot center on the safety level. Afterwards, the probe moves to the first measuring point with G1 and to calibration height with infeed feed to enable plunging at reduced velocity.

If the position of the spigot center is not exactly known, MC2 is to be programmed. In this case, the exact position of the center is measured first. To prevent measuring errors due to uncalibrated probes, SP and SO are to be programmed. With these specifications, measuring errors are minimized by turning the spindle in measuring direction (reversal measurement). The center is determined by four measuring steps.

Now, the switching offsets are determined in four axis directions (without spindle orientation) and afterwards positioned to the center of the spigot. Afterwards, the output variables are stored in the permanent system variables and the "Number of measurements" (RUNS) variable is set to the value 0 in the SysPrResult structure.

Finally, the infeed axis is retracted. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

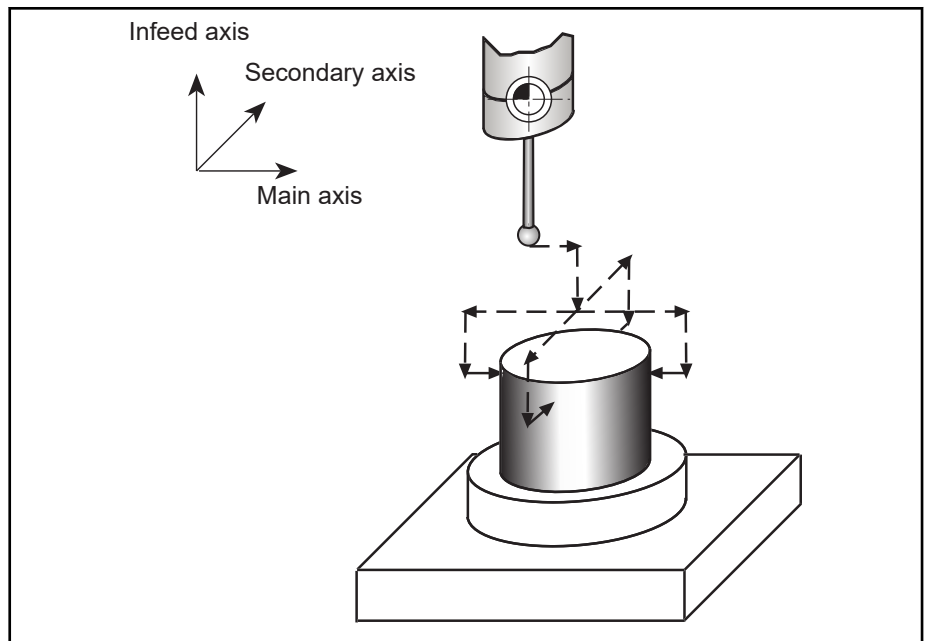


Fig. 4-14: Traversing motion: Calibrate spigot

Example

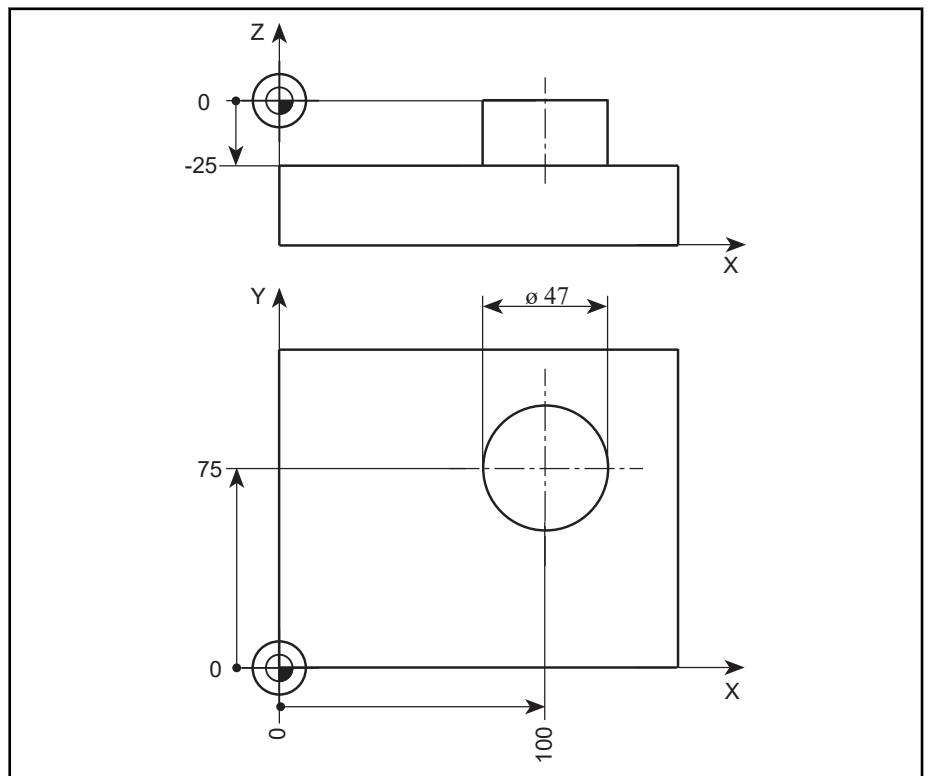


Fig. 4-15: Example: Calibrate spigot

Calibrate spigot

```

;-----
;----- Probe spigot D47 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load Probel
N30 ED1 M97              ;Probel ON and enable edge
N40 M19 S=0
N50 G47 G54 X0 Y0 Z150 ;enable tool length and ZPO
;call cycle

```

```
N60 G319 (PNO2, IAX Z, SL10, CLE-10, CDI20, CFE500, CX1 X, CX2 Y,
    CA1 100, CA2 75, DIA47.000)
;displaying measurement results on the screen
1 PRN#(0,"calibration value X+ : ####.## X- : ####.##",
    SD.SysPrResult.CAL[2].AXIS[1].DIR[1].VAL,
    SD.SysPrResult.CAL[2].AXIS[1].DIR[1].VAL)
2 PRN#(0,"calibration value Y+ : ####.## Y- : ####.##",
    SD.SysPrResult.CAL[2].AXIS[2].DIR[1].VAL,
    SD.SysPrResult.CAL[2].AXIS[2].DIR[1].VAL)
N70 G0 Z100 ;retracting
N80 M30
```

4.3.3 Probe calibration for tool measuring

G311 Calibrate probe - Tool length

Syntax G311 (CAX <cax>, CDI<cdi>, CFE<cfe>, PNO<pno>{, SL<sl>})

Brief description The "Calibrate probe - Tool length" (G311) cycle determines the switching offset for the selected axis direction by sampling a tool probe with a measuring standard (zero tool).

Overview figure

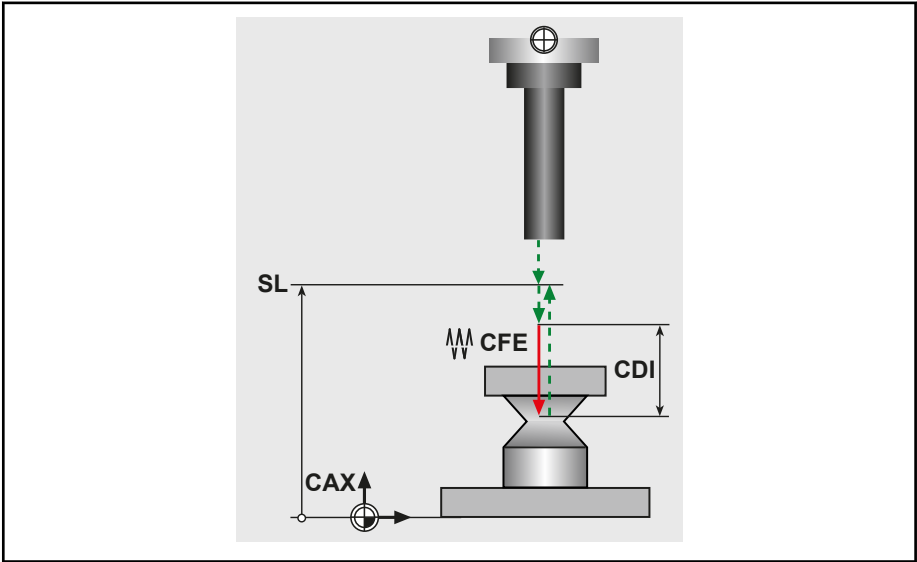


Fig. 4-16: Overview: Calibrate probe - Tool length

Parameter

Parameter	Name	Properties	Values	Pre-assign-ment/range
SL	Safety level	optional	REAL	Absolute
CAX	Calibration axis	Mandatory	STRING	8
CDI	Calibration distance (the sign defines the calibration direction)	Mandatory	REAL	Relative
CFE	Calibration feed	Mandatory	REAL	mm/min
PNO	Probe number	Mandatory	INTEGER	1..2

Tab. 4-8: Parameter call

Result variables

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter
[n] 1..2 Probe number
[i] 1..3 Axis number
[j] 1..2 Direction (1 = positive, 2 = negative)

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
Parameter	Description	Values	Area
CALI	Calibrated	BOOL	TRUE..FALSE
VAL	Switching offset	REAL	
FEED	Calibration feed	REAL	
PRPOS	Switching position MCS	REAL	
YEAR	Year: YYYY	STRING	4
DATE	Day and month: DD:MM	STRING	5
TIME	Time: HH.MM.SS	STRING	8
RUNS	Number of measurements	INTEGER	

Tab. 4-9: Output values

Description

The G311 cycle calibrates the probe for tool length measurement. For this purpose, a measuring standard (zero tool) with known length is to be loaded and activated. The initial position has to be approached prior to the cycle as the cycle is only triggered in motions in the direction of the calibration axis. If a safety level is programmed, the zero tool moves in rapid traverse to this absolute workpiece coordinate. Afterwards, the tool is positioned in rapid traverse over the probe.

If no safety level is programmed, it is immediately positioned over the probe. During positioning over the measuring system, the basic offsets and cutting lengths are already taken into consideration. Afterwards, the zero tool is monitored and moves with positioning feed up to the measuring system by half the calibration distance. The following calibration distance is traveled with calibration feed. If the probe deflects within the calibration distance, the switching offset value, the machine coordinate (without compensation and coordinate offset), the calibration feed, the status "calibrated" on "TRUE", the year, date and time are written to the system data. Additionally, the number of measurements is set to zero. Otherwise, the message "Position not found" is returned and the status "calibrated" is set to "FALSE". Now, the infeed axis is retracted in rapid traverse. It is either moved to the initial position or the position of the programmed safety level.

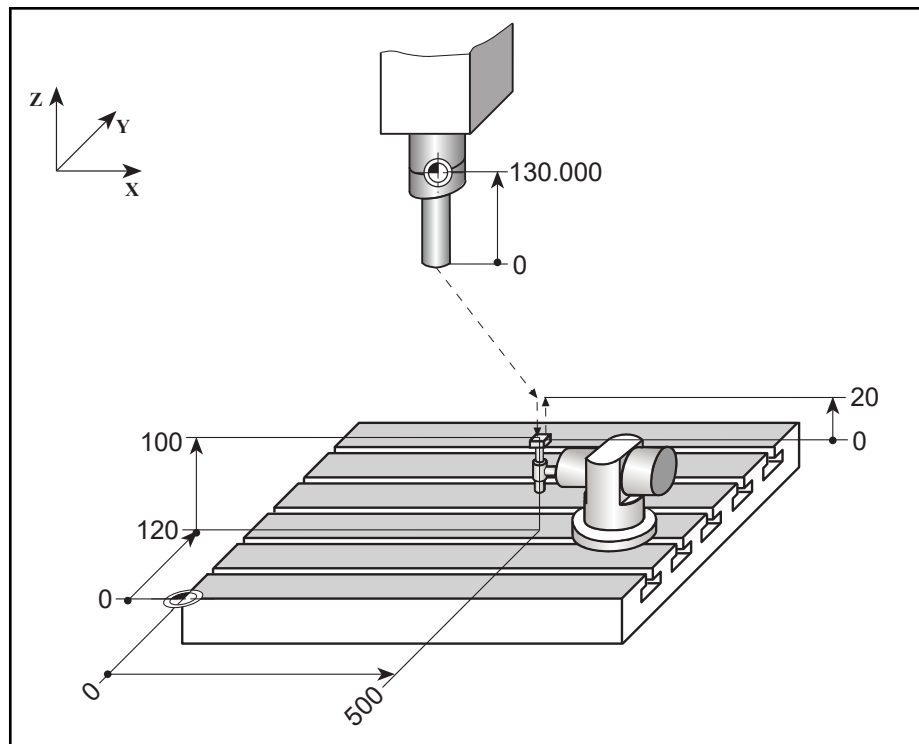
Example

Fig. 4-17: Example: Calibrate probe - Tool length
Calibration - Tool length

```

;-----
;----- Calibrating tool length with zero tool -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZP0 table
N20 T24 M6              ;load zero tool
N30 ED1 M99             ;Probe2 ON and enable edge
N40 G47 G53             ;tool length ON, enable ZP0
N50 G0 X500 Y120 Z120 M19 S=0 ;approaching
;call cycle
N60 G311 (SL 10, CAX Z, CDI -20, CFE 500, PNO 2)
N70 G0 Z100             ;retracting
;displaying measurement results on the screen
1 WAIT
2 ERG=SD.SysPrResult.CAL[2].AXIS[3].DIR[2].VAL
3 PRN#(0,"calibration value Z- : ####.####",ERG)
N80 M30

```

G315 Calibrate probe - Tool radius

Syntax G315 (CAX <cax>, CDI<cdi>, CFE<cfe>, PNO<pno>{, SL<sl>})

Brief description The "Calibrate probe - Tool radius" (G315) cycle determines the switching offset of this probe for this axis direction by sampling a tool probe with a measuring standard (zero tool).

Overview figure

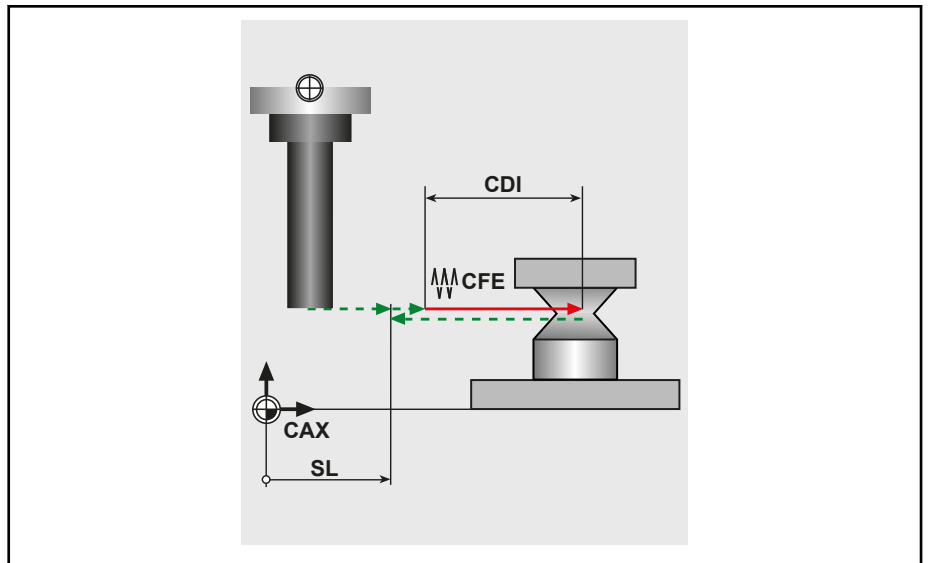


Fig. 4-18: Overview: Calibrate probe - Tool radius

Parameter

Parameter	Name	Properties	Values	Pre-assignment/range
SL	Safety level	optional	REAL	Absolute
CAX	Calibration axis	Mandatory	STRING	1..8
CDI	Calibration distance (the sign defines the calibration direction)	Mandatory	REAL	Relative
CFE	Calibration feed	Mandatory	REAL	mm/min
PNO	Probe number	Mandatory	INTEGER	1..2

Tab. 4-10: Parameter call

Result variables

[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
CALI	Calibrated	BOOL	TRUE..FALSE
VAL	Switching offset	REAL	
FEED	Calibration feed	REAL	
PRPOS	Switching position MCS	REAL	
YEAR	Year: YYYY	STRING	4
DATE	Day and month: DD:MM	STRING	5
TIME	Time: HH.MM.SS	STRING	8
RUNS	Number of measurements	INTEGER	

Tab. 4-11: Output values

Description

The G315 cycle calibrates the probe for tool radius measurement. For this purpose, a measuring standard (zero tool) with known radius is loaded. If a safety level is programmed, the zero tool moves to this absolute workpiece

Measuring cycle automatic

coordinate on the selected axis. Afterwards, the cycle positions the non-measuring axis of the level to the center of the tool probe.

If no safety level is specified, the zero tool moves immediately to the center of the tool probe on the non-measuring axis in rapid traverse. This traversing motion is not monitored. For this reason, it is always recommended to specify a safety distance to prevent a collision of the tool with the probe. Afterwards, the zero tool is monitored and moves with positioning feed up to the probe by half the calibration distance. During this, the basic offsets and cutting lengths are already taken into consideration. Afterwards, the zero tool travels over the calibration distance with calibration feed. If the probe deflects, the switching offset value, the machine coordinate (without compensation and coordinate offset), the calibration feed and the status "calibrated" are written to the system data.

The retraction motion of the measuring axis is also monitored and takes place with positioning feed. It is either moved to initial position or the position of the programmed safety level.

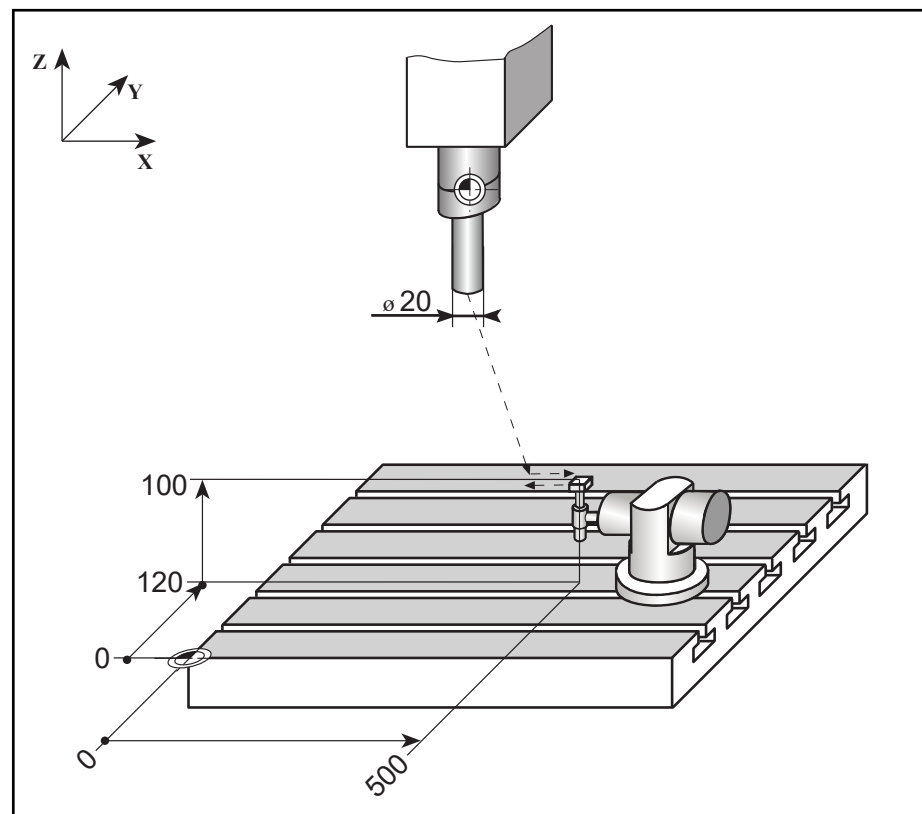
Example

Fig. 4-19: Example: Calibrate probe - Tool radius

Calibration - Tool radius

```

;----- Calibrating tool radius with zero tool -----
;
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T24 M6               ;load zero tool
N30 ED1 M99              ;Probe2 ON and enable edge
N40 G47 G53              ;tool length ON, enable ZPO
N50 G0 X400 Y120 Z90 M19 S=0 ;approaching
;call cycle
N60 G315 (SL 450, CAX X, CDI 20, CFE 500, PNO 2)
N70 G0 Z100              ;retracting
;displaying measurement results on the screen
1 WAIT
2 ERG=SD.SysPrResult.CAL[2].AXIS[1].DIR[1].VAL

```

```
3 PRN#(0,"calibration value X+ : ####.####",ERG)
N80 M30
```

4.4 Measurement

4.4.1 Tool Measurement

G301 Tool length measurement

Syntax G301 (PNO<pno>, PAX<pax>, PDI<pdi>{, SL<sl>}{, PFE<pfe>}
{, SST <sst>})

Brief description The "Probe tool length" (G301) cycle determines the respective tool length by sampling a tool probe with a tool. The resulting tool length is stored in the SysPrResult structure.

Overview figure

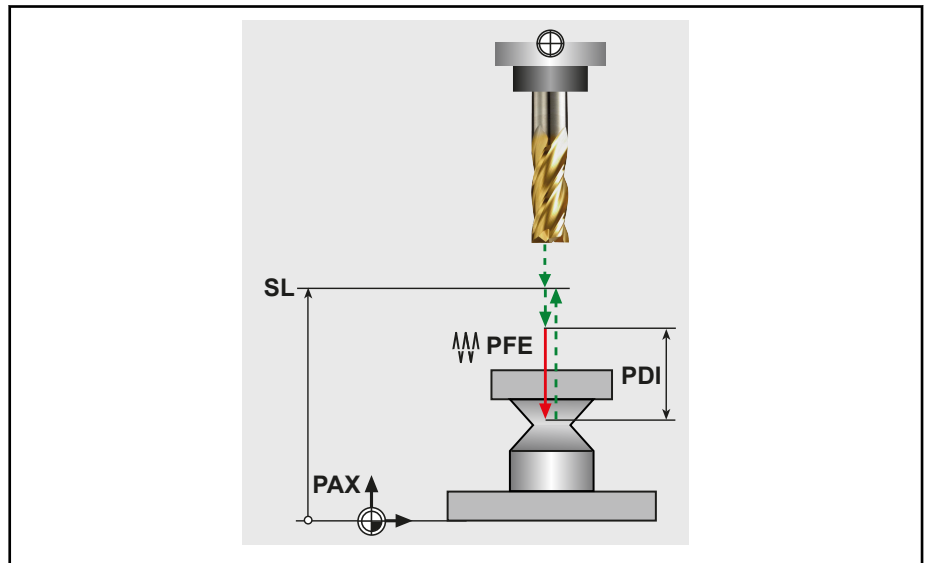


Fig. 4-20: Overview: Probe tool

Parameter

Parameter	Name	Properties	Values	Pre-assignment/range
SL	Safety level (optional)	optional	REAL	Absolute
PAX	Measuring axis	Mandatory	STRING	8
PDI	Measuring distance (the sign defines the measuring direction)	Mandatory	REAL	Relative
PFE	Measuring feed (optional)	optional	REAL	mm/min
SST	Spindle stop command	optional	STRING	4
PNO	Probe number	Mandatory	INTEGER	1..2

Tab. 4-12: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Measured value	REAL	

Tab. 4-13: Output values

Measuring cycle automatic

Description Prior to the cycle call, the respective initial position to the measuring system is to be approached as the cycle only travels in the direction of the measuring axis. If the tool is to be measured in rotating state, the spindle has to be activated first against the cutting direction. If no safety level is programmed, it is immediately positioned over the probe at the starting position of the measuring distance.

If a safety level is programmed, the tool moves to this absolute workpiece coordinate on the infeed axis in rapid traverse. During positioning over the measuring system, the basic offsets and cutting lengths are already taken into consideration. Afterwards, the measuring system is monitored and moves with positioning feed up to the measuring system by half the measuring distance. If a measuring feed is specified, the following measuring distance is traveled with it. If no measuring feed is programmed, the cycle automatically applies the respective calibration feed from the SysPrResult structure. As soon as the probe deflects, the effective length of the tool is also written to this structure and the spindle is stopped if the SST parameter was programmed.

The retracting motion of the feed axis also monitors and guides the tool with positioning feed. It is either moved to the initial position or the position of the programmed safety level.

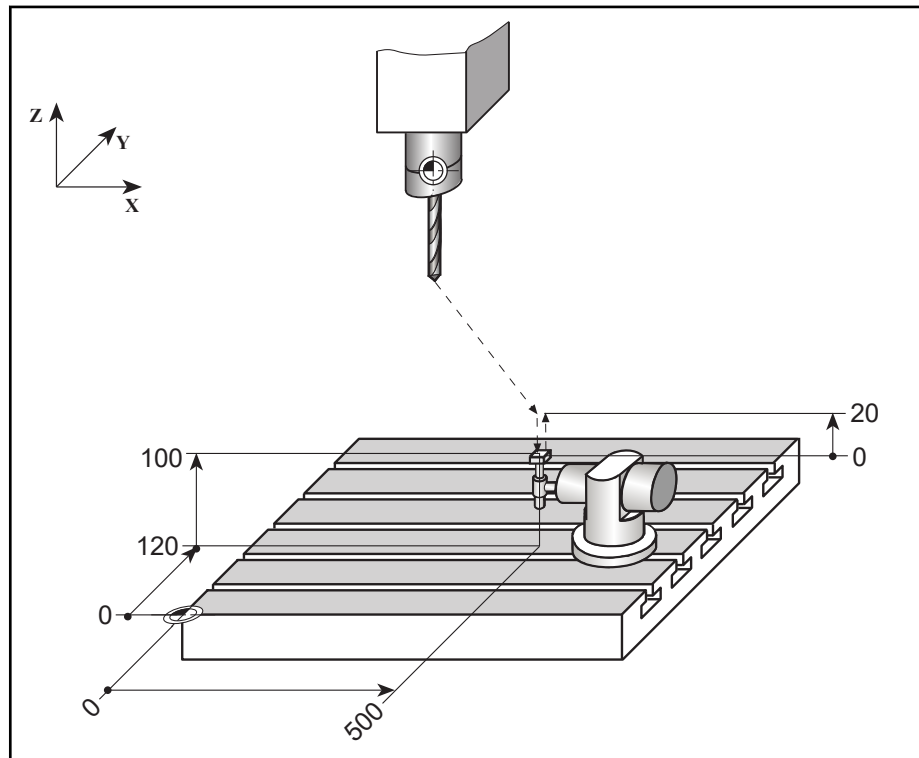
Example

Fig. 4-21: Example: Probe tool length

Probe tool length

```

;-----
;----- Probe tool length drill1 T24 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T24 M6               ;load zero tool
N30 ED1 M99              ;Probe2 ON and enable edge
N40 G47 G53              ;tool length ON, enable ZPO
N50 G0 X500 Y120 Z120 S200 M4 ;approaching
;call cycle
N60 G301 (SL20, PAX Z, PDI-20, SST M5, PNO2)
N70 G0 Z100              ;retracting

```

```

;displaying measurement results on the screen
1 WAIT
2 ERG=SD.SysPrResult.AXISRES[3]
3 PRN#(0,"calibration value Z : ####.####",ERG)
N80 M30

```

G303 Probe tool radius

Syntax G303 (PNO<pno>, PAX <pax>, PDI<pdi>{, SL<sl>}{, PFE<pfe>}{, SST <sst>})

Brief description The "Probe tool radius" (G303) cycle determines the effective tool radius by sampling a tool probe with a tool. The resulting tool radius is stored in the SysPrResult structure.

Overview figure

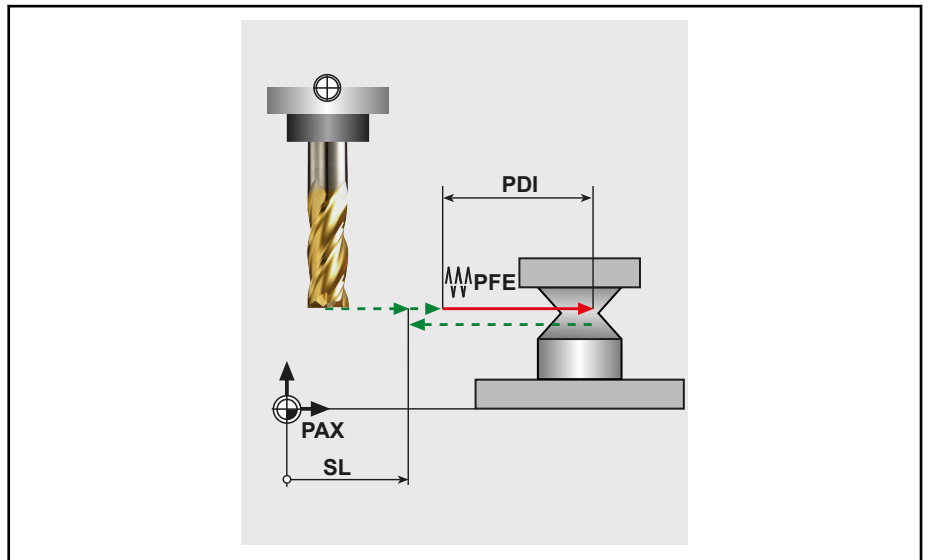


Fig. 4-22: Overview: Probe tool radius

Parameter

SL	Safety level (optional)	optional	REAL	Absolute
PAX	Measuring axis	Mandatory	STRING	8
PDI	Measuring distance (the sign defines the measuring direction)	Mandatory	REAL	Relative
PFE	Measuring feed (optional)	optional	REAL	mm/min
SST	Spindle stop command	optional	STRING	5
PNO	Probe number	Mandatory	INTEGER	1..2

Tab. 4-14: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Measured value	REAL	

Tab. 4-15: Output values

Description

The cycle G303 determines the effective radius of a tool in the spindle. If the tool is to be measured in rotating state, the spindle has to be activated first against the cutting direction. If a safety level is programmed, the tool moves to this absolute workpiece coordinate on the selected axis.

Measuring cycle automatic

Subsequently, the cycle positions the non-measuring axis of the level to the center of the tool probe. If no safety level is programmed, the tool moves immediately to the center of the tool probe on the non-measuring axis in rapid traverse. This traversing motion is not monitored, thus, it is always recommended to specify a safety level to prevent a collision of the tool with the probe. Afterwards, the tool is monitored and moves with positioning feed up to the probe by half the measuring distance. During this, the basic offsets and cutting lengths are already taken into consideration. If a measuring feed is specified, the following measuring distance is traveled with it. If no measuring feed is programmed, the cycle automatically applies the respective calibration feed from the SysPrResult structure. As soon as the probe deflects, the effective radius of the tool is also written to the SysPrResult structure and the spindle is stopped if the SST parameter was programmed.

The retraction motion of the measuring axis is also monitored and takes place with positioning feed. It is either moved to the initial position or to the safety level.

Example

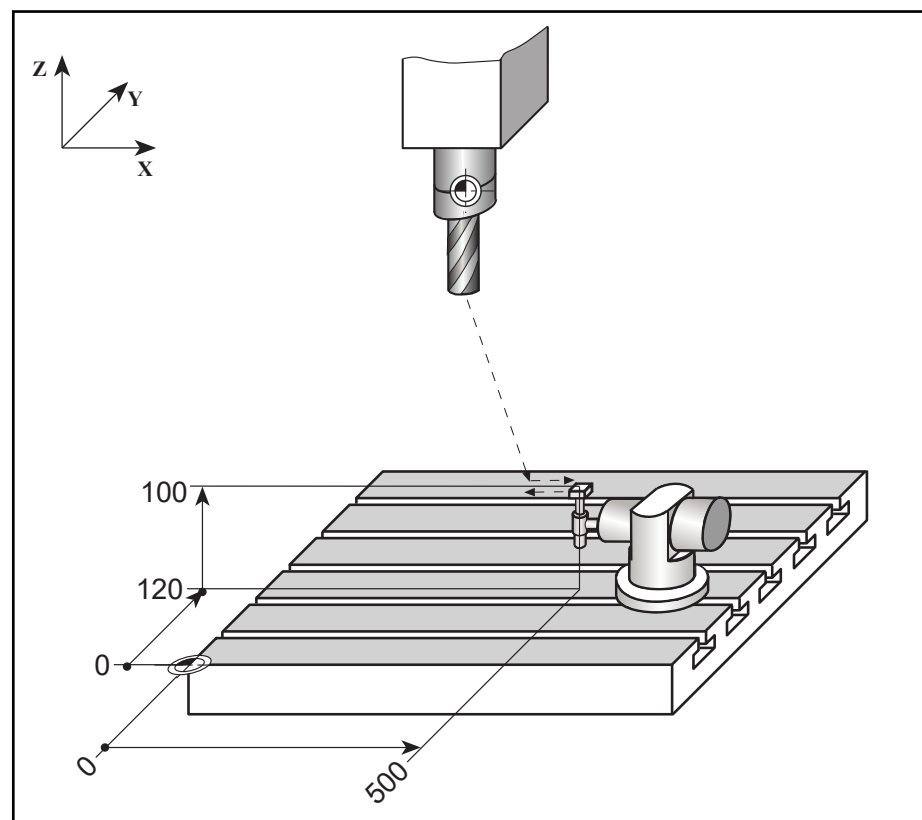


Fig. 4-23: Example: Probe tool radius

Probe tool radius

```

;-----
;----- Probe tool radius milling cutter D20 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T24 M6               ;load zero tool
N30 ED1 M99              ;Probe2 ON and enable edge
N40 G47 G53              ;tool length ON, enable ZPO
N50 G0 X450 Y120 S200 M4 ;approaching
;call cycle
N60 G303 (SL450, PAX X, PDI10, SST M5, PNO2)
N70 G0 Z100              ;retracting
;displaying measurement results on the screen
1 WAIT
2 ERG=SD.SysPrResult.AXISRES[1]

```

```
3 PRN#(0,"Tool radius: ####.####",ERG)
N80 M30
```

4.4.2 Probe Workpiece

G321 Probe point

- Syntax** G321 (PNO<pno>, IAX <iax>, PLE<ple>, PAX <pax>, PDI<pdi>,), PPO<ppo>{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})
- Brief description** With the "Probe point" (G321) cycle, any point of the workpiece can be measured, i.e. its coordinates determined. The measurement results are stored in the system data elements SD.SysPrResult.RESULT[1..2] and the output variable "RUNS" is increased by value 1.

Overview

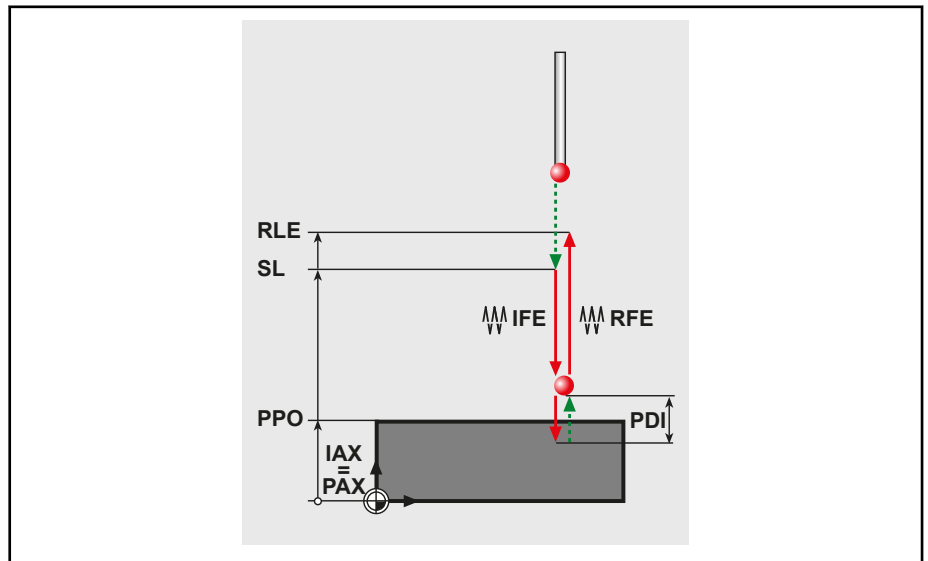


Fig. 4-24: Overview: Probe point with measuring axis equal to infeed axis

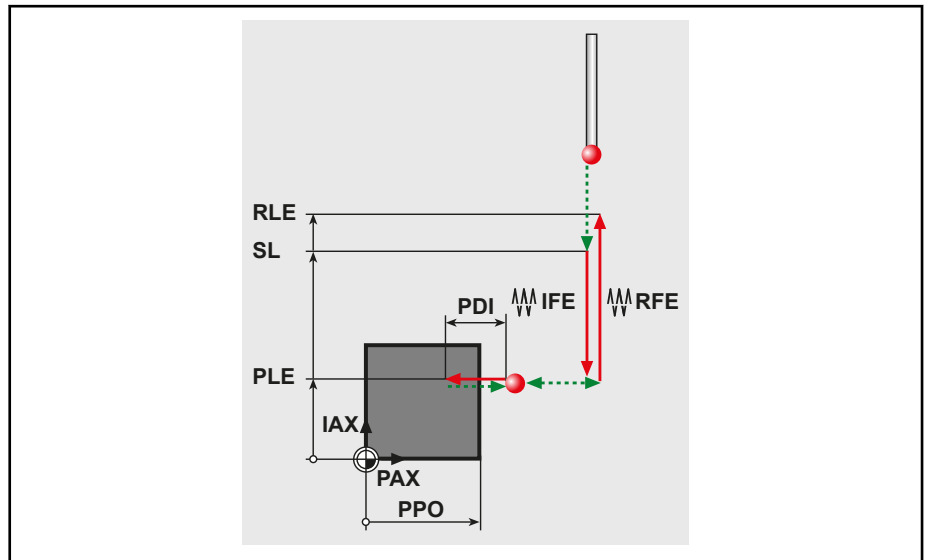


Fig. 4-25: Overview: Probe point with measuring axis unequal to infeed axis

Measuring cycle automatic

Parameter

Parameter	Name	Properties		Values	Pre-assignment/Range
PNO	Probe number	Mandatory		INTEGER	1..2
IAX	Infeed axis	Mandatory		STRING	8
SL	Safety level	optional		REAL	Absolute
IFE	Infeed feed	optional		REAL	mm/min
PLE	Measuring height	Mandatory	If infeed axis unequal to measuring axis	REAL	Absolute
		optional	If infeed axis equal to measuring axis		
RLE	Retraction height	optional		REAL	Absolute
RFE	Retraction feed	optional		REAL	mm/min
PDI	Measuring distance	Mandatory		REAL	Relative
PFE	Measuring feed	optional		REAL	mm/min
PAX	Measuring axis	Mandatory		STRING	8
PPO	Measuring position	Mandatory		REAL	Absolute

Tab. 4-16: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-17: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RESULT[1]	Measured value	REAL	double precision
SD.SysPrResult.RESULT[2]	Position difference	REAL	double precision
#RESULT1	Measured value	REAL	single precision
#RESULT2	Position difference	REAL	single precision

Tab. 4-18: Output values 1

[n] 1..2 Probe number
[i] 1..3 Axis number

[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-19: Output values 2

Description

The cycle enables to include a workpiece coordinate point with the probe system. Prior to calling, a suitable initial position is to be approached, particularly on axes other than the infeed or measuring axis. If no safety level is specified, the infeed takes place with rapid traverse on the measuring height or, if infeed axis and measuring axis are equal, directly to the starting point of the measuring distance. If a safety level is specified, the probe is first positioned in the safety level in rapid traverse. Afterwards, the probe moves to measuring height with G1 and the infeed feed to enable plunging at reduced velocity.

Then, the actual measuring process takes place. If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables "measured value" (SD.SysPrResult.RESULT[1]), the "Position difference" (SD.SysPrResult.RESULT[2]) is written and the variable "Number of measurements" (RUNS) is increased by value 1 in the SysPrResult structure. Afterwards, the probe is repositioned at the initial position.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

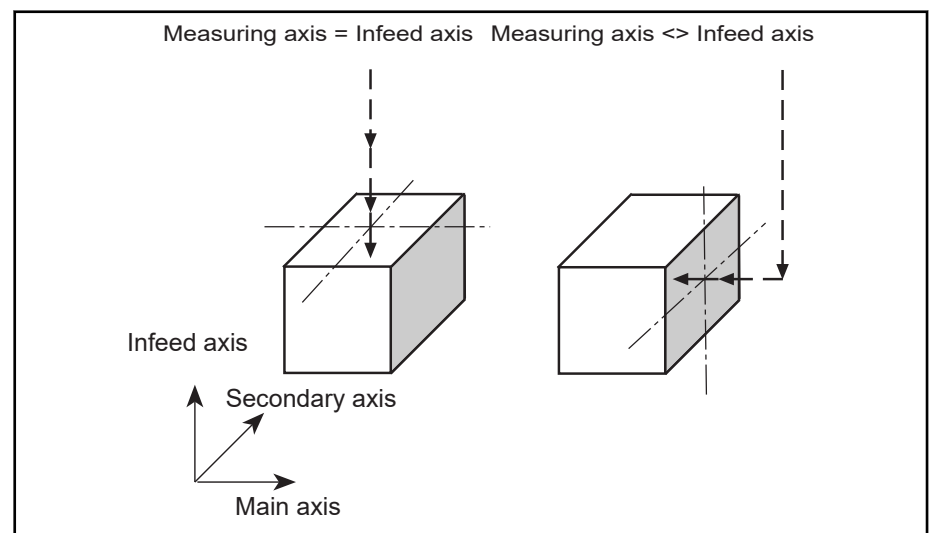
Procedure/processing

Fig. 4-26: Traversing motion: Probe point

Measuring cycle automatic

Example

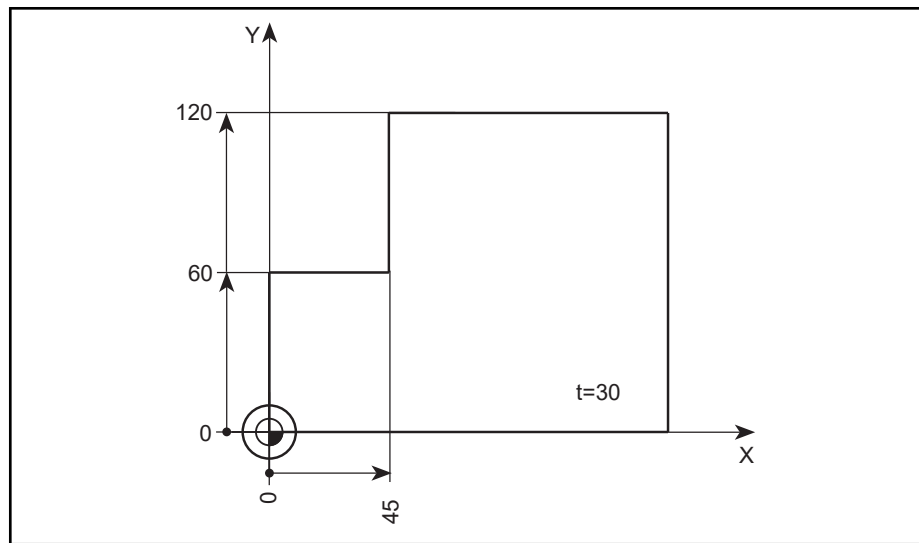


Fig. 4-27: Example: Probe point

Probe point

```

;-----
;----- Probe point -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load zero tool
N30 ED1 M97              ;Probel ON and enable edge
N40 G47 G54 G0 X20 Y75 Z50 M19 S0 ;enable tool length and ZPO
;call cycle
N50 G321 (PNO1, IAX Z, SL10, IFE3500, PLE-10,PDI5, PFE500,PAX X,
      PPO45)
;displaying measurement results on the screen
1 PRN#(0,"Measured value : ####.##", SD.SysPrResult.RESULT[1])
2 PRN#(0,"Diff. : ####.##", SD.SysPrResult.RESULT[2])
N60 X-100 Y100 Z100 ;retracting
N70 M30

```

Program:

G323 Check workpiece availability

Syntax G323 (PNO<pno>, IAX <iax>, PLE<ple>, PAX <pax>, PDI<pdi>, PPO<ppo>, {, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description The "Check workpiece availability" (G323) cycle enables checking whether a part is clamped or a hole or other properties are available. The test result is stored in the system date SD.SysPrResult.RESB. If a part was detected, the measuring results are available in the data elements SD.SysPrResult.RESULT[1..2] for further processing.

Overview figure

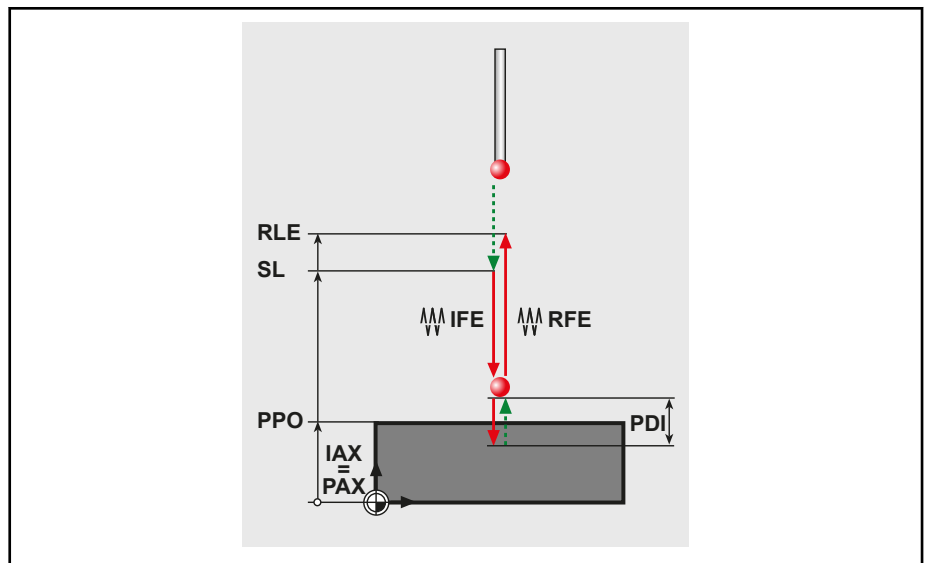


Fig. 4-28: Overview: Check workpiece availability with test axis equal to infeed axis

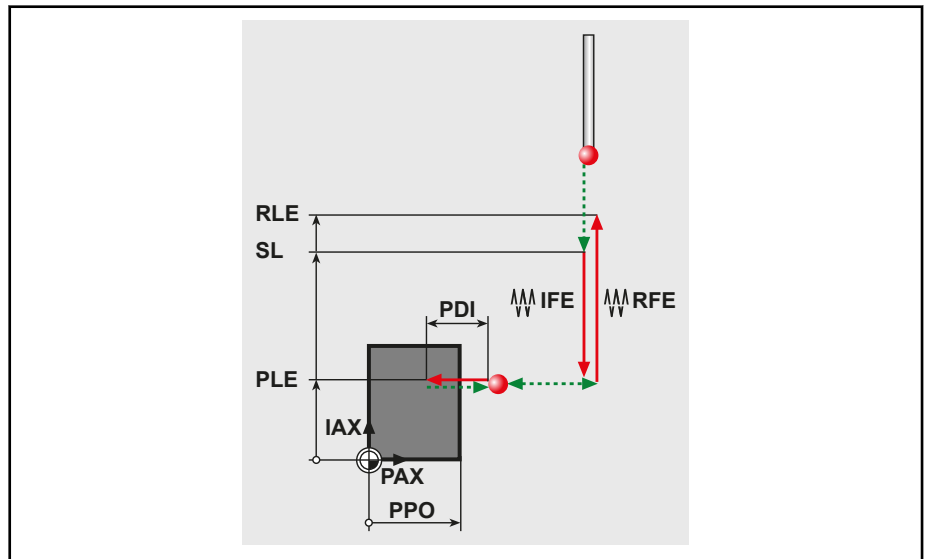


Fig. 4-29: Overview: Check workpiece availability with test axis unequal to infeed axis

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety level	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	mm/min
PLE	Test height	Mandatory if infeed axis unequal to measuring axis	REAL	Absolute

Measuring cycle automatic

Parameter	Name	Properties		Values	Pre-assignment/Range
		optional	if infeed axis equal to measuring axis		
RLE	Retraction height	optional		REAL	Absolute
RFE	Retraction feed	optional		REAL	mm/min
PDI	Test distance	Mandatory		REAL	Relative
PFE	Test feed	optional		REAL	mm/min
PAX	Test axis name	Mandatory		STRING	8
PPO	Test position	Mandatory		REAL	Absolute

Tab. 4-20: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-21: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RESULTB	Part available	BOOL	TRUE..FALSE
SD.SysPrResult.RESULT[1]	Measured value	REAL	double precision
SD.SysPrResult.RESULT[2]	Position difference	REAL	double precision
#RESULT?	Part available	BOOL	TRUE..FALSE
#RESULT1	Measured value	REAL	single precision
#RESULT2	Position difference	REAL	single precision

Tab. 4-22: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-23: Output values 2

Description Prior to calling, a suitable initial position is to be approached, particularly on axes other than the infeed or test axis. If no safety level is specified, the infeed takes place with rapid traverse on the test height or, if infeed axis and test axis are equal, directly to the starting point of the test distance. If a safety level is specified, the probe is first positioned in the safety level in rapid traverse. Afterwards, the probe moves to test height with G1 and the infeed feed to enable plunging at reduced velocity.

Then, the actual test/measuring process takes place. If no test feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULTB to SD.SysPrResult.RESULT[2] are written and the variable "Number of measurements" (RUNS) is increased by value 1 in the SysPrResult structure. The probe returns to the initial position.

At the cycle end, the infeed axis is retracted. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Example

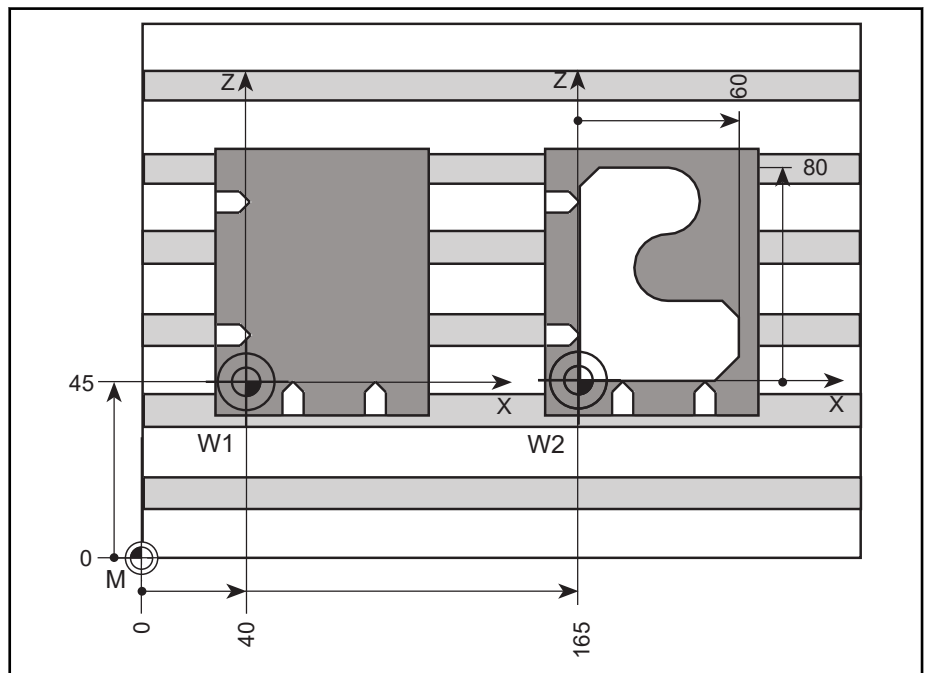


Fig. 4-30: Example: Check workpiece availability

Check workpiece availability

```

;-----
;----- Check if workpiece is available -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load tool
N30 ED1 M97              ;Probel ON and enable edge
N40 G47 G54 G0 X30 Y10 Z150 M19 S0 ;enable tool length and ZPO
;Clamping device1 G54 Check if workpiece is available
;call cycle
N60 G323(PNO1, IAX Z, PDI80,PAX Z, PPO0)
;Display test result G54 on screen
1 IF SD.SysPrResult.RESULTB THEN PRN#(0,"Zero point 1 Workpiece detected")
1 ELSE PRN#(0,"Zero point 1 - No workpiece detected") ENDIF
N70 G0 Z150              ;retracting in Z
;Clamping device 2 G55 Check if workpiece is available

```

Measuring cycle automatic

```

N80 G55 X30 Y10           ;Positioning at 2. device
;call cycle
N100 G323(PNO1, IAX Z, PDI80,PAX Z,PP00)
N110 G0 Z150             ;retracting in Z
;Display test result G55 on screen
2 IF SD.SysPrResult.RESULTB THEN PRN#(0,"Zero point 2 Workpiece detected")
2 ELSE PRN#(0,"Zero point 2 - No workpiece detected") ENDIF
N120 Z150                ;retracting in Z
N130 M30

```

Program:

G324 Probe boring

Syntax G324 (PNO<pno>, IAX <iax>, PLE<ple>, PDI<pdi>,
PA1 <pa1>, PA2 <pa2>, CA1<ca1>, CA2<ca2>, BDI<bdi>
{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description The "Probe boring" (G324) cycle measures a boring parallel to the axis by determining the diameter and center. The measurement results are provided in the system data elements SD.SysPrResult.RESULT[1..9] and the output variable "RUNS" is increased by value 4.

Overview figure

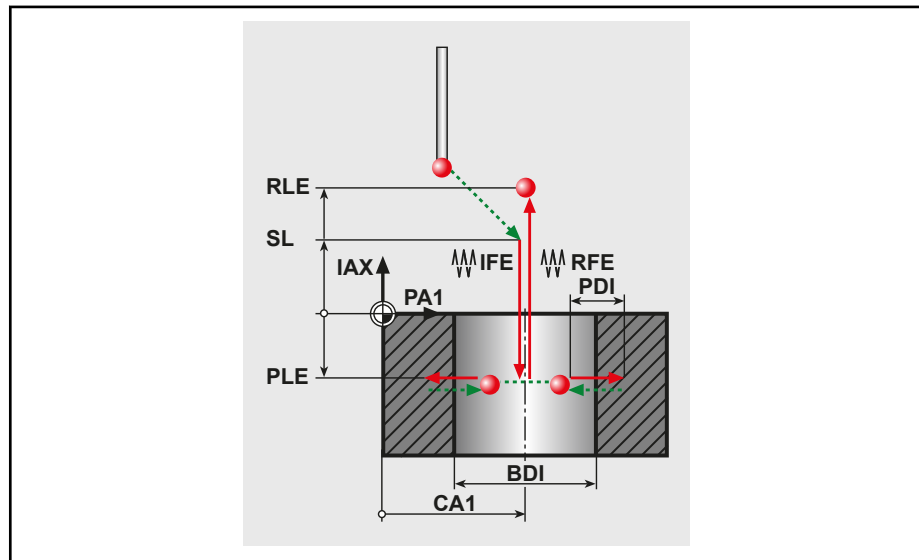


Fig. 4-31: Overview: Probe boring (infeed)

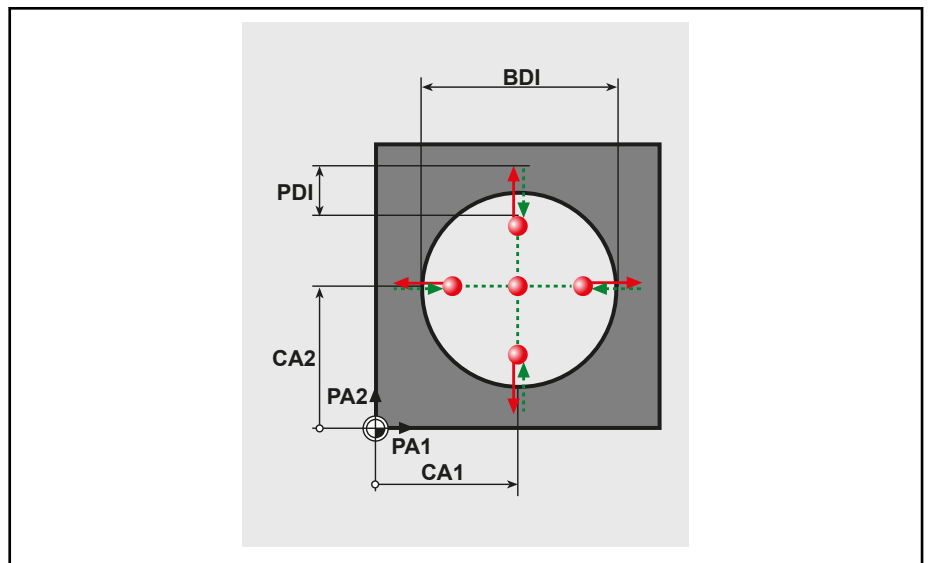


Fig. 4-32: Overview: Probe boring (measuring level)

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety level	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
PLE	Measuring height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative
PFE	Measuring feed	optional	REAL	mm/min
PA1	Measuring axis 1 (main axis)	Mandatory	STRING	8
PA2	Measuring axis 2 (secondary axis)	Mandatory	STRING	8
CA1	Center point of first measuring axis	Mandatory	REAL	Absolute
CA2	Center point of second measuring axis	Mandatory	REAL	Absolute
BDI	Diameter	Mandatory	REAL	

Tab. 4-24: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-25: Runtime variable

Measuring cycle automatic

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Position measuring axis 1 positive	REAL	double precision
SD.SysPrResult.RE-SULT[2]	Position measuring axis 1 negative	REAL	double precision
SD.SysPrResult.RE-SULT[3]	Position of measuring axis 2 positive	REAL	double precision
SD.SysPrResult.RE-SULT[4]	Position of measuring axis 2 negative	REAL	double precision
SD.SysPrResult.RE-SULT[5]	Center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[6]	Center point of measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[7]	Difference center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[8]	Difference center point to measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[9]	Boring diameter	REAL	double precision
#RESULT1	Position measuring axis 1 positive	REAL	single precision
#RESULT2	Position measuring axis 1 negative	REAL	single precision
#RESULT3	Position of measuring axis 2 positive	REAL	single precision
#RESULT4	Position of measuring axis 2 negative	REAL	single precision
#RESULT5	Center of measuring axis 1	REAL	single precision
#RESULT6	Center point of measuring axis 2	REAL	single precision

#RESULT7	Difference center of measuring axis 1	REAL	single precision
#RESULT8	Difference center point to measuring axis 2	REAL	single precision
#RESULT9	Boring diameter	REAL	single precision

Tab. 4-26: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-27: Output values 2

Description

If no safety level is programmed, the infeed takes place in rapid traverse on measuring height. If a safety level is specified, the probe is first positioned in the safety level in rapid traverse. Afterwards, the probe moves to measuring height with G1 and the infeed feed to enable plunging at reduced velocity. The measuring process is now traveled by the basic cycle for each axis and direction. Afterwards, the probe is repositioned at the center of the boring.

Then, measuring takes place by means of four axis-parallel measuring steps. If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..9] are written and the variable "Number of measurements" (RUNS) is increased by value 4 in the SysPrResult structure.

At the cycle end, the infeed axis is retracted. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Measuring cycle automatic

Example

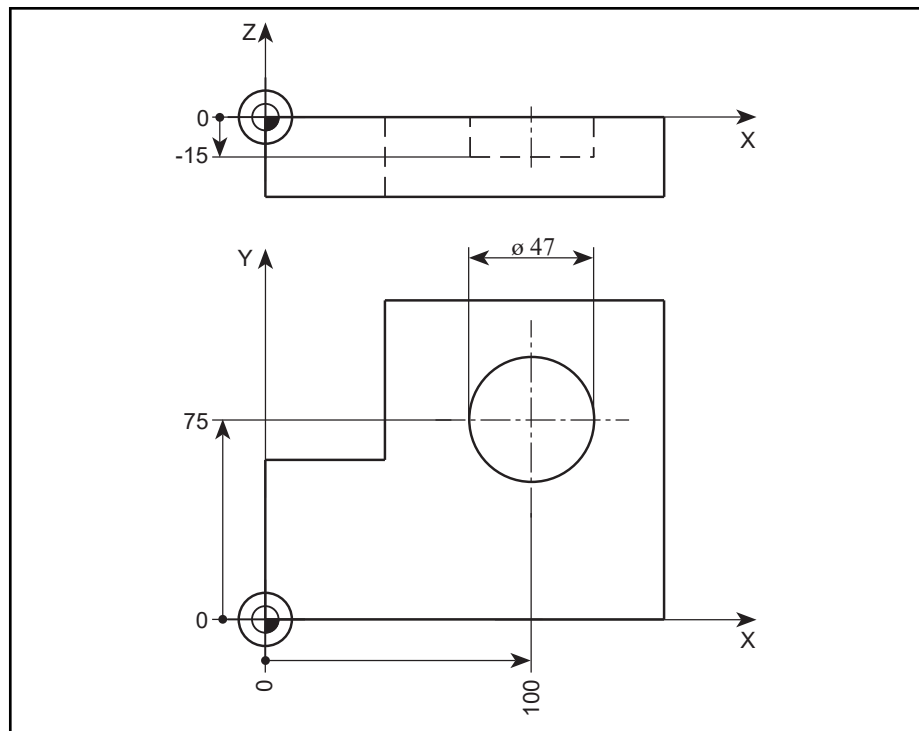


Fig. 4-33: Example: Probe boring
Probe boring

```

;-----
;----- Probe boring D47 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load tool
N30 ED1 M97              ;Probel ON and enable edge
N40 G47 G54 X100 Y75 Z20 ;enable tool length and ZPO
;call cycle
N50 G324 (PNO1,IAX Z, SL20, IFE5000, PLE-10, PDI6, PA1 X, PA2 Y,
  CA1 100,CA2 75, BDI47)
;displaying measurement results on the screen
1 PRN#(0,"Measured value X+ : ####.##",SD.SysPrResult.RESULT[1])
2 PRN#(0,"Measured value X- : ####.##",SD.SysPrResult.RESULT[2])
3 PRN#(0,"Measured value Y+ : ####.##",SD.SysPrResult.RESULT[3])
4 PRN#(0,"Measured value Y- : ####.##",SD.SysPrResult.RESULT[4])
5 PRN#(0,"Center point X: ####.##",SD.SysPrResult.RESULT[5])
6 PRN#(0,"Center point Y: ####.##",SD.SysPrResult.RESULT[6])
7 PRN#(0,"Difference X: ####.##",SD.SysPrResult.RESULT[7])
8 PRN#(0,"Difference Y: ####.##",SD.SysPrResult.RESULT[8])
9 PRN#(0,"Diameter : ####.##",SD.SysPrResult.RESULT[9])
N60 G0 Z100 ;retracting
N70 M30

```

G327 Probe spigot

Syntax G327 (PNO<pno>, IAX <iax>, PLE<ple>, PDI<pdi>, PA1 <pa1>, PA2 <pa2>, CA1<ca1>, CA2<ca2>, DIA<dia> {, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description The "Probe spigot" (G327) cycle measures a spigot in parallel to the axis by determining the diameter and the center of the spigot. The measurement results are stored in the system data elements SD.SysPrResult[1..9] and the output variable "RUNS" is increased by a value of 4.

Overview figure

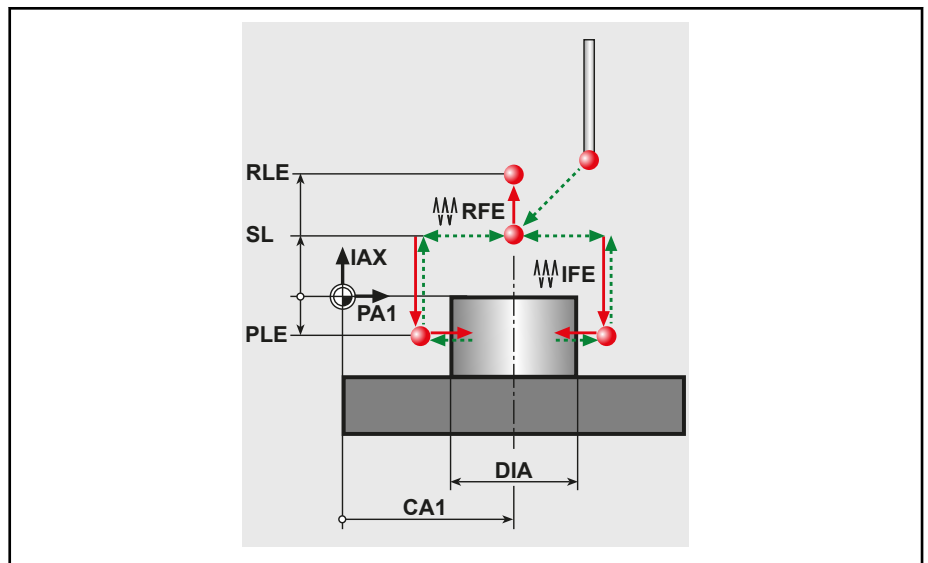


Fig. 4-34: Overview: Probe spigot (infeed)

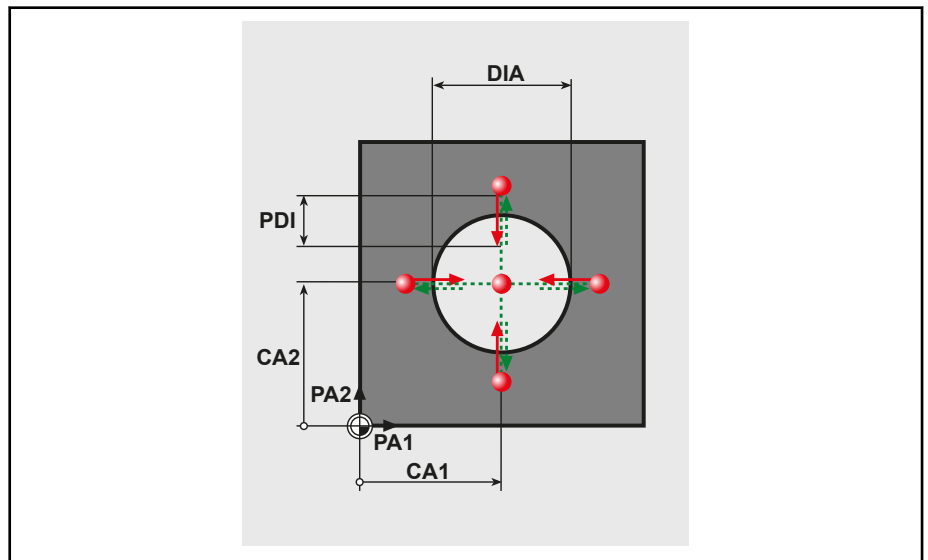


Fig. 4-35: Overview: Probe spigot (measuring level)

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety distance	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
PLE	Measuring height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative
PFE	Measuring feed	optional	REAL	mm/min

Measuring cycle automatic

Parameter	Name	Properties	Values	Pre-assignment/Range
PA1	Measuring axis 1 (main axis)	Mandatory	STRING	8
PA2	Measuring axis 2 (secondary axis)	Mandatory	STRING	8
CA1	Center point of first measuring axis	Mandatory	REAL	Absolute
CA2	Center point of second measuring axis	Mandatory	REAL	Absolute
DIA	Diameter	Mandatory	REAL	

Tab. 4-28: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-29: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Position measuring axis 1 positive	REAL	double precision
SD.SysPrResult.RE-SULT[2]	Position measuring axis 1 negative	REAL	double precision
SD.SysPrResult.RE-SULT[3]	Position of measuring axis 2 positive	REAL	double precision
SD.SysPrResult.RE-SULT[4]	Position of measuring axis 2 negative	REAL	double precision
SD.SysPrResult.RE-SULT[5]	Center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[6]	Center point of measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[7]	Difference center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[8]	Difference center point to measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[9]	Spigot diameter	REAL	double precision

#RESULT1	Position measuring axis 1 positive	REAL	single precision
#RESULT2	Position measuring axis 1 negative	REAL	single precision
#RESULT3	Position of measuring axis 2 positive	REAL	single precision
#RESULT4	Position of measuring axis 2 negative	REAL	single precision
#RESULT5	Center of measuring axis 1	REAL	single precision
#RESULT6	Center point of measuring axis 2	REAL	single precision
#RESULT7	Difference center of measuring axis 1	REAL	single precision
#RESULT8	Difference center point to measuring axis 2	REAL	single precision
#RESULT9	Spigot diameter	REAL	single precision

Tab. 4-30: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-31: Output values 2

Description

If no safety level is programmed, positioning takes place to the center in rapid traverse on the measuring axis. If a safety level is specified, the probe is first positioned there in rapid traverse over the spigot center.

Afterwards, the probe moves to measuring height during every measuring step for each axis and direction with G1 and the infeed feed to enable plunging at reduced velocity. Now, the actual measuring takes place before the probe is positioned over the center of the spigot.

If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..9] are written and the variable

Measuring cycle automatic

"Number of measurements" (RUNS) is increased by value 4 in the SysPrResult structure.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

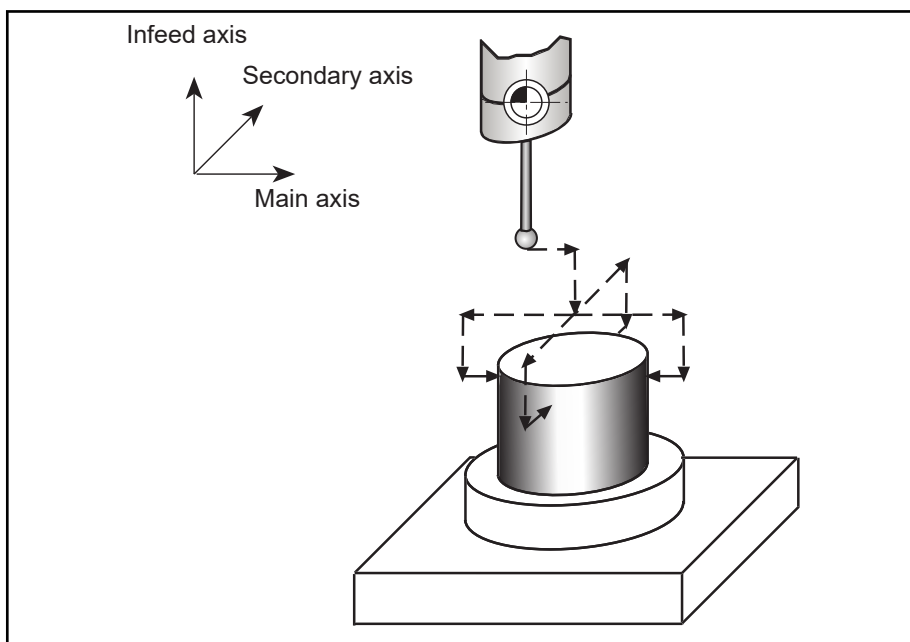


Fig. 4-36: Traversing motion: Probe spigot

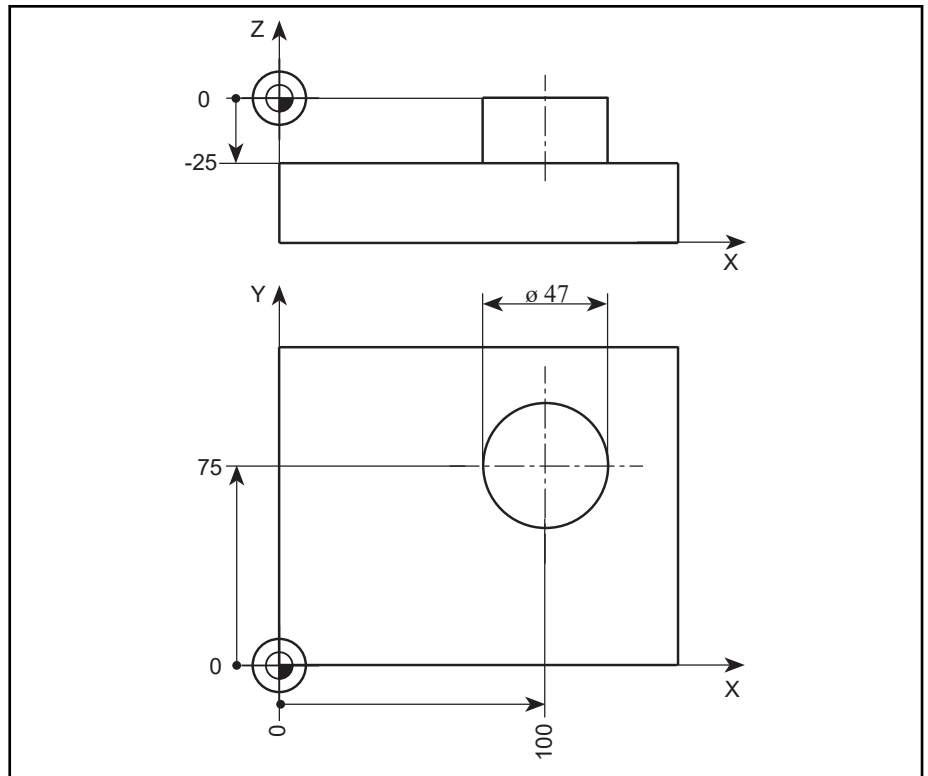
Example

Fig. 4-37: Example: Probe spigot

Probe spigot

```

;-----
;----- Probe spigot D47 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6             ;load tool
N30 ED1 M97             ;Probel ON and enable edge
N40 M19 S=0
N50 G47 G54 X0 Y0 Z150 ;enable tool length and ZPO
;call cycle
N60 G327 (PNO1, IAX Z, SL20, IFE1500, PLE-10, PDI10, PA1 X, PA2 Y,
  CA1 100,CA2 75, DIA47)
;displaying measurement results on the screen
1 PRN#(0,"Measured value X+ : ####.##",SD.SysPrResult.RESULT[1])
2 PRN#(0,"Measured value X- : ####.##",SD.SysPrResult.RESULT[2])
3 PRN#(0,"Measured value Y+ : ####.##",SD.SysPrResult.RESULT[3])
4 PRN#(0,"Measured value Y- : ####.##",SD.SysPrResult.RESULT[4])
5 PRN#(0,"Center point X: ####.##",SD.SysPrResult.RESULT[5])
6 PRN#(0,"Center point Y: ####.##",SD.SysPrResult.RESULT[6])
7 PRN#(0,"Difference X: ####.##",SD.SysPrResult.RESULT[7])
8 PRN#(0,"Difference Y: ####.##",SD.SysPrResult.RESULT[8])
9 PRN#(0,"Diameter: ####.##",SD.SysPrResult.RESULT[9])
N70 G0 Z100 ;retracting
N80 M30

```

G328 Probe ball**Syntax** G328 (PNO<pno>, PDI<pdi>, R <r>

PA1 <pa1>, PA2 <pa2>, PA3 <pa3>, CA1<ca1>, CA2<ca2>, CA3 <ca3>
 {, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description

Use the cycle "Probe ball" (G328), the center point of a ball with known radius is determined using axis-parallel measurement. The measurement results are provided in the system data elements SD.SysPrResult[1..6] and the output variable "RUNS" is increased by value 5.

Overview figure

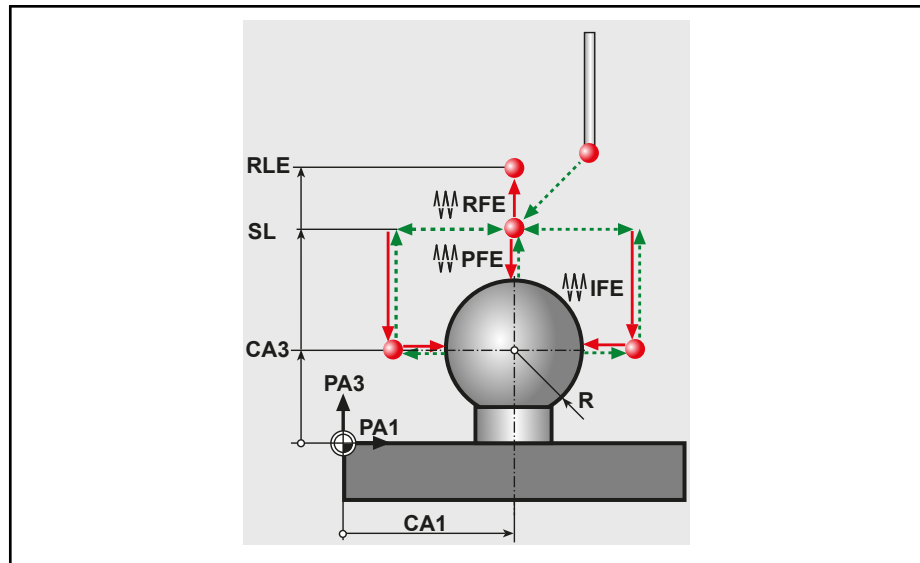


Fig. 4-38: Overview Ball head measuring (infeed)

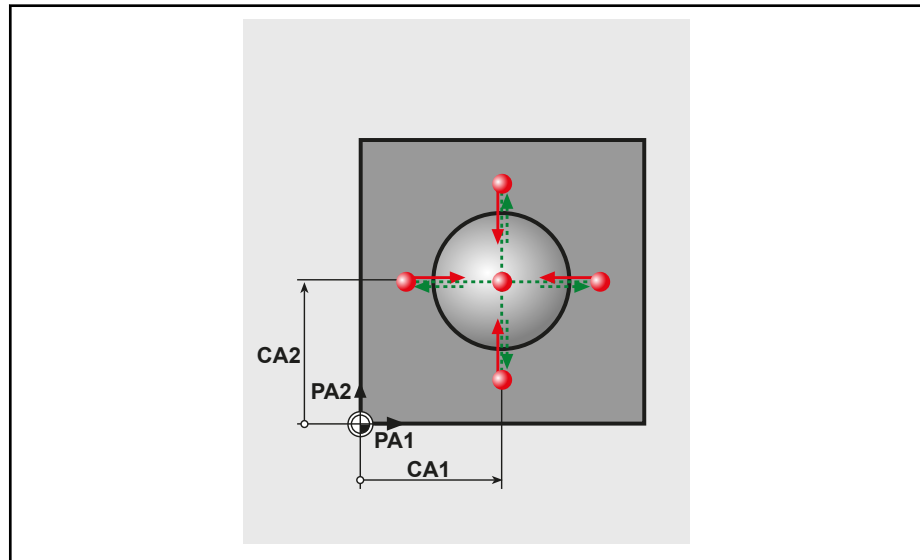


Fig. 4-39: Overview figure Probe ball (axes 1 and 2)

Parameter

PNO	Probe number	Mandatory	INTEGER	1..2
SL	Safety distance	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative
PFE	Measuring feed	optional	REAL	mm/min
R	Ball radius	Mandatory	REAL	>0
PA1	Measuring axis 1 (main axis)	Mandatory	STRING	8
PA2	Measuring axis 2 (secondary axis)	Mandatory	STRING	8

PA3	Measuring axis 3 (feed axis)	Mandatory	STRING	8
CA1	Center point of first measuring axis	Mandatory	REAL	Absolute
CA2	Center point of second measuring axis	Mandatory	REAL	Absolute
CA3	Center point of third measuring axis	Mandatory	REAL	Absolute

Tab. 4-32: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-33: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[2]	Center point of measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[3]	Center point of measuring axis 3	REAL	double precision
SD.SysPrResult.RE-SULT[4]	Difference center of measuring axis 1	REAL	double precision
SD.SysPrResult.RE-SULT[5]	Difference center point to measuring axis 2	REAL	double precision
SD.SysPrResult.RE-SULT[6]	Difference center point to measuring axis 3	REAL	double precision
#RESULT1	Center point of measuring axis 1	REAL	single precision
#RESULT2	Center point of measuring axis 2	REAL	single precision
#RESULT3	Center point of measuring axis 3	REAL	single precision
#RESULT4	Difference center of measuring axis 1	REAL	single precision

Measuring cycle automatic

#RESULT5	Difference center point to measuring axis 2	REAL	single precision
#RESULT6	Difference center point to measuring axis 3	REAL	single precision

Tab. 4-34: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-35: Output values 2

Description If no safety level is programmed, positioning takes place to the center on the measuring axes 1 and 2 in rapid traverse. If a safety level is specified, the probe is first positioned in the three axes in rapid traverse. The target position of axis 3 is parameter SL.

Subsequently, the probe travels in each of the four following measuring steps in axis 1 or 2 in any direction radially outside the ball with G1. Then, the probe travels to the ball center with axis 3 at infeed feed. The actual measurement with axis 1 or 2 takes place and the probe is positioned back to the first position in the cycle.

During the fifth and last step during measurement, the ball pole is probed in infeed direction using axis 3. The fifth sign of the measuring distance PDI determines the starting position of measurement and the direction of measurement.

If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..6] are written and the variable "Number of measurements" (RUNS) is increased by value 5 in the SysPrResult structure.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

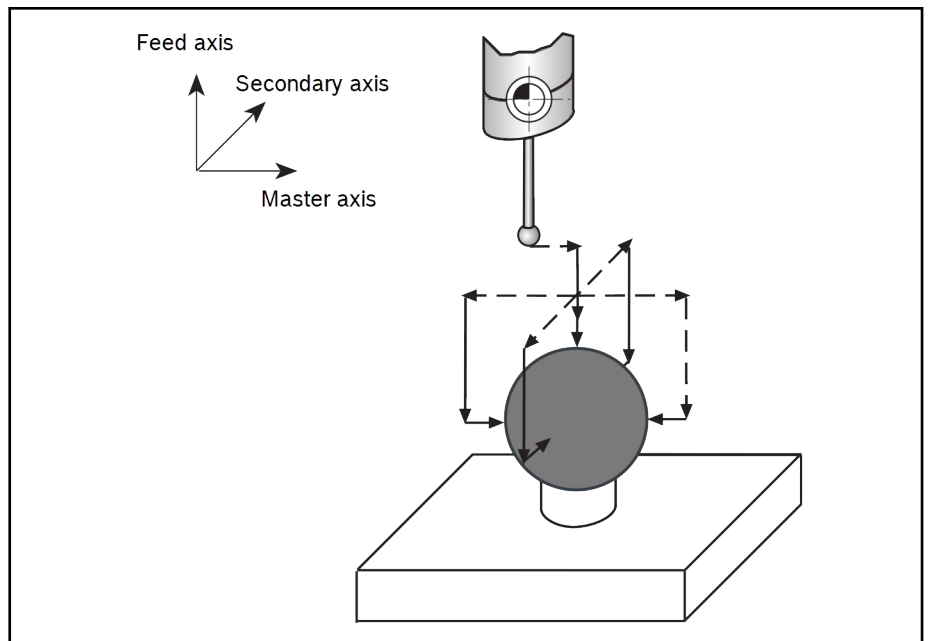
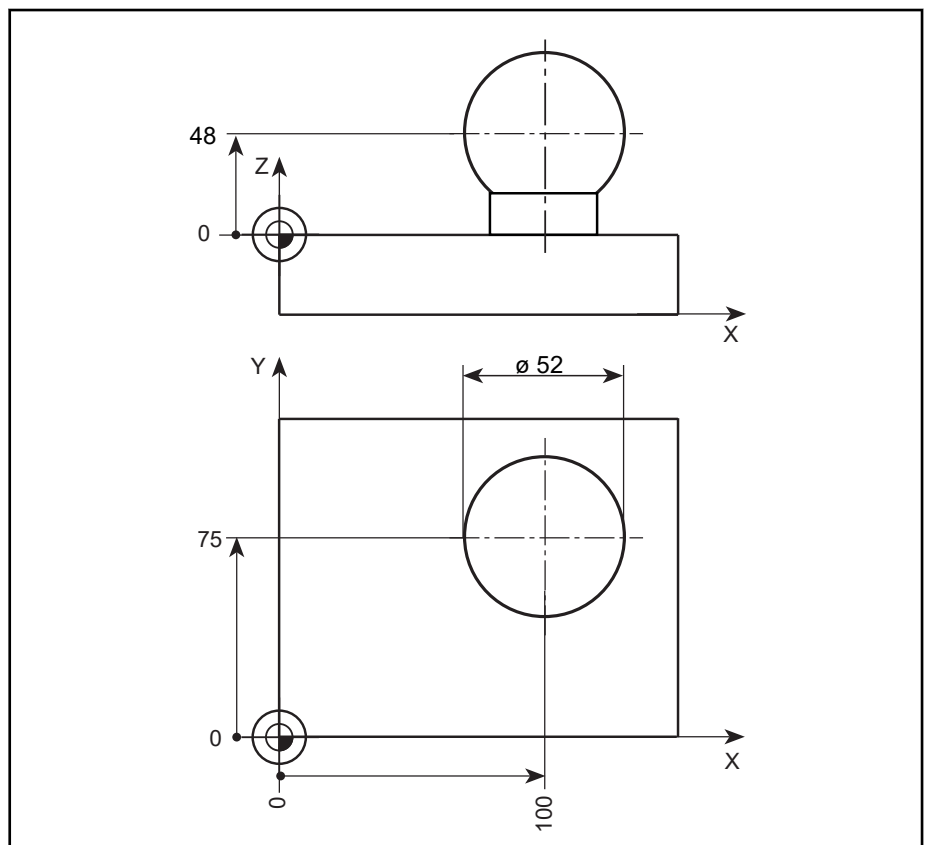


Fig. 4-40: Travel motions during probe ball

Example

Fig. 4-41: Example Probe ball
Probe ball

```

;-----
;----- Probe Ball D52 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6             ;load tool
N30 ED1 M97             ;Probe1 ON and enable edge

```

Measuring cycle automatic

```

N40 M19 S=0
N50 G0 G47 G54 X0 Y0 Z150 ;enable tool length and ZPO
;call cycle
N60 G328 (PNO1, SL85, IFE1500, PDI-12, R26,
        PA1 X, CA1 100, PA2 Y, CA2 75, PA3 Z, CA3 48)
;displaying measurement results on the screen
1 PRN#(0,"Measured center X: ####.##",SD.SysPrResult.RESULT[1])
2 PRN#(0,"Measured center Y: ####.##",SD.SysPrResult.RESULT[2])
3 PRN#(0,"Measured center Z: ####.##",SD.SysPrResult.RESULT[3])
4 PRN#(0,"Difference X: ####.##",SD.SysPrResult.RESULT[4])
5 PRN#(0,"Difference Y: ####.##",SD.SysPrResult.RESULT[5])
6 PRN#(0,"Difference Z: ####.##",SD.SysPrResult.RESULT[6])
N70 G0 Z150 ;retracting
N80 M30

```

G329 Probe land

Syntax G329 (PNO<pno>, IAX <iax>, PLE<ple>, PDI<pdi>, PAX<pax>, NCE<nce>, , NWI<nwi>{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description The "Probe land" (G329) cycle measures a land in parallel to the axis by determining its width and center. The measurement results are provided in the system data elements SD.SysPrResult.RESULT[1..5] and the output variable "RUNS" is increased by value 2.

Overview

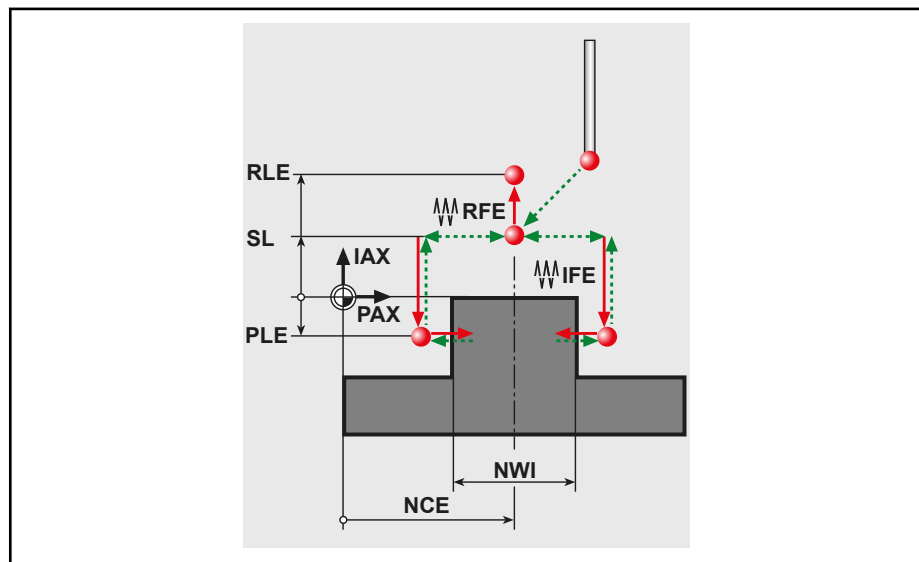


Fig. 4-42: Overview: Probe land (infeed)

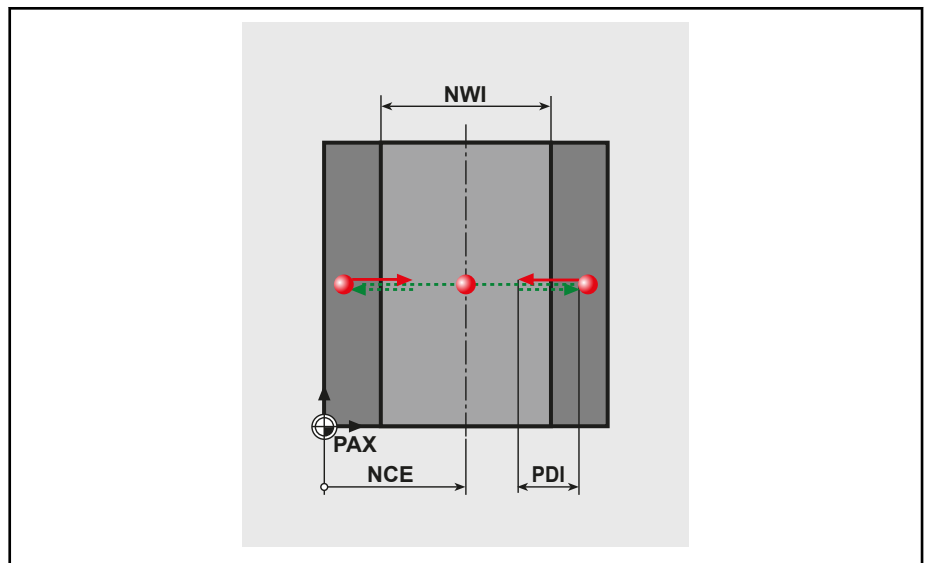


Fig. 4-43: Overview: Probe land (measuring level)

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety level	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
PLE	Measuring height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative
PFE	Measuring feed	optional	REAL	mm/min
PAX	Measuring axis	Mandatory	STRING	8
NCE	Land center	Mandatory	REAL	Absolute
NWI	Land width	Mandatory	REAL	Relative

Tab. 4-36: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-37: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Position positive	REAL	double precision

Measuring cycle automatic

SD.SysPrResult.RE-SULT[2]	Position negative	REAL	double precision
SD.SysPrResult.RE-SULT[3]	Land center	REAL	double precision
SD.SysPrResult.RE-SULT[4]	Land center difference	REAL	double precision
SD.SysPrResult.RE-SULT[5]	Land width	REAL	double precision
#RESULT1	Position positive	REAL	single precision
#RESULT2	Position negative	REAL	single precision
#RESULT3	Land center	REAL	single precision
#RESULT4	Land center difference	REAL	single precision
#RESULT5	Land width	REAL	single precision

Tab. 4-38: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-39: Output values 2

Description

Prior to the cycle, a suitable position is to be approached at the axis not included in the motion sequence. If no safety level is programmed, positioning takes place to the land center in rapid traverse on the measuring axis. If a safety level is specified, the probe is first positioned there in rapid traverse over the land center. Afterwards, the probe moves to measuring height with G1 and the infeed feed to enable plunging at reduced velocity.

Measuring sequences in both directions follow. If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..5] are written and the variable "Number of measurements"

(RUNS) is increased by value 2 in the SysPrResult structure. Afterwards, the probe is positioned over the land center.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Procedure/processing

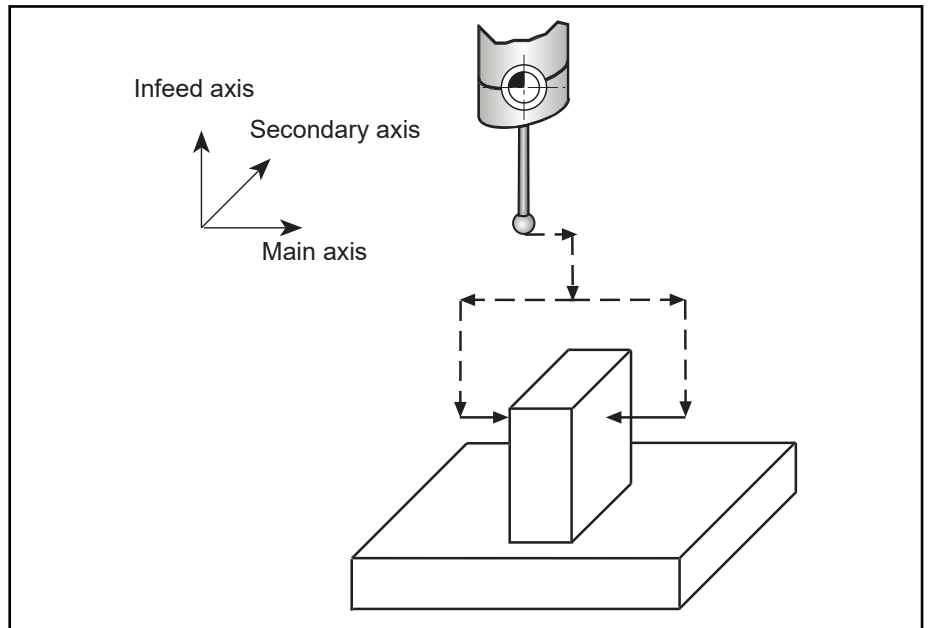


Fig. 4-44: Traversing motion: Probe land

Measuring cycle automatic

Example

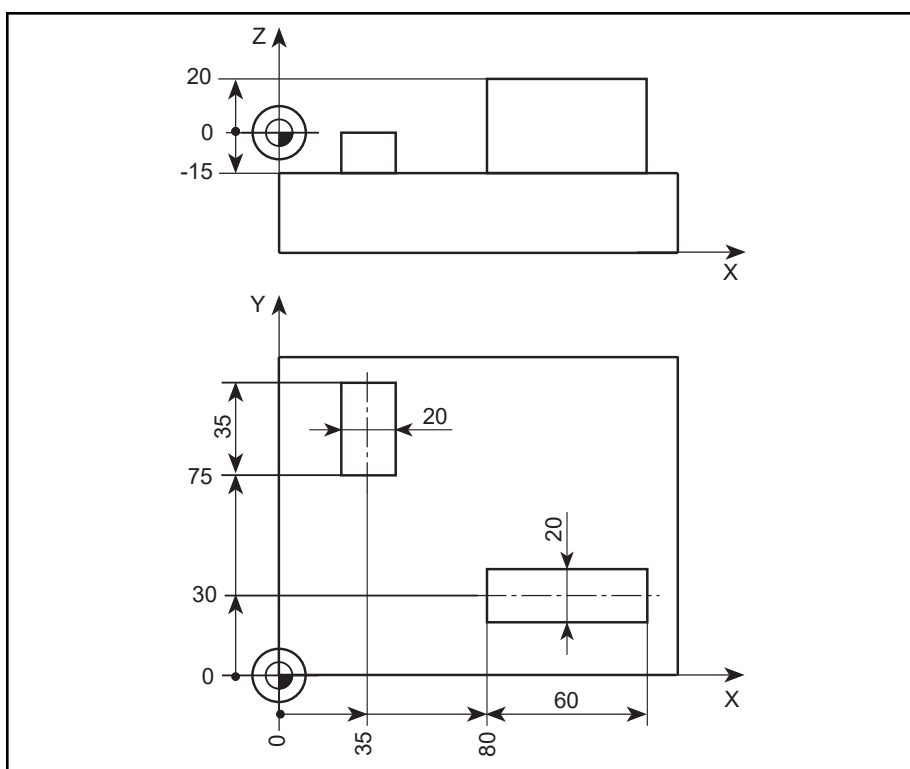


Fig. 4-45: Example: Probe land

Probe land

```

;-----
;----- Probe lands with a width of 20 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load tool
N30 ED1 M97              ;Probel ON and enable edge
N40 G47 G54 X110 Y30 Z30 M19 S=0;enable tool length and ZPO
;Probe Land 1 at X110 Y30
;call cycle
N50 G329 (PNO1, IAX Z, SL30, PLE15, PDI10, PAX Y, NCE30, NWI20)
;displaying measurement results Land 1 on the screen
10 PRN#(0,"Pos: ####.###",SD.SysPrResult.RESULT[1])
15 PRN#(0,"Neg: ####.###",SD.SysPrResult.RESULT[2])
20 PRN#(0,"Center probed: ####.###",SD.SysPrResult.RESULT[3])
25 PRN#(0,"Center difference: ####.###",SD.SysPrResult.RESULT[4])
30 PRN#(0,"Land width : ####.###",SD.SysPrResult.RESULT[5])
N60 G0 Y92.5              ;Positioning
;Probe Land 2 at X35 Y92.5
;call cycle
N70 G329 (PNO1, IAX Z, SL30, PLE-5, PDI10, PAX X, NCE35, NWI20)
;displaying measurement results Land 2 on the screen
35 PRN#(0,"Pos: ####.###",SD.SysPrResult.RESULT[1])
40 PRN#(0,"Neg: ####.###",SD.SysPrResult.RESULT[2])
45 PRN#(0,"Center probed: ####.###",SD.SysPrResult.RESULT[3])
50 PRN#(0,"Center difference: ####.###",SD.SysPrResult.RESULT[4])
55 PRN#(0,"Land width : ####.###",SD.SysPrResult.RESULT[5])
N80 G0 Z100              ;retracting
N90 M30

```

Program:

G331 Probe groove

Syntax G331 (PNO<pno>, IAX <iax>, PLE<ple>, PDI<pdi>, PAX<pax>, GCE<nce>, GWI<nwi>{, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description The "Probe groove" (G331) cycle measures a groove in parallel to the axis and determines the width and the center. The measurement results are stor-

ed in the system data elements SD.SysPrResult.REULT[1..5] and the output variable "RUNS" is increased by a value of 2.

Overview

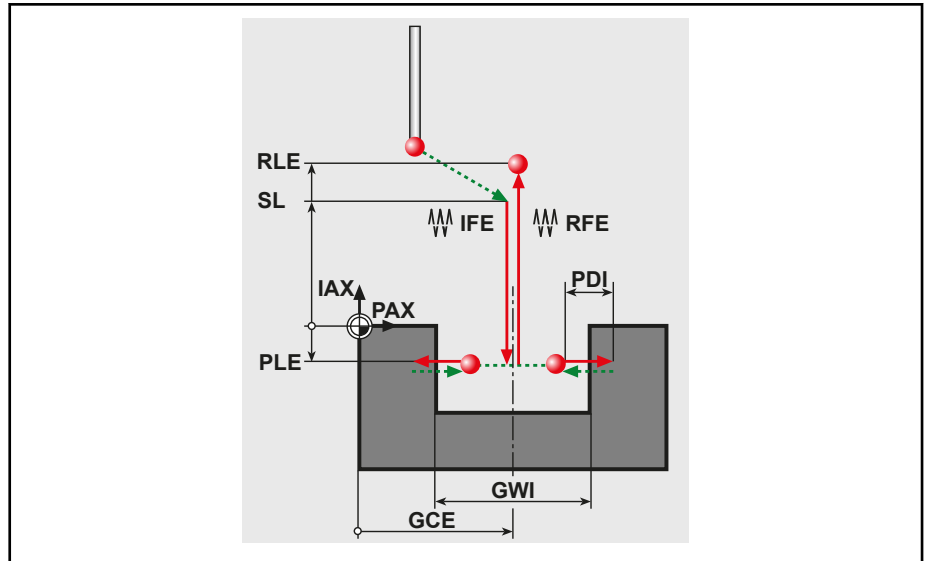


Fig. 4-46: Overview: Probe groove (infeed)

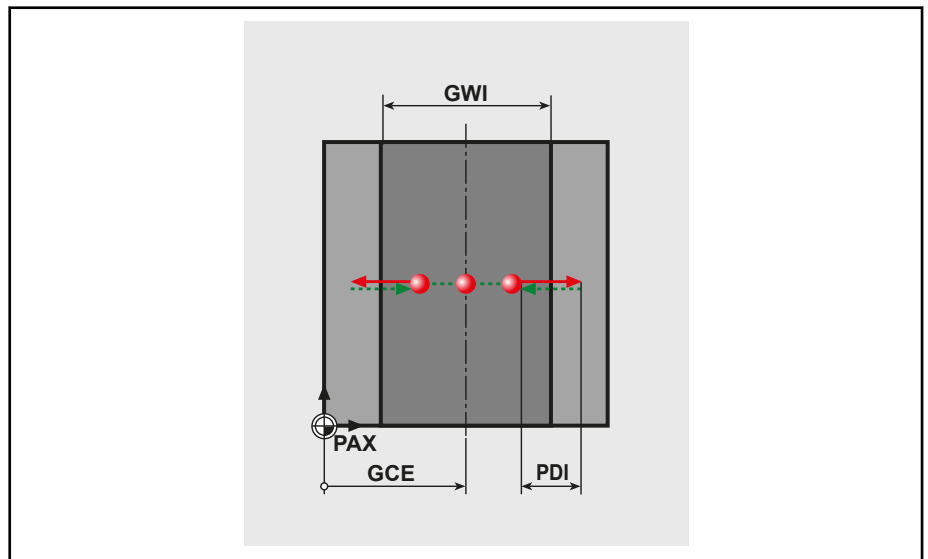


Fig. 4-47: Overview: Probe groove (measuring level)

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety level	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
PLE	Measuring height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative

Measuring cycle automatic

Parameter	Name	Properties	Values	Pre-assignment/Range
PFE	Measuring feed	optional	REAL	mm/min
PAX	Measuring axis	Mandatory	STRING	8
GCE	Groove center	Mandatory	REAL	Absolute
GWI	Groove width	Mandatory	REAL	Relative

Tab. 4-40: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-41: Runtime variable

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Position positive	REAL	double precision
SD.SysPrResult.RE-SULT[2]	Position negative	REAL	double precision
SD.SysPrResult.RE-SULT[3]	Groove center	REAL	double precision
SD.SysPrResult.RE-SULT[4]	Groove center difference	REAL	double precision
SD.SysPrResult.RE-SULT[5]	Groove width	REAL	double precision
#RESULT1	Position positive	REAL	single precision
#RESULT2	Position negative	REAL	single precision
#RESULT3	Groove center	REAL	single precision
#RESULT4	Groove center difference	REAL	single precision
#RESULT5	Groove width	REAL	single precision

Tab. 4-42: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-43: Output values 2

Description

Prior to the cycle, a suitable position is to be approached at the axis not included in the motion sequence. If no safety level is specified, the infeed takes place in rapid traverse on measuring height. If a safety level is specified, the probe is first positioned in the safety level in rapid traverse. Afterwards, the probe moves to measuring height with G1 and the infeed feed to enable plunging at reduced velocity. Now, the measuring sequence is executed in both directions. Afterwards, the probe is positioned over the groove center.

If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..5] are written and the variable "Number of measurements" (RUNS) is increased by value 2 in the SysPrResult structure.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

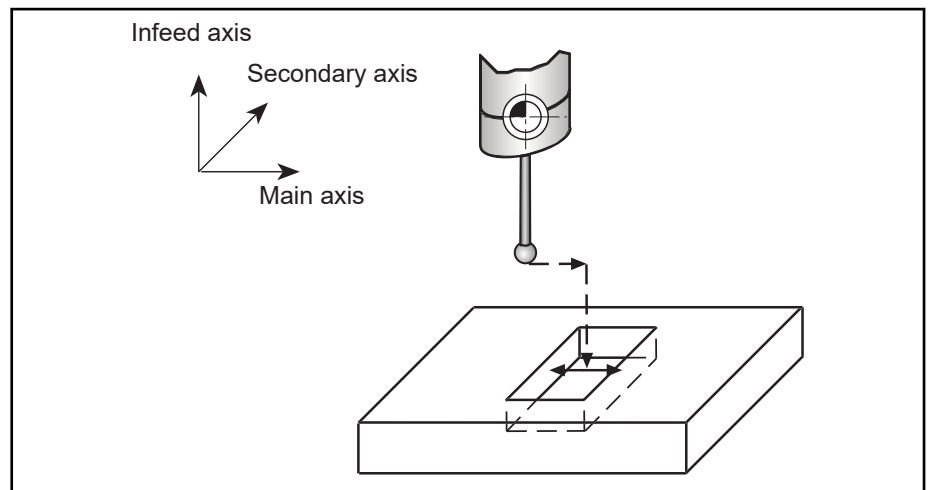
Procedure/processing

Fig. 4-48: Traversing motion: Probe groove

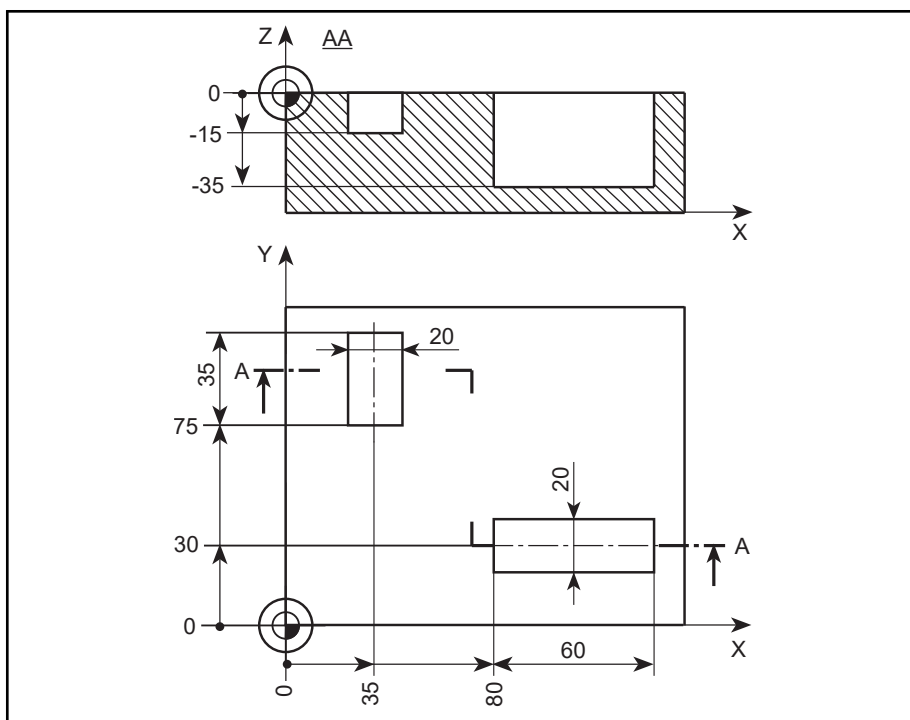
Example

Fig. 4-49: Example: Probe groove

Probe groove

```

;-----
;----- Probe slots with a width of 20 -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6 ;load tool
N30 ED1 M97 ;Probel ON and enable edge
N40 M19 S=0
N50 G47 G54 X110 Y30 Z10 ;enable tool length and ZPO
;Probe Slot 1 at X110 Y30
;call cycle
N60 G331 (PNO1, IAX Z, SL5, PLE-15, PDI10, PAX Y, GCE30, GWI20)
;displaying measurement results Slot 1 on the screen
10 PRN#(0,"Pos: ####.###",SD.SysPrResult.RESULT[1])
15 PRN#(0,"Neg: ####.###",SD.SysPrResult.RESULT[2])
20 PRN#(0,"Center probed: ####.###",SD.SysPrResult.RESULT[3])
25 PRN#(0,"Center difference: ####.###",SD.SysPrResult.RESULT[4])
30 PRN#(0,"Slot width : ####.###",SD.SysPrResult.RESULT[5])
N70 G0 Y92.5 ;Positioning
;Probe Slot 2 at X35 Y92.5
N80 G331[1,3,,, -7.5,,, 6,, 1,35,20]
;call cycle
G331 (PNO1, IAX Z, SL5, PLE-7.5, PDI10, PAX X, GCE30, GWI20)
;displaying measurement results Slot 2 on the screen
35 PRN#(0,"Pos: ####.###",SD.SysPrResult.RESULT[1])
40 PRN#(0,"Neg: ####.###",SD.SysPrResult.RESULT[2])
45 PRN#(0,"Center probed: ####.###",SD.SysPrResult.RESULT[3])
50 PRN#(0,"Center difference: ####.###",SD.SysPrResult.RESULT[4])
55 PRN#(0,"Slot width : ####.###",SD.SysPrResult.RESULT[5])
N90 G0 Z100 ;retracting
N100 M30

```

G333 Probe angle

Syntax G333 (PNO<pno>, IAX <iax>, PLE<ple>, PDI<pd>, PA1 <pa1>, PA2 <pa2>, PP1<pp1>, PP2<pp2>, DIS<dis>, ANG<ang> {, SL<sl>}{, IFE<ife>}{, RLE<rle>}{, RFE<rfe>}{, PFE<pfe>})

Brief description With the "Probe angle" (G333) cycle, the angle of a flat surface can be measured. In this respect, the angle and the angle difference are determined. The measuring results are stored in the system data elements SD.SysPrRe-

sult.RESULT[1..2] and the output variable "RUNS" is increased by a value of 2.

Overview figure

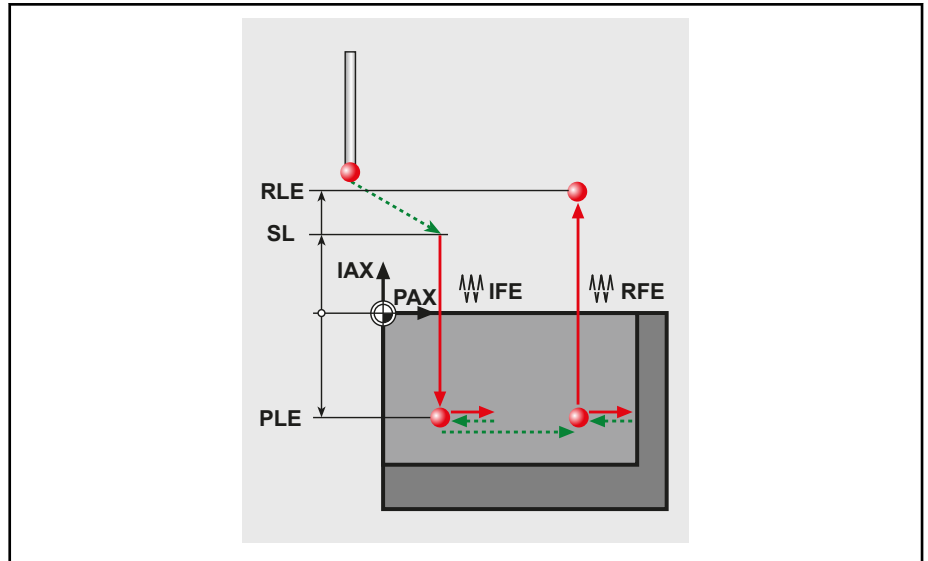


Fig. 4-50: Overview: Probe angle (infeed)

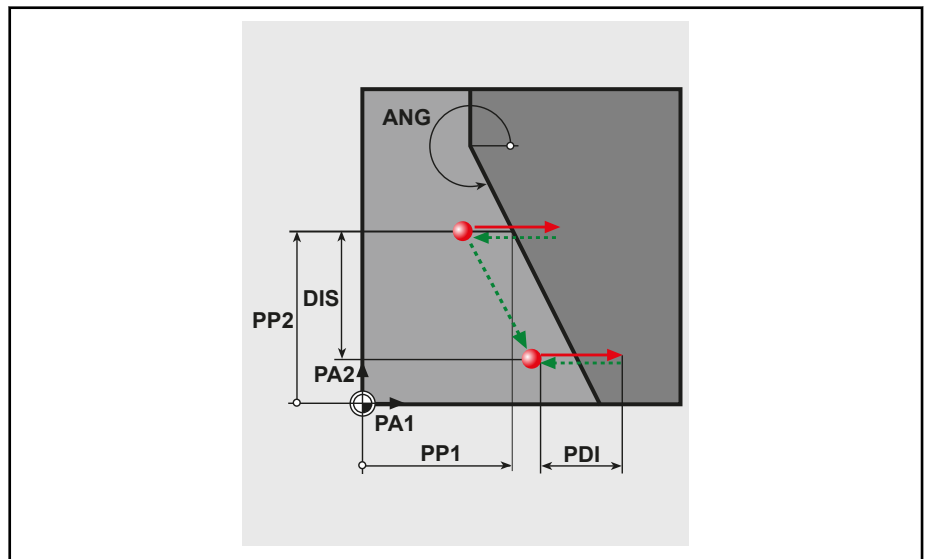


Fig. 4-51: Overview: Probe angle ($225^\circ \leq \text{ANG} < 315^\circ$)

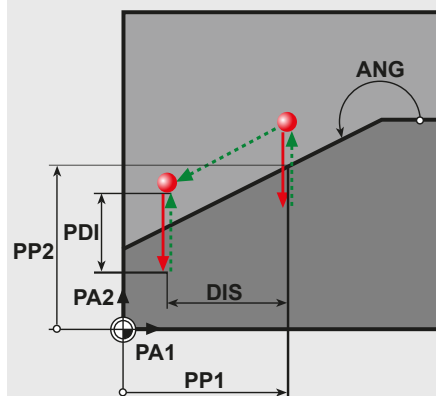


Fig. 4-52: Overview: Probe angle ($135^\circ \leq \text{ANG} < 225^\circ$)

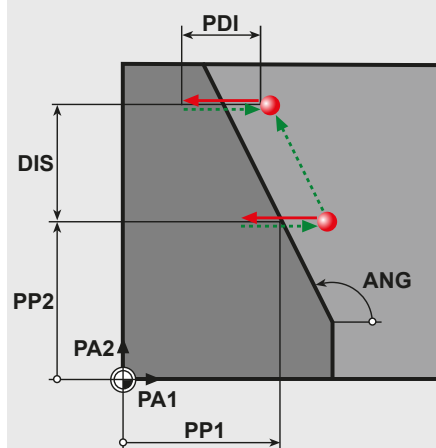
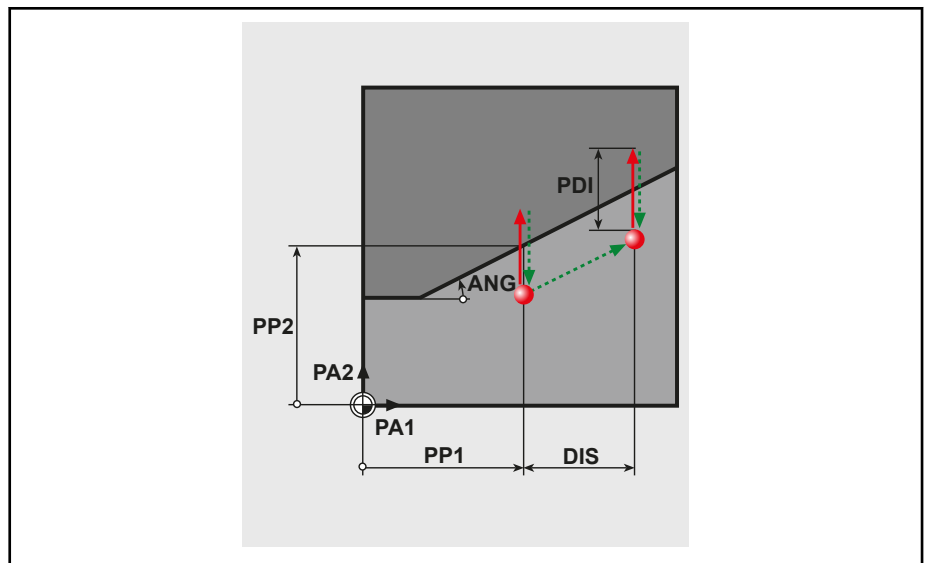


Fig. 4-53: Overview: Probe angle ($45^\circ \leq \text{ANG} < 135^\circ$)

Fig. 4-54: Overview: Probe angle ($-45^\circ \leq \text{ANG} < 45^\circ$)

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
PNO	Probe number	Mandatory	INTEGER	1..2
IAX	Infeed axis	Mandatory	STRING	8
SL	Safety distance	optional	REAL	Absolute
IFE	Infeed feed	optional	REAL	Absolute
PLE	Measuring height	Mandatory	REAL	Absolute
RLE	Retraction height	optional	REAL	Absolute
RFE	Retraction feed	optional	REAL	mm/min
PDI	Measuring distance	Mandatory	REAL	Relative
PFE	Measuring feed	optional	REAL	mm/min
PA1	Measuring axis 1 (main axis)	Mandatory	STRING	8
PA2	Measuring axis 2 (secondary axis)	Mandatory	STRING	8
PP1	Main axis position	Mandatory	REAL	Absolute
PP2	Secondary axis position	Mandatory	REAL	Absolute
DIS	Distance	Mandatory	REAL	Relative
ANG	Angle	Mandatory	REAL	Degree

Tab. 4-44: Parameter call

Result variables

SD.SysPrResult.Parameter[i]			
[i] 1..3 Axis number			
Parameter	Description	Values	Area
AXISRES[1..3]	Intermediate results	REAL	

Tab. 4-45: Runtime variable

Measuring cycle automatic

Parameter	Description	Values	Area
SD.SysPrResult.RE-SULT[1]	Measured angle	REAL	double precision
SD.SysPrResult.RE-SULT[2]	Angle difference	REAL	double precision
#RESULT1	Measured angle	REAL	single precision
#RESULT2	Angle difference	REAL	single precision

Tab. 4-46: Output values 1

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction (1 = positive, 2 = negative)			
Parameter	Description	Values	Area
RUNS	Number of measurements	INTEGER	

Tab. 4-47: Output values 2

Description

The direction of measurement is a result of the command angle. The probe is positioned over the calculated starting point of the first measuring distance and afterwards on the measuring height. If no safety level is specified, both traversing motions are executed in rapid traverse. If a safety level is specified, the probe is first positioned there in rapid traverse. Afterwards, the probe moves to measuring height with G1 and the infeed feed to enable plunging at reduced velocity.

Now, the two measurements are executed. Between the measurements, the axes are moved incrementally with safety feed to the resulting starting position of the second measuring distance (see figure above).

If no measuring feed is programmed, the cycle automatically applies the respective calibration feed the axis was calibrated with. Subsequently, the output variables SD.SysPrResult.RESULT[1..2] are written and the variable "Number of measurements" (RUNS) is increased by value 2 in the SysPrResult structure.

At the cycle end, the infeed axis is returned. If no retraction height is specified, positioning takes place in rapid traverse to the initial cycle position. If a retraction height is specified, it is moved to in rapid traverse or, if a retraction feed is additionally specified, with G1 and this feed value.

The cycle resets the modal functions of the groups ABS/REL (G90/G91), interpolation (G0/G1/G2/G3/G5/G6) and feed programming (G93/G94/G95) to their initial state prior to the cycle.

Angle specifications

The reference axis for the angle is always the main axis (PA1) of the measuring level. The angle line always passes through point (PP1/PP2). The absolute angle to the main axis defines whether the workpiece is on the left or right side of this angle line.

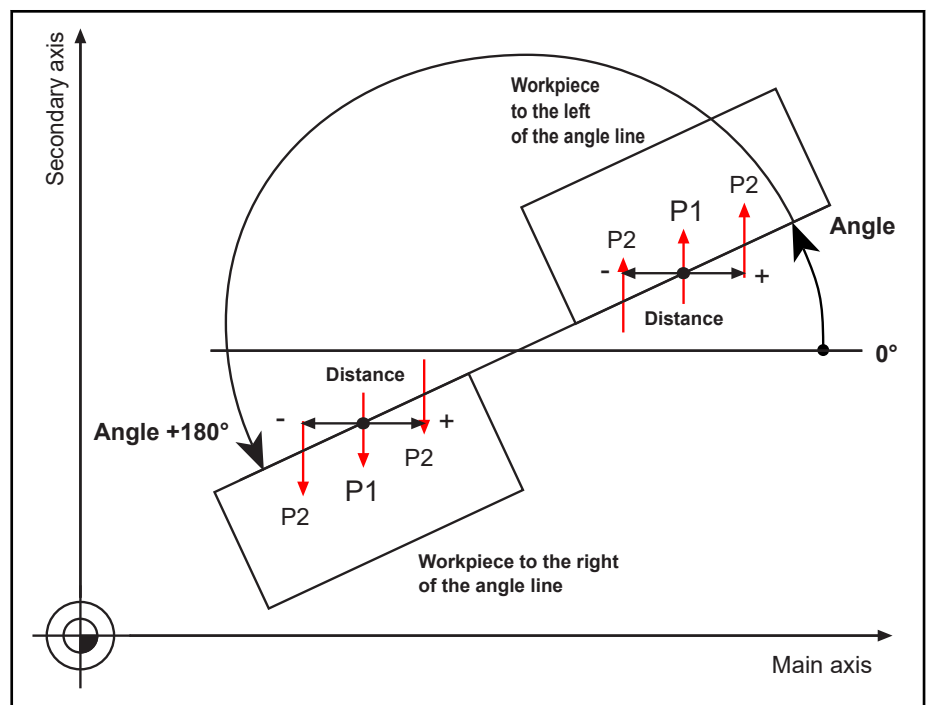


Fig. 4-55: Angle reference and angle line

Procedure/processing

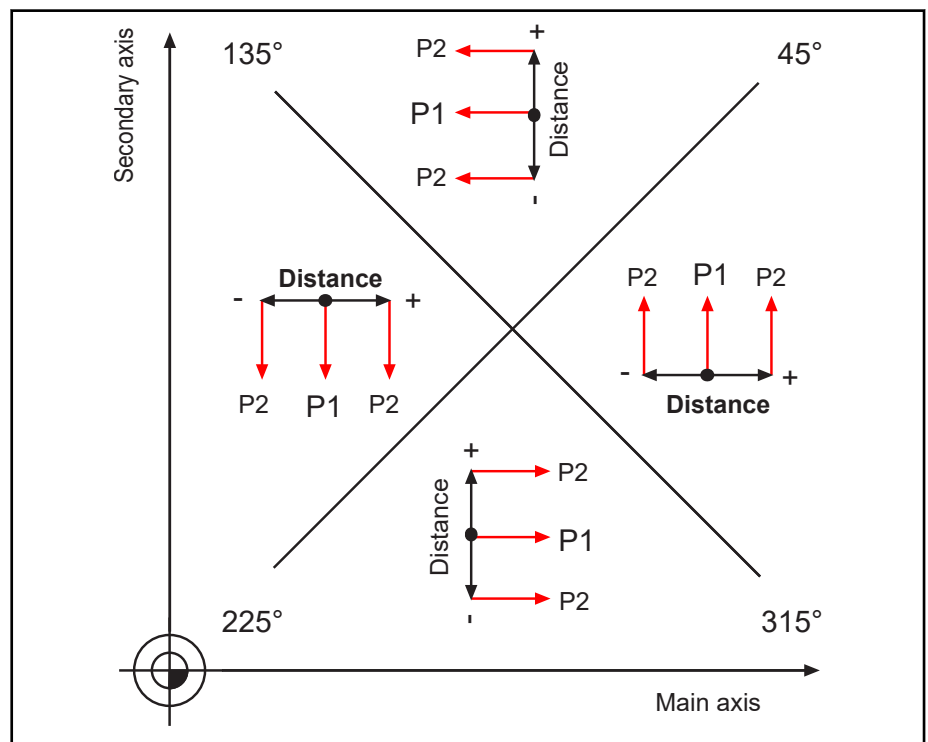


Fig. 4-56: Angle ranges

Example 1 Probe angle XY

Measuring cycle automatic

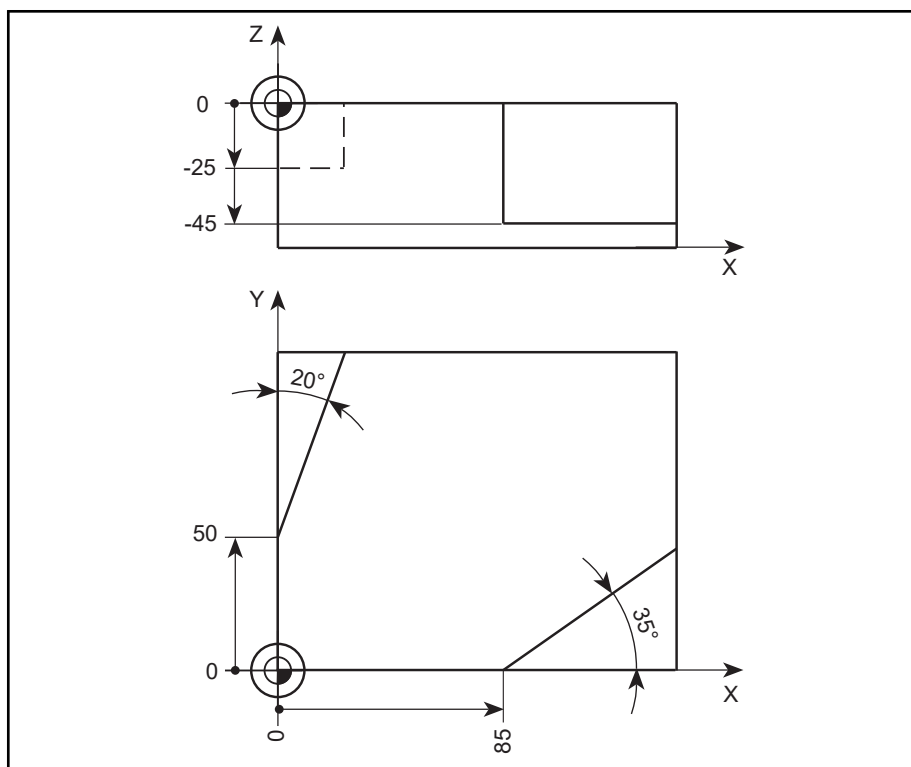


Fig. 4-57: Example: Probe angle XY

Probe angle XY

```

;-----
;----- Probe angle XY -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load tool
N30 ED1                  ;enable edge
N40 G47 G54 X100 Y-20 Z50 ;enable tool length and ZPO
;call cycle
N50 G333 (PNO1, IAX Z, SL10, IFE3000, PLE-25, PDI10, PA1 X, PA2 Y,
  PP1 90, PP2 3.501, DIS30, ANG35)
;displaying measurement results of angle 35° on the screen
1 PRN#(0,"Probed angle: ####.###",SD.SysPrResult.RESULT[1])
2 PRN#(0,"Angle difference: ####.###",SD.SysPrResult.RESULT[2])
N60 G0 X-20 Y60          ;Positioning
;call cycle
N70 G333 (PNO1, IAX Z, SL10, IFE3000, PLE-15, PDI10, PA1 X, PA2 Y,
  PP1 3.64, PP2 60, DIS30, ANG250)
;displaying measurement results of angle 250° (20°) on the screen
3 PRN#(0,"Probed angle: ####.###",SD.SysPrResult.RESULT[1])
4 PRN#(0,"Angle difference: ####.###",SD.SysPrResult.RESULT[2])
N80 G0 Z100 M30          ;retracting

```

Example 2 Probe angle XY

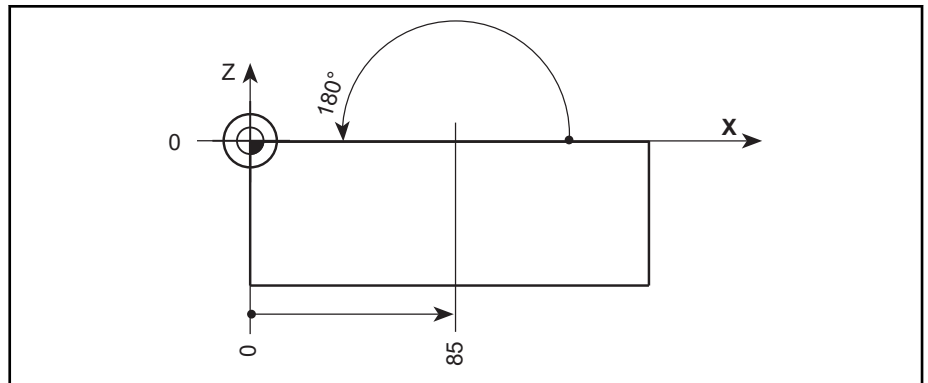


Fig. 4-58: Example: Probe angle XY

Probe angle XY

```

;-----
;----- Probe angle ZX -----
;-----
N10 ZOTSEL(MYTABLE.ZOT) ;select ZPO table
N20 T999 M6              ;load tool
N30 ED1                  ;enable edge
N40 G0 G47 G54 X85 Y20 Z50 ;enable tool length and ZPO
;call cycle
N50 G333 (PNO1, IAX Z, SL50, IFE3000, PLE0, PDI-10, PA1 X, PA2 Z,
  PP1 85, PP2 0, DIS30, ANG180)
;displaying measurement results of angle 180° on the screen
1 PRN#(0,"Probed angle: ####.###°",SD.SysPrResult.RESULT[1])
2 PRN#(0,"Angle difference: ####.###°",SD.SysPrResult.RESULT[2])
N60 G0 X-20 Y60          ;Positioning
N70 G0 Z100 M30          ;Retracting

```

G628 G629 Measuring in space**Description**

The function "Measuring in space" contains two cycle commands:

- G629
- G628

The cycle **G629** determines the center point of a measuring ball. The touch probe is positioned and oriented in front of the ball using "Jogging in space". It points approximately into the direction of the ball center. The measuring cycle is started and measures the ball automatically by sampling five points. The position of the ball center is measured in the BCS and in the WCS. The tool vector does not have to be parallel to an axis.

The cycle **G628** computes the orientation of a plane using three ball center points determined using **G629**.

System design

The ball center point can be measured in different transformation types.

- **RRLLL**: The axis of the touch probe moves parallel to the x-/y-/z-coordinates in the BCS
- **RLLLR**: The transformation angle Theta Θ determines the direction of motion of the touch probe axis
- **LLRRR**: The transformation angles Theta Θ and Phi Φ determine the direction of motion of the touch probe axis

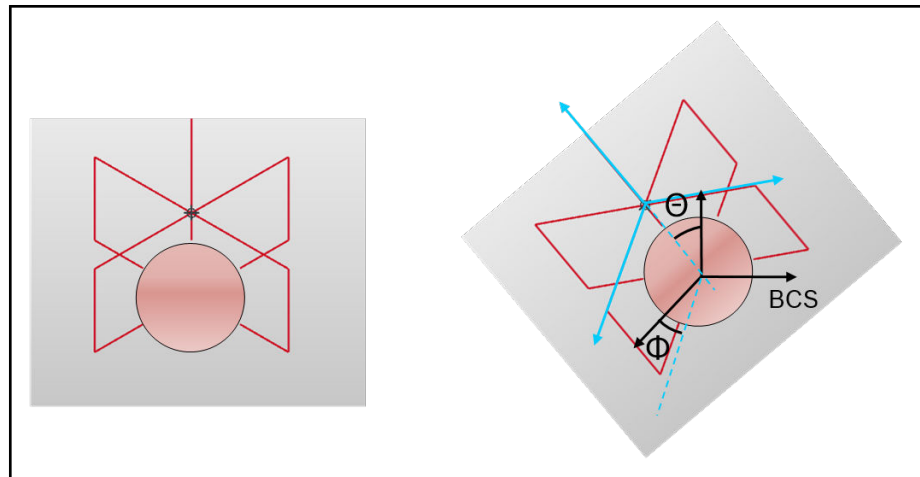


Fig. 4-59: Schematic representation of the direction of motion of the touch probe. a): RRLLL, b): RLLLR and RLLLR

System data Input parameters and intermediate data are saved in SD variables. The structure `SD.SysPrBall.Ball` includes the parameters of the balls to be measured. The parameters of up to nine balls can be logged during a measuring run. To compute the plane orientation in BCS `SD.SysPrBall.PLANE` and in WCS `SD.SysPrBall.PLANE_WCS`, three ball positions are required. The ball center points are determined using five measuring points per ball. The points are saved in the substructure `SD.SysPrBall.Ball.PNT`.

SD variables	Description
<code>SD.SysPrBall.PLANE</code>	Plane orientation in BCS
<code>SD.SysPrBall.PLANE_WCS</code>	Plane orientation in WCS
<code>SD.SysPrBall.Ball[*]</code>	Ball parameter for the measurement
<code>SD.SysPrBall.Ball[*].TRN</code>	Macoda parameter of the axis transformation
<code>SD.SysPrBall.Ball[*].TRS</code>	Transformation data (system date)
<code>SD.SysPrBall.Ball[*].PNO</code>	Index of the touch probe. 1: Probe 1; 2: Probe 2
<code>SD.SysPrBall.Ball[*].PDI</code>	Distance between the starting position and the first point of contact, positive values
<code>SD.SysPrBall.Ball[*].RAD</code>	Ball radius
<code>SD.SysPrBall.Ball[*].IFE</code>	Feeding velocity
<code>SD.SysPrBall.Ball[*].PFE</code>	Feed velocity of the measurement
<code>SD.SysPrBall.Ball[*].NPF</code>	Path of the measuring result
<code>SD.SysPrBall.Ball[*].ERT</code>	Maximum permitted deviation of the measuring result (deviation from the measured ball radius)
<code>SD.SysPrBall.Ball[*].RES</code>	Measuring result
<code>SD.SysPrBall.Ball[*].RES.BCP</code>	Measured position of the ball center point in the BCS

SD variables	Description
SD.SysPr-Ball.Ball[*].RES.BCP_WCS	Measured position of the ball center point in the WCS
SD.SysPrBall.Ball[*].RES.RAD	Measured radius Sum of the ball and touch probe radius
SD.SysPrBall.Ball[*].RES.ERT	Deviation from the measured ball radius (ABS(Measured calibrated ball radius – RES.RAD)/ RES.RAD)
SD.SysPrBall.Ball[*].PNT[**]	Intermediate data when measuring the surface points.
SD.SysPr-Ball.Ball[*].PNT[**].TouP	Position of contact on the ball surface under WCS
SD.SysPr-Ball.Ball[*].PNT[**].BCSP	Position of contact on the ball surface under BCS
SD.SysPr-Ball.Ball[*].PNT[**].Ori	Orientation when measuring the surface points.
SD.SysPr-Ball.Ball[*].PNT[**].StrP	Starting point of measuring motion
SD.SysPr-Ball.Ball[*].PNT[**].TarP	Target point of the measuring motion
SD.SysPr-Ball.Ball[*].PNT[**].IP1	Intermediate point 1 when feeding
SD.SysPr-Ball.Ball[*].PNT[**].IP2	Intermediate point 2 when feeding
SD.SysPr-Ball.Ball[*].PNT[**].MRD	Measured radius of the current point
SD.SysPr-Ball.Ball[*].PNT[**].ERT	Measuring radius deviation of the current point

* Index of the ball. Up to 9 balls can be measured during a run
 ** Index of the points of contact of the ball surface. 5 points per measurement

Tab. 4-48: System data for measuring cycles

Parameter The cycle commands **G629** and **G628** require the following input parameters:

Input parameter	Description	Property	Data type	Unit/setting range
TRN	Macoda parameter of the axis transformation	Mandatory	INT	1 - 20
TRS	Transformation data (system date)	Optional	STRING	200
BNO	Ball index	Mandatory	INT	1 - 9

Measuring cycle automatic

Input parameter	Description	Property	Data type	Unit/setting range
PNO	Index of the touch probe. 1: Probe 1; 2: Probe 2	Mandatory	INT	1 - 2
PDI	Measuring distance	Mandatory	DOUBLE	Positive
RAD	Ball radius	Mandatory	DOUBLE	mm
NPF	Path for the measuring result	Optional	STRING	Default "/usr/mtb"
IFE	Feeding velocity	Mandatory	DOUBLE	mm/min
PEF	Feed velocity during measurement	Mandatory	DOUBLE	mm/min
ERT	Maximum permitted deviation of the measuring result	Optional	DOUBLE	

Tab. 4-49: Input parameter for G629

Input parameter	Description	Property	Data type	Unit/setting range
BIDX	Index of the balls used to determine the plane orientation	Mandatory	INT	BIDX: 123-987 Three different balls have to be selected. The index has to be between 1 and 9. The index order influences the direction vector of the new x-axis related to the start coordinate system

Tab. 4-50: Input parameter for G628

Commissioning

Preparation

The following steps are required for the measurement:

1. Importing the file "SDDefProbeBall.xml" from /feprom to /usrfep.
2. Activating the 5-axis transformation and specifying the parameters TRN with the transformation type used (see "System design" on page 77).
3. Setting the touch probe on the tool number N by PNO=N and activating the tool N. Setting the tool parameters L3 with a probe length (up to the center point of the touch probe).
4. Ensure that the touch probe is calibrated. The resulting measured calibrated ball radius SD.SysPrBase.PROBE[].GEO.R is used in the G629 measuring cycle.

5. Activating the tool length correction G47. When activating the tool length correction, G41/G42 may **NOT** be used as the position of the probe center points is required.
 6. The radius RAD of the ball to be measured is required as input value.
 7. Configuration and feed velocity during the measurement **ERT** and the feeding velocity **PFE**.
- Commissioning**
1. Index specification of the ball to be measured by the input parameter **BNO**.
 2. Manual moving of the touch probe close to the ball interface. This position is used as starting position.



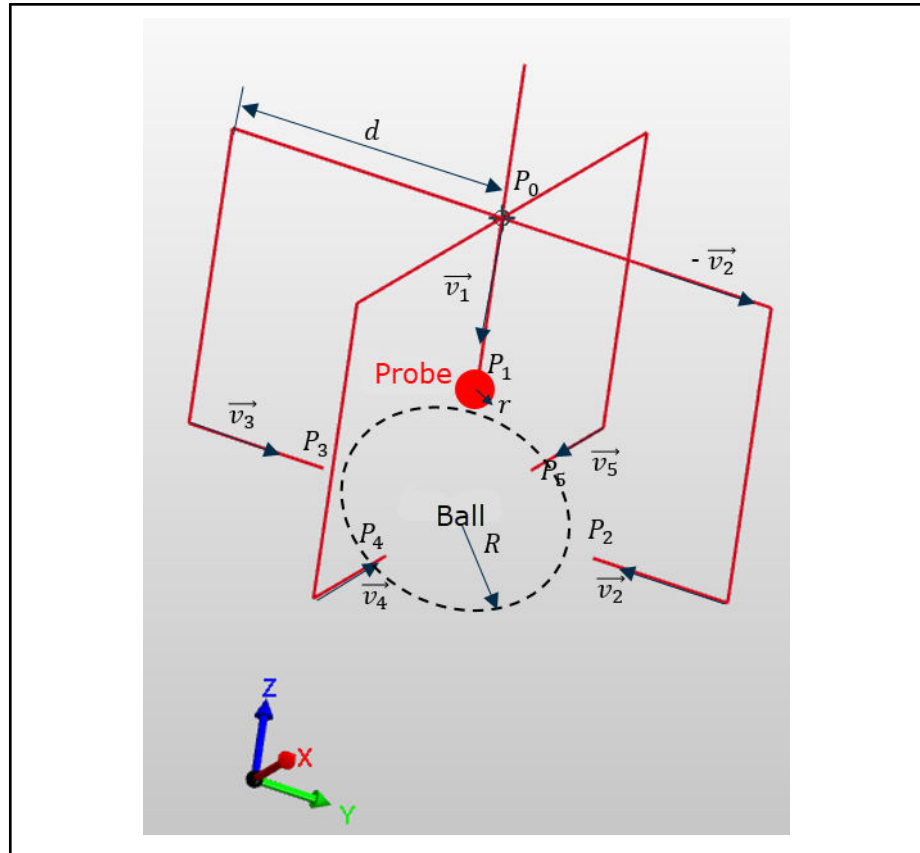
- 2.1 The longitudinal axis of the touch probe has to point towards the ball center point.
- 2.2 The distance between the probe and the ball surface should be smaller than the input parameter "Measuring distance PDI".

3. Measurement start
4. Measurement repeated for the next ball.



Three balls are required to determine the orientation of a surface

- Measuring**
1. The vector $\mathbf{v}_1$ describes the distance between the starting position and the measured ball center point.
 2. Measuring the first point of contact
 - 2.1 The probe moves along the tool orientation $\mathbf{v}_1$ using the measuring cycle G75.
 - 2.2 When the probe touches the ball surface, the motion is stopped.
 - 2.3 The point of contact is logged with the $\mathbf{P}_1$
 - 2.4 The touch probe returns to the initial position $\mathbf{P}_0$.
 3. Measuring the second point of contact.
 - 3.1 The touch probe moves parallelly to the xy-plane along the vector $-\mathbf{v}_1$. The distance of the motion is $d = 2 * @ + r$.
 - 3.2 The touch probe moves parallelly to $\mathbf{v}_1$ by $\mathbf{v}_1 + R$.
 - 3.3 Touch probe moves towards the ball center point $\mathbf{v}_2$.
 - 3.4 Measurement of the point of contact with the measuring cycle G75.
 - 3.5 The point of contact is logged with the $\mathbf{P}_2$
 - 3.6 The touch probe returns to the initial position $\mathbf{P}_0$.
 4. Measuring the third point of contact as in step 3.
 5. Measuring the fourth point of contact along $\mathbf{v}_4$. The vector $\mathbf{v}_4$ is vertical to $\mathbf{v}_1$ and $\mathbf{v}_2$.
 6. Measuring the fifth point of contact.
 7. Computing the ball center point using five ball surface points.
 8. Checking the deviation of the ball radius. The measurement is aborted if the deviation is too high.



Use case This section shows an example NC program to determine a plane orientation by measuring of three ball center points. The measuring log is stored in the "SysPrRes_ddmm_hhmmss.txt " file in *PATH\$* . The plane orientation is saved in the structure "SD.SysPrBall.PLANE" and can be used as parameter for the "Inclined plane" function.

Program:

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```

; Program position should be probe center position
N90 X-200 Y-200 Z0 phi90 theta-45
;Measure first ball center position
N100 G629(TRN[TRN%],BNO1,PNO[PNO%],PDI[PDI],RAD[R1],IFE[IFE],PFE[PFE],
NPF[PATH$],ERT0.00001)

;Step 3: Go to ball number 2 initial measurement point.
;Make probe orientation go through ball center.
N110 X0 Y0 Z0 phi90 theta45
N100 G629(TRN[TRN%],BNO2,PNO[PNO%],PDI[PDI],RAD[R2],IFE[IFE],PFE[PFE],
NPF[PATH$],ERT0.00001)

;Step 4: Go to ball number 3 initial measurement point.
;Make probe orientation go through ball center.
N130 X0 Y200 Z10 phi30 theta-60
N100 G629(TRN[TRN%],BNO3,PNO[PNO%],PDI[PDI],RAD[R3],IFE[IFE],PFE[PFE],
NPF[PATH$],ERT0.00001)

;Step 5: Calculate orientation of target plane
;Calculate plane orientation by ball index(BINX) 1 2 3
N150 G628(BIDX 123)
N160 WAIT
80 PRN#(0, "(BCS) PHI: #####.####",SD.SysPrBall.PLANE.PHI,"
  THETA: #####.####",SD.SysPrBall.PLANE.THETA," PSI: #####.####",
  SD.SysPrBall.PLANE.PSI)
80 PRN#(0, "(WCS) PHI: #####.####",SD.SysPrBall.PLANE_WCS.PHI,"
  THETA: #####.####",SD.SysPrBall.PLANE_WCS.THETA," PSI: #####.####",
  SD.SysPrBall.PLANE_WCS.PSI)
N170 WAIT

;-----
;Set inclined plane paras and activate inclined plane
;G153 ; Activate inclined plane.
;-----
N180 Coord(0)
N190 G0 X0 Y0 Z0 A0 C0
N200 M30

```

Diagnostics						
Number	Ca	Area	Date	Time	Description (filter: inactive)	
8002			05.11.2020	13:39:06.290	Nc Channel / ready for NC Start	
0		\$1	05.11.2020	13:39:06.271	Plane orientation PSI: 102.1623	
0		\$1	05.11.2020	13:39:06.267	Plane orientation THETA: 40.3321	
0		\$1	05.11.2020	13:39:06.263	Plane orientation PHI: 254.2133	
0		\$1	05.11.2020	13:38:21.999	Ball 3 file path: /usr/user/result/SysPrRes_0511_133821.txt	

NC screen				
Variables	Name	Value		
SysPrBall[1]	SysPrBall[1]			
CURB	PLANE			
CALC	PHI	254.21330		
BIDX	THETA	40.33210		
PLANE	PSI	102.16234		
PHI				
THETA				
PSI				

Fig. 4-61: An exemplary measuring result of the plane orientation

Troubleshooting

The measuring cycles **G629** and **G628** can generate the following error messages in the table:

Measuring cycle automatic

ErrorID	Description
4304	Only use parameters <Parameter names> optionally
4311	Value range exceeded
4355	No edge active
4402	Tool length correction is not active
4407	
4410	Transformation not defined
4413	Transformation incorrect
4426	Tool radius correction active
4431	Axis transformation type is not supported by the cycle
4433	Mandatory parameter is not programmed
4461	SD.SysPrBase.PROBE[<Probe no.>].DRVINP is not 1 or 2
4553	No free logic file number available
4554	Invalid path name
4555	The radius of the ball to be measured is too small
4556	Error when writing the log file to the <directory name> directory
4557	Radius of ball or of probe is too small
4558	The probe <probe no.> is not a workpiece probe
4560	(Warning, no error) The measuring error at the ball <Index> exceeds the adjustment value.
4561	Error when calculating the displacement vector
4562	Error when calculating the center of the calibrating ball
4563	Path name <Parameter name> too long (maximum 70 characters)

Tab. 4-51: Error codes of the measuring cycle **G629**

ErrorID	Description
4433	Mandatory parameter is not programmed
4311	Value range exceeded
4559	Error when calculating the normal vector of the plane

Tab. 4-52: Error codes of the measuring cycle **G628**

4.5 Measuring Value Evaluation

4.5.1 General Information

After recording one or several measuring positions, the measuring results can be evaluated. The compensation values for each measuring position are calculated according to the measuring results. Operating instructions and error messages are generated according to the measuring results.

The calculated compensations are to be taken into consideration by the user in the processing program during processing. Depending on the requirement, the values can be offset against the programmed dimensions with zero offset or directly with the tool data.

For evaluation, measuring results can be directly processed in evaluation cycles directly after recording. For this, the evaluation cycles have to be called in the processing program.

Depending on the required compensation process, the following evaluation cycles are available:

- G541 Tolerance monitoring
Determination of the differential dimension between actual dimension (from measuring value recording) and the center of the specified tolerance field. Different limit values that can be defined via variables are checked and error and alarm messages returned.
- G542 Averaging
Determination of the compensation value by means of evaluated averaging of the differential dimension taking limit values and an evaluation of the differential dimension into account.
- G543 Percentage compensation
Determination of the compensation value in form of a percentage evaluation of the differential dimension taking limit values into account limit values.

A full determination of the compensation value always includes the following cycle calls:

- Measured value recording, e.g. the "Probe boring" cycle
- Measuring data monitoring, e.g. the "Measuring data monitoring" cycle
- Compensation value determination, e.g. the "Averaging" or "Percentage compensation" cycle

4.5.2 Terms

General information

For measuring value evaluation, determination of compensation values and monitoring of different limit values to generate messages, the tolerance limits illustrated in the following figures are defined.

The "nominal dimension" as well as "the top deviation" and the "lower deviation" define a tolerance field for the workpiece dimensions (gray range).

The ideal desired size of the workpiece is the center of the tolerance zone. This dimension is referred to as "tolerance center". The tolerance center is symmetrically assigned to tolerance ranges. This makes it easier to handle the values.

The tolerance ranges are defined by NC variables and are taken into consideration in monitoring of measured data and in determination of compensation values.

Measuring cycle automatic

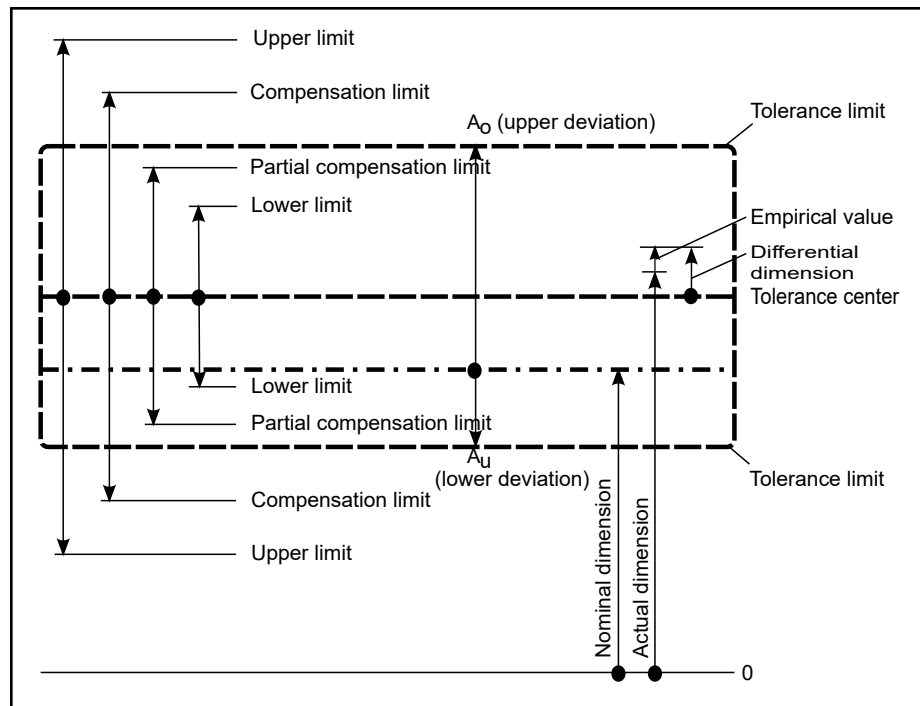


Fig. 4-62: Terms

Nominal dimension Dimensions specified in the drawing the tolerance limit specifications A_o and A_u refer to.

Lower deviation A_u

Upper deviation A_o The upper deviation A_o and the lower deviation A_u define the tolerance limit according to the nominal dimension for the actual dimension corrected by the empirical value to comply with tolerance requirements.

The following applies:

$$\text{Maximum dimension} = \text{nominal dimension} + A_o$$

$$\text{Minimum dimension} = \text{nominal dimension} + A_u$$

Tolerance center The tolerance center defines the point in the center of the defined tolerance limits A_o and A_u according to the nominal dimension. All tolerance limits refer to the tolerance center and apply symmetrically to it.

The following applies:

$$\text{Tolerance center} = \text{Nominal dimension} + \frac{A_o + A_u}{2}$$

Actual dimension The actual dimension of one of the measured values provided by one of the cycles described under [chapter 4 "Measuring cycle automatic" on page 15](#) and which was recorded partially by the measuring system during measuring.

Empirical value The empirical value compensates the difference of the measured values between the internal measurement by means of the the measuring system (refer to actual dimension) and an external reference measurement, e.g. by means of a measuring unit. The empirical value can be stored as a variable for every measuring position. It is applied as an additive to the nominal value.



The empirical value is not taken into consideration before the measuring data monitoring cycle.

Differential dimension	The differential dimension is the calculated difference between the actual dimension corrected by the empirical value and the tolerance center. Respectively, it specifies at least theoretically the dimensions to be corrected to achieve the ideal state, the tolerance center: $\text{Differential dimension} = \text{act. dim.} + \text{empirical value} - \text{tolerance center}$
Upper limit	The upper limit is a limit value that is only used for diagnostics. If this value is exceeded, no compensation is applied. If this is the case, it can be assumed that the measurement was not carried out successfully due to a critical error in application programming (e.g. incorrect measuring position) or that it has not been carried out correctly in the probe mechanics. The cycle is stopped with an error. The following NC message is returned: "Inadmissibly high dimensional deviation".
Compensation limit	The compensation limit is a limit value that is only used for diagnostics. If this value is exceeded, no compensation is applied. This value may be exceeded due to excessive tool wear. The dimensions are only compensated under the compensation limit. The cycle is stopped with an error. The following NC message is returned: "CHECK TOOL".
Tolerance limit	The tolerance limit is a control dimension without any influence on compensation value determination. The tolerance limit restricts the tolerance field defined by A_o and A_u according to the tolerance center. The comparison with the actual dimension under consideration of the empirical value provides the information whether the workpiece dimensions are within the required tolerance. If the recorded dimension is between the tolerance limit and the compensation limit, the NC warning message "[Over dimension] (differential dimension > 0)" or "[Under dimension] (differential dimension < 0)" is returned. The program is interrupted. After acknowledging the message, the program can be continued. Workpiece compensation is still permitted.
Partial compensation limit	If the differential dimension exceeds the partial compensation limit and lies under the compensation limit, a full compensation is carried out. The compensation value corresponds to the full differential dimension. In the range between the partial compensation limit and the lower limit, the determined differential dimension of a measuring point is provided to an evaluation in the compensation value determination cycle (G542, G543). Respectively, no full compensation is carried out.
Lower limit	The lower limit is a range in which no compensation is carried out. The occurring deviations (differential dimensions) are statically distributed in this tolerance band. By means of a targeted compensation of processing, no improvement of dimensional accuracy could be achieved. If compensations are applied by means of averaging, the determined differential dimension is applied for averaging.



All tolerance limits referring to the tolerance center, are always set as inputs for measuring data monitoring and compensation value determination with a positive sign. The upper deviation A_o and the lower deviation A_u have to be entered with the correct sign (according to the nominal dimension).

G541 Tolerance monitoring

Syntax G541 (NDI<ndi>, UTO<uto>, LTO<lto>, UPL<upl>, COB<cob>, ADI<adi>, EXV<exv>)

Measuring cycle automatic

Brief description The tolerance monitoring (G541) cycle monitors and checks the previously measured values (actual dimensions) according to their tolerance limits and writes the results to SD variables. These are available in NC programs for further processing.

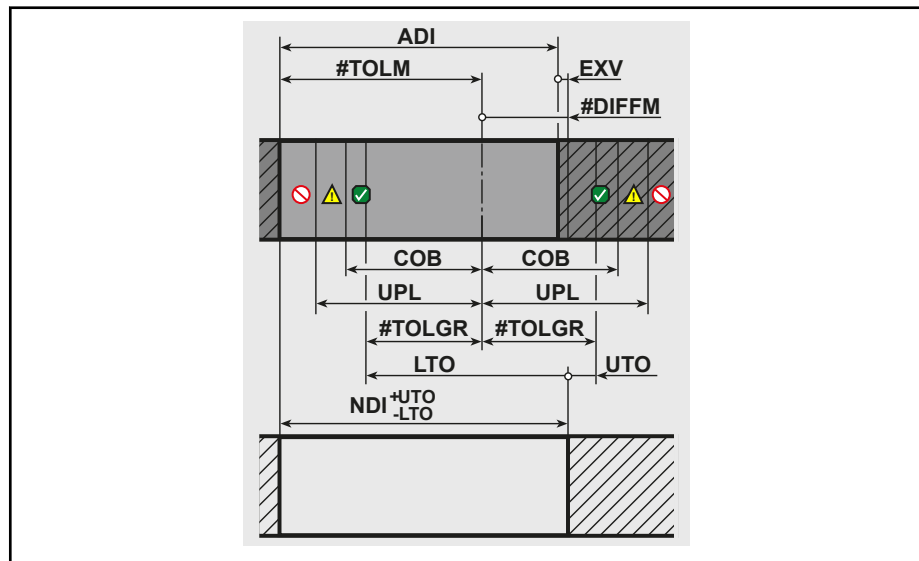
Overview

Fig. 4-63: Tolerance monitoring overview

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
NDI	Nominal dimension	Mandatory	REAL	
UTO	Upper deviation	Mandatory	REAL	
LTO	Lower deviation	Mandatory	REAL	
UPL	Upper limit	Mandatory	REAL	
COB	Compensation limit	Mandatory	REAL	
ADI	Actual dimension	Mandatory	REAL	
EXV	Empirical value	Mandatory	REAL	

Tab. 4-53: Parameter call

Result variables

Parameter	Description	Values	Area
SD.SysPrResult.TOL.TOLM	Tolerance center	REAL	double precision
SD.SysPrResult.TOL.DIFFM	Differential dimension	REAL	double precision
SD.SysPrResult.TOL.TOLGR	Tolerance limit	REAL	double precision
SD.SysPrResult.TOL.VALCHK	Dimensional accuracy	INTEGER	0..4
#TOLM	Tolerance center	REAL	single precision

#DIFFM	Differential dimension	REAL	single precision
#TOLGR	Tolerance limit	REAL	single precision
#VALCHK%	Dimensional accuracy	INTEGER	0..4

Tab. 4-54: Output values

SD.SysPrResult.TOL.VALCHK bzw. #VALCHK%: Dimensional accuracy 0..4

Dimensional accuracy = 0	The determined actual dimension under consideration of the empirical value lies within the tolerance field $A_o - A_u$. This means, the workpiece accuracy required by the tolerance specifications was achieved.
Dimensional accuracy = 1	The differential dimension lies between the tolerance limit and the compensation limit. The admissible range according to the tolerance field $A_o - A_u$ was exceeded but can be corrected. Cycle interruption with the NC warning [Over dimension]. Continuing the cycle is possible.
Dimensional accuracy = 2	The differential dimension lies between the tolerance limit and the compensation limit. The admissible range according to the tolerance field $A_o - A_u$ was dropped below but can be corrected. Cycle interruption with the NC message [Under dimension]. Continuing the cycle is possible.
Dimensional accuracy = 3	The differential dimension is over the upper limit. No further compensation value can be determined. The cycle is interrupted with the NC error message [Check tool] and cannot be continued. A serious error has occurred.
Dimensional accuracy = 4	The differential dimension is over the compensation limit. No further compensation value can be determined. The cycle is interrupted with the NC error message "Inadmissibly high dimensional deviation" and cannot be continued. A serious error has occurred during measuring value determination or at the workpiece.

Description The measuring data monitoring (G541) cycle monitors and checks the measured values (actual dimensions) determined from the cycles according to the tolerance limits described under [chapter 4.5.2 "Terms" on page 85](#).

In this subroutine, the differential dimension is defined under consideration of the empirical value for a measuring point. It can be applied as input value for the compensation value determination cycles "Averaging" (G542) or "Percentage compensation" (G543) and the determined dimensional accuracy to further influence the main program sequence (reworking/rejected parts).

At runtime, warnings and error messages with respect to the tolerance limits are returned. If the differential dimension exceeds the upper limit, the control switches to stop state and the error message "Inadmissibly high dimensional deviation" is returned. If the differential dimension exceeds the compensation limit, the error message "Check tool" is returned and the control switches to stop state. If the differential dimension is negative, the "Under dimension" warning message is returned. If the differential dimension is positive, the "Over dimension" warning message is displayed. If the differential dimension and the tolerance limit are equal, no message is displayed. The following flow chart illustrates the cycle logics.

Procedure/processing

Measuring cycle automatic

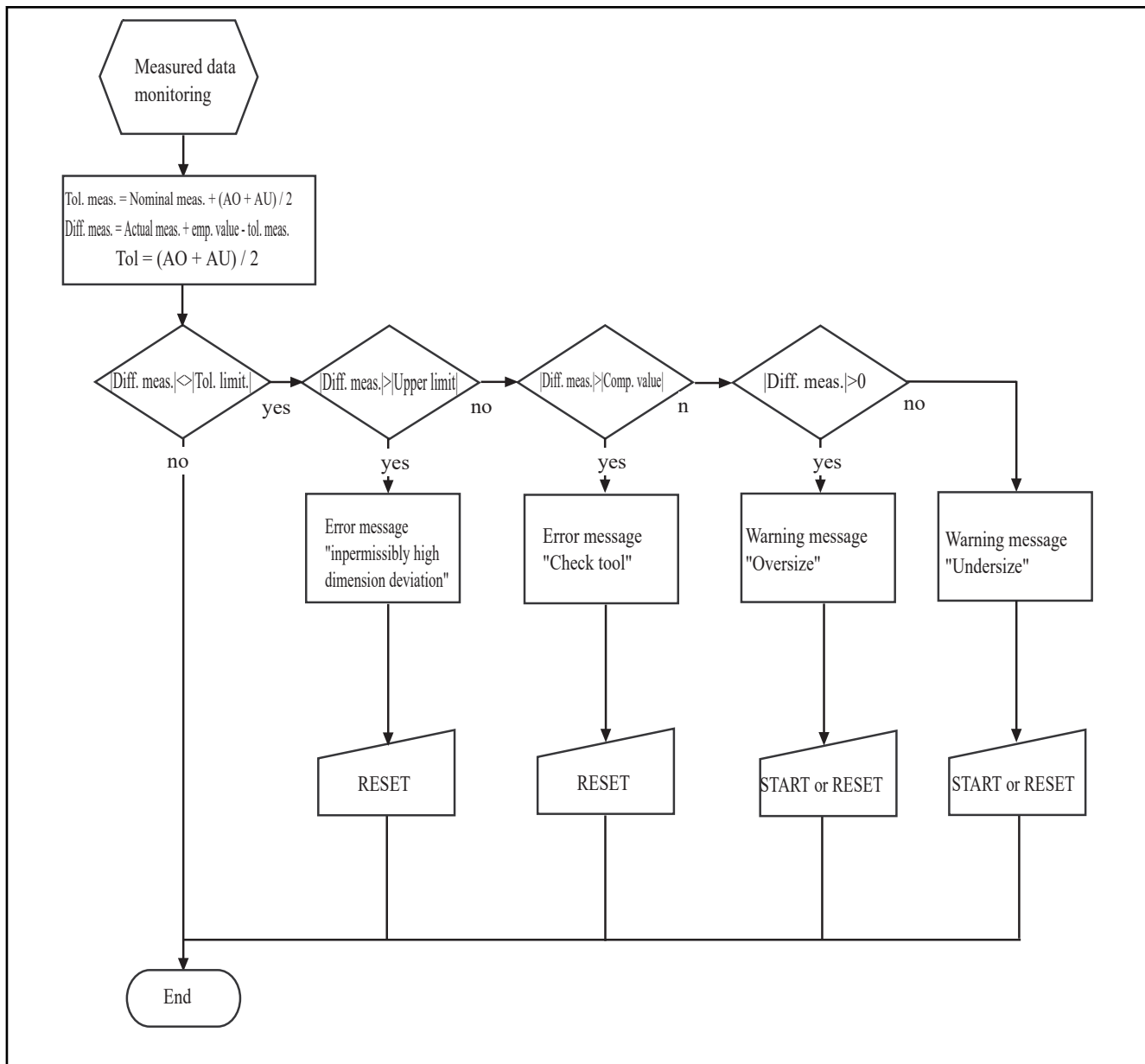


Fig. 4-64: Flow chart: Tolerance monitoring

Example

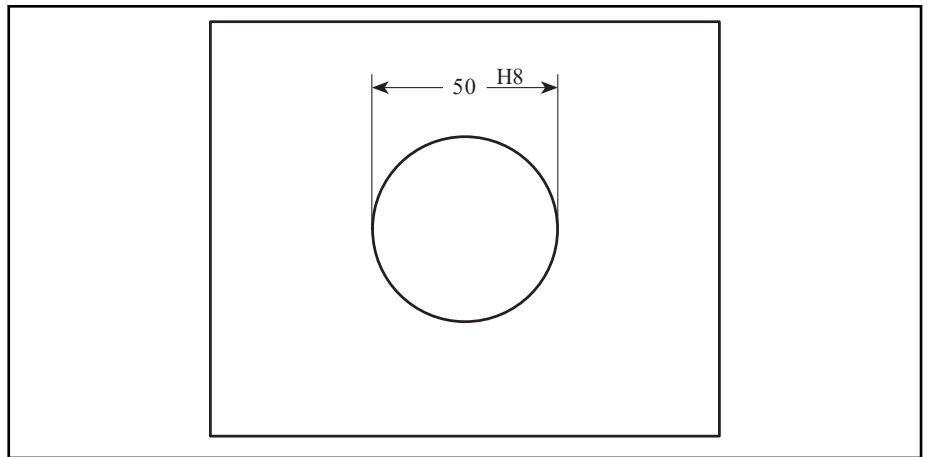


Fig. 4-65: Programming example: Tolerance monitoring
Tolerance monitoring

```
N10 G341 (NDI50, UTO0.039, LTO0, UPL0.1, COB0.05,
        ADI50.02, EXV0)
```

After processing of this NC program, the output variables are assigned the following values:

Tolerance center SD.SysPrResult.TOL.TOLM: 50.0195

Differential dimension SD.SysPrResult.TOL.DIFFM: 0.0005

Tolerance limit D.SysPrResult.TOL.TOLGR: 0.195

Dimensional accuracy SD.SysPrResult.TOL.VALCHK: 0

G542 Mean value generation

Syntax G542 (DIF<dif>, LMV<lmv>, SCF<scf>, COB<cob>, PCL<pcl>, LOL<lol>)
Brief description The "Averaging" (G342) cycle determines the effective compensation value at a measuring point by evaluated averaging.

Overview

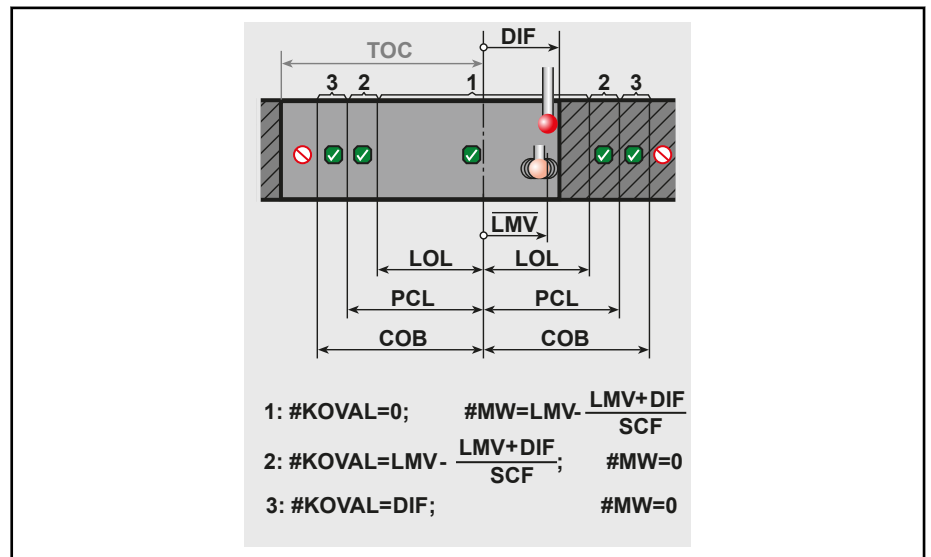


Fig. 4-66: Averaging overview

Measuring cycle automatic

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
DIF	Differential dimension	Mandatory	REAL	
LMV	Average value of the last measurement	Mandatory	REAL	
SCF	Scaling factor	Mandatory	REAL	
COB	Compensation limit	Mandatory	REAL	
PCL	Partial compensation limit	Mandatory	REAL	
LOL	Lower limit	Mandatory	REAL	

Tab. 4-55: Parameter call

Result variables

Parameter	Description	Values	Area
SD.SysPrResult.VAL.MW	New average	REAL	double precision
SD.SysPrResult.VAL.KOVAL	Dimensional compensation	REAL	double precision
#MW	New average	REAL	single precision
#KOVAL	Dimensional compensation	REAL	single precision

Tab. 4-56: Output values

Description

The Averaging (G542) cycle determines the effective compensation value at a measuring point by evaluated averaging by means of the measured values recorded at this measuring point. If the differential dimension exceeds the compensation limit, no compensation value is returned and the control reports "Compensation limit exceeded". If the value of the differential dimension is between the partial compensation limit and the compensation limit, the compensation value is equal to the differential dimension. The average value is set to zero. If the differential dimension is below the partial compensation limit, the average value is recalculated with the scaling factor. In this respect, if the new average value is below the lower limit, the compensation value is zero. Otherwise, the compensation value and the average value are reset to zero. The following flow chart illustrates the cycle logics.

Procedure/processing

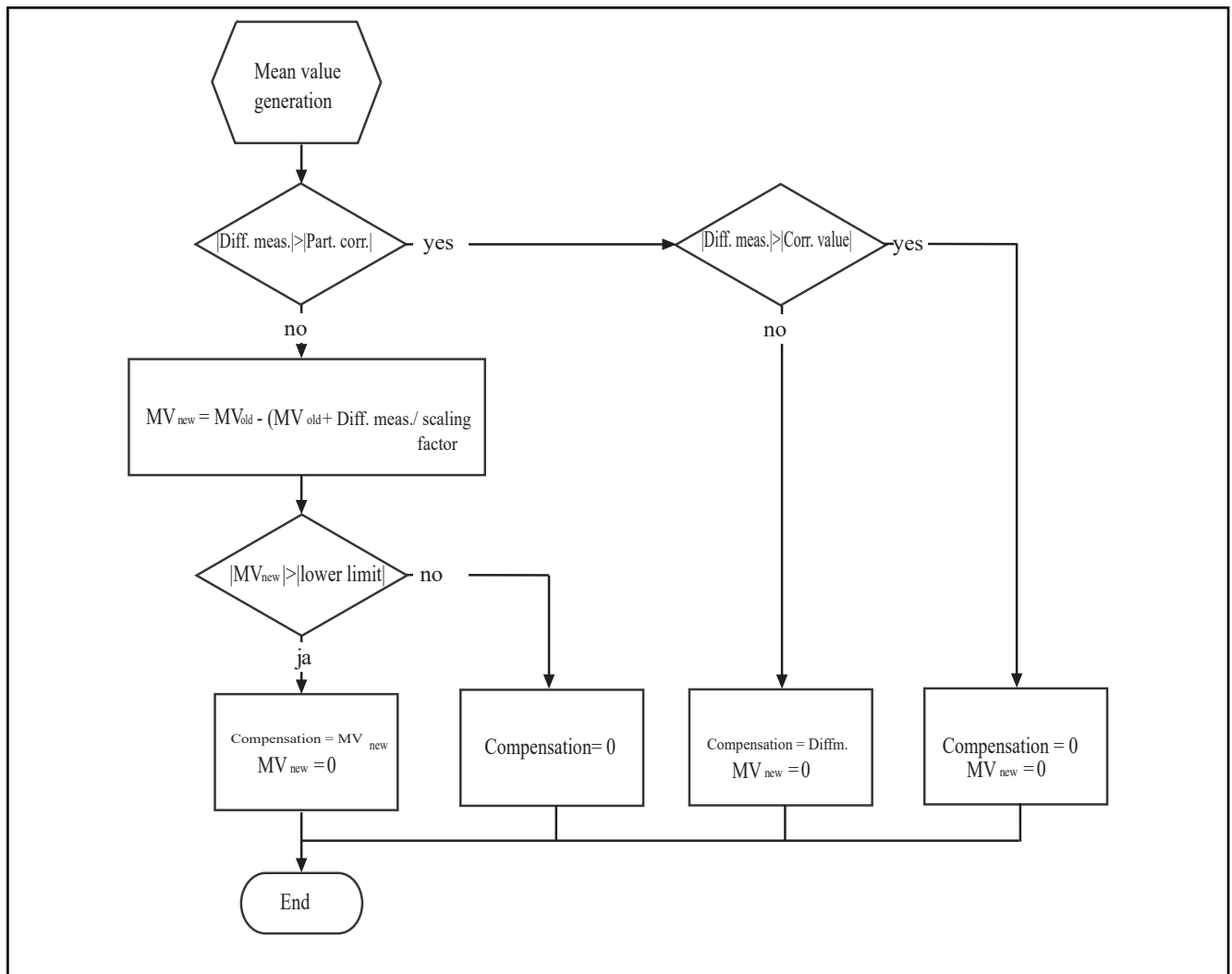


Fig. 4-67: Flow chart: Averaging

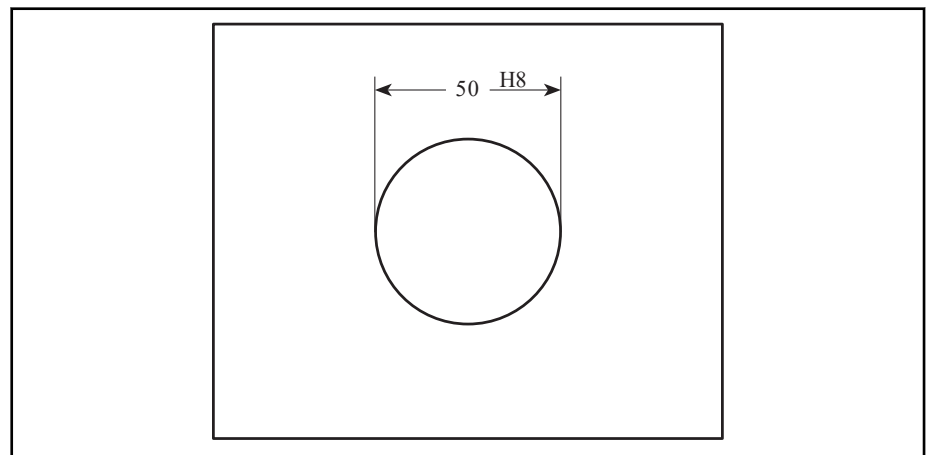
Example

Fig. 4-68: Programming example: Averaging

Average

N10 G542 (DIF0.009, LMV0.020, SCF90, CBB0.039, PCL0.030, LOL0.010)

After processing of this NC program, the output variables are assigned the following values:
New average #MW -0.0061
Dimensional compensation #KOVAL 0

G543 Percentage compensation

Syntax G543 (DIF<dif>, PCV<pcv>, COB<cob>, PCL<pcl>, LOL<lol>)
Brief description The "Percentage compensation" (G543) program determines the compensation value for a differential dimension.

Overview

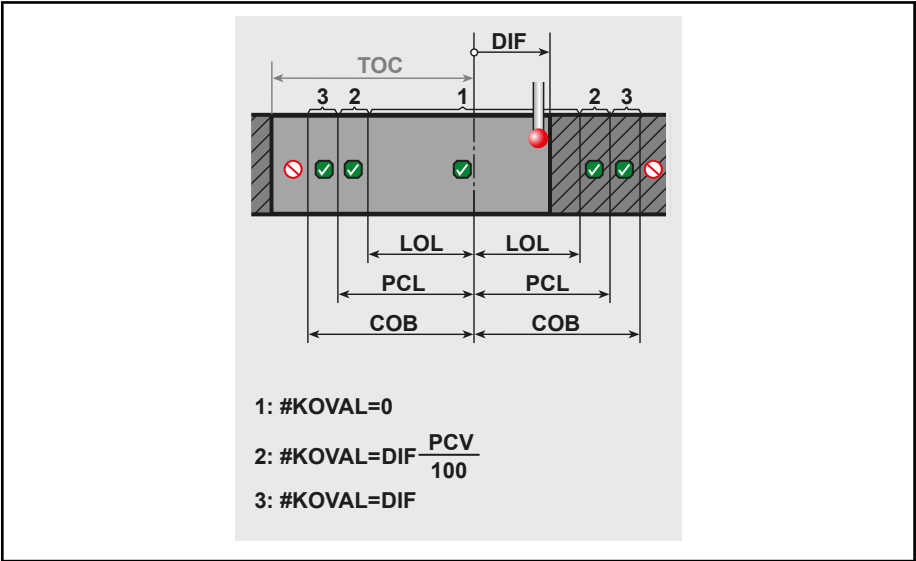


Fig. 4-69: Percentage compensation overview

Parameter

Parameter	Name	Properties	Values	Pre-assignment/Range
DIF	Differential dimension	Mandatory	REAL	
PCV	Percentage compensation value	Mandatory	REAL	
COB	Compensation limit	Mandatory	REAL	
PCL	Partial compensation limit	Mandatory	REAL	
LOL	Lower limit	Mandatory	REAL	

Tab. 4-57: Parameter call

Result variables

Parameter	Description	Values	Area
SD.SysPr-Re-sult.VAL.KOVAL	Dimensional compensation	REAL	double precision
#KOVAL	Dimensional compensation	REAL	single precision

Tab. 4-58: Output values

Description The Percentage compensation (G543) cycle determines the effective compensation value for a measuring point by percentage evaluation of the meas-

uring value recorded for a measuring point under consideration of the empirical value.

For percentage compensation, the following has to apply:

Between the partial compensation limit and the compensation limit, a full compensation applies. Under the lower limit, no compensation applies.

If the differential dimension is below the lower limit, the compensation value SD.SysPrResult.VAL.KOVAL is assigned zero. If the differential dimension is between the lower limit and the partial compensation limit, the output variable returns the differential dimension under consideration of the percentage compensation value. If the differential dimension is between the partial compensation limit and the compensation limit, the differential dimension is transmitted to the output variable without any compensation. If the differential dimension exceeds the compensation limit, the control switches to stop state and the error message "Rejected part" is returned. The following flow chart illustrates the cycle logics.

Procedure/processing

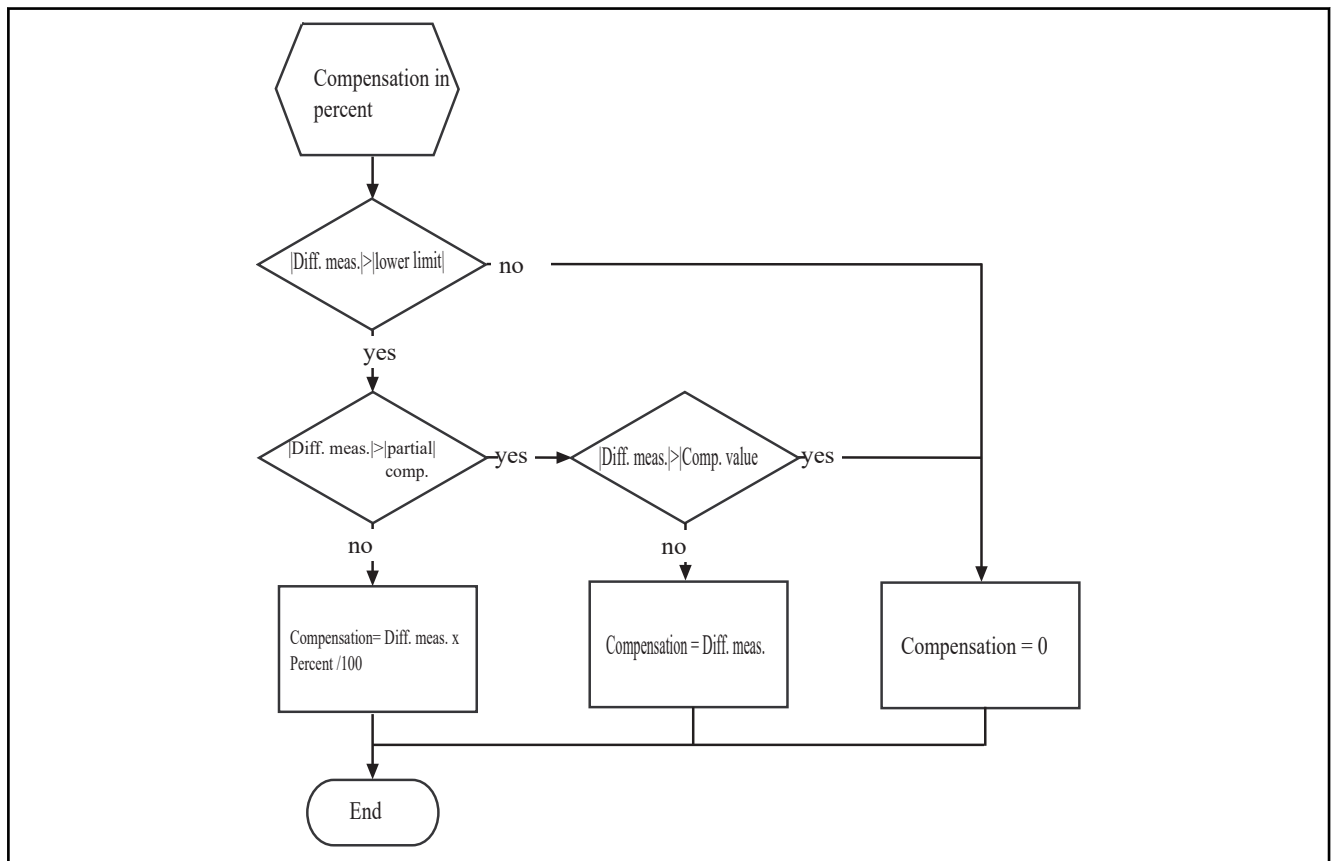


Fig. 4-70:

Flow chart: Percentage compensation

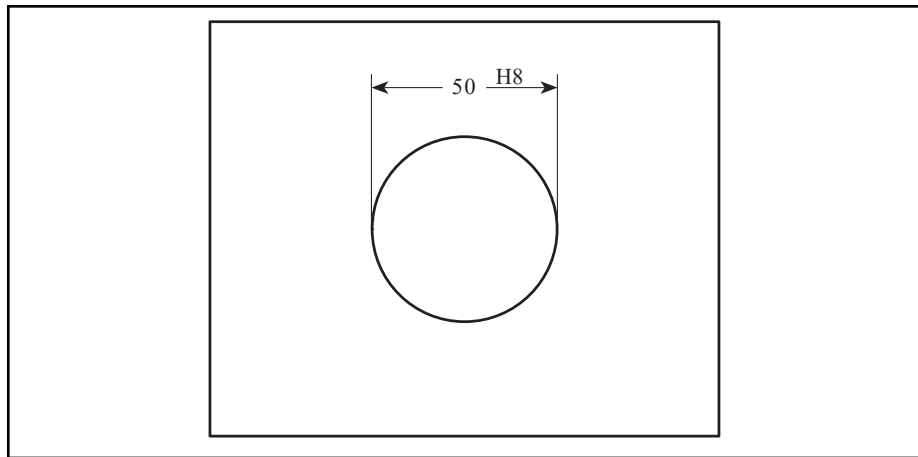
Example

Fig. 4-71: Programming example: Percentage compensation value
Percentage compensation

```
N10 G543 (DIF0.009, PCV90, COB0.039, PCL0.030, LOL0)
```

After processing of this NC program, the output variable is assigned the following value:

Dimensional compensation #KOVAL -0.0081

4.6 Processing Compensation

4.6.1 Workpiece Compensation

General information

Incorrect workpiece dimensions are corrected depending on the error cause.

The following two methods are most common:

- Zero point offset (all dimensions in one axis)
- Position offset (individual dimension) by adding a compensation value

Zero point

Zero point offset

```
1 KORR=0.5 ;user variable with content of a compensation value
N10 ZOTSEL (/mnt/BRC_DEMO/Fraesen/MYTABLE.zot)
N20 G54 X0 ;NPV G54 Correct axis X
1 ZOT("X", 54)=ZOT("X", 54)+CORR
N30 X0 ;retract compensation
```

Position

Position offset

```
1 CORR=0.05 ;user variable with content of a compensation value
N190 (MSG FINISH EXTERNAL CONTOUR)
N200 G0 X90 Z10 S250 M4
N210 G0 G42 G96 X80 Z0 RND(0.1)
N220 G1 X[140+KORR] CHL(0.5) ;External diameter compensation
N230 G1 Z-25 RND(1.2)
N240 G1 X200 CHL(1)
N250 G40 G1 Z-30 CHL()
N260 G0 Z100
```

4.6.2 Tool Compensation

General information

Prior to their initial use, tools are only roughly measured on a tool presetter and then automatically, exactly measured in the machine. Additionally, tools have to be measured again due to the wear occurring during processing. In the following examples for length and radius, the tool in sector 2 position 1 is corrected.

Length

Tool compensation- length

```

1 CORR=0.3 ;user variable with content of a compensation value
N10 T[1]
N20 G47 Z0
1 WAIT
;Reading out L3 Sector2 Position1 from database
2 L3_OLD!=DBTAB("/DBT1/Rec.UD.Ed[1].Geo.L3",2,1)
;Writing compensation L3 Sector2 Position1 in database
3 DBTAB("/DBT1/Rec.UD.Ed[1].Geo.L3",2,1)=L3_OLD!+KORR
;Writing compensation L3 to control
4 DCT(3,1,0)=DCT(3,1,0)+CORR
N30 Z0 ;retract compensation

```

Radius

Tool compensation - radius

```

1 CORR=0.05 ;user variable with content of a compensation value
N10 T[4] ;Load milling cutter D50
N20 ED1 ;Select Edge1
N30 G47 G0 X-30 Y-30 Z10 S4500 M3
N40 Z-5
N50 G1 G42 X0 Y0 F1000 ;establish radius compensation
N60 X50 ;contour machining with radius compensation
N70 G40 X80 Y0 ;remove radius compensation
N80 Z10
1 WAIT
;Reading out R Sector 2 Position1 from database
2 R_OLD!=DBTAB("/DBT1/Rec.UD.Ed[1].Geo.Rad",2,1)
;Writing compensation R Sector2 Position1 in database
3 DBTAB("/DBT1/Rec.UD.Ed[1].Geo.Rad",2,1)=R_OLD!+KORR
;Writing compensation R to control
4 DCT(4,1,0)=DCT(4,1,0)+KORR
N90 G0 X-30 Y-30 Z10
N100 Z-5
N110 G1 G42 X0 Y0 F1000 ;establish radius compensation
N120 X50 ;contour machining with new radius compensation
N130 G40 X80 Y0 ;remove radius compensation
N140 Z10 M5 M30

```

5 Developing an individual measuring cycle automatic

5.1 General information

To process special measuring tasks, individual measuring cycles can be created as extension to the listed sample solutions. It is recommended, to use the STP_PRBASE measuring cycle which is also called within the sample solutions.

In the following section, a special measuring task is given as example. The task is solved by an individual measuring cycle and an individual input mask. Subsequently, the basic cycle STP_PRBASE as well as the SD variable PRBASE_t is then explained in detail.

5.2 Example: Creating a user-defined cycle for automatic

5.2.1 Task

Creating a cycle to probe the offset

5.2.2 Task steps

General information

- Define a file name
- Define input variables
- Define output variables
- Generating a subroutine
- Generate an input mask
- Functional test

Define a file name

The file name is defined with MSHOULDER.

Define input variables

Parameter	Mandatory	Type	Area	Description	
PNO	Yes	INTEGER	1..2	Probe number	
IAX	Yes	STRING	8	Infeed axis	
SDI	No	REAL	REAL	Safety distance	ABS
IFE	No	REAL	REAL	Infeed feed	mm/min
PLE	Yes/No	REAL	REAL	Measuring height	ABS
	Yes	If infeed axis(IAX) unequal to measuring axis(PAX)			
	No	If infeed axis(IAX) equal to measuring axis(PAX)			
RLE	No	REAL	REAL	Retraction height	ABS
RFE	No	REAL	REAL	Retraction feed	mm/min
PDI	Yes	REAL	REAL	Measuring distance	REL
PFE	No	REAL	REAL	Measuring feed	mm/min
PAX	Yes	STRING	8	measuring axis	
PPO	Yes	REAL	REAL	Measuring position	ABS

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Parameter	Mandatory	Type	Area	Description	
MAX	Yes	STRING	8	Traversing axis	
DIS				Position distance in the traversing axis	REL
SDT	Yes	REAL	REAL	Offset depth	REL

Define output variables

Parameter	Type	Area	Description
#RESULT1	REAL	REAL	Measured value1
#RESULT2	REAL	REAL	Difference measured value1
#RESULT3	REAL	REAL	Measured value2
#RESULT4	REAL	REAL	Difference measured value2
#RESULT5	REAL	REAL	Offset dimension with sign

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction 1=positive 2= negative			
Parameter	Type	Area	Description
RUNS	INTEGER	INTEGER	Number of measurements

Generating a subroutine

Solution: The basic cycle is called twice. The first position is the position approached before the cycle call. The second position is the distance defined by the input variables "DIS". The results of the two measurements are offset against one another and provided in the global output variables #RESULT1 to #RESULT5 for evaluation.

Program excerpt:

*Subroutine**Program:*

```

;---- 1. subroutine call---
10560 CALL STP_PRBASE[PPO!,PDI!,FEED!,PAXNO%,PNO%,1,0,0]
10570 #RESULT1=SD.SysPrResult.AXISRES[PAXNO%]
10580 #RESULT2=PPO!-#RESULT1
;---- 2. approach measuring position
N1040 G91 G1 [AXP(MAXNO%,DIS!)] F[ZFEED!]
N1050 [AXP(IAXNO%,SDT!)] F[ZFEED!]
N1060 G90
;---- 2. subroutine call ---
10590 CALL STP_PRBASE[PPO!+SDT!,PDI!,FEED!,PAXNO%,PNO%,1,0,0]
10600 #RESULT3=SD.SysPrResult.AXISRES[PAXNO%]
10610 #RESULT4=PPO!+SDT!-#RESULT3 : #RESULT5=#RESULT3-#RESULT1

```

Entire subroutine:

Entire subroutine

```

(ADR_PARA)
(%SRunEntry%=NO)
10000 SRLOCK%=SD.SysChSRun.LockTargBlock : SD.SysChSRun.LockTargBlock=1 : GOTO .NOCOM
;-----
; program: MSHOULDER
; author : Mustermann
; version: 1.0.00

```

```

; date : 09/01/2014
;
;-- Interface: -----
; MSHOULDER (PNO, IAX, SL, IFE, PLE, RLE, RFE, PDI, PFE, PAX, PPO, MAX, DIS, SDT)
;
; Parameter:
; PNO% = probe number          mandatory 1..2
; IAX$ = infeed axis           mandatory max. 8 characters
; SL! = safety distance        optional standard=output position
; IFE! = infeed                optional >0, Standard=SD.SysPrBase.PROBE[PNO%].POSFEED
; PLE! = measuring height      mandatory if IAX$<>PAX$
; RLE! = retracting height     optional Standard=SL!
; RFE! = retracting feed       optional Standard=rapid traverse
; PDI! = measuring distance    mandatory <>0
; PFE! = measuring feed        optional >0,
;                               Standard=SD.SysPrResult.CAL[PNO%].AXIS[PAXNO%].DIR[<Richtung>].FEED
;
; PAX$ = measuring axis        mandatory max. 8 characters
; PPO! = measuring position    mandatory
; MAX$ = traversing axis       mandatory max. 8 characters
; DIS! = distance              mandatory <>0
; SDT! = depth mandatory
;
; error messages: "Mandatory parameter not programmed"
; "Value range exceeded! Valid range ..."
; "Invalid axis name in parameter ..."
; "Measuring distance = 0 invalid"
; warning messages: "Measuring feed unequal to calibration feed"
; subroutines: 1 STP_PRBASE
;-----
10010 .NOCOM
10020 WAIT
10030 DIM IAX$(9) : DIM PAX$(9) : DIM MAX$(9)
10040 IF IAX$=NUL THEN SETERR(4433,"IAX") ENDIF
10050 IF PAX$=NUL THEN SETERR(4433,"PAX") ENDIF
10060 IF MAX$=NUL THEN SETERR(4433,"MAX") ENDIF
;---- AXINF: from the name (ID on number)
10070 CHAN%=SD(8)
10080 IAXNO%=AXINF(IAX$,1,CHAN%,11,ERRNO)
10090 IF ERRNO <> 0 THEN SETERR(4463,"IAX") ENDIF
10100 PAXNO%=AXINF(PAX$,1,CHAN%,11,ERRNO)
10110 IF ERRNO <> 0 THEN SETERR(4463,"PAX") ENDIF
10120 MAXNO%=AXINF(MAX$,1,CHAN%,11,ERRNO)
10130 IF ERRNO <> 0 THEN SETERR(4463,"MAX") ENDIF
;---- Save basic offset in the infeed feed on variable BO3!
10140 BO3!=SD.SysPrBase.PROBE[PNO%].GEO.BO[IAXNO%]
;---- save current position ---
10150 SAD!=WCS(IAXNO%)
;---- Checking the input parameters ---
10160 IF PPO!=NUL THEN SETERR(4433,"PPO") ENDIF
10170 IF SL!<>NUL THEN SAD!=SL!-BO3! ENDIF
10180 IF PDI!=NUL THEN SETERR(4433,"PDI") ENDIF
10190 IF PDI!=0 THEN SETERR(4438,"PDI") ENDIF
10200 IF PNO%=NUL THEN SETERR(4433,"PNO") ENDIF
10210 IF DIS!=NUL THEN SETERR(4433,"DIS") ENDIF
10220 IF SDT!=NUL THEN SETERR(4433,"SDT") ENDIF
;---- obtain measuring direction from signs of the measuring distance PDI
10230 IF PDI!>0 THEN DIR%=1 : DIRFAC!=1 ELSE DIR%=2 : DIRFAC!=-1 ENDIF
;---- Provide infeed feed ZFEED!
10240 ZFEED!=SD.SysPrBase.PROBE[PNO%].SAVFEED
10250 IF IFE!<>NUL THEN
10260 IF IFE!<=0 THEN SETERR(4311,"IFE>0") ENDIF
10270 ZFEED!=IFE!
10280 ENDIF
;---- Provide measuring feed FEED!
10290 FEED!=SD.SysPrResult.CAL[PNO%].AXIS[PAXNO%].DIR[DIR%].FEED
10300 IF PFE!<>NUL THEN IF PFE!<>FEED! THEN
10310 IF PFE!<=0 THEN SETERR(4311,"PFE>0") ENDIF
10320 FEED!=PFE!
10330 WAIT
; Warning "Measuring feed unequal to calibration feed"
10340 SETWARN(4442)
10350 ENDIF ENDIF
10360 IF RFE!<>NUL THEN
10370 IF RFE!<=0 THEN SETERR(4311,"RFE>0") ENDIF
10380 ENDIF
10390 IF IAXNO%=PAXNO% THEN
10400 IF SD.SysPrBase.PROBE[PNO%].TOOL=FALSE THEN
10410 BALLRAD!=SD.SysPrBase.PROBE[PNO%].GEO.R
10420 ELSE
10430 BALLRAD!=TCV("RAD")
10440 ENDIF
10450 KRM!=ABS(PDI!/2)+BALLRAD!
10460 MH!=PPO!-KRM!*DIRFAC!-BO3! 10470 ELSE

```

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```

10480 IF PLE!=NUL THEN SETERR(4433,"PLE") ENDIF
10490 MH!=PLE!-SD.SysPrBase.PROBE[PNO%].GEO.BO[IAXNO%]
10500 ENDIF
;---- Save G-functions ---
10510 DIM RELABS$(3) : DIM RAP$(3) : DIM GF_FEED$(3)
10520 RELABS$=NCF("G90") : RAP$=NCF("G00") : GF_FEED$=NCF("G94") : F!=SD(5,1,2)
;---- Probe ON
N1000 [SD.SysPrBase.PROBE[PNO%].LOG.AUXON] G94 G90
10530 IF SL!<>NUL THEN
; Use absolute approach for safety distance infeed axis
N1010 G0 [AXP(IAXNO%,SAD!)]
; use absolute approach for measuring height with G1 infeed axis
N1020 G1 [AXP(IAXNO%,MH!)] F[ZFEED!]
10540 ELSE ; use absolute approach for measuring height with G0 infeed axis
N1030 G0 [AXP(IAXNO%,MH!)]
10550 ENDIF
;---- subroutine call ---
10560 CALL STP_PRBASE[PPO!,PDI!,FEED!,PAXNO%,PNO%,1,0,0]
10570 #RESULT1=SD.SysPrResult.AXISRES[PAXNO%]
10580 #RESULT2=PPO!-#RESULT1
;---- Approach second measuring position
N1040 G1 [AXP(MAXNO%,DIS!)] F[ZFEED!]
N1050 [AXP(IAXNO%,SDT!)] F[ZFEED!]
N1060 G90
;---- 2. subroutine call ---
10590 CALL STP_PRBASE[PPO!+SDT!,PDI!,FEED!,PAXNO%,PNO%,1,0,0]
10600 #RESULT3=SD.SysPrResult.AXISRES[PAXNO%]
10610 #RESULT4=PPO!+SDT!-#RESULT3 : #RESULT5=#RESULT3-#RESULT1
;---- delete warning message ---
10620 CLRWARN(,4442)
;---- Retract ---
10630 IF RLE!=NUL THEN RPOS!=SAD! ELSE RPOS!=RLE!-BO3! ENDIF
10640 IF RFE!=NUL THEN N1070 G0 [AXP(IAXNO%,RPOS!)]
10650 ELSE N1080 G1 [AXP(IAXNO%,RPOS!)] F[RFE!]
10660 ENDIF
;---- Restore G-functions ---
N1090 [RELABS$] [RAP$] [GF_FEED$] F[F!]
10670 WAIT
10680 SD.SysChSRun.LockTargBlock=SRLOCK%

```

Generate an input mask

The input mask "Probe Point" has been copied and adjusted.

Entry screen

```

;--- Measure offset ---
;/%CHBEGIN%
;/%GROUP% PROBE_WP_MILL
;/%LANG% MTXCyclesProbe
;/%NAME% Measure offset
;/%P% %%PNO INT[1..2] %TN0154% %VALID%MAND
;/%P% %%IAX STRING[8] %TN0134% %VALID%MAND
;/%P% %%SL %TN0170%
;/%P% %%IFE REAL[0.001..999] %TN0136%
;/%P% %%PLE %TN0152%
;/%P% %%RLE %TN0166%
;/%P% %%RFE REAL[0.001..999] %TN0164%
;/%P% %%PDI %TN0148% %VALID%MAND
;/%P% %%PFE REAL[0.001..999] %TN0150%
;/%P% %%PAX STRING[8] %TN0146% %VALID%MAND
;/%P% %%PPO %TN0160% %VALID%MAND
;/%P% %%MAX STRING[8] traversing axis %VALID%MAND
;/%P% %%DIS distance of traversing axis %VALID%MAND
;/%P% %%SDT depth of offset %VALID%MAND
;/%GF% MSHOULDER_H1.jpg %TN0045%
;/%C% #RESULT1 = measured value1
;/%C% #RESULT2 = difference measured value1
;/%C% #RESULT3 = measured value2
;/%C% #RESULT4 = Difference measured value2
;/%C% #RESULT5 = offset measure with sign
;/%N% MSHOULDER(%P%)
;/%CHEND%

```

The file C0.jpg is provided as template to create user-defined graphics.

For more information to create cycle input masks, see "Rexroth IndraMotion MTX 13VRS Commissioning".

Functional test

Create a main program to test different transfer parameters. The transfer parameters have to be changed using the input mask.

Example main program, probe offset:

Functional test

```

N10 $1
;-----
; measure offset at workpiece
;-----
N20 T999 M6
N30 ED1
N40 G47
N50 M97 ; workpiece probe ON
N60 G54 G0 X120 Y0 Z100
N70 MSHOULDER (PNO2, IAX Z, IFE1500, PDI-20, PAX Z, PPO0, MAX X, DIS34, SDT-30)
1 PRN#(0,"1. measured value: ####.#### Diff: ####.####",#RESULT1,#RESULT2)
2 PRN#(0,"2. measured value: ####.#### Diff: ####.####",#RESULT3,#RESULT4)
3 PRN#(0,"offset: ###.####",#RESULT5)
N80 M98 ; workpiece probe OFF
N90 M30

```

5.3 The basic cycle STP_PRBASE

5.3.1 General information

The cycle task consists in probing a point, returning the measurement result as measured value or to write it as switching offset.

The probe base offsets of the SD variables are automatically taken into consideration. In the initialization variables, it is specified whether the probe length and its radius/cube edge lengths are taken from the tool management or also from the SD variables for calculation.

Additionally, it is possible in this cycle to resume travelling of the measuring distance following a probe error (e.g. by reset) without cancelling the NC program

The input variable probe number is limited to the value 2. The input variable axis number and the output variable AXISRES are limited to the value 3 and mirror the first 3 channel axes. If required, these limits can be raised (see [chapter 7 "Commissioning" on page 191](#)).

5.3.2 Basic cycle



As the basic cycle is not supported by an input mask with graphics, no corresponding short designations are used.

Syntax
Input variables

STP_PRBASE(P1,P2,P3,P4%,P5%,P6%,P7%,P8%,P9\$)

Parameter	Mandatory	Type	Area	Description
P1	Yes	REAL	REAL	Position
P2	Yes	REAL	REAL	Measuring/calibration distance
P3	Yes	REAL	REAL	Measuring/calibration feed
P4%	Yes	INT	1..3	Axis
P5%	Yes	INT	1..2	Probe number
P6%	Yes	INT	0..2	Calibrate/probe/reversal measurement
P7%	Yes	INT	0..1	Probe tool radius/tool length
P8%	NO	INT	0..1	Probe/check
P9\$	NO	STRING	8	Spindle stop command

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Initialization variables

SD.SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction 1=positive 2= negative			
Parameter	Type	Area	Description
CALI	BOOL	TRUE..FALSE	Calibrated
VAL	REAL	REAL	Switching offset
FEED	REAL	REAL	Calibration feed
PRPOS	REAL	REAL	Switching position MCS

Output variables

SD. SysPrResult.CAL[n].AXIS[i].DIR[j].Parameter			
[n] 1..2 Probe number			
[i] 1..3 Axis number			
[j] 1..2 Direction 1=positive 2= negative			
Parameter	Type	Area	Description
CALI	BOOL	TRUE..FALSE	Calibrated
VAL	REAL	REAL	Switching offset
FEED	REAL	REAL	Calibration feed
PRPOS	REAL	REAL	Switching position MCS
YEAR	STRING	4	Year: YYYY
DATE	STRING	5	Day and month: DD:MM
TIME	STRING	8	Time: HH.MM.SS
RUNS	INT	INT	Number of measurements
Probe (P6=1)			
SD. SysPrResult.AXISRES[i]			
[i] 1..3 Axis number			
Parameter	Type	Area	Description
AXISRES	REAL	REAL	Measured value
Reversal measurement (P6=2)			
Parameter	Type	Area	Description
#RESULT!	DOUBLE	DOUBLE	Measured value

Error messages

- Position not found
- Probe deflected during positioning
- Position not programmed
- Measuring distance not programmed
- Feed not programmed

- Axis not programmed
- Probe number invalid
- Probe no.: Axis: Direction: Not calibrated
- Tool length correction is not active
- Parameter P6 has to have value 0, 1 or 2
- Measuring distance or sphere radius too large
- Invalid starting position or measuring distance sign incorrect!

Sequence

The probe approaches the starting position with positioning feed from its initial position. The probe always positions half the measuring distance (P2) before the command position (P1). The sphere radius, the tool or probe length as well as the geometries of a table probe are taken into consideration. Approaching of the starting position by the cycle is monitored. If the probe is deflected while approaching the starting position, the axis is decelerated with maximum delay and a language-dependent error message is reported. This serves as probe and collision protection.

Measurement is started after the starting position has been approached. The sign of the measuring distance (P2) determines the direction of motion of the axis. The probe travels the specified measuring distance with the specified measuring feed (P3).

If no measuring feed is programmed, the cycle uses the calibration feed to increase measuring accuracy. If a deviating measuring feed is programmed, the cycle outputs a warning without interrupting the measurement.

When triggering the probe, the axis is decelerated with maximum negative acceleration. Distance to go is deleted. The position at which the probe is triggered is saved in the variable `AXISRES[n]` (`sdprbase.xsd` structure) during the measurement. During reversal measurement, the position is saved in the global variable `#RESULT!` and during the calibration, the position is saved in the variable `VAL` of the corresponding axis and direction (also structure `sdprbase.xsd`). The status "calibrated", the calibration velocity and the machine coordinate position are also saved. All parameters influencing the resulting value (probe and tool length, probe sphere and basic offsets) have already been removed. If a radio probe switches off on the measuring distance to prolong the battery life, the cycle approaches the starting position again. Thus, it is ensured that the axis reaches the programmed velocity at any rate.

Subsequently, the probe which is also monitored travels back to its initial position. The use case with the probe being positioned on the table and the tool in the spindle is almost identical and is therefore not explained in detail.

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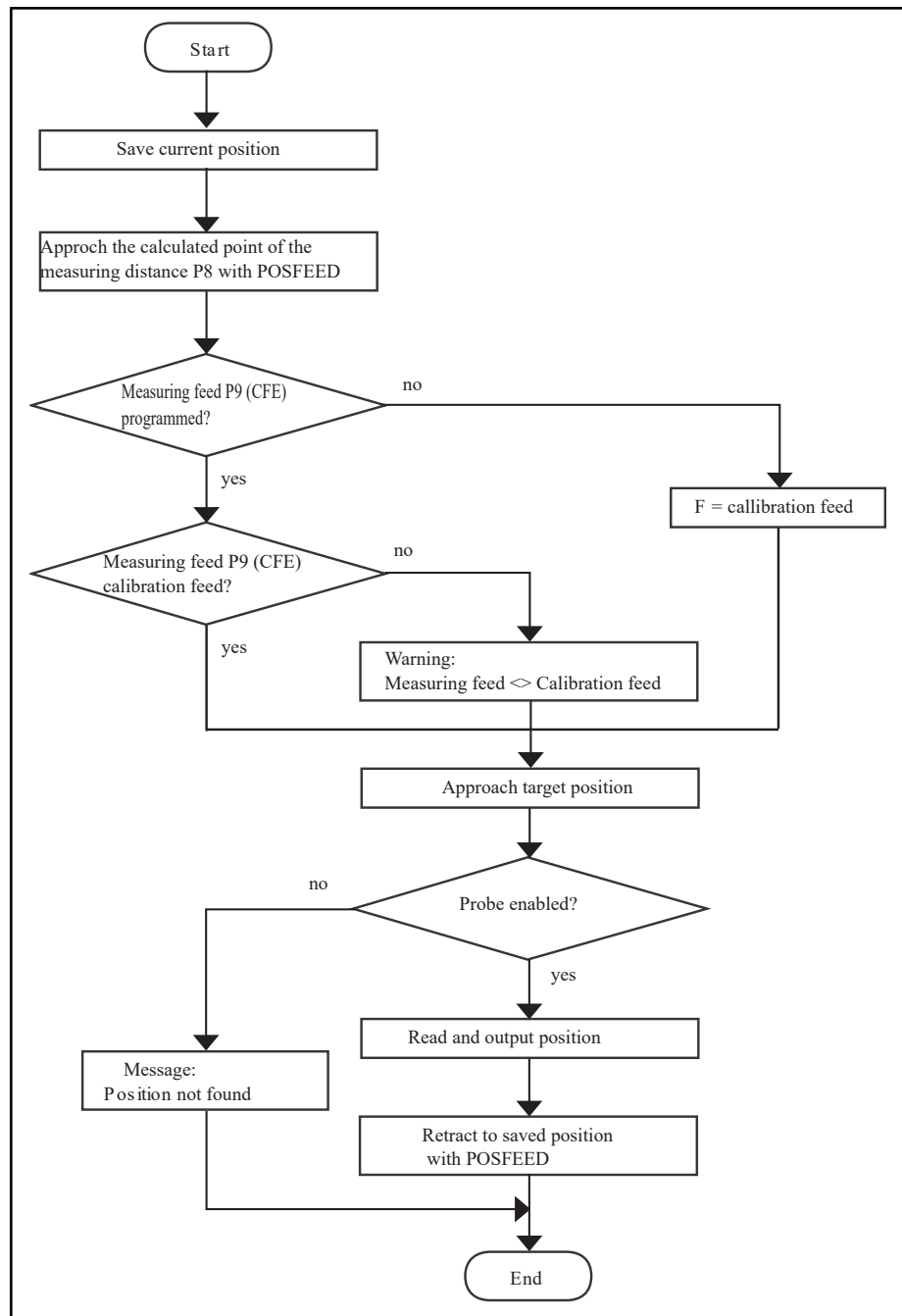


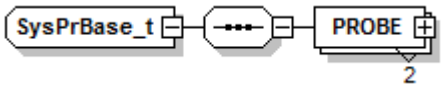
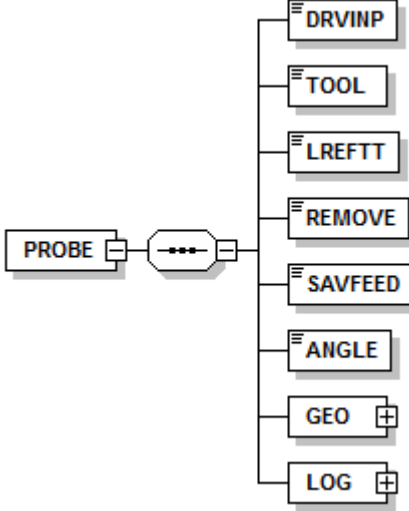
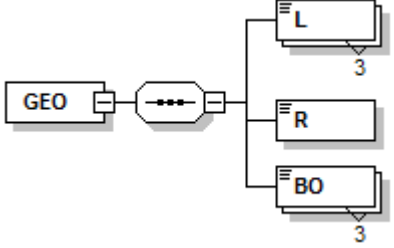
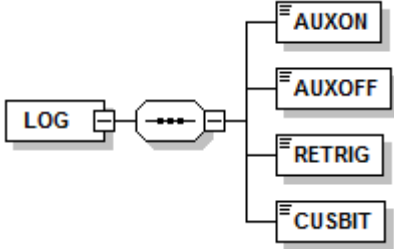
Fig. 5-1: Basic cycle sequence in the measuring axis

5.4 SD variables for probe data

5.4.1 General information

In the following structures, the geometry data of a tool probe, the positioning velocity, the auxiliary functions, the calibration values as well as the measurement results are stored. The variable names are SD.SysPrBase, SD.SysPrResult and SD.SysPrMan.

5.4.2 SD variable structure "SysPrBase"

SysPrBase_t			
		PROBE	See "PROBE" on page 108
SysPrBase_t/PROBE			
		DRVINP	Int_t See "DRVINP" on page 108
		TOOL	xs:Boolean See "TOOL" on page 108
		LREFTT	xs:Boolean See "LREFTT" on page 108
		REMOVE	Int_t See "REMOVE" on page 108
		SAVFEED	xs:float See "SAVFEED" on page 108
		ANGLE	xs:float See "ANGLE" on page 108
		GEO	See "GEO" on page 108
		LOG	See "LOG" on page 108
SysPrBase_t/PROBE/GEO			
		L	xs:float See "L" on page 108
		R	xs:float See "R" on page 108
		BO	xs:float See "BO" on page 108
SysPrBase_t/PROBE/GEO			
		AUXON	isoLatin1String See "AUXON" on page 108
		AUXOFF	isoLatin1String See "AUXOFF" on page 108
		RETRIG	xs:Boolean See "RETRIG" on page 108
		CUSBIT	isoLatin1String See "CUSBIT" on page 108

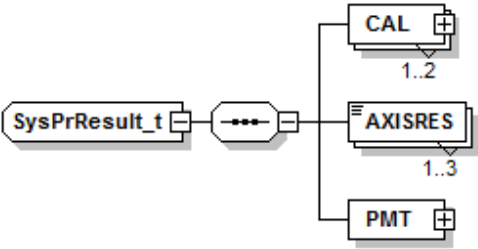
Tab. 5-1: SD.SysPrBase

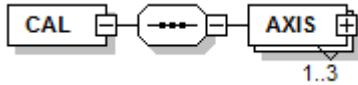
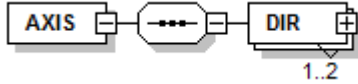
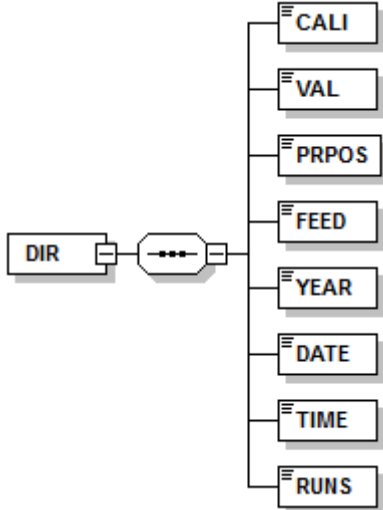
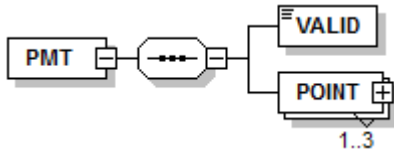
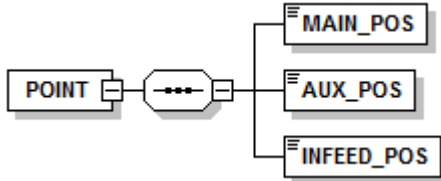
The structured variable of type SysPrBase_t contains the structure PROBE which is instantiated twice. The structured variable of type SysPrResult_t contains a three times instantiated variable AXISRES of type Real and the substructure CAL that has been instantiated twice. In the substructure, the switching offset values are saved by the calibration cycle. By means of this variable, individual measuring cycles can be realized for automatic operation.

For more information about the syntax and the variables for manual operation, refer to the following table "Scheme SD.SysPrMan".

PROBE	The PROBE structure is divided into the substructures GEO and LOG.
DRVINP	If the variable DRVINP is assigned with value "1", the measuring blocks are travelled with G75.1 in the NC program, in case of "2", G75.2 is used.
TOOL	If the variable TOOL is assigned with the value "false", the data of the substructure GEO are evaluated (see fig. 5-4 "HMI commissioning screen 2" on page 117). If the value is "true", the data is read out of the active CPU memory (see fig. 5-3 "HMI commissioning screen 1" on page 117).
LREFTT	If the variable LREFTT is assigned with the value "true", the probe length is related to the tool tip. If the value is assigned with "false", the length refers to the sphere center point.
REMOVE	If the variable REMOVE is assigned with the value "0", the probe is retracted with G00. G01 is used if the value "1" is used and G75.x for the value "3".
SAVFEED	The velocity is entered in mm/min in the float variable SAVFEED with which the cycles are positioned in the probe or the tool. The variable does not correspond to the measurement or calibration velocity during probing. The variable has to be programmed separately in the respective cycle.
ANGLE	The float variable ANGLE is prepared for the orientation angle of the spindle (only applies to spindles with servo functionality).
GEO	The substructure GEO is prepared in case a tool probe is installed in the working space.
L	The respective probe lengths are entered in the float variables L[1..3].
R	The float value R stands for the probe sphere radius.
BO	The float variables BO[1..3] (base offset <axis number>) represent the probe coordinates in the workspace (probe base offset).
LOG	The substructure LOG is intended for PLC communication as well as auxiliary functions.
AUXON	The M-functions to enable the probe are stored in the string variable AUXON.
AUXOFF	The M-functions to disable the probe are stored in the string variable AUX-OFF.
RETRIG	If the probe has to be retriggered, "true" has to be entered in the Bool variable RETRIG. This only applies to radio probes.
CUSBIT	The string variable CUSBIT (custom bit) is used for communication between NC-kernel and PLC. The variable is also only required for retriggerable probes. In the attachment 2 and attachment 4, the probe that is used and a corresponding PLC program section are listed.

5.4.3 SD variable structure "SysPrResult"

SysPrResult_t			
	CAL	See "CAL" on page 109	
	AXISRES	xs:float	See "AXISRES" on page 109
	PMT	See "PMT" on page 109	

SysPrResult_t/CAL			
	AXIS	See "CAL" on page 109	
SysPrResult_t/CAL/AXIS			
	DIR	1..2 direction (1 = positive, 2 = negative)	
SysPrResult_t/CAL/AXIS/DIR			
	CALI	xs:Boolean	See "CALI" on page 110
	VAL	xs:float	See "VAL" on page 110
	PRPOS	xs:float	See "PRPOS" on page 110
	FEED	xs:float	See "FEED" on page 110
	YEAR	isoStrYear_t	See "YEAR" on page 110
	DATE	isoStrDate_t	See "DATE" on page 110
	TIME	isoStrTime_t	See "TIME" on page 110
	RUNS	xs:unsignedInt	See "RUNS" on page 110
SysPrResult_t/PMT			
	VALID	xs:Boolean	
	POINT		
SysPrResult_t/PMT/POINT			
	MAIN_POS	xs:float	
	AUX_POS	xs:float	
	INFEED_POS	xs:float	

Tab. 5-2: SD.SysPrResult

- AXISRES** In the AXISRES variable, the measurement results of the cycles of the respective axis are stored.
- PMT** In the PMT substructure, the respective measurement result of the cycle is written for measurement of an inclined plane.
- CAL** In the CAL substructure, the switching offset values for each axis (AXIS[1..3]) are written in positive and negative axis direction (DIR[1,2]) by the calibration cycle.

- CALI** As soon as the calibration cycle has been completed successfully for the corresponding axis direction, the Bool value CALI is set to "true". The measuring cycles check whether the probe is calibrated for the corresponding axis direction by querying this variable.
- VAL** The switching offset values are saved in the corresponding float variable VAL.
- PRPOS** Simultaneously, the switching point is saved in machine coordinates in the float variable PRPOS.
- FEED** The used calibration rate is saved in the float variable FEED.
- YEAR** Calibration year string length 4 [YYYY]
- DATE** Calibration day and month string length 5 [DD.MM]
- TIME** Calibration time string length 8 [HH.MM.SS]
- RUNS** Number of measurements after the calibration. Unsigned integer: Is set to 0 by the calibration and increased by 1 during the measurement after each cycle.

5.4.4 SD variable structure "SysPrMan"

SysPrMan_t

FUNCNO

FUNCRUN

RESET

INIT

ZOT

CAL

MEAS

+

+

+

+

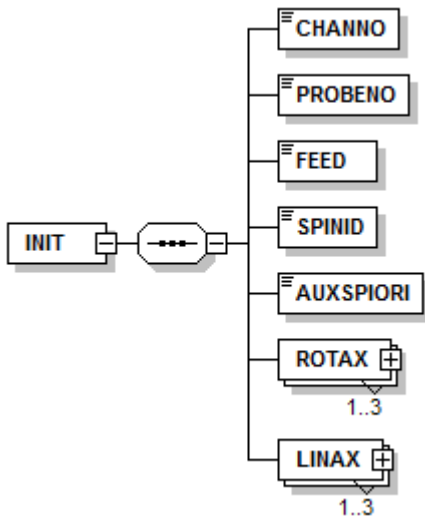
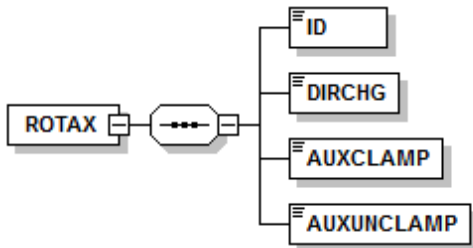
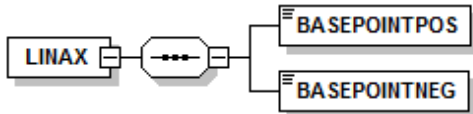
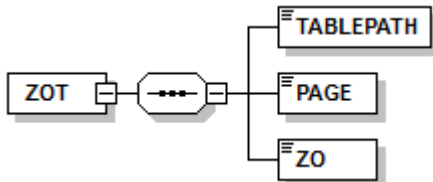
+

+

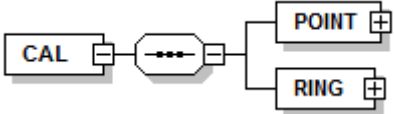
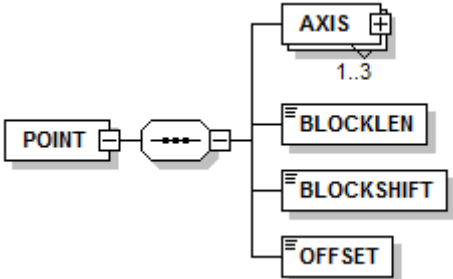
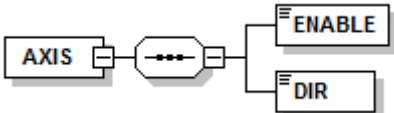
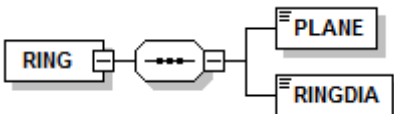
FUNCNO	Int_t	
FUNCRUN	Boolean_t	
RESET	Boolean_t	
INIT	Basic settings	
ZOT	Target description (zero point offset)	
CAL	Calibration settings	
MEAS	Measurement settings	

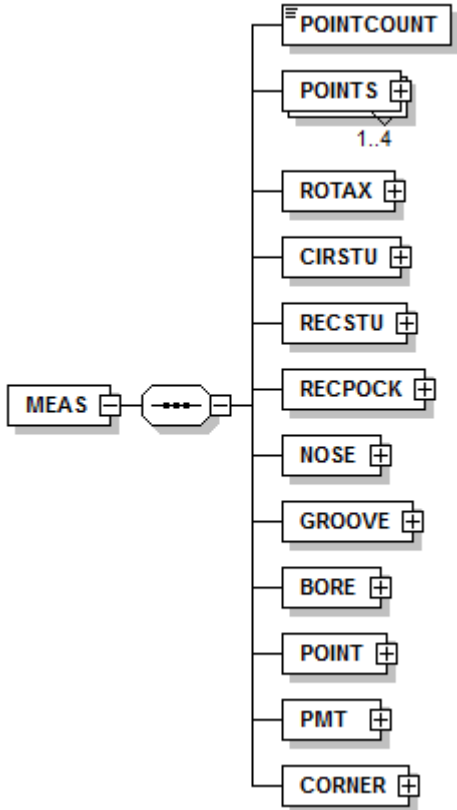
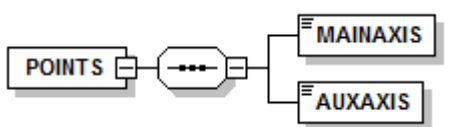
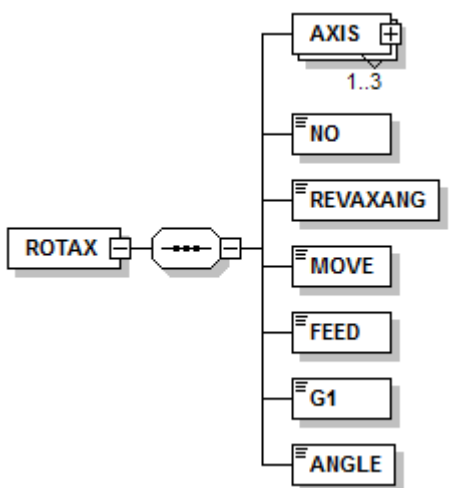
SysPrMan_t/INIT

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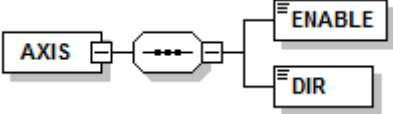
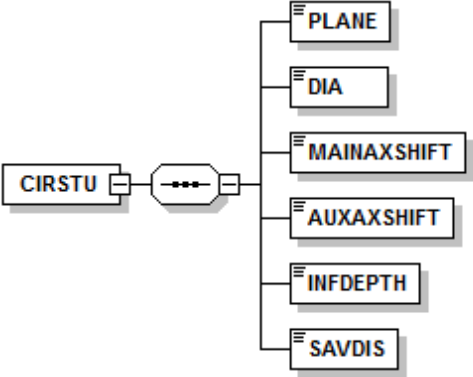
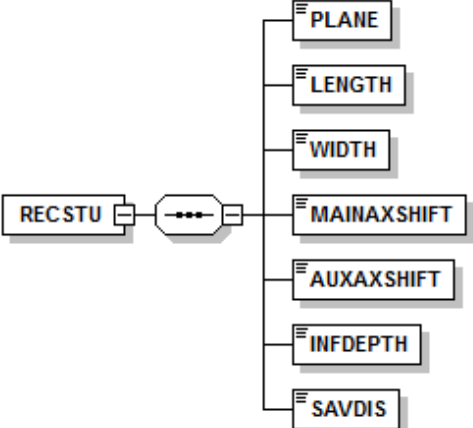
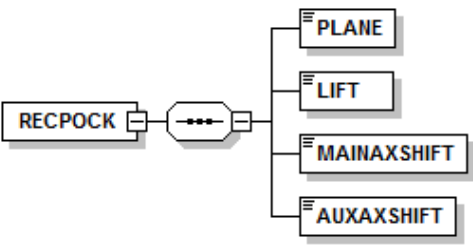
	CHANNO	Int_t	Channel number (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	PROBENO	Int_t	Probe number (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	FEED	Float_t	Calibration and measuring feed (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	SPINID	isoLatin1String	Spindle ID (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	AUXSPIORI	isoLatin1String	Auxiliary function for spindle orientation (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	ROTAX	Rotary axis settings	
	LINAX	Linear axis settings	
SysPrMan_t/INIT/ROTAX			
	ID	isoLatin1String	Rotary axis ID (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	DIRCHG	xs:Boolean	Direction of rotation (see fig. 5-2 "Probe initialization of manual functions" on page 116).
	AUXCLAMP	isoLatin1String	Auxiliary function for clamps (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	AUXUNCLAMP	isoLatin1String	Auxiliary function for unclamping (see fig. 5-2 "Probe initialization of manual functions" on page 116)
SysPrMan_t/INIT/LINAX			
	BASEPOINT-POS	Float_t	Positive calibration position of the linear axis on the machine (see fig. 5-2 "Probe initialization of manual functions" on page 116)
	BASEPOINT-NEG	Float_t	Negative calibration position of the linear axis on the machine (see fig. 5-2 "Probe initialization of manual functions" on page 116)
SysPrMan_t/ZOT			
	TABLEPATH	isoLatin1String	Path and name of the zero point table
	PAGE	Int_t	Zero point offset block
	ZO	Int_t	Zero offset
SysPrMan_t/CAL			

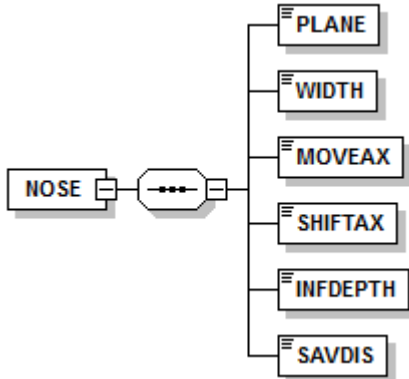
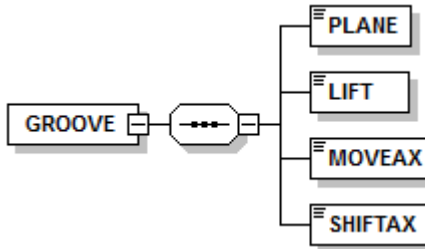
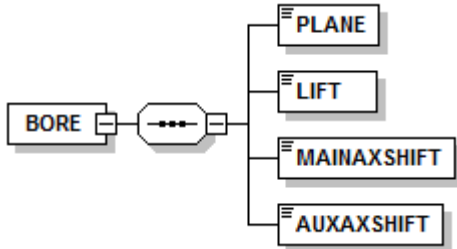
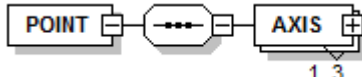
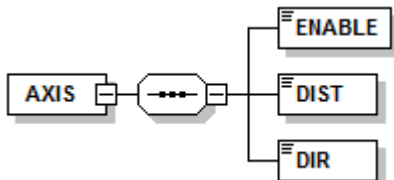
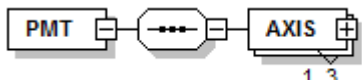
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	POINT	Calibrate point	
	RING	Calibrate in ring	
SysPrMan_t/CAL/POINT			
	AXIS	Calibration axis and direction: A or B or C	
	BLOCKLEN	Float_t	End measure length
	BLOCKSHIFT	Float_t	Offset
	OFFSET	Boolean_t	With or without zero point offset
SysPrMan_t/CAL/POINT/AXIS			
	ENABLE	Boolean_t	
	DIR	Boolean_t	Calibration direction
SysPrMan_t/CAL/RING			
	PLANE	isoLatin1String	Interpolation level
	RINGDIA	Float_t	Calibration ring diameter
SysPrMan_t/MEAS			

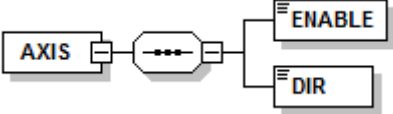
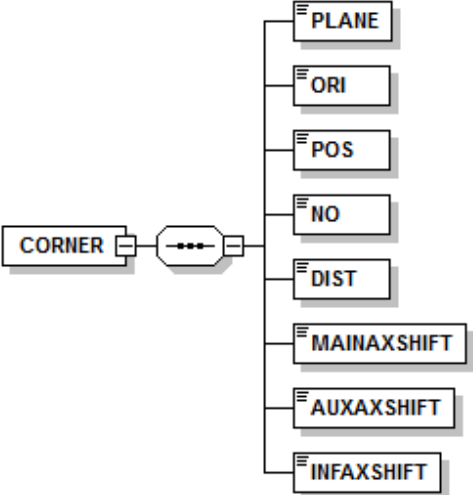
 A block diagram showing a 'MEAS' block connected to a multi-selector (a circle with three dots). This multi-selector branches into eleven separate blocks: 'POINTCOUNT', 'POINTS' (with a '1..4' range indicator), 'ROTAX', 'CIRSTU', 'RECSTU', 'RECPOCK', 'NOSE', 'GROOVE', 'BORE', 'POINT', 'PMT', and 'CORNER'.	<table><tr><td>POINTCOUNT</td><td>Int_t</td><td>Measuring point counter</td></tr><tr><td>POINTS</td><td colspan="2">Maximum 4 measuring points</td></tr><tr><td>ROTAX</td><td colspan="2">ZP probe rotary axis</td></tr><tr><td>CIRSTU</td><td colspan="2">ZP probe circular spigot</td></tr><tr><td>RECSTU</td><td colspan="2">ZP probe rectangular spigot</td></tr><tr><td>RECPOCK</td><td colspan="2">ZP probe (rectangular) pocket</td></tr><tr><td>NOSE</td><td colspan="2">ZP probe land</td></tr><tr><td>GROOVE</td><td colspan="2">ZP probe groove</td></tr><tr><td>BORE</td><td colspan="2">ZP probe boring</td></tr><tr><td>POINT</td><td colspan="2">ZP probe point</td></tr><tr><td>PMT</td><td colspan="2">Probe inclined plane</td></tr><tr><td>CORNER</td><td colspan="2">ZP probe corner</td></tr></table>	POINTCOUNT	Int_t	Measuring point counter	POINTS	Maximum 4 measuring points		ROTAX	ZP probe rotary axis		CIRSTU	ZP probe circular spigot		RECSTU	ZP probe rectangular spigot		RECPOCK	ZP probe (rectangular) pocket		NOSE	ZP probe land		GROOVE	ZP probe groove		BORE	ZP probe boring		POINT	ZP probe point		PMT	Probe inclined plane		CORNER	ZP probe corner	
POINTCOUNT	Int_t	Measuring point counter																																			
POINTS	Maximum 4 measuring points																																				
ROTAX	ZP probe rotary axis																																				
CIRSTU	ZP probe circular spigot																																				
RECSTU	ZP probe rectangular spigot																																				
RECPOCK	ZP probe (rectangular) pocket																																				
NOSE	ZP probe land																																				
GROOVE	ZP probe groove																																				
BORE	ZP probe boring																																				
POINT	ZP probe point																																				
PMT	Probe inclined plane																																				
CORNER	ZP probe corner																																				
SysPrMan_t/MEAS/POINTS																																					
 A block diagram showing a 'POINTS' block connected to a multi-selector (a circle with three dots). This multi-selector branches into two separate blocks: 'MAINAXIS' and 'AUXAXIS'.	<table><tr><td>MAINAXIS</td><td>Float_t</td><td>Main axis</td></tr><tr><td>AUXAXIS</td><td>Float_t</td><td>Secondary axis</td></tr></table>	MAINAXIS	Float_t	Main axis	AUXAXIS	Float_t	Secondary axis																														
MAINAXIS	Float_t	Main axis																																			
AUXAXIS	Float_t	Secondary axis																																			
SysPrMan_t/MEAS/ROTAX																																					
 A block diagram showing a 'ROTAX' block connected to a multi-selector (a circle with three dots). This multi-selector branches into seven separate blocks: 'AXIS' (with a '1..3' range indicator), 'NO', 'REVAXANG', 'MOVE', 'FEED', 'G1', and 'ANGLE'.	<table><tr><td>AXIS</td><td colspan="2">Measuring axis and direction: A or B or C</td></tr><tr><td>NO</td><td>Int_t</td><td>Rotary axis: A=1 or B=2 or C=3</td></tr><tr><td>REVAXISANG</td><td>isoLatin1String</td><td>Reference axis</td></tr><tr><td>MOVE</td><td>Boolean_t</td><td>Traverse rotary axis</td></tr><tr><td>FEED</td><td>Float_t</td><td>Measuring feed</td></tr><tr><td>G1</td><td>Boolean_t</td><td>Positioning mode rotary axis</td></tr><tr><td>ANGLE</td><td>Float_t</td><td>Set angle</td></tr></table>	AXIS	Measuring axis and direction: A or B or C		NO	Int_t	Rotary axis: A=1 or B=2 or C=3	REVAXISANG	isoLatin1String	Reference axis	MOVE	Boolean_t	Traverse rotary axis	FEED	Float_t	Measuring feed	G1	Boolean_t	Positioning mode rotary axis	ANGLE	Float_t	Set angle															
AXIS	Measuring axis and direction: A or B or C																																				
NO	Int_t	Rotary axis: A=1 or B=2 or C=3																																			
REVAXISANG	isoLatin1String	Reference axis																																			
MOVE	Boolean_t	Traverse rotary axis																																			
FEED	Float_t	Measuring feed																																			
G1	Boolean_t	Positioning mode rotary axis																																			
ANGLE	Float_t	Set angle																																			
SysPrMan_t/MEAS/ROTAX/AXIS																																					

Developing an individual measuring cycle automatic

	ENABLE	Boolean_t	
	DIR	Boolean_t	Measuring direction
SysPrMan_t/MEAS/CIRSTU			
	PLANE	isoLatin1String	Interpolation level
	DIA	Float_t	Spigot diameter
	MAINAXSHIFT	Float_t	Main axis offset
	AUXAXSHIFT	Float_t	Auxiliary axis offset
	INFDEPTH	Float_t	Feed increment till measuring height
	SAVDIS	Float_t	Safety distance
SysPrMan_t/MEAS/RECSTU			
	PLANE	isoLatin1String	Interpolation level
	LENGTH	Float_t	Length
	WIDTH	Float_t	Width
	MAINAXSHIFT	Float_t	Main axis offset
	AUXAXSHIFT	Float_t	Auxiliary axis offset
	INFDEPTH	Float_t	Feed increment till measuring height
	SAVDIS	Float_t	Safety distance
SysPrMan_t/MEAS/RECPOC			
	PLANE	isoLatin1String	Interpolation level
	LIFT	Boolean_t	Obstacle in pocket
	MAINAXSHIFT	Float_t	Main axis offset
	AUXAXSHIFT	Float_t	Auxiliary axis offset
SysPrMan_t/MEAS/NOSE			

	PLANE	isoLatin1String	Interpolation level
	WIDTH	Float_t	Land width
	MOVEAX	Int_t	measuring axis
	SHIFTAX	Float_t	Offset
	INFDEPTH	Float_t	Feed increment till measuring height
	SAVDIS	Float_t	Safety distance
SysPrMan_t/MEAS/GROOVE			
	PLANE	isoLatin1String	Interpolation level
	LIFT	Boolean_t	Obstacle in groove
	MOVEAX	Int_t	measuring axis
	SHIFTAX	Float_t	Offset
SysPrMan_t/MEAS/BORE			
	PLANE	isoLatin1String	Interpolation level
	LIFT	Boolean_t	Obstacle in boring
	MAINAXSHIFT	Float_t	Main axis offset
	AUXAXSHIFT	Float_t	Auxiliary axis offset
SysPrMan_t/MEAS/POINT			
	AXIS	Measuring axis and direction: X or Y or Z	
SysPrMan_t/MEAS/POINT/AXIS			
	ENABLE	Boolean_t	
	DIST	Float_t	Offset
	DIR	Boolean_t	Measuring direction
SysPrMan_t/MEAS/PMT			
	AXIS	Measuring axis and direction: X or Y or Z	
SysPrMan_t/MEAS/PMT/AXIS			

Developing an individual measuring cycle automatic

	ENABLE	Boolean_t	
	DIR	Boolean_t	Direction
SysPrMan_t/MEAS/CORNER			
	PLANE	isoLatin1String	Interpolation level
	ORI	Boolean_t	Position: External or internal
	POS	Boolean_t	Position: Top or bottom
	NO	Int_t	Corner number: C1,C2,C3,C4
	DIST	Float_t	Offset
	MAINAXSHIFT	Float_t	Main axis offset
	AUXAXSHIFT	Float_t	Auxiliary axis offset
	INFAXSHIFT	Float_t	Infeed axis offset

Tab. 5-3: SD.SysPrMan

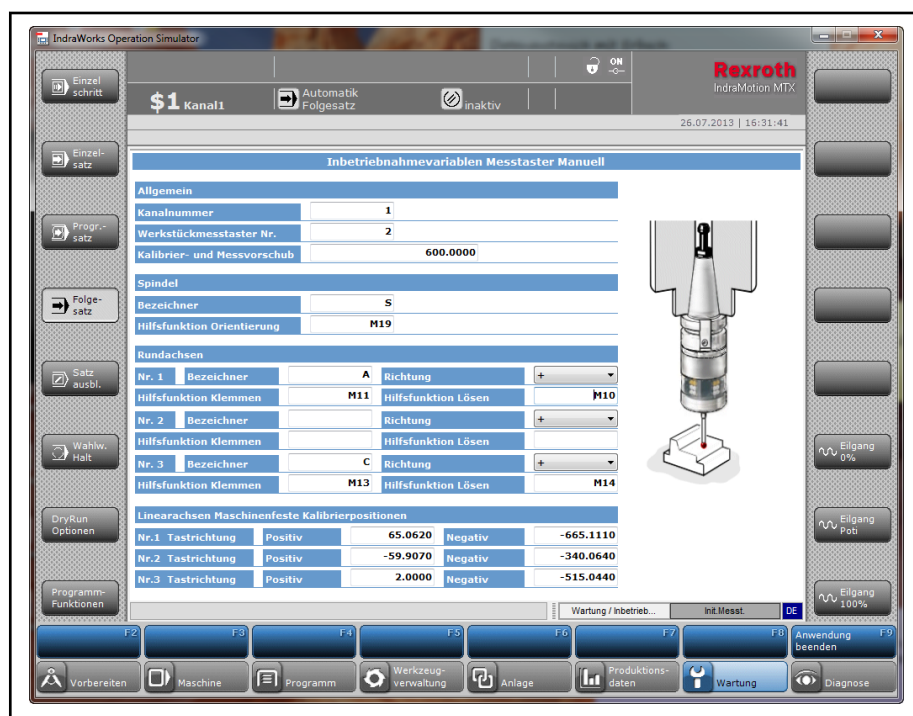


Fig. 5-2: Probe initialization of manual functions

5.4.5 Data input

The following options are available to enter and display SD variables:

- **Data input with variable list**
The SD variable values can be displayed and edited in a variable list.
- **Data input via commissioning image in the maintenance operating area**

The SD variable values for initialization can be displayed and edited in a commissioning image. This screen contains the variables required to commission a probe.

Use <OP8> for the call.

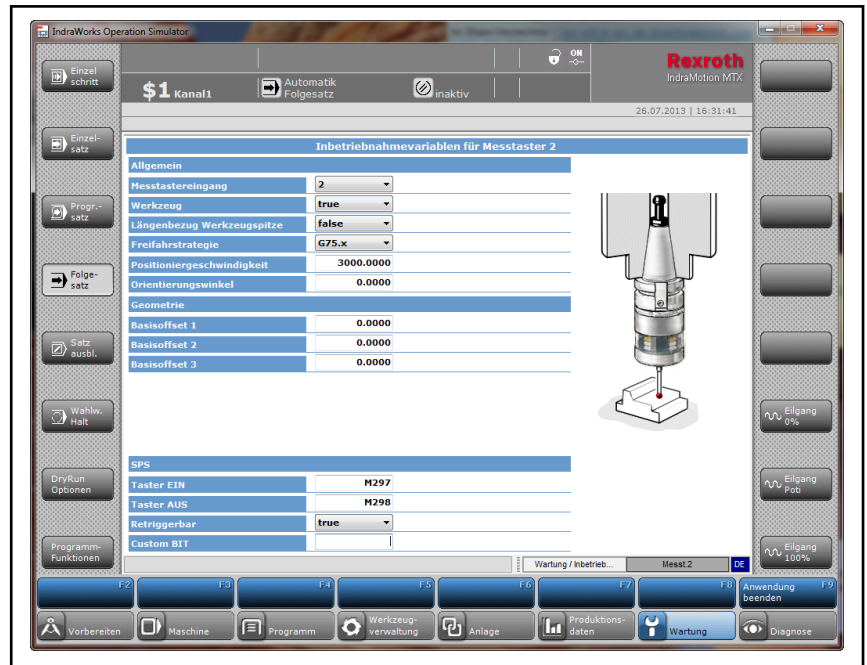


Fig. 5-3: HMI commissioning screen 1

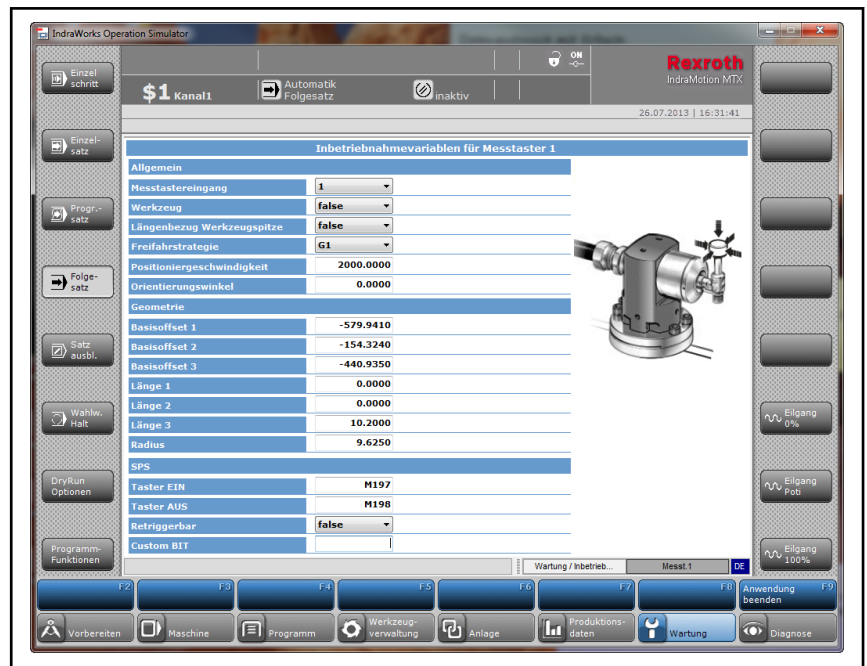


Fig. 5-4: HMI commissioning screen 2

6 Manual probing

6.1 General information

Functions *The following functions are provided:*

- *Probe workpiece zero point*
 - Point
 - Corner
 - Sphere
 - Boring
 - Circular spigot
 - Groove
 - Land
 - Rectangular pocket
 - Rectangular pin
 - Rotary axis
- *Calibrate workpiece probe*
 - at a known point
 - in an adjusting ring
- *Probing inclined plane*
 - Measured values for G230

Preparation The probe has to be loaded via MDI before using the described measuring functions.

Only a single calibrated ball is used in the measurement program. The tool edge and the tool length compensation assigned to the ball have to be enabled before starting the measurement.

The probe has to be enabled before jogging to ensure an active collision monitoring during jogging.

- Sequence**
1. Press the OP key "Prepare" in the "Manual" operation mode
 2. Press the F-key of the measuring task group ("Probe zero point", "Calibrate probe" etc.)
 3. Left-click to select the measuring task
 4. In case of many measuring tasks, a zero point can be included in the chain dimensioning or a zero point is the objective for storing the result. In these cases, keys are available to select a zero point table. Select the zero point table using <F5> "Select table". See the following information
 5. The input table is completed with the parameter values required for the measuring task. The displayed graphic provides support and can change after an input



The key <F2> "Start program" is enabled after all required parameters have been entered and only in the "Jog" mode and starts the measurement.

6. Before starting the measurement, check the initial position or a safe initial position has to be manually approached (see graphics)



Only now press <F2> "Start Program" to apply the parameters in the NC. The parameters are then available for the next measuring task.

7. Execute program with NC start. The message "Program is running" is displayed

Some measuring function required multiple manual positioning between the measuring steps (e.g. zero point probe rotary axis or probing at an internal contour with obstacle). The different initial positions for the measuring steps are displayed by the numbers 1 to 2 or 1 to 4 in the graphics. The first initial position for point 6 has the number 1. After each measuring step, the program stops and the operator is prompted to manually approach the next position. The respective positions have to correspond to the displayed graphics with regard to axis direction and sequence. After the next position has been set, execute NC start again. Repeat until all measuring steps have been executed.

8. After the measuring steps and calculations have been completed, the program stops. The measurement result is stored in SD data during zero point probing for verification purposes and for further processing. The result is displayed as operator prompt. The result is applied after actuating NC start again.

Zero point table Select a zero point table with <F5> "Select table".

The name of the selected zero point table is displayed in the "selected zero point table" field in the position display.

The active zero point table is set to the selected zero point table with <F6> "apply current table".

The axis names in the zero point table have to correspond to the configured axis names.

Position display Display the current position values and the zero point table instead of a supported text using <F7> "Position Display". In case of a changed zero point table, the position and zero point table display is automatically displayed.

Spindle orientation In case of measuring task with alternating probing in positive and negative axis direction, the probe can be turned in the new measuring direction by means of spindle orientation so that the switching offset (calibration value) does not affect the measurement result. This procedure is called reversal measurement and facilitates accurate measurement even if a noncalibrated probe is used.

The spindle is only oriented in case of an active edge number 1. In case of a cross probe, it is assumed that the foremost calibrating ball is assigned to edge 1. Only for this measuring ball, the reversal measurement can be performed.

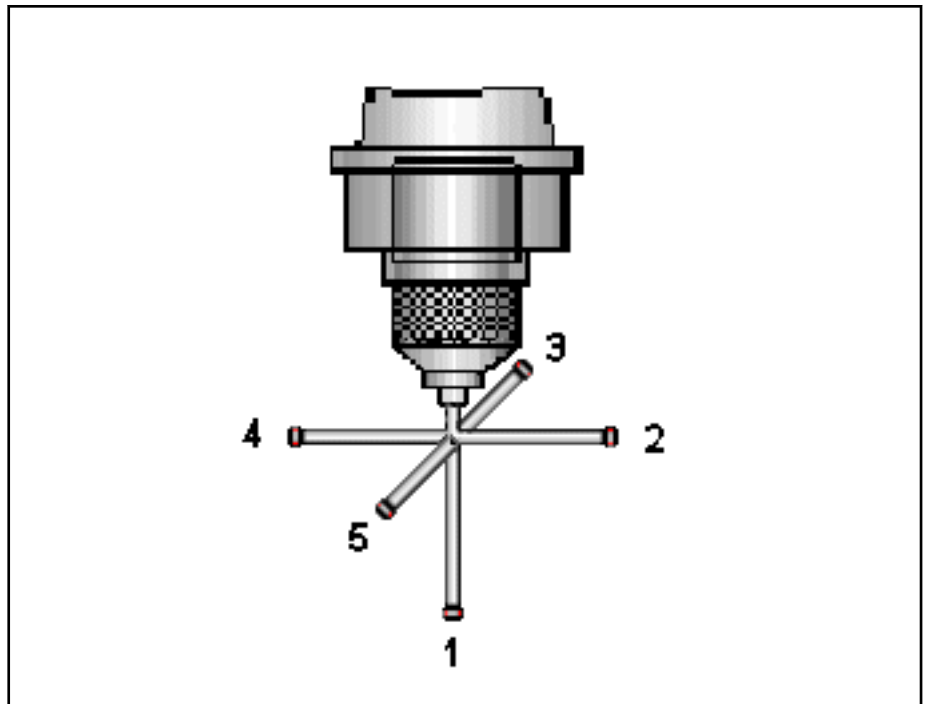


Fig. 6-1: Edge numbers at the cross probe

6.2 Calibrating the probe

6.2.1 M-key menu

Prepare <OP1>

F-key pad 1

- <F8> Calibrate probe

M-Key level 1

- <M1> Calibrate point
- <M2> Calibrate ring

6.2.2 Calibrating the probe point

Short description

The cycle "Calibrating probe point" determines the calibration value for an axis and a direction. A known point is measured and the switching offset is saved depending on the measuring direction (positive/negative).

Overview

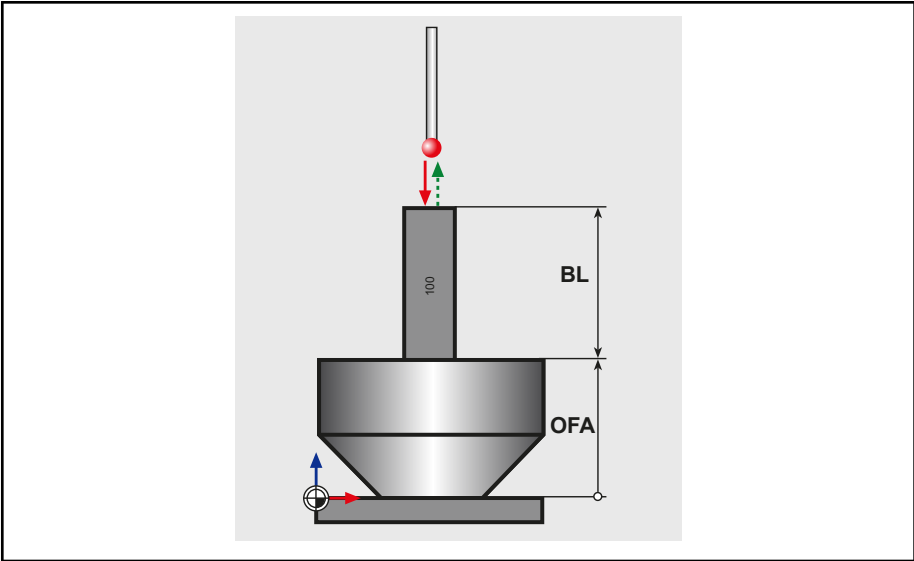


Fig. 6-2: Calibrating the probe, point with zero point and with distance

There are 3 calibration options:

- With zero point and a distance
- With zero point without distance (= 0)
- Without zero point without distance (= 0)

Depending on the inputs, a special graphic is displayed and different parameters are shown/hidden.

Sequence

1. Press <M1> "Calibrate point"
2. Adjust feed if required
3. Optionally, a distance and a finishing dimension length can be entered
4. Select with or without zero point
Only in case of selection with zero point: Select zero point and group
Select <F6> "Apply active table" or <F5> "Select table"
5. Press <F2> "Start program"
6. Press NC start (program is running)
The determined calibration value as well as the axis and the direction are displayed in the diagnostic line
7. Press NC start
The calibration value is applied

Input field

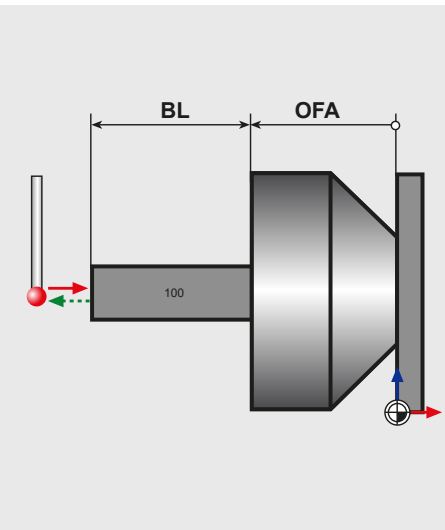
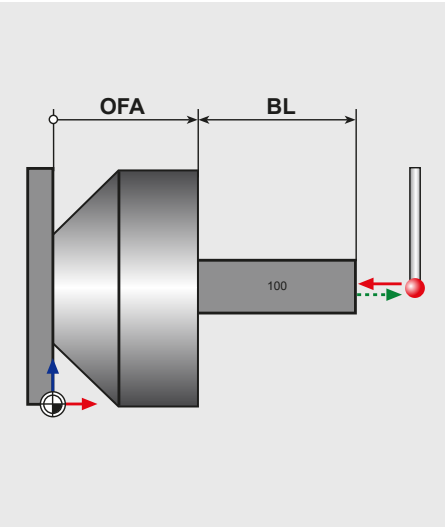
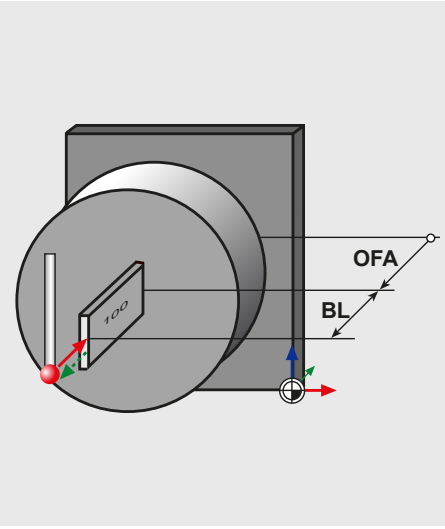
Parameter	Name	Properties	Values	Area
CAX	Calibration axis and direction		X- X+ Y- Y+ Z- Z+	
BL	Length of finishing dimension		REAL	

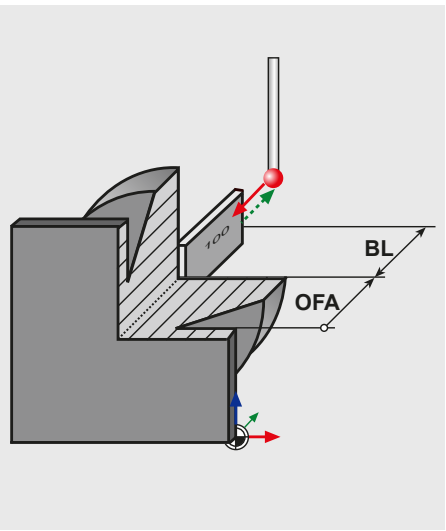
Parameter	Name	Properties	Values	Area
OFU	Include zero offset		Yes no	
OFA	Offset	if OFU = yes	REAL	
ZO	Zero offset	if OFU = yes	G54 G55 G56 G57 G58 G59	Absolute
PAGE	ZO bank	if OFU = yes	INTEGER	1...5
CFE	Calibration feed		REAL	mm/min, >0

Tab. 6-1: *Input field calibrating probe, point*

Graphic field

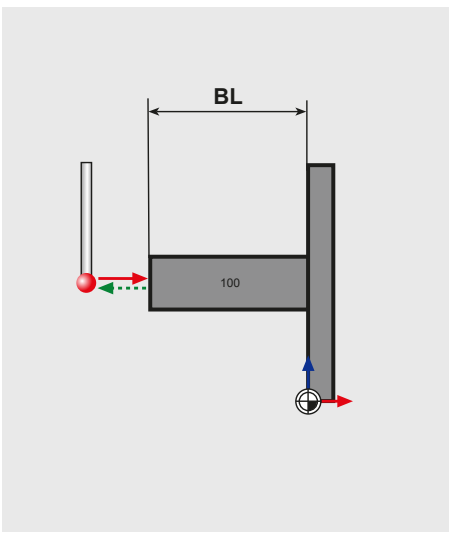
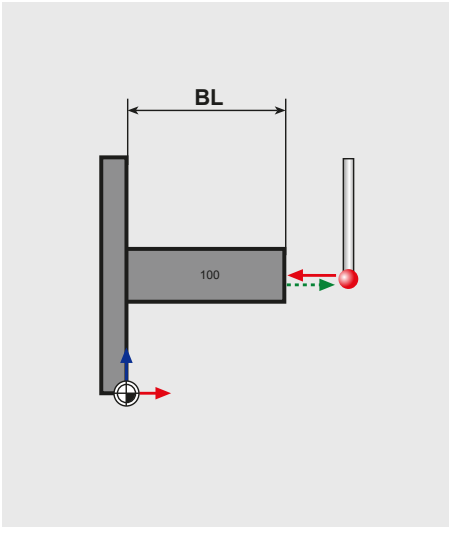
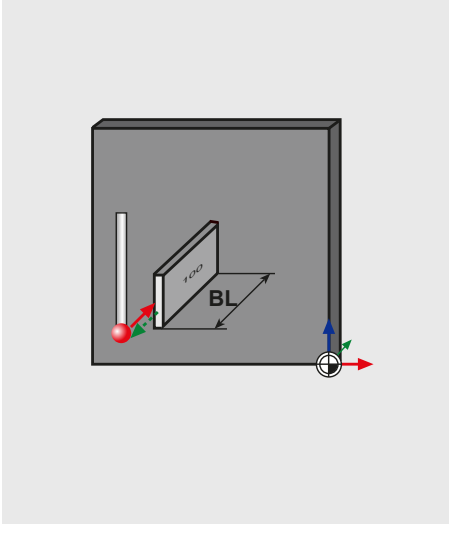
The following graphics are displayed depending on the inputs.

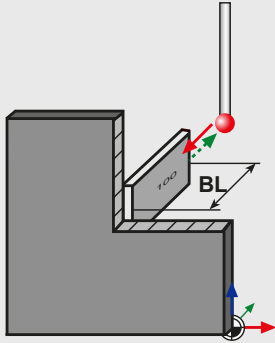
Selection	Graphic
X +	 The diagram illustrates the X+ selection for manual probing. It shows a 3D model of a part with a cylindrical section of diameter 100. A probe is positioned to the left of the part. The distance from the probe tip to the start of the cylindrical section is labeled BL (Back Length). The distance from the end of the cylindrical section to the probe tip is labeled OFA (Offset Factor). A red arrow indicates the probe's approach direction, and a green dashed line shows the retraction path. A coordinate system at the bottom right shows the X-axis pointing right, Y-axis pointing up, and Z-axis pointing out of the page.
X -	 The diagram illustrates the X- selection for manual probing. It shows the same 3D model of the part. The probe is positioned to the right of the part. The distance from the probe tip to the end of the cylindrical section is labeled OFA. The distance from the start of the cylindrical section to the probe tip is labeled BL. A red arrow indicates the probe's approach direction, and a green dashed line shows the retraction path. The coordinate system at the bottom right shows the X-axis pointing left, Y-axis pointing up, and Z-axis pointing out of the page.
Y +	 The diagram illustrates the Y+ selection for manual probing. It shows a 3D model of a part with a cylindrical section of diameter 100. A probe is positioned to the left of the part. The distance from the probe tip to the start of the cylindrical section is labeled BL. The distance from the end of the cylindrical section to the probe tip is labeled OFA. A red arrow indicates the probe's approach direction, and a green dashed line shows the retraction path. A coordinate system at the bottom right shows the X-axis pointing right, Y-axis pointing up, and Z-axis pointing out of the page.

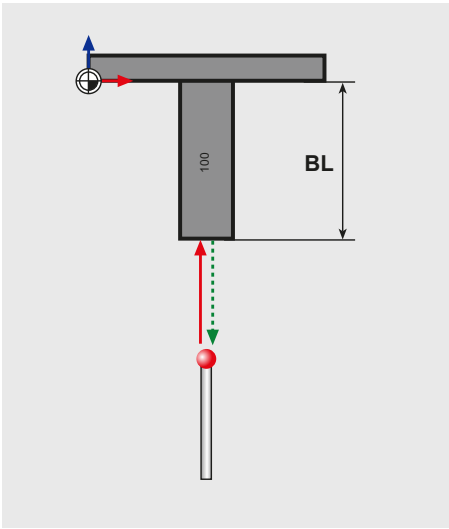
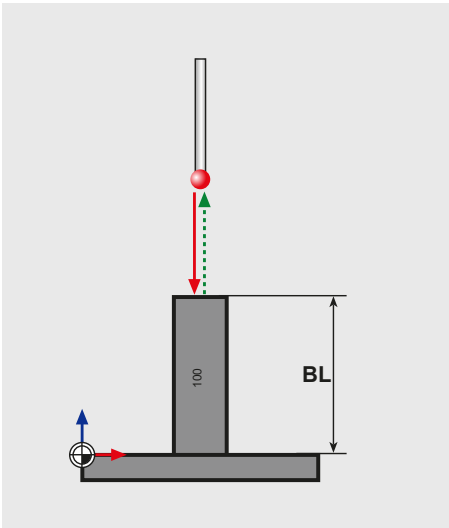
Selection	Graphic
Y -	

Selec- tion	Graphic
Z +	
Z -	

Tab. 6-2: Method 1: With zero point and distance $\neq 0$

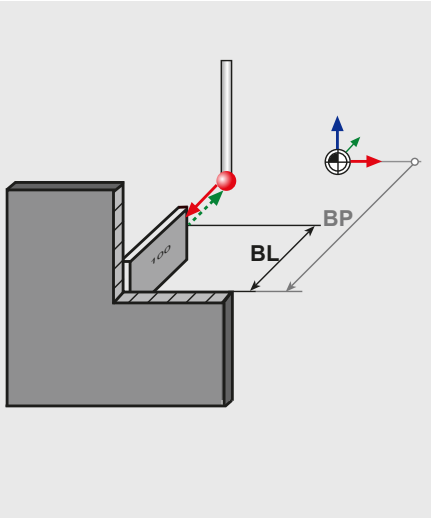
Selection	Graphic
X +	
X -	
Y +	

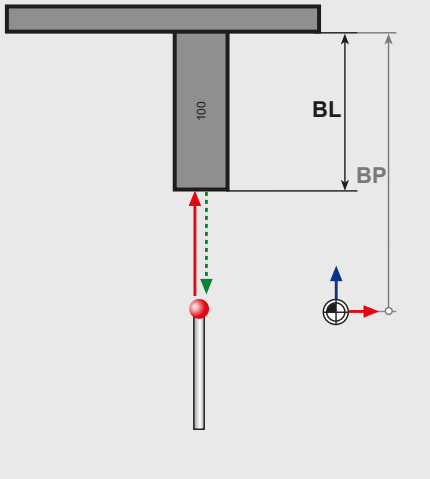
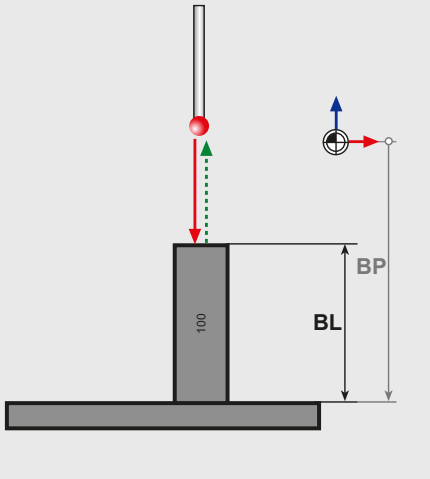
Selection	Graphic
Y -	 The diagram shows a 3D perspective view of a grey L-shaped part. A vertical probe with a red spherical tip is positioned above the part. A red arrow indicates the probe's approach direction. A green arrow points to the contact point on the top surface of the part. A dimension line labeled '100' indicates the distance from the probe tip to the contact point. A dimension line labeled 'BL' indicates the distance from the contact point to the edge of the part. A blue arrow points to the edge of the part. A red arrow points to the bottom surface of the part. A green arrow points to the contact point on the bottom surface of the part.

Selection	Graphic
Z +	
Z -	

Tab. 6-3: Method 2: With zero point and distance = 0

Selec- tion	Graphic
X +	
X -	
Y +	

Selection	Graphic
Y -	 The diagram illustrates the Y-axis manual probing function. It shows a 3D L-shaped part with a vertical feature. A probe is shown in a vertical position, with a red dot indicating the contact point. A coordinate system is shown with a blue arrow pointing up (Z-axis), a green arrow pointing right (X-axis), and a red arrow pointing forward (Y-axis). The distance from the origin to the contact point is labeled 'BP' (Probe Position). The distance from the origin to the contact point along the Y-axis is labeled 'BL' (Probe Length). The distance from the origin to the contact point along the X-axis is labeled 'Y-CD' (Y-axis Center Distance).

Selection	Graphic
Z +	
Z -	

Tab. 6-4: Method 3: Without zero point (and distance=0)

6.2.3 Calibrating the probe adjusting ring

Short description The cycle "Calibrating probe, ring" records the calibration values for both axes of a plane. Measurements take place in an adjusting ring or in a calibration boring and the switching offsets per axis and measuring direction (positive/negative) are saved.

Overview

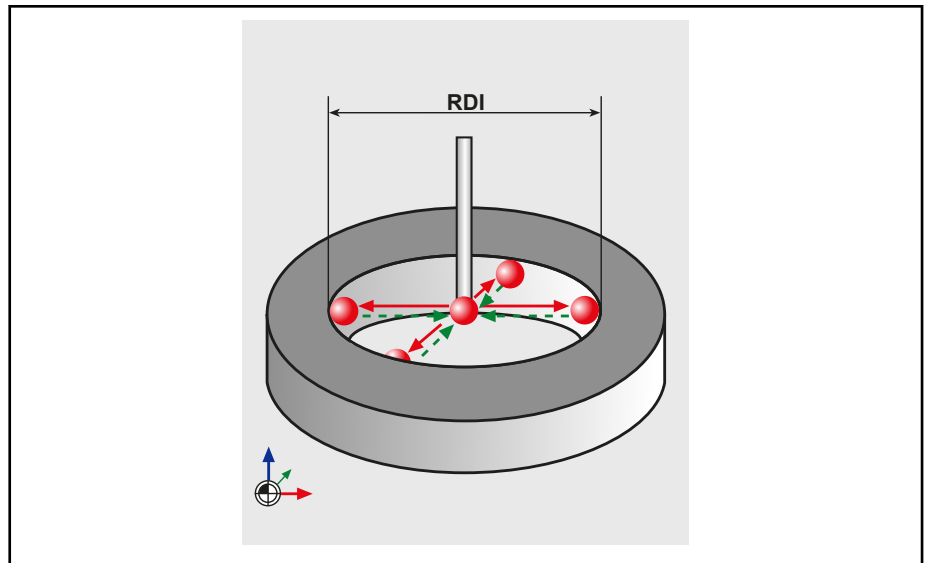


Fig. 6-3: Calibrating the probe, adjusting ring

Sequence

1. Call <M2> "Calibrate rng"
2. Select plane, enter diameter and adjust feed, if required
3. Press <F2> "Start program"
4. Press NC start (program is running)
The determined calibration values as well as the axes and the directions are displayed in the diagnostic line
5. Press NC start
The calibration values are applied

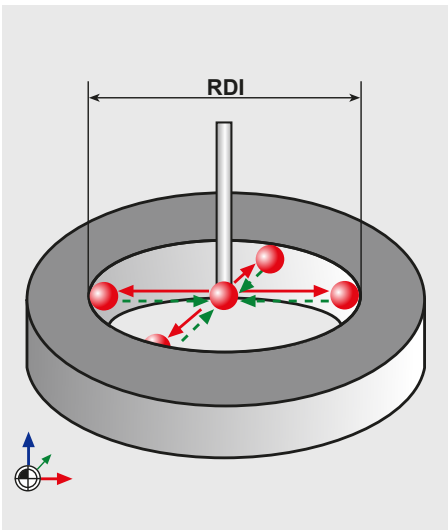
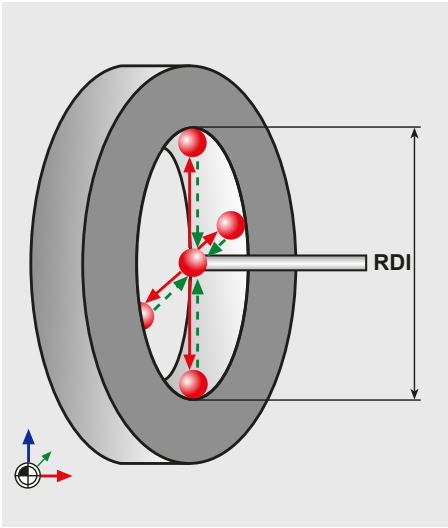
Input field

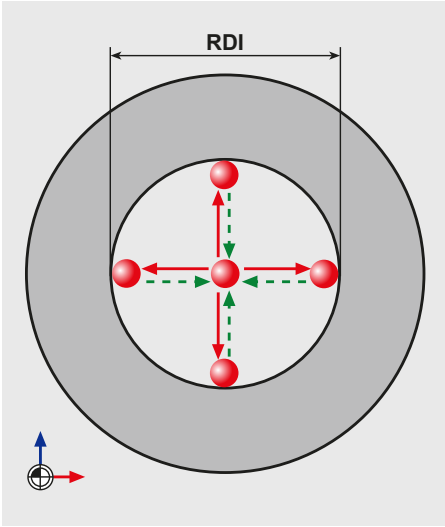
Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
RDI	Ring diameter		REAL	>0
CFE	Calibration feed		REAL	mm/min, <0

Tab. 6-5: Input field calibrating probe, adjusting ring

Graphic field

One of the following graphics is displayed depending on the selected plane G17, G18, G19:

Select plane	Graphic
G17	 The diagram shows a 3D perspective of a ring-shaped part. A vertical probe is positioned at the center of the ring's top surface. A horizontal dimension line above the probe is labeled 'RDI', indicating the radius of the inner circle. Red spheres represent probe points on the inner surface, with red arrows showing the radial direction. Green dashed lines and arrows indicate the coordinate system. A small icon in the bottom left shows the selected G17 plane (top face) with a blue arrow pointing up.
G18	 The diagram shows a 3D perspective of the same ring-shaped part, viewed from the side. A horizontal probe is positioned at the center of the ring's side face. A vertical dimension line to the right of the probe is labeled 'RDI', indicating the radius of the inner circle. Red spheres represent probe points on the inner surface, with red arrows showing the radial direction. Green dashed lines and arrows indicate the coordinate system. A small icon in the bottom left shows the selected G18 plane (side face) with a blue arrow pointing right.

Select plane	Graphic
G19	

Tab. 6-6: Graphics depending on the input in the plane

6.3 Zero point probing using the probe

6.3.1 M-key menu

Prepare <OP1>

F-key pad 1

- <F3> Probe zero point

M-Key level 1

- <M1> Point
- <M2> Rotary axis
- <M3> Corner
- <M5> Groove
- <M6> Boring
- <M7> Pocket
- <M8> M-Key level 2

M-key level 2

- <M3> Sphere
- <M5> Land
- <M6> Circular spigot
- <M7> Rectangular spigot
- <M8> M-Key level 1

6.3.2 Zero point probing, point

Short description The zero point in an axis is recording by probing a plane and is applied to the previously selected zero point table with "Probe zero point, point".

Overview

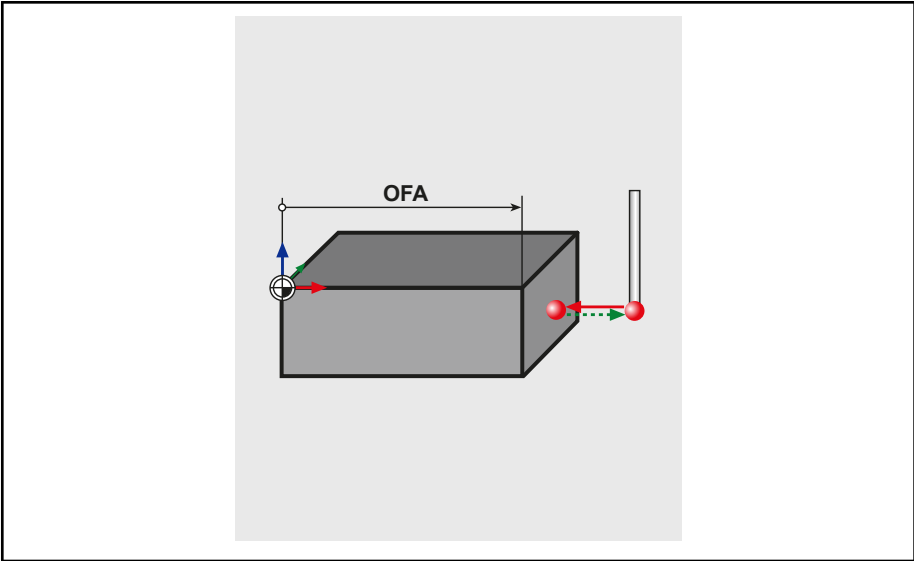


Fig. 6-4: Probe zero point, point

- Sequence
1.

Press <M1> "Zero point, point"
2.

Select measuring direction, enter distance and adjust feed, if required
3.

Select zero point and group
4.

Select <F6> "Apply active table" or <F5> "Select table"
5.

Press <F2> "Start program"
6.

Press NC start (program is running)
7.

Determined measured value as well as axis are displayed in the diagnostic line
8.

Press NC start
9.

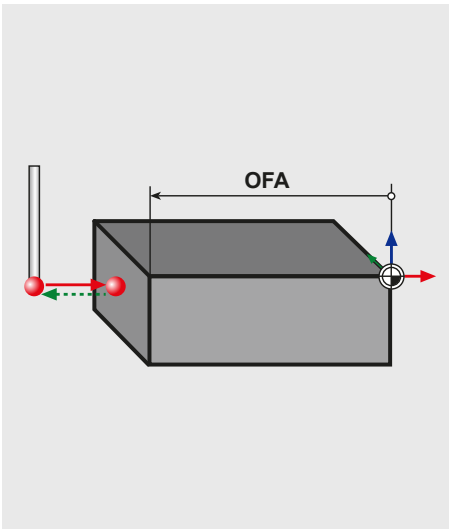
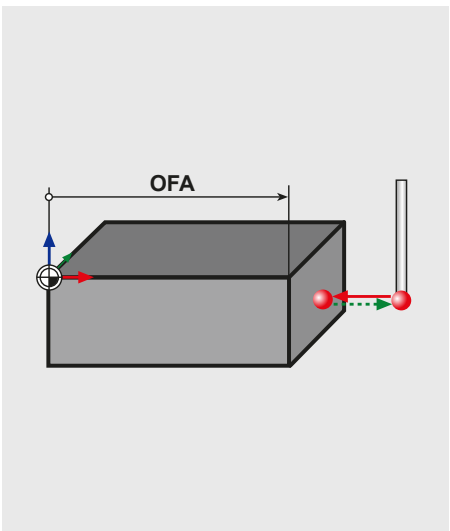
The measured value is applied to the selected zero point table

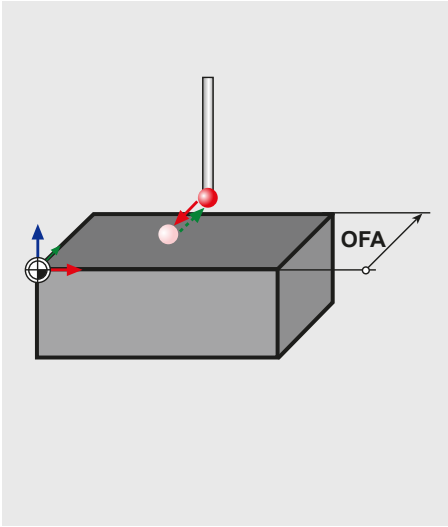
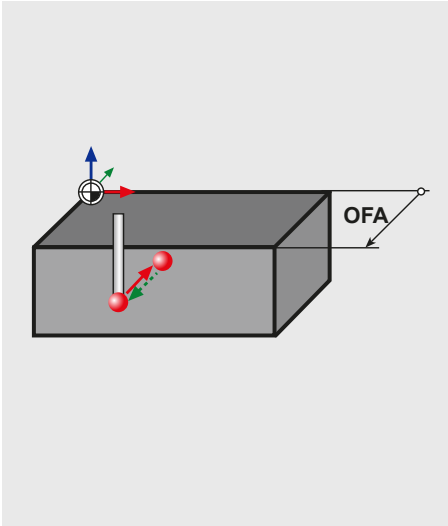
Input field

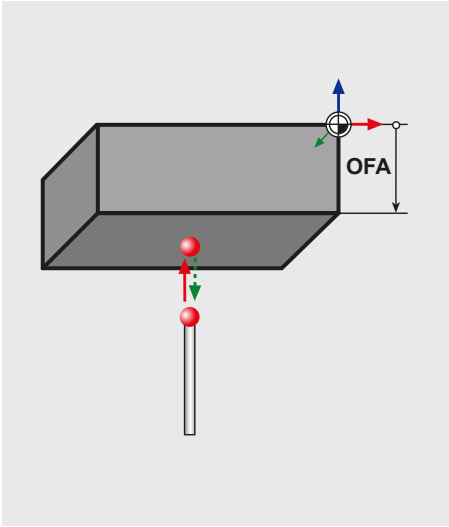
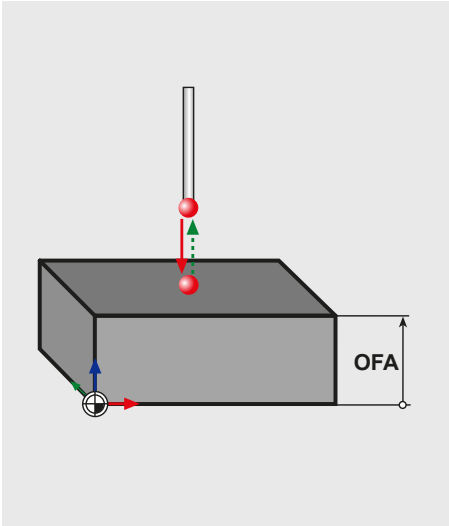
Parameter	Name	Properties	Values	Area
PAX	Measuring axis and direction		X- X+ Y- Y+ Z- Z+	
OFA	Offset		REAL	
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-7: Input field probe zero point, point

Graphic field One of the following graphics is displayed depending on the selected axis and the selected direction:

Selection	Graphic
X +	
X -	

Selec- tion	Graphic
Y +	 The diagram shows a 3D rectangular block with a vertical probe. A red dot on the top surface indicates the current position. A green arrow points from this dot towards the front-left corner. A blue arrow points upwards from the front-left corner. A red arrow points from the front-left corner towards the right. A label 'OFA' with a double-headed arrow indicates the distance from the front-left corner to the red dot along the top edge.
Y -	 The diagram shows a 3D rectangular block with a vertical probe. A red dot on the top surface indicates the current position. A green arrow points from this dot towards the back-right corner. A blue arrow points upwards from the back-right corner. A red arrow points from the back-right corner towards the left. A label 'OFA' with a double-headed arrow indicates the distance from the back-right corner to the red dot along the top edge.

Selection	Graphic
Z +	
Z -	

Tab. 6-8: Graphics depending on the selected axis and direction

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.PO INT.AX- IS[1].RESULT	Zero point X	REAL	
SD.SysPr- Man.MEAS.PO INT.AX- IS[2].RESULT	Zero point Y	REAL	
SD.SysPr- Man.MEAS.PO INT.AX- IS[3].RESULT	Zero point Z	REAL	

Tab. 6-9: Output values

6.3.3 Zero point probing, corner

Short description The zero point coordinates in all three coordinate system axes are determined using "Probe zero point, corner" by sampling three planes and are applied to the previously selected zero point table.

Overview

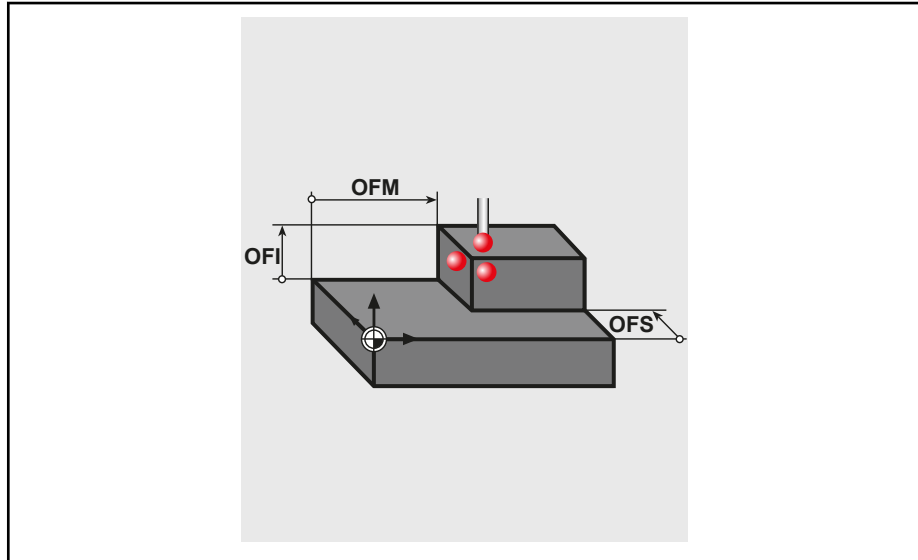


Fig. 6-5: Probe zero point, corner

- Sequence:**
1. Press <M3> "Corner"
 2. Select plane and adjust feed, if required. Select position and number for the corner. Enter the distance to the corner and if required, enter the offset
 3. Select zero point and group
 4. Select <F6> "Apply active table" or <F5> "Select table"
 5. Press <F2> "Start program"
 6. Press NC start (program is running)
The determined measured values are displayed in the diagnostic line
 7. Press NC start
The measured values are applied to the zero point table

The selected edge always has to point perpendicular to the plane. The offset value sign determines the direction of the feed motion. A positive length indicates a feed in negative direction, a negative length indicates a feed in the positive direction of the feed axis.

Example Feed axis X, plane G19 with edge 4 (tool length positive) and edge 2 (tool length negative).

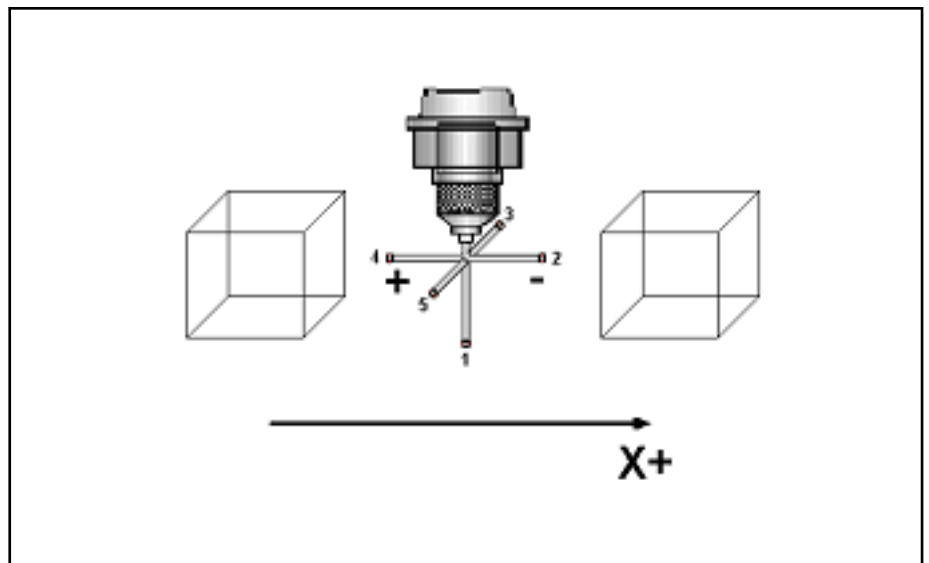


Fig. 6-6: Probe zero point corner in G19

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
ORI	Position		External Internal	
POS	Position	If ORI = internal	Bottom Top	
NO	Corner number		C1 C2 C3 C4	
DI	Distance	If ORI = external	REAL	>0
OFM	Main axis offset			
OFS	Auxiliary axis offset			
OFI	Infeed axis offset			
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-10: Input field probe zero point, corner

If "External" is selected as corner position, "Top" is selected as position of the corner. "Bottom" can then not be selected as position.

If "Internal" is selected as corner position and "Bottom" is selected as position, no distance (DI) is required (hiding the parameter).

Graphic field The following graphic is displayed when entering the offset of the main, secondary and feed axis:

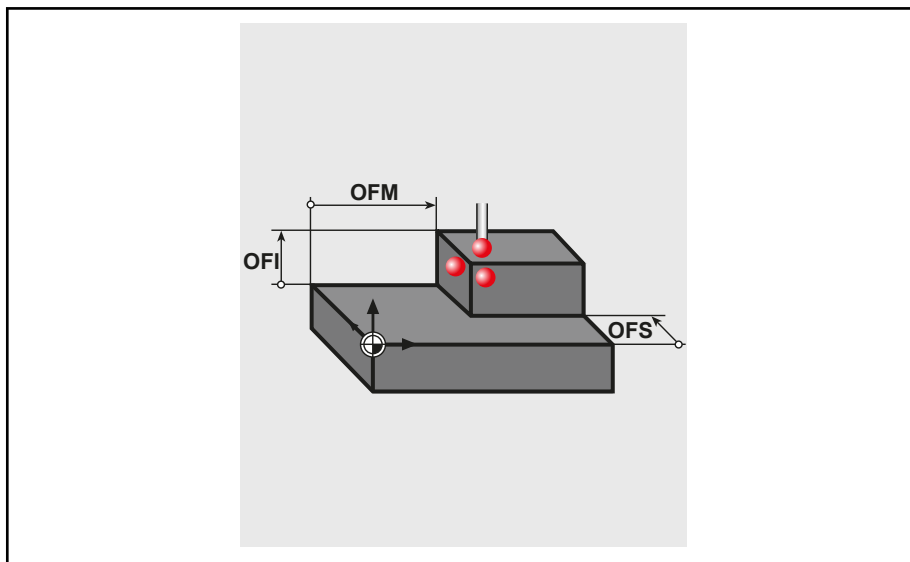
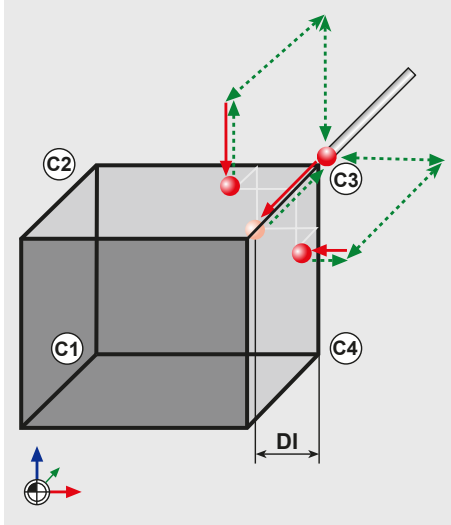
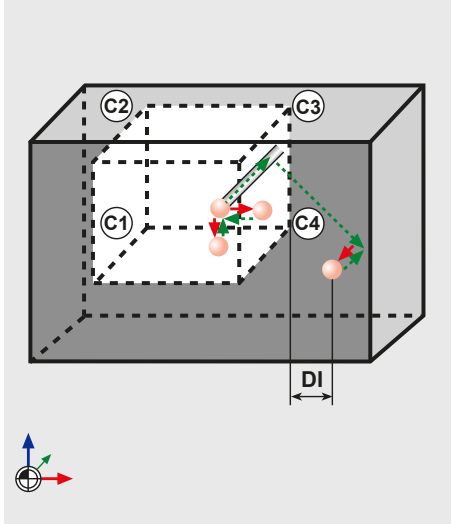
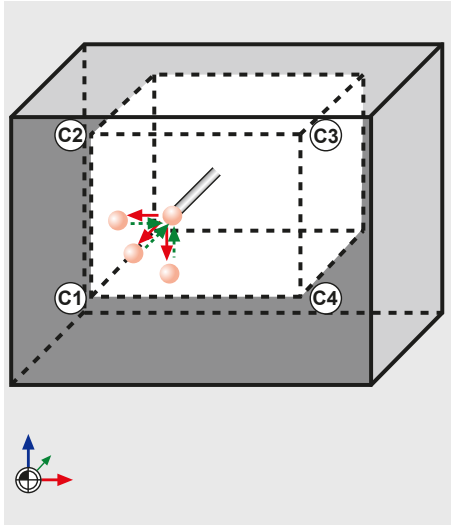
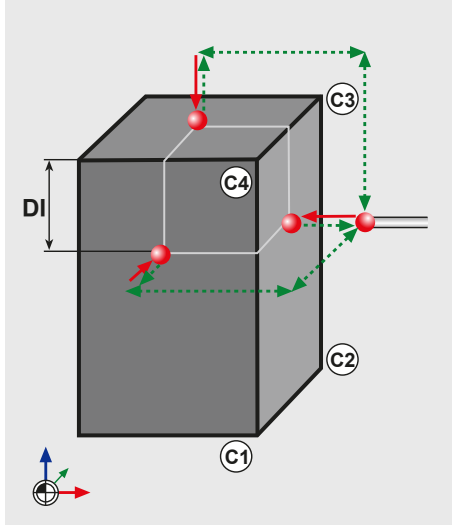
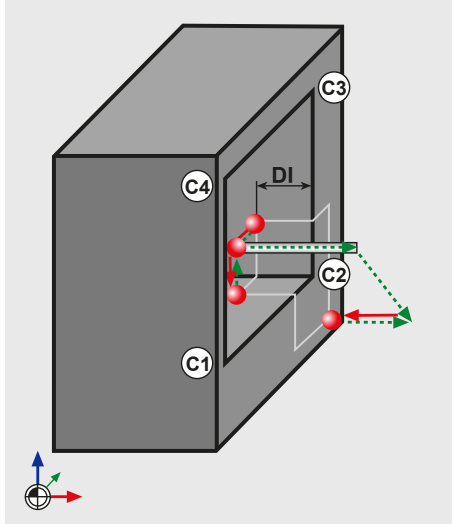
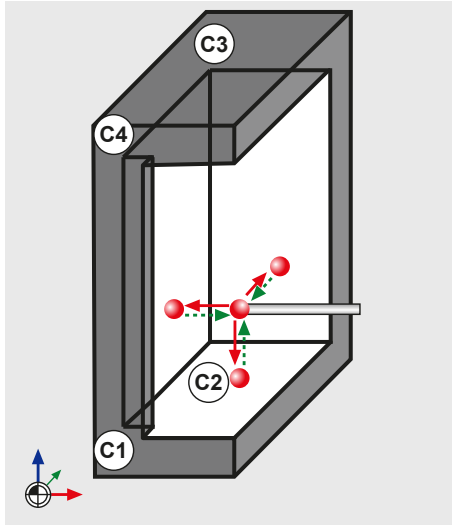


Fig. 6-7: *Help image when entering the offset of the main, secondary and feed axis*

Depending on the selected plane, number and position, the graphic is switched.

Level	Position	Position	Graphic
G17	External	Top	
	Internal	Top	
		Bottom	

Level	Position	Position	Graphic
G18	External	Top	 A 3D perspective view of a rectangular block. A coordinate system is shown at the bottom left with a blue arrow pointing up, a green arrow pointing right, and a red arrow pointing forward. Four red spheres are positioned at the corners of the top face: C1 at the front-left, C2 at the back-left, C3 at the back-right, and C4 at the front-right. Dashed green lines extend from C2 and C3, and red arrows indicate movement. A probe is shown touching the top surface. A dimension line labeled 'DI' is shown at the bottom right.
	Internal	Top	 A 3D perspective view of a rectangular block with a dashed internal cube. The coordinate system is at the bottom left. Four red spheres are at the corners of the internal cube: C1 (front-left), C2 (back-left), C3 (back-right), and C4 (front-right). Dashed green lines and red arrows indicate movement. A probe is shown touching the top surface. A dimension line labeled 'DI' is shown at the bottom right.
		Bottom	 A 3D perspective view of a rectangular block with a dashed internal cube. The coordinate system is at the bottom left. Four red spheres are at the corners of the internal cube: C1 (front-left), C2 (back-left), C3 (back-right), and C4 (front-right). Dashed green lines and red arrows indicate movement. A probe is shown touching the bottom surface. A dimension line labeled 'DI' is shown at the bottom right.

Level	Position	Position	Graphic
G19	External	Top	
	Internal	Top	
		Bottom	

Tab. 6-11: Graphics depending on the input in the plane

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.CO RNER.RE- SULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.CO RNER.RE- SULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.CO RNER.RE- SULT[3]	Zero point Z	REAL	

Tab. 6-12: Output values

6.3.4 Zero point probing, sphere

Short description Using "Zero point probing, sphere", the zero point in three linear axes in relation to the center of an existing sphere with known radius is determined and is applied to the selected zero point table.

Overview

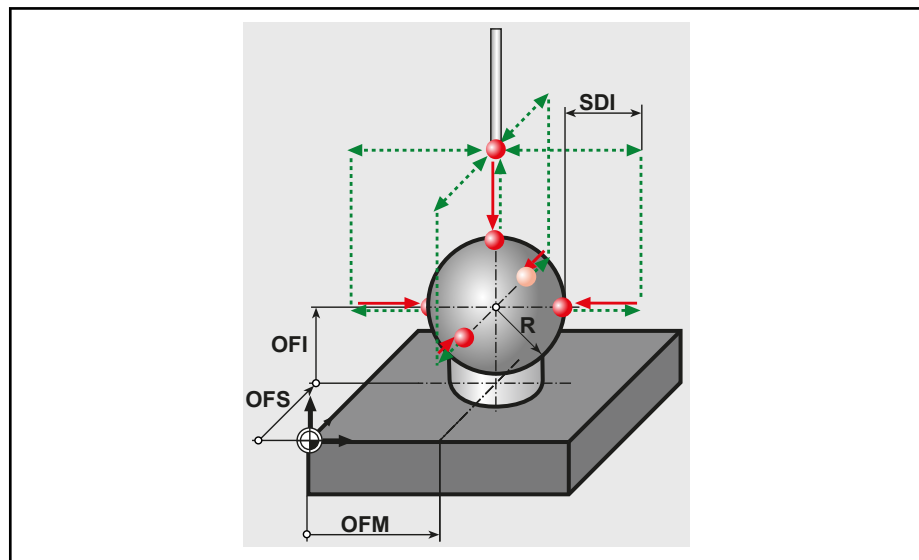


Fig. 6-8: Zero point probing, sphere

- Sequence**
1. Press <M6> "Zero point sphere" in the 2nd key level
 2. Select the axis and the direction of measurement in which the offset in feed direction is determined by probing the sphere pole. Select the sphere radius and the safety distance, adjust the feed if required and enter the offset
 3. Select zero point and group
 4. Select <F6> "Apply active table" or <F5> "Select table"
 5. Press <F2> "Start program"
 6. Press NC start (program is running)
- First, the sphere pole is roughly measured in infeed direction to subsequently determined the center point in other axes, close to the equator.

Finally, the pole is measured precisely at the established center point coordinates in feed direction.

The determined measured values are displayed in the diagnostic line

7. Press NC start

The measured values are applied to the zero point table

Input field

Parameter	Name	Properties	Values	Area
DIR	Infeed of measuring axis and direction		X- X+ Y- Y+ Z- Z+	
R	Sphere radius		REAL	>0
SDI	Safety distance		REAL	>0
OFM	Main axis offset			
OFS	Auxiliary axis offset			
OFI	Infeed axis offset			
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-13: Zero point probing, circular spigot

Graphic field

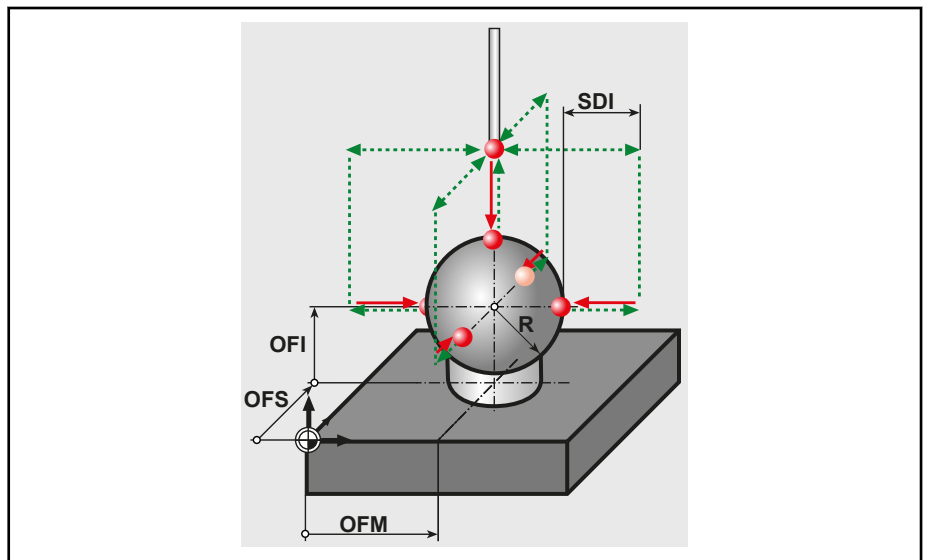


Fig. 6-9: Help image, zero point probing, sphere

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.BA LL.RESULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.BA LL.RESULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.BA LL.RESULT[3]	Zero point Z	REAL	

Tab. 6-14: Output values

6.3.5 Zero point probing, boring

Short description Using "Zero Point Probing, Boring", the zero point in the main and secondary axis of a plane is determined in relation to the boring center. The determined zero point is applied to the selected zero point table.

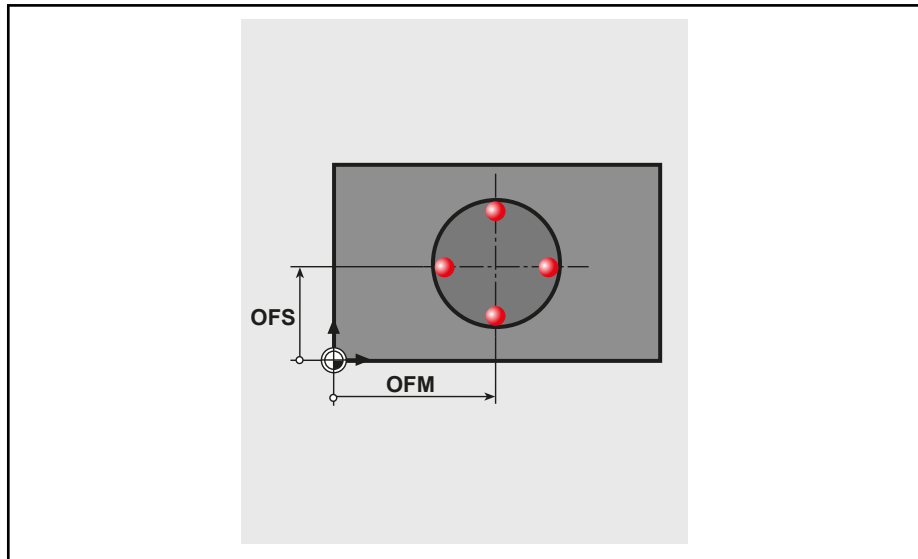
Overview

Fig. 6-10: Zero point probing, boring

There are 2 methods to record the measuring points:

- Without obstacle
- With obstacle

Sequence

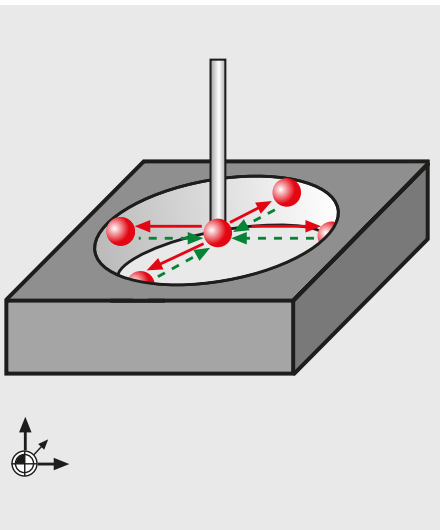
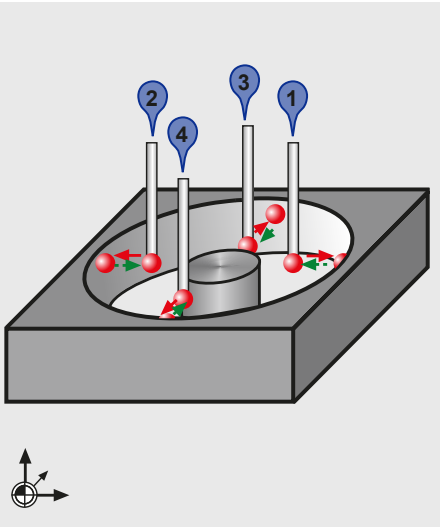
1. Press <M6> "Boring"
2. Select plane, adjust feed if required and enter offset
3. Select with or without obstacle
4. Select zero point and group
5. Select <F6> "Apply active table" or <F5> "Select table"
6. Press <F2> "Start program"
7. Press NC start (program is running)
The determined measured values are displayed in the diagnostic line
8. Press NC start
The measured values are applied to the zero point table

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
OFM	Main axis offset			
OFS	Auxiliary axis offset			
LUP	Obstacle in boring		no Yes	
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-15: *Input field zero point probing, boring***Graphic field**

The following graphics are displayed when entering "Obstacle yes/no".

Obsta- cle	Graphic
No	
Yes	

Tab. 6-16: Graphics depending on "Obstacle yes/no"

The following graphic is displayed when entering the offset of the main and secondary axis:

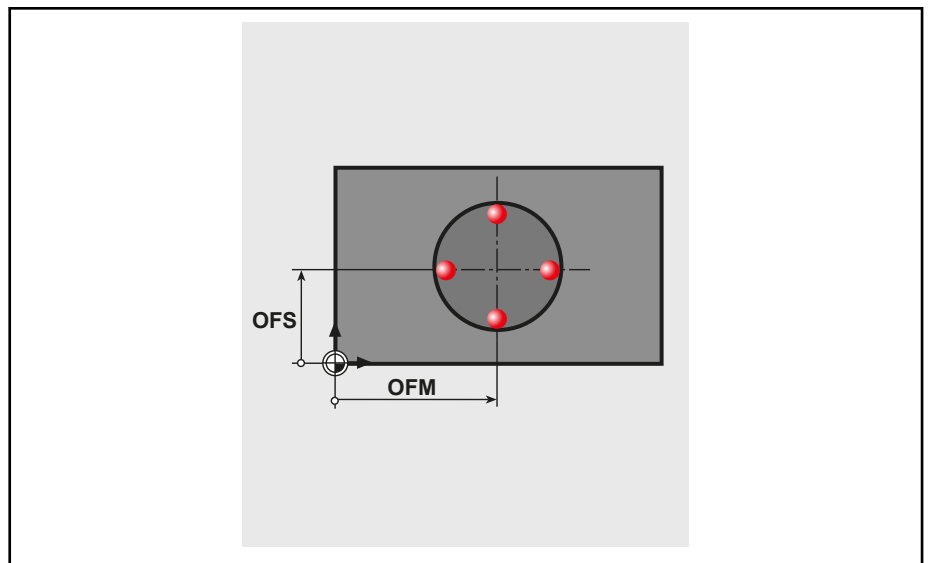


Fig. 6-11: Help image when entering the offset of the main and secondary axis

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.BO RE.RESULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.BO RE.RESULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.BO RE.RESULT[3]	Zero point Z	REAL	

Tab. 6-17: Output values

6.3.6 Zero point probing, circular spigot

Short description Using "Zero Point Probing, Boring", the zero point in the main and secondary axis of a plane is determined in relation to the boring center. The determined zero point is applied to the selected zero point table.

Overview

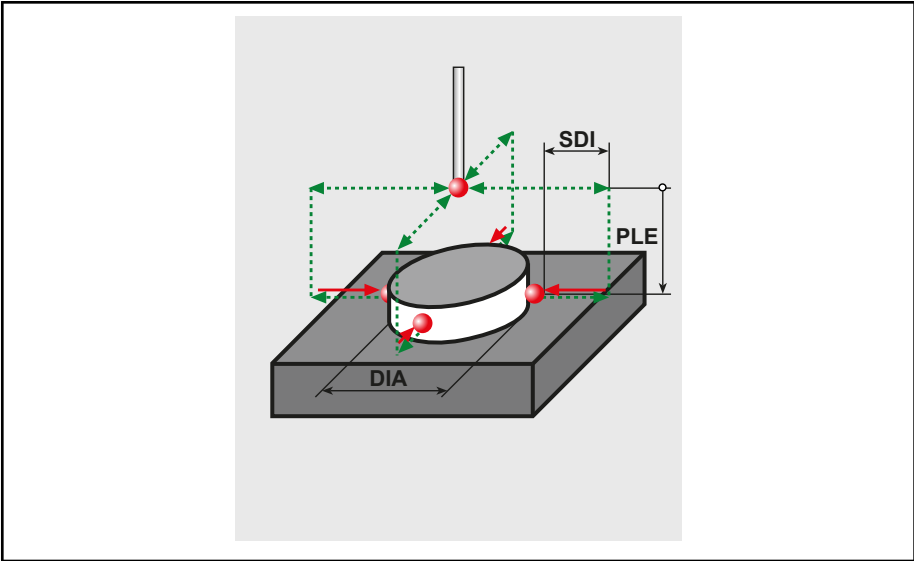


Fig. 6-12: Zero point probing, circular spigot

- Sequence
1.

Press <M6> "Zero point circular spigot" in the 2nd key level

2.

Select diameter, depths, level and safety distance, adjust feed if required and enter offset

3.

Select zero point and group

4.

Select <F6> "Apply active table" or <F5> "Select table"

5.

Press <F2> "Start program"

6.

Press NC start (program is running)

The determined measured values are displayed in the diagnostic line

7.

Press NC start

The measured values are applied to the zero point table

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
DIA	Spigot diameter		REAL	>0
SDI	Safety distance		REAL	>0
PLE	Feed increment till measuring height		REAL	
OFM	Main axis offset			
OFS	Auxiliary axis offset			
PFE	Measuring feed		REAL	mm/min, >0

Parameter	Name	Properties	Values	Area
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-18: Zero point probing, circular spigot

Graphic field This image is always displayed except for when entering the offset of the main and secondary axis.

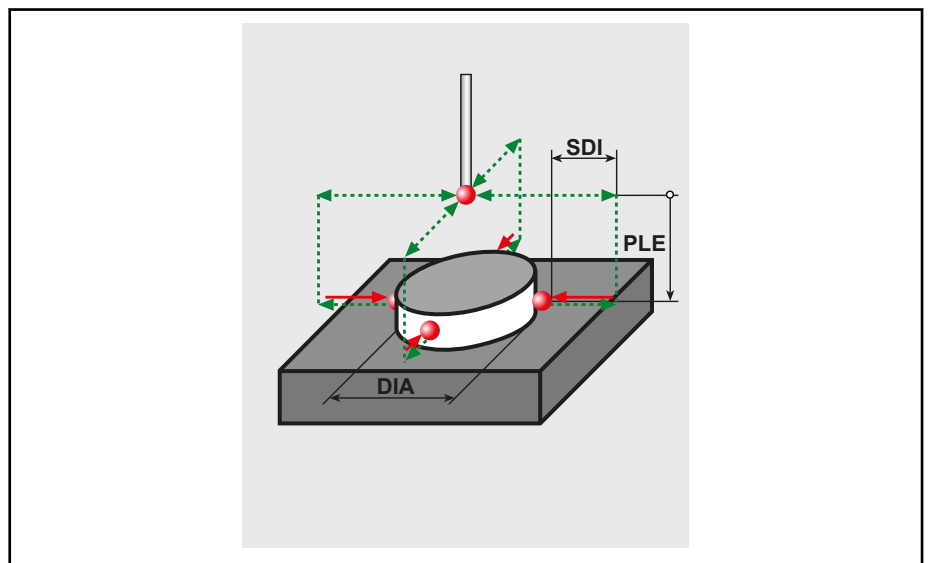


Fig. 6-13: Help image, zero point probing, circular spigot

The following graphic is displayed when entering the offset of the main and secondary axis:

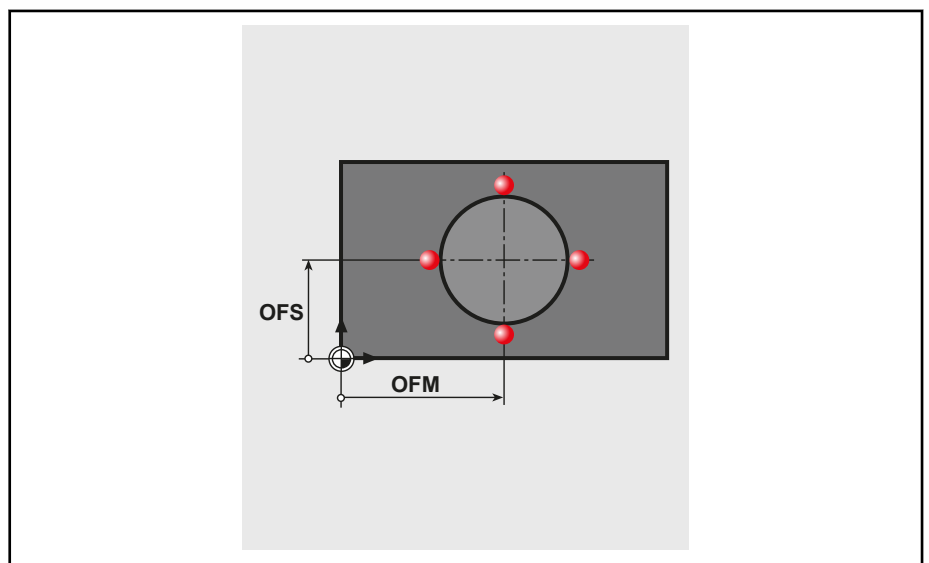


Fig. 6-14: Help image when entering the offset of the main and secondary axis

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.BO RE.RESULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.BO RE.RESULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.BO RE.RESULT[3]	Zero point Z	REAL	

Tab. 6-19: Output values

6.3.7 Zero point probing, groove

Short description "Zero point probing, groove" determines the axis zero point which is perpendicular to an available groove. The measured value is applied to the selected zero point table.

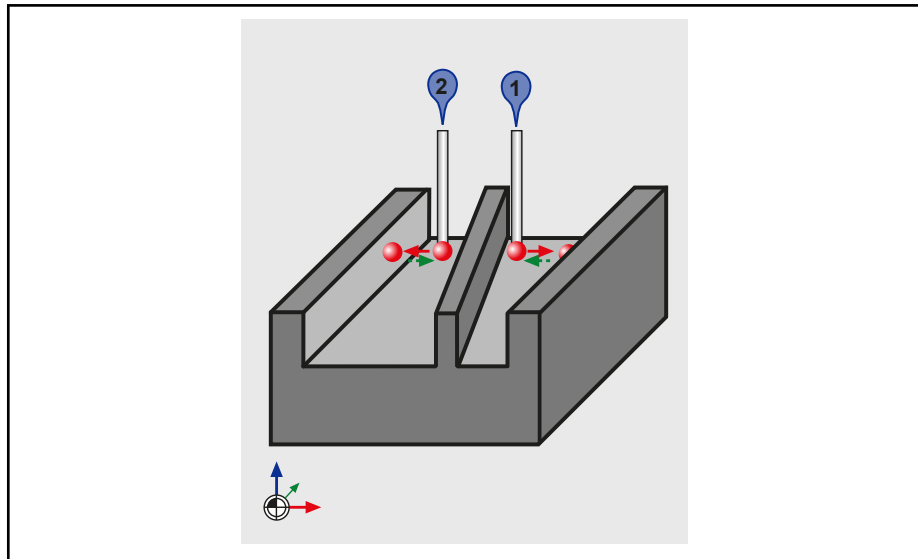
Overview

Fig. 6-15: Zero point probing, groove

There are 2 methods to record the measuring points:

- Without obstacle
- With obstacle

Sequence

1. Press <M5> "Groove"
2. Select plane and measuring axis, adjust feed if required and enter offset
3. Select with or without obstacle
4. Select zero point and group
5. Select <F6> "Apply active table" or <F5> "Select table"
6. Press <F2> "Start program"
7. Press NC start (program is running)
The determined measured value is displayed in the diagnostic line
8. Press NC start
The measured value is applied to the zero point table

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
PAX	Measuring axis	Depending on IPL	X Z Y Y X Z	
OFA	Offset			
LUP	Obstacle in boring		no Yes	
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-20: Zero point probing, groove

Only the main and the secondary axis of the selected plane can be selected as measuring axes:

Level	Main axis	Secondary axis
G17	X	Y
G18	Z	X
G19	Y	Z

Tab. 6-21:

Graphic field

The following graphic is displayed when entering the offset:

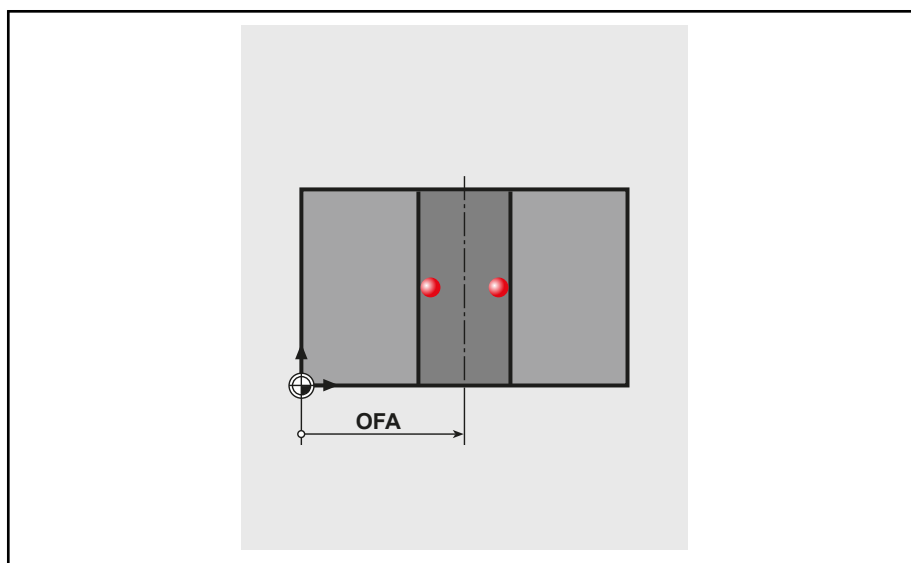
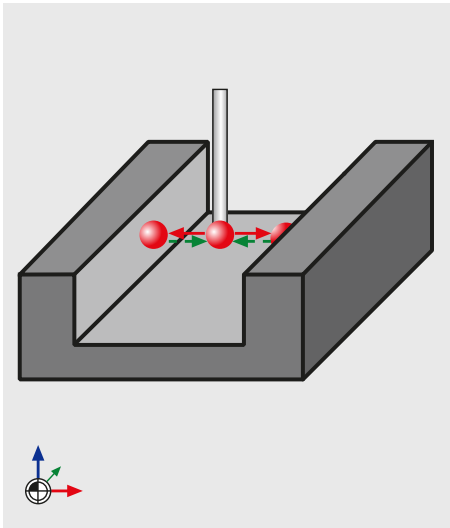
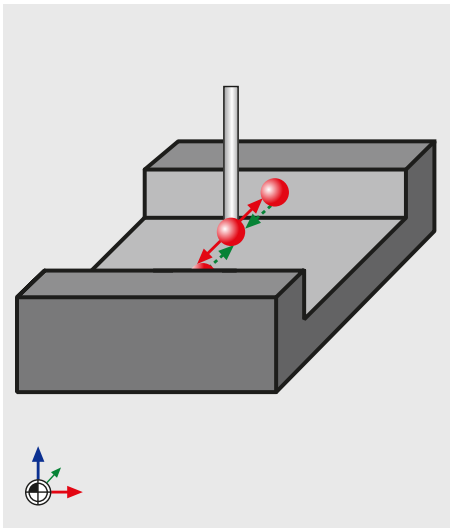
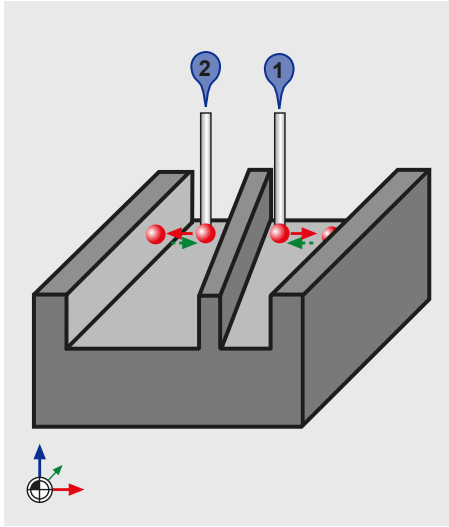
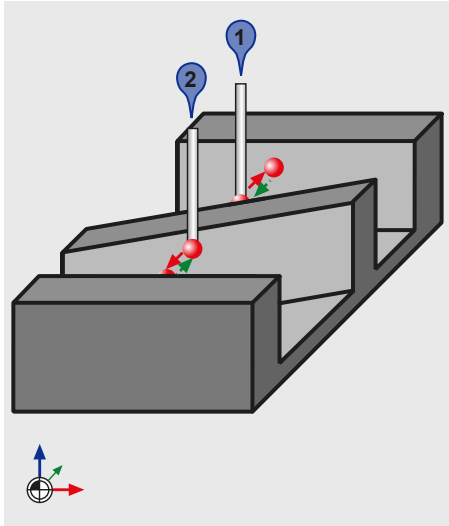
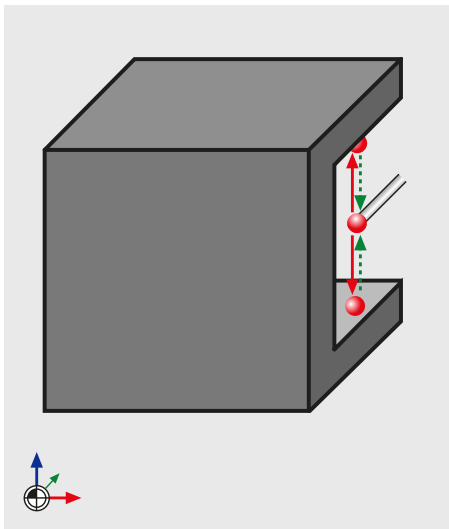
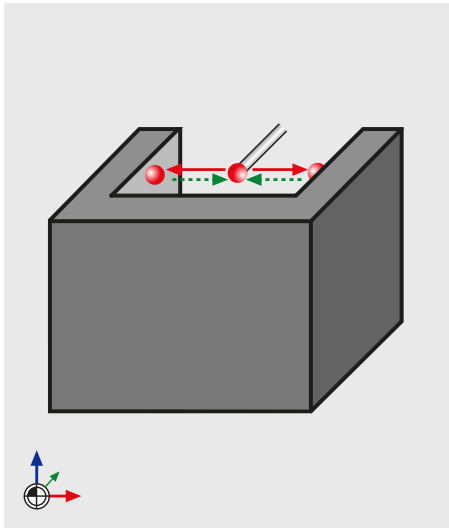


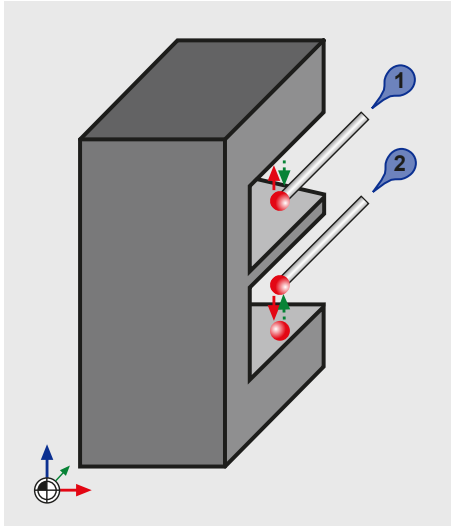
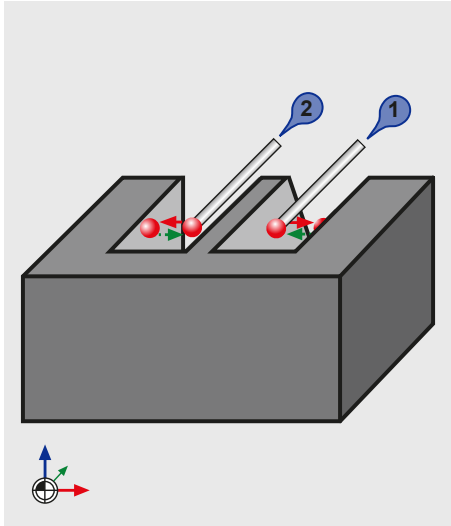
Fig. 6-16: Help image when entering the offset

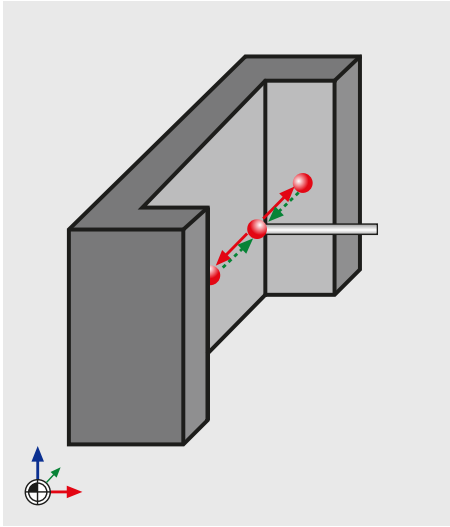
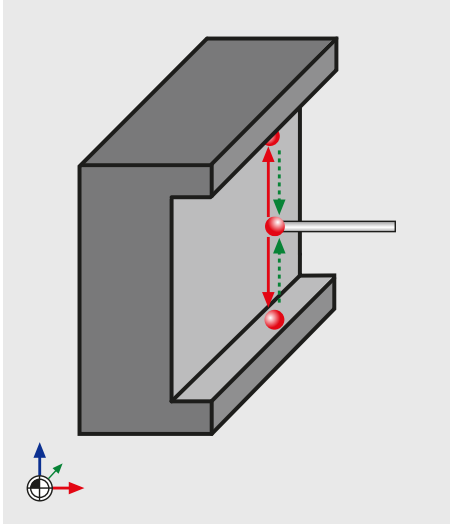
The following graphics are displayed when entering "Obstacle yes/no":

Level	Obstacle	Measuring axis	Graphic
G17	No	X	
		Y	

Level	Obstacle	Measuring axis	Graphic
G17	Yes	X	
		Y	

Level	Obstacle	Measuring axis	Graphic
G18	No	Z	
		X	

Level	Obstacle	Measuring axis	Graphic
G18	Yes	Z	
		X	

Level	Obstacle	Measuring axis	Graphic
G19	No	Y	 A 3D perspective view of a stepped metal part. A red probe tip is shown in contact with the top surface of the rightmost step. A red dashed line with arrows at both ends indicates the Y-axis measurement direction, extending from the probe tip to the left. A small coordinate system icon with a blue arrow pointing up, a green arrow pointing right, and a red arrow pointing out of the page is located at the bottom left of the diagram.
		Z	 A 3D perspective view of the same stepped metal part. A red probe tip is shown in contact with the top surface of the rightmost step. A red dashed line with arrows at both ends indicates the Z-axis measurement direction, extending vertically upwards from the probe tip. A small coordinate system icon with a blue arrow pointing up, a green arrow pointing right, and a red arrow pointing out of the page is located at the bottom left of the diagram.

Level	Obstacle	Measuring axis	Graphic
G19	Yes	Y	
		Z	

Tab. 6-22: Graphics depending on the input in the plane

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.GR OOVE.RE- SULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.GR OOVE.RE- SULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.GR OOVE.RE- SULT[3]	Zero point Z	REAL	

Tab. 6-23: Output values

6.3.8 Zero point probing, land

Short description "Zero point probing, land" determines the axis zero point which is perpendicular to an available land. The measured value is applied to the selected zero point table.

Overview

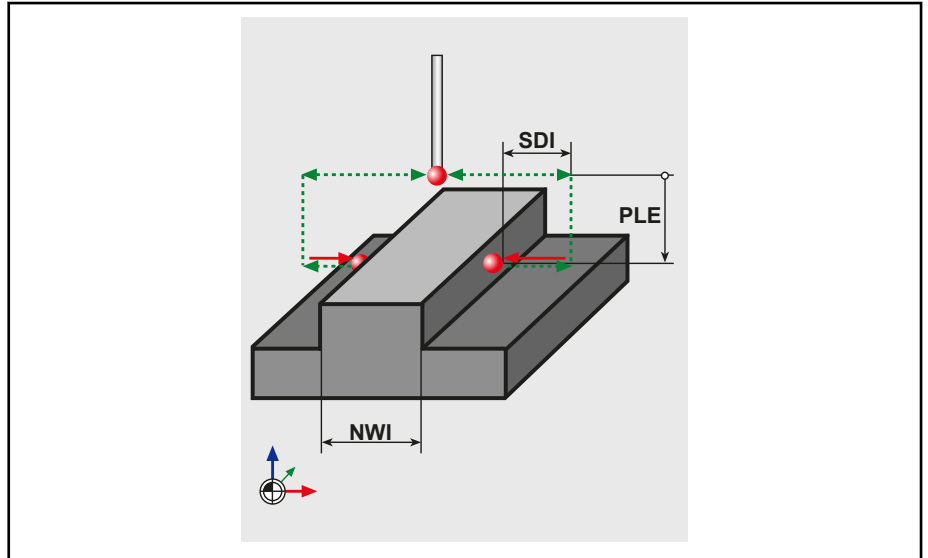


Fig. 6-17: Zero point probing, land

- Sequence**
1. Press <M5> "Zero point land" in the 2nd key level
 2. Select land width, depths, level, measuring axis and safety distance, adjust feed if required and enter offset
 3. Select zero point and group
 4. Select <F6> "Apply active table" or <F5> "Select table"
 5. Press <F2> "Start program"
 6. Press NC start (program is running)
The determined measured value is displayed in the diagnostic line
 7. The measured value is applied to the selected zero point table with NC start

Input field

Parameter	Name	Properties	Values			Area
IPL	Interpolation level		G17 G18 G19			
PAX	Measuring axis	Depending on IPL	X Y	Z X	Y Z	
NWI	Land width		REAL			>0
SDI	Safety distance		REAL			>0
PLE	Feed increment till measuring height		REAL			
OFA	Offset		REAL			
PFE	Measuring feed		REAL			mm/min, >0

Parameter	Name	Properties	Values	Area
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

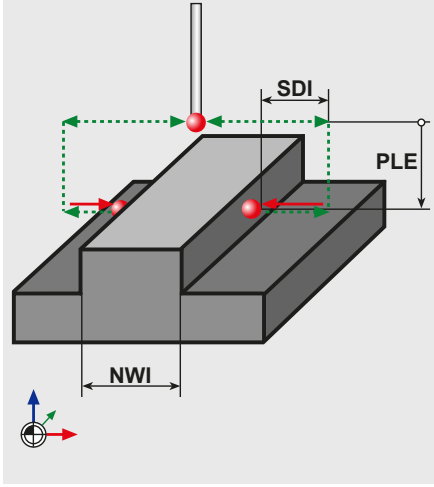
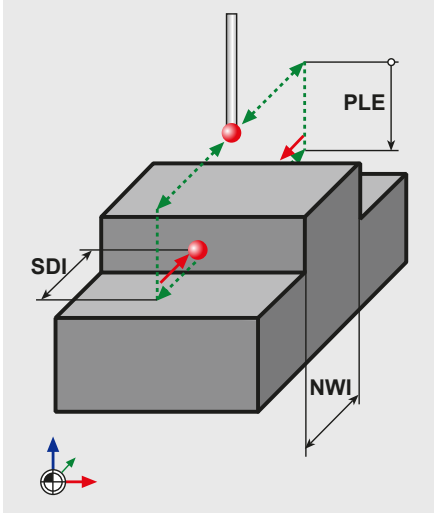
Tab. 6-24: Input field, zero point probing, land

Only the main and the secondary axis of the selected plane can be selected as measuring axes:

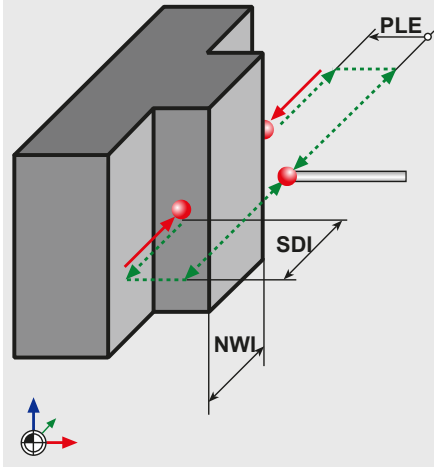
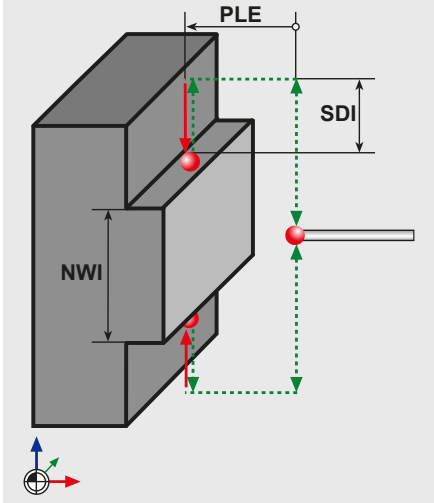
Level	Main axis	Secondary axis
G17	X	Y
G18	Z	X
G19	Y	Z

Tab. 6-25:

Graphic field

Level	Measuring axis	Graphic
G17	X	 The diagram shows a 3D perspective of a stepped cylindrical part. A vertical probe is positioned above the part. Red dots indicate the contact points on the top and side surfaces. Green dashed lines and arrows show the movement of the probe along the X-axis. Dimension lines indicate SDI (Side Distance Indicator) for the side surface and PLE (Probe Length Error) for the top surface. A NWI (Normal Width Indicator) dimension is shown for the base of the part. A coordinate system icon with blue, green, and red arrows is located at the bottom left.
	Y	 The diagram shows the same stepped cylindrical part from a different perspective. The probe is positioned above the part. Red dots indicate the contact points on the top and side surfaces. Green dashed lines and arrows show the movement of the probe along the Y-axis. Dimension lines indicate SDI (Side Distance Indicator) for the side surface and PLE (Probe Length Error) for the top surface. A NWI (Normal Width Indicator) dimension is shown for the base of the part. A coordinate system icon with blue, green, and red arrows is located at the bottom left.

Level	Measuring axis	Graphic
G18	Z	The diagram shows a 3D perspective of a rectangular block with a stepped top surface. A vertical measuring axis 'Z' is indicated. A red probe tip is shown at two positions on the step. Green dashed lines and arrows illustrate the measurement process: 'SDI' (Surface Distance Indicator) shows the vertical distance from the probe tip to the surface, and 'PLE' (Probe Length Error) shows the distance from the probe tip to the end of the probe. A coordinate system icon with blue, green, and red arrows is shown at the bottom left.
	X	The diagram shows a 3D perspective of a rectangular block with a stepped top surface. A horizontal measuring axis 'X' is indicated. A red probe tip is shown at two positions on the step. Green dashed lines and arrows illustrate the measurement process: 'SDI' (Surface Distance Indicator) shows the horizontal distance from the probe tip to the surface, and 'PLE' (Probe Length Error) shows the distance from the probe tip to the end of the probe. A coordinate system icon with blue, green, and red arrows is shown at the bottom left.

Level	Measuring axis	Graphic
G19	Y	
	Z	

Tab. 6-26: Graphics depending on "Obstacle yes/no"
The following graphic is displayed when entering the offset:

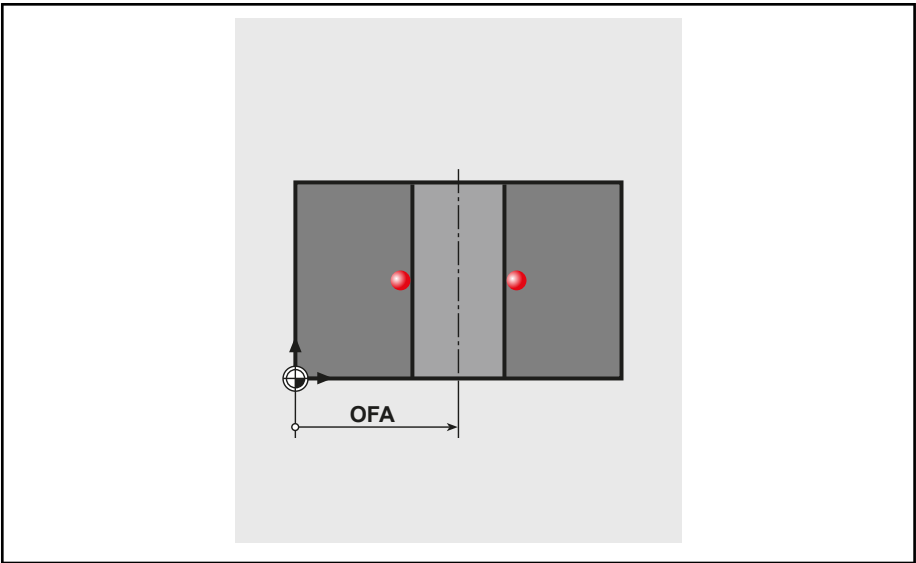


Fig. 6-18: Help image when entering the offset

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.NO SE.RESULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.NO SE.RESULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.NO SE.RESULT[3]	Zero point Z	REAL	

Tab. 6-27: Output values

6.3.9 Zero point probing, rectangular pocket

Short description Using "Zero point probing, rectangular pocket", the zero point in the main and secondary axis of a plane is recorded on the basis of a rectangular pocket center. The measured values of both axes are applied to the selected zero point table.

There are 2 methods to record the measuring points:

- Without obstacle
- With obstacle

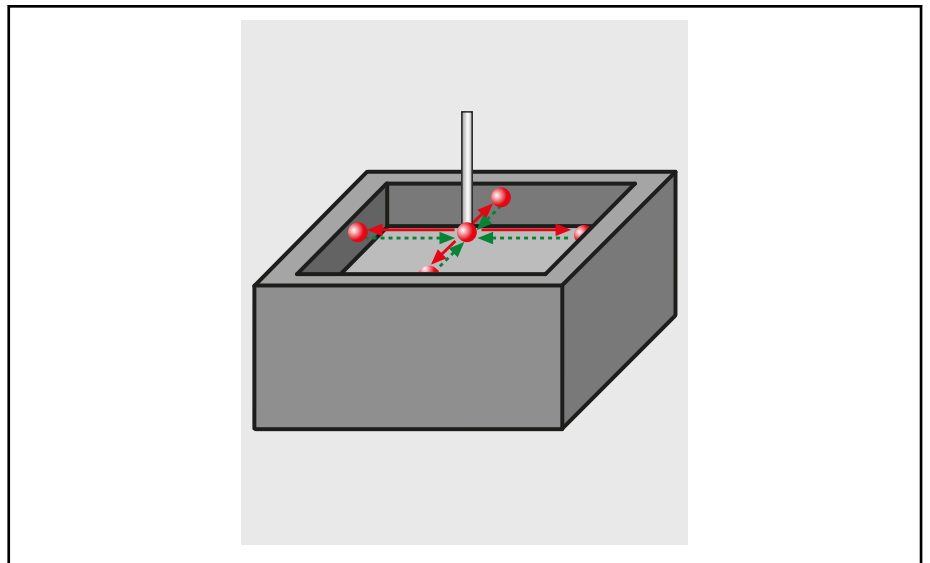


Fig. 6-19: Zero point probing, rectangular pocket

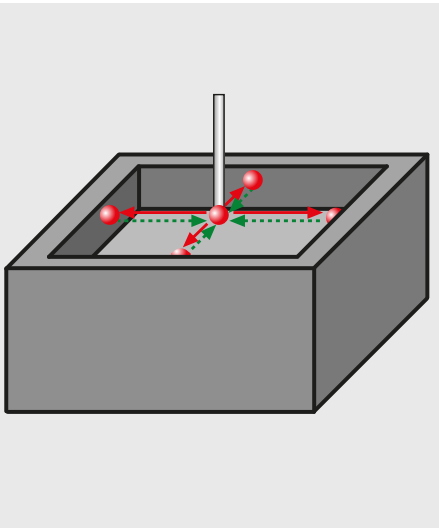
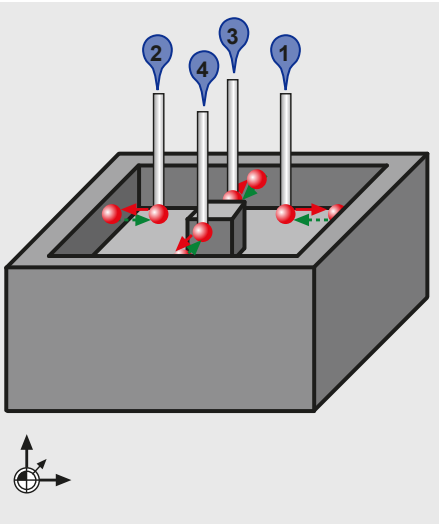
- Sequence**
1. Press <M7> "Zero point pocket"
 2. Select plane, adjust feed if required and enter offset
 3. Select with or without obstacle
 4. Select zero point and group
 5. Select <F6> "Apply active table" or <F5> "Select table"
 6. Press <F2> "Start program"
 7. The measured values are applied to the selected zero point table with NC start

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
OFM	Main axis offset		REAL	
OFS	Auxiliary axis offset			
LUP	Obstacle in pocket		no Yes	
PFE	Measuring feed		REAL	mm/min, >0
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-28: Input field, zero point probing, rectangular pocket

Graphic field The following graphics are displayed when entering "Obstacle yes/no":

Obsta- cle	Graphic
No	
Yes	

Tab. 6-29: Graphics depending on "Obstacle yes/no"

The following graphic is displayed when entering the offset of the main and secondary axis:

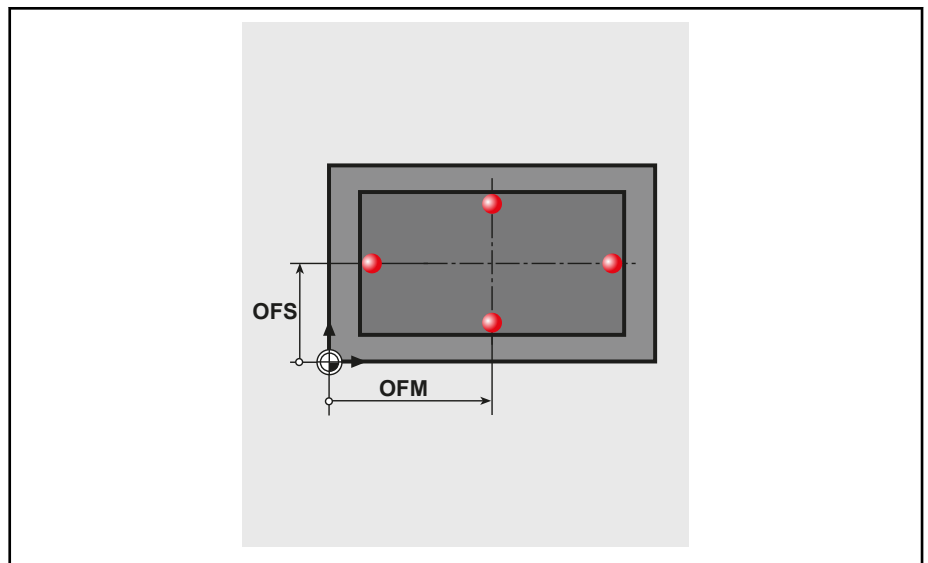


Fig. 6-20: Help image when entering the offset of the main and secondary axis

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.RE CPOCK.RE- SULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.RE CKPOCK.RE- SULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.RE CPOCK.RE- SULT[3]	Zero point Z	REAL	

Tab. 6-30: Output values

6.3.10 Zero point probing, rectangular spigot

Short description Using "Zero point probing, rectangular spigot", the zero point in the main and secondary axis of a plane is recorded on the basis of a rectangular spigot center. The measured values of both axes are applied to the selected zero point table.

Overview

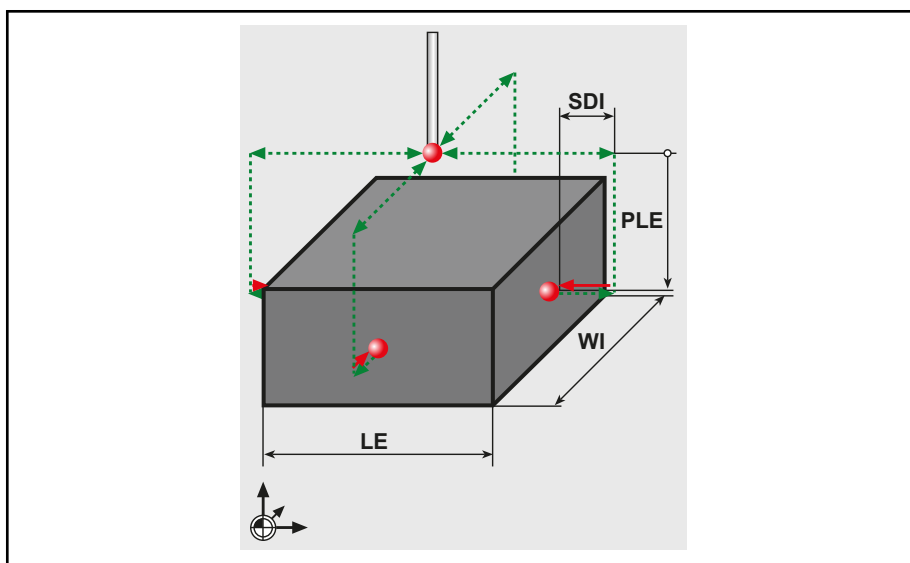


Fig. 6-21: Zero point probing, rectangular spigot

- Sequence**
1. Press M-Key with symbol "rectangular spigot"
 2. Select length, width, depth, level and safety distance, adjust feed if required and enter offset
 3. Select zero point and group
 4. Select <F6> "Apply active table" or <F5> "Select table"
 5. Press <F2> "Start program"
 6. Press NC start (program is running)
The determined measured values are displayed in the diagnostic line
 7. The measured values are applied to the selected zero point table with NC start

Input field

Parameter	Name	Properties	Values	Area
IPL	Interpolation level		G17 G18 G19	
LE	Length		REAL	>0
WI	Width		REAL	>0
SDI	Safety distance		REAL	>0
PLE	Feed increment till measuring height		REAL	
OFM	Main axis offset		REAL	
OFS	Auxiliary axis offset		REAL	
PFE	Measuring feed		REAL	mm/min, >0

Parameter	Name	Properties	Values	Area
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-31: Input field, zero point probing, rectangular spigot

Graphic field

This image is always displayed except for when entering the offset of the main and secondary axis:

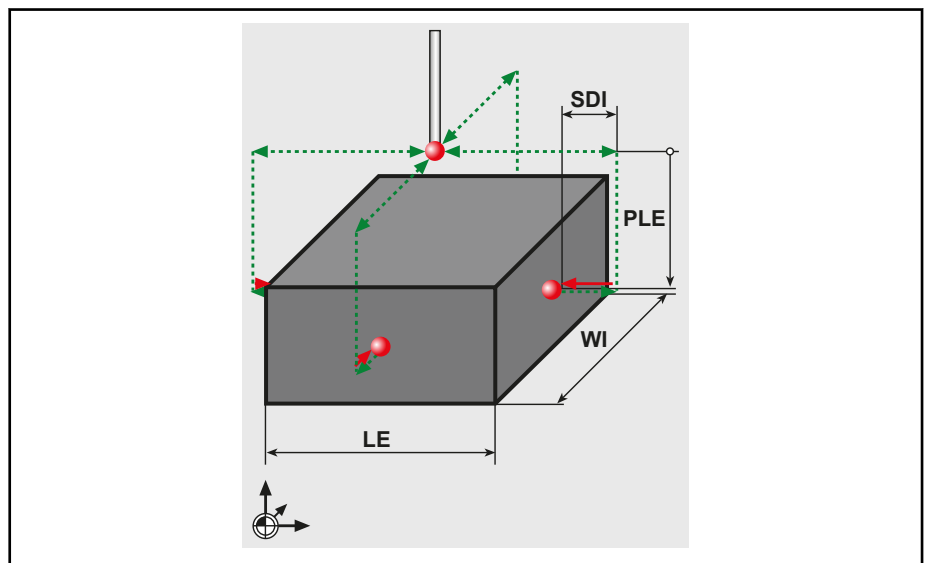


Fig. 6-22: Help image when entering the offset of the main and secondary axis

The following graphic is displayed when entering the offset of the main and secondary axis:

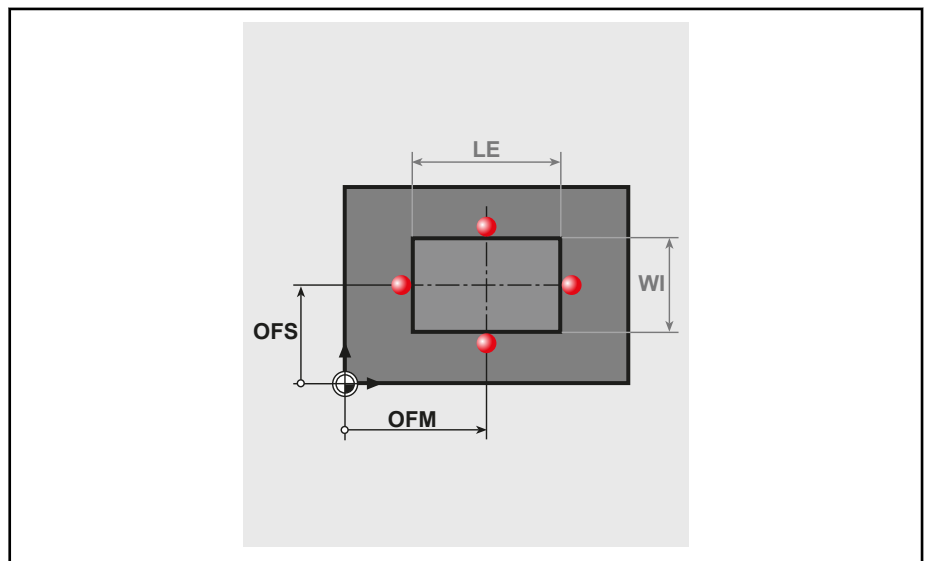


Fig. 6-23: Help image when entering the offset of the main and secondary axis

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.RE CSTU.RE- SULT[1]	Zero point X	REAL	
SD.SysPr- Man.MEAS.RE CSTU.RE- SULT[2]	Zero point Y	REAL	
SD.SysPr- Man.MEAS.RE CSTU.RE- SULT[3]	Zero point Z	REAL	

Tab. 6-32: Output values

6.3.11 Zero point probing, rotary axis

Short description Using "Probe zero point rotary axis", the angle of rotation of a plane is determined using a two-point measurement. The angle of rotation is applied to the selected zero point table as zero point of the rotary axis.

Overview When selecting the two measuring points, make sure that always the first measuring point is the pole for determining the angle.

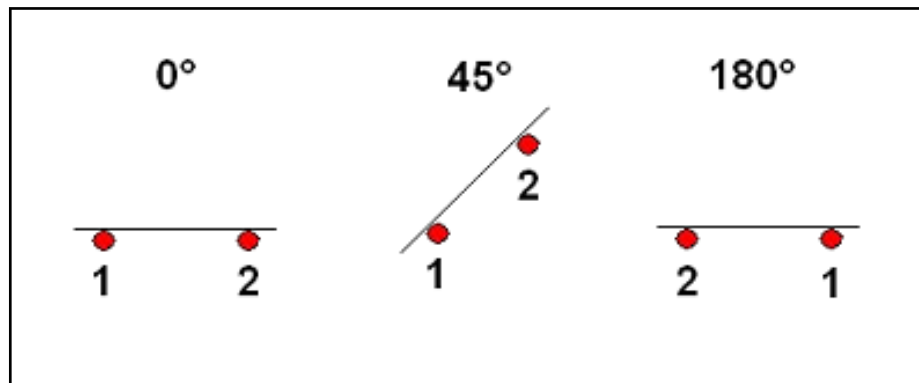


Fig. 6-24: Pole for determining the angle

The distance between the measuring points 1 and 2 has to be larger than the sphere diameter of the probe.

- Sequence**
1. Press <M2> "Zero point, rotary axis"
 2. Select rotary axis and measuring direction, adjust feed if required. Enter reference axis and command angle
 3. Traverse rotary axis. Select Yes/No. If Yes is selected, select rapid traverse or optionally, the feed and the velocity
 4. Select zero point and group
 5. Press <F2> "Start program"
 6. Press NC start (program is running)
The determined measured values are displayed in the diagnostic line
 7. Press NC start
The measured value is applied to the zero point table

Input field

Parameter	Name	Properties	Values	Area
RA	Rotary axis	Depending on the configuration data	A B C	
PAX	Measuring axis and direction	Depending on RA	Y- Z- X- Y+ Z+ X+ Z- X- Y- Z+ X+ Y+	
PFE	Measuring feed		REAL	mm/min, >0
BAX	Reference axis	Depending on RA	Y Z X Z X Y	
ANG	Set angle		REAL	Absolute
RM	Traverse rotary axis		Yes no	
ZO	Zero offset (ZO)		G54 G55 G56 G57 G58 G59	
PAGE	ZO bank		INTEGER	1...5

Tab. 6-33: Input field probe zero point, rotary axis

Graphic field

Only a main or a secondary axis can be selected as reference

Rotary axis	Main axis	Secondary axis
C	X	Y
B	Z	X
A	Y	Z

Tab. 6-34:

The following graphics are displayed depending on the selected rotary axis, the measuring direction and the reference:

Graphics displayed when selecting the A-axis:

Rotary axis	Measuring direction	Reference	Graphic
A	Y+	Y	
		Z	

Rotary axis	Measuring direction	Reference	Graphic
A	Y-	Y	
		Z	

Rotary axis	Measuring direction	Reference	Graphic
A	Z+	Y	
		Z	

Rotary axis	Measuring direction	Reference	Graphic
A	Z-	Y	
		Z	

Tab. 6-35: Graphics when selecting the A-axis

Graphics displayed when selecting the B-axis:

Rotary axis	Measuring direction	Reference	Graphic
B	Z+	Z	
		X	

Rotary axis	Measuring direction	Reference	Graphic
B	Z-	Z	
		X	

Rotary axis	Measuring direction	Reference	Graphic
B	X+	Z	
		X	

Rotary axis	Measuring direction	Reference	Graphic
B	X-	Z	
		X	

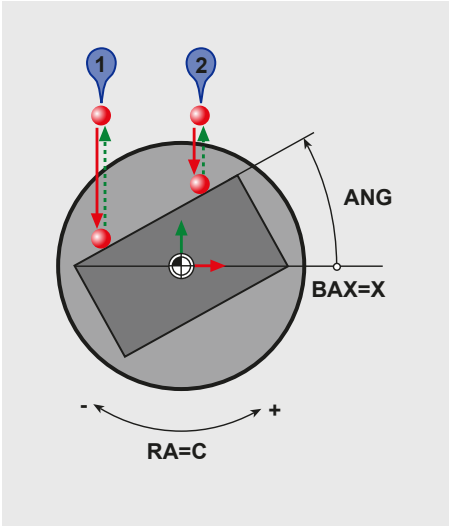
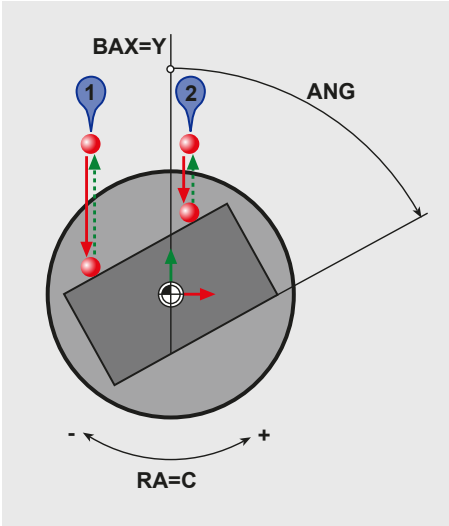
Tab. 6-36: Graphics when selecting the B-axis

Graphics displayed when selecting the C-axis:

Rotary axis	Measuring direction	Reference	Graphic
C	X+	X	
		Y	

Rotary axis	Measuring direction	Reference	Graphic
C	X-	X	
		Y	

Rotary axis	Measuring direction	Reference	Graphic
C	Y+	X	
		Y	

Rotary axis	Measuring direction	Reference	Graphic
C	Y-	X	
		Y	

Tab. 6-37: Graphics when selecting the C-axis

Result variables

Parameter	Description	Values	Area
SD.SysPr- Man.MEAS.RO TAX.RESULT	Zero point rotary axis	REAL	

Tab. 6-38: Output values

6.4 Probing inclined plane

Short description Use "Measured values for G230" to establish 3 points of a plane. These points are the basis for the manual function "Swiveling after probing" or cycle G230 (swiveling over measured values).

Overview

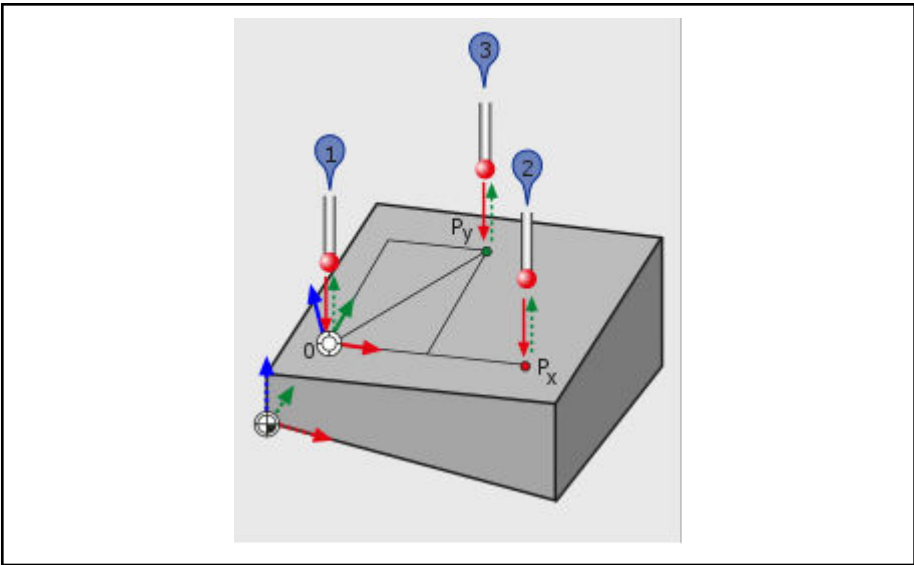


Fig. 6-25: 3 points probing for G230

- Sequence**
1. Press <M1> "Probing for G230"
 2. Select measuring direction and adjust feed, if required
 3. Approach position 1
 4. Press <F2> "Start program"
 5. Press NC start (program is running)
 6. Approach position 2
 7. Press <F2> "Start program"
 8. Approach position 3
 9. Press <F2> "Start program"
 10. Determined measured value are stored in the system date `SD.SysPr-Result.PMT`. The message "Function completed" is displayed in the diagnostic line.

Input field

Parameter	Name	Properties	Values	Area
PAX	Measuring axis and direction		X- X+ Y- Y+ Z- Z+	
PFE	Measuring feed		REAL	mm/min, >0

Tab. 6-39: Input field measured values for G230



Via <M2>"G230 Probing", the manual function 'Swiveling' can be directly called using the operating mode "Swiveling via probed points" (MS1).

The preset operating mode, however, cannot be changed any more.

For any further operation, refer to "Swivel function" in document "Standard NC Cycles 14VRS " (DOK-MTX***-NC*CYC**V14-APRS-EN-P), chapter "G230 Swivelling".

7 Commissioning

7.1 General information

The described measuring cycles are intended for the use at machine tools. The cycles can be used for probes to measures tools or workpieces.

Commissioning includes the following steps:

1. Setting the machine parameters
2. Adjusting Sercos files in the IndraMotion MTX NC control
3. Setting the drive parameters
4. Adjusting the PLC user program

Once these steps have been completed, the measuring functions are available.

7.2 Setting machine parameters

To use the measuring cycles, the machine parameters in IndraWorks Engineering have to be adjusted. For details on operating the configurator, also refer to:

DOK-MTX***-MA*PAR**V13-RERS-EN-P

Enabling the probe

In the first step, the probe function is enabled for the control.

The control is enabled in the data group **Setup of configuration data** via the parameter:

SUP/FuncGr[1]/EnablMeas	measure-	Value: Yes
ment (MEAS)		

Probe axis settings

Enter the axis names and the axis description to select the axes in the operating screens.

The data can be entered in the data group **Basic parameter channels** via the parameters:

ChAxName axis name (701000010)	Value: <Axis identifier>
ChAxClass axis description (701000030)	Value: Main axis X Y Z A B C

Probe drive settings

After the function has been enabled for the probe, the probe function and the edge type can be entered for each measuring axis.

The data can be entered in the data group **Optional parameters** via the parameters:

MEAS/DR[x]EnabMeas	Probe	function	Value: Yes
available (1003 000012)			
MEAS/DR[x]MeasEdge	Probe	edge	Value: positive/negative
(1003 000011)			

7.3 Setting drive parameters

Drive settings

To ensure that drives can use the integrated probe function, the "Servo function" function package has to be configured. The release of function packages can be checked in the **Function Packages** menu function at the drive node.

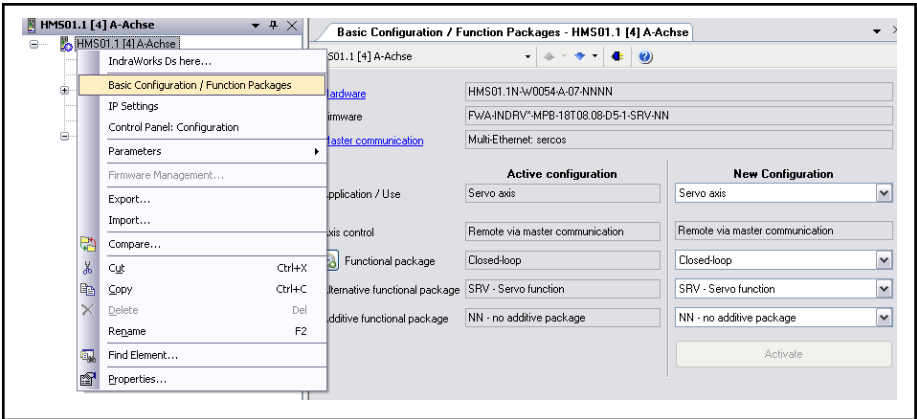


Fig. 7-1: checking the function package release in IndraWorks

Due to the properties on the control side, only 1 probe per drive axis can currently be supported. Please observe that only one probe per channel is listed in the control in parallel to the relevant drives that have been provided in the control configuration (machine parameters) for measuring.

 To connect several probes, these are to be switched via relays or PLC input modules (relay contacts). This switchover has to be considered in the PLC user program.

Probe function specification

On the drive side, the following settings have to be configured in IndraWorks. Under "Local I/Os", one of the digital inputs is to be selected by left-click. Afterwards, the mask is displayed. For quick, μ s-accurate evaluation of the probe, it is recommended to assign it to the X31/3 input. For this, X31/8 has to be supplied with a voltage of 24 V against X31/9. The respective input is then assigned the "S-0-0401 probe 1" parameter in the pull-down menu.

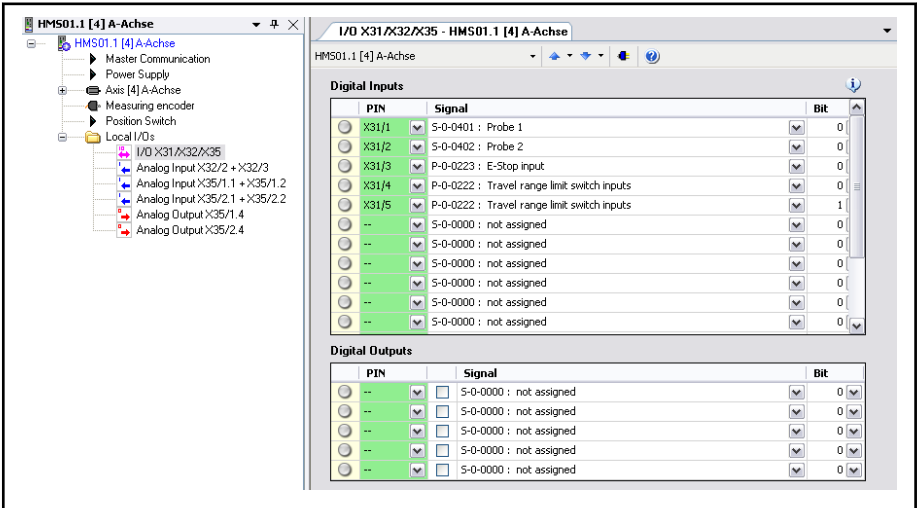


Fig. 7-2: Definition of the digital probe inputs in IndraWorks for single-axis devices

Special features of double-axis devices

Please ensure that the inputs X31/3 and X31/4 are used for double-axis devices.

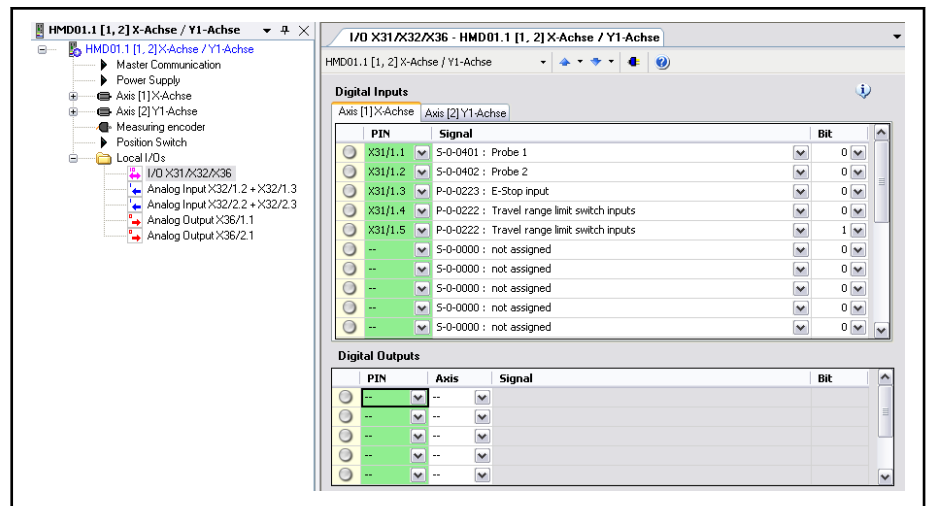


Fig. 7-3: Definition of the digital probe inputs in IndraWorks for double-axis devices

Signal selection touch probe

In S-0-0426, the signal selection for probe 1 is made:

- S-0-0051 Actual position value, encoder 1
- S-0-0053 Actual position value, encoder 2

In S-0-0427, the signals for probe 2 are selected:

- S-0-0051 Actual position value, encoder 1
- S-0-0053 Actual position value, encoder 2

7.4 PLC user program adjustment

7.4.1 General information

In the PLC user program, probe support functions are/have to be programmed:

1. *Mandatory PLC programming*
 - Activation/deactivation of probes
 - Collision monitoring for feed axes
2. *Optional PLC programming*
 - Reactivation of radio probes
 - Switching between several probes



The following description only illustrates the principle and the general tasks, partly according to a concrete example. In any case, the manufacturer documentation of the probe has to be observed for implementing PLC functions!

7.4.2 Activating/deactivating the probes

For activation/deactivation, the release of and, if necessary, switching between probes is usually realized by M-functions that have to be acknowledged.

Accordingly, a distinction is made:

- Probes that are activated once and never deactivated (e.g. fixed probes for tool and workpiece measurements)

- Probes that are activated via the NC program and temporarily deactivated and reactivated, if necessary (e.g. radio probes for workpiece measurements). In this case, a "Probe activated" PLC input signal is often provided.

In the SD.SysPrbase.PROBE[x].LOG.AUXON and .AUXOFF SD variables, the M-functions for activation/deactivation are stored. These are read out and applied by the measuring cycles. They have to be configured as auxiliary functions in the machine parameters that have to be acknowledged. It is recommended to display the state of the auxiliary function (on/off) in the M code display. For this purpose, these auxiliary functions have to be entered in groups and displayed.

AUXON The M-function to activate the probe is stored in the AUXON string variable (e.g. M97 for probe 1: SD.SysPrbase.PROBE[1].LOG.AUXON).

AUXOFF The M-function to deactivate the probe is stored in the AUXOFF string variable (e.g. M98 for probe 1: SD.SysPrbase.PROBE[1].LOG.AUXOFF).



These M-functions have to be accordingly programmed in the PLC. Also refer to [chapter "Specification of a probe PLC program" on page 200](#).

Manual probing



If "Manual probing" is activated, the reset information has to be written to the "SysPrMan.Reset" system date. Refer to [fig. 7-11 "Writing reset information in SD.SysPrMan.RESET system date" on page 206](#).

7.4.3 Collision monitoring for feed axes - PLC function block MT_AxProbeMon

General information

Principles

For the actual NC measuring task (NC command G75), the deflection signal of the probe is connected to the drive etc.

However, the PLC requires additional status information from the probe to be able to detect the following situations:

- Probe deflection without G75 (no active measurement)
- Probe deactivation during G75 (measuring distance active)
- Deactivated probe during G75 (measuring distance active)
- Prevention of motion "in the wrong direction" at the deflected probe

In all of these cases, it is recommended to set the **Axis motion lock**. Please refer to the following function block MT_AxProbeMon.

For this reason, the PLC has to know the following probe signals:

- Activation/deactivation state: "Ready for measuring" release with additional PLC input depending on the probe type
- Deflection state: same signal as drive, always with an additional PLC input
- G75 (measuring distance active): Derivations of the drive status bit in PLC via scs file (see below and documentation)

Prerequisite: Assigning G75 to the axis interface

By configuring the signal status word as described in chapter 4.2 (refer to the excerpt from the scs file regarding S-0-26 and S-0-328), the bit 0 of S-0-405

(probe 1 release) is mapped on the axis interface signal iAx_ScsState01, i.e. if G75 is active, iAx_ScsState01=TRUE applies. This signal has to be assigned to the bMeasureStatus input of the MT_AxProbeMon function block.

Brief description

Function block for probe axis monitoring

As of version 13, this function block is available in the "MT_BaseAdditional" PLC library. In order to implement the function block, this library has to be added to the PLC project.

Interface description

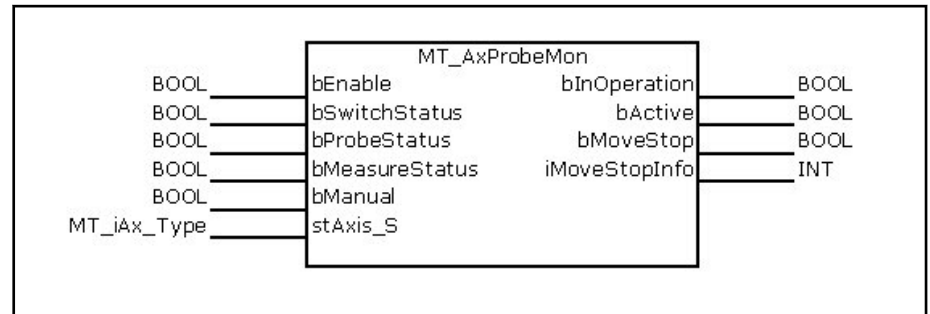


Fig. 7-4: Structure

	Name	Type	Description
VAR_INPUT	bEnable	BOOL	Activating probe monitoring
	bSwitchStatus	BOOL	Activation state of the probe (1==on, 0==off)
	bProbeStatus	BOOL	Deflection state of the probe (1==deflected, 0==not deflected)
	bMeasureStatus	BOOL	Measuring status (1==measurement active (G75), 0==measurement not active)
	bManual	BOOL	Main operating mode manual (1==manual active, 0==manual not active)
	stAxis_S	MT_iAx_Type	Axis interface status
VAR_OUTPUT	bInOperation	BOOL	Probe deflected, probe monitoring in progress
	bActive	BOOL	Probe monitoring active
	bMoveStop	BOOL	The motion lock for the axis has to be specifically programmed in the PLC program!
	iMoveStopInfo	INT	The motion lock message number has to be specifically programmed in the PLC program!

Tab. 7-1: Interface signals

Functional description

The function block MT_AxProbeMon enables monitoring an axis included in the measuring process. Axis motions after deflection of the activated probe in the same direction that leads to the destruction of the probe is prevented. This is possible during positioning of the probe by means of the NC program (G75 not active) and in jog mode if the output signal of the function block is respectively projected in the PLC user program.



The deflection signal of the probe is directly connected to the drive and in parallel to the PLC. When measuring with G75, the deflection signal triggers an immediate stop of the axis at the drive. The drive does not react if the probe is deflected without G75. The signal is running from the probe to the PLC. From there, DriveLock is sent to the NC and the signal is forwarded to the drive via Sercos. This long signal runtime leads to a respectively long reaction time. For this reason, stopping the axis by the PLC cannot replace the probe function in the drive!

In general, the function block output bMoveStop provides the option to prevent the axis motion via the interface signal qAx_DrvLock of the respective axis. The link has to be implemented by the PLC programmer.

If the function block is activated by setting bEnable, the states of all inputs are monitored. This is indicated by the bActive output. If a direction-related motion lock becomes active, the output bInOperation is set to TRUE. The reset of bEnable deletes all states stored in the function block as well as all outputs.



If the probe is deactivated, the function block cannot determine its actual deflection state. The deflection state (bProbeStatus) is only monitored if the probe is activated (bSwitchStatus).

In the moment of the deflection, the function block stores the active motion direction of the axis and recommends a motion lock in the following situations:

Motion lock on assumed probe abort

- iMoveStopInfo=1000
- If an activated probe aborts during driving without G75, this corresponds to a brief deflection. If this happens in automatic mode, a motion lock is recommended (bMoveStop) even if the probe is no longer deflected. This can only be canceled by deleting the travel command.

Motion lock if probe deflected and deactivated

- iMoveStopInfo=1001
- If a previously deflected probe is deactivated, the previously recommended motion lock is retained. This can either be canceled by reactivation of the probe or by canceling the travel command.

Motion lock on measuring with deactivated probe

- iMoveStopInfo=1003
- When traveling with G75, the NC programmer expects that the drive stops the axis if the probe is triggered. However, this is only the case if it is activated. For this reason, the motion lock is recommended if the probe is not activated and the travel command for measuring (G75) applies. This can only be canceled by canceling the travel command or activation of the probe.

Direction-related motion lock

- iMoveStopInfo=2001 or 2002
- If the probe is activated and deflected, a motion lock is recommended (bMoveStop) if a motion is signaled in deflection direction. For a deflection direction opposite to the motion signal, the motion lock (bMoveStop) is deleted.

Message texts

The function block provides an explanation for all recommended motion locks (bMoveStop) at the iMoveStopInfo output.

The following messages are recommended to the operator and have to be integrated in the message text file:

iMoveStopInfo	Message type	Message text	Cause text	Remedy text
1000	Errors	Axis stopped, probe potentially broken off, delete travel command	The probe is currently not deflected, however, was previously deflected during travel without G75. For this reason, a probe breakage is assumed	The motion lock can be canceled by deleting the travel command
1001	Warning	Axis stopped, probe deflected and deactivated, reactivate probe	The probe was deflected and deactivated. The motion lock is still active	Reactivate probe
1003	Warning	Axis stopped, G75 travel command on deactivated probe, activate probe	The measurement was started with G75 and the travel command for this axis was detected. However, the probe required for measurement was not activated	The motion lock can be canceled by activating the probe or by aborting the measurement
2002	Note	Axis stopped, probe deflected, move axis only in positive direction	Motion signal of the axis in negative direction although the probe is deflected in this direction	Move the axis in positive direction
2001	Note	Axis stopped, probe deflected, move axis only in negative direction	Motion signal of the axis in positive direction although the probe is deflected in this direction	Move the axis in negative direction

Tab. 7-2: Operator message recommendations

Implementation example

The function block has to be programmed separately for each feed axis in the PLC.

For a complete example, refer to the end of this chapter.

7.4.4 Reactivation of Radio Probes

Radio probes remain only active for a limited time after activation (e.g. 2 minutes) and are automatically deactivated after this time if no switching process has taken place during this time (otherwise, the deactivation time is re-triggered by the internal logics of the radio probe on switching).



For the exact conditions, refer to the manufacturer documentation of the probe.

For proper function, "reactivation after automatic deactivation" is required. The PLC has to detect automatic deactivation and reactivate the probe. Depending on the probe, it may be necessary to wait a specific time (e.g. 9 sec).

PLC tasks during this time:

- Activation of the motion lock for the axes
- Setting the stipulated "Custom bit x" in the channel interface to the NC

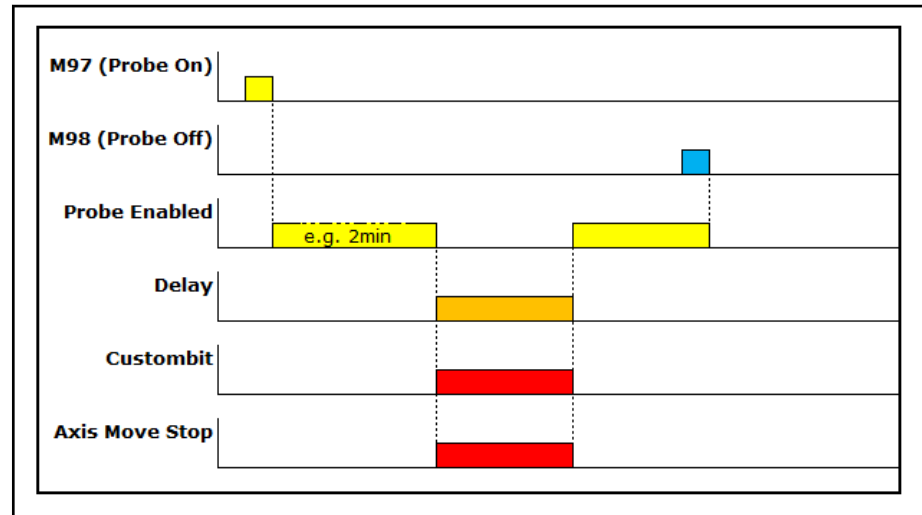


Fig. 7-5: Signal curve on reactivation of radio probes



If required, this function has to be accordingly programmed in the PLC. Also refer to the example at the end of this chapter.

Whether and with which behavior radio probes are applied has to be defined in the SD.SysPrbase.PROBE[x].LOG.RETRIG and .CUSBIT SD variables. These are read out and processed by the NC measuring cycles.

RETRIG The Boolean variable RETRIG has to be set to "TRUE" if a probe with time-related self-deactivation is applied (e.g. TRUE for probe 1: SD.SysPrbase.PROBE[1].LOG.RETRIG).

CUSBIT In the single-digit string variable CUSBIT, the number of the channel custom bit for the PLC for reporting the "Reactivation after automatic deactivation" information is stored (e.g. "8" for probe 1: SD.SysPrbase.PROBE[1].LOG.CUSBIT for probe 1 etc.)



The property "Reactivation" and the stipulated "Custom bit" also have to be specified in the PLC. In the example at the end of this chapter, the data are programmed in the PLC, however not read out from the SD variable.

7.4.5 PLC implementation example

General information

The following example illustrates mandatory and optional programming for PLC integration of probes.

Requirements

The example is subject to the following requirements:

- Two probes with a switchover in between

- *M-functions to be acknowledged for activation and deactivation of the probes or for release:*
 - Probe 1: On: M97; Off: M98
 - Probe 2: On: M99; Off: M100
- *Probe 1 is a radio probe (for "workpiece measurement"):*
 - Consideration of reactivation on automatic deactivation
 - Provides signal for "activated" to the PLC
 - Application of the inverted switching signal for deflection
- Probe 2 is permanently activated and provides a switching signal, however no signal for "activated" to the PLC (for "tool measurement")
- The switchover between probe 1 and 2 is implemented by a PLC output signal to a relay

The SD variables for probe 1 and 2 have to be assigned the following values (entered in the HMI setup mask or in the NC variable editor):

- *Probe 1 SD.SysPrbase.PROBE[1].LOG.*
 - AUXON M97
 - AUXOFF M98
 - RETRIG true
 - CUSBIT 8
- *Probe 2: SD.SysPrbase.PROBE[2].LOG.*
 - AUXON M99
 - AUXOFF M100
 - RETRIG false or <do not enter any value>
 - CUSBIT <do not enter a value>

Probe example data



The following description only illustrates the principle and the general tasks using an example. In any case, the manufacturer documentation of the probe has to be observed for implementing PLC functions!

Global Variables

Some general signals and I/O variables are functionally specified, e.g. in a global variable list.

Global variable list for the probe example

```
VAR_GLOBAL
(*
conditions at Mahomat shopfloor Lohr:
1.) probe 2 is always on and therefore needn't to switch on/off again (no M99, M100)
   It doesn't exist an PLC-input for the switched on status for probe 2.

2.) probe 2 supports a single signal for deflection
   probe 1 supports a double signal for deflection (normal and inverted signal)

3.) The selection of the right probe must be done with an external electrical switch.
   Only this signal is transferred to the drive and the PLC as the "deflection signal".
   The input-signal in the PLC is always on "%IX23.3".
   The inverted signal "%IX23.0" from probe 1 is not wired to the drives!
   That's why this signal is also not wired into the PLC neither.
   (*iPROBEpos          AT %IX23.0 : BOOL; (* probe status positiv*)*)
*)

(*signal: probe is deflected for probe 1 and 2*)
(*signal is only valid for the selected probe 1 or 2*)
iPROBEneg          AT %IX23.3      : BOOL; (* input: probe status negativ *)
```

Commissioning

```

iPROBE_LOWBAT      AT %IX23.1      : BOOL; (* input: probe 1 battery low status*)
iPROBE_OK          AT %IX23.2      : BOOL; (* input: probe 1 OK and active*)
qPROBE_ON          AT %QX7.6       : BOOL;  (* output: probe 1 switch on*)

(*bProbeSwitchRelay AT %QX13.0: BOOL :=TRUE; (*not used*)*)

(*to switch the deflection signal between probe 1 and 2*)
(*1 == probe 2 is selected *)
(*0 == probe 1 is selected*)
bProbeChange       AT %QX14.0      : BOOL;  (*output: switch between probe 1 (FALSE) and 2 (TRUE)*)
END_VAR

```

Specification of a probe PLC program

An independent PLC program with all mandatory and optional program parts is functionally programmed.

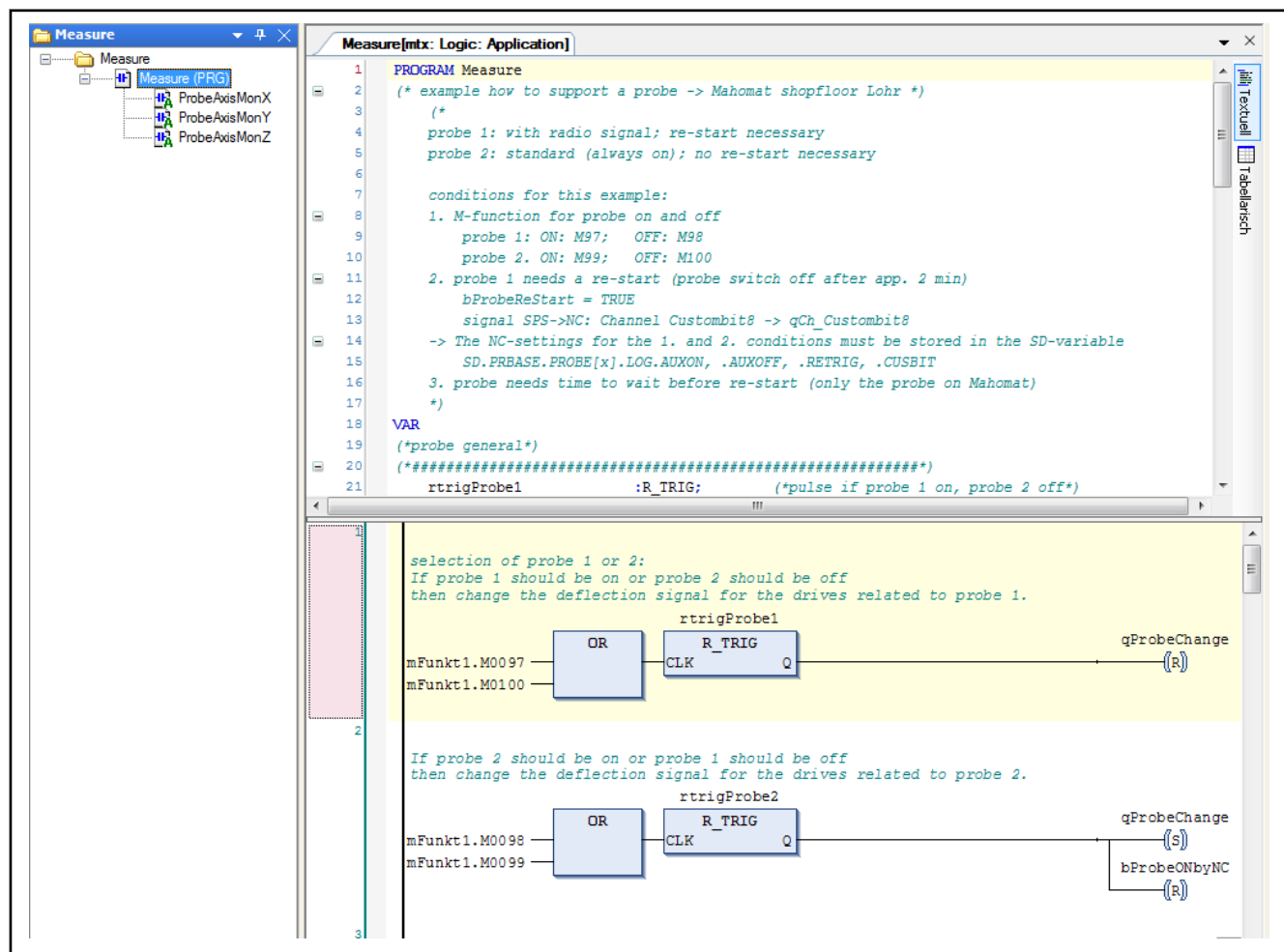


Fig. 7-6: Program measure for probe example

Declaration example program measure

Declaration program measure for probe example

```

PROGRAM Measure
(* example how to support a probe -> Mahomat shopfloor Lohr *)
(*
  probe 1: with radio signal; re-start necessary
  probe 2: standard (always on); no re-start necessary

  conditions for this example:
  1. M-function for probe on and off
    probe 1: ON: M97;   OFF: M98
    probe 2: ON: M99;   OFF: M100

```

```

2. probe 1 needs a re-start (probe switch off after app. 2 min)
   bProbeReStart = TRUE
   signal SPS->NC: Channel Custombit8 -> qCh Custombit8
-> The NC-settings for the 1. and 2. conditions must be stored in the SD variable
   SD.SysPrbase.PROBE[x].LOG.AUXON, .AUXOFF, .RETRIG, .CUSBIT
3. probe needs time to wait before re-start (only the probe on Mahomat)
*)
VAR
(*probe general*)
(#####)
rtrigProbe1      :R_TRIG;      (*pulse if probe 1 on, probe 2 off*)
rtrigProbe2      :R_TRIG;      (*pulse if probe 2 on, probe 1 off*)

(*probe 1*)
(*-----*)
bProbeReStart    :BOOL:= TRUE;  (*! must be TRUE if probe has to be re-started !*)
bProbeONbyNC     :BOOL;         (*probe was activated by NC (M-function)*)

rtrigProbeOK     :R_TRIG;      (*pulse if probe switched on *)
ftrigProbeOK     :F_TRIG;      (*pulse if probe switched off*)
bSwitchStatus    :BOOL;        (*probe status on / off*)

tWaitBeforeProbeReStart :TIME:=T#9s;  (*time to wait before next re-start of probe*)
tpWaitBeforeProbeReStart :TP;        (*timer to wait before next re-start of probe*)
bProbeReStartReq :BOOL;         (*automatically probe re-start requested*)

fbProbeSwitch    :IL Toggle;    (*toggle to switch on the probe*)
tProbeSwitch     :TIME:=T#2s;    (*time to wait for change output-signal (Renishaw)*)
tonProbeSwitch   :TON;          (*timer because of Renishaw behaviour*)

(*axes monitoring*)
(#####)
(*monitoring axis X*)
(*-----*)
fbProbeAxisMonX   :MT_AxProbeMon; (*FB for probe monitoring of an axis*)
bInOperationX     :BOOL;          (*The probe is on and the correct traveldirection monitored *)
bActiveX          :BOOL;          (*process active*)
bMoveStopX        :BOOL;          (*signal for drive lock*)
iMoveStopInfoX    :INT;           (* for all axes:
    1000 probe potentially broken, reset axis travel command (Measuring active)
    1001 Collision through travelling without G75 (Measuring active)
    1002 Collision through travelling with G75 (Measuring active)
    2001 positive direction is not possible, probe was pushed in this direction
    2002 negative direction is not possible, probe was pushed in this direction*)

(*monitoring axis Y*)
(*-----*)
fbProbeAxisMonY   :MT_AxProbeMon; (*FB for probe monitoring of an axis*)
bInOperationY     :BOOL;          (*The probe is on and the correct traveldirection monitored *)
bActiveY          :BOOL;          (*process active*)
bMoveStopY        :BOOL;          (*signal for drive lock*)
iMoveStopInfoY    :INT;           (*see X-axis*)

(*monitoring axis Z*)
(*-----*)
fbProbeAxisMonZ   :MT_AxProbeMon; (*FB for probe monitoring of an axis*)
bInOperationZ     :BOOL;          (*The probe is on and the correct traveldirection monitored *)
bActiveZ          :BOOL;          (*process active*)
bMoveStopZ        :BOOL;          (*signal for drive lock*)
iMoveStopInfoZ    :INT;           (*see X-axis*)
END_VAR

```

Commissioning

Implementation example program Measure

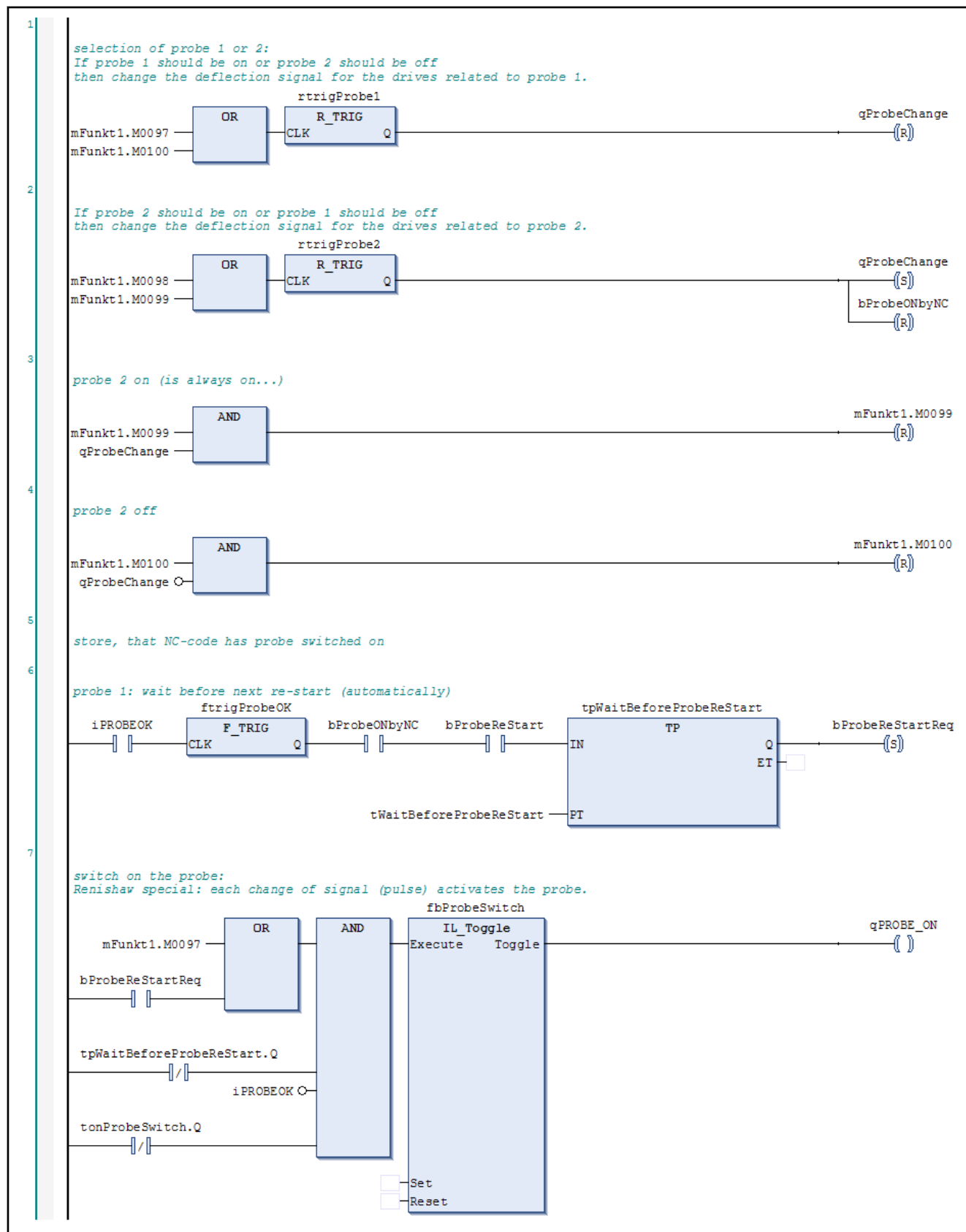


Fig. 7-7: Implementation program measure for probe example 1

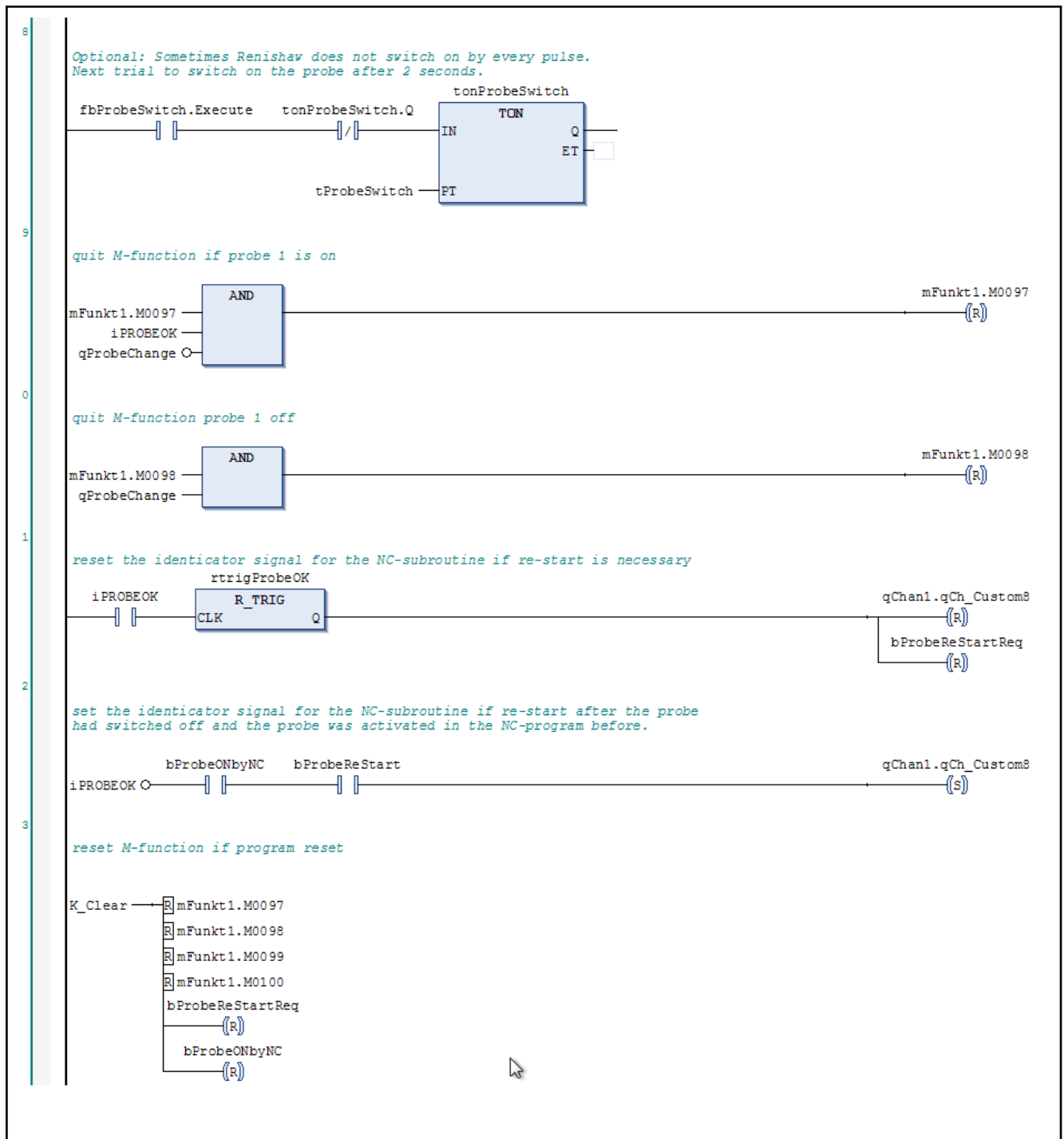


Fig. 7-8: Implementation program measure for probe example 2

Measure.ProbeAxisMonX action with MT_AxProbeMon function block (Y, Z respectively equal):

Commissioning

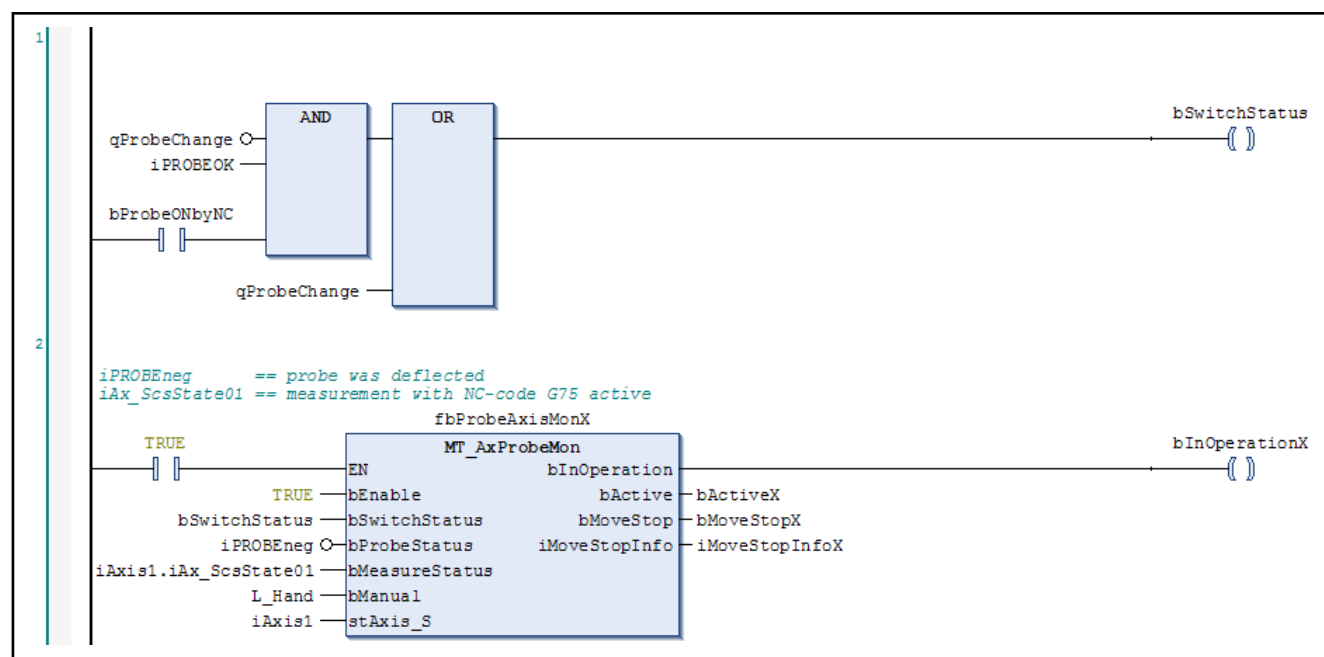


Fig. 7-9: Implementation action for X axis monitoring for probe example 1

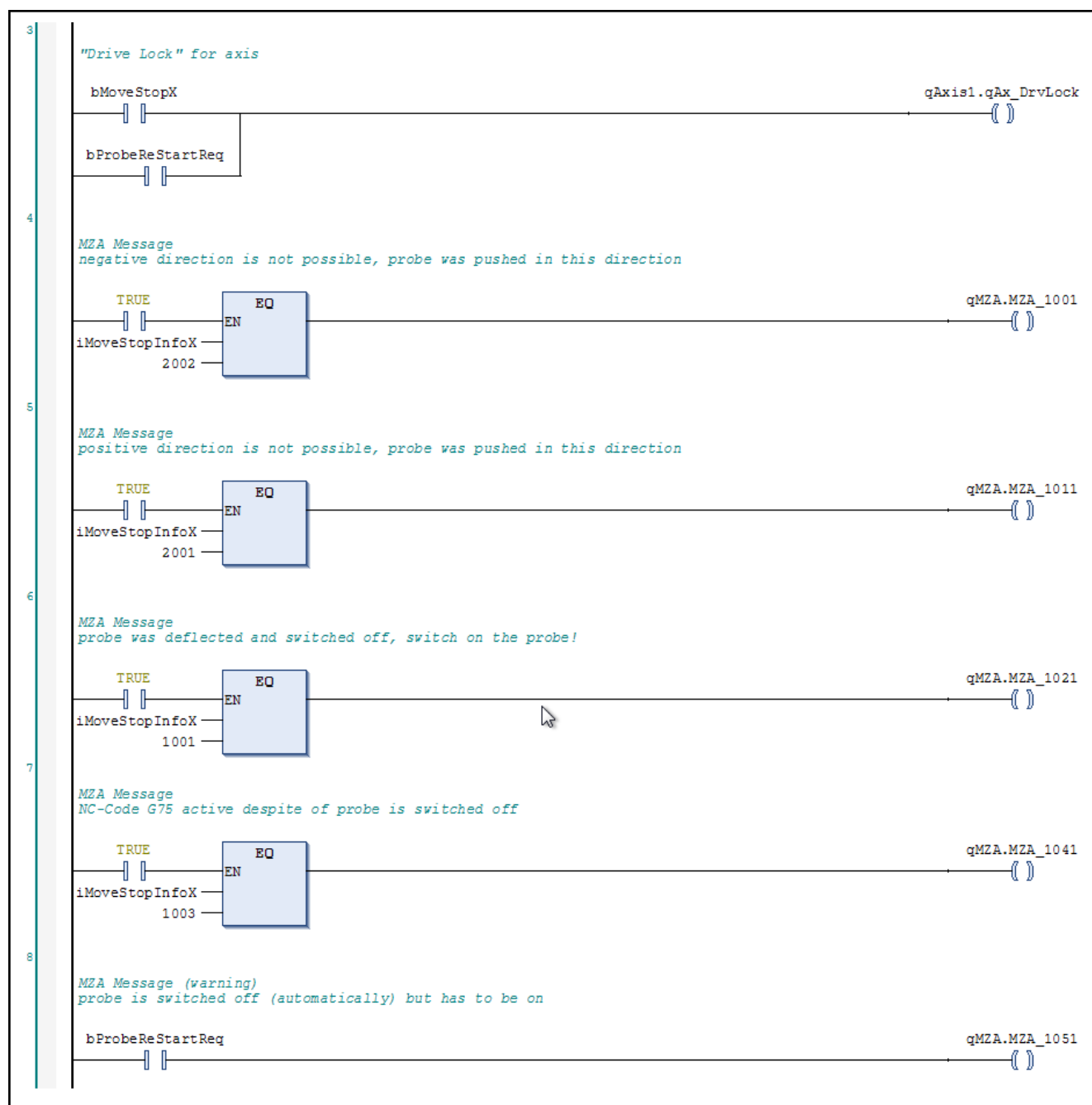


Fig. 7-10: Implementation action for X axis monitoring for probe example 2

As message text for motion lock of the axis during the time period of expected reactivation of the probe by the PLC, the following message text file entry is recommended.

Event	Message type	Message text	Cause text	Remedy text
PLC variable bProbeReStartReq according to example	Warning	Axis stopped, the probe was deactivated automatically, automatic reactivation not active	After expiry of the activation time, the probe was automatically deactivated, axis motion lock active	The probe is activated by the PLC or has to be reactivated by the "probe on function", the motion lock is then canceled again

Tab. 7-3: Operator message recommendation



Before an ASUP is processed in "manual" operation mode for "Manual probing", it has to be ensured that a NC start can also be executed in this operation mode.

Example to write the reset information to "SysPrMan.Reset" on "Manual probing":

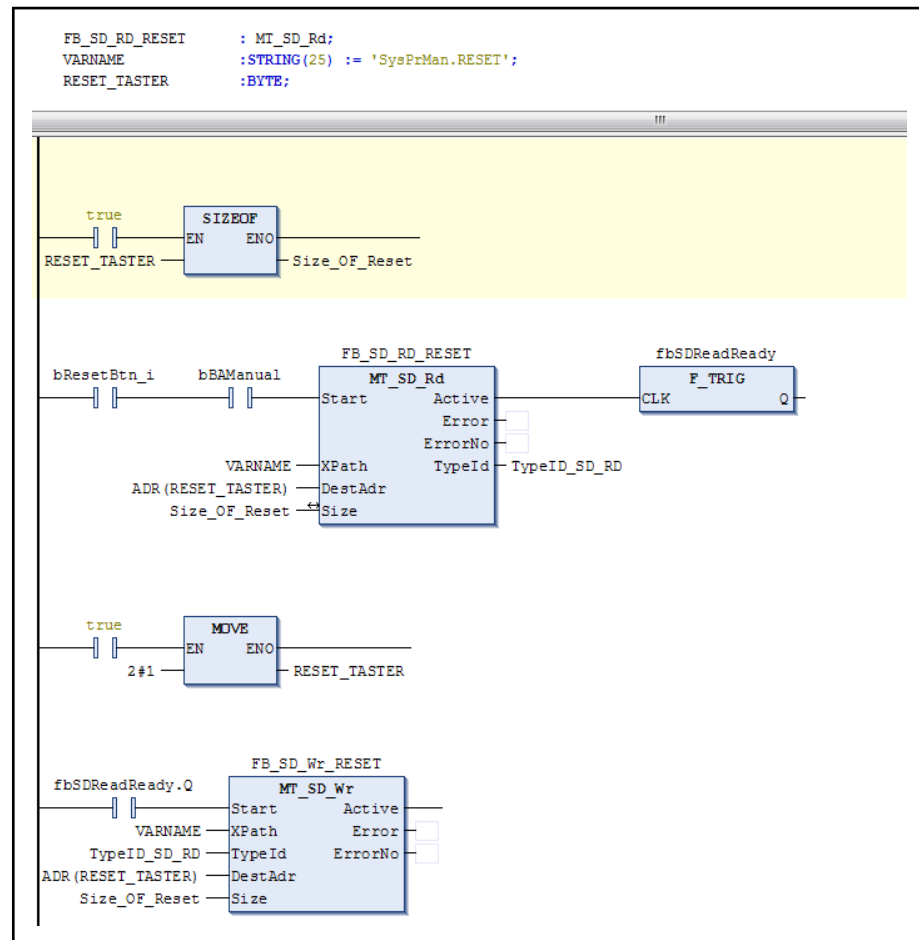


Fig. 7-11: Writing reset information in "SD.SysPrMan.RESET" system date

7.5 SD variables

7.5.1 Standard structure

In order to be able to define the SD variables, the relevant scheme types as well as the definition files have to be provided by copying and renaming the template files available in the root/feprom or root/feprom/schemes directory to the root/usrfep or root/usrfep/schemes directory.

The standard SD variables contain the geometry data of a tool probe, the positioning velocity, the auxiliary functions, the calibration values as well as the variables for storing the measuring results. The variable names are SD.SysPrBase, SD.SysPrResult and SD.SysPrMan and are available in the standard.

Scheme definitions:

Type	Definition file in the root/feprom/ schemes directory	Structure of SD variables
SysPrBase_t	sdprbase.xsd	chapter 5.4 "SD variables for probe data" on page 106
SysPrMan_t	sdprman.xsd	chapter 5.4 "SD variables for probe data" on page 106
SysPrResult_t	sdprresult.xsd	chapter 5.4 "SD variables for probe data" on page 106

Tab. 7-4: Scheme definitions

SD definition files:

	Definition file in the root/feprom directory
Variable definition:	SDDefPrb.xml
Variable initialization:	SDDatPrb.xml

Tab. 7-5: SD definition files

7.5.2 Structure expansion

Files in *.xsd format can be opened with the provided scheme editor. The editor can be found in the start menu under **Programs ▶ Rexroth ▶ IndraWorks ▶ MTXTools ▶ SchemeEditor**. In order to expand the structure for multiple probes, axes or channels, the respective scheme file (e.g. sdprbase.xsd) has to be copied to the root/schemes directory and opened to make changes. After successfully checking the changes, the changed files are to be moved to the usr/feprom/schemes directory.



In order to apply the changes of the files sdprbase.xsd or SDDefPrb.xml, an NC restart has to be carried out.

Expanding the structure for multiple probes

In the provided file sdprbase.xsd, two probes are already available. For example, if three probes are to be operated, line 7 of sdprbase.xsd is to be changed as follows:

Original: Line 8: <xs:elementname="PROBE"maxOccurs="2">

Changed: Line 8: <xs:elementname="PROBE"maxOccurs="3">

Expanding the structure for multiple axes

In the provided file sdprresult.xsd, three axes are available. For example, if the structure is to be extended to eight axes, the lines 11 and 34 of sdprresult.xsd are to be changed as follows:

Original: Line 11: <xs:elementname="AXIS"maxOccurs="3">

Line 11: <xs:elementname="AXISRES"type="xs:float"maxOccurs="3"/>

Changed: Line 11: <xs:elementname="AXIS"maxOccurs="8">

Line 11: <xs:elementname="AXISRES"type="xs:float"maxOccurs="8"/>

Expanding the structure for multiple channels

The file SDDefPrb.xml can be opened with the SD configurator.

In the **Dimension** column, "Channel" is to be selected.

7.6 Initialization screen

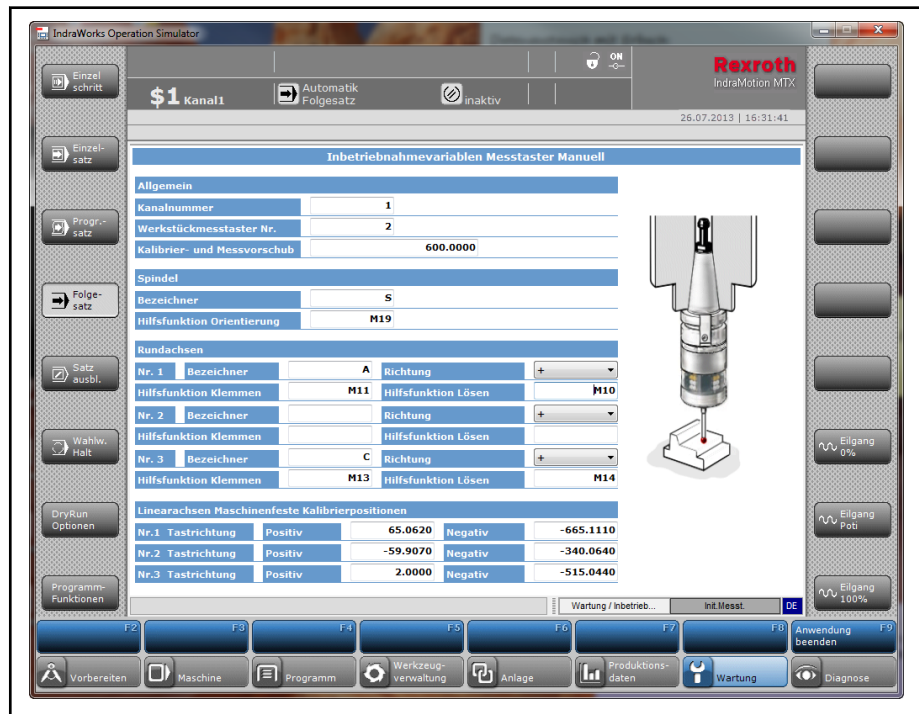


Fig. 7-12: Probe initialization of manual functions

The initialization screen serves for easy adjustment of individual functions to the machine.

The following variables are to be entered:

Channel number for the functions

Probe number

Measuring and calibration feed

Spindle identifier

Auxiliary function for spindle orientation

Rotary axes:

Axis no. 1

Identifier (A)

Direction (+/-)

Auxiliary function for clamping

Auxiliary function for unclamping

Axis no. 2

Identifier (B)

Direction (+/-)

Auxiliary function for clamping

Auxiliary function for unclamping

Axis no. 3

Identifier (C)

		Direction (+/-)
		Auxiliary function for clamping
		Auxiliary function for unclamping
Machine-fixed positions of the linear axes:		
	Axis no. 1	Probing direction X+
		Probing direction X-
	Axis no. 2	Probing direction Y+
		Probing direction Y-
	Axis no. 3	Probing direction Z+
		Probing direction Z-

Tab. 7-6: Probe initialization of manual functions

Probe images

Probe 1 (tool probe):



Fig. 7-13:

Probe 2 (workpiece probe):



Fig. 7-14:

Tab. 7-7: Probe images

Workpiece probe commissioning and service screen

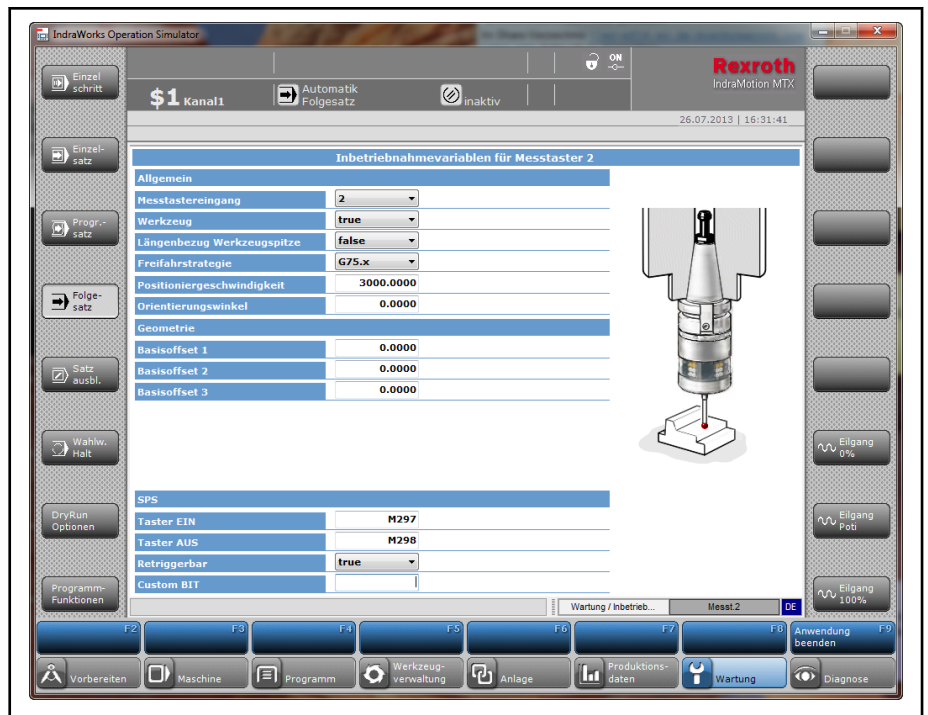


Fig. 7-15: Commissioning screen 1

Tool probe commissioning and service screen

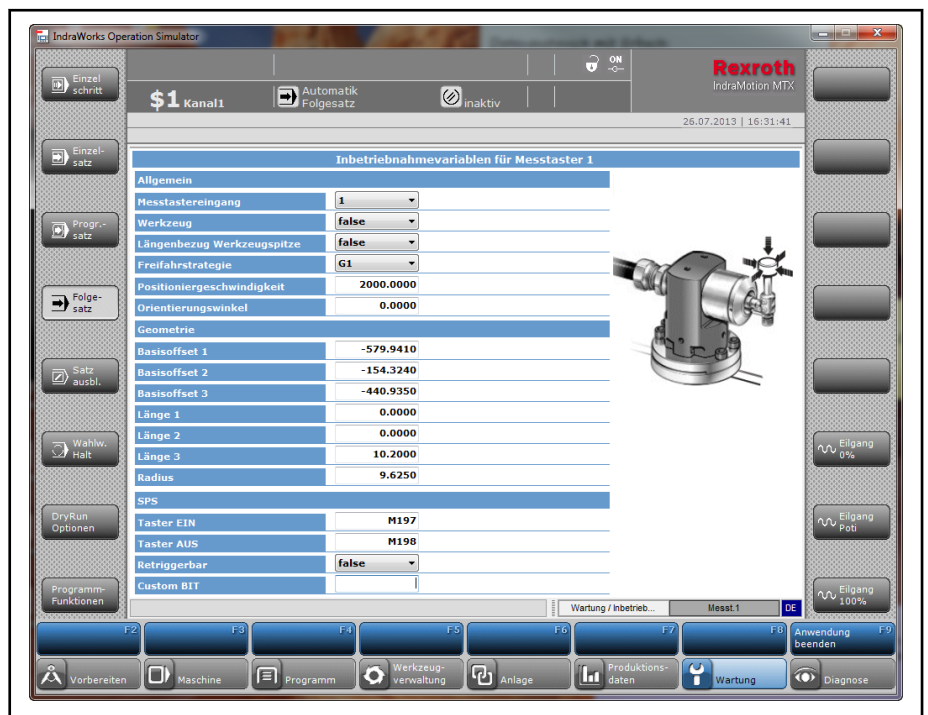


Fig. 7-16: Commissioning screen 2



The screens for "manual and automatic" probe commissioning can be used for a maximum of 2 probes.

If the number of probes was extended to more than 2 as described under [chapter 7.5 "SD variables"](#) on page 206, the values can be entered only by means of a variable list.

7.7 Mechanical installation examples

7.7.1 Probe installation examples

Lathe - Workpiece probing

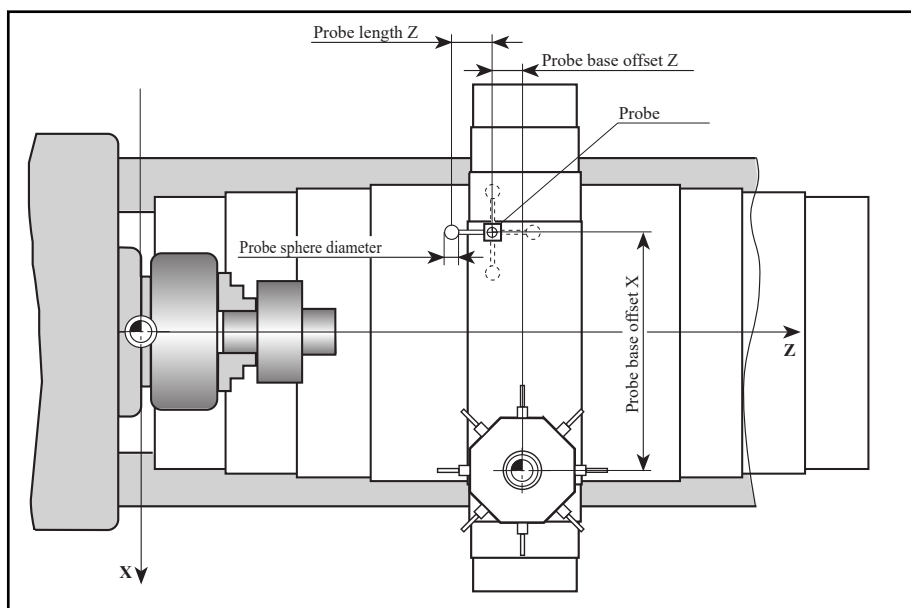


Fig. 7-17: Lathe - Workpiece probing

Lathe - Tool probing

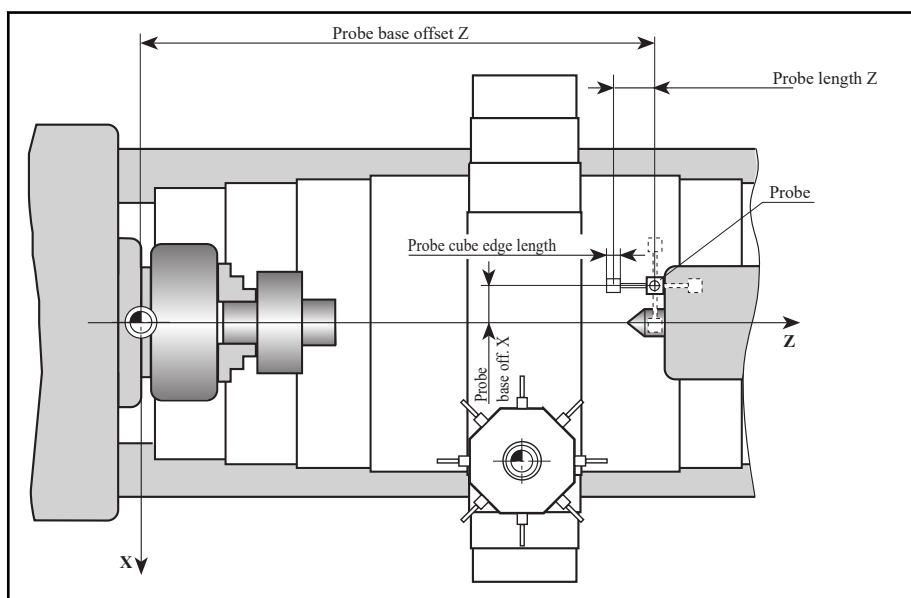


Fig. 7-18: Lathe - Tool probing

Milling machine - Workpiece probing

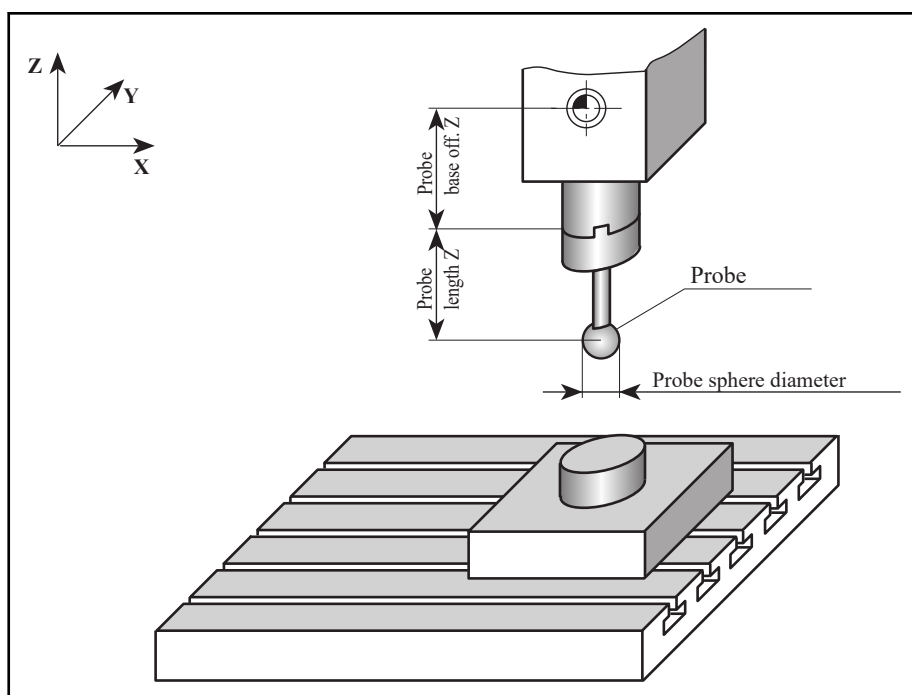


Fig. 7-19: Milling machine - Workpiece probing

Milling machine - Tool probing

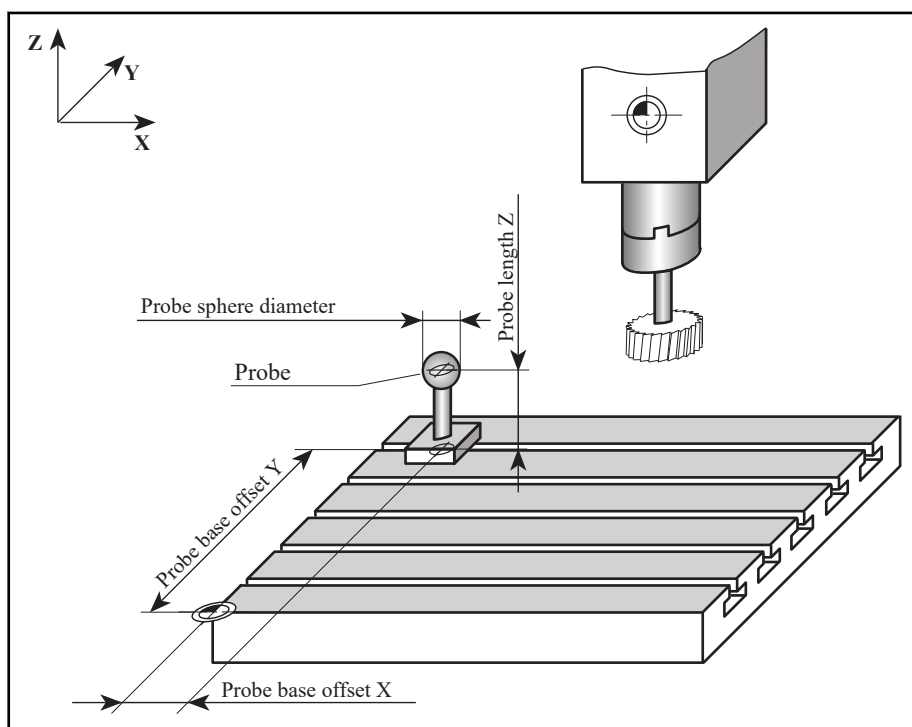


Fig. 7-20: Milling machine - Tool probing

7.8 Electrical connection diagram example

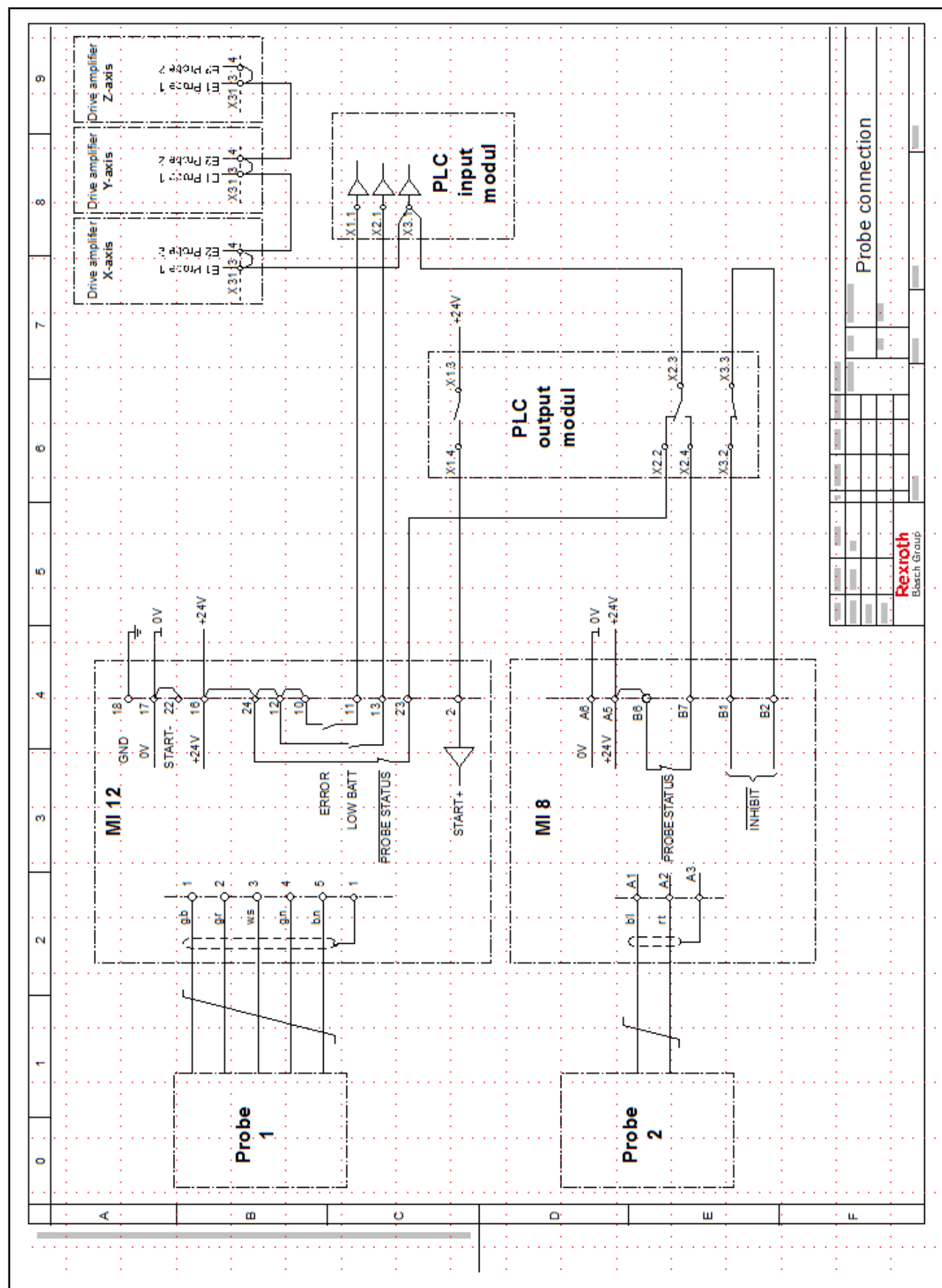


Fig. 7-21: Probe connection

8 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries. You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	+49 9352 40 5060
Fax:	+49 9352 18 4941
E-mail:	service.svc@boschrexroth.de
Internet:	http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

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