SIEMENS

SINUMERIK

SINUMERIK 840D sl/840D/840Di sl/840Di/810D
Measuring cycles HMI sl

Programming Manual

Valid for

SINUMERIK 840D sl/840DE sl
SINUMERIK 840Di sl/840DiE sl controls

Software	Version
NCU system software for 840D sl/840DE sl	2.6
With measuring cycles HMI sl	2.6

03/2009 Edition
6FC5398-4BP10-2BA0

Legal information

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

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

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CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

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

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Preface

Structure of the documentation

The SINUMERIK documentation is organized in 3 parts:

- General Documentation
- User documentation
- Manufacturer/service documentation

Information on the following topics is available at http://www.siemens.com/motioncontrol/docu:

- Ordering documentation

  Here you can find an up-to-date overview of publications.
- Downloading documentation

  Links to more information for downloading files from Service & Support.
- Researching documentation online

  Information on DOConCD and direct access to the publications in DOConWEB.
- Compiling individual documentation on the basis of Siemens contents with the My Documentation Manager (MDM), refer to http://www.siemens.com/mdm.

  My Documentation Manager provides you with a range of features for generating your own machine documentation.
- Training and FAQs

  Information on our range of training courses and FAQs (frequently asked questions) are available via the page navigation.

Target group

This documentation is intended for machine tool programmers using the HMI sl software.

Benefits

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

Standard scope

This documentation only describes the functionality of the standard version of the measuring cycles. The machinery construction OEM documents supplements or changes that he makes (the machinery construction OEM).

Other functions not described in this documentation might be executable in the control. However, no claim can be made regarding the availability of these functions when the equipment is first supplied or in the event of servicing.

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

Definitions

The meanings of some basic terms used in this documentation are given below.

Program

A program is a sequence of instructions to the CNC which combine to produce a specific workpiece on the machine.

Contour

The term contour refers generally to the outline of a workpiece. More specifically, it also refers to the section of the program that defines the outline of a workpiece comprising individual elements.

Cycle

A cycle, such as milling tools/measure drills, is a subroutine specified by HMI sl for carrying out a recurring machining process.

Technical Support

If you have any questions, please contact our Hotline:

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Phone	+49 180 5050 222
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Internet	http://www.siemens.com/automation/support-request

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Note

Country telephone numbers for technical support are provided under the following Internet address:

http://www.automation.siemens.com/partner

Questions about the manual

If you have any queries (suggestions, corrections) in relation to this documentation, please fax or e-mail us:

Fax	+49 9131- 98 2176
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A fax form is available in the appendix of this document.

Internet address

http://www.siemens.com/motioncontrol

Validity

This User's Guide is valid for the following controls:

Measuring cycles, version 02.06.

Structure of descriptions

All cycles and programming options have been described according to the same internal structure, as far as this is meaningful and practicable. The various levels of information have been organized such that you can selectively access the information you need for the task in hand.

Supplementary devices

The applications of SIEMENS controls can be expanded for specific purposes through the addition of special add-on devices, equipment and expansions supplied by SIEMENS.

Note

Measuring cycles GUD parameters

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used up to and including measuring cycles version 7.5, compared to the machine and setting data as of measuring cycles version 2.6, is included in appendices A1, A2 and A3.

Table of contents

General 1

1.1 Basics

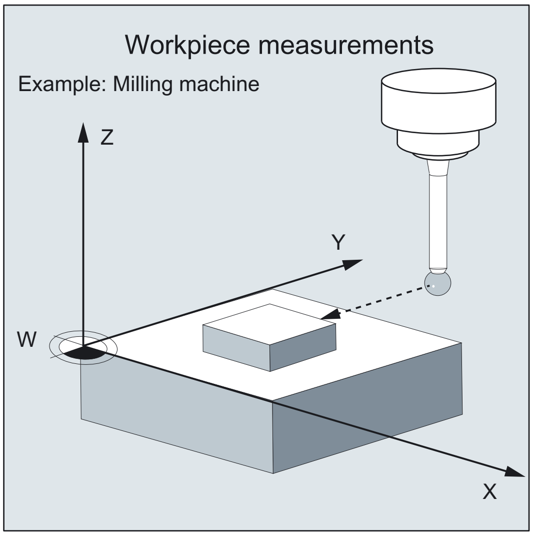
General information

Measuring cycles are general subroutines designed to solve specific measurement tasks. They can be adapted to specific problems via parameter settings.

When taking general measurements, a distinction is made between

- tool measurements and
- workpiece measurements.

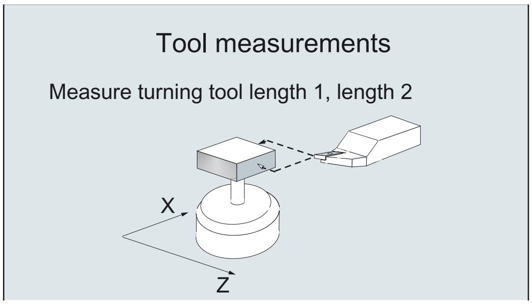
Workpiece measurements

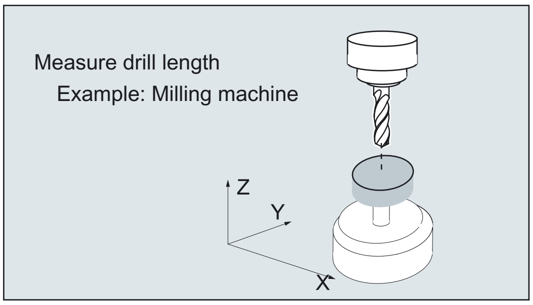


In workpiece measurement, a measuring probe is moved up to the clamped workpiece in the same way as a tool and the measured values are acquired. The flexibility of measuring cycles makes it possible to perform nearly all measurements required on a milling or turning machine.

An automatic tool offset or ZO correction can be applied to the workpiece measurement result.

Tool measurements





In tool measurement, the selected tool is moved up to the probe and the measured values are acquired. The probe is either in a fixed in position or is swung into the working area with a mechanism. The tool geometry measured is entered in the appropriate tool offset data set.

1.2 General prerequisites

Certain preconditions must be met before measuring cycles can be used.

These are detailed in Part 2 Description of Functions (Chapter 8 ff.).

The following checklist is useful for checking which preconditions have been met:

Machine

- All machine axes are designed in accordance with DIN 66217.
- Machine data have been adapted.

Existence of measuring cycles, data blocks

References:

Commissioning Manual SINUMERIK 840D sl base software and HMI sl

Starting position

- The reference points have been approached.
- The starting position can be reached by linear interpolation without collision.

Display functions of the measuring cycles

A HMI/PCU or HMI/TCU is required for showing the measuring result displays and for measuring cycle support.

Please observe the following when programming:

- Tool radius compensation is deselected before it is called (G40).
- All parameters for the cycle call have been defined beforehand.
- The cycle is called no later than at the 5th program level.
- The system of units allows measuring in the programmed unit system that deviates from the basic system with switchable technology data.
  - For **metric** dimension system with active G70, G700.
  - For **inch**-based dimension system with active G71, G710.

1.3 Behavior on block search, dry run, program testing, simulation

Function

The measuring cycles are skipped during execution if one of the following execution modes is active:

- "Trial run" ($P_DRYRUN=1)
- "Program test" ($P_ISTEST=1)
- "Block search" ($P_SEARCH=1), only if $A_PROTO=0.

Simulation

- On HMI Advanced ($P_SIM=1)

  The measuring cycle programs are executed when "Simulation" is selected on the HMI.
- On Jobshop products ($P_SEARCH=1 and $A_PROTO=1)

The measurements are simulated. No selected tool or zero offset is applied. Active functions such as "measuring result display", "travel with collision monitoring", "measuring cycle logging" are not executed.

Suppression of simulation execution

Execution of the measuring cycles in simulation can be suppressed in simulation by resetting the variable _MC_SIMSIM=0 in data block GUD6. The measuring cycles are then skipped.

Specifying differences for simulation

The variable _MC_SIMDIFF of data type REAL permits specification of simulated measurement deviations at measuring points. The value is a dimension in the basic system of the control.

Excessive values of _MC_SIMDIFF with corresponding value assignment of the defining parameters cause cycle alarms to be output.

Note

It is not ensured that the correction value contains the correct sign of _MC_SIMDIFF. This depends on the measurement or calibration task and the direction of measurement. The sign is influenced in such a way that the overall result makes sense (e.g. "Measure hole"). Changing the sign always causes the sign of the result to change.

1.4 Reference points on the machine and workpiece

General information

Depending on the measuring task, measured values may be required in the machine coordinate system or in the workpiece coordinate system.

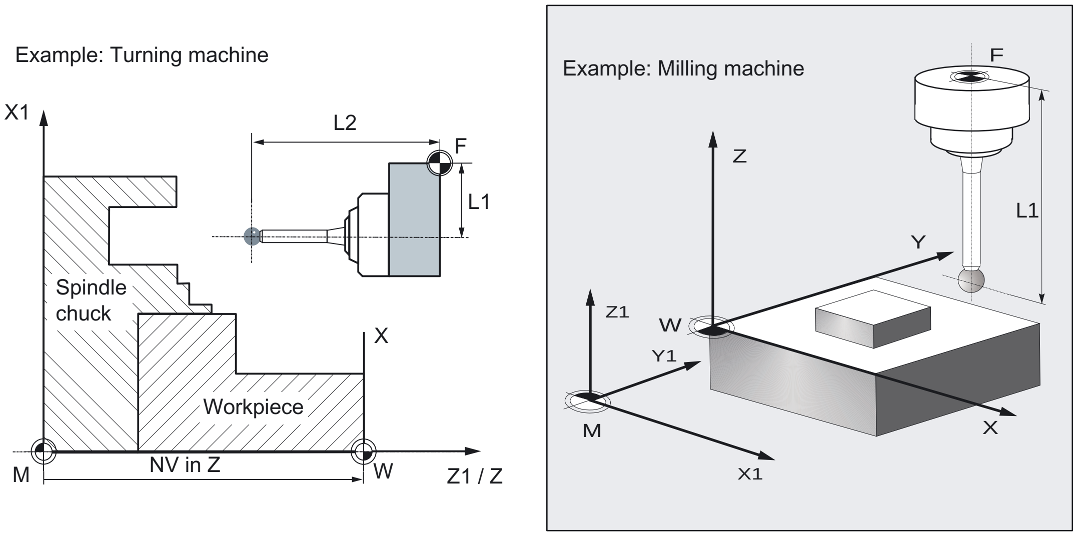
e.g.: It may be easier to ascertain the tool length in the machine coordinate system.

Workpiece dimensions are measured in the workpiece coordinate system.

Where:

- M = Machine zero
- W = Workpiece zero
- F = Tool reference point

Reference points



The position of tool reference point F in the machine coordinate system is displayed with machine zero M as the **machine actual value**.

The position of the tool tip (active tool) in the workpiece coordinate system is displayed with workpiece zero W as the **workpiece actual value**. If a workpiece probe is active, the position usually refers to the center point of the probe ball.

The **zero offset** (ZO) characterizes the position of the workpiece on the machine.

The ZO is the position of workpiece zero W in the machine coordinate system.

In addition to the pure offset, a ZO might also include rotation, mirroring, and a dimension factor. Together these are termed a **frame**.

SINUMERIK controls use numerous frames: various basic frames, system frames, settable frames (e.g. G54), programmable frames: They interact in a frame chain to produce the overall frame and the workpiece coordinate system.

Measuring cycles do not support any frames with an active scale factor. Rotation or mirroring is not supported in some cycles and measuring variants.

The machine and workpiece coordinate system can be set and programmed separately in the "inch" or "metric" measuring system.

Note

Transformation

If kinematic transformation is active, the control makes a distinction between the basic coordinate system and machine coordinate system.

If kinematic transformation is deactivated, this distinction is made.

All descriptions provided below assume that kinematic transformation is deactivated and therefore refer to the machine coordinate system.

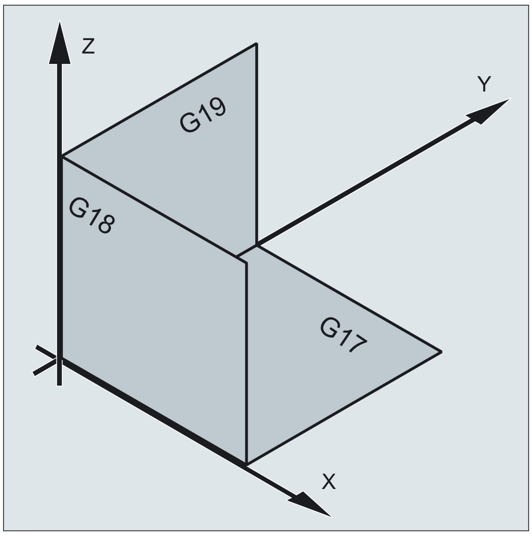
1.5 Definition of the planes, tool types

The G17, G18 or G19 tool radius correction planes can be selected.

Depending on the tool type, the tool lengths are assigned to the axes as follows:

- Milling cutter, workpiece probe for milling: 1xy or workpiece probe for milling: 710
- Drill: 2xy
- Turning tool, workpiece probe for turning: 5xy

Milling



G17 plane

Tool type	1xy / 2xy / 710
Length 1	active in Z (applicate)
Length 2	active in Y (ordinate)
Length 3	active in X (abscissa)

G18 plane

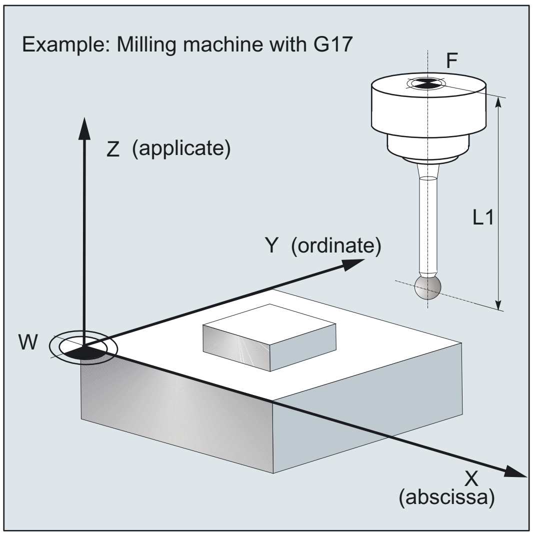
Tool type	1xy / 2xy / 710
Length 1	active in Y (applicate)
Length 2	active in X (ordinate)
Length 3	active in Z (abscissa)

G19 plane

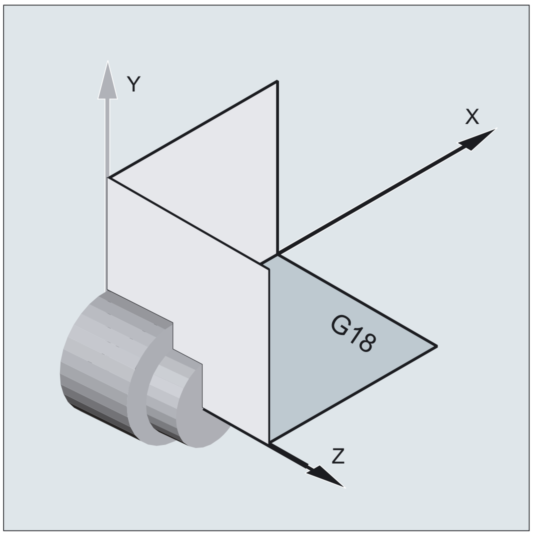
Tool type	1xy / 2xy / 710
Length 1	active in X (applicate)
Length 2	active in Z (ordinate)
Length 3	active in Y (abscissa)

Lengths 2 and 3 are used in special cases, for example, if an angle head is attached.

Example of plane definition for milling



Turning



Turning machines generally only use axes Z and X and therefore:

G18 plane	
Tool type	5xy (turning tool, workpiece probe)
Length 1	active in X (ordinate)
Length 2	active in Z (abscissa)

G17 and G19 are used for milling on a turning machine. If there is no machine axis Y, milling can be implemented with the following kinematic transformations.

- TRANSMIT
- TRACYL

In principle, measuring cycles support kinematic transformations. This is stated more clearly in the individual cycles, measuring variants.

Note

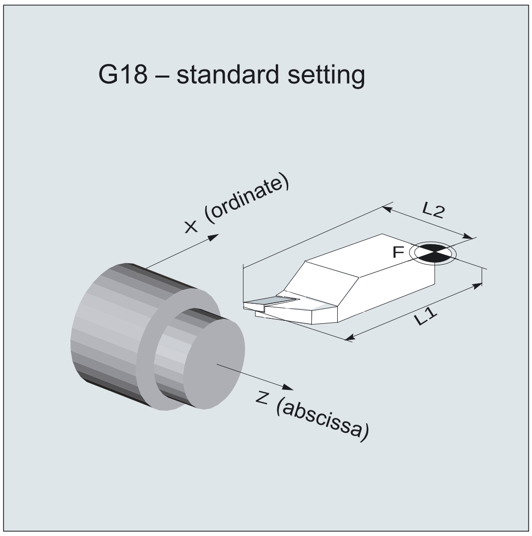
If a drill or milling cutter is measured on a turning machine, in most cases, setting data SD 42950: TOOL_LENGTH_TYPE = 2 set. These tools are then length-compensated like a turning tool.

SINUMERIK controls have other machine and setting data that can influence calculation of a tool.

References:

- /FB1/, Description of Functions - Basic Machine
- /FB2/, Description of Functions - Extended Functions
- /FB3/, Description of Functions - Special Functions

Example of plane definition for turning



1.6 Probes that can be used

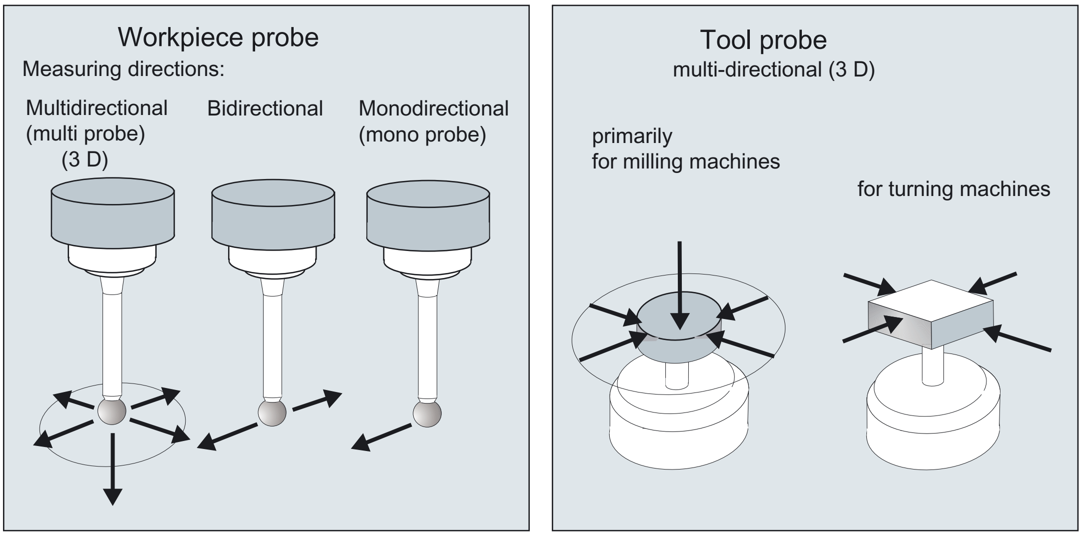
General information

To measure tool and workpiece dimensions, a touch-trigger probe is required that provides a signal change (edge) when deflected.

The probe must operate virtually bounce-free.

Different types of probe are offered by different manufacturers. Probes are distinguished according to the number of measuring directions.

- Monodirectional (mono probe)
- Bidirectional
- Multidirectional (multi probe)



The probe type is defined by a parameter (_PRNUM) in measuring cycles (see Section 2.10).

Monodirectional probe

This type of probe can only be used if the spindle can be positioned with NC function SPOS and the switching signal of the probe can be transmitted through 360° to the receiving station (at the machine column).

The probe must be mechanically aligned in the spindle to permit measurements in the following directions at the 0 degree position of the spindle.

X-Y plane G17:	Positive X direction
Z-X plane G18:	Positive Z direction
Y-Z plane G19:	Positive Y direction

NOTICE

- The measurement takes longer with mono probes since the spindle must be positioned in the cycle several times by means of SPOS.
- In workpiece measurement, a bidirectional probe is treated like a mono probe.
- The mono- and bi-directional probe should only be used for minor precision requirements!

Table 1- 1 Probe assignment

Probe type	Turning machines		Milling and machining centers
	Tool measurements	Workpiece measurements	Workpiece measurements
Multidirectional (multi probe)	X	X	X
Bidirectional	--	X	X
Monodirectional (mono probe)	--	--	X

Note

If a workpiece probe is used, both the direction of deflection and transmission of switching signal to the machine column (radio, infrared light or cable) must be taken into account.

In some versions, transmission is only possible in particular spindle positions or in particular ranges.

This may further limit the use of the probe.

In any case, please follow the advice of the probe or machine manufacturer.

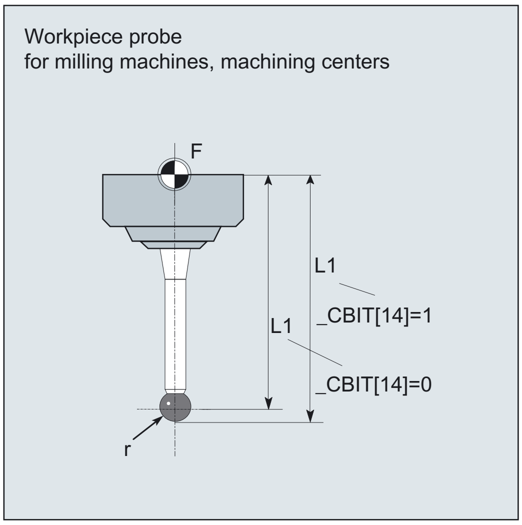
1.7 Probe, calibration body, calibration tool

1.7.1 Measuring workpieces on milling machines, machining centers

Workpiece probe

On milling machines and machining centers, the probe is classified as tool type 1xy or 710 (3D probe) and must therefore be entered as such in the tool memory.

Entry in tool memory	
Tool type (DP1):	710 or 1xy
Length 1 - geometry (DP3):	L1
Radius (DP6):	r
Length 1 - basic measurement (DP21):	only if required



The wear and other tool parameters must be assigned the value 0.

In _CBIT[14] you can set whether length L1 refers to the ball center point or the ball circumference.

Note

_CBIT[14]

see Subsection 9.2.4 (central bits).

Calibration

A probe must be calibrated before it can be used. Calibration involves determining the triggering points (switching points), positional deviation (skew), and active ball radius of the workpiece probe and then entering them in special data fields _WP[ ] in data block GUD6.DEF.

The default setting has data fields for 3 probes. Up to 99 are possible.

Calibration can be performed on holes of a known size or workpiece surfaces with a sufficient form precision and low surface roughness.

Use of special gauging blocks is not supported on milling and machine centers.

Use the same measuring velocity for calibrating and measuring.

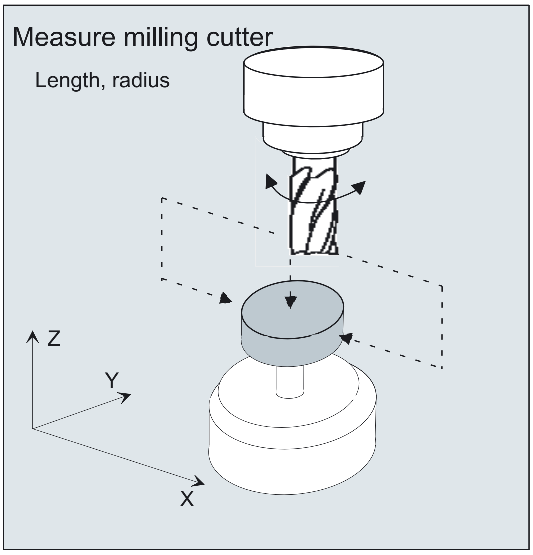
A special cycle is available for calibration.

1.7.2 Measuring tools on milling machines, machining centers

Tool probe

The tool probes have dedicated data fields _TP[ ] and _TPW[ ] in data block GUD6.DEF.

The triggering points (switching points), upper disk diameter and edge length are entered here.



Approximate values must be entered here before calibration – if cycles are used in automatic mode. The cycle will then recognize the position of the probe.

The default setting has data fields for 3 probes. Up to 99 are possible.

Calibration, calibrating tool

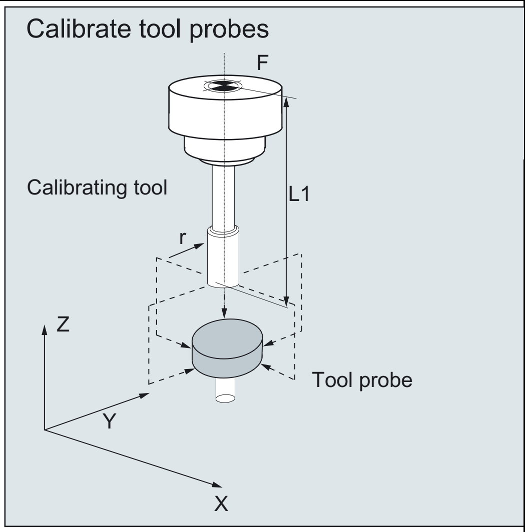
A probe must be calibrated before it can be used. Calibration involves precisely determining the triggering points (switching points) of the tool probe and entering them in special data fields.

Calibration is performed with a calibration tool. The precise dimensions of the tool are known.

Use the same measuring velocity for calibrating and measuring.

A special cycle is available for calibration.

Entry in tool memory	
Tool type (DP1):	1xy
Length 1 - geometry (DP3):	L1
Radius (DP6):	r
Length 1 - basic measurement (DP21):	only if required



The wear and other tool parameters must be assigned the value 0.

1.7.3 Measuring workpieces at the turning machines

Workpiece probe

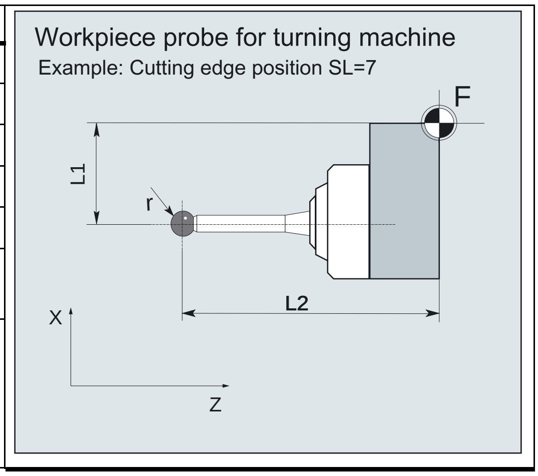
On turning machines, the workpiece probes are treated as tool type 5xy with permissible cutting edge positions (SL) 5 to 8 and must be entered in the tool memory accordingly.

Lengths specified for turning tools always refer to the tool tip, except in the case of workpiece probes on turning machines where they refer to the probe center.

Probes are classified according to their position:

Workpiece probe SL 7

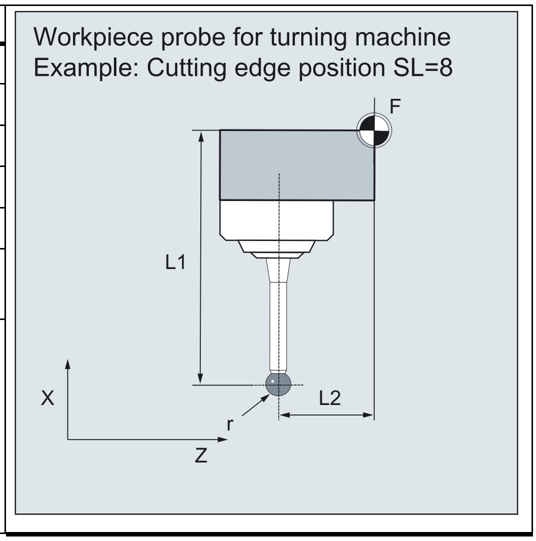
Entry in tool memory	
Tool type (DP1):	5xy
Cutting edge position (DP2):	7
Length 1 - geometry:	L1
Length 2 - geometry:	L2
Radius (DP6):	r
Length 1 - basic measurement (DP21):	only if required
Length 2 - basic measurement (DP22):	only if required



The wear and other tool parameters must be assigned the value 0.

Workpiece probe SL 8

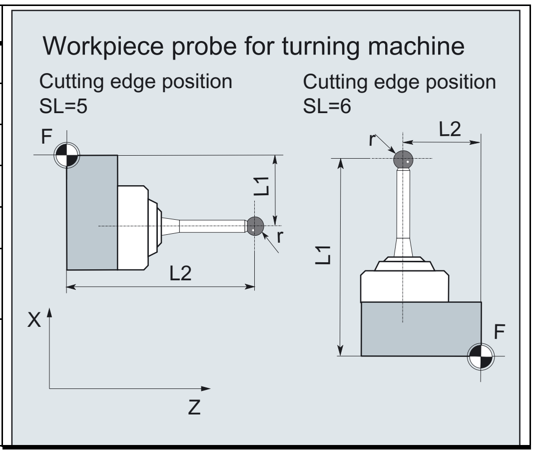
Entry in tool memory	
Tool type (DP1):	5xy
Cutting edge position (DP2):	8
Length 1 - geometry:	L1
Length 2 - geometry:	L2
Radius (DP6):	r
Length 1 - basic measurement (DP21):	only if required
Length 2 - basic measurement (DP22):	only if required



The wear and other tool parameters must be assigned the value 0.

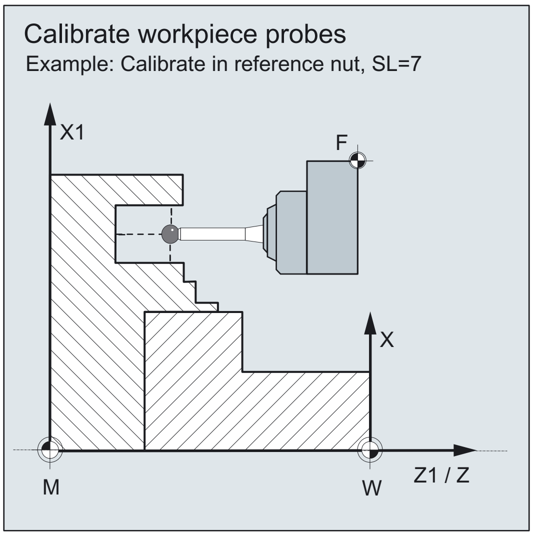
Workpiece probe SL 5 or SL 6

Entry in tool memory	
Tool type (DP1):	5xy
Cutting edge position (DP2):	5 or 6
Length 1 - geometry:	L1
Length 2 - geometry:	L2
Radius (DP6):	r
Length 1 - basic measurement (DP21):	only if required
Length 2 - basic measurement (DP22):	only if required



The wear and other tool parameters must be assigned the value 0.

Calibration, gauging block



A probe must be calibrated before it can be used. During calibration the triggering points (switching points), positional deviation (skew), and precise ball radius of the workpiece probe are determined and then entered in special data fields _WP[ ] in data block GUD6.DEF.

The default setting has data fields for 3 probes. Up to 99 are possible.

Calibration of the workpiece probe on turning machines is usually performed with gauging blocks (reference grooves). The precise dimensions of the reference groove are known and entered in the relevant data fields _KB[ ] in data block GUD6.DEF.

The default setting has data fields for 3 calibration bodies. The gauging block is selected in the program with variable _CALNUM.

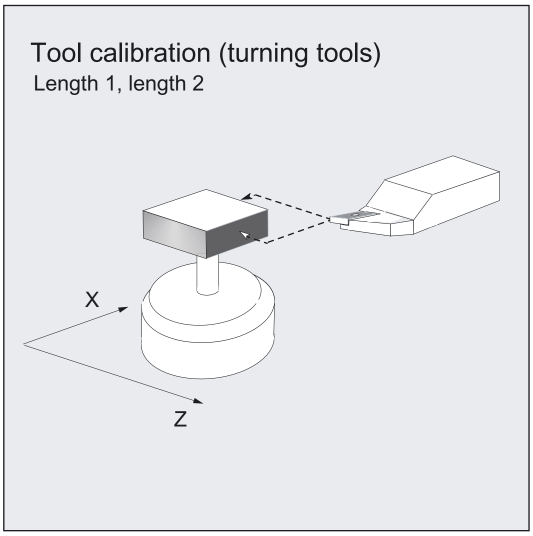
It is also possible to calibrate on a known surface.

Use the same measuring velocity for calibrating and measuring.

A cycle with different measuring versions is provided for calibration.

1.7.4 Measuring tools at lathes

Tool probe



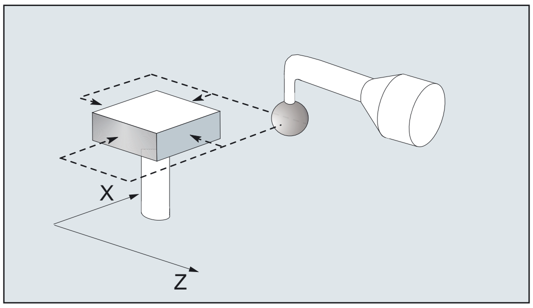
The tool probes have dedicated data fields _TP[ ] and _TPW[ ] in data block GUD6.DEF.

The triggering points (switching points) are entered here. Approximate values must be entered here before calibration – if cycles are used in automatic mode. The cycle will then recognize the position of the probe.

The default setting has data fields for 3 probes. Up to 99 are possible.

In addition to turning tools, drills and mills can also be measured.

Calibration, gauging block



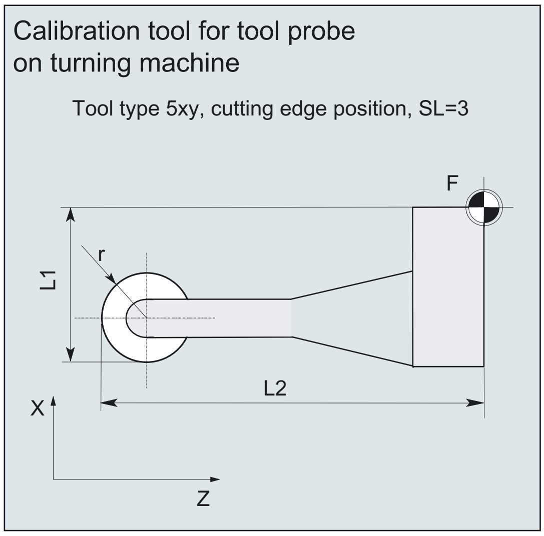
A probe must be calibrated before it can be used. Calibration involves precisely determining the triggering points (switching points) of the tool probe and entering them in special data fields.

Calibration is performed with a calibration tool. The precise dimensions of the tool are known.

Use the same measuring velocity for calibrating and measuring.

A special measuring variant in a cycle is available for calibration.

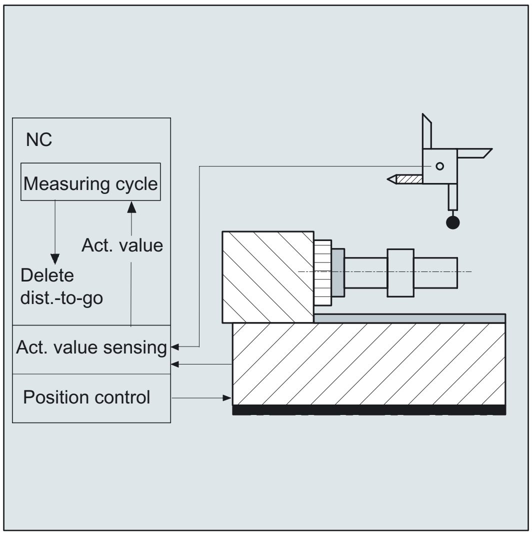
On turning machines, the calibration tool is treated like a turning tool with cutting edge position 3. The lengths refer to the ball circumference, not to the ball center.

Entry in tool memory		
Tool type (DP1):	5xy	
Cutting edge position (DP2):	3	
Length 1 - geometry:	L1	
Length 2 - geometry:	L2	
Radius (DP6):	r	
Length 1 - basic measurement (DP21):	only if required	
Length 2 - basic measurement (DP22):	only if required	

The wear and other tool parameters must be assigned the value 0.

1.8 Measurement principle

on-the-fly measurement

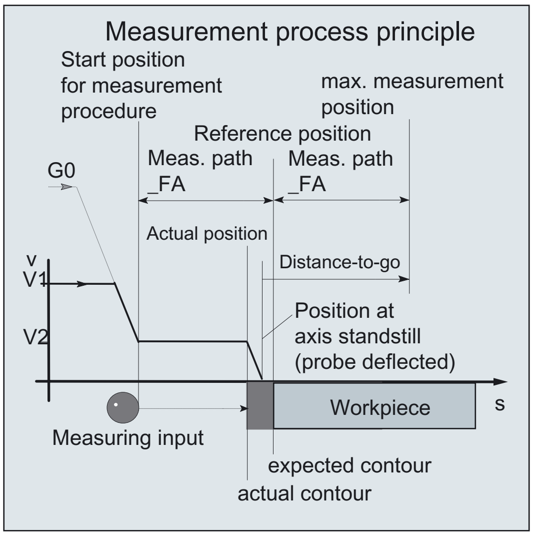


The principle of "on-the-fly" measurement is implemented in the SINUMERIK control. The probe signal is processed directly on the NC so that the delay when acquiring measured values is minimal. This permits a higher measuring speed for the prescribed measuring precision and time needed for measuring is reduced.

Connecting probes

Two inputs for connecting touch trigger probes are provided on the I/O device interface of the SINUMERIK control systems.

Measurement operation



The procedure is described using the **workpiece measurement**. The procedure is the same for tool measurement. In this case, however, the tool is moved and the probe is fixed.

Depending on its design, the actual movements of a machine may be different anyway. Workpiece measurement is described as follows:

The workpiece is stationary and the probe moves.

The **starting position** for the measuring procedure is a position **_FA** in front of the specified **set position** (expected contour).

The starting position is calculated in the cycle based on parameter entries and probe data. The starting position is approached either with rapid traverse G0 or with positioning velocity G1; then from the starting position with **measuring velocity.**

The switching signal is expected along path 2 · _FA as from the starting position. Otherwise, an alarm will be triggered or the measurement repeated.

The resulting **maximum measuring position** is in the measuring block of the cycle.

At the instant the switching signal is output by the probe, the current **actual position** is stored internally "on-the-fly" as the actual value, the measuring axis is stopped and then the "**Delete distance-to-go**" function is executed.

The distance-to-go is the path not yet covered in the measuring block. After deletion, the next block in the cycle can be processed. The measuring axis travels back to the starting position. Any measurement repetitions selected are restarted from this point.

Measurement path _FA

Measurement path _FA defines the distance between the starting position and the expected switching position (setpoint) of the probe (see section 2).

Measuring velocity

The measuring velocity is dependent on the measurement path _FA and its default setting is 150 mm/min if _FA=1; if FA>1: 300 mm/min. Cycles parameter _VMS is then =0.

Other measuring velocities can be set by the user to a value of >0 in _VMS (see Chapter 2).

The **maximum permissible measuring velocity** is derived from:

- the deceleration behavior of the axis.
- the permissible deflection of the probe.
- the signal processing delay.

Deceleration distance, deflection of probe

CAUTION
Safe deceleration of the measuring axis to standstill within the permissible deflection path of the probe must always be ensured. Otherwise damage will occur!

A delay "t" typical of the control is taken into account in signal processing (IPO cycle) for the time between detection of the switching signal and output of the deceleration command to the measuring axis MD 10050: SYSCLOCK_CYCLE_TIME and MD 10070: IPO_SYSCLOCK_TIME_RATIO). This results in the deceleration path component.

The following error of the measuring axis is reduced. The following error is velocity dependent and at the same time dependent on the control factor of the measuring axis (servo gain of the associated machine axis: servo gain factor).

The deceleration rate of the axis must also be taken into account.

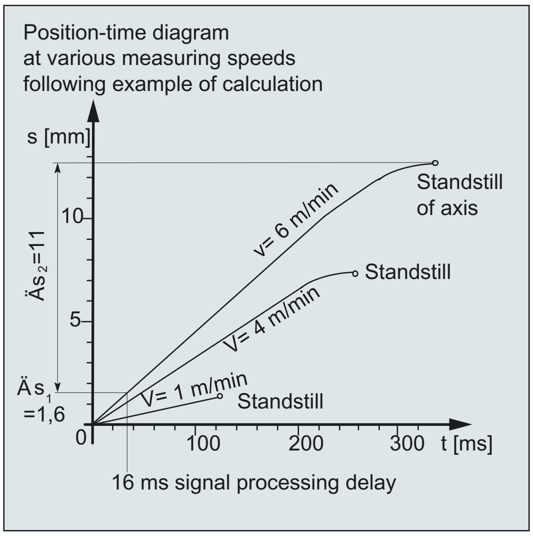
Together they produce an axis-specific velocity-dependent deceleration distance.

The servo gain factor is MD 32200: POSCTRL_GAIN.

Axis acceleration / deceleration rate a is stored in MD 32300: MAX_AX_ACCEL. It may have a lesser effect due to other influences.

Always used the lowest values of the axes involved in the measurement.

Calculation of the deceleration path



The deceleration path to be considered is calculated as follows:

$$s_b = \underbrace{1000 \cdot v \cdot t}_{\Delta s_1} + \underbrace{\frac{1000 \cdot v^2}{2a} + \Delta s}_{\Delta s_2}$$

sb	Deceleration path	in mm
v	Measuring velocity	in m/s
t	Delay signal	in s
a	Deceleration	in m/s²
Δs	Following error	in mm
Δs = v / Kv		v here in m/min
Kv	Servo gain	in (m/min)/mm

Example of calculation:

- v = 6 m/min = 0.1 m/ s measuring velocity
- a = 1 m/s^2 deceleration
- t = 16 ms signal delay
- Kv = 1 in (m/min)/mm

The deflection of the probe = deceleration distance to zero speed of axis is:
sb = 12,6 mm.

The deceleration distance components are:

Δs = 6/ 1 = 6 mm	Following error
Δs2 = 1000 · 0.01 / 2 + 6 = 11 mm	axis-specific component
Δs1 = 1000 · 0.1 · 0.016 = 1.6 mm	Percentage due to signal delay

Measuring accuracy

A delay occurs between detection of the switching signal from the probe and transfer of the measured value to the control. This is caused by signal transmission from the probe and the hardware of the control. In this time a path is traversed that falsifies the measured value. This influence can be minimized by reducing the measuring speed.

The rotation when measuring a mill on a rotating spindle has an additional influence. This can be compensated for by compensation tables. (see Section 5.2.2 CYCLE971 "Measurement and correction strategy").

The measurement accuracy that can be obtained is dependent on the following factors:

- Repeat accuracy of the machine
- Repeatability of the probe
- Resolution of the measuring system

Note

Repeat accuracy

A test program for determining the overall repeatability of a machine is described in Section 10.4.

1.9 Measuring strategy for measuring workpieces with tool offset

The actual workpiece dimensions must be measured exactly and compared with the setpoint values to be able to determine and compensate the actual dimensional deviations on the workpiece. An offset value can then be ascertained for the tool used for machining.

Function

When taking measurements on the machine, the actual dimensions are derived from the path measuring systems of the position-controlled feed axes. For each dimensional deviation determined from the set and actual workpiece dimensions there are many causes which essentially fall into 3 categories:

- **Dimensional deviations with causes that are n o t subject to a particular trend**, e.g. positioning scatter of the feedforward axes or differences in measurement between the internal measurement (measuring probe) and the external measuring device (micrometer, measuring machine, etc.).

  In this case, it is possible to apply **empirical values**, which are stored in separate memories. The set/actual difference determined is automatically compensated by the empirical value.
- **Dimensional deviations with causes that a r e subject to a particular trend**, e.g. tool wear or thermal expansion of the leadscrew.
- **Accidental dimensional deviations**, e.g. due to temperature fluctuations, coolant or slightly soiled measuring points.

  Assuming the ideal case, only those dimensional deviations that are subject to a trend can be taken into account for compensation value calculation. Since, however, it is hardly ever known to what extent and in which direction accidental dimensional deviations influence the measurement result, a strategy (sliding averaging) is needed that derives a compensation value from the actual/set difference measured.

Mean value calculation

Mean value calculation in conjunction with measurement weighting has proven a suitable method.

The formula of the mean value generation chosen is:

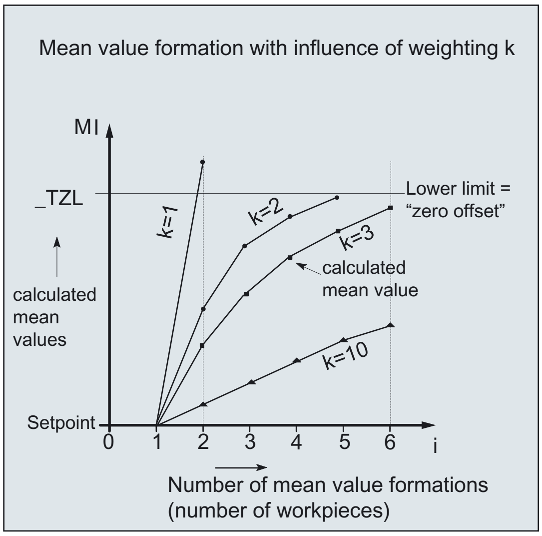
$$Mi_{neu} = Mi_{alt} - \frac{Mi_{alt} - D_i}{k}$$

Mvnew	Mean value new = amount of compensation
Mvold	Mean value prior to last measurement
k	Weighting factor for average value calculation
Di	Actual/set difference measured (minus any empirical value)

The mean value calculation takes account of the trend of the dimensional deviations of a machining series. The **weighting factor k** from which the mean value is derived is selectable.

A new measurement result affected by accidental dimensional deviations only influences the new tool offset to some extent, depending on the weighting factor.

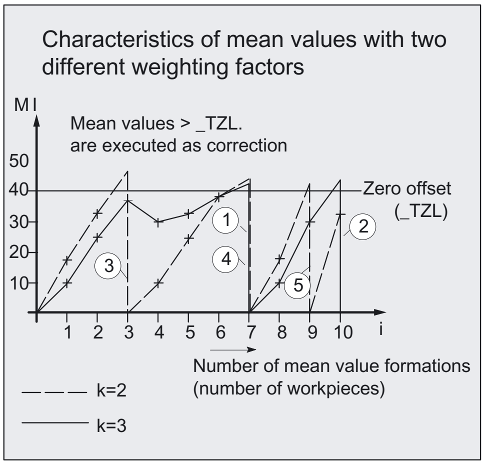
Computational characteristic of the mean value with different weightings k



- The greater the value of k, the slower the formula will respond when major deviations occur in computation or counter compensation. At the same time, however, accidental scatter will be reduced as k increases.
- The lower the value of k, the faster the formula will react when major deviations occur in computation or counter compensation. However, the effect of accidental variations will be that much greater.
- The mean value Mi is calculated starting at 0 over the number of workpieces i, until the calculated mean value exceeds the range of "zero compensation"(cycle parameter _TZL, see Chapter 2). From this limit on, the calculated mean value is applied as an offset.
- Once the mean value has been used for the offset, it is deleted from the memory. The next measurement then starts again with Miold = 0.

Table 1- 2 Example of mean value calculation and offset

	Lower limit = 40 µm (_TZL = 0.04)		
i	Di [µm]	Mi k = 3 [µm]	Mi k = 2 [µm]
1. Measurement	30	10	15
2. Measurement	50	23,3	32,5
3. Measurement	60	35,5	46,2 ③
4. Measurement	20	30,3	10
5. Measurement	40	32,6	25
6. Measurement	50	38,4	37,5
7. Measurement	50	42,3 ①	43,75 ④
8. Measurement	30	10	15
9. Measurement	70	30	42,5 ⑤
10. Measurement	70	43,3 ②	35



In the measurements with marked fields, tool compensation is performed with the mean value (calculated mean value >_TZL):

- If k=3 in the 7th and 10th measurement (① and ②),
- If k=2 in the 3rd, 7th, and 9th meas. (③, ④ and ⑤).

1.10 Parameters for checking the measurement result and offset

For constant deviations not subject to a trend, the dimensional deviation measured can be compensated by an empirical value in certain measuring variants.

For other compensations resulting from dimensional deviations, symmetrical tolerance bands are assigned to the set dimension which result in different responses.

Empirical value/mean value _EVNUM

The empirical values are used to suppress dimensional deviations that are **not subject to a trend**.

Note

If you do not want to apply any empirical values, _EVNUM = 0 must be set.

The empirical values themselves are stored in data block (GUD5) in field **_EV[ ] empirical value**.

_EVNUM specifies the number of the empirical value memory. The actual/set difference determined by the measuring cycle is corrected by this value**before** any further correction measures are taken.

This is the case:

- for workpiece measurement with automatic tool offset.
- for single-point measurement with automatic zero offset.
- tool measurement.

Mean value _EVNUM is active only for workpiece measurement with automatic tool offset.

When calculating the mean value in a series of machining operations, the mean value determined by the measurement at the same measurement location on the previous workpiece can be taken into account (_CHBIT[4]=1).

The mean values are stored in data block (GUD5) in field **_MV[ ] Mean value**. **_EVNUM** specifies the number of the mean value memory in this field.

Safe area_TSA

The safe area is effective for almost all measuring variants and does not affect the offset value; it is used for diagnostics.

If this limit is reached then the following can be assumed:

- a probe defect, or
- an incorrect setpoint position, or
- an illegal deviation from the setpoint position can be assumed.

Note

AUTOMATIC mode

AUTOMATIC operation is interrupted and the program cannot continue. An alarm text appears to warn the user.

Dimensional difference check _TDIF

_TDIF is active only for workpiece measurement with automatic tool offset and for tool measurement.

This limit has no effect on generation of the compensation value either. When it is reached, the tool is probably worn and needs to be replaced.

Note

An alarm text is displayed to warn the operator and the program can be continued by means of an NC start.

This tolerance limit is generally used by the PLC for tool management purposes (twin tools, wear monitoring).

Tolerance of the workpiece _TLL, _TUL

Both parameters are active only for tool measurement with automatic tool offset.

When measuring a dimensional deviation ranging between "2/3 tolerance of workpiece" and "Dimensional difference control", this is regarded 100 % as tool compensation. The previous average value is erased.

This enables a fast response to major dimensional deviations.

Note

When the tolerance limit of the workpiece is exceeded, this is indicated to the user depending on the tolerance position "oversize" or "undersize".

2/3 workpiece tolerance _TMV

_TMV is active only for workpiece measurement with automatic tool offset.

Within the range of "Lower limit" and "2/3 workpiece tolerance" the mean value is calculated according to the formula described in Section "Measuring strategy".

Note

My_{new}

My_{new} is compared with the zero compensation range:

- If My_{new} is **greater** than this range, compensation is corrected by My_{new} and the associated mean value memory is cleared.
- If My_{new} is **less** than this range, no compensation is carried out. to prevent excessively abrupt compensations.

Weighting factor for mean value calculation _k

_K is active only workpiece measurement with automatic tool offset. The weighting factor can be used to give a different weighting for each measurement.

A new measurement result thus has only a limited effect on the new tool offset as a function of _K.

Lower limit (zero compensation area) _TZL

_TZL active for

- Workpiece measurement with automatic tool offset
- Tool measurement and calibration for milling tools and tool probes

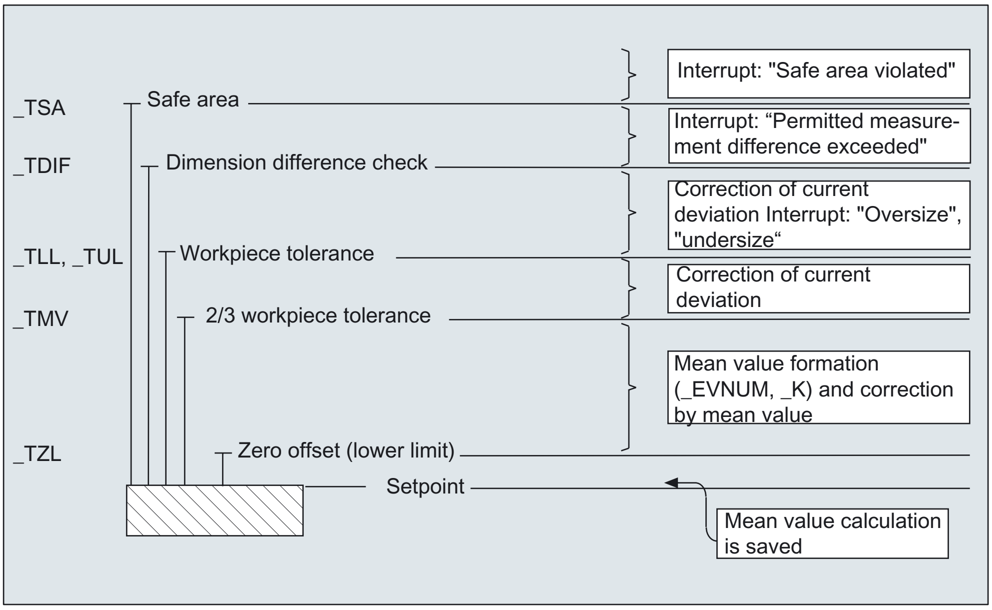
This tolerance range corresponds to the amount of maximum accidental dimensional deviations. It has to be determined for each machine.

No tool compensation is made within these limits.

In workpiece measurement with automatic tool offset, however, the mean value of this measuring point is updated and re-stored with the measured actual/set difference, possibly compensated by an empirical value.

The tolerance bands (range of permissible dimensional tolerance) and the responses derived from them are as follows:

- **For workpiece measurement with automatic tool offset**

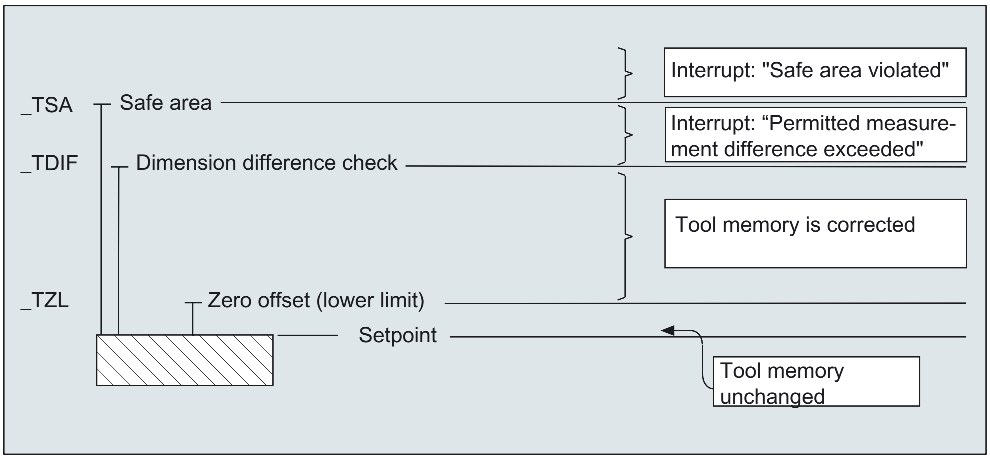


Note

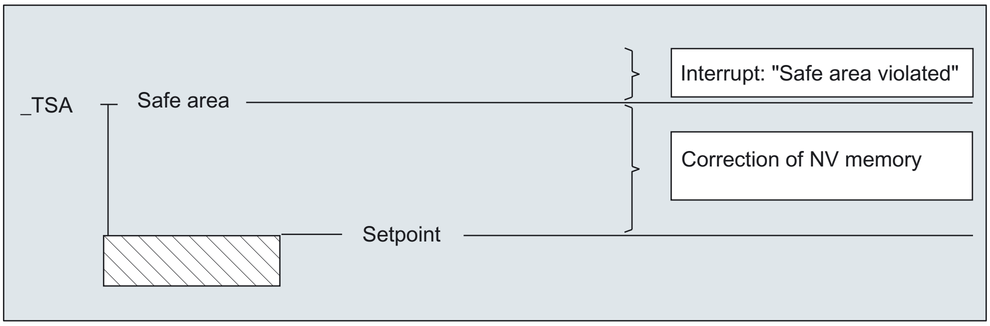
In measuring cycles, the workpiece setpoint dimension is placed in the middle of the permitted ± tolerance limit for reasons associated with symmetry.

See Subsection 2.3.11 "Tolerance parameters..."

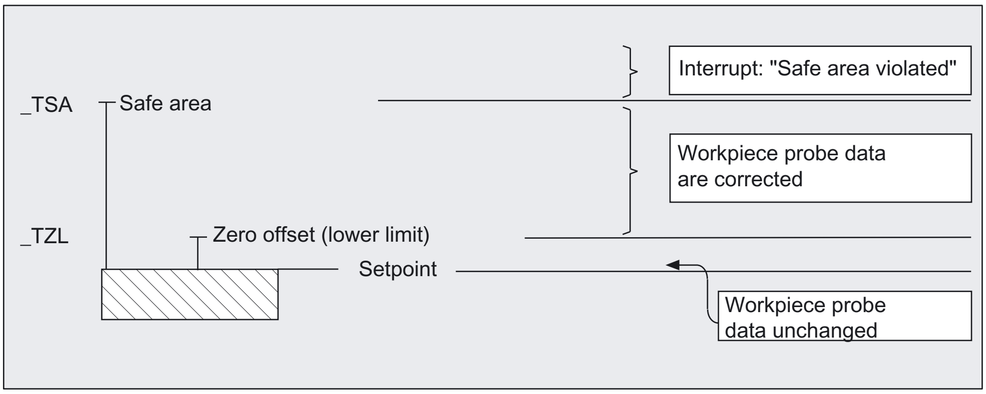
- For tool measurement



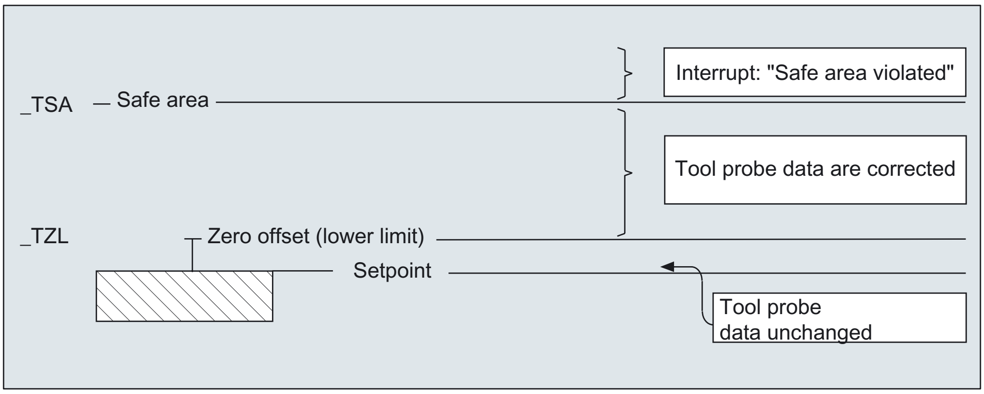
- For workpiece measurement with zero offset



- For workpiece probe calibration



- For tool probe calibration



1.11 Effect of empirical value, mean value, and tolerance parameters

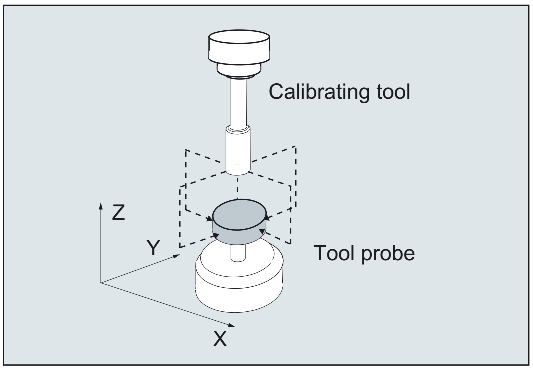
The following flowchart shows the effect of empirical value, mean value, and tolerance parameters on workpiece measurement with automatic tool offset.

1.12 Overview of measuring cycle functions for milling technology

1.12.1 Tool measurement on milling machines, machining centers

Measuring cycle CYCLE971 can be used to calibrate a tool probe and measure the tool length and/or radius for milling tools.

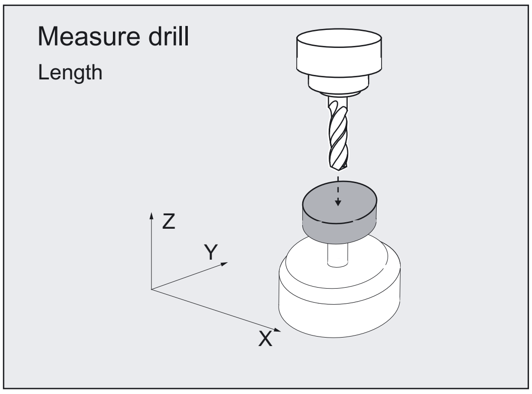
Calibrating tool probes

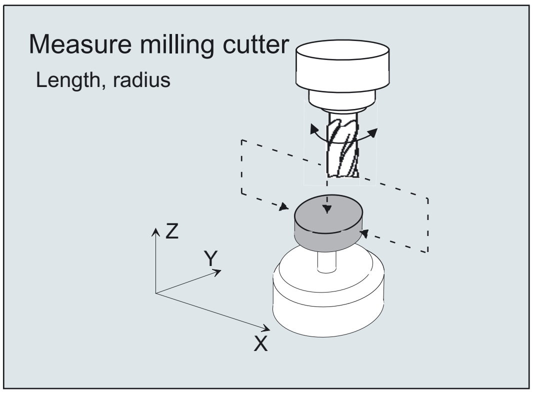


Result:

Probe switching point with reference to machine or workpiece zero.

Measuring tool



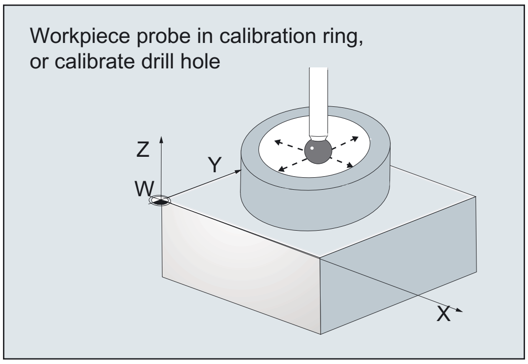


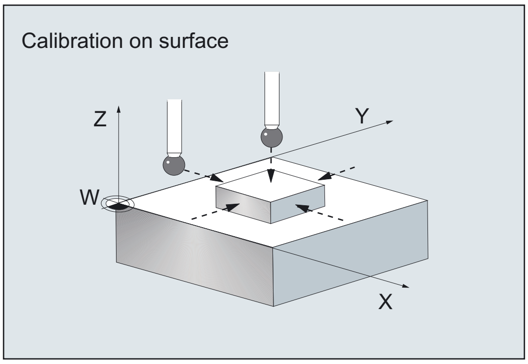
Result:

- Tool length
- Tool radius

1.12.2 Calibrating workpiece probes

With cycle CYCLE976 a workpiece probe can be calibrated in a hole (calibration ring) or on a surface for a particular axis and direction.





Result:

Probe switching point (trigger value), possibly an additional position deviation, active ball diameter of probe

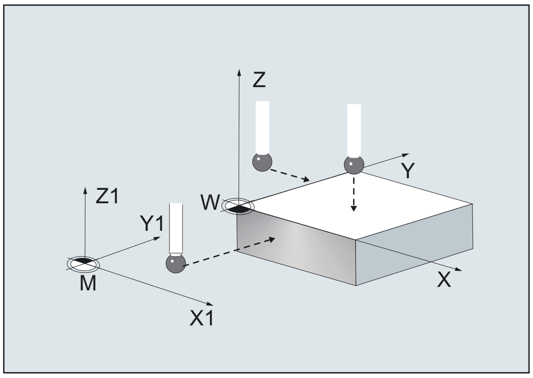
1.12.3 Workpiece measurement at one point

CYCLE978 permits measurement at one point of a surface.

The measuring point is approached paraxially in the active workpiece coordinate system.

Depending on the measuring variant, the result may influence the selected tool offset or zero offset.

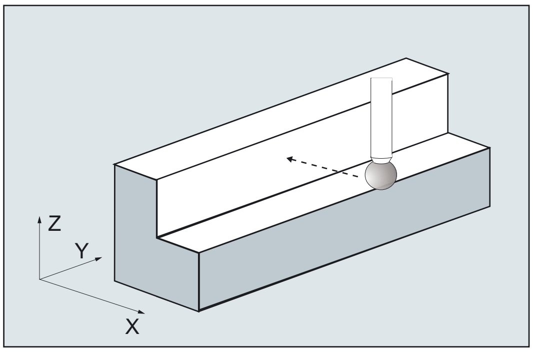
Workpiece measurement: Blank measurement



Result:

- Position
- Deviation
- Zero point offset

Workpiece measurement: 1-point measurement



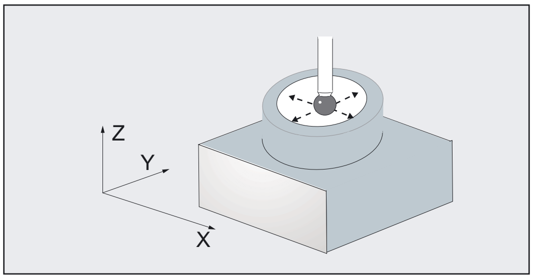
Result:

- Actual dimension
- Deviation
- Tool offset

1.12.4 Measuring the workpiece parallel to the axis

The following measuring variants are provided for the paraxial measurement of a hole, shaft, groove, web, or rectangle. They are executed by cycle CYCLE977.

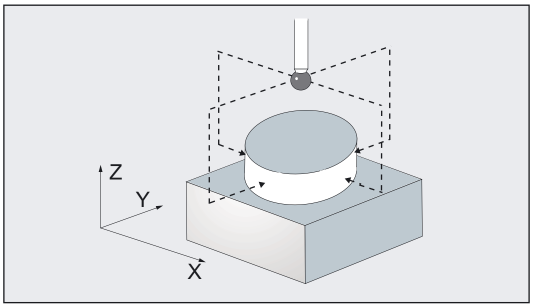
Workpiece measurement: Measure hole



Result:

- Actual dimension, deviation: Diameter, center point
- Deviation: Tool offset of the zero offset

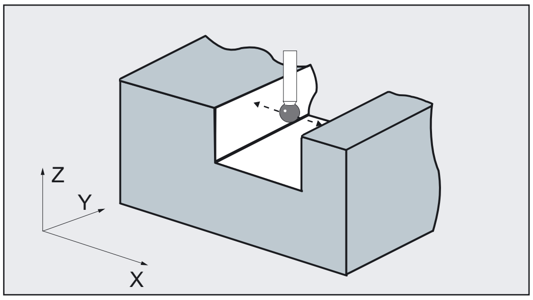
Workpiece measurement: Measuring a shaft



Result:

- Actual dimension, deviation: Diameter, center point
- Deviation: Tool offset of the zero offset

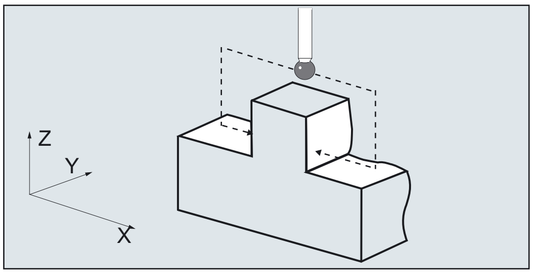
Workpiece measurement: Measuring a groove



Result:

- Actual dimension, deviation: Groove width, groove center
- Deviation: Tool offset of the zero offset

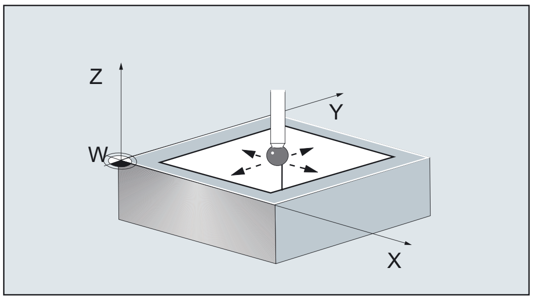
Workpiece measurement: Measuring a web



Result:

- Actual dimension, deviation: Web width, web center
- Deviation: Tool offset of the zero offset

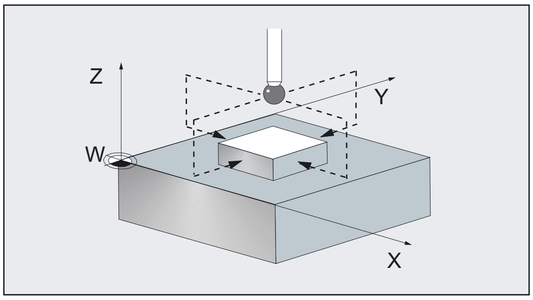
Workpiece measurement: Inside rectangle



Result:

- Actual dimension, deviation: Rectangle length and width, rectangle center
- Deviation: Tool offset of the zero offset

Workpiece measurement: Outside rectangle



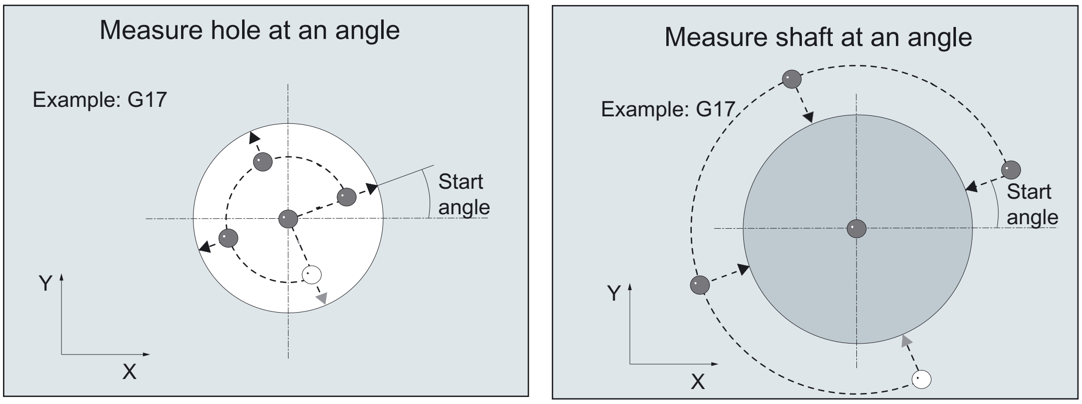
Result:

- Actual dimension: Rectangle length and width, rectangle center
- Deviation: Rectangle length and width, rectangle center
- Deviation: Tool offset of the zero offset

1.12.5 Measuring a workpiece at an angle

The following measuring variants are provided for the measurement of a hole, shaft, groove, or web at an angle. They are executed by CYCLE979.

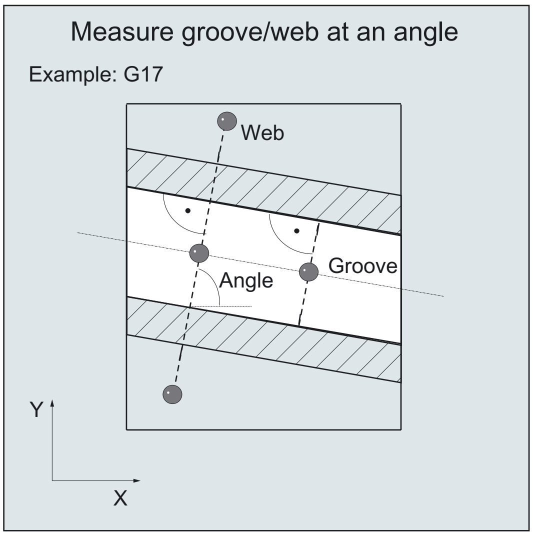
Three- or four-point measurement at an angle



Result:

- Actual dimension, deviation: Diameter, center point
- Deviation: Tool offset of the zero offset

Two-point measurement at an angle



Result:

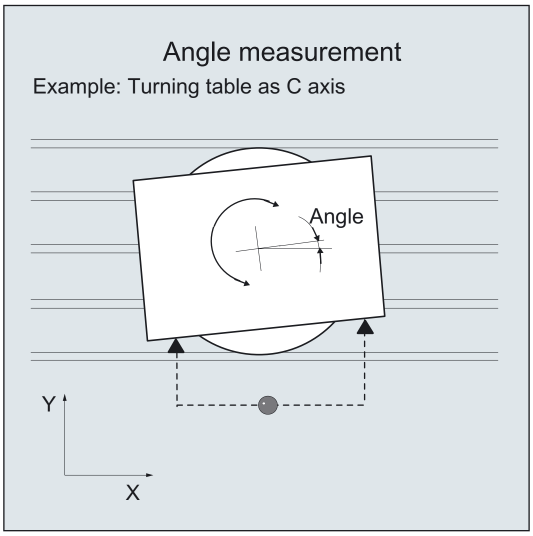
- Actual dimension, deviation: Groove, web width, groove, web center
- Deviation: Zero point offset

1.12.6 Measuring a surface at an angle

CYCLE998 permits correction of the zero offset after measurement of a surface at an angle.

It is still possible to determine the angles on an oblique surface in space.

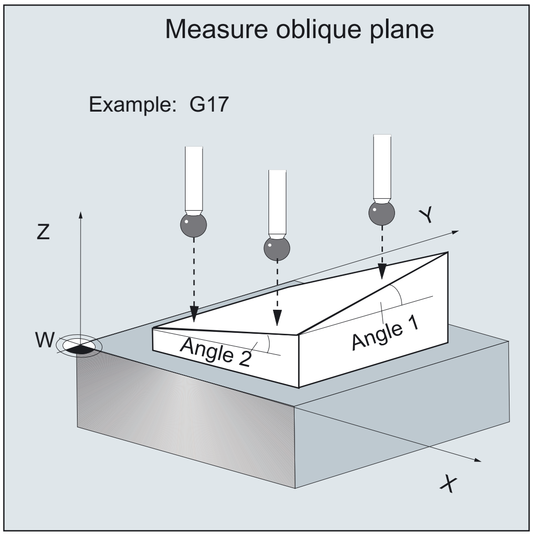
Workpiece measurement: Angle measurement



Result:

- Actual dimension: Angle
- Deviation: Zero point offset

Workpiece measurement: Two-angle measurement



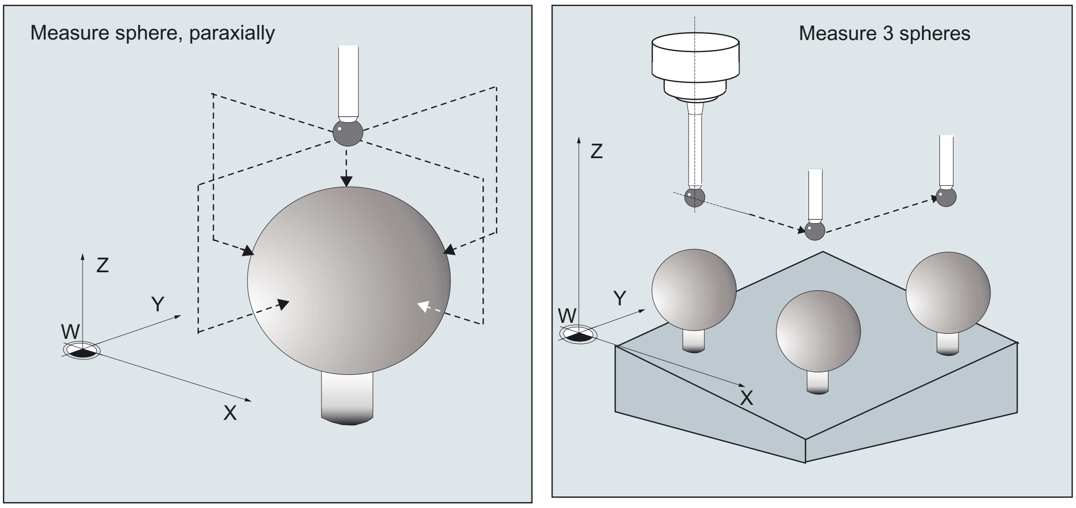
Result:

- Actual dimension: 2 angle
- Deviation: Zero point offset

1.12.7 Measuring spheres

CYCLE997 permits correction of the zero offset after measurement of a sphere or of three identically sized spheres on a common base (workpiece). Either paraxial measurement or measurement at an angle can be selected.

Workpiece measurement: sphere



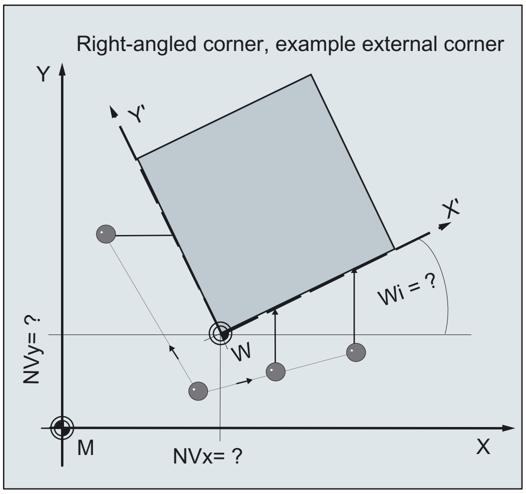
Result:

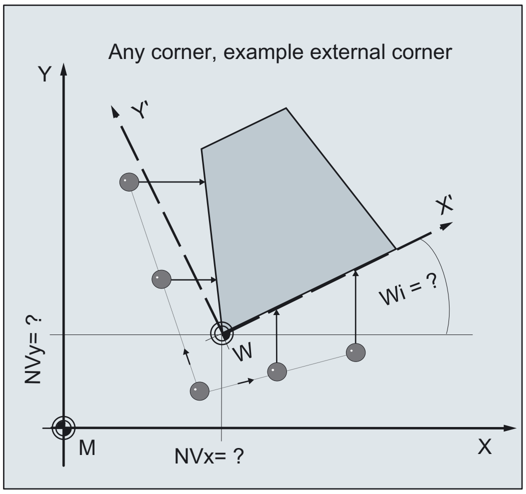
- Actual dimension: Actual position of center, diameter
- Deviation: Zero offset (for one sphere translation only, for three spheres also rotation in space)

1.12.8 Workpiece measurement: Setting-up a corner

Using the CYCLE961 cycle, it is possible to determine the position of a workpiece corner (inner or outer) and use this as zero offset.

Measuring a corner by specifying clearances and angles

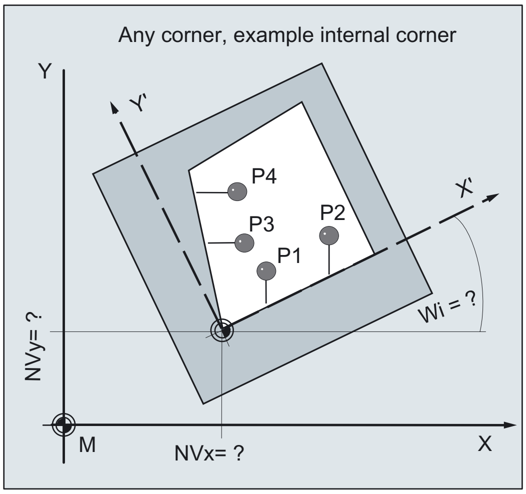




Result:

- Actual position of the corner with angle
- Zero offset, rotation

Measuring a corner, specifying 4 points



Result:

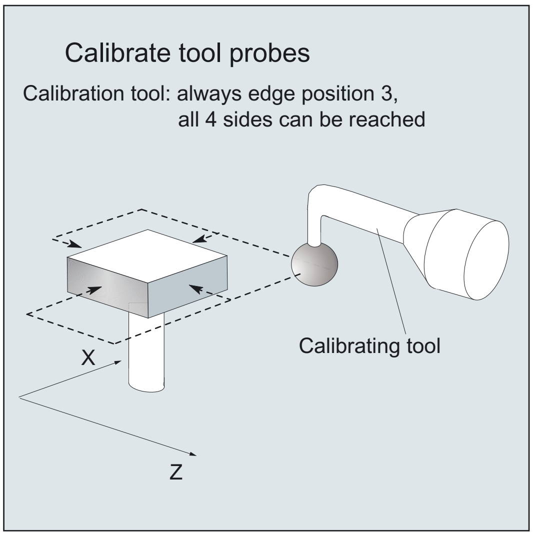
- Actual position of the corner with angle
- Zero offset, rotation

1.13 Overview of measuring cycle functions for turning technology

1.13.1 Measuring tools at lathes

Cycle CYCLE982 is used to calibrate a tool probe and measure turning, drilling, and milling tools on turning machines.

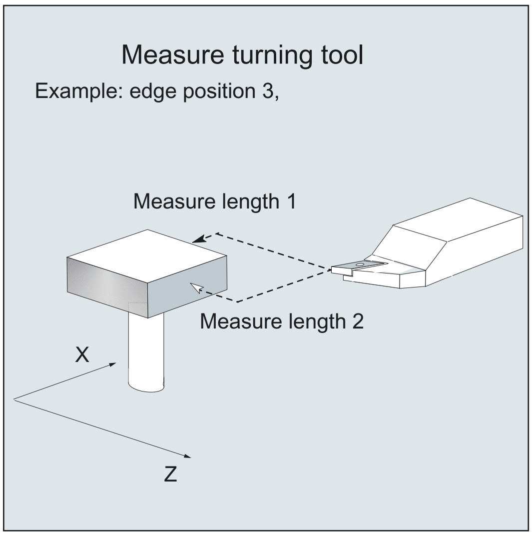
Calibrating tool probes

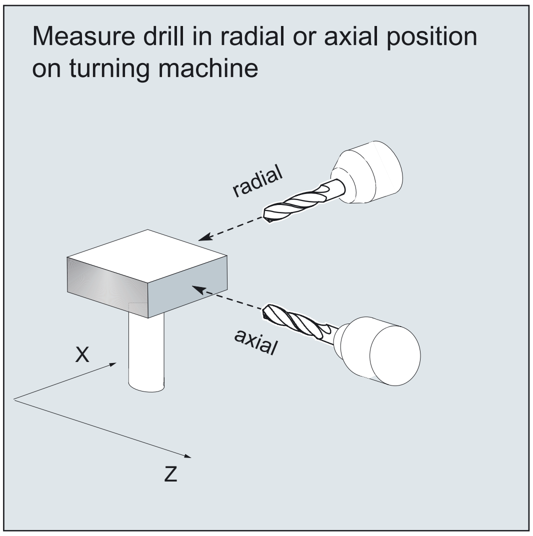


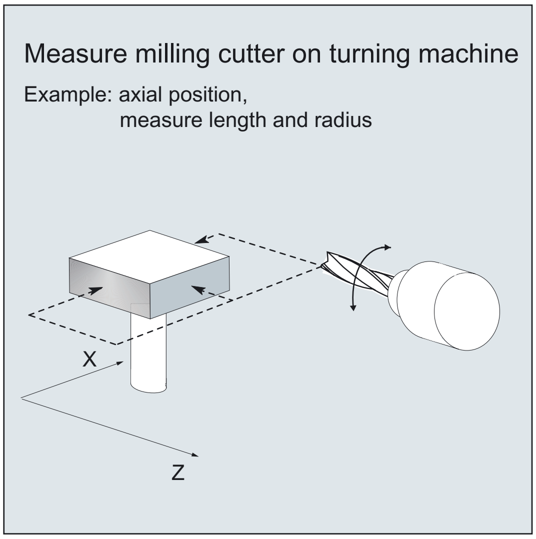
Result:

Probe switching point with reference to machine or workpiece zero

Measuring tool







Result:

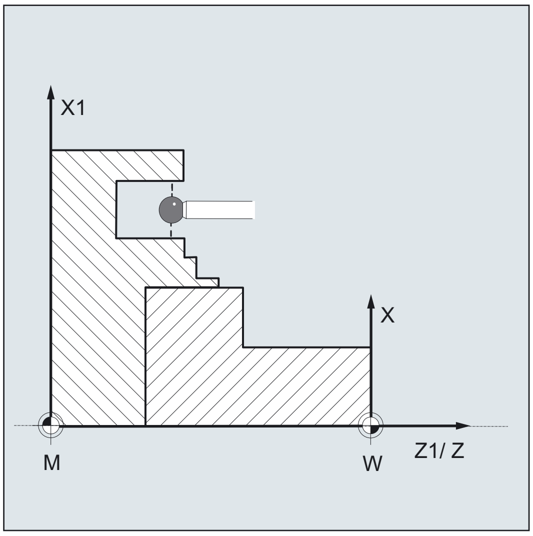
- Tool length: length 1, length 2
- Milling cutter radius: R - for milling tools

1.13.2 Calibrating workpiece probes

CYCLE973 permits calibration of a probe on a surface of the workpiece or in a calibration groove.

Example:

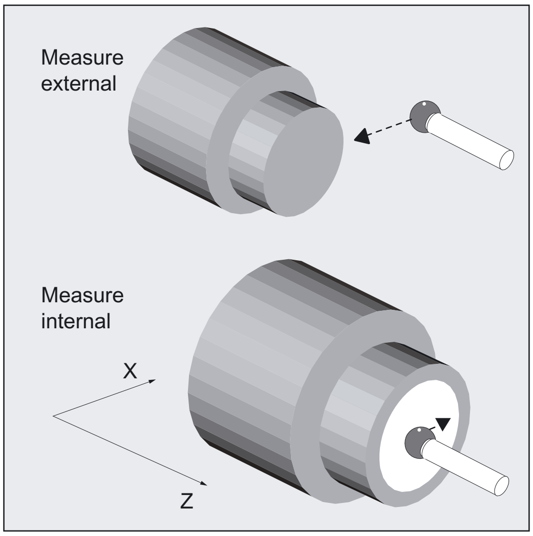
Calibrate probe with cutting edge position 7, in X axis in both directions in a calibration groove.



1.13.3 Measuring workpieces at lathes: 1-point measurement

CYCLE974 is used to determine the actual value of the workpiece in the selected measuring axis with reference to the workpiece zero with 1-point measurement.

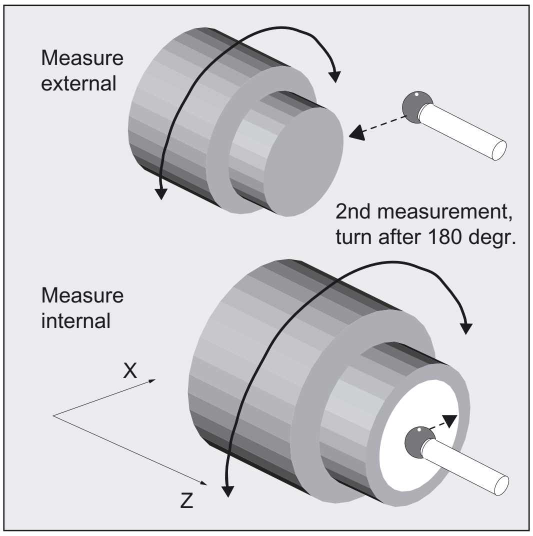
1-point measurement, outside or inside



Result:

- Actual dimension: Diameter, length
- Deviation: Tool offset of the zero offset

One-point measurement, outside or inside with 180° spindle reversal



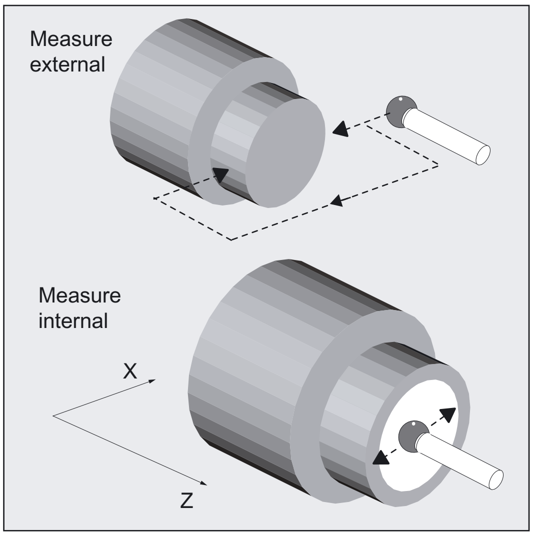
Result:

- Actual dimension: Diameter, length
- Deviation: Tool offset

1.13.4 Measuring workpieces at lathes: 2-point measurement

CYCLE994 is used to determine the actual value of the workpiece in the selected measuring axis with reference to the workpiece zero with 2-point measurement. This is done automatically by approaching two opposite measuring points on the diameter.

2-point measurement on diameter, outside or inside



Result:

- Actual dimension: Diameter
- Deviation: Tool offset

Parameter description 2

2.1 Parameter concept of the measuring cycles

General

Measuring cycles are general subroutines designed to solve specific measurement tasks, which are suitably adapted to the problem at hand with parameter settings. They can be adapted for this purpose via **defining parameters**.

The measuring cycles also return data such as measuring results. They are stored in **result parameters**.

These measuring cycle parameters are called **G**lobal **U**ser **D**ata (abbreviated to GUD).

They are located in the battery-backed memory of the control. These values are therefore not lost when the control is switched off and on.

Data block

The global user data is kept in data blocks.

- GUD5.DEF
- GUD6.DEF and
- GUD7.DEF (for measuring in JOG)

Note

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used until now, compared to the new machine and setting data, is included in appendices A1, A2 and A3.

Delivery of the measuring cycles

On delivery, these data have default settings (see Section Parameter overview). These must be adapted by the user or machine manufacturer on installation (see chapter Data description)

Value assignments

The defining parameters must be assigned values before the measuring cycle is called:

- Either in the program or
- Operator input in the measuring cycle support

Data display

The data in the operating area "Parameters" can be displayed by means of "User data", "Global user data", "GUD…" or "Channel-specific user data", "GUD…".. As an alternative, parameters that are not assigned values in the program or in the measuring cycles support can be assigned values directly by experts.

Internal parameters

Measuring cycles also require **internal parameters** for calculations. **L**ocal **U**ser **D**ata (abbreviated to LUDs) are used in the measuring cycles as internal arithmetic parameter.

These are set up in the cycle and exist only during runtime.

2.2 Parameter overview

2.2.1 Defining parameters

General

The defining parameters of the measuring cycles can be classified as follows:

- Mandatory parameters
- Auxiliary parameters

Mandatory parameters

Mandatory parameters are parameters that have to be adapted to the measuring task at hand (for example, setpoint axis, measuring axis, etc,) **before each** measuring cycle call.

Parameter	Type	Validity	Default	Meaning
_SETVAL[1)]	REAL	CHAN	–	Setpoint
_SETV[ ][1)]	REAL	CHAN	–	Setpoints – additional, e.g. for measuring rectangle
_ID[1)]	REAL	CHAN	–	Incremental infeed depth/offset
_CPA[1)]	REAL	CHAN	–	Center point abscissa for measuring at angle
_CPO[1)]	REAL	CHAN	–	Center point ordinate for measuring at angle
_SZA[1)]	REAL	CHAN	–	Protection zone in abscissa
_SZO[1)]	REAL	CHAN	–	Protection zone in ordinate
_STA1	REAL	CHAN	–	Start angle
_INCA	REAL	CHAN	–	Incrementing angle
_MVAR	INT	CHAN	–	Measuring variant
_MA	INT	CHAN	–	Measuring axis
_MD	INT	CHAN	–	Measuring direction
_TNUM	INT	CHAN	–	T number
_TNAME	STRING[32]	CHAN	–	Tool name (alternative to _TNUM in tool management)
_KNUM	INT	CHAN	–	Correction number (D No. or ZO No.)
_RA	INT	CHAN	–	Number of rotary axis at angle measurement
_TENV	STRING[32]	CHAN	–	Name of tool environment
_DLNUM	INT	CHAN	–	DL number for setup or additive offset

Auxiliary parameters

Additional parameters can generally be assigned once on a machine. They are then valid **for each additional measuring cycle call** until modified by programming or operation.

Parameter	Type	Validity	Default	Meaning
_VMS	REAL	CHAN	0	Variable measuring speed
_RF	REAL	CHAN	0	Feedrate in circular-path programming
_CORA	REAL	CHAN	0	Compensation angle, e.g. for mono probe
_TZL	REAL	CHAN	0.001	Zero offset area
_TMV	REAL	CHAN	0.7	Mean value generation with compensation
_TNVL	REAL	CHAN	1.2	Limit value for distortion of triangle
_TUL1)	REAL	CHAN	1.0	Tolerance upper limit
_TLL1)	REAL	CHAN	-1.0	Tolerance lower limit
_TDIF	REAL	CHAN	1.2	Dimension difference check
_TSA	REAL	CHAN	2	Safe area
_FA2)	REAL	CHAN	2	Measurement path in mm
_CM[ ]	REAL	NCK	100, 1000, 1, 0.005, 20, 4, 10, 0	Monitoring parameters for tool measurement for a rotating spindle
_PRNUM	INT	CHAN	1	Probe number
_EVNUM	INT	CHAN	0	Number of empirical value memory
_CALNUM	INT	CHAN	0	Calibration block number
_NMSP	INT	CHAN	1	Number of measurements at the same location
_K	INT	CHAN	1	Weighting factor for mean value calculation

Note

1)

All parameters with dimensions, except for those marked 1), must be programmed in the unit of measurement of the basic system. The parameters marked 1) must be programmed in the unit of the active system of units.

2)

_FA is always a value in mm, even when the unit system set is inches.

Parameters for logging only

Parameter	Type	Validity	Meaning
_PROTNAME[ ]	STRING[32]	NCK	[0]: Name of main program the log is from [1]: name of log file
_HEADLINE[ ]	STRING[80]	NCK	6 strings for protocol headers
_PROTFORM[ ]	INT	NCK	Log formatting
_PROTSYM[ ]	CHAR	NCK	Separator in the log
_PROTVAL[ ]	STRING[100]	NCK	[0, 1]: Log header line [2...5]: Specification of the values to be logged
_DIGIT	INT	NCK	Number of decimal places

Variable

In addition to defining parameters for calculation or character string input, there are also BOOLEAN type variables. These bits can be used to vary planned cycle sequences or enable or disable certain settings. These **cycle bits** are arrays of variables and of two types:

- Central bits: _CBIT[ ]
- Channel-oriented bits: _CHBIT[ ]

Their name defines their validity and occurrence:

- Central bits → NCK: once present, applies for all channels
- Channel bits → CHAN: extra for each channel.

An overview of central and channel-oriented bits is given in Section Data description, cycle data.

These bits can also be changed by programming or operation.

2.2.2 Result parameters

Result parameters are measurement results provided by the measuring cycles.

Parameter	Type	Validity	Meaning
_OVR[ ]	REAL	CHAN	Result parameter – real number: Setpoint values, actual values, differences, offset values, etc.
_OVI[ ]	INTEGER	CHAN	Result parameter - integer

If the result parameters (_OVR[]) are used as input or transfer parameters for other standard or measuring cycles, the ranges of values defined in the "Fundamentals" Programming Manual apply.

The following specifications apply to angular values (in accordance with the "Fundamentals" Programming Manual):

- Rotation around 1st geometry axis: -180 degrees to +180 degrees
- Rotation around 2nd geometry axis: -90 degrees to +90 degrees
- Rotation around 3rd geometry axis: -180 degrees to +180 degrees

Note

If the angular values to be transferred are smaller than the programmed calculation resolution in the NCU, they are rounded down to zero.

The calculation resolution for angle positions on the NCU is specified in machine data 10210 $MN_INT_INCR_PER_DEG.

Example:

Transfer of parameter _OVR[21] (compensation value, angle at 1st axis of level) of measuring cycle CYCLE998 (Measure angle), e.g., to swivel cycle Cycle800.

In accordance with MD $MN_INT_INCR_PER_DEG, the calculation resolution = 1000.

```
_OVR[21]=-0.000345
IF ((ABS(_OVR[21] * $MN_INT_INCR_PER_DEG)) < 1)
_OVR[21]=0
ENDIF
```

Explanation

If the value of parameter _OVR[21] is less than the programmed calculation resolution, it is rounded down to zero.

2.3 Description of the most important defining parameters

2.3.1 Measurement variant: _MVAR

Parameter

The measuring variant of each individual cycle is defined in parameter **_MVAR**. _MVAR can be assigned certain positive integer values.

Please refer to the individual cycle descriptions!

Note

Validity

The value in _MVAR is plausibility checked by the cycle. If it does not have a defined value, alarm 61307 is output: **"Incorrect measuring variant".**

The cycle must be interrupted by an NC RESET. _MVAR must be corrected.

2.3.2 Number of the measuring axis: _MA

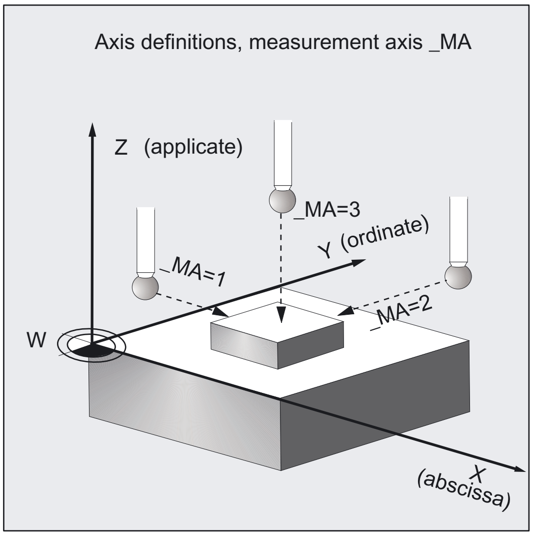
Parameter

In some cycles or measuring variants, number 1, 2, or 3 must be specified in _MA for the measuring axis. This might by axis X, Y, or Z in the workpiece coordinate system depending on whether G17, G18, or G19 is active.

This always results in:

Measuring axis, abscissa	_MA = 1
Measuring axis, ordinate	_MA = 2
Measuring axis, applicate	_MA = 3

Example:
Workpiece measurement on milling machine with G17, various measuring directions



With some measuring variants, for example, in CYCLE998, positioning in another axis that must be defined, also called offset axis can be performed between measurements in the measuring axis. This must be defined in parameter _MA with offset axis/measuring axis. The higher digit codes the offset axis, the lower digit the measuring axis, the tens digit is 0.

Example of _MA in CYCLE998:

_MA	= 102	
	→ Offset axis	1 (abscissa)
	→ Measuring axis	2 (ordinate)

2.3.3 Tool number and tool name: _TNUM and _TNAME

Parameter

The tool to be offset is entered during workpiece measurement in the parameters **_TNUM** and **_TNAME**.

The parameter _TNAME is only relevant if tool management is active. Here it can be used as an alternative to _TNUM. However, a programmed _TNUM >0 always has priority.

Example

- **Without tool management:**

_TNUM = 12	the tool , T number 12, is corrected

- **With tool management:**

_TNUM = 0	_TNAME = "DRILL"
	→ the tool called "DRILL" is corrected
or	
_TNUM = 13	_TNAME = "DRILL"
	→ the tool with internal T number 13 is corrected

In the case of replacement tools, the tool that was last used is corrected.

However, it is necessary that only one tool in a group be "active" at any one time. Otherwise, the internal tool number of the tool used must be determined and assigned to _TNUM via the system variable $P_TOOLNO during processing.

2.3.4 Offset number: _KNUM

Parameter

With measuring variant _MVAR you can select whether **automatic tool offset** will be used or a **zero offset** will be corrected in a **workpiece measuring cycle**.

Parameter **_KNUM** contains the

- **tool offset memory number** (D number)

  or a

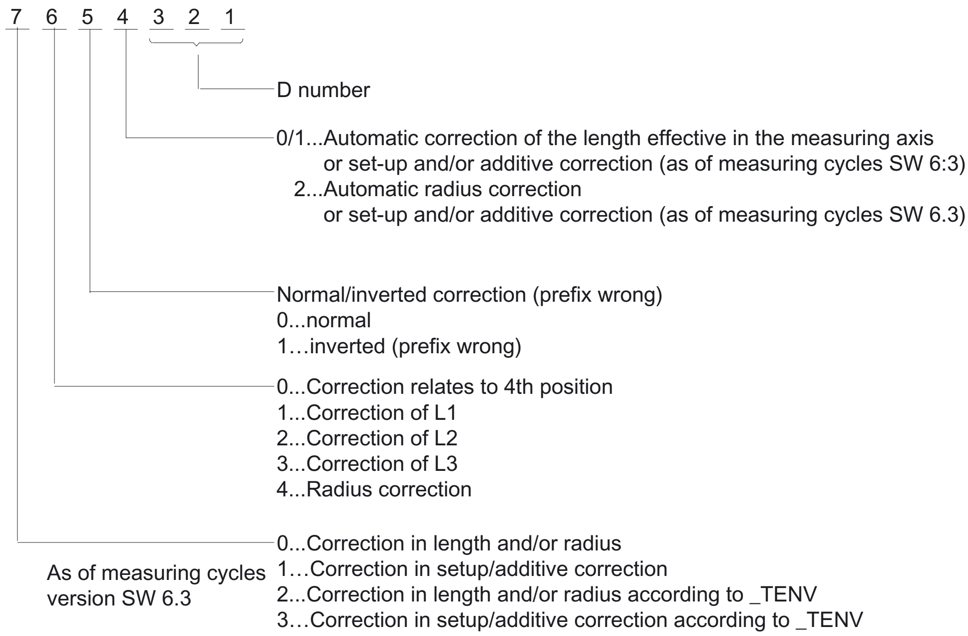
- code for the **zero offset** to be corrected .

Values of _KNUM: ≥0, integer

1. Specification _KNUM for tool offset, 7 digits:

_KNUM can accept values with up to 7 digits (for special MD settings, even 9 digit values).

_KNUM=0: no automatic tool offset



In the default setting, the D number has values between 0 and 9.

Depending on MD 18102: MM_TYPE_OF_CUTTING_EDGE = 0 and MD 18105: MM_MAX_CUTTING_EDGE_NO and a value of this MD of between 10...999, the last three digits are read as a D number.

With a value ≥1000, _KNUM is evaluated as a 5-digit D number (unique D number, as in flat D number structure, see next Section).

Example of _KNUM=12003: D3 is correct, calculated as a radius offset, inverted (sign inverted).

2. Specification _KNUM for zero offset:

- _KNUM=0:

  No automatic ZO correction.

- _KNUM=1... 99:

  Automatic ZO correction in settable frame / NV G54...G57, G505...G599.

- _KNUM=1000:

  Automatic ZO correction in the last active channel basic frame according to MD 28081: MM_NUM_BASE_FRAMES.

  The offset is calculated to have the right effect when G500 is activated. The corresponding basic frame must then also be active (relevant bit in $P_CHBFRMASK must be set).

- _KNUM=1011...1026:

  automatic ZO in 1st to 16th channel basic frame ($P_CHBFR[0]...$P_CHBFR[15]).

- _KNUM=1051...1066:

  automatic ZO in 1st to 16th basic frame (NCU global) ($P_NCBFR[0]...$P_NCBFR[15])

- _KNUM=2000:

  automatic ZO in system frame (scratch system frame $P_SETFR).

- _KNUM=9999:

  automatic ZO in active frame:

  – active settable frame G54...G57, G505...G599 or

  – If G500 active: last active basic frame acc. to $P_CHBFRMASK (highest set bit).

The modified frame is only activated immediately in the cycle if _KNUM=9999, otherwise by the user by writing G500, G54...G5xy.

Note

The remaining active frame chain must be retained.

With NCU-global frames, correction for rotation is not possible.

Start up

The following must be set during installation (default setting):

- MD 28082: MM_SYSTEM_FRAME_MASK,
  - Bit 5=1 (system frame for cycles)
  - and bit 0=1 (system frame for scratching), recommended[1)]
- Additionally the MDs for the required basic frames

Note

Regarding 1)

If bit 0 = 0, then corrections cannot be made in the basic frame in "Measuring in JOG" and the parameterization variant KNUM=2000 cannot be used when measuring in automatic mode!

AUTOMATIC mode

In the measuring cycles in AUTOMATIC mode the offset for the default setting is corrected additively with **fine offset** (if MD 18600: MM_FRAME_FINE_TRANS=1).

Otherwise (when MD 18600=0), or in CYCLE961, or when _KNUM=2000, or when "measuring in JOG" is active, the offset is implemented in the **coarse offset**. Any existing fine offset is included in the calculation and then deleted.

When measuring workpieces with ZO (offset in CYCLE974, CYCLE977, CYCLE978, CYCLE979, CYCLE997) in AUTOMATIC mode, values can be written either to the coarse or fine offset:

_CHBIT[21]:

0:	ZO translation additive in FINE
1:	ZO translation into COARSE, FINE =0 When undertaking offset in the coarse offset, an existing fine offset is included in the offset value and the fine offset deleted.

Note

If _KNUM=2000 (scratch system frame $P_SETFR), the offset value is always written to the coarse offset.

2.3.5 Offset number _KNUM extended for tool offset: up to 9 digits

Parameter

For special tool offset structures (D number structures), parameter **_KNUM** can have up to nine digits.

The **"Flat D number"** functionality is implemented as from NCK-SW 4.

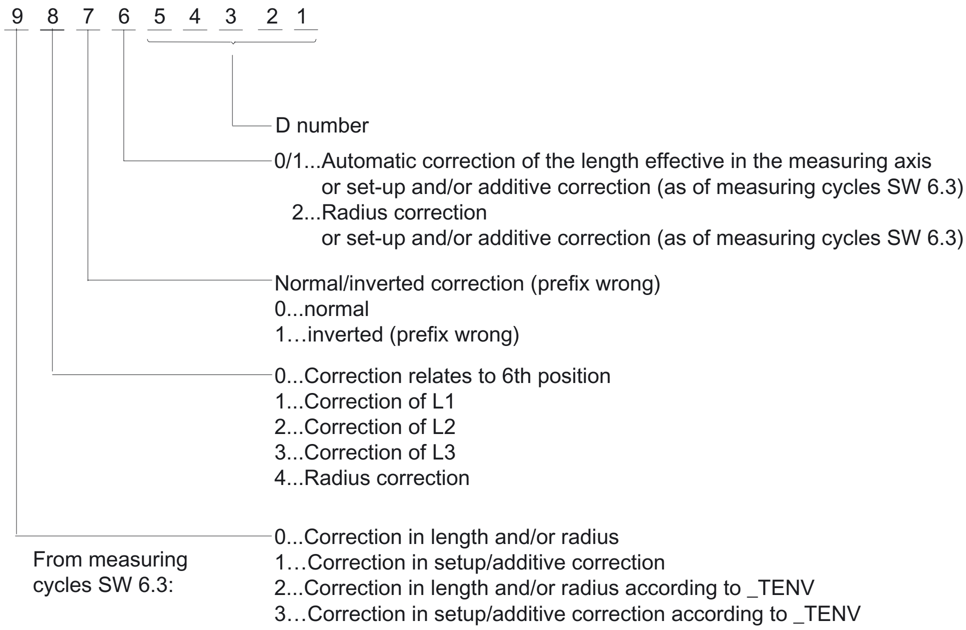
This function is defined with MD 18102: MM_TYPE_OF_CUTTING_EDGE=1. Up to 5-digit D numbers are therefore possible.

"Unique D number" is a second method of implementing a 9-digit _KNUM.

As from NCK-SW 5 and depending on MD 18102: MM_TYPE_OF_CUTTING_EDGE=0 and MD 18105: MM_MAX_CUTTING_EDGE_NO ³1000 the D number contains 5 digits and _KNUM therefore has 9 digits.

References:/FB/, W1, "Tool Compensation"

The D number is contained in the five lowest digits of _KNUM. This is automatically recognized in the cycles by the MD settings. The remaining digits of _KNUM still have the same meaning but have been shifted two places along.



2.3.6 Correcting setup and additive offset in workpiece measurement: _DLNUM

Parameter

Setup and additive offsets are assigned to the tool and a D number. Each D number can be assigned up to 6 setup and additive offsets using DL numbers in the program. If DL=0, no setup or additive offset is activated.

The existence or number of setup or additive offset is set in the machine data.

References: /FB1/, W1, "Tool Compensation"

When measuring workpieces, it is possible to correct a selected setup or additive offset in the measuring cycles with automatic tool offset using parameters _TNUM and _TNAME, _KNUM (D-number coded) and the additional parameter **_DLNUM**.

_DLNUM is an integer. The value range is 0 to 6. This variable need only be defined by the user if the corresponding digit is also programmed in variable _KNUM.

Two **channel-oriented bits** are available for selecting additive and setup offsets (see Section Data description).

The measuring cycles for workpiece measurement with automatic tool offset use channel bit _CHBIT[6] for selecting length and radius offsets in wear or geometry.

0: The offset value is added to the existing wear.
1: Geometry(new) = geometry (old) + wear (old) + offset value,
wear (new) = 0

_CHBIT[6] is also used for correcting setup and additive offsets:

0: The offset value is added to the existing additive offset.
1: Setup offset (new) = setup offset (old) + additive offset (old) offset value, additive offset (new) = 0

Additionally **_CHBIT[8]:**

0: Correct additive/setup offset according to _CHBIT[6].
1: The offset value is added to the existing setup offset, regardless of _CHBIT[6].

2.3.7 Correcting the tool of a stored tool environment: _TENV

Parameter

As from NCK SW 6.3, you can save the operating environment of a particular tool you are using. This is to allow you to correct the tool used to measure a workpiece taking into account the operating conditions
(environment: e.g. plane, length assignment, …).

You then no longer have to specify the T, D, DL number in the offset explicitly. These are included in the stored tool environment. The name of a tool environment can have up to 32 characters.

References: /PGA/, "Programming Guide Advanced"

Parameter _TENV is used in measuring cycles for workpiece measurement with automatic tool offset to define the tool environment.

_TENV is type string [32]. _TENV is only considered if the corresponding digit is programmed in parameter _KNUM.

Note

_TENV can only be used if function
TOOLENV("NAME") has already been programmed by the user in the workpiece machining program. This sets up the tool environment.

The number tool environments that can be created in the SINUMERIK control is set in

MD 18116: MM_NUM_TOOL_ENV.

A tool offset used in conjunction with a tool environment offers many possibilities. These will be shown in more detail using examples in the next Section.

2.3.8 Example of automatic tool offset with and without saved tool environment in workpiece measuring cycles

General information

During workpiece machining, if the tool environment was saved with TOOLENV("NAME"), it is possible to subsequently correct a tool under these stored conditions while measuring a workpiece.

First, the name of the tool environment _TENV="name" must be specified in the offset.

_TENV is evaluated if the corresponding position in _KNUM has value 2 or 3 (offset ... according to _TENV).

To correct tool T stored in tool environment "NAME", _TNUM=0 must be set. Otherwise, the programmed _TNUM / TNAME, D (contained in _KNUM), _DLNUM is corrected with the conditions of the specified tool environment "NAME". Further alternatives: See examples.

In "flat D number " structure _TNUM has no significance. Here, only _KNUM (for D) and _DLNUM are relevant.

Example 1: (without _TENV)

The wear of length 1 is to be corrected additively for tool T7 with D2. The tool environment is to be the environment currently active (= measuring environment).

Relevant data:

_TNUM=7 _KNUM=0100002 _CHBIT[6]=0

Example 2: (without _TENV)

For tool T8 with D3, the wear of the length assigned to measuring axis _MA for this tool type and setting (G17, G18, or G19 etc.) is to be corrected additively.

The tool environment is to be the environment currently active (= measuring environment).

Relevant data:

_TNUM=8 _KNUM=3 _CHBIT[6]=0 _MA=1

Example 3: (without _TENV)

For tool T5 with D2, the additive offset of DL=3, active in the length as defined for measuring axis _MA, is to be corrected additively.

The tool environment is to be the environment currently active (= measuring environment).

Relevant data:

_TNUM=5 _KNUM=1001002 (or =1000002)_DLNUM=3 _CHBIT[6]=0 _CHBIT[8]=0 _MA=1

Example 4: (with TENV)

The wear of length 1 or the tool and D number stored in tool environment "WZUMG1" is to be corrected additively (T and D not directly known).

Relevant data:

_TNUM=0 _TENV= "WZUMG1" _KNUM=2100000 _CHBIT[6]=0

Example 5: (with TENV)

For tool T stored in tool environment "WZUMG2" but specific D number D2, the wear of the length assigned to measuring axis _MA for the stored tool type and stored setting (G17, G18, or G19) is to be corrected additively.

Relevant data:

_TNUM=0 _TENV= "WZUMG2" _KNUM=2001002 (or _KNUM=2000002) CHBIT[6]=0 _MA=2

Example 6: (with TENV)

Tool environment is to be the tool environment stored in "WZUMG3".

However, the following is to be corrected irrespective of T, D, DL stored in it.

For tool T6 with D2 the additive offset of DL=4 that is assigned to the length for tool type T6 and setting (G17, G18, or G19) stored in "WZUMG3" of the measuring axis is to be corrected additively.

Relevant data:

_TNUM=6 _TENV="WZUMG3" _KNUM=3001002 (or _KNUM=3000002) _DLNUM=4 _CHBIT[6]=0 _CHBIT[8]=0 _MA=1

2.3.9 Variable measuring velocity: _VMS

Parameter

The measuring velocity can be freely selected by means of **_VMS**. It is specified in mm/min or inch/min depending on the basic system.

The maximum measuring velocity must be selected to ensure safe deceleration within the probe deflecting path.

When _VMS = 0, 150 mm/min is the default value for the feedrate (when _FA=1). This feedrate value automatically increases to 300 mm/min if _FA>1 is selected.

If the basic system is in inches, 5.9055 inch/min or 11.811 inch/min takes effect.

2.3.10 Offset angle position: _CORA

Parameter

The parameter _CORA contains an offset angular position for mono probes, i.e. alignment of the probe according to its single-dimensional direction of switching ("high point").

Note

In CYCLE982 _CORA is also used to correct the spindle setting after measurement with reversal during milling.

2.3.11 Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA

In the "General section, measuring principle" chapter, the correction strategy of measuring cycles is explained and a description of the effect of the parameters given.

Parameter

Parameter	Data type	Meaning
`_TZL`	REAL ³0	Zero offset 1)2)
`_TMV`	REAL >0	Mean value generation with compensation 1)
`_TUL/_TLL`	REAL	Workpiece tolerance 1)
`_TDIF`	REAL >0	Dimension difference check 1)2)
`_TSA`	REAL >0	Safe area
`_TZL`	REAL ³0	Zero offset 1)2)
1) For workpiece measurement with automatic tool offset only		
2) Also for tool measurement		

Range of values

All of these parameters can have any value. However, only values increasing from _TZL to _TSA are meaningful (absolute values). Parameters _TUL/_TLL are specified in mm or inches depending on the active dimension system and are signed. All other parameters are programmed in the basic system.

Making the workpiece tolerance and setpoint symmetrical

If asymmetrical values are chosen for the tolerance parameters _TUL, _TLL (workpiece tolerance), the setpoint (_SETVAL) is corrected internally to place it in the center of a new, symmetrical tolerance band. These changed values appear in the result parameters: OVR[0] – setpoint, OVR[8] – upper tolerance limit, OVR[12] – lower tolerance limit.

The defining parameters themselves (_TUL, _TLL, _SETVAL) remain unchanged.

Example

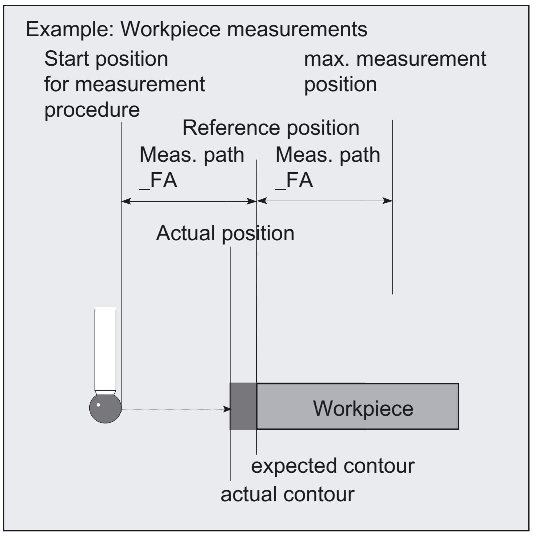
_TUL=0.0 _TLL=-0.004 _SETVAL=10

The result is:

OVR[8]=0.002 OVR[12]=-0.002 OVR[0]=9.998

2.3.12 Measurement path: _FA

Parameter



Measurement path _FA defines the distance between the **starting position** and the expected switching position (**setpoint**) of the probe. _FA is data type REAL with values >0.

Values <0 can only be programmed in CYCLE971

Always specify _FA in **mm**.

The measuring cycles automatically generate a total measuring distance = 2 · _FA in mm.

The **maximum measuring position** is therefore _FA behind the set position.

Note

See also Chapter 1 "General section, measuring principle".

Example

The default setting is _FA=2.0.

In the measuring cycle, a total measuring distance of 4 mm is therefore generated, starting 2 mm in front of and 2 mm behind the defined set position.

_FA is also used as a distance for traveling around workpieces or tool probes.

CAUTION
Even if inches is selected as the measuring system, measurement distance _FA is always specified in **mm**! In that case, convert the measurement distance to mm: _FA [mm] = _FA‘ [inch] · 25.4

Note

In previous measuring cycle versions, _FA was the name for "multiplication factor of measurement distance". Its task and function remain the same.

_FA is now directly assigned mm as the unit of measurement.

2.3.13 Probe type, probe number: _PRNUM

General

- The data for the workpiece probes are stored in the data block (GUD6) in array **_WP[ ] workpiece probe**.
- The data for the tool probes are stored (in relation to machine) in the data block (GUD6) in array **_TP[ ] - tool probe**.
- The data for the tool probes is stored (specifically for each machine) in the data block (GUD6) in array **_TPW[ ] - tool probe in any workpiece coordinate system**.

Arrays are available for up to 99 probes. In the default setting, there are arrays for three probes each.

_PRNUM states the number of the probe. This number is used as the index for the probe's array.

Array type _WP, _TP, or _TPW is selected in the cycle via the measuring variant and measuring task: workpiece or tool measurement.

Note

Which **measuring input** (1 or 2) is used for workpiece measurement and which is used for tool measurement is defined in _CHBIT[0] and _CHBIT[1] (see chapter "Data description, cycle data").

The arrays are configured by the machine manufacturer during installation (see Chapter "Data description").

Parameters

Value of _PRNUM: >0, integer

_PRNUM can only have three digits in workpiece measurement. In that case the most significant digit is evaluated as the **probe type**.

The two least significant digits represent the probe number.

Digit			Meaning
3	2	1	
	–	–	Probe number (two digits)
0			Multi probe
1			Mono probe

Example of workpiece measurement

_PRNUM	= 102	
	→ Probe type	Mono probe
	→ Probe number	2
	→Array index	_WP[1,n]

Example of tool measurement

_PRNUM	= 3	
	→ Probe number	3
	→Array index	_TP[2,n]

2.3.14 Empirical value, mean value: _EVNUM

General information

The effect of empirical and mean values is described in the chapter "General section, measuring principle and measurement strategy".

The empirical values and mean values are stored in data block (GUD5) in arrays

- **_EV[ ] empirical values** and
- **_MV[ ] mean values.**

The unit of measurement is mm in the metric basic system and inch in the inch basic system, irrespective of the active system of units.

The number of existing empirical and mean values is entered in data block (GUD6) **_EVMVNUM[m,n].**

- m: array dimension _EV[m]
- n: array dimension _MV[n]

The default setting provides 20 values each (array index _EV, _MV: 0...19).

Parameter

Values of _EVNUM	
=0	without empirical value, without mean value memory
>0to 9999	Empirical value memory number = mean value memory number
>9999	The top 4 digits of _EVNUM are interpreted as the **mean value memory number**, the lower 4 digits as the **empirical value memory number**.

The array index for _EV and _MV is formed from the value in _EVNUM.

Example

_EVNUM	= 11	
	→ EV memory: 11	→ _EV[10]
	→ MV memory: 11	→ _MV[10]
_EVNUM	= 90012	
	→ EV memory: 12	→ _EV[11]
	→ MV memory: 9	→ _MV[8]

2.3.15 Multiple measurement at the same location: _NMSP

Parameter

Parameter **_NMSP** can be used to determine the number of measurements at the same location.

The measured values or distances-to-go Si (i=1...n) are averaged.

That results, for example, in distance-to-go D:

$D = (S_1 + S_2 + ... S_n) / n$

n: Number of measurements

2.3.16 Weighting factor for mean value calculation: _K

Parameter

The parameter for weighting factor **_K** can be applied to allow different weighting to be given to an individual measurement.

Note

A detailed description is given in the chapter "General section, measuring strategy and compensation value definition".

---

3 Measuring cycle help programs

3.1 Package structure of the measuring cycles

Note

References

For additional information, please refer to the following documentation:

HMI sl / SINUMERIK 840D sl Commissioning Manual

3.2 Measuring cycle subroutines

3.2.1 Overview

General

The measuring cycle subroutines are called directly by the cycles. They cannot be executed if called directly by the user.

Programming

Cycle	Function		Note
CYCLE102	Measuring result display		
CYCLE109	Internal subroutine:	Data transfer	
CYCLE110	Internal subroutine:	Plausibility checks	
CYCLE111	Internal subroutine:	Measuring functions	
CYCLE112	Internal subroutine:	Measuring functions	
CYCLE114	Internal subroutine:	Load ZO memory, load tool offset	
	Internal subroutine:	Load tool offset	
CYCLE115	Internal subroutine:	Load ZO memory	
CYCLE116	Calculation of center point and radius of a circle		
CYCLE117	Internal subroutine:	Pre-positioning	
CYCLE118	Internal subroutine:	Log	
CYCLE119	Internal subroutine:	Arithmetic cycle for determining position in space	

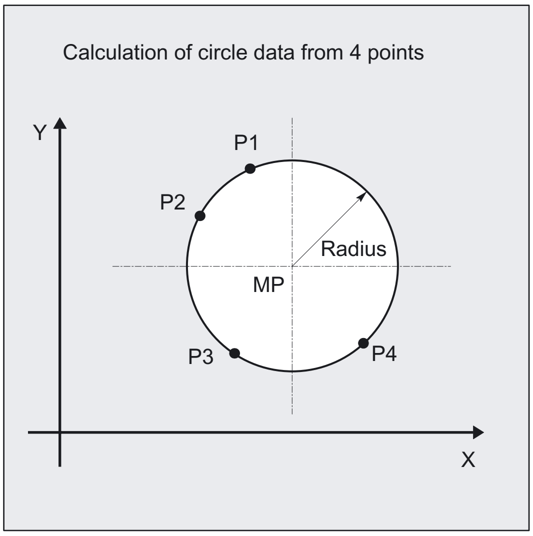
3.2.2 CYCLE116: Calculation of center point and radius of a circle

Function

This cycle calculates from three or four points positioned on one plane the circle they inscribe with center point and radius.

To allow this cycle to be used as universally as possible, its data are transferred via a parameter list.

An array of REAL variables of length 13 must be transferred as the parameter.



Programming

```
CYCLE116(_DATE, _ALM)
```

Parameter

- **Input data**

Parameter	Data type	Meaning
_DATE [0]	REAL	Number of points for calculation (3 or 4)
_DATE [1]	REAL	Abscissa of first point
_DATE [2]	REAL	Ordinate of first point
_DATE [3]	REAL	Abscissa of second point
_DATE [4]	REAL	Ordinate of second point
_DATE [5]	REAL	Abscissa of third point
_DATE [6]	REAL	Ordinate of third point
_DATE [7]	REAL	Abscissa of fourth point
_DATE [8]	REAL	Ordinate of fourth point

- Output data

Parameter	Data type	Meaning
_DATE [9]	REAL	Abscissa of circle center point
_DATE [10]	REAL	Ordinate of circle center point
_DATE [11]	REAL	Circle radius
_DATE [12]	REAL	Status for calculation 0 Calculation in progress 1 Error occurred
_ALM	INTEGER	Error number (61316 or 61317 possible)

Note

This cycle is called as a subroutine by, for example, measuring cycle CYCLE979.

Example

```
%_N_Circle_MPF
DEF INT _ALM
DEF REAL _DATE[13]= (3,0,10,-10,0,0,    ;3 points specified          P1: 0,10
-10,0,0,0,0,0,0)                                                     P2: -10,0
                                                                     P3: 0,-10
CYCLE116(_DATE, _ALM)                   ;Result:                     _DATE[9]=0
                                                                     _DATE[10]=0
                                                                     _DATE[11]=10
                                                                     _DATE[12]=0
                                                                     _ALM=0
M0
STOPRE
M30
```

3.3 Measuring cycle user programs

3.3.1 General information

Measuring cycle user programs CYCLE198 and CYCLE199 are called in the measuring cycles and can be used to program necessary adjustments before or after a measurement (e.g. activate probe, position spindle).

Note

As of measuring cycle version V2.6, the user cycles CYCLE198 and CYCLE199 are combined in the cycle CUST_MEACYC.

References:

HMI sl / SINUMERIK 840D sl Commissioning Manual

3.3.2 CUST_MEACYC: User program before/after measurements are performed

Function

CYCLE198 is called at the beginning of each measuring cycle.

It can be used to program actions necessary before starting a measurement (e.g. activate probe).

In the as-delivered state, this cycle only contains one CASE statement that executes a jump to a label with subsequent M17 (end of subroutine) for each measuring cycle.

Example

```
_M977:    ;before measurement in CYCLE977
M17       ;end of cycle
```

From this label all actions to be executed on each CYCLE977 call must be programmed.

Function

CYCLE199 is called in each measuring cycle when measurement is complete. It can be used to program actions necessary following completion of a measurement
(e.g. deactivate probe).

The internal structure of the cycle is the same as that of CYCLE198, i.e. the program lines must be inserted between the label for a particular cycle and M17 (end of subroutine).

4 Measuring in JOG

General

When measuring, a distinction is made between **workpiece measurement** and **tool measurement.** These measurements may be undertaken

- **automatically**

  or

- **semi-automatically**

Workpiece measurements

Workpiece measurements may include:

- Calibrating the workpiece probe.
- Measuring the contour elements on a workpiece (edge, corner, hole, spigot, rectangle) and then aligning the workpiece by determining and setting a zero offset.

Tool measurements

Tool measurements may include:

- Calibrating the tool probe.
- Determining the tool length or radius of milling tools, or tool length of drills and then setting the appropriate offset in the tool offset memory.

Sequence

For a description of workpiece measurements and tool measurements, see:

References:
SINUMERIK 840d HMI sl Operating Manual, Milling;

Chapter "Machine set-up, Measuring the workpiece zero".

Measuring Cycles for Milling and Machining Centers 5

5.1 General prerequisites

5.1.1 General information

The measuring cycles below are intended for use on milling machines and machining centers.

Under certain conditions, workpiece measuring cycles CYCLE976, CYCLE977, and CYCLE978 can also be used on turning machines.

To be able to run the measuring cycles described in this chapter, the following programs must be stored in the part program memory of the control.

The measuring cycle data are defined in the data blocks:

- GUD5.DEF
- GUD6.DEF

Note

As of HMI sl software version 2.6

The GUD parameters are stored in the machine or setting data.

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used up to and including measuring cycles version 7.5, compared to the machine and setting data as of measuring cycles version 2.6, is included in appendices A1, A2 and A3.

5.1.2 Overview of measuring cycles

Cycle	Function
`CYCLE961`	Workpiece: Setup inside and outside corner
`CYCLE971`	Tool measurement for milling tools, calibrate tool probe
`CYCLE976`	Calibrate workpiece probe in a hole or on a surface
`CYCLE977`	Workpiece: Paraxial measurement of hole, shaft, groove, web or ZO calculation
`CYCLE978`	Workpiece: 1-point measurement or ZO determination on surface
`CYCLE979`	Workpiece: Measurement of hole, shaft, groove, web, or ZO determination at an angle
`CYCLE996`	Workpiece: Measure kinematics (from measuring cycles SW 7.5)
`CYCLE997`	Workpiece: Measuring spheres or ZO determination (from measuring cycles SW 6.3)
`CYCLE998`	Workpiece: Angle measurement (ZO determination only)

5.1.3 Overview of the auxiliary programs required

Cycle	Function
CYCLE102	Measurement result display selection
CYCLE109	Internal subroutine: Data transfer
CYCLE110	Internal subroutine: Plausibility checks
CYCLE111	Internal subroutine: Measuring functions
CYCLE112	Internal subroutine: Measuring functions
CYCLE114	Internal subroutine (tool offset)
CYCLE115	Internal subroutine (zero offset)
CYCLE116	Calculate circle center point
CYCLE118	Format real values
CYCLE119	Internal subroutine: Determining position in space

5.1.4 Call and return conditions

The following general call and return conditions must be observed:

- The D offset must be activated with the data of the probe for workpiece measurement before the cycle is called. Tool type 1x0 or 710 (3D probe) is permitted. Dimension factors <> 1 may be active.
- The workpiece measuring cycles can also be used on turning machines if the following conditions are fulfilled:
  - The 3rd geometry axis exists.
  - Tool type of probe 5xy with cutting edge positions 5 to 8.
  - The tool length correction is specific to the turning machine (SD TOOL_LENGTH_TYPE=2).
  - With cutting edge positions 5 or 7, measurements are taken in the G17 plane, with cutting edge positions 6 or 8, in the G19 plane.
- Coordinate rotation is permitted for workpiece measuring cycles.
- Mirroring for the workpiece measuring cycles is permitted with the exception of calibration (condition: MD 10610=0).
- When using a multidirectional probe the best measurement results are achieved if, during calibration and measurement, the probe in the spindle is mechanically oriented to have one and the same point on the probe ball point, for example, in the + direction of the abscissa (+X with active G17) in the active workpiece coordinate system.
- The G functions active before the measuring cycle is called remain active after the measuring cycle call, even if they have been changed inside the measuring cycle.
- Measurements must always be performed under the same conditions as applied when the probe was calibrated.

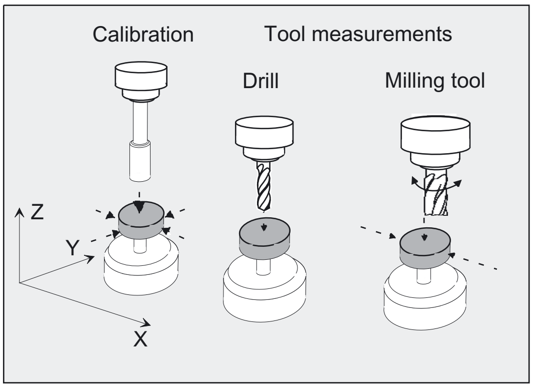
5.2 CYCLE971 tool: Measuring milling tools, drills

5.2.1 Function overview

Function

Measuring cycle CYCLE971 implements:

- Calibration of a tool probe
- Measurement of the tool length with motionless or rotating spindle for drills and milling tools
- Measure tool radius with motionless and rotating spindle for milling tools



Programming

CYCLE971

Measuring variants

Measuring cycle CYCLE971 permits the following measuring variants which are specified via parameter _MVAR.

Value	Measuring variant
0	Calibrate tool probe (machine-related)
1	Measure tool with motionless spindle (length or radius, machine-related)
2	Measure tool with rotating spindle (length or radius, machine-related)
10000	Calibrate tool probes incrementally (machine-related)
10	Calibrate tool probe (workpiece-related)
11	Measure tool with motionless spindle (length or radius, workpiece-related)
12	Measure tool with rotating spindle (length or radius, workpiece-related)
10010	Calibrate tool probe incrementally (workpiece-related)

Result parameters

The measuring cycle CYCLE971 returns the following values in the data block GUD5 for the measuring variant **calibration**:

Parameters	Data type	Result
_OVR [8]	REAL	Trigger point in minus direction, actual value of 1st geometry axis
_OVR [10]	REAL	Trigger point in plus direction, actual value of 1st geometry axis
_OVR [12]	REAL	Trigger point in minus direction, actual value of 2nd geometry axis
_OVR [14]	REAL	Trigger point in plus direction, actual value of 2nd geometry axis
_OVR [16]	REAL	Trigger point in minus direction, actual value of 3rd geometry axis
_OVR [18]	REAL	Trigger point in plus direction, actual value of 3rd geometry axis
_OVR [9]	REAL	Trigger point in minus direction, difference of 1st geometry axis
_OVR [11]	REAL	Trigger point in plus direction, difference of 1st geometry axis
_OVR [13]	REAL	Trigger point in minus direction, difference of 2nd geometry axis
_OVR [15]	REAL	Trigger point in plus direction, difference of 2nd geometry axis
_OVR [17]	REAL	Trigger point in minus direction, difference of 3rd geometry axis
_OVR [19]	REAL	Trigger point in plus direction, difference of 3rd geometry axis
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVI [2]	INTEGER	Measuring cycle number
_OVI [3]	INTEGER	Measurement variant
_OVI [5]	INTEGER	Probe number
_OVI [9]	INTEGER	Alarm number

Measuring cycle CYCLE971 returns the following values in the data block GUD5 for **tool measurement**:

Parameters	Data type	Result
_OVR [8]	REAL	Actual value length L1
_OVR [10]	REAL	Actual value radius R
_OVR [9]	REAL	Difference length L1
_OVR [11]	REAL	Difference radius R
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29]	REAL	Permissible dimensional difference
_OVR [30]	REAL	Empirical value
_OVI [0]	INTEGER	D number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [3]	INTEGER	Measurement variant
_OVI [5]	INTEGER	Probe number
_OVI [7]	INTEGER	Number of empirical value memory
_OVI [8]	INTEGER	T number
_OVI [9]	INTEGER	Alarm number

5.2.2 Measurement and correction strategy

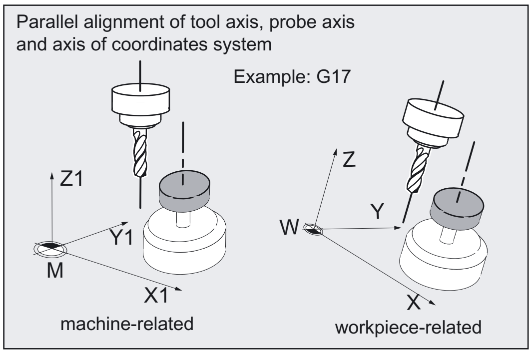
5.2.2.1 Measuring strategy

Pre-positioning the tool

The tool must be aligned vertically with the probe before the measuring cycle is called.

Tool axis parallel to center line of probe.

It must be prepositioned in such as way that collision-free approach to the probe is possible. First, the measuring cycle generates traverse paths to the position where measuring starts with a reduced rapid traverse velocity (_SPEED[0]), or with active collision monitoring at the position feedrate set in _SPEED[1] or _SPEED[2].



Tool measurement with motionless spindle

Before the cycle call for measurement of milling tools the tool and spindle must be moved such that the selected cutting edge can be measured (length or radius).

The measurement feedrate is defined in _VMS.

Tool measurement with rotating spindle

Typically, measurements of the radius of milling tools are executed with rotating spindle, that is the largest edge determines the measuring result.

Length measurement of milling tools with rotating spindle might also be practical.

Points to bear in mind:

- Is the tool probe permissible for measuring with rotating spindle with length and/or radius calculation? (Manufacturer documentation).
- Permissible peripheral speed for the tool to be measured.
- Maximum permissible speed.
- Maximum permissible feedrate for probing.
- Minimum feedrate for probing.

- Selection of the rotation direction depending on the cutting edge geometry to prevent hard impacts when probing.
- Required measuring accuracy.

When measuring with rotating tool the relation between measuring feedrate and speed must be taken into account. One cutting edge is taken into account. With multiple cutters, the longest edge is used for the measuring result.

The following connections have to be taken into account:

$n = S / (2\pi \cdot r \cdot 0.001)$

$F = n \cdot \Delta$

Where:		Basic system	
		Metric	*inch*
n	Spindle speed	rpm	rpm
I	Max. permissible peripheral speed	m/min	feet/min
r	Tool radius	mm	inch
F	Measuring feedrate	mm/min	inch/min
Δ	Measuring accuracy	mm	inch

Example:

Given a peripheral speed of S = 90 m/min, speeds of n = 2865 to 143 rpm will result for milling tools with a radius of r = 5 to 100 mm.

Given a specified measuring accuracy of Δ = 0.005 mm measuring feedrates of

F= 14 mm/min to F= 0.7 mm/min will result.

5.2.2.2 Compensation strategy

The tool measuring cycle is provided for various applications:

- **First-time measurement of a tool**

  (_CHBIT[3]=0):

  The tool offset values in geometry and wear are replaced.

  Compensation is written in the geometry component of length or radius. The wear component is reset.
- **Remeasurement of a tool (_CHBIT[3]=1):**

  The resulting difference is calculated into the wear component (radius or length).

Further, for tool measurement, the measured values can be corrected by empirical values.

Compensation of length 1 or the tool radius only occurs in **tool measurement** if the measured difference lies in the tolerance band between _TZL and _TDIF!

Compensation of the tool probe trigger points _TP[ ] and. _TPW[ ] only occurs when the tool probe is **calibrated** if the measured difference lies in the tolerance band between _TZL and _TSA!

5.2.2.3 Compensation with correction table when measuring with rotating spindle

When measuring tools with a rotating spindle, the measuring precision can be compensated for by additional compensation values during measurement of the cutter radius or cutter length. These compensation values are stored in tables in the dependency peripheral speed / cutter radius. Users can also create their own compensation values in dedicated tables in data block GUD6.

This offset is activated with variable of data type INTEGER _MT_COMP >0.

_MT_COMP= 0:	No compensation
_MT_COMP= 1:	Automatic compensation, i.e. internal compensation when using a TT130 (Heidenhain) or TS27R (Renishaw)
_MT_COMP= 2:	Correction using user-defined compensation, i.e. even if Heidenhain or Renishaw are specified (deviating probe)

Preproduced compensation tables of some tool probe models can be activated using variables of the data type INTEGER _TP_CF:

_TP_CF= 0:	No data
_TP_CF= 1:	TT130 (Heidenhain)
_TP_CF= 2:	TS27R (Renishaw)

The user can enter his own compensation values in two arrays of data type REAL:

- _MT_EC_R[6,5] for radius measurements and
- _MT_EC_L[6,5] for length measurements.

Structure of user arrays

_MT_EC_R _MT_EC_L [n,m]	m = 0	m = 1	m = 2	m = 3	m = 4
n = 0	0	1. Radius	2. Radius	3. Radius	4. Radius
n = 1	1. Peripheral speed	Compensation value for 1st radius/ 1. Peripheral speed	Compensation value for 2nd radius/ 1. Peripheral speed	Compensation value for 3rd radius/ 1. Peripheral speed	Compensation value for 4th radius/ 1. Peripheral speed
n = 2	2. Peripheral speed	Compensation value for 1st radius/ 2. Peripheral speed	Compensation value for 2nd radius/ 2. Peripheral speed	Compensation value for 3rd radius/ 2. Peripheral speed	Compensation value for 4th radius/ 2. Peripheral speed
n = 3	3. Peripheral speed	Compensation value for 1st radius/ 3. Peripheral speed	Compensation value for 2nd radius/ 3. Peripheral speed	Compensation value for 3rd radius/ 3. Peripheral speed	Compensation value for 4th radius/ 3. Peripheral speed
n = 4	4. Peripheral speed	Compensation value for 1st radius/ 4. Peripheral speed	Compensation value for 2nd radius/ 4. Peripheral speed	Compensation value for 3rd radius/ 4. Peripheral speed	Compensation value for 4th radius/ 4. Peripheral speed
n = 5	5. Peripheral speed	Compensation value for 1st radius/ 5. Peripheral speed	Compensation value for 2nd radius/ 5. Peripheral speed	Compensation value for 3rd radius/ 5. Peripheral speed	Compensation value for 4th radius/ 5. Peripheral speed
Units:	mm or inch		for tool radius and compensation value		
	m/min or ft/min		for peripheral speed		

Function and notes:

In the as-delivered state of the measuring cycles the default setting of the of the arrays is 0. The radii and peripheral speeds must be entered in ascending order.

These arrays are only accessed in automatic mode when _MT_COMP = 2. When tool measuring with a rotating spindle, the tool radius of the tool being measured is used to calculate a compensation value from these tables. The value for the next lowest table peripheral speed and the next lowest table radius are always the values used. In radius measurement the corresponding compensation value in array _MT_EC_R[n,m] is subtracted from the measured tool radius. In length measurement the corresponding compensation value in array _MT_EC_L [n,m] is subtracted from the measured tool length.

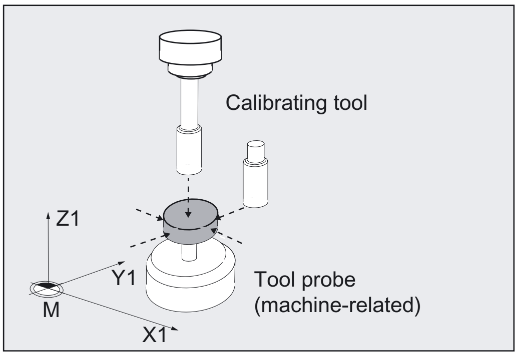
5.2.3 Calibrating tool probes

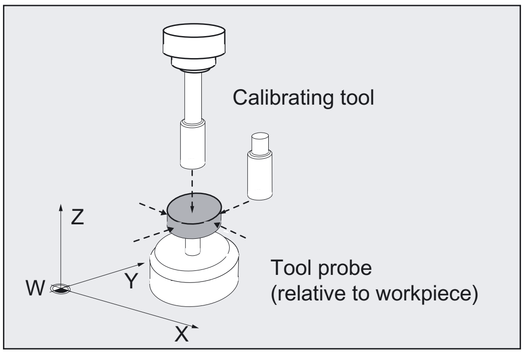
5.2.3.1 Calibration

Function

The cycle uses the calibration tool to ascertain the current distance dimensions between machine zero (machine-related calibration) and workpiece zero (workpiece-relatedcalibration) and the tool probe trigger points, and automatically loads them into the appropriate data area in data block GUD6.

Values are corrected without empirical and mean values.





Prerequisite

- The approximate coordinates of the tool probe must be entered before calibration starts in array _TP[_PRNUM-1, 0] to _TP[_PRNUM-1, 9] (machine-related) or _TPW[_PRNUM-1, 0] to _TPW[_PRNUM-1, 9] (workpiece-related).
- The precise length and radius of the calibration tool must be stored in a tool offset data block.

  This tool offset must be active when the measuring cycle is called. Tool type 120 can be entered.

  There is no special "calibration tool" type.
- Machining plane G17, G18, or G19 must be defined before the cycle is called.
- All the necessary parameters have been assigned values.

Parameter

Parameter	Data type	Meaning
_MVAR	0 10 10000 10010	Calibrate tool probe (machine-related) Calibrate tool probe (workpiece-related) Calibrate tool probes incrementally (machine-related) Calibrate tool probe incrementally (workpiece-related)
_MA	1...3 103, 203 102, 201	Number of the measuring axis Number of the offset and measuring axis (not for _MVAR=10000 and _MVAR=10010)
_FA	>0 <0	Measurement path For **incremental** calibration (_MVAR=1000x0) the travel direction is also defined via _FA. _FA > 0: Travel direction + _FA < 0: Travel direction -
_ID	REAL, ≥0	Offset The offset affects calibration of 3rd measuring axis if the calibration tool diameter is larger than the upper diameter of the probe. Here the tool is offset by the tool radius from the center of the probe, minus the value in _ID. The offset axis is also specified in _MA. Parameter _ID should usually set to 0.

The following additional parameters are also valid:

`_VMS, _TZL, _TSA, _PRNUM` and `_NMSP`.

`_TZL, _TSA` not for incremental calibration!

See also

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

5.2.3.2 Programming example 1

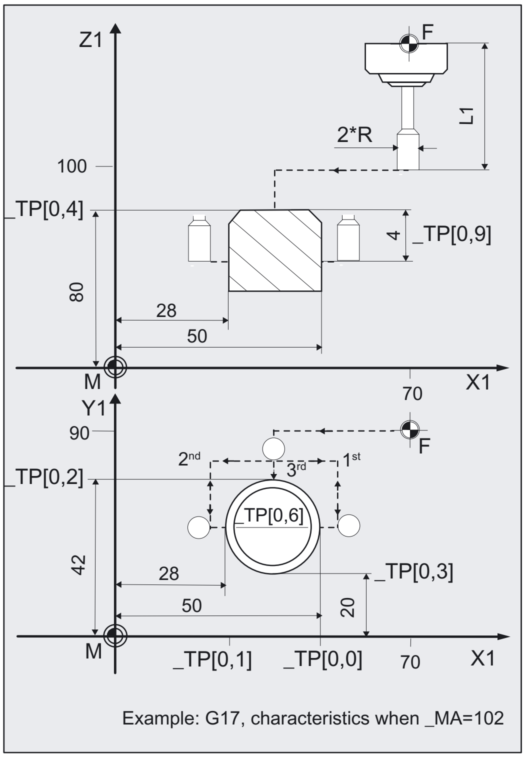
Fully calibrate tool probe (machine-related)

Values of the calibration tool T7 D1:

Tool type (DP1):	120
Length 1 - geometry (DP3).	L1 = 20.000
Radius - geometry (DP6):	R = 5.000

Values of the tool probe 1 in data block GUD6, approximate values before calibration begins (machine-related):

_TP[0,0] = 50
_TP[0,1] = 28
_TP[0,2] = 42
_TP[0,3] = 20
_TP[0,4] = 80
_TP[0,6] = 20 (upper diameter)
_TP[0,9] = 4
_TP[0,0] = 50



Example: G17, characteristics when _MA=102

```
%_N_CALIBRATE_MTT_MPF
N05 G0 G17 G94 G90                        ;Machining plane, define feedrate type
N10 T7 D1                                 ;Select calibration tool
N15 M6                                    ;Change calibration tool and
                                          ;activate compensation
N30 SUPA G0 Z100                          ;Position infeed axis over tool
                                          ;
N35 SUPA X70 Y90                          ;Position in plane on tool
                                          ;
N40 _TZL=0.005 _TSA=5 _VMS=0 _NMSP=1      ;Parameter for calibrating in the Y axis
_PRNUM=1 _FA=6                            ;with prior determination of probe
N41 _MVAR=0 _MA=102                       ;center in X. The data array of
                                          ;tool probe 1 is effective: _TP[0,i]
N50 CYCLE971                              ;Calibration in minus Y direction
N55 SUPA Z100                             ;Traverse up in infeed axis in rapid
                                          traverse
N60 SUPA Y0                               ;Move in plane to position from which
N65 _MA=2                                 ;plus Y direction can be calibrated
N70 CYCLE971                              ;Calibration in plus Y direction (probe
                                          ;at center in X
```

```
N80 SUPA X70 Z100                      ;Retract probe in X axis and Z axis, rapid
                                       traverse

N85 _MA=1                              ;Calibration in the X axis
N90 CYCLE971                           ;Calibration in minus X direction
N100 SUPA Z100                         ;Retract from probe in Z axis, rapid
                                       traverse
                                       ;
N110 SUPA X10                          ;In X axis move to position from which
                                       ;calibration in the plus direction is
                                       possible
N120 CYCLE971                          ;Calibration in plus X direction
N130 SUPA Z100                         ;Traverse up in infeed axis
N140 _MA=3                             ;Calibration in the Z axis on G17
N150 CYCLE971                          ;Calibration in minus Z direction
N160 M2                                ;End of program
```

Explanation of example 1

The new trigger values in -X, +X, -Y, +Y, and -Z are stored in the global data of tool probe 1 (_PRNUM=1) _TP[0,0...4] if they deviate by more than 0.005 mm (_TZL=0.005) from the old values. Deviations of up to 5 mm (_TSA=5) are permissible.

5.2.3.3 Programming example 2

Calibrate tool probe in minus X (workpiece-related)

Values of the calibration tool T7 D1:

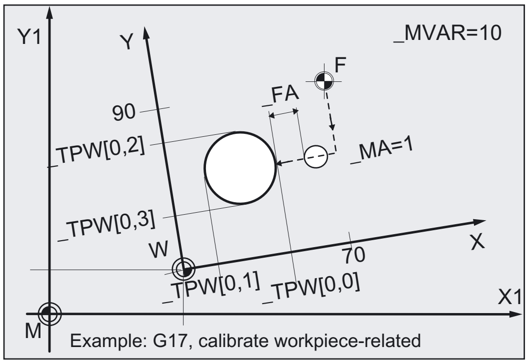
Tool type (DP1):	120
Length 1 - geometry (DP3).	L1 = 20.000
Radius - geometry (DP6):	R = 5.000

Values of the settable ZO for G54:

Displacement:	X = 60, Y = 15, Z = 30
Rotation around:	X = 0, Y = 0, Z = 18 degrees

Values of the tool probe 1 in data block GUD6, approximate values before calibration begins (workpiece-related):

_TPW[0,0] = 50
_TPW[0,1] = 28
_TPW[0,2] = 42
_TPW[0,3] = 20
_TPW[0,4] = 80
_TPW[0,9] = 4



Example: G17, calibrate workpiece-related

```
%_N_CALIBRATE_MTT_X_MPF
N05 G0 G17 G94 G54                  ;Define machining plane, zero offset and
                                    ;feed type
N10 T7 D1                           ;Select calibration tool
N15 M6                              ;Change calibration tool and
                                    ;activate compensation
N30 G0 Z100                         ;Position infeed axis over tool
                                    ;
N35 X70 Y90                         ;Position in plane on tool
                                    ;
N40 _TZL=0.005 _TSA=5 _VMS=0 _NMSP=1  ;Parameters for calibration in the X axis
_PRNUM=1 _FA=6
N41 _MVAR=10 _MA=1                  ;The array of
                                    ;tool probe 1 is effective: _TPW[0,i]
N50 CYCLE971                        ;Calibration in minus X direction
N55 Z100                            ;Traverse up in infeed axis in rapid
                                    traverse
N60 M2                              ;End of program
```

Explanation of example 2

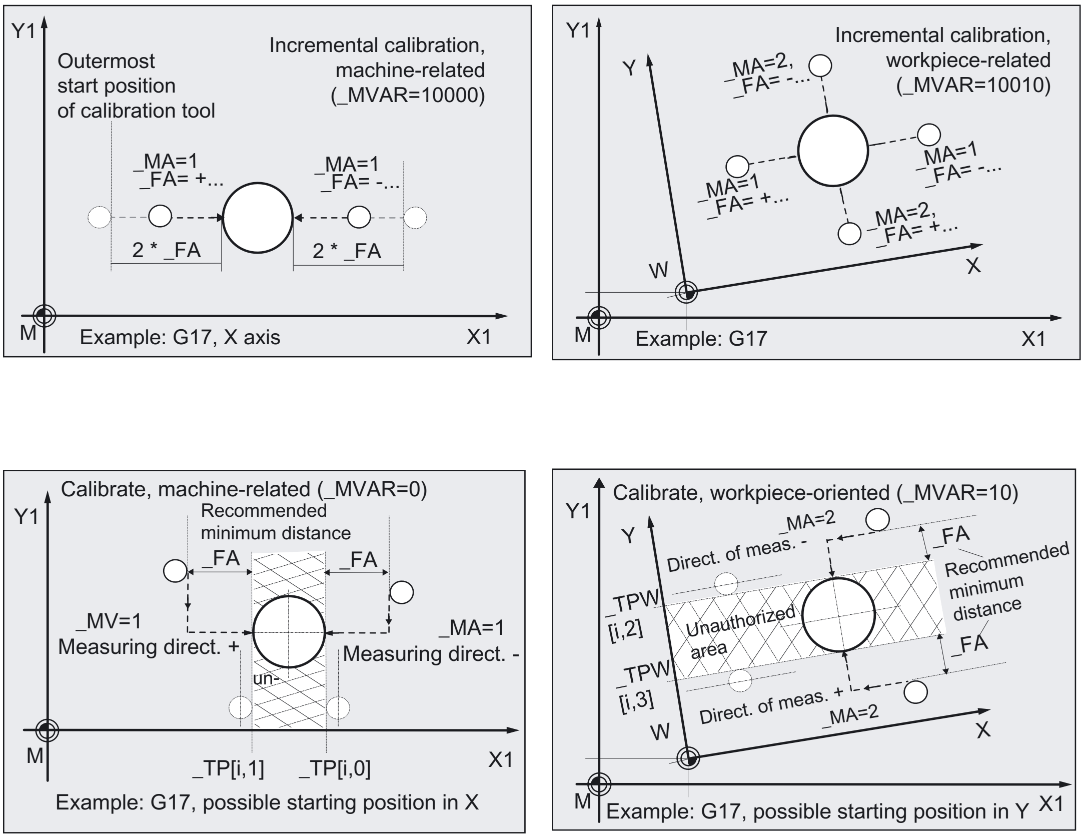
The calibration tool moves with its point from the starting position at N35 (X70, Y90, Z100) in Y to the center of the probe Y31 ((_TPW[0,2] + (_TPW[0,3]) / 2 = (42+20) / 2=31)); then in the measuring axis X (_MA=1, G17) to position X61 (_TPW[0,0] + _FA + R = 50 + 6 + 5 = 61). Here it is lowered to position Z76 (_TPW[0,4] - _TPW[0,9] = 80 - 4 = 76). Then measuring (calibration) is performed in the minus X direction. At the end, the calibration tool is again at position X61.

The new trigger values in minus X are stored in the data of tool probe 1 (_PRNUM=1) _TP[0,0] if they deviate by more than 0.005 mm (_TZL=0.005) from the old values. Deviations of up to 5 mm (_TSA=5) are permissible.

In block N55 the calibration tool is moved up to position Z100 and the program ends with block N60.

5.2.3.4 Operational sequence

Position before measuring cycle call



The calibration tool must be prepositioned as shown in the figure and for the selected variant. The tool must have reached a permissible starting position.

With incremental calibration, there is no generation of traversing movements before the actual measured block. The calibration tool must be positioned in front of the tool probe such that the calibration tool traverses to the tool probe when the measuring axis and a signed incremental measuring path up to the expected edge are entered in FA.

In normal calibration the measuring cycle calculates the approach path to the probe independently from the starting position and then generates the appropriate traverse blocks.

Note on calibrating in the 3rd measuring axis (_MA=3, _MA=103, _MA=203):

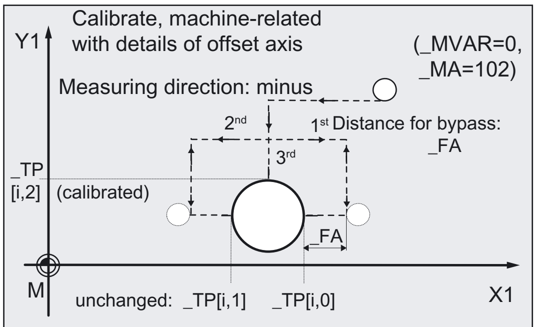
If the tool diameter (2x $TC_DP6) is smaller than the upper diameter of the probe (_TP[i,6]), the calibration tool is always positioned in the center of the probe.

If the tool diameter is larger, the calibration tool is offset by the tool radius toward the center onto the probe. The value of _ID is subtracted.

The axis in which the offset is applied (offset axis) is also specified in _MA (_MA=103 or MA=203).

If no offset axis is specified (_MA=3), the offset is applied in the abscissa, if necessary, (for G17: X axis).

Sequence on additional offset axis specification



Example: G17, determine center in X, calibrate in Y

Additionally specifying the offset axis in _MA (_MA= 102 or _MA= 201) first causes the exact center of the tool probe to be detected in the offset axis before calibration takes place in the measuring axis.

An entry in the array is only made for the measuring axis in the selected direction of measurement.

Position after end of measuring cycle

On completion of calibration, the calibration tool (radius) is _FA from the measuring surface.

5.2.4 Calibrating tool probes automatically

5.2.4.1 Automatic calibration

Function

Measuring variants

- _MVAR=100000 (machine-related)
- _MVAR=100010 (workpiece-related)

are used to calibrate the tool probe automatically.

The cycle uses the calibration tool to determine the tool probe trigger points in **all axes** and loads them into the relevant data area of data block GUD6.

A measuring axis does not have to be specified in _MA.

Otherwise, the same parameters apply as for calibration of an axis.

Values are corrected without empirical and mean values.

Prerequisite

The approximate coordinates of the tool probe must be entered before calibration starts in array _TP[_PRNUM-1, 0] to _TP[_PRNUM-1, 9] (machine-related) or _TPW[_PRNUM-1, 0] to _TPW[_PRNUM-1, 9] (workpiece-related). These values must be so precise that the parameter values of _TSA and _FA are fulfilled.

The precise length and radius of the calibration tool must be stored in a tool offset data block. This tool offset must be active when the measuring cycle is called. Tool type 120 can be entered. There is no special "calibration tool" type.

Machining plane G17, G18, or G19 must be defined before the cycle is called.

All the necessary parameters have been assigned values.

Parameter

Parameter	Value	Meaning
_MVAR	100000	Calibrate tool probe automatically (machine-related)
	100010	Calibrate tool probe automatically (workpiece-related)
_FA	>0	Measurement path

The following additional parameters are also valid:

_VMS, _TZL, _TSA, _PRNUM, _ID and _NMSP.

Set offset _ID=0 as standard.

See also

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Probe type, probe number: _PRNUM (Page 79)

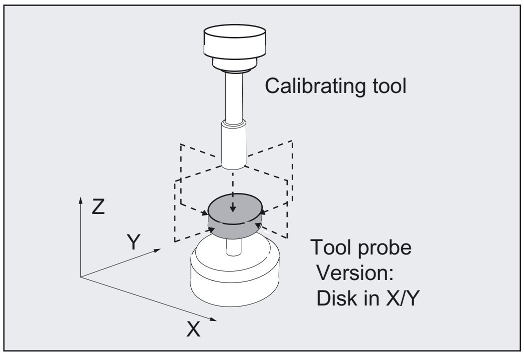
Multiple measurement at the same location: _NMSP (Page 81)

5.2.4.2 Programming example

Calibrate tool probe automatically, machine-related for G17

Values of the calibration tool T7 D1:

Tool type (DP1):	120
Length 1 - geometry (DP3).	L1 = 70.123
Radius - geometry (DP6):	R = 5.000



Values of tool probe 1 in block GUD6 before calibration:

_TP[0,0] = 50 (minus X axis)
_TP[0,1] = 28 (plus X axis)
_TP[0,2] = 42 (minus Y axis)
_TP[0,3] = 20 (plus Y axis)
_TP[0,4] = 80 (minus Z axis)
_TP[0,6] = 21 (cutting edge diameter on upper edge)
_TP[0,7] = 133 (can be calibrated: minus Z axis, in both X and Y directions)
_TP[0,8] = 101 (cutting edge in X/Y)
_TP[0,9] = 4 (distance to upper edge, depth of calibration)

```
%_N_AUTO_CALIBRATE_MPF
N10 G17 G0 G90 G94
N20 T7 D1                                   ;Preselect calibration tool
N30 M6                                      ;Change calibration tool and
                                            ;activate offset
N40 SUPA X39 Y31 Z100                       ;Take up start position
N20 _MVAR=100000 _FA=6 _TSA=5 _TZL=0.001    ;Parameters for calibration cycle
_PRNUM=1 _VMS=0 _NMSP=1
N30 CYCLE971                                ;Automatic calibration (complete)
N99 M2
```

Explanation of example

The tool probe is calibrated from the starting position in the –Z, +X, -X, +Y, -Y and again -Z axes. The values are entered in the _TP field and _OVR field if the results (values of the differences) are within the limits:

>_TZL, <_TSA.

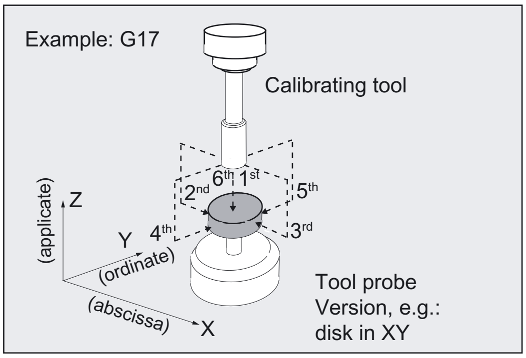
5.2.4.3 Operational sequence

Position before measuring cycle call

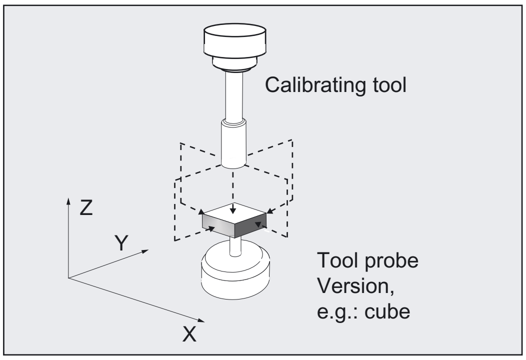
The position before measuring cycle call can be anywhere, but:

The cycle must be able to position the 1st calibration point at distance _FA above the center of the probe without collision.

The cycle approaches this point in the axis sequence: applicate (tool axis) followed by axis of the plane.



All subsequent traversing movements are also performed by the measuring cycle with "automatic calibration" using the values entered in array _TP[ ] or TPW[ ] of the probe and the dimensions of the active calibration tool.



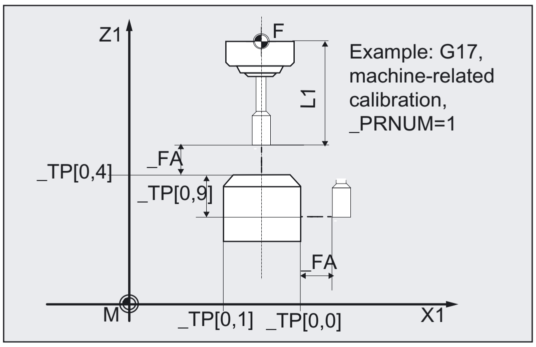
Calibration is performed in this sequence:

- applicate, +abscissa, –abscissa, +ordinate, –ordinate;

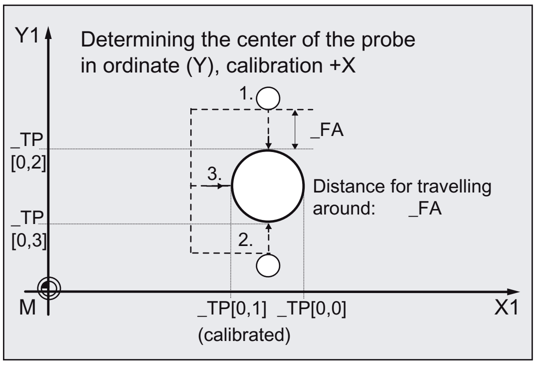
then finally again in

- applicate, but now in the located center.

For G17, for example, these are the axes: –Z, +X, –X, +Y, –Y, –Z.



Calibration in the plus direction of the abscissa is performed after ascertaining the center of the probe in the ordinate. Additional movements are performed in the plane.



This sequence applies to

_TP[_PRNUM-1, 7]=133 or _TPW[_PRNUM-1, 7]=133:

probe in Z axis can only be calibrated in minus direction, X, Y, in both directions.

Value _TP[k, 7] or _TPW[k, 7] =133 is the default value.

If some axes or axis directions on the probe cannot be approached the value must be changed.

Significance:

Decimal point	ones	1. geometry axis (X)
	tens:	2. geometry axis (Y)
	hundreds:	3. geometry axis (Z)
Value	0:	axis not possible
	1:	only minus direction possible
	2:	only plus direction possible
	3:	both directions possible

Example _TP[k, 7]=123:

X in both directions,

Y only in plus direction,

Z can only be calibrated in minus direction.

It must always be possible to approach the tool axis (applicate, for example, Z axis for G17) in the minus direction. Otherwise, automatic calibration is not possible.

The sequence described above changes according to the value of _TP[k, 7] or _TPW[k, 7].

Position after end of measuring cycle

On successful completion of the calibration process, the calibration tool is positioned distance _FA above the center of the probe.

5.2.5 Measuring tool

5.2.5.1 Measurement

Function

The cycle determines the new tool length or the new tool radius and checks whether the difference can be corrected with an empirical value to the old tool length or radius within a defined tolerance range (upper limits: Safe area _TSA and dimensional deviation check _TDIF, lower limit: Zero offset range _TZL,).

If this range is not violated, the new tool length or radius is accepted, otherwise an alarm is output. Violation of the lower limit is not corrected.

Measuring is possible either with:

- motionless spindle
- rotating spindle

Prerequisite

- The tool probe must be calibrated.
- The tool geometry data (approximate values) must be entered in a tool offset data record.
- The tool must be active.
- The desired machining plane must be activated.
- The tool must be prepositioned in such as way that collision-free approach to the probe is possible in the measuring cycle.

Special features of measurement with rotating spindle

- An additional compensation can be activated with variable _MT_COMP>0. (See Measuring and compensation strategy chapter).
- By default, the cycle-internal calculation of feed and speed is executed from the limit values defined in array _CM[] for peripheral speed, rotation speed, minimum feed, maximum feed and measuring accuracy, as well as the intended direction of spindle rotation for measurement.

  Measuring is conducted by probing twice; the first probing action causes a higher feedrate. A maximum of three probing operations are possible for measuring.

  If probing is performed several times the speed is additionally reduced on the last probing operation. This speed reduction can be suppressed by setting channel-related bit _CHBIT[22].
- The operator can deactivate the cycle-internal calculation via the measuring cycle bit _CBIT[12]=1 and specify his or her own values for feed and speed.

  Array _MFS[ ] is for entering the values. If the bit is set, the values from _MFS[0/1] are valid for the first probing and the values from _MFS[2/3] (speed/feedrate) for the second. If _MFS[2] = 0 only one probing action is performed. If _MFS[4]> 0 and_MFS[2]> 0, probing is performed in three probing actions; the values from _MFS[4/5] are valid in the third action.

  The monitoring functions from array _CM[] are not active!
- If the spindle is motionless when the measuring cycle is called, the direction of rotation is determined from _CM[5].

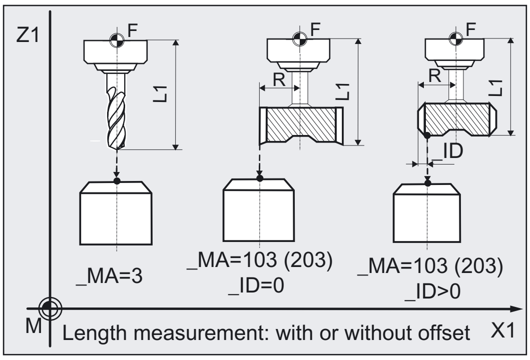
Monitoring for measuring with rotating spindle and cycle-internal calculation

<table>
<tr><th>Parameter</th><th>Type</th><th colspan="2">Meaning</th></tr>
<tr><td>_CM[0]</td><td>REAL</td><td colspan="2">Maximum permissible peripheral speed [m/min]/[feet/min]
Default setting: 100 m/min</td></tr>
<tr><td>_CM[1]</td><td>REAL</td><td colspan="2">Maximum permissible speed for measuring with rotating spindle [rpm]
(speed is automatically reduced if this is exceeded)
Default setting: 1000 RPM</td></tr>
<tr><td>_CM[2]</td><td>REAL</td><td colspan="2">Minimum feedrate for first probing operation [mm/min]/[inch/min]
(prevents feed rates which are too low when working with large tool radii)
Default setting: 1 mm/min</td></tr>
<tr><td>_CM[3]</td><td>REAL</td><td colspan="2">Required measuring accuracy [mm]/[inch]
Is effective during last probing
Default setting: 0.005 mm</td></tr>
<tr><td>_CM[4]</td><td>REAL</td><td colspan="2">Maximum feedrate for probing [mm/min]/[inch/min]
Default setting: 20 mm/min</td></tr>
<tr><td>_CM[5]</td><td>REAL</td><td colspan="2">Direction of spindle rotation during measuring
Default setting: 4 = M4</td></tr>
<tr><td rowspan="4">_CM[6]</td><td rowspan="4">REAL</td><td colspan="2">Feed factor 1</td></tr>
<tr><td rowspan="2">Values:</td><td>0: Probing just once with calculated feedrate (but at least value of _CM[2])</td></tr>
<tr><td>≥1: 1. Probing with calculated feedrate (but at least value of _CM[2]) · Feed factor 1</td></tr>
<tr><td colspan="2">Default setting: 10</td></tr>
<tr><td rowspan="4">_CM[7]</td><td rowspan="4">REAL</td><td colspan="2">Feed factor 2</td></tr>
<tr><td rowspan="2">Values:</td><td>0: 2. Probing with calculated feedrate
(only active when _CM[6]>0)</td></tr>
<tr><td>≥1: 2. Probing action with calculated feed · Feed factor 2
3. Probing with calculated feed</td></tr>
<tr><td colspan="2">Feed factor 2 should be smaller than feed factor 1.
Default setting: 0</td></tr>
</table>

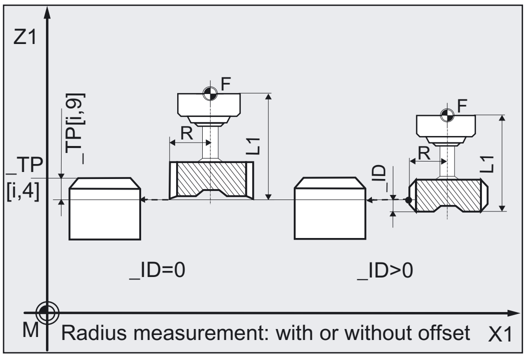
NOTICE
If the spindle is already rotating when the measuring cycle is called, this direction of rotation remains independent of _CM[5]!

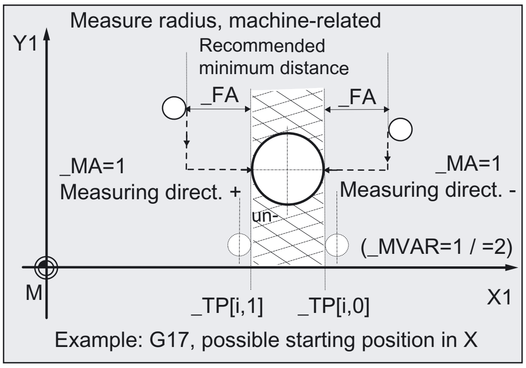
Measuring variants

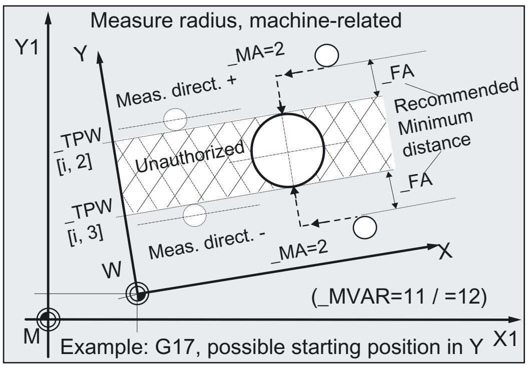
- **Length measuring variants (**Example: G17, machine-related)



- **Radius measuring variants (milling tool) (**Example: G17, machine-related, _MA=1)







Note

If the tool diameter (2x $TC_DP6) is smaller than the upper diameter of the probe (_TP[i,6]), the tool is always positioned in the center of the probe,

if the tool diameter is larger, the tool is offset by the tool radius toward the center onto the probe. The value of _ID is subtracted. The axis in which the offset is applied (offset axis) is also specified in _MA (_MA=103 or MA=203).

If no offset axis is specified (_MA=3), the offset is applied in the abscissa, if necessary, (for G17: X axis).

Parameter

Parameter	Value	Meaning
`_MVAR`	1	Measure with motionless spindle, machine-related
	2	Measure with rotating spindle, machine-related
	11	Measure with motionless spindle, workpiece-related
	12	Measure with rotating spindle, workpiece-related
`_MA`		Number of the measuring axis
	1	Measure radius in abscissa direction (milling tool)
	2	Measure radius in ordinate direction (milling tool)
	3	Measure length at center point of the tool probe (drill or milling tool)
	103	Measure length, offset by radius in abscissa direction (milling tool)
	203	Measure length, offset by radius in ordinate direction (milling tool)
`_ID`	REAL, ≥0	Offset Parameter is usually set to 0. With multiple cutters the offset of tool length and the highest point of the tool edge must be specified in _ID for radius measurement and the offset from the tool radius to the highest point of the tool edge must be specified for length measurement.
`_MFS[0]`	REAL	Speed 3rd probing (only with _CBIT[12]=1)
`_MFS[1]`		Feed 1st probing
`_MFS[2]`		Speed 2nd probing 0: Measurement terminated after 1st probing
`_MFS[3]`		Feed 2nd probing
`_MFS[4]`		Speed 3rd probing 0: Measurement terminated after 2nd probing
`_MFS[5]`		Feed 3rd probing

The following additional parameters are also valid:

`_VMS, _TZL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM` and `_NMSP`.

See also

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

5.2.5.2 Programming examples 1

Measuring the length and radius of a milling tool (machine-related)

Milling tool F3 with D1 is to be measured for the first time along length L1 and radius R (to determine geometry).

The length measurement is to be performed with motionless spindle. Radius measurement is to be performed with rotating spindle – in the X axis.

The tool has a specially shaped cutting edge and therefore requires an offset for measurement.

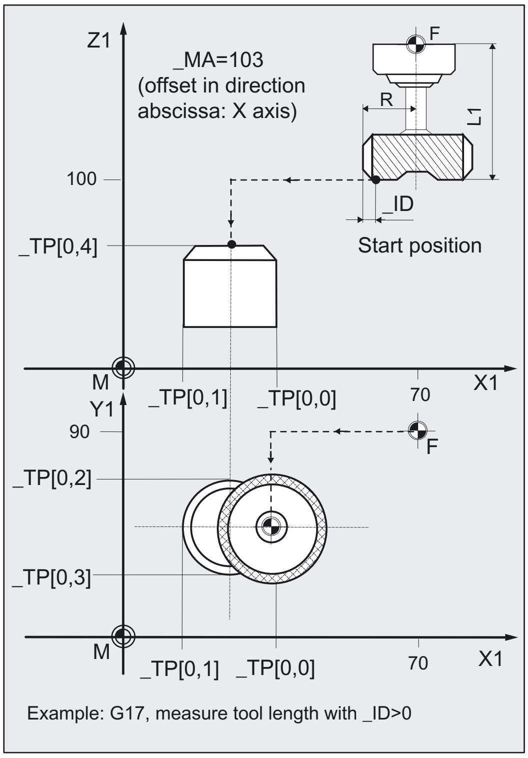
A measured value deviation of < 1.6 mm compared with the entered values is expected.

Values of calibration tool T3 D1, before the measurement:

Tool type (DP1):	123
Length 1 - geometry (DP3):	L1 = 70
Radius - geometry (DP6):	R = 18
Length 1 - wear (DP12):	0
Radius - wear (DP15):	0

Tool probe 1 is used. It has already been calibrated under the same conditions.

Values: See programming example 1 "Calibration"



```
%_N_T3_MEAS_MPF
N01 G17 G90 G94
N05 T3 D1                          ;Selection of the tool to be measured
N10 M6                             ;Insert tool, offset active
N15 G0 SUPA Z100                   ;Position infeed axis with probe
N16 SUPA X70 Y90 SPOS=15           ;Position X/Y, align cutting edge
                                   ;(if needed)
N20 _CHBIT[3]=0 _CBIT[12]=0        ;Compensation of tool geometry, internal
                                   cycle
                                   ;calculation of feedrate and
                                   ;speed during measurement with rotating
                                   spindle
N30 _TZL=0.04 _TDIF=1.6 _TSA=2     ;Parameters for cycle
_PRNUM=1 _VMS=0 _NMSP=1 _FA=3 _EVNUM=0
N31 _ID=2.2 _MVAR=1 _MA=103        ;Offset in X axis for length measurement
N40 CYCLE971                       ;Measure length with motionless spindle
N50 SUPA X70                       ;Retract from probe in X
N70 _ID=2.4 _MA=1 _MVAR=2          ;New offset for radius measurement
N80 CYCLE971                       ;Measure radius in minus X direction with
                                   ;rotating spindle
N90 SUPA Z100 M2                   ;Raise in Z, end of program
```

Explanation of example 1

Length 1 (derived in block N40) and the radius (derived in block N80) of the active tool (T3, D1) are entered in the relevant geometry memory (_CHBIT[3]=0) if they

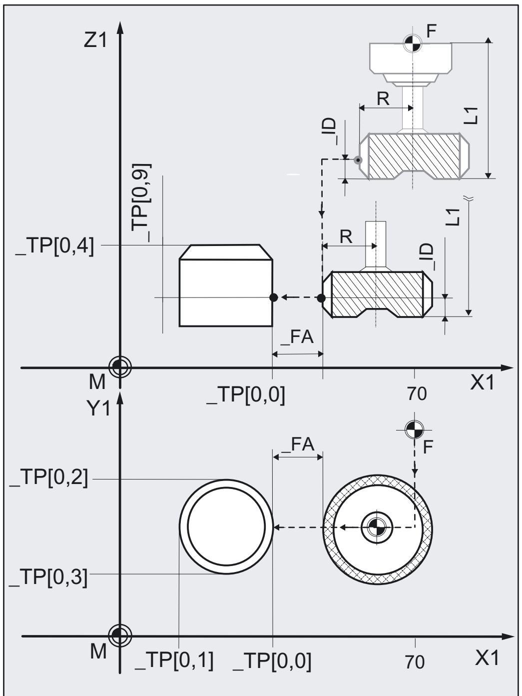
- deviate by more than 0.04 mm (_TZL=0.04) and
- less than 1.6 mm (_TDIF=1.6)

from entered values L1, R.

If the differences are ≥ _TDIF or _TSA alarms are output.

Values are corrected without empirical values (_EVNUM=0).

Wear values L1 and R of the tool are reset (_CHBIT[3]=0).



Example: G17, measure tool radius with _ID>0

5.2.5.3 Programming example 2

Measure radius of milling tool (workpiece-related)

Milling tool T4 with D1 is to be remeasured in radius R (to ascertain wear).

Radius measurement is to be performed with rotating spindle – in the X axis.

A measured value deviation of < 0.6 mm compared with the entered values is expected.

Values of calibration tool T4 D1, before the measurement:

Tool type (DP1):	120
Length 1 - geometry (DP3):	L1 = 70
Radius - geometry (DP6):	Rg = 18.0
Radius - wear (DP15):	Rv = 0.024
	R = Rg + Rv

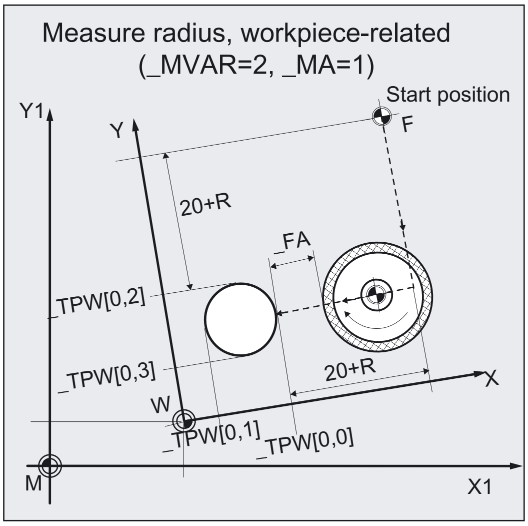
Values of the settable ZO for G54:

Displacement: X=60, Y=15, Z= 30

Rotation about: X=0, Y=0, Z=18 degrees

Tool probe 1 is used. It has already been calibrated under the same conditions (G17, G54, …).

Values: See programming example 2 "Calibration"




```
%_N_T4_MEASURE_MPF
N01 _PRNUM=1                               ;Select tool probe 1
N02 G17 G54 G94 G90                        ;Plane, ZO, feedrate type, dimensioning
N05 T4 D1                                  ;Selection of the tool to be measured
N10 M6                                     ;Insert tool, offset active
N15 G0 Z=_TPW[_PRNUM-1,4]+20               ;Position in infeed axis above the
                                           ;tool probe
N16 X=_TPW[_PRNUM-1,0]+$P_TOOLR+20         ;Position X/Y plane: tool edge 20 mm next
Y=_TPW[_PRNUM-1,2] +$P_TOOLR +20           to
                                           ;probe edge +X, +Y
N20 _CHBIT[3]=1 _CBIT[12]=0                ;Compensation in wear, internal cycle
                                           ;calculation of feedrate and speed
                                           ;during measurement with rotating spindle
N30 _TZL=0.04 _TDIF=0.6 _TSA=2 _VMS=0      ;Remaining parameters for cycle
_NMSP=1 _FA=3 _EVNUM=0
N31 _ID=0 _MVAR=12 _MA=1                   ;Without offset
N40 CYCLE971                               ;Measurement with rotating spindle
N50 Z=_TPW[_PRNUM-1,4]+20                  ;Raise from probe in Z
N60 M2
```

Explanation of example 2

The tool moves in N40 (in cycle) with its point from the starting position in N16 in Y to the center of the probe (_TPW[0,2] + (_TPW[0,3]) / 2); then in the measuring axis X (_MA=1, G17) to position (_TPW[0,0] + _FA + R). Here it is lowered to the position in Z (_TPW[0,4] - _TPW[0,9]. Then measuring is performed in the minus X direction. At the end, the tool (radius) is again positioned distance _FA in X in front of the probe. In block N50 the tool is raised 20 mm in Z above the probe. Then the program is ended (N60).

The difference in radius (derived in block N40) of the active tool (T4, D1) is subtracted from the wear and entered (_CHBIT[3]=1), if they

- deviate by more than 0.04 mm (_TZL=0.04) and
- less than 0.6 mm (_TDIF=0.6).

If the difference is ≥ _TDIF or _TSA, alarms are output.

Values are corrected without empirical values (_EVNUM=0).

5.2.5.4 Operational sequence

Position before measuring cycle call

Before cycle call a starting position must be taken up from which approach to the probe is possible without collision. The measuring cycle calculates the continued approach path and generates the necessary travel blocks.

Position after end of measuring cycle

On completion of the cycle, the tool nose or tool radius is positioned facing the measuring surface at a distance corresponding to _FA.

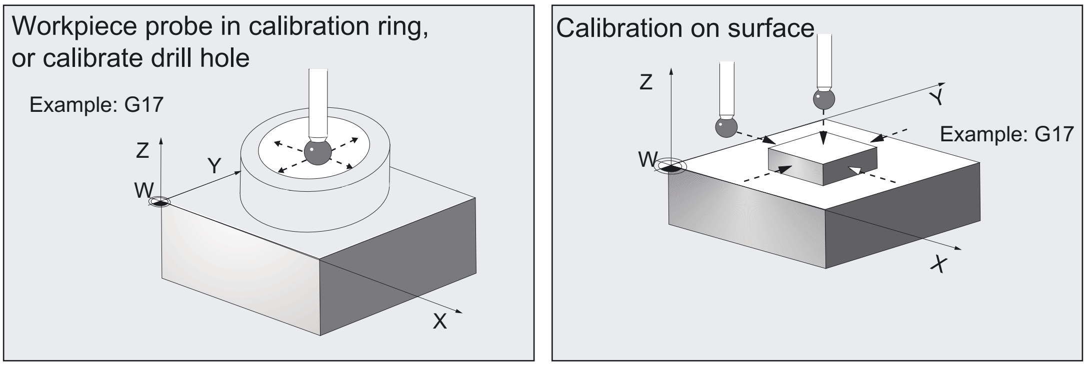
5.3 CYCLE976 calibrate workpiece probe

5.3.1 Function overview

Function

With milling machines and machining centers, the probe is usually loaded into the spindle from a tool magazine.

This may result in errors when further measurements are taken on account of probe clamping tolerances in the spindle.

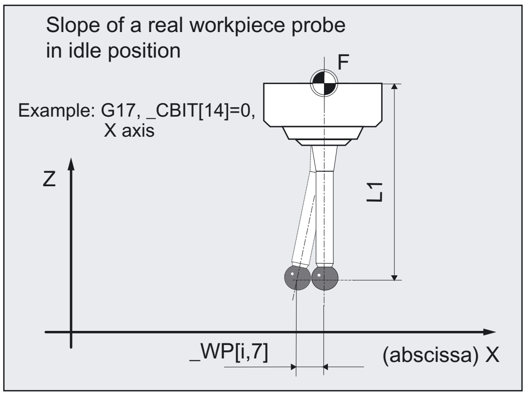


The probe trigger points must be determined in the axis directions that are dependent on:

- the probe ball diameter:
- the mechanical design of the probe.
- speed at which the probe hits an obstacle.

With this calibration cycle it is possible to calibrate a workpiece probe in a hole (axes in the plane) or on suitable surfaces for a particular axis and direction.

Determining the positional deviation of the workpiece probe



A real workpiece probe can deviate from its ideal vertical position even when not deflected. This positional deviation (skew) can be determined with measuring variants in this cycle and then entered in the intended array of the workpiece _WP[i, 7] for abscissa and _WP[i, 8] for ordinate (for detailed data: refer to Data description chapter "Cycle data").

These values are taken into account in precise probe positioning in subsequent measurements with a similarly calibrated workpiece probe.

Workpiece probe types that can be used

- Multidirectional probe (_PRNUM=xy)
- Monodirectional, bidirectional probe (_PRNUM=1xy)

Programming

```
CYCLE976
```

Measuring variants

Measuring cycle `CYCLE976` permits the following **calibration** variants which are specified via parameter `_MVAR`.

- Calibration in hole (axes of the plane)

Digit						Measuring variant
6	5	4	3	2	1	
					1	Hole (for measurement in the plane), center of the hole known
					8	Hole (for measurement in the plane), center of the hole not known
				0		With any data in the plane (workpiece-related)
			0			Without including probe ball in calculation
			1			Including probe ball in calculation (for measurement in plane)
		0				4 axis directions
		1				1 axis direction (also specify measuring axis and axis direction)
		2				2 axis directions (also specify measuring axis)
	0					Without determining position deviation of probe
	1					With determining position deviation of probe
0						Paraxial calibration (in the plane)
1						Calibration at an angle (in the plane)

Note

When _MVAR=xx1x0x calibration is only performed in one direction. It is not possible to determine position deviation or calculate probe ball.

Result parameters

Measuring cycle `CYCLE976` returns the following values in data block GUD5 for **calibration**:

Parameter	Data type	Result
`_OVR [4]`	REAL	Actual value probe ball diameter
`_OVR [5]`	REAL	Difference probe ball diameter
`_OVR [6]1)`	REAL	Center point of the hole in the abscissa
`_OVR [7]1)`	REAL	Center point of the hole in the ordinate
`_OVR [8]`	REAL	Trigger point in minus direction, actual value, abscissa
`_OVR [10]`	REAL	Trigger point in plus direction, actual value, abscissa
`_OVR [12]`	REAL	Trigger point in minus direction, actual value, ordinate
`_OVR [14]`	REAL	Trigger point in plus direction, actual value, ordinate
`_OVR [16]`	REAL	Trigger point in minus direction, actual value, applicate
`_OVR [18]`	REAL	Trigger point in plus direction, actual value, applicate
`_OVR [9]`	REAL	Trigger point in minus direction, difference, abscissa
`_OVR [11]`	REAL	Trigger point in plus direction, difference, abscissa

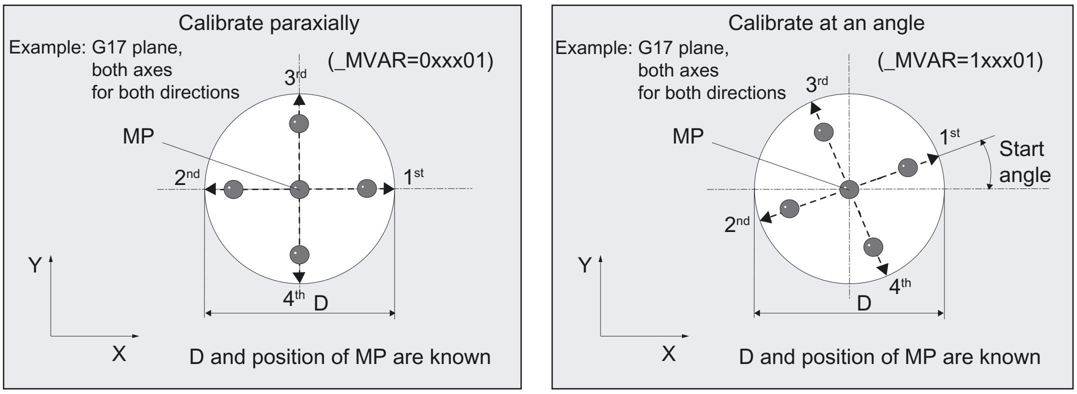
Parameter	Data type	Result
_OVR [13]	REAL	Trigger point in minus direction, difference, ordinate
_OVR [15]	REAL	Trigger point in plus direction, difference, ordinate
_OVR [17]	REAL	Trigger point in minus direction, difference, applicate
_OVR [19]	REAL	Trigger point in plus direction, difference, applicate
_OVR [20]	REAL	Positional deviation abscissa (skew of probe)
_OVR [21]	REAL	Positional deviation ordinate (skew of probe)
_OVR [22] 2)	REAL	Probe length of the workpiece probe
_OVR [24]	REAL	Angle at which the trigger points were determined
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVI [2]	INTEGER	Measuring cycle number
_OVI [5]	INTEGER	Probe number
_OVI [9]	INTEGER	Alarm number
1) For calibration variant with unknown hole center point only 2) For determining probe length only		

5.3.2 Calibrating a workpiece probe in a hole of known hole center point

5.3.2.1 General information

Function

Using the measuring cycle and the _MVAR=xxxx01
measuring variant, it is possible to calibrate the probe in the axes of the plane (G17, G18, or G19) in a calibration ring. A hole that is perpendicular to the selected plane and with the same quality requirements regarding geometrical accuracy and surface roughness can also be used.



The center point (CP) of the hole and its diameter (D) must be known for this calibration variant!

The calculated trigger points are automatically loaded in the relevant data area _WP[ ] of block GUD6.DEF if the calculated difference from the stored trigger points lies within the tolerance band between _TZL and _TSA. If _TSA is exceeded an error message is output.

Calibration is performed either **paraxially** with the axes of the active workpiece coordinate system or **at an angle** to these axes.

The number of axes and axis directions can be selected in _MVAR. If fewer than four axis directions are selected (_MVAR= xx1xx01, xx2xx01), additional information must be supplied in _MA and possibly in _MD.

Prerequisite

The probe must be called with tool length offset.

Tool type, preferably: 710.

NOTICE
The first time calibration is performed the default setting in the array of probe _WP[ ] is still "0". For that reason _TSA> probe ball radius must be programmed to avoid alarm "Safe area violated".

Parameter

Parameter	Data type	Meaning
_MVAR	xxxx01	Calibration variant
_SETVAL	REAL, >0	Calibration setpoint = diameter of hole
_MA	1, 2	Meas. axis, only for _MVAR= xx1xx01, = xx2xx01 (only 1 axis or only 1 axis direction)
_MD	0 positive axis direction 1 negative axis direction	Meas. axis, only for _MVAR= xx1x01 (calibrate one axis direction only)
_PRNUM	>0	Probe number
_STA1	REAL	Starting angle, only for _MVAR= 1xxx01 (calibration performed at this angle)

The following additional parameters are also valid:

_VMS, _CORA, _TZL, _TSA, _FA and _NMSP.

_CORA only relevant for monodirectional probe.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

5.3.2.2 Programming example

Calibrating a workpiece probe in the X-Y plane, known hole center point

Workpiece probe 3, used as tool T9, D1, is to be recalibrated in a known hole with

MPx=100,000, MPy=80,000, D=110,246 mm

in axes X and Y in both axis directions with G17 and paraxially (to redetermine trigger values _WP[i,1] to _WP[i,4].

The positional deviation (skew _WP[i,7], _WP[i,8]) and precise ball diameter _WP[i,0] of the probe is also to be ascertained.

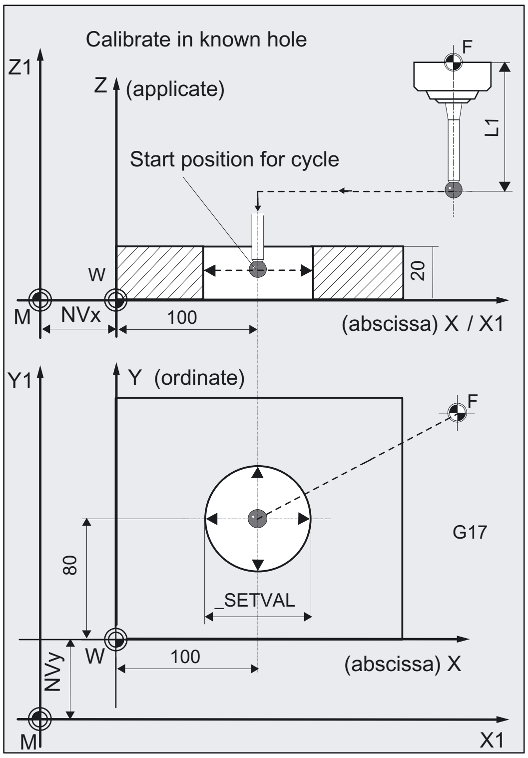
The radius of the probe ball and length 1 must be entered in the tool offset memory under T9 D1, before the cycle is called.

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball: _CBIT[14]=0.

Careful when positioning! Radius R in length (L1) is ignored. But the desired calibration height can be entered directly.

Zero offset, with settable ZO G54:	NVx, NVy, ...
Arrays for workpiece probe 3: (already contains approximate values)	_WP[2, ...]




```
%_N_CALIBRATE_IN_X_Y_MPF
N10 G54 G90 G17 T9 D1                  ;ZO selection, select probe as tool and
                                       ;operating plane
N20 M6                                 ;Insert probe and activate tool offset
                                       ;
N30 G0 X100.000 Y80.000                ;Position probe at center of hole
                                       ;
N40 Z10                                ;Position probe in hole at
                                       ;calibration height
N50 _CBIT[14]=0                        ;Length 1 relative to probe ball center
N60 _TSA=1 _PRNUM=3 _VMS=0 _NMSP=1     ;Set parameter for calibration cycle:
_FA=1 _TZL=0                           ;Calibrate probe 3 in
N61 _MVAR=010101 _SETVAL=110.246       ;4 axis directions with calculation of
                                       ;positional deviation and calculation of
                                       effective diameter of probe ball
N70 CYCLE976                           ;Measuring cycle call, calibrate paraxially
N80 Z40                                ;Position probe above workpiece
N100 M2                                ;End of program
```

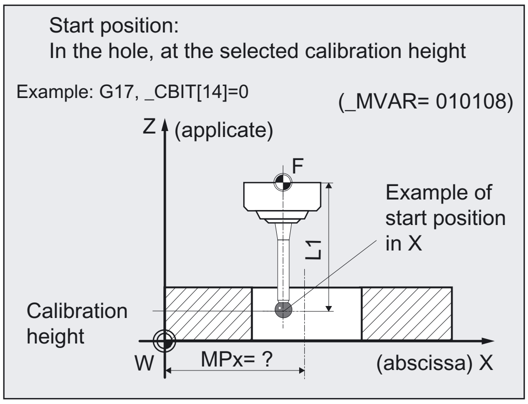
Explanation of example

The new trigger values in –X, +X, -Y and +Y are stored in the global data of measuring probe 3 _WP[2,1...4]. The positional deviation calculated in the X and Y direction is stored in _WP[2,7], _WP[2,8], the active probe ball diameter in _WP[2,0].

5.3.2.3 Operational sequence

Position before measuring cycle call

The probe must be positioned at the center of hole (MP) in the abscissa and the ordinate of the selected measuring plane and at the calibration depth in the hole.



Axis sequence, axis direction sequence

- Paraxial, two axis directions:

  Calibration starts in the positive axis direction. If _MVAR=xx0xx1 (all four directions), calibration starts in the abscissa. This is followed by the ordinate.
- At an angle:

  The axes travel in combination acc. to starting angle _STA1 plus steps of 90 degrees. Otherwise, the same principle as for "paraxial" applies.

Position after end of measuring cycle

When calibration is complete the probe is again positioned at calibration depth in the center of the hole.

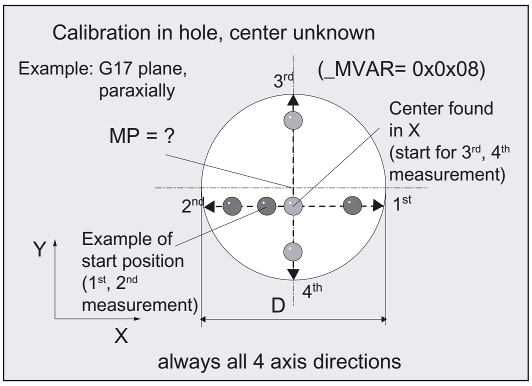
5.3.3 Calibrating a workpiece probe in a hole of unknown hole center point

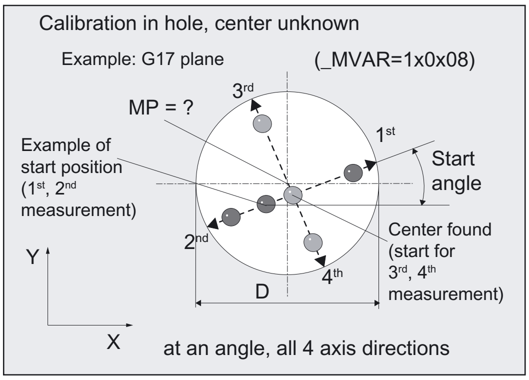
5.3.3.1 General information

Function

Using the measuring cycle and the _MVAR=xx0x08
measuring variant, it is possible to calibrate the probe in the axes of the plane (G17, G18, or G19) in a calibration ring. A hole that is perpendicular to the selected plane and with the same quality requirements regarding geometrical accuracy and surface roughness can also be used.

The center (CP) of the hole is **unknown** in the precise position. But diameter (D) is known.





In this measuring variant first the hole center and then the positional deviation (skew) of the probe is calculated. Then the trigger points in all 4 axis directions on the plane are calculated.

In addition to the values in array _WP[ ], the measuring cycle also provides the determined hole center point in result array _OVR[6], _OVR[7].

Calibration can be performed paraxially or at an angle to the active workpiece coordinate system. All 4 axis directions are always calibrated.

Prerequisite

- The probe must be called with tool length offset.
- Tool type, preferably: 710.
- The exact diameter of the hole is known.
- The spindle must be SPOS-capable.
- Probe in spindle can be positioned 0...360 degrees (all-round coverage).

NOTICE
The first time calibration is performed the default setting in the array of the probe is still "0". For that reason _TSA> probe ball radius must be programmed to avoid alarm "Safe area violated".

Parameter

Parameter	Data type	Meaning
`_MVAR`	xx0x08	Calibration in hole, center unknown
`_SETVAL`	REAL, >0	Calibration setpoint = diameter of hole
`_PRNUM`	>0	Probe number
`_STA1`	REAL	Starting angle, only for MVAR=1xxx08 (calibration performed at this angle)

The following additional parameters are also valid:

`_VMS`, `_CORA`, `_TZL`, `_TSA`, `_FA` and `_NMSP`.

`_CORA` only relevant for monodirectional probe.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Multiple measurement at the same location: _NMSP (Page 81)

5.3.3.2 Programming example

Calibrating a workpiece probe in the X-Y plane, unknown hole center point

Workpiece probe 2, used as tool T10, D1, is to be recalibrated in a hole with D=110.246 mm and not precisely known center point (CP) in axes X and Y in both axis directions with G17 and paraxially (to redetermine trigger values _WP[i,1] to _WP[i,4].

The positional deviation (skew _WP[i,7], _WP[i,8]) and precise ball diameter _WP[i,0] of the probe is also to be ascertained.

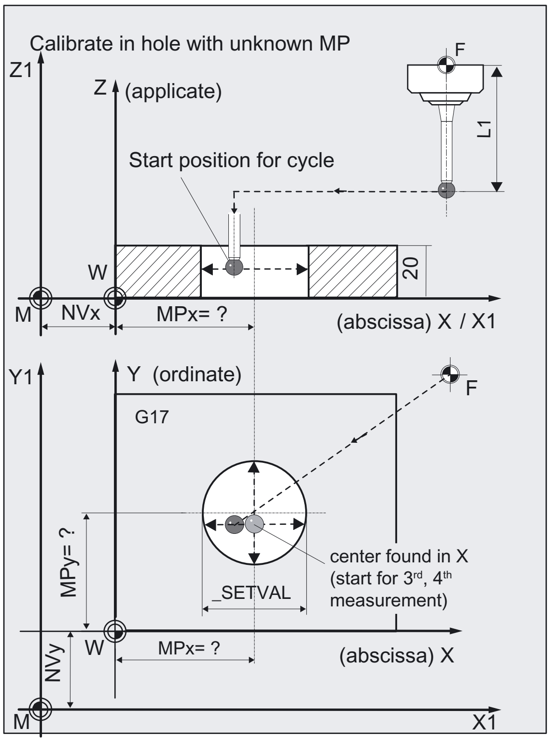
The radius of the probe ball and length 1 must be entered in the tool offset memory under T10, D1, before the cycle is called.

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball: _CBIT[14]=0.

Careful when positioning! Radius R in length (L1) is ignored. But the desired calibration height can be entered directly.

Zero offset, with settable ZO G54:	NVx, NVy, ...
Arrays for workpiece probe 2: (already contains approximate values)	_WP[1, ...]




```
%_N_CALIBRATE2_IN_X_Y_MPF
N10 G54 G90 G17 T10 D1                    ;ZO selection, select probe as tool and
                                          ;operating plane
N20 M6                                    ;Insert probe and activate tool offset
                                          ;
N30 G0 X100 Y80                           ;Position probe in hole
N40 Z10                                   ;Position probe in hole at
                                          ;calibration height
N50 _CBIT[14]=0                           ;Length 1 relative to probe ball center
N60 _TSA=1 _PRNUM=2 _VMS=0 _NMSP=1        ;Set parameter for calibration cycle:
_TZL=0                                    ;Calibrate probe 2 in
N61 _MVAR=010108 _SETVAL=110.246          ;4 axis directions with calculation of
_FA=_SETVAL/2                             ;positional deviation and calculation of
                                          ;diameter of probe ball
N70 CYCLE976                              ;Measuring cycle call, calibrate paraxially
N80 Z40                                   ;Position probe above workpiece
N100 M2                                   ;End of program
```

Explanation of example

The hole center is determined twice, the spindle with the probe being rotated through 180° between each measurement if a multi probe is used, in order to record any positional deviation (skew) of the measuring probe. Triggering is then determined in all 4 axis directions.

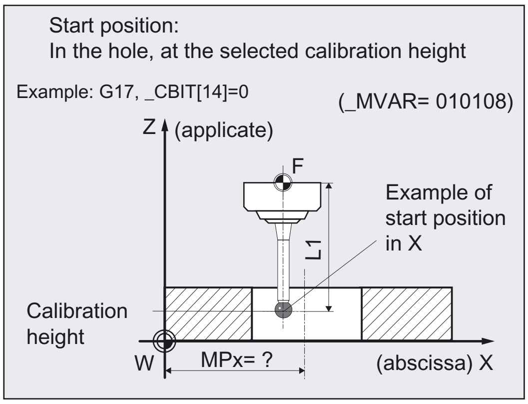
The new trigger values in -X, +X, -Y and +Y are stored in the global data of probe 2_WP[1,1...4], the positional deviation in the X and Y direction in _WP[1,7], _WP[1,8], the active probe ball diameter in _WP[1,0].

The calculated hole center is entered in OVR[6], OVR[7].

5.3.3.3 Operational sequence

Position before measuring cycle call

The probe must be positioned near the hole center in the abscissa and the ordinate of the selected measuring plane and at the calibration height in the hole.



Axis sequence, axis direction sequence

- Paraxial:

  Calibration always starts in the positive axis direction, first in the abscissa, then in the ordinate.

- At an angle:

  The axes always travel in combination acc. to starting angle _STA1, _STA1+180 degrees, _STA1+90 degrees, and _STA1+270 degrees.

  Otherwise, the same principle as for "paraxial" applies.

2 measuring runs, one with spindle reversal

The cycle performs two measurement operations to determine the positional deviance of the probe and the center point of the hole.

1. Spindle positioned 180 degrees from initial position with SPOS and all axis directions traversed.
2. Spindle positioned at initial position and all axis directions traversed again.

Position after end of measuring cycle

When calibration is complete the probe is again positioned at calibration height in the center of the hole.

Note

Repeating calibration using the determined hole center is advisable if the starting position at the beginning is severely eccentric or measuring accuracy demands are high.

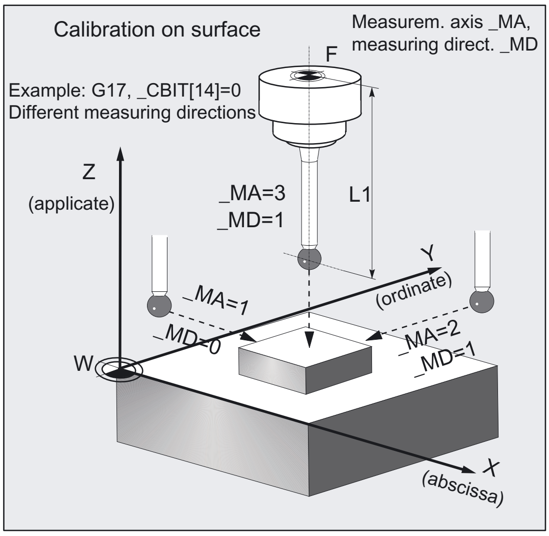
5.3.4 Calibration of a workpiece probe on a surface

5.3.4.1 General information

Function

Using this measuring cycle and the **_MVAR=0**
measuring variant, a workpiece probe can be calibrated in one axis and one direction on a known surface with sufficiently good surface roughness and which is perpendicular to the measuring axis. This can be done on a workpiece, for example.

The trigger point of the relevant axis and axis direction is calculated and entered in the workpiece probe array _WP[i,1] to _WP[i,5] provided.



Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

Parameter

Parameter	Data type	Meaning
_MVAR	0	Calibration variant: Calibration on surface
_SETVAL	REAL	Calibration setpoint (position of surface)
_MA	1, 2 or 3	Measuring axis
_MD	0 positive axis direction 1 negative axis direction	Measuring direction
_PRNUM	INT, >0	Probe number

The following additional parameters are also valid:

_VMS, _CORA, _TZL, _TSA, _FA and _NMSP.

_CORA only relevant for monodirectional probe.

NOTICE
The first time calibration is performed the default setting in the array of the probe is still "0". For that reason _TSA>probe ball radius must be programmed to avoid alarm "Safe area violated".

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

5.3.4.2 Programming example

Calibrating a workpiece probe on the workpiece.

Workpiece probe 1 is to be calibrated in the Z axis on the surface at position
Z= 20,000 mm of a clamped workpiece: Determine trigger value in minus direction _WP[0.5].

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

The workpiece probe is to be inserted as tool T9 with offset D1.

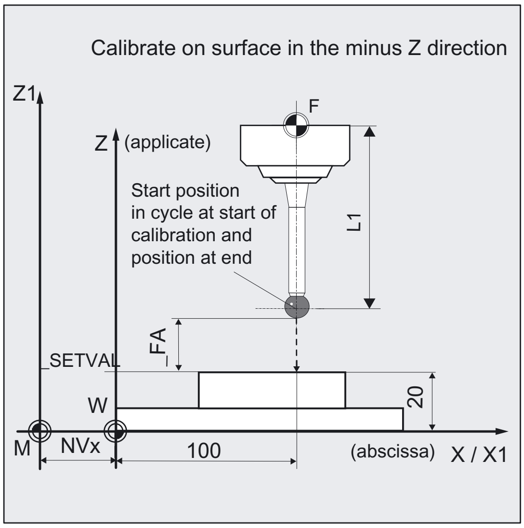
The radius of the probe ball and length 1 must be entered in the tool offset memory under T9 D1, before the cycle is called.

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball: _CBIT[14]=0.

Careful when positioning! Radius R in length (L1) is ignored. But the desired calibration height can be entered directly when calibrating in the abscissa or ordinate (_MA=1, =2).

Arrays for workpiece probe 1: _WP[0, ...]




```
%_N_CALIBRATE_IN_Z_MPF
N10 G54 G90 G17 T9 D1                  ;ZO selection, select probe as tool and
                                       ;operating plane
N20 M6                                 ;Insert probe and activate tool offset
                                       ;
N30 G0 X100 Y80                        ;Position probe above surface
N40 Z55                                ;Lower probe, distance > (_FA + R)
N50 _CBIT[14]=0                        ;Length 1 relative to probe ball center
N60 _TSA=4 _TZL=0 _PRNUM=1 _VMS=0      ;Define parameter for calibration cycle,
_NMSP=1 _FA=2                          ;calibrate probe 1 in minus Z axis
N61 _MVAR=0 _SETVAL=20 _MA=3 _MD=1
N70 CYCLE976                           ;Measuring cycle call
N80 Z55                                ;Position probe above workpiece
N100 M2                                ;End of program
```

Explanation of example

The new trigger value in the minus Z direction is entered in the global data of workpiece probe 1 in _WP[0,5].

5.3.4.3 Operational sequence

Position before measuring cycle call

The probe must be positioned facing the calibration surface.

Recommended distance: >_FA.

Position after end of measuring cycle

When calibration is complete the probe (ball radius) is distance _FA from the calibration surface if _MA=3, if _MA=1 or _MA=2 it is at the starting position.

5.3.5 Calibrating a workpiece probe in the applicate determining probe length

5.3.5.1 General information

Function

Using this measuring cycle and the _MVAR=10000
measuring variant, a workpiece probe can be calibrated in the tool axis (applicate) on a known surface with sufficiently good surface roughness and which is perpendicular to the measuring axis.

This can be done on a workpiece, for example.

The trigger point of the relevant axis and axis direction is calculated and entered in the workpiece probe array _WP[i,5] provided.

At the same time length 1 (L1) of the probe is calculated according to the setting of _CBIT[14] and entered in the tool compensation memory:

- _CBIT[14]=0: L1 referred to ball center
- _CBIT[14]=1: L1 ref. to ball circumference

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

NOTICE
If you want to position with the tool in the program, the approximate probe length should be known and entered in the tool offset memory. Otherwise, position the probe with JOG in front of the calibration surface. The exact ball radius must be known and entered. The first time calibration is performed the default setting in the array of the probe is still "0". Therefore: _TSA> probe ball radius must be programmed to avoid alarm "Safe area violated".

Parameter

Parameter	Data type	Meaning
`_MVAR`	10000	Calibration in applicate with length calculation
`_SETVAL`	REAL	Calibration setpoint (position of surface)
`_MA`	3	Measuring axis, only tool axis (applicate) possible
`_MD`	0 positive axis direction 1 negative axis direction	Measuring direction
`_PRNUM`	>0	Probe number

The following additional parameters are also valid:

`_VMS`, `_CORA`, `_TZL`, `_TSA`, `_FA` and `_NMSP`.

`_CORA` only relevant for monodirectional probe.

`_TSA` is only evaluated with reference to the trigger value, not with reference to the tool length.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

5.3.5.2 Programming example

Calibration of a workpiece probe in the Z axis on the workpiece with length calculation

Workpiece probe 1 is to be calibrated in the Z axis on the surface at position Z= 20,000 mm of a clamped workpiece: Determine trigger value in minus direction _WP[0,5] and length 1 (L1).

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

The workpiece probe is inserted as tool T9 with offset D1.

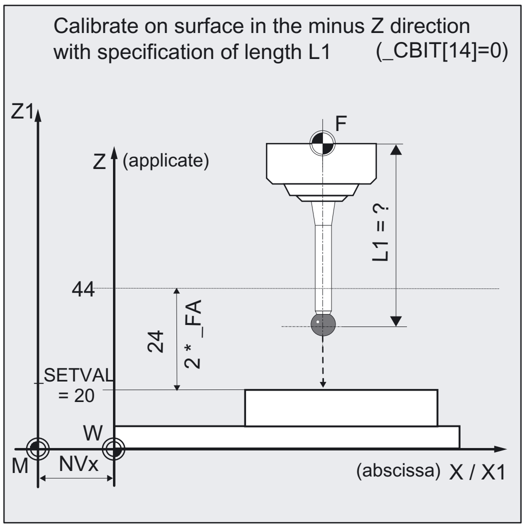
The radius of the probe ball and length 1 must be entered in the tool offset memory under T9 D1, before the cycle is called.

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = ?
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball: _CBIT[14]=0.

Careful when positioning! Radius R in length (L1) is ignored. But the desired calibration height can be entered directly when calibrating in the abscissa or ordinate (_MA=1, =2).

Arrays for workpiece probe 1: _WP[0, ...]




```
%_N_CALIBRATE_Z_L_MPF
N10 G54 G90 G17 T9 D1                    ;ZO selection, select probe as tool and
                                         ;operating plane
N20 M6                                   ;Insert probe and activate tool offset
                                         ;
; ...                                    ;The probe is prepositioned in front of the
                                         calibration surface
                                         ;within a distance of 2 × _FA
                                         ;.
N50 _CBIT[14]=0                          ;Length 1 relative to probe ball center
N60 _TSA=25 _TZL=0 _PRNUM=1 _VMS=0       ;Define parameter for calibration cycle,
_NMSP=1 _FA=12                           ;calibrate probe 1 in minus Z axis
N61 _MVAR=10000 _SETVAL=20 _MA=3 _MD=1   ;with determination of length 1
N70 CYCLE976                             ;Measuring cycle call
                                         ;determine calibration in minus Z and L1
N100 M2                                  ;End of program
```

Explanation of example

On cycle call, the probe travels in the minus Z direction max. 24 mm (_FA=12) at measuring feedrate 300 mm/min (_VMS=0, _FA>1). If the probe is triggered within this measuring path of 24 mm, length 1 (geometry) is calculated and entered in tool offset memory T9, D1, D3.

The trigger value of probe 1 in the minus Z direction is used as the ball radius of the probe from T9, D1, DP6 and then entered in _WP[0,5] – if _CBIT[14]=0.

If _CBIT[14]=1, this value is =0.

5.3.5.3 Operational sequence

Position before measuring cycle call

The probe should be positioned opposite the calibration surface such that it is deflected at the start of the cycle within the **max. measurement path of 2 × _FA [mm]**.

Position after end of measuring cycle

When the calibration procedure is completed the probe is positioned on the starting position.

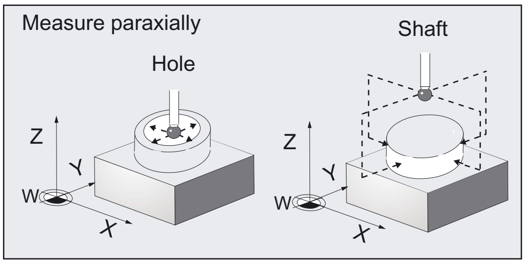
5.4 CYCLE977 workpiece: Measure hole/shaft/groove/web/rectangle parallel to axes

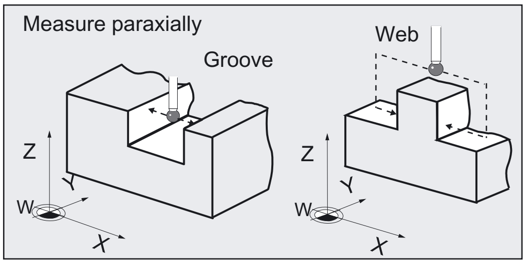
5.4.1 Function overview

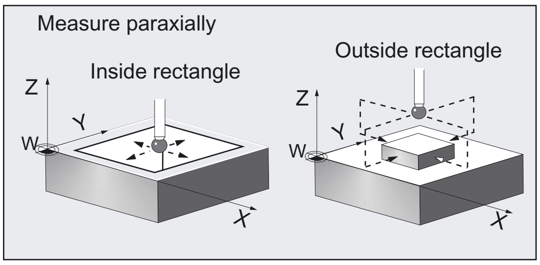
Function

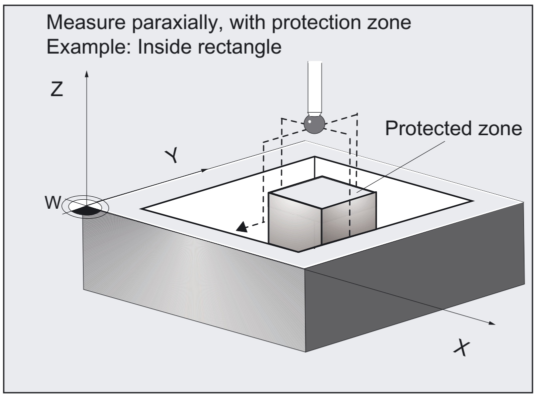
With this measuring cycle you can measure the dimensions of the following contour elements on a workpiece using different measuring variants:

- Hole
- Shaft
- Groove
- Web
- Inside rectangle
- Outside rectangle









Measurement is performed paraxially to the workpiece coordinate system.

In some measuring variants defined safety zones are taken into account during the measuring operation.

`CYCLE977` can

- measure the contour elements

  and additionally either

- perform an automatic **tool offset**

  for a specified tool based on the differences in diameter or width, or

- a **zero offset** (ZO) based on the differences between the center positions.

Workpiece probe types that can be used

- Multidirectional probe (_PRNUM=xy)
- Monodirectional, bidirectional probe (_PRNUM=1xy)

Programming

`CYCLE977`

Measurement variants

Measuring cycle `CYCLE977` permits the following measuring variants which are specified via parameter `_MVAR`:

Value	Measurement variant
1	Measure hole with tool offset
2	Measure shaft with tool offset
3	Measure groove with tool offset
4	Measure web with tool offset
5	Measure rectangle inside with tool offset
6	Measure rectangle outside with tool offset
101	ZO calculation in hole with ZO compensation
102	ZO calculation on shaft with ZO compensation
103	ZO calculation in groove with ZO compensation
104	ZO calculation on web with ZO compensation
105	ZO determination in inside rectangle with ZO correction
106	ZO determination in outside rectangle with ZO correction
1001	Measure hole traveling around a safety zone and tool offset
1002	Measure shaft taking account of a safety zone and tool offset
1003	Measure groove traveling around a safety zone and tool offset
1004	Measure web taking account of a safety zone and tool offset
1005	Measure inside rectangle with safety zone and tool offset
1006	Measure outside rectangle with safety zone and tool offset
1101	ZO determination, hole traveling around a safety zone with ZO correction
1102	ZO determination, shaft taking account of a safety zone with ZO correction
1103	ZO determination, groove traveling around a safety zone with ZO correction
1104	ZO determination, web taking account of a safety zone with ZO correction
1105	ZO determination, inside rectangle with safety zone with ZO correction

Result parameters

Depending on the measuring variant _MVAR=xxx1 to _MVAR=xxx4, measuring cycle CYCLE977 supplies the following values as results in data block GUD5 (**not** for rectangle measurement, see next table for this):

Parameters	Data type	Result
_OVR [0]	REAL	Setpoint diameter/width hole, shaft, groove, web
_OVR [1]	REAL	Setpoint center point/center hole, shaft, groove, web in abscissa
_OVR [2]	REAL	Setpoint center point/center hole, shaft, groove, web in ordinate
_OVR [4]	REAL	Actual value diameter/width hole, shaft, groove, web
_OVR [5]	REAL	Actual value center point/center hole, shaft, groove, web in abscissa
_OVR [6]	REAL	Actual value center point/center hole, shaft, groove, web in ordinate
_OVR [8] 1)	REAL	Upper tolerance limit for diameter/width hole, shaft, groove, web
_OVR [12] 1)	REAL	Lower tolerance limit for diameter/width hole, shaft, groove, web
_OVR [16]	REAL	Difference diameter/width hole, shaft, groove, web
_OVR [17]	REAL	Difference center point/center hole, shaft, groove, web in abscissa
_OVR [18]	REAL	Difference center point/center hole, shaft, groove, web in ordinate
_OVR [20] 1)	REAL	Compensation value
_OVR [27] 1)	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29] 1)	REAL	Dimensional difference
_OVR [30] 1)	REAL	Empirical value
_OVR [31] 1)	REAL	Mean value
_OVI [0]	INTEGER	D number or ZO number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [4] 1)	INTEGER	Weighting factor
_OVI [5]	INTEGER	Probe number
_OVI [6] 1)	INTEGER	Mean value memory number
_OVI [7] 1)	INTEGER	Empirical value memory number
_OVI [8]	INTEGER	Tool number
_OVI [9]	INTEGER	Alarm number
_OVI [11] 2)	INTEGER	Status offset request
_OVI [13] 1)	INTEGER	DL number
1) for workpiece measurement with tool offset only 2) for ZO correction only		

Measuring cycle CYCLE977 supplies the following values as results in data block GUD5 depending on the **rectangle measurement** (_MVAR= xxx5, =xxx6) measuring variant:

Parameters	Data type	Result
_OVR [0]	REAL	Setpoint value rectangle length (in the abscissa)
_OVR [1]	REAL	Setpoint value rectangle length (in the ordinate)
_OVR [2]	REAL	Setpoint for rectangle center point, abscissa
_OVR [3]	REAL	Setpoint for rectangle center point, ordinate
_OVR [4]	REAL	Actual value for rectangle length (in the abscissa)
_OVR [5]	REAL	Actual value for rectangle length (in the ordinate)
_OVR [6]	REAL	Actual value for rectangle center point, abscissa
_OVR [7]	REAL	Actual value for rectangle center point, ordinate
_OVR [8] 1)	REAL	Upper tolerance limit for rectangle length (in the abscissa)
_OVR [9] 1)	REAL	Upper tolerance limit for rectangle length (in the ordinate)
_OVR [12] 1)	REAL	Lower tolerance limit for rectangle length (in the abscissa)
_OVR [13] 1)	REAL	Lower tolerance limit for rectangle length (in the ordinate)
_OVR [16]	REAL	Difference of rectangle length (in the abscissa)
_OVR [17]	REAL	Difference of rectangle length (in the ordinate)
_OVR [18]	REAL	Difference of rectangle center point, abscissa
_OVR [19]	REAL	Difference of rectangle center point, ordinate
_OVR [20] 1)	REAL	Offset value
_OVR [27] 1)	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29] 1)	REAL	Dimensional difference
_OVR [30] 1)	REAL	Empirical value
_OVR [31] 1)	REAL	Mean value
_OVI [0]	INTEGER	D number or ZO number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [4] 1)	INTEGER	Weighting factor
_OVI [5]	INTEGER	Probe number
_OVI [6] 1)	INTEGER	Mean value memory number
_OVI [7] 1)	INTEGER	Empirical value memory number
_OVI [8]	INTEGER	Tool number
_OVI [9]	INTEGER	Alarm number
_OVI [11] 2)	INTEGER	Status offset request
_OVI [13] 1)	INTEGER	DL number

1) for workpiece measurement with tool offset only

2) For ZO correction only

5.4.2 Measuring contour elements

5.4.2.1 General information

Function

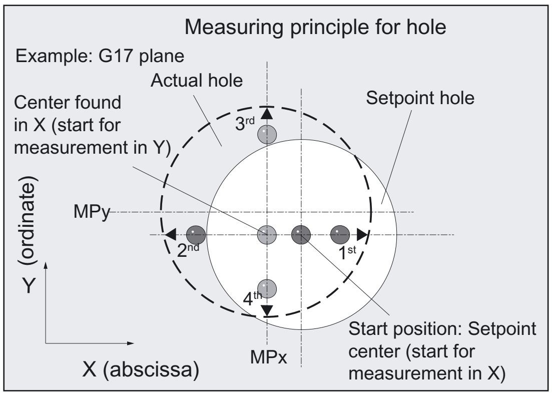
Using this measuring cycle and various _MVAR measuring variants the following contour elements can be measured:

_MVAR=xxx1	- hole
_MVAR=xxx2	- shaft
_MVAR=xxx3	- groove
_MVAR=xxx4	- web
_MVAR=xxx5	- rectangle, inside
_MVAR=xxx6	- rectangle, outside

If no tool offset or ZO correction is to be applied, _KNUM=0 should be set.

Detailed information on the parameters: see Parameter description section "Description of the most important defining parameters".

Measuring principle for hole or shaft



Two points each are measured in the abscissa and ordinate. The actual position of the center point (CP) in relation to workpiece zero is calculated from these four measured values. The actual diameter is calculated from the two points in the ordinate.

The center of the abscissa is calculated from the two points in the abscissa. Then the probe is positioned on this calculated center and the two points on the ordinate measured. The hole and shaft center points are now known and the results entered in array _OVR[ ].

The positive direction of an axis is measured first.

Measuring principle for groove or web

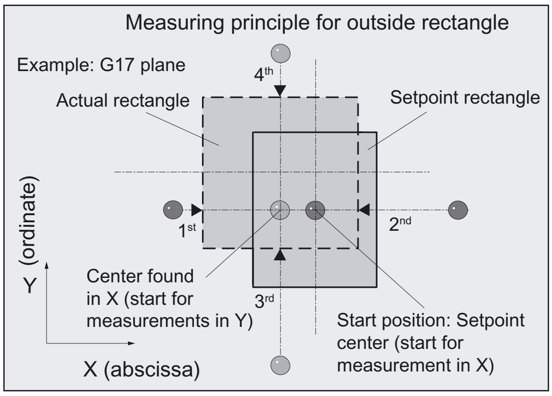
The groove or web lies parallel to the axes of the workpiece coordinate system.

2 measuring points are measured with specified measuring axis _MA.

The actual value of the groove width and web width and the actual position of the groove center and web center in relation to workpiece zero are calculated from the two measured values. The results are entered in array _OVR[ ].

The positive direction of the axis is measured first.

Measuring principle for inside and outside rectangle



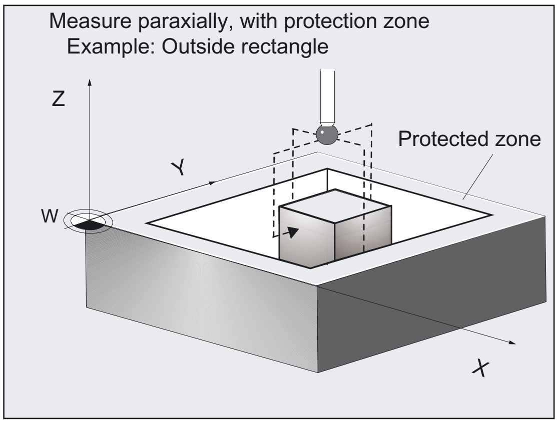
The rectangle lies parallel to the axes of the workpiece coordinate system.

The measuring cycle ascertains 2 measuring points in both axes and determines the actual rectangle center and both actual values of the rectangle lengths. The procedure is the same as for hole and shaft.

The results are entered in array _OVR[ ].

The positive direction of an axis is measured first.

Procedure for specifying a safety zone



If required,

_MVAR=1xxx

can take account of a safety zone (_SZA, _SZO) in the travel movement. The safety zone refers to the center point or center line of the hole, shaft, groove, web, and rectangle. The starting point in the height is always above the hole, shaft, groove, web, or rectangle.

Supplementary functions for hole and shaft diameter, groove or web width, and tool compensation.

- An empirical value from data block GUD5 can be included with the correct sign.
- A mean value can be derived from several workpieces, measurement calls.

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

Parameter

Parameters	Data type	Meaning
`_MVAR`	xxx1 xxx2 xxx3 xxx4 xxx5 xxx6	Measure hole Measure shaft Measure groove Measuring a web Measure rectangle, inside Measure rectangle, outside
`_SETVAL`	REAL, >0	Setpoint (acc. to drawing) (only for hole, shaft, groove, web)
`_SETV[0]` `_SETV[1]`	REAL, >0	Setpoint value rectangle length (in the abscissa) Setpoint for rectangle length (in the ordinate) (only for measuring rectangle)
`_ID`	REAL	Incremental infeed in the applicate, direction indicated by prefix (only for measuring shaft, web, or rectangle, and for measuring hole/groove/shaft/web traveling around or taking account of a safety zone)
`_SZA`	REAL, >0	• Diameter or width of the protection zone (inside for hole/groove, outside for shaft/web) • Length of the safety zone in the abscissa (only for measuring rectangle)
`_SZO`	REAL, >0	Length of the protection zone in the ordinate (only for measuring rectangle)
`_MA`	1, 2	Number of measuring axis (only for measuring a groove or a web)
`_KNUM`	0	0: Without automatic tool offset, without ZO determination

The following additional parameters are also valid:

`_VMS, _CORA, _TSA, _FA_, PRNUM, _EVNUM`, and `_NMSP`.

The following also applies for measuring variants with tool compensation (even when `KNUM=0`):

`_TZL, _TMV, _TUL, _TLL, _TDIF`

With `_TSA`, the diameter or width is monitored for "tool compensation", the center for "ZO determination".

`_CORA` only relevant for monodirectional probe.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

5.4.2.2 Programming example

Measuring a web - paraxial

In the G17 plane, a web is to be measured with a setpoint width of 132 mm. The assumed center is X=220.

The maximum possible deviation of the center is taken as 2 mm, the width 1 mm. To obtain a minimum measuring path of 1 mm, the measuring path is programmed as _FA=2+1+1=4 mm (max. measuring path _FA=8 mm). A measured variance of web center of >1.2 mm is not however permissible.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

Workpiece probe 1, used as tool **T9, D1**, is to be used.

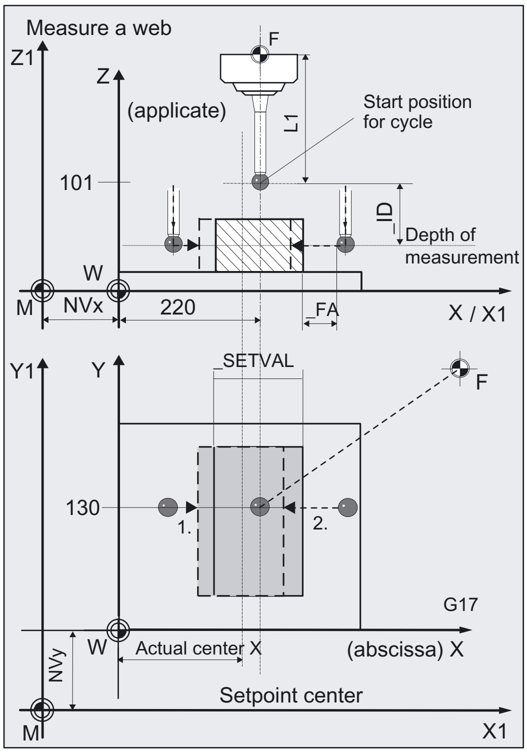
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.




```
%_N_WEB_MEASURE_MPF
N10 G54 G17 G90 T9 D1                  ;ZO, select tool as probe ...
N20 M6                                 ;Insert probe,
                                       ;activate tool offset
N30 G0 X220 Y130                       ;Position probe in X/Y plane at setpoint web
                                       center
                                       ;position in X and measurement position Y
N40 Z101                               ;Position Z axis above web
N60 _TSA=1.2 _PRNUM=1 _VMS=0 _NMSP=1   ;Set parameter for measuring cycle call
_FA=4                                  ;with ZO and without tool compensation,
N61 _MVAR=104 _SETVAL=132 _MA=1 _ID=-  ;note negative prefix for _ID!
40 _KNUM=0                             ;Probe lowered in Z axis!
                                       ;Measuring variant with ZO calculation has
                                       been
                                       ;selected (MVAR=X1xxx) because web center
                                       ;is to be monitored (with _TSA),
                                       ;but KNUM=0: without running
                                       ;the ZO calculation and ZO compensation
N70 CYCLE977                           ;Call measuring cycle
N80 G0 Z160                            ;Traverse up Z axis
N100 M2                                ;End of program
```

Explanation of example

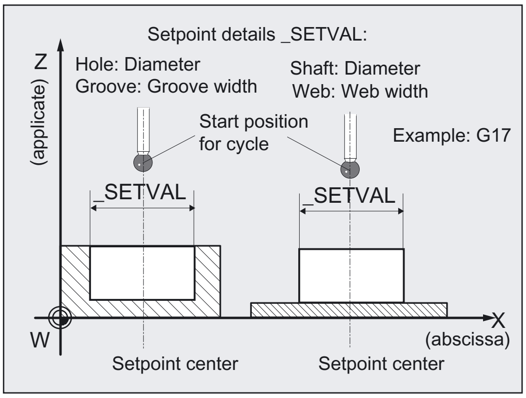
The measuring results of web width, web center in X, and associated differences are entered in result array _OVR[ ]. If the difference in the position of the web center is >1.2 mm (_TSA=1.2) an alarm is output. Only cancellation with NC RESET is then possible.

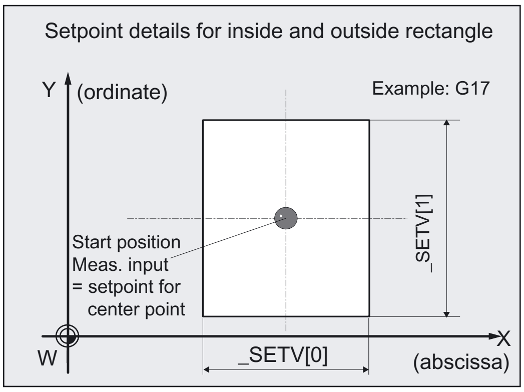
The setpoint of the web center is the position of the probe in the workpiece coordinate system at the beginning of the cycle in the X axis.

5.4.2.3 Operational sequence

Specification of setpoints

- For diameter and/or with using _SETVAL
- For the lengths of the rectangle using _SETV[0], _SETV[1]





The position of the probe in the abscissa, ordinate at the beginning of a cycle is evaluated for the setpoint of the center point of a hole, shaft, or rectangle, or for the center of a groove, web.

This value is also entered in the following result array:

- _OVR[1], _OVR[2] (for hole, shaft, groove, web).
- _OVR[2], _OVR[3] (for rectangle).

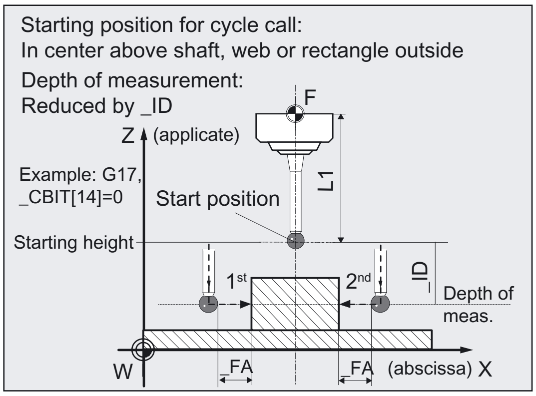
Specification of measuring axis:

The measuring axis in _MA only has to be specified for web or groove:

- _MA=1: measurement in abscissa
- _MA=2: measurement in ordinate.

For the remaining contour elements, measurement is always performed in both axes of the plane and in both directions.

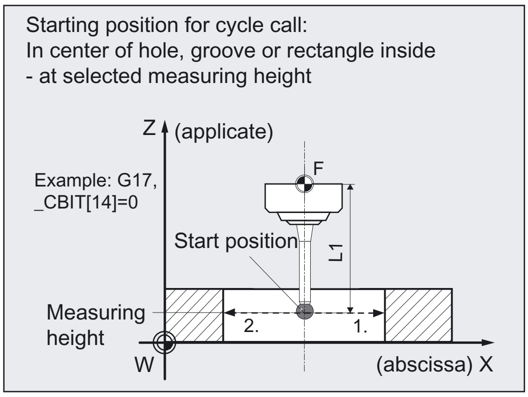
Position before measuring cycle call for shaft, web, rectangle - outside



_MVAR	Pre-positioning	
	in the plane	in applicate
2/102	Shaft center point	Above shaft
4/104	Web center, meas. axis	Above web
6/106	Rectangle center point	Above rect.

The probe must be positioned at the center point in the plane and the probe ball positioned above the upper edge such that when infeed of value _ID (sign) is applied, measurement depth is reached.

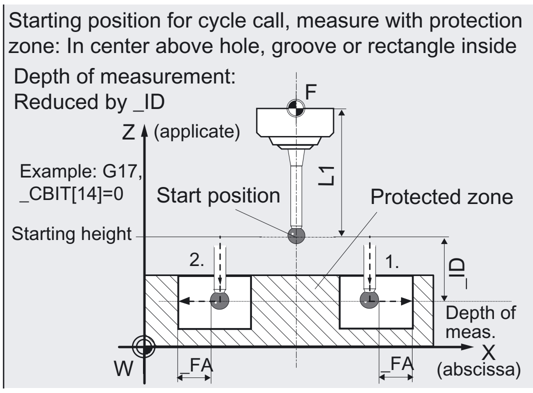
Position before cycle call for hole, groove, rectangle - inside



_MVAR	Pre-positioning	
	in the plane	in applicate
1/101	Hole center point	At meas. height
3/103	Groove center, meas. ax.	At meas. height
5/105	Rectangle center point	At meas. height

The probe must be positioned at the center point in the plane. The probe ball must be positioned at measurement height inside the hole/groove/rectangle.

Position before measuring cycle call when measuring with safety zone

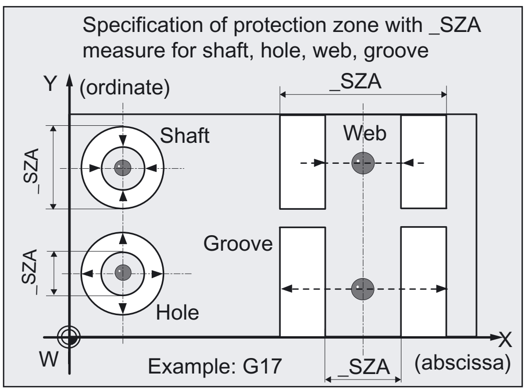


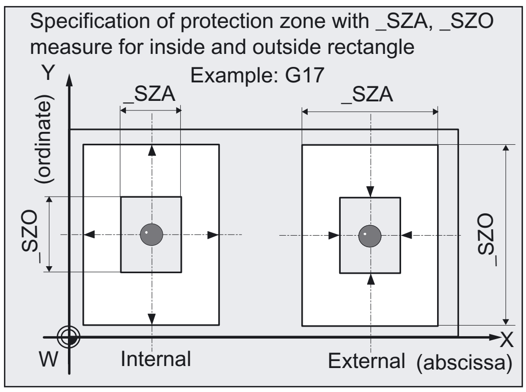
_MVAR	Pre-positioning	
	in the plane	in applicate
1001/1101	Hole center point	Above hole
1003 /1103	Groove center, meas. ax.	Above groove
1005/1105	Rectangle center point	Above rect.
1002 /1102	Shaft center point	Above shaft
1004/1104	Web center, meas. axis	Above web
1006 /1006	Rectangle center point	Above rect.

Note

If the value selected for _FA is so large that the safety zone is violated the distance is automatically reduced in the cycle. However, there must be sufficient room for the probe ball.

Specification of safety zone:



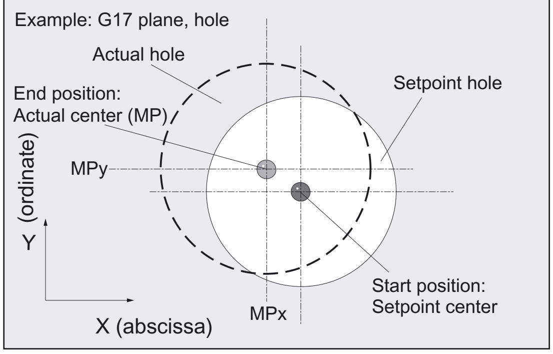


The safety zone (diameter or width) for shaft, hole, web, and groove is defined in _SZA.

For a rectangle, the safety zone (length) is defined with _SZA in the abscissa and with _SZO in the ordinate.

Position after end of measuring cycle

Measuring cycle positions at start and end



When measurement is complete the probe is positioned above the calculated center point or center at starting position height.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

The range of positions of the center or diameter, or groove, web width, rectangle length, must be within the value specified in _FA for all workpieces to be measured.

Otherwise, there is danger of collision or the measurement cannot be performed!

5.4.3 Measuring and tool offset

5.4.3.1 General information

Function

Using this measuring cycle and the _MVAR = x0xxmeasurement variants, a hole, shaft, groove, a web, or a rectangle can be measured paraxially.

Automatic tool offset is also possible. This tool is specified in `_TNUM` and `_TNAME`.

The D number and type of offset are specified in coded form in variable `_KNUM`.

With an extended tool offset, a tool from a particular stored tool environment "_TENV" and additive or setup offsets can be corrected by specifying the DL number in _DLNUM.

Detailed information on the parameters: see Parameter description section "Description of the most important defining parameters".

If the dimensions of a tool are corrected to this extent, the next workpiece can be manufactured with lower tolerances.

Parameters

Parameters	Data type	Meaning
`_MVAR`	1	Measure hole with tool offset
	2	Measure shaft with tool offset
	3	Measure groove with tool offset
	4	Measure web with tool offset
	5	Measure rectangle inside with tool offset
	6	Measure rectangle outside with tool offset
	1001	Measure hole by contouring a protection zone with tool offset
	1002	Measure shaft by including a protection zone with tool offset
	1003	Measure groove by contouring a protection zone with tool offset
	1004	Measure web by including a protection zone with tool offset
	1005	Measure rectangle inside with protection zone with tool offset
	1006	Measure rectangle outside with protection zone with tool offset
`_SETVAL`	REAL, >0	Setpoint (acc. to drawing) (only for hole, shaft, groove, web)
`_SETV[0]` `_SETV[1]`	REAL, >0	Setpoint value rectangle length (in the abscissa) Setpoint for rectangle length (in the ordinate) (only for measuring rectangle)
`_ID`	REAL	Incremental infeed of applicate with sign (only for measuring shaft, web, or rectangle, and for measuring hole/groove/shaft/web traveling around or taking account of a safety zone)
`_SZA`	REAL, >0	• Diameter/width of the protection zone (inside for hole/groove, outside for shaft/web) • Length of the safety zone in the abscissa (only for measuring rectangle)

Parameters	Data type	Meaning
_SZO	REAL, >0	Length of the protection zone in the ordinate (only for measuring rectangle)
_MA	1...2	Number of measuring axis (only for measuring a groove or a web)
_KNUM	0, >0	0: without automatic tool offset >0: with automatic tool offset (individual values: Parameter _KNUM)
_TNUM	INT, ≧0	Tool number for automatic tool offset
_TNAME	STRING[32]	Tool name for automatic tool compensation (alternative for _TNUM if tool management active)
_DLNUM	INT, ≧0	DL number for additive/setup offset
_TENV	STRING[32]	Name of tool environment for automatic tool offset

The following additional parameters are also valid:

_VMS, _CORA, _TZL, _TMV, _TUL, _TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP and _K.

_CORA only relevant for monodirectional probe. With _TSA, the diameter or width is monitored for "tool compensation". The other parameters must also be assigned if _KNUM=0 because they refer to the workpiece.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

Tool number and tool name: _TNUM and _TNAME (Page 68)

Offset number: _KNUM (Page 69)

Offset number _KNUM extended for tool offset: up to 9 digits (Page 72)

5.4.3.2 Programming example

Measuring a hole - paraxially with tool offset

The diameter of a hole in a workpiece is to be measured in the G17 plane and the radius of a tool corrected accordingly.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

Workpiece probe 1, used as tool **T9, D1**, is to be used.

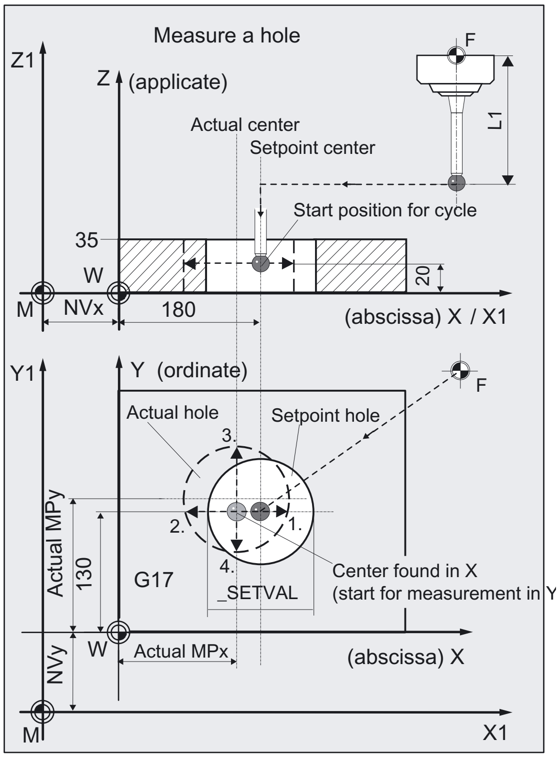
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.



The hole was machined with milling tool **T20, D1** in the same environment as for measuring (G17, …) with circular milling.

The radius of this tool should be corrected in wear according to the measuring result for the hole diameter difference (actual value - set value). This tool offset will therefore affect the production of the next workpieces or possible remachining.

The offset must take the empirical value in memory _EV[9] into consideration. Mean value calculation _MV[9] and inclusion in calculation are also to be used.

A maximum deviation of the diameter from the setpoint of 1 mm is expected.

```
%_N_DRILL_MEASURE_MPF
N10 G54 G17 G90 T9 D1                    ;ZO, select tool as probe ...
N20 M6                                   ;Insert probe,
                                         ;activate tool offset
N30 G0 X180 Y130                         ;Position probe in X/Y plane to
                                         ;hole center point
N40 Z20                                  ;Position Z axis to measuring depth
N50 _CHBIT[4]=1                          ;Include average value
N60 _TUL=0.03 _TLL=-0.03 _EVNUM=10       ;Set parameter for measuring cycle call,
_K=3 _TZL=0.01 _TMV=0.02 _TDIF=0.06      ;probe 1 (multi-directional),
_TSA=1 _PRNUM=1 _VMS=0 _NMSP=1 _FA=1     ;measure hole, setpoint diameter
N61 MVAR=1 _SETVAL=132 _TNUM=20          ;132 mm, compensation in radius of T20, D1
_KNUM=2001
N70 CYCLE977                             ;Call measuring cycle
N560 G0 Z160                             ;Retract Z axis from hole
N570 M2                                  ;End of program
```

Explanation of example

The difference calculated from the actual and setpoint diameter is compensated for by the empirical value in the empirical value memory _EV[9] and compared with the tolerance parameter.

- If it is more than 1 mm (_TSA), alarm "Safe area violated" is output and the program is halted.
- Cancel with NC RESET on the control!
- If it is more than 0.06 mm (_TDIF), no compensation is performed and alarm "Permissible dimensional difference exceeded" is output and the program continues.
- If ±0.03 mm (_TUL/_TLL) is exceeded, the radius in T20 D1 is compensated 100% by this difference/2.
- Alarm "Oversize" or "Undersize" is displayed and the program is continued.
- If 0.02 mm (_TMV) is exceeded, the radius in T20, D1 is compensated 100% by this difference/2.
- If it is less than 0.02 mm (_TMV), the mean value is calculated from the mean value in mean value memory _MV[9] and inclusion of weighting factor _K=3 (only for _CHBIT[4]=1! with mean value memory).
  - If the mean value obtained is >0.01 (_TZL), the reduced compensation of the radius for T20 D1 is the mean value/2 and the mean value is deleted in _MV[9].
  - If the mean value is <0.01 (_TZL) the radius in T20 D1 is not compensated but is stored in mean value memory _MV[9].

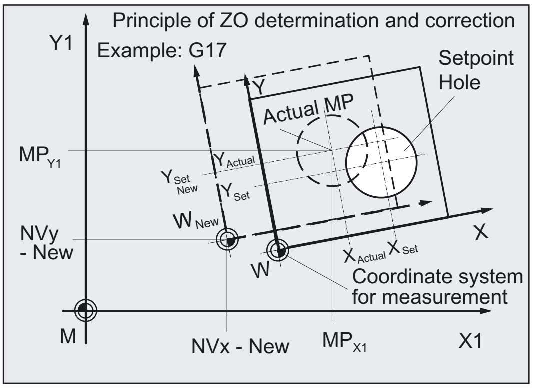
The results are entered in result array _OVR[ ]. The wear of the radius of T20, D1 is included if a change is necessary.

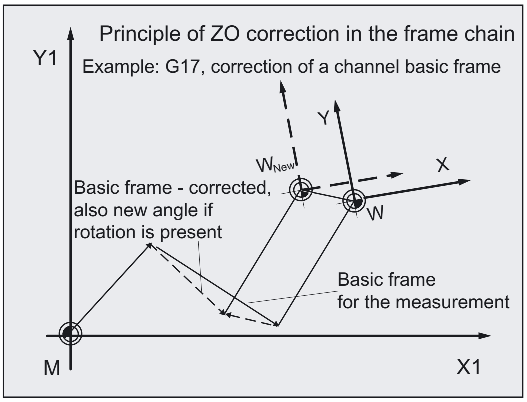
5.4.4 Measurement and ZO determination

5.4.4.1 General information

Function

Using this measuring cycle and the _MVAR = x1xx
measuring variant, a hole, shaft, groove, a web, or a rectangle can be measured paraxially. The zero offset (ZO) of the associated workpiece can also be determined and corrected. A possible rotation of the workpiece is kept without changing it.





The angular position cannot be determined with this cycle.

Compensation of the ZO is executed in such a way that the actual center (position of center on the machine,
e.g.: MPX1, MPY1) includes the desired setpoint position in the workpiece coordinate system when the compensated ZO (frame) is applied.

Mirroring can be active in a frame of the frame sequence. Dimension factors must never be active.

The ZO to be corrected is specified in coded form with variable _KNUM >0.

The ZO can be specified and corrected by various methods, e.g. in various settable frames, in various basic frames, system frames, fine offset, or coarse offset, etc.

For detailed information on specifying _KNUM for the zero offset: see Parameter description section "Description of the most important defining parameters".

ZO determination in a hole, on a shaft, or rectangle

ZO correction of a workpiece is applied in the abscissa and ordinate using the actual value/setpoint difference of the position of the center point.

ZO determination in a groove or on a web

ZO correction of a workpiece is applied in measuring axis _MA (abscissa and ordinate) using the actual value/setpoint difference of the position of the center.

Parameter

Parameter	Data type	Meaning
`_MVAR`	101	ZO calculation in hole with ZO compensation
	102	ZO determination on a shaft with ZO correction
	103	ZO determination in a groove with ZO correction
	104	ZO determination on a web with ZO correction
	105	ZO determination in inside rectangle with ZO correction
	106	ZO determination in outside rectangle with ZO correction
	1101	ZO determination in hole traveling around a safety zone with ZO correction
	1102	ZO determination, shaft taking account of a safety zone with ZO correction
	1103	ZO determination in groove traveling around a safety zone, ZO correction
	1104	ZO determination, web taking account of a safety zone with ZO correction
	1105	ZO determination, inside rectangle with safety zone with ZO correction
	1106	ZO determination, outside rectangle with safety zone with ZO correction
`_SETVAL`	REAL, >0	Setpoint (acc. to drawing) (only for hole, shaft, groove, web)
`_SETV[0]` `_SETV[1]`	REAL, >0	Setpoint value rectangle length (in the abscissa) Setpoint for rectangle length (in the ordinate) (only for measuring rectangle)
`_ID`	REAL	Incremental infeed of applicate with sign (only for measuring shaft, web, or rectangle, and for measuring hole/groove/shaft/web traveling around or taking account of a safety zone)
`_SZA`	REAL, >0	• Diameter/width of the protection zone (inside for hole/groove, outside for shaft/web) • Length of the safety zone in the abscissa (only for measuring rectangle)
`_SZO`	REAL, >0	Length of the protection zone in the ordinate (only for measuring rectangle)
`_MA`	1...2	Number of measuring axis (only for measuring a groove or a web)
`_KNUM`	0, >0	0: without automatic tool offset >0: with automatic tool offset (Individual values: Parameter _KNUM)

The following additional parameters are also valid:

`_VMS`, `_CORA`, `_TSA`, `_FA`, `_PRNUM`, and `_NMSP`.

`_CORA` only relevant for monodirectional probe. With `_TSA` the center is monitored with ZO determination.

See also

Offset number: _KNUM (Page 69)

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

5.4.4.2 Programming example

ZO determination on a rectangle with CYCLE977

In the G17 plane, an outside rectangle web is to be measured with setpoint lengths width in X=100.000 and in Y=200.00 mm. The settable ZO G54 is to be corrected in such a way that the center of the rectangle is at X=150.000 and Y=170.000 mm.

Measurement is also performed at G54. After measurement is complete, the changed ZO is activated.

The maximum possible deviation of the center is taken as 2 mm; the maximum possible variance in lengths is 3 mm. To obtain a minimum measuring path of 1 mm, the measuring path is programmed as _FA=2+3+1=6 mm (max. measuring path _FA=12 mm).

A measured deviation of the center of the rectangle from the setpoint of >1.8 mm is however not permitted in either axis.

Height of rectangle and measuring height in Z: see Fig.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ... (values when measuring)

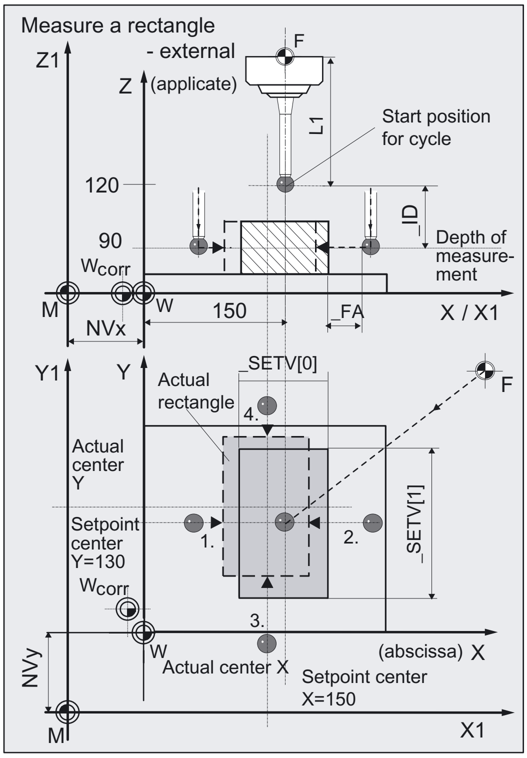
Workpiece probe 1, used as tool **T9, D1**, is to be used.

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.



```
%_N_ZO_RECTANGLE_MPF
N10 G54 G17 G90 T9 D1                  ;ZO, select tool as probe ...
N20 M6                                 ;Insert probe,
                                       ;activate tool offset
N30 G0 X150 Y170                       ;Position probe in X/Y plane to
                                       ;rectangle center (setpoint position)
N40 Z120                               ;Position Z axis above rectangle
N60 _KNUM=1 _TSA=1.8 _PRNUM=1 _VMS=0   ;Set parameters for measuring cycle call,
_NMSP=1 _FA=6
N61 _MVAR=106 _SETV[0]=100             ;Measuring height lowered by 30 mm in Z
_SETV[1]=200 _ID=-30
N70 CYCLE977                           ;Call measuring cycle
N80 G54                                ;Repeat call of ZO G54
                                       ;The changed ZO correction is therefore
                                       ;effective!
N90 G0 Z160                            ;Traverse up Z axis
N100 M2                                ;End of program
```

Explanation of example

Automatic compensation is performed in G54 – translation in axes X and Y by the calculated difference between actual value and setpoint of the rectangle center point, if it is less than 1.8 mm (_TSA=1.8) in both axes. Otherwise, alarm "Safe area violated" is output and program execution cannot be continued.

If the values are inside the tolerance, the setpoint and actual values for center point and length of rectangle in the abscissa and ordinate as well as the differences are entered in result array OVR[]. The zero offset (ZO) for G54 is entered in the data management ($P_UIFR[1]) and is activated by programming G54 again in block N80.

5.5 CYCLE978 workpiece: Measuring a surface parallel to the axis

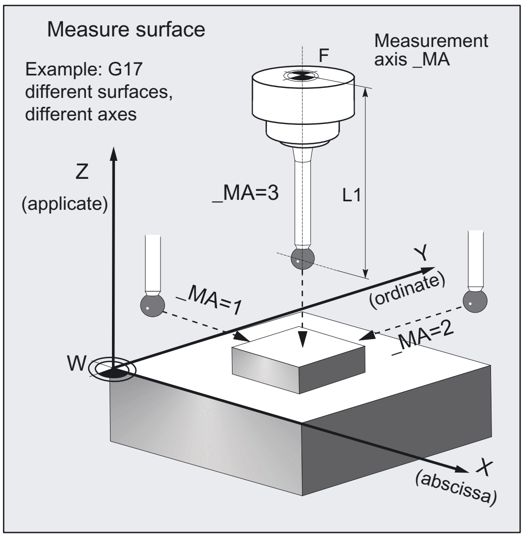
5.5.1 Function overview

Function

This measuring cycle determines the position of a paraxial surface in the workpiece coordinate system. This is done with 1-point measurement

On the basis of the measuring results and depending on the measuring variant selected,

- automatic tool compensation can also be undertaken for a tool or
- a zero offset (ZO) can also be corrected.



A special measuring variant permits differential measurement with the axes of the plane. The special procedure for this measurement permits use of an uncalibrated multidirectional probe.

Workpiece probe types that can be used

- Multidirectional probe (_PRNUM=0xy)
- Monodirectional, bidirectional probe (_PRNUM=1xy)

  (These probes should be used only with low accuracy requirements!)

NOTICE
A monodirectional or bi-directional probe must always be calibrated! These probes cannot be used for the differential measurement!

Preconditions for differential measurement

- Spindle can be positioned between 0...360 degrees (at least every 90 degrees, with SPOS command)
- Multidirectional probe (all-round coverage)

Programming

`CYCLE978`

Measurement variants

Measuring cycle `CYCLE978` permits the following measuring variants which are specified via parameter `_MVAR`.

Value	Measurement variant
0	Measure surface and tool offset
100	ZO determination on surface and ZO correction
1000	Measure surface with differential measurement and tool offset
1100	ZO determination on surface with differential measurement and ZO correction

Result parameters

Depending on the measuring variant, measuring cycle `CYCLE978` makes the following values available as results in data block GUD5:

Parameters	Data type	Result
`_OVR [0]`	REAL	Setpoint value for measuring axis
`_OVR [1]`	REAL	Setpoint in abscissa → only when _MA=1
`_OVR [2]`	REAL	Setpoint in ordinate → only when _MA=2
`_OVR [3]`	REAL	Setpoint in applicate → only when _MA=3
`_OVR [4]`	REAL	Actual value for measuring axis
`_OVR [5]`	REAL	Actual value in abscissa → only when _MA=1
`_OVR [6]`	REAL	Actual value in ordinate → only when _MA=2
`_OVR [7]`	REAL	Actual value in applicate → only when _MA=3
`_OVR [8]` 1)	REAL	Upper tolerance limit for measuring axis
`_OVR [12]` 1)	REAL	Lower tolerance limit for measuring axis
`_OVR [16]`	REAL	Difference for measuring axis
`_OVR [17]`	REAL	Difference in abscissa → only when _MA=1
`_OVR [18]`	REAL	Difference in ordinate → only when _MA=2
`_OVR [19]`	REAL	Difference in applicate → only when _MA=3
`_OVR [20]` 1)	REAL	Offset value
`_OVR [27]` 1)	REAL	Zero offset area
`_OVR [28]`	REAL	Safe area
`_OVR [29]` 1)	REAL	Dimensional difference
`_OVR [30]`	REAL	Empirical value

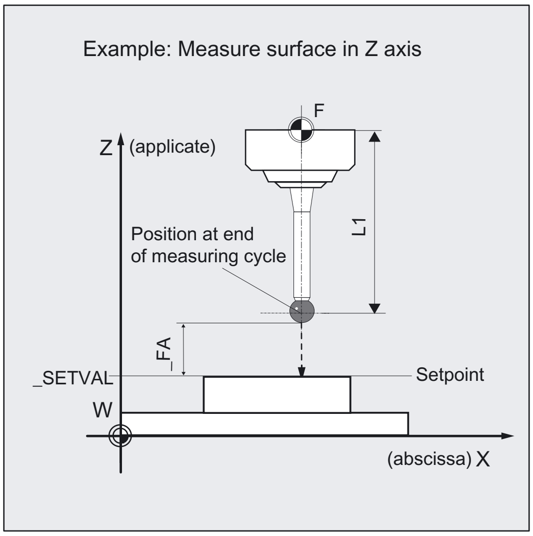
Parameters	Data type	Result
`_OVR [31]` 1)	REAL	Mean value
`_OVI [0]`	INTEGER	D number or ZO number
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [4]` 1)	INTEGER	Weighting factor
`_OVI [5]`	INTEGER	Probe number
`_OVI [6]` 1)	INTEGER	Mean value memory number
`_OVI [7]` 1)	INTEGER	Empirical value memory number
`_OVI [8]`	INTEGER	Tool number
`_OVI [9]`	INTEGER	Alarm number
`_OVI [11]` 2)	INTEGER	Status offset request
`_OVI [13]` 1)	INTEGER	DL number
1) For 1-point measurement with automatic tool offset only 2) For ZO correction only		

5.5.2 Measuring the surface

Position before measuring cycle call

The probe is positioned in relation to the surface to be measured in such a way that during traversal of the specified measuring axis _MA in the direction of the setpoint _SETVAL, the intended measuring point on the surface will be reached.

Recommended distance from surface: >_FA.



The absolute value of the positional deviation from the setpoint must not be greater than the measuring path _FA. Otherwise, no measurement will be performed.

Position after end of measuring cycle

After the end of the measuring cycle, the probe (ball circumference) is at a distance _FA from the measuring surface.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

Special procedure for differential measurement

The measuring point is measured twice during differential measurement.

1. With spindle rotated through 180 degrees compared with the position at the beginning of the cycle
   (rotation of the probe by 180 degrees).
2. With the spindle position that applied at the beginning of the cycle.

The tool radius of the probe + R or - R is defined as the trigger point defined for the axis direction.

A multidirectional probe does not have to be calibrated at the beginning of the cycle for measuring variants.

```
_MVAR= 1000 or _MVAR=1100
```

However, with these measuring variants, only the measuring axes _MA=1 or _MA=2 are of any use.

NOTICE
In the case of great measurement accuracy demands, differential measurement is not recommended!

5.5.3 Measurement and ZO determination

5.5.3.1 General information

Function

Using this measuring cycle and the **_MVAR=100, _MVAR=1100** measuring variants, the position of a paraxial surface can be determined in the workpiece coordinate system.

The zero offset (ZO) of the associated workpiece can also be determined and corrected.

The offset is corrected in such a way that the real position of the surface (actual value) adopts the required set angle (_SETVAL) in the workpiece coordinate system when the corrected ZO (frame) is used.

Mirroring can be active in a frame of the frame sequence. Dimension factors must never be active.

The ZO to be corrected is specified in coded form with variable **_KNUM >0**.

The ZO can be specified and corrected by various methods, e.g. in various settable frames, in various basic frames, system frames, fine offset, or coarse offset, etc.

If _KNUM=0, there is no ZO correction.

For detailed information on specifying _KNUM for the zero offset: see Parameter description section "Description of the most important defining parameters".

An empirical value stored in data block GUD5 in array _EV[ ] can be included in calculation of the result after measurement is completed.

This is activated in _EVNUM (see Parameter description Section "Description of the most important defining parameters").

Parameter

Parameter	Data type	Meaning
`_MVAR`	100	ZO determination on surface and ZO correction
	1100	ZO determination on surface with differential measurement and ZO correction
`_SETVAL`	REAL, >0	Setpoint with respect to workpiece zero
`_MA`	1...3	Number of the measuring axis
`_KNUM`	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (individual values: see Parameter description section "Description of the most important defining parameters", Parameter _KNUM)

The following additional parameters are also valid:

`VMS, _CORA, _TSA, _FA, _PRNUM, _EVNUM` and `_NMSP`

`_CORA` only relevant for monodirectional probe.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

5.5.3.2 Programming example

ZO calculation at a workpiece with CYCLE978

A rectangular workpiece is clamped in the G17 plane. The ZO in axes X and Y is to be checked. Any deviation from the active values should be automatically corrected in settable ZO G54. The corrected ZO should also be activated so that machining of the workpiece can start directly after.

The empirical value entered in array _EV[9] (data block GUD5) for the X axis and _EV[10] for the Y axis are to be included in the measuring results.

The permissible deviation is 3 mm from the setpoint value is assumed. To obtain a minimum measurement path of 1 mm to the surface, the measurement path is programmed with _FA=3+1=4 mm (max. total measurement path = 8 mm).

The value of the positional deviation should not be monitored. Therefore _TSA > _FA is set.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ... (values when measuring)

Workpiece probe 1, used as tool **T9, D1**, is to be used.

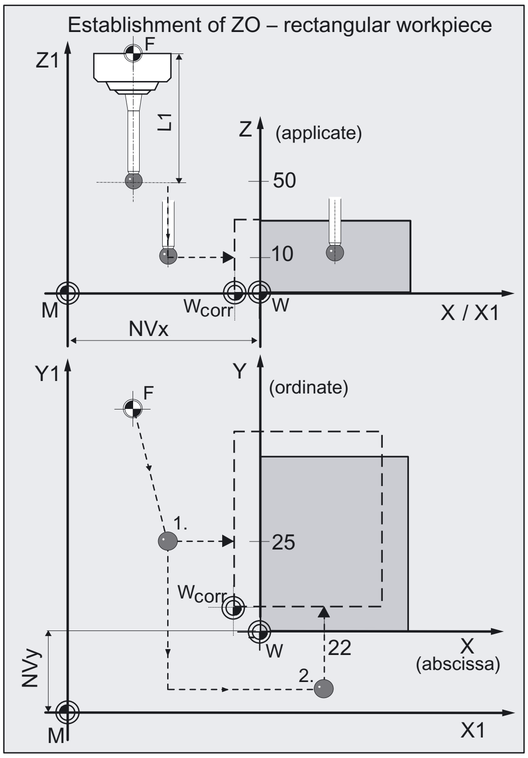
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.



```
%_N_ZO_DETERMINING_1_MPF
N10 G54 G17 G90 T9 D1                    ;ZO, select tool as probe ...
N20 M6                                   ;Insert probe,
                                         ;activate tool offset
N30 G0 G90 X-20 Y25                      ;Position probe in X/Y plane in front of
                                         ;measuring surface
N40 Z10                                  ;Position probe at measuring height
N60_TSA=6 _PRNUM=1 _VMS=0 _NMSP=1        ;Set parameters for measuring cycle call
_FA=4
N61 _MVAR=100 _SETVAL=0 _MA=1 _KNUM=1
_EVNUM=10
N70 CYCLE978                             ;Measuring cycle for ZO determination in □X
                                         axis
N80 G0 X-20                              ;Retract in X axis
N90 Y-20                                 ;Position in Y axis
N100 X22                                 ;Position in X axis
N110 _EVNUM=11 _MA=2                     ;Set parameters for measuring cycle call
N120 CYCLE978                            ;ZO determination in Y axis
N130 G54                                 ;Repeat call of ZO G54
                                         ;This activates the changes!
N140 G0 Y-20                             ;Retract in Y axis
N150 Z50                                 ;Retract in Z axis
N160 X-40 Y80                            ;Retract in X/Y
N200 M2                                  ;End of program
```

Explanation of example

Automatic compensation is performed in G54 – translation of axes X and Y by the calculated difference between actual value and setpoint.

The setpoints and actual values as well as the differences are entered in result array OVR[ ]. At the end of the program the values for the Y axis (ordinate) are in the result array as these were the last to be measured.

The zero offset (ZO) for G54 is entered in the data management ($P_UIFR[1]) and is activated by programming G54 again in block N130.

5.5.4 Measuring and tool offset

5.5.4.1 General information

Function

Using this measuring cycle and the _MVAR=0, _MVAR=1000measurement variants, the measurement (position) of a paraxial surface can be determined in the workpiece coordinate system.

Automatic tool offset is also possible. This tool is specified in _TNUM and _TNAME. The D number and type of offset are specified in coded form in variable _KNUM.

With an extended tool offset, a tool from a particular stored tool environment _TENV, and additive or setup offsets can be corrected by specifying the DL number in _DLNUM.

Detailed information on the parameters: see Parameter description section "Description of the most important defining parameters".

Empirical values and mean values

An empirical value stored in data block GUD5 in array _EV[ ] can be included in calculation of the result after measurement is completed.

Optionally, averaging is performed over a number of parts (array _MV[ ]) and the tolerance bands are checked.

Both are activated in _EVNUM (see Parameter description Section "Description of the most important defining parameters").

Parameters

Parameters	Data type	Meaning
_MVAR	0	Measure surface and tool offset
	1000	Measure surface with differential measurement and tool offset
_SETVAL	REAL, >0	Setpoint (acc. to drawing)
_MA	1...3	Number of the measuring axis
_KNUM	0, >0	0: without automatic tool offset >0: with automatic tool offset
_TNUM	INT, ≧0	Tool number for automatic tool offset
_TNAME	STRING[32]	Tool name for automatic tool offset (alternative to _TNUM with tool management active)
_DLNUM	INT, ≧0	DL number for additive/setup offset
_TENV	STRING[32]	Name of tool surroundings for automatic tool offset

The following additional parameters are also valid:

_VMS, _CORA, _TZL, _TMV, _TUL, _TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP and _K

_CORA only relevant for monodirectional probe.

The parameters must also be assigned if _KNUM=0 because they refer to the workpiece.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

5.5.4.2 Programming example

1-point measurement in X axis with tool compensation

A surface parallel with the Y axis has been machined with milling tool T20, D1 on a set-up workpiece.

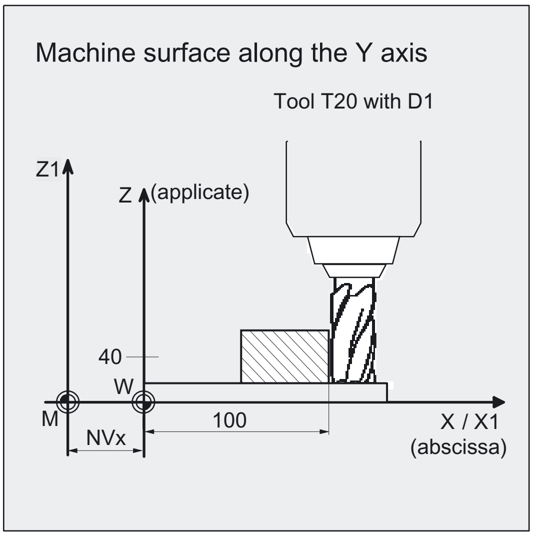
This surface should be positioned exactly 100.000 mm in the X axis from the defined workpiece zero and be measured.

If the absolute value of the difference determined is >0.01, the radius of this tool is to be automatically offset in the wear.

1 mm is assumed to be the maximum permissible deviation of the position of the surface.

To obtain a minimum measuring path of 1 mm, the measuring path is programmed as _FA= 1+1=2 mm
(max. total measuring path = 4 mm).

The offset must take the empirical value in memory _EV[19] into consideration. Mean value calculation _MV[19] and inclusion in calculation are also to be used.



This tool offset will therefore affect the production of the next workpieces or possible remachining.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

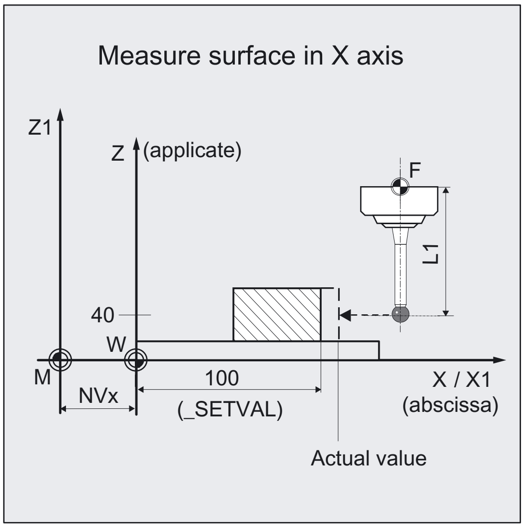
Workpiece probe 1, used as tool **T9, D1**, is to be used.

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.




```
%_N_ONE_POINT_MEASURE_MPF
N10 G54 G17 G90 T9 D1                   ;ZO, select tool as probe ...
N20 M6                                  ;Insert probe,
                                        ;activate tool offset
N30 G0 G90 X120 Y150                    ;Position probe in X/Y plane in front of
                                        ;measuring surface
N40 Z40                                 ;Position probe at measuring height
N50 _CHBIT[4]=1                         ;with mean value calculation
N60 _TUL=0.03 _TLL=-0.03 _TNUM=20       ;Set parameters for measuring cycle call
_EVNUM=20 _K=3 _TZL=0.01 _TMV=0.02
_TDIF=0.06 _TSA=1 _PRNUM=1 _VMS=0
_NMSP=1 _FA=2
N61 _MVAR=0 _SETVAL=100 _MA=1
_KNUM=2001
N70 CYCLE978                            ;Measuring cycle for 1-point measurement in
                                        ;X axis
N80 G0 Z160                             ;Traverse up Z axis
N100 M2                                 ;End of program
```

Explanation of example

The difference calculated from the actual and setpoint value (position of surface) is compensated for by the empirical value in the empirical value memory _EV[19] and compared with the tolerance parameter.

- If it is more than 1 mm (_TSA), alarm "Safe area violated" is output and program execution cannot be continued.
- If it is more than 0.06 mm (_TDIF), no compensation is performed and alarm "Permissible dimensional difference exceeded" is output and the program continues.
- If 0.03 mm (_TUL/_TLL) is exceeded, the radius in T20 D1 is compensated 100% by this difference. Alarm "Oversize" or "Undersize" is displayed and the program is continued.
- If 0.02 mm (_TMV) is exceeded, the radius in T20 D1 is compensated 100% by this difference.
- If it is less than 0.02 mm (_TMV), the mean value is calculated from the mean value in mean value memory _MV[19] and inclusion of weighting factor _K=3 (only for _CHBIT[4]=1! with mean value memory).
  - - If the mean value obtained is >0.01 (_TZL), the reduced compensation of the radius for T20 D1 is the mean value/2 and the mean value is deleted in _MV[19].
  - If the mean value is < 0.01 (_TZL), the radius value in T20 D1 is not corrected, but if the mean value memory is active (_CHBIT[4]=1), it is saved in the mean value memory _MV[19].

The results are entered in result array _OVR[ ]. The wear of the radius of T20, D1 is included if a change is necessary.

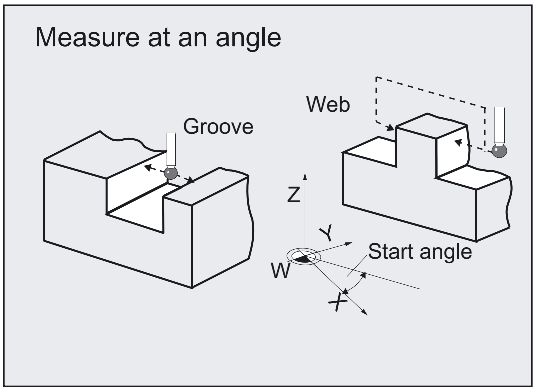
5.6 CYCLE979 workpiece: Measure hole/shaft/groove/rib at an angle

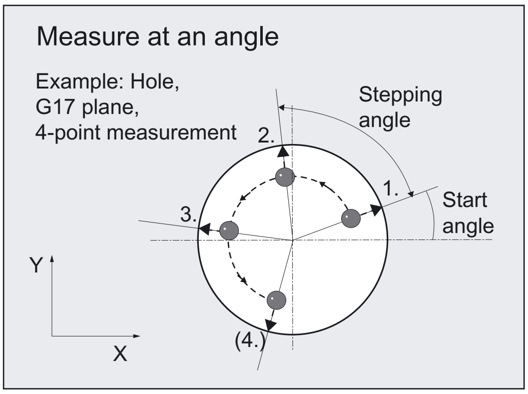
5.6.1 Function overview

Function

With this measuring cycle you can measure the dimensions of the following contour elements on a workpiece using different measuring variants:

- Hole
- Shaft
- Groove
- Web





Measurement is performed at a specified starting angle to the abscissa of the workpiece coordinate system.

For hole, shaft, additional measurements are performed at an indexing angle, added to the previous angle.

This allows you to measure circle segments of a workpiece contour whose center points lie outside the machine.

`CYCLE979` can

- measure the contour elements

  and additionally either
- perform an automatic tool offset

  for a specified tool based on the differences in diameter or width, or
- correct a zero offset (ZO)

based on the differences between the center positions.

Workpiece probe types that can be used

- Multidirectional probe (_PRNUM=0xy)
- Monodirectional, bidirectional probe (_PRNUM=1xy)

When measuring contour elements **hole**, **shaft,** a **3-** or **4-point measurement**can be used. Parameters for this selection are only set in this cycle, in the 4th digit of _PRNUM:

_PRNUM=0zxy ⇒ 3-point measurement

_PRNUM=1zxy ⇒ 4-point measurement

The 1st to 3rd digit of _PRNUM retains its significance depending on the illustration given in Section "Description of the most important defining parameters"!

Note

(_PRNUM) probes, which are calibrated with the calibration variant "Calibrate with calculation of positional deviation", must be used in conjunction with CYCLE979.

Exceptions: The probe is precision-adjusted mechanically and the positional deviation is less than +/-1 µm.

Programming

```
CYCLE979
```

Measuring variants

Measuring cycle `CYCLE979` permits the following measuring variants which are specified via parameter **_MVAR.**

Value	Measuring variant
1	Measure hole with tool offset
2	Measure shaft with tool offset
3	Measure groove with tool offset
4	Measure web with tool offset
101	ZO calculation in hole with ZO compensation
102	ZO calculation on shaft with ZO compensation
103	ZO calculation in groove with ZO compensation
104	ZO calculation on web with ZO compensation

Result parameters

Depending on the measuring variant, measuring cycle `CYCLE979` makes the following values available as results in data block GUD5:

Parameter	Data type	Result
`_OVR [0]`	REAL	Setpoint diameter/width hole, shaft, groove, web
`_OVR [1]`	REAL	Setpoint center point/center in abscissa
`_OVR [2]`	REAL	Setpoint center point/center in ordinate
`_OVR [4]`	REAL	Actual value diameter/width hole, shaft, groove, web
`_OVR [5]`	REAL	Actual value center point/center in abscissa
`_OVR [6]`	REAL	Actual value center point/center in ordinate
`_OVR [8]` 1)	REAL	Upper tolerance limit for diameter of hole, shaft or width of groove, web
`_OVR [12]` 1)	REAL	Lower tolerance limit for diameter of hole, shaft or width of groove, web
`_OVR [16]`	REAL	Difference diameter/width hole, shaft, groove, web
`_OVR [17]`	REAL	Difference center point/center in abscissa
`_OVR [18]`	REAL	Difference center point/center in ordinate
`_OVR [20]` 1)	REAL	Compensation value
`_OVR [27]` 1)	REAL	Zero offset area
`_OVR [28]` 1)	REAL	Safe area
`_OVR [29]` 1)	REAL	Permissible dimensional difference
`_OVR [30]` 1)	REAL	Empirical value
`_OVR [31]` 1)	REAL	Mean value
`_OVI [0]`	INTEGER	D number or ZO number
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [4]` 1)	INTEGER	Weighting factor
`_OVI [5]`	INTEGER	Probe number
`_OVI [6]` 1)	INTEGER	Mean value memory number
`_OVI [7]` 1)	INTEGER	Empirical value memory number
`_OVI [8]`	INTEGER	Tool number
`_OVI [9]`	INTEGER	Alarm number
`_OVI [11]` 2)	INTEGER	Status offset request
`_OVI [13]` 1)	INTEGER	DL number
1) for workpiece measurement with tool offset only 2) For ZO correction only		

5.6.2 Measure shaft, groove, web

5.6.2.1 General information

Function

Using this measuring cycle and various _MVAR measuring variants the following contour elements can be measured at an angle:

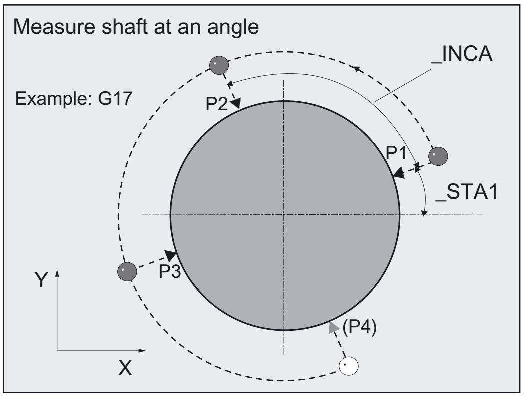
- _MVAR=x01 ⇒ hole
- _MVAR=x02 ⇒ shaft
- _MVAR=x03 ⇒ groove
- _MVAR=x04 ⇒ web

If no tool offset or ZO correction is to be applied, _KNUM=0 should be set.

Detailed information on the parameters: see Parameter description section "Description of the most important defining parameters".

Measuring principle for hole or shaft

The measuring cycle measures points P1, P2, P3 and/or also P4 inside the hole and/or when outside the hole by passing the shaft.



The position of the points is determined by starting angle _STA1, indexing angles _INCA, the diameter and the set center point.

These four measured values are used to calculate the actual value of the diameter and position of the center point in the abscissa and ordinate relative to the workpiece zero.

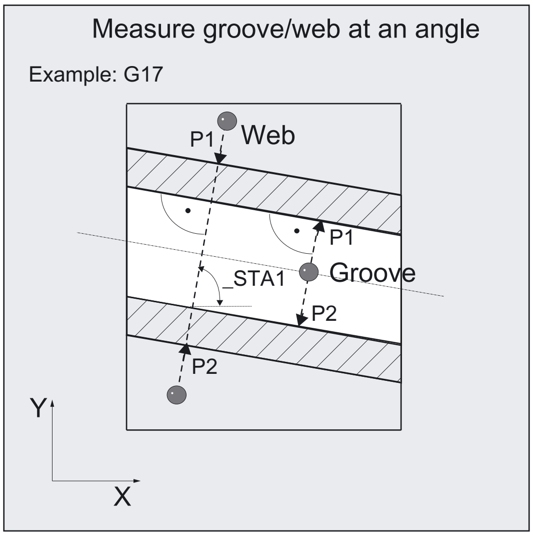
Measurement is performed in the radial direction:

- toward the set center point in the case of shaft,
- away from the set center point in the case of a hole.

The sum of the starting angle plus all incremental angles must not exceed 360 degrees.

Measuring principle for groove or web

The measuring cycle measures points P1 and P2 inside the groove and outside the web.



The actual value of the groove width and web width and the position of the groove center and web center in relation to workpiece zero are calculated from the measured values.

Supplementary functions for hole and shaft diameter, groove or web width, and tool compensation.

- An empirical value from data block GUD5 can be included with the correct sign.
- A mean value can be derived from several workpieces, measurement calls.

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

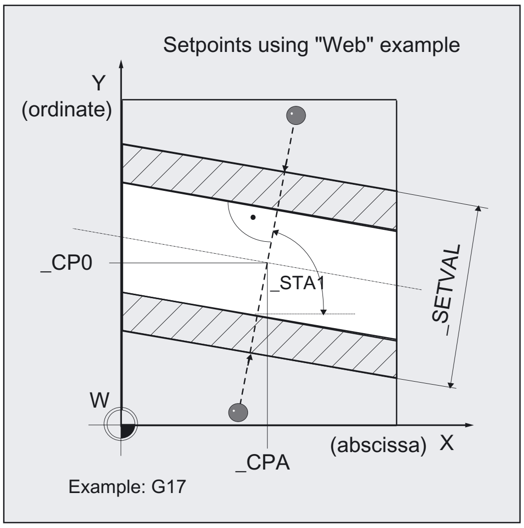
When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

The probe must have been calibrated with "Determine active probe ball diameter". Calibration with an additional "Determine position deviation" of the workpiece probe improves the measuring precision.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

5.6.2.2 Operational sequence

Specification of setpoints



The setpoint for diameter or width is specified in _SETVAL.

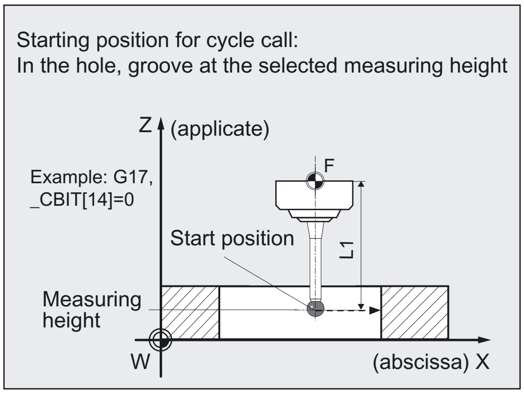
The setpoint for the center point of the hole, shaft, or for the measured center of the groove, web, is specified by

- _CPA for the abscissa and
- _CPO for the ordinate.

Measuring axes

Measuring axes are not specified. As a rule, both axes of the plane are included in the measurements, depending on the angle.

Position before measuring cycle call

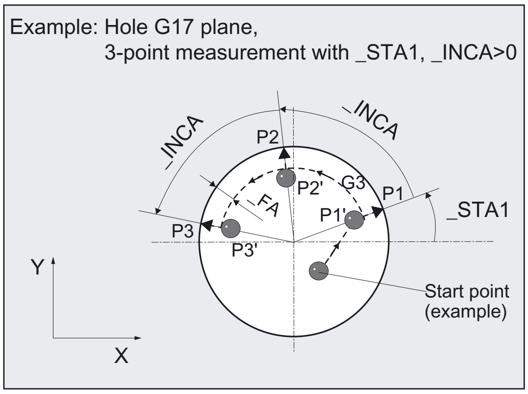


In all measuring variants the probe must be positioned at the required **measuring height** in the applicate (tool axis) close to the first measuring point P1.

It must be possible to approach the first measuring point P1 via intermediate point P1' from this position without collision using linear interpolation.

Recommended distance from contour: >_FA.

Procedure for hole, shaft



Note

When measuring circle segments of < 90 grd, it should be noted that, mathematically speaking, measuring points that deviate from the circular shape exert a particularly great influence on the accuracy of the results (center point, diameter).

For this reason, an especially high degree of care should be taken when measuring small circle segments. Good results can be attained if the following procedures are used:

The circle segment to be measured should be:

- Free from production deposits.
- Have as exact a circular form as possible, as guaranteed by the production technology used.
- Have as smooth a surface as possible, as guaranteed by the production technology used.
- Be measured with high-quality probes, i.e, the shape of the probe ball is as homogeneous as possible.
- Be measured with the 4-point-measurement measuring variant (_PRNUM=1xxx).
- Be measured with a recently calibrated probe

The intermediate positions of the measuring points are approached along a circular path (G2, G3). The distance between the probe ball (ball circumference) and the hole or shaft is _FA. The travel direction G2 or G3 is derived from the sign of _INCA: G3 is angle is positive.

The velocity along the circular path is programmed with `_RF`.

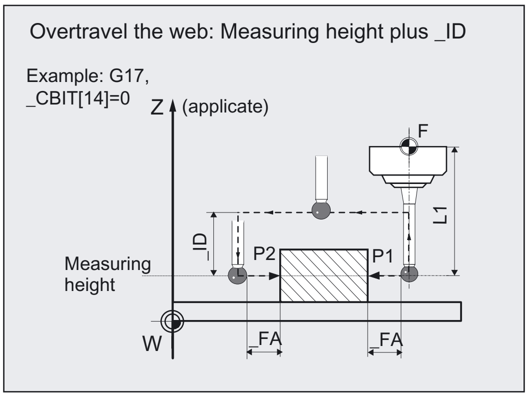
Procedure for groove

The probe is in the groove and approaches both measuring points one after the other in the selected measuring height along an oblique straight line as defined by angle _STA1 and which travels through CPA, CPO.

Procedure for web

When using the measuring variants for the web _MVAR=4, _MVAR=104 , additional details are needed for crossing the web with _ID.

`_ID` specifies the distance (with prefix) from the measuring height.



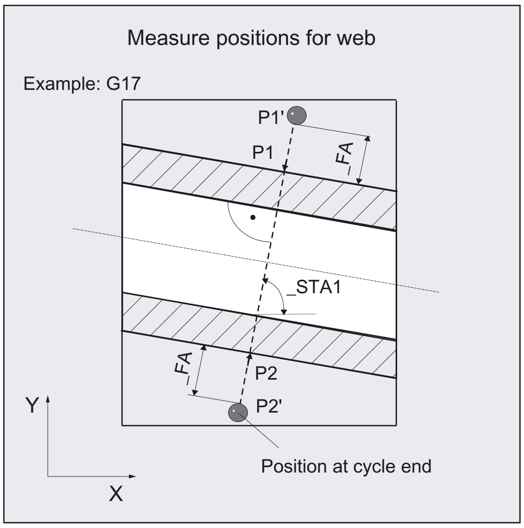
CAUTION
If _CBIT[14]=0, length 1 (L1) of the probe refers to the ball center. Radius R is then not taken into account in the length and must be included in _ID!

Measuring point P2 is approached via P2' along an oblique straight line according to angle _STA1 and which runts through _CPA, _CPO.

P1’, P2’ are both distance _FA (path) from the contour.

Position at end of measuring cycle

At the end of the measuring cycle, the probe (ball circumference) is distance _FA (path) from the last measuring point (setpoint) at measuring height.



NOTICE
The range of positions of the center or diameter, or groove, web width, must be within the value specified in _FA for all workpieces to be measured. Otherwise, there is danger of collision or the measurement cannot be performed!

5.6.3 Measuring and tool offset

5.6.3.1 General information

Function

Using this measuring cycle and various _MVAR=1...4measurement variants, the contour elements hole, shaft, groove, web, can be measured at an angle.

Automatic tool offset is also possible. This tool is specified in _TNUM and _TNAME. The D number and type of offset are specified in coded form in variable _KNUM.

With an extended tool offset, a tool from a particular stored tool environment _TENV, and additive or setup offsets can be corrected by specifying the DL number in _DLNUM.

Detailed information on the parameters: see the Parameter description section "Description of the most important defining parameters".

Empirical values and mean values

An empirical value stored in data block GUD5 in array _EV[ ] can be incorporated in the result calculation after measurement is completed.

Optionally, averaging is performed over a number of parts (array _MV[ ]) and the tolerance bands are checked.

Both are activated in _EVNUM (see Parameter description Section "Description of the most important defining parameters").

Parameters

Parameters	Data type	Meaning
_MVAR	1	Measure hole with tool offset
	2	Measure shaft with tool offset
	3	Measure groove with tool offset
	4	Measure web with tool offset
_SETVAL	REAL, >0	Setpoint diameter, width (acc. to drawing)
_CPA	REAL	Center point of abscissa (with reference to workpiece zero)
_CPO	REAL	Center point of ordinate (with reference to workpiece zero)
_STA1	-360 to +360 degrees	Start angle
_ID	REAL	Incremental lifting of applicate with prefix (only measure with web, lift for crossing)
_INCA	-360 to +360 degrees	Indexing angle (only for measuring hole or shaft) useful values for 3-point measurement: -120 ... + 120 degrees useful values for four-point measurement: -90 ... +90 degrees
_RF	REAL, >0	Feed for circular interpolation (mm/min) (only measure for hole and/or shaft)
_KNUM	0, >0	0: without automatic tool offset >0: with automatic tool offset (Individual values: see Parameter description section "Description of the most important defining parameters", Parameter _KNUM)
_TNUM	INT, ≥0	Tool number for automatic tool offset
_TNAME	STRING[32]	Tool name for automatic tool offset (alternative for _TNUM if tool management active)
_DLNUM	INT, ≥0	DL number for additive/setup offset
_TENV	STRING[32]	Name of tool environment for automatic tool offset

The following additional parameters are also valid:

_VMS, _CORA, _TZL, _TMV, _TUL, _TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP and _K.

_CORA only relevant for monodirectional probe.

The other parameters must also be assigned if _KNUM=0 because they refer to the workpiece.

The diameter or width difference is monitored here with _TSA.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

5.6.3.2 Programming example

Measuring a hole with CYCLE979

The trueness of a circular segment in plane G17 (semi-circle, contour element "hole") is to be checked. Machining was performed with milling tool T20, D1.

With a variance of >0.01 mm from the setpoint diameter _SETVAL = 130 mm, the tool radius of this tool should be automatically offset in the wear. The maximum permissible deviation is taken as max. 1 mm. To obtain a minimum measuring path of 1 mm to the contour, the measuring path is specified as _FA = 1+1 =2 mm (max. total measuring path = 4 mm).

The center point of the circular segment (setpoint) is X = 180 mm, Y = 0 mm (_CPA, _CPO).

Measurement is to be performed with three-point measurement at a measuring height of Z = 20 mm at initial angle 15° and following angles 80°.

Traversing between points is carried out with a circular feed of _RF= 900 mm/min.

The offset must take the empirical value in memory _EV[19] into consideration. Mean value calculation _MV[19] and inclusion in calculation are also to be used.

This tool offset will therefore affect the production of the next workpieces or possible remachining.

Clamping for workpiece:

Zero offset, with settable ZO G54: NVx, NVy, ...

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

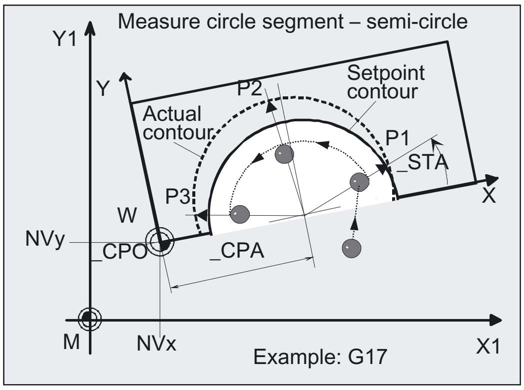
Workpiece probe 1, used as tool **T9, D1**, is to be used.

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.




```
%_N_DRILL_SEGMENT_MPF
N10 G54 G17 G90 T9 D1                  ;ZO, select tool as probe ...
N20 M6                                 ;Insert probe,
                                       ;activate tool offset
N30 G0 X210 Y-20                       ;Position probe in X/Y plane close to
                                       ;P1
N40 Z20                                ;Position probe at measuring height
N50 _CHBIT[4]=1                        ;With mean value calculation
N60 _TUL=0.03 _TLL=-0.03 _EVNUM=20     ;Set parameters for measuring cycle call
_K=3 _TZL=0.01 _TMV=0.02 _TDIF=0.06    ;Three-point measurement with probe 1
_TSA=1 _PRNUM=1 _VMS=0 _NMSP=1 _FA=2
N61 _MVAR=1 _SETVAL=130 _STA1=15
_INCA=80 _RF=900 _TNUM=20 _KNUM=2001
_CPA=180 _CPO=0
N70 CYCLE979                           ;Call measuring cycle for hole measurement
                                       in Y
                                       ;X/Y plane
N80 G0 Z160                            ;Traverse up Z axis
N100 M2                                ;End of program
```

Explanation of example

The difference calculated from the actual and setpoint diameter is compensated for by the empirical value in the empirical value memory _EV[19] and compared with the tolerance parameter.

- If it is more than 1 mm (_TSA), alarm "Safe area violated" is output and program execution cannot be continued.
- If it is more than 0.06 mm (_TDIF), no compensation is performed and alarm "Permissible dimensional difference exceeded" is output and the program continues.

- If 0.03 mm is exceeded (_TUL/_TLL), the radius in T20 D1 is compensated 100% by this difference/2. Alarm "oversize" or "undersize" is displayed and the program continues.
- If 0.02 mm (_TMV) is exceeded, the radius in T20 D1 is compensated 100% by this difference/2.
- If it is less than 0.02 mm (_TMV), the mean value is calculated from the mean value in mean value memory _MV[19] and inclusion of weighting factor _K=3 (only for _CHBIT[4]=1! with mean value memory).
  - - If the mean value obtained is >0.01 (_TZL), the reduced compensation of the radius for T20 D1 is the mean value/2 and the mean value is deleted in _MV[19].
  - If the mean value is < 0.01 (_TZL), the radius value in T20 D1 is not corrected, but if the mean value memory is active (_CHBIT[4]=1), it is saved in the mean value memory _MV[19].

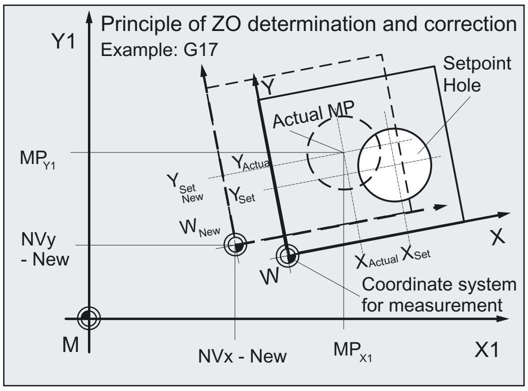
The results are entered in result array _OVR[ ].

5.6.4 Measurement and ZO determination

5.6.4.1 General information

Function

Using this measuring cycle and the **_MVAR=10x**
measuring variant, a hole, shaft, groove or a web can be measured at an angle. The zero offset (ZO) of the associated workpiece can also be determined and corrected. A possible rotation of the workpiece is kept without changing it.



The angular position cannot be determined with this cycle.

Compensation of the ZO is executed in such a way that the actual center (position of center on the machine, e.g.: MPX1, MPY1) includes the desired setpoint position in the workpiece coordinate system when the compensated ZO (frame) is applied.

Mirroring can be active in a frame of the frame sequence.

Dimension factors must never be active.

The ZO to be corrected is specified in coded form with variable **_KNUM** >0.

The ZO can be specified and corrected by various methods, e.g. in various settable frames, in various basic frames, system frames, fine offset, or coarse offset, etc.

For detailed information on specifying _KNUM for the zero offset: see Parameter description section "Description of the most important defining parameters".

The following applies to all measuring variants with ZO determination in CYCLE979:

The difference between the setpoint (_CPA and _CPO) and the actual value of the **center point** derived by the cycle determines the ZO correction (offset).

This value is monitored here with _TSA.

Parameter

Parameter	Data type	Meaning
_MVAR	101	ZO calculation in hole with ZO compensation
	102	ZO calculation on shaft with ZO compensation
	103	ZO calculation in groove with ZO compensation
	104	ZO calculation on web with ZO compensation
_SETVAL	REAL, >0	Setpoint diameter, width (acc. to drawing)
_CPA	REAL	Center point of abscissa (with reference to workpiece zero)
_CPO	REAL	Center point of ordinate (with reference to workpiece zero)
_STA1	-360 to +360 degrees	Start angle
_ID	REAL	Incremental lifting of applicate with prefix (only measure with web, lift for crossing)
_INCA	-360 to +360 degrees	Indexing angle (only for measuring hole or shaft) useful values for 3-point measurement: -120 ... + 120 degrees useful values for four-point measurement: -90 ... +90 degrees
_RF	REAL, >0	Feed for circular interpolation (mm/min) (only measure for hole and/or shaft)
_KNUM	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (Individual values: see Parameter description section "Description of the most important defining parameters", Parameter _KNUM)

The following additional parameters are also valid:

`_VMS, _CORA, _TSA, _FA, _PRNUM` and `_NMSP`

`_CORA` only relevant for monodirectional probe.

The center point difference is monitored here with `_TSA`.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

5.6.4.2 Programming example

Measuring a groove and determining the ZO with CYCLE979

The groove width on a workpiece is to be measured in plane G17 and measuring height Z=40 mm. The groove lies at an angle of 70° in its width from the X axis (_STA1).

The resulting center of the slot in the measured path should lie in the corrected workpiece coordinate system at X = 150 mm, Y = 130 mm (_CPA, _CPO).

Any deviation from the selected ZO must be compensated for automatically in G55 by means of additive ZO.

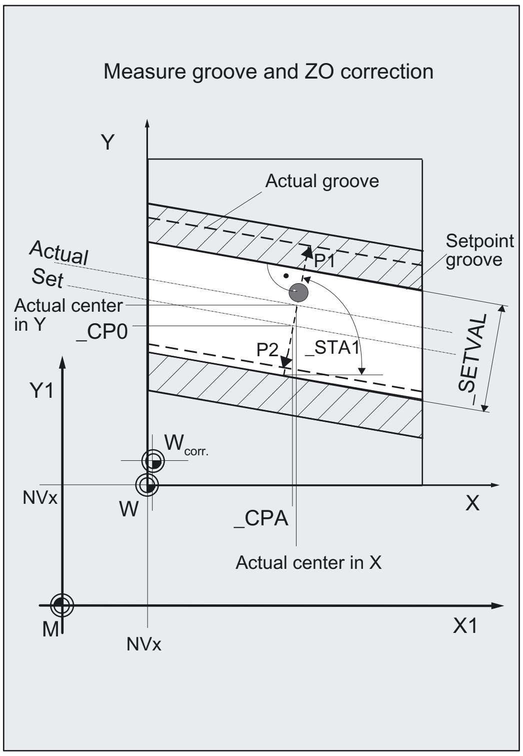
Measurement is also performed with G55.

The maximum conceivable deviation of the groove center is taken as 1 mm. The measuring path is therefore specified as _FA= 2 mm (max. measuring path = 4 mm) and ensures that there is still a minimum measuring path of 1 mm up to the edge of the groove.

A deviation of < 0.8 mm of the center is permitted. This should be monitored with _TSA.

Clamping for workpiece:

Zero offset, with settable ZO G55: NVx, NVy, ... (values before the correction [offset])



```
%_N_OFFSET_GROOVE_MPF
N10 G55 G17 G90 T9 D1                     ;ZO, select tool as probe ...
N20 M6                                    ;Insert probe,
                                          ;activate tool offset
N30 G0 X150 Y130                          ;Position probe in X/Y plane
                                          ;in setpoint center
N40 Z40                                   ;Position probe at measuring height
N60 _TSA=0.8 _PRNUM=1 _VMS=0 _NMSP=1      ;Set parameters for measuring cycle call
_FA=2
N61 _MVAR=103 _SETVAL=130 _CPA=150
_CPO=130 _STA1=70 _KNUM=2
N70 CYCLE979                              ;Call measuring cycle for ZO
                                          ;determination in X/Y plane
N80 G0 Z160                               ;Traverse up Z axis
N90 G55                                   ;Repeat call of zero offset G55
                                          ;The changes thereby take effect!
N100 M2                                   ;End of program
```

Explanation of example

Automatic compensation is performed in G55, offset in X and Y by the calculated difference between the actual value and set position of the groove center point, should it be less than 1 mm (_TSA) in both axes. Otherwise, alarm "Safe area violated" is output and program execution cannot be continued. It must be interrupted with NC RESET.

The corrected ZO G55 is activated in block N90.

The results are entered in result array _OVR[ ].

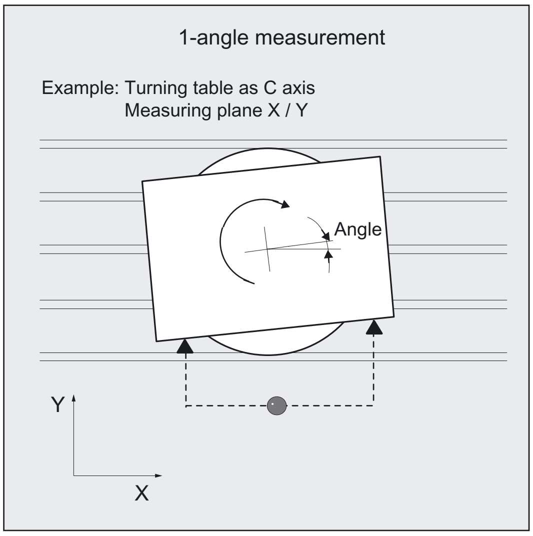
5.7 CYCLE998 workpiece: Angle measurement and ZO determination

5.7.1 Function overview

Function

This measuring cycle enables you to determine the angular position of surfaces of a workpiece. This can be used to close the workpiece clamping and correct the ZO as regards angular position.

With 1-angle measurement:

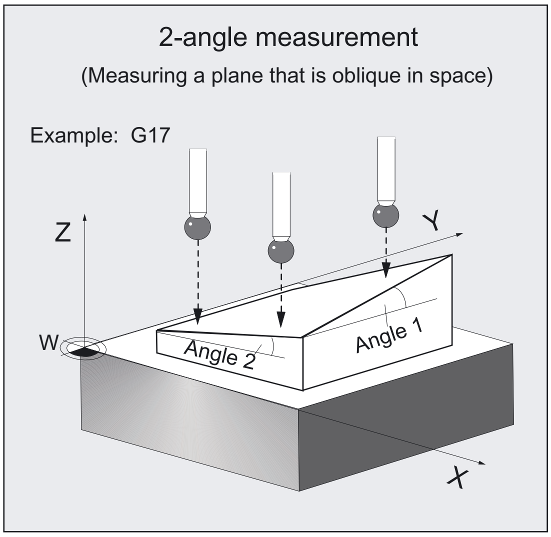


- When a workpiece is clamped rotated in the plane:

  The angular offset is applied in the rotation component of the geometry axis that is perpendicular to the measurement plane.
- If a workpiece is on a rotary table:

  The angular offset is applied additively in the translation component of the rotary axis (table axis).

With 2-angle measurement:



- If a workpiece has a plane that is inclined in space:

  The angular offsets are applied in the rotation part of the geometry axes.

The angular position is corrected, taking account of set angles in the specified frame (ZO).

Note

In this cycle, only the **rotation** components of the frame are determined and corrected (except for rotary table). To complete correction of the ZO (frame), a further measuring cycle is required to determine the translation component (e.g. CYCLE977 or CYCLE978).

An empirical value _EV[ ] stored in the GUD5 data block can be included in the measurement result with the correct sign. This is activated in _EVNUM (see Parameter description Section "Description of the most important defining parameters").

A special measuring variant permits **differential measurement** with the axes of the plane. The special procedure for this measurement permits use of an **uncalibrated** multidirectional probe.

Workpiece probe types that can be used

- Multidirectional probe (_PRNUM=0xy)
- Mono-directional, bi-directional probe (_PRNUM=1xy)
  (These probes should be used only with low accuracy requirements!)

NOTICE
A monodirectional or bi-directional probe must always be calibrated! These probes cannot be used for the differential measurement!

Preconditions for differential measurement

- Spindle can be positioned between 0...360 degrees (at least every 90 degrees, with SPOS command)
- Multidirectional probe (all-round coverage)

Maximum measurement angle

The cycle is capable of measuring a maximum angle of -45 ... +45 degrees.

Programming

`CYCLE998`

Measuring variants

Measuring cycle `CYCLE998` permits the following measuring variants which are specified via parameter `_MVAR`.

Value	Measuring variant
105	Angle measurement and ZO determination, positioning at an angle from measuring point to measuring point
1105	Angle measurement with differential measurement and ZO determination, positioning at an angle from measuring point to measuring point
100105	Angle measurement and ZO determination, paraxial positioning from measuring point to measuring point in the offset axis
106	2-angle measurement and ZO determination, positioning at an angle from measuring point to measuring point at height
100106	2-angle measurement and ZO determination, paraxial positioning from measuring point to measuring point at height

Result parameters

Measuring cycle CYCLE998 makes the following values available as results in the GUD5 data block:

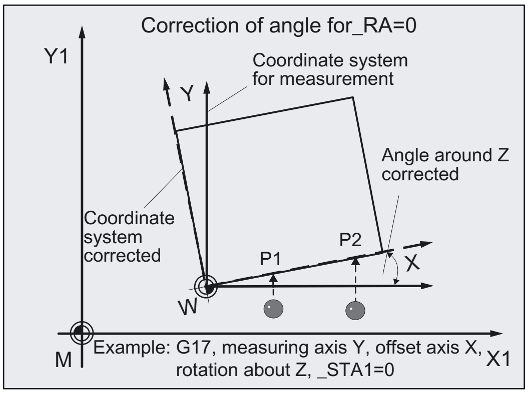
Parameter	Data type	Result
_OVR [0]	REAL	Setpoint angle or setpoint angle between workpiece area and 1st axis of the plane (abscissa) of the active WCS1)
_OVR [1] 1)	REAL	Setpoint angle between workpiece area and 2nd axis of the plane (ordinate) of the active WCS
_OVR [4]	REAL	Actual value angle or actual value angle between workpiece area and 1st axis of the plane (abscissa) of the active WCS 1)
_OVR [5] 1)	REAL	Actual value angle between workpiece area and 2nd axis of the plane (ordinate) of the active WCS
_OVR [16]	REAL	Difference angle or difference angle about 1st axis of plane 1)
_OVR [17] 1)	REAL	Difference angle about 2nd axis of the plane
_OVR [20]	REAL	Offset value angle
_OVR [21] 1)	REAL	Offset value angle about 1st axis of the plane
_OVR [22] 1)	REAL	Offset value angle about 2nd axis of the plane
_OVR [23] 1)	REAL	Offset value angle about 3rd axis of the plane
_OVR [28]	REAL	Safe area
_OVR [30]	REAL	Empirical value
_OVI [0]	INTEGER	ZO number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [5]	INTEGER	Probe number
_OVI [7]	INTEGER	Empirical value memory number
_OVI [9]	INTEGER	Alarm number
_OVI [11] 1)	INTEGER	Status offset request
1) for measuring variant _MVAR=x00106 only		

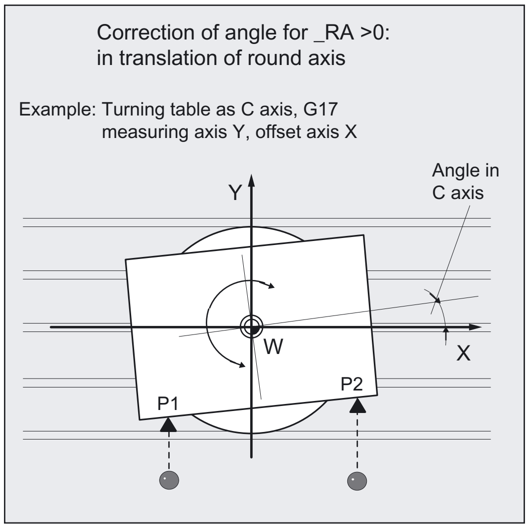
5.7.2 1-angle measurement

5.7.2.1 General information

Function

Using this measuring cycle and the **_MVAR=x0x105** measuring variants, it is possible to determine the angular position of a surface in the plane of the workpiece coordinate system.





This can be used to determine and correct the rotation component in the zero offset (ZO, frame) of the workpiece in the plane.

The rotation is corrected in such a way that the real position of the surface (actual value) adopts the required set angle (_STA1) in the workpiece coordinate system when the corrected ZO (frame) is used.

The ZO to be corrected is specified in coded form with variable **_KNUM** >0.

The ZO can be specified and corrected by various methods, e.g. in various settable frames, in various basic frames, system frames.

If _KNUM=0, there is no ZO correction.

For detailed information on specifying _KNUM for the zero offset: see Parameter description section "Description of the most important defining parameters".

In addition to _KNUM, another item of data is required to determine the type of angular offset in

Parameter **_RA** needed:

- _RA=0:

  Offset of rotation about 3rd axis that is not contained in _MA (neither measurement nor offset axis)

- _RA>0:

  Channel axis number of the rotary table. The angular offset is undertaken in the translation component of the channel axis _RA.

Parameter for 1-angle measurement

Parameter	Data type	Meaning
_MVAR	105	Angle measurement and ZO determination, positioning at an angle from measuring point to measuring point
	1105	Angle measurement with differential measurement and ZO determination, positioning at an angle from measuring point to measuring point
	1001105	Angle measurement and ZO determination, paraxial positioning from measuring point to measuring point in the offset axis
_SETVAL	REAL, >0	Setpoint (axis position) at measuring point 1 in the meas. axis (for _MVAR=105 and _MVAR=1105 only)
_STA1	REAL, -45 to +45 degrees	Setpoint angle
_MA[1)]	201	Measuring axis: 1 (abscissa), offset axis: 2 (ordinate)
	102	Measuring axis: 2 (ordinate), offset axis: 1 (abscissa)
	301	Measuring axis: 1 (abscissa), offset axis: 3 (applicate)
	302	Measuring axis: 2 (ordinate), offset axis: 1 (applicate)
	203	Measuring axis: 3 (applicate), offset axis: 2 (ordinate)
	103	Measuring axis: 3 (applicate), offset axis: 1 (abscissa)
_ID	REAL, >0	Distance between measuring points P1 and P2 in offset axis
_RA	0	Offset of rotation about axis that is not contained in _MA
	>0	Channel axis number of rotary table The angular offset is applied in the translation component of the channel axis number (rotary axis).
_MD	INT, 0 or 1	0: positive measuring direction 1: negative measuring direction (only for variants with paraxial intermediate positioning _MVAR=10x10x)
_KNUM	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (Individual values: see Parameter description section "Description of the most important defining parameters"., Parameter _KNUM)
1) depending on planes		

The following additional parameters are also valid:

_VMS, _CORA, _TSA, _FA, _PRNUM, _EVNUM and _NMSP

_CORA only relevant for monodirectional probe.

With _TSA, the difference of the angle is monitored and this value is additionally traversed to _STA1 with intermediate positioning at an angle. _TSA has the dimension unit degrees in this case!

NOTICE
Precise angle definition requires a minimum surface finish at least at the measuring points. The distances between the measuring points must be selected as large as possible.

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

5.7.2.2 Programming example

1-angle measurement with CYCLE998

A rectangular workpiece (60 x 40 mm) is clamped in the G17 plane on a rotary table. The intention is to orient it with its edges running parallel with axes X and Y.

An angular deviation detected is to be compensated automatically through additive ZO compensation of the rotary axes. The maximum possible angular deviation is taken as _TSA = 5°. The measuring path is programmed as _FA = 8 mm (max. total measurement path = 16 mm). The measuring points should be 40 mm apart. Intermediate positioning is to be at an angle.

The rotary table is the 4th axis in the channel (C axis).

Clamping for workpiece:

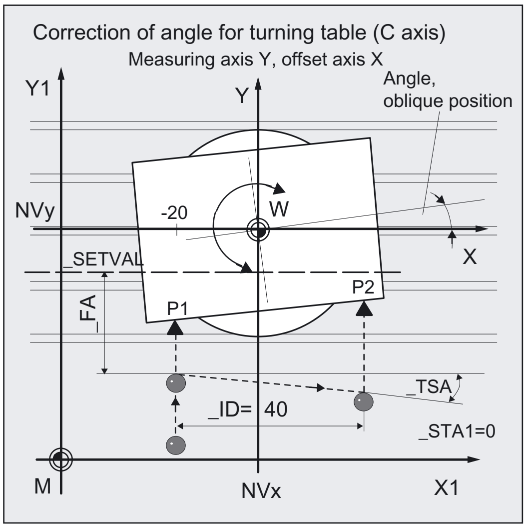
Zero offset, with settable ZO G54: NVx, NVy, NVz, NVc

Workpiece probe 1, used as tool **T9, D1**, is to be used.

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000



Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.

```
%_N_ANGLEMEAS_MPF
N10 G54 G17 G90 T9 D1                  ;Select T No. probe
N20 M6                                 ;Insert probe as tool,
                                       ;activate offset
N30 G0 C0                              ;Position rotary table at 0°
N40 X-20 Y-40                          ;Position probe in X/Y plane opposite
                                       ;measuring point
N50 Z40                                ;Z axis at measurement height
N60 _PRNUM=1 _VMS=0 _NMSP=1 _EVNUM=0   ;Set parameters for measuring cycle call
N61 _MVAR=105 _SETVAL=-18 _MA=102
_ID=40 _RA=4 _KNUM=1 _STA1=0 _TSA=5
_FA=8
N70 CYCLE998                           ;Measuring cycle for angle measurement
N80 G0 Z160                            ;Traverse up Z axis
N90 G54 C0                             ;Repeat call of ZO G54
                                       ;The changes thereby take effect!
                                       ;Position rotary table at 0°
                                       ;(edge is now setup).
N100 M2                                ;End of program
```

Explanation of example

Measurement is performed in the Y direction, offset is in X direction, intermediate position at an angle. The cycle determines the measuring direction from the actual position in the Y direction and _SETVAL.

Automatic correction is performed in G54, offset in the C axis (4th channel axis) with the calculated angle (_STA1=0).

In block N90, the corrected ZO G54 is activated and the C axis is moved from position zero to position zero; the ZO difference is eliminated. The workpiece is then paraxial.

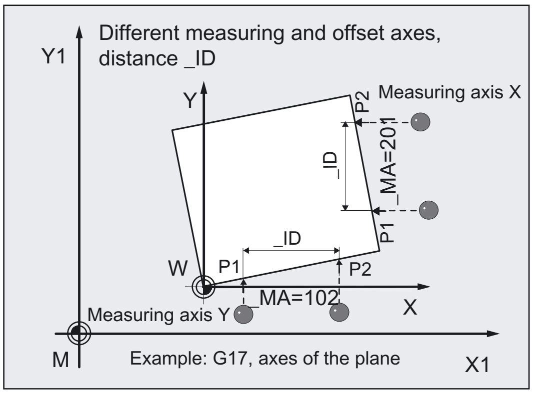
The results are entered in result array _OVR[ ].

5.7.2.3 Operational sequence

General information

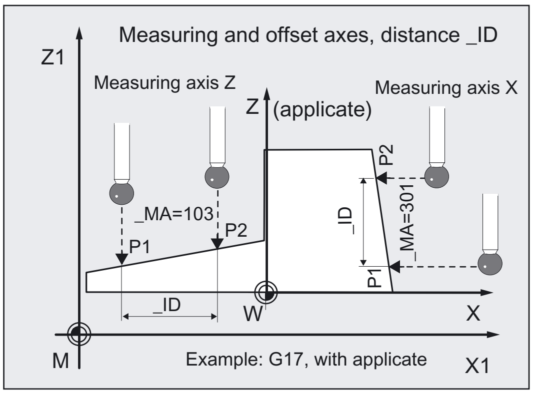
Measurement axis _MA

In this cycle, not only the measuring axis but also the offset axis are specified in _MA. The offset axis is the 2nd axis of the measuring plane. Intermediate positioning to the measuring point is performed in this axis for paraxial positioning; for positioning at an angle it is performed in both axes. It is also possible to specify the applicate as the measurement or offset axis.



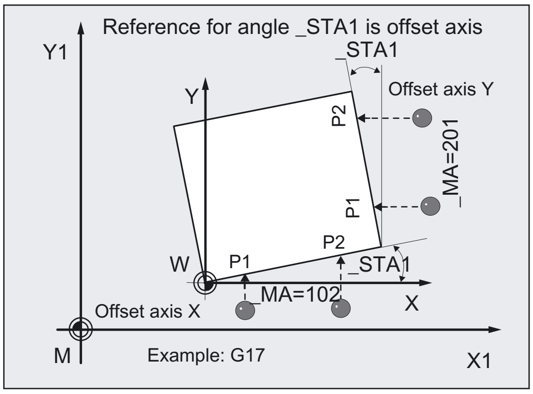
Distance of measuring point 1 to measuring point 2 in the offset axis: _ID

Parameter _ID is used to define the distance between P1 and P2 in the offset axis. Only positive values are permissible for _ID. P1 must therefore be selected in the offset axis before the cycle begins.



_STA1 set angle

The setting in `_MA` makes all 3 measurement planes possible. The set angle **_STA1** therefore refers to the positive direction of the offset axis and is negative in the clockwise direction, positive in the counterclockwise direction.



The set angle `_STA1` specifies the required angle between the edge and the positive direction of the offset axis. In the case of `_STA1=0`, the edge is aligned paraxially with regards to the offset axis after correction.

With measuring variants "Positioning at an angle“ `(_MVAR=00x105)` `_STA1` is also used for positioning. The positioning angle is formed together with **_TSA**. `_STA1` should therefore deviate only a little from the measured angle.

Prerequisite

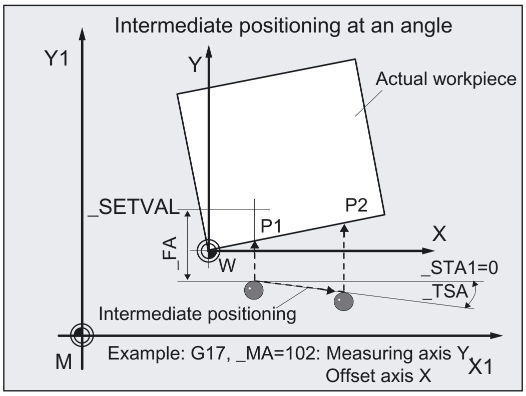
The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

Procedure with **`MVAR=00x105`**: Intermediate positioning at an angle

Position before measuring cycle call



The probe is positioned with respect to the surface to be measured in such a way that during traversal of the measuring axis `_MA` specified in the direction of the setpoint **_SETVALmeasuring point 1** on the surface will be reached.

Recommended distance from `_SETVAL: >_FA`.

The measuring operation then starts with the measuring feed at distance **_FA** in front of `_SETVAL`.

The absolute value of the positional deviation from the setpoint must not be greater than the measuring path `_FA`. Otherwise, no measurement will be performed.

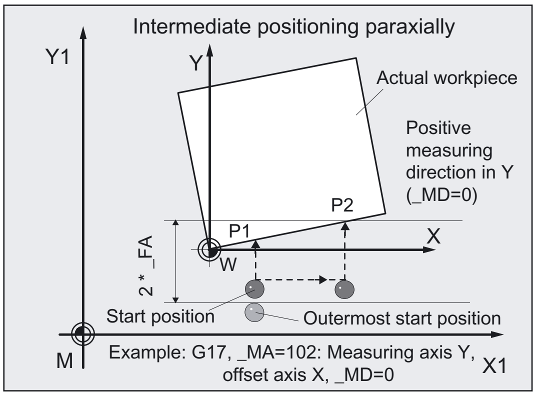
In the other two axes, the positions are retained for the measurement in measuring point 1 at the beginning of a cycle.

Intermediate positioning at an angle

The starting point for measurement 2 is approached at an angle. The angle comprises `_STA1` and `_TSA`. `_TSA` contains the value for a permissible angle deviation and leads away from the setpoint.

Procedure with MVAR=10x105: paraxial intermediate positioning

Position before measuring cycle call



The probe is positioned with respect to the surface to be measured in such a way that during traversal in the specified measuring axis _MA and direction of the measurement in _MD both measuring points on the surface within the total measurement path: 2 · _FA in mm is reached.

Otherwise, no measurement or complete measurement will result.

In the other two axes, the positions are retained for the measurement in measuring point 1 at the beginning of a cycle.

The starting point for measurement 2 is approached paraxially in the offset axis. Measuring point 2 is also approached with the measuring axis in direction _MD.

Position after end of measuring cycle

After the end of measurement, the probe is at the last measuring point at distance _FA from the measuring surface.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

Special procedure for differential measurement

The measuring point P1 is measured twice during differential measurement:

1. With spindle rotated through 180 degrees compared with the position at the beginning of the cycle (rotation of the probe by 180 degrees).
2. With the spindle position that applied at the beginning of the cycle.

The tool radius of the probe + R or - R is defined as the trigger point defined for the axis direction.

A multidirectional probe does not have to be calibrated at the beginning of the cycle for measuring variant _MVAR=1105.

This measuring variant with differential measurement is only useful with the measuring axes `_MA=x01` or `_MA=x02`.

NOTICE
In the case of great measurement accuracy demands, differential measurement is not recommended!

5.7.3 2-angle measurement

5.7.3.1 General information

Function

Using the measuring variants _MVAR=106 and _MVAR=100106
, it is possible to calculate and correct the angular position of a plane oblique in space on a workpiece by measuring three points. The angles refer to rotation about the axes or the active plane G17 to G19.

Otherwise, the same conditions apply as for simple angle measurement.

Additional data are required for the setpoint input of the 2nd angle. A ZO is implemented in the rotary part of the set ZO memory (coordinate rotation)

Parameter for 2-angle measurement

Parameter	Data type	Meaning
_MVAR	106	2-angle measurement and ZO determination, intermediate positioning at an angle
	1001106	2-angle measurement and ZO determination, intermediate positioning paraxially
_SETVAL	REAL, >0	Setpoint (axis position): Expected position on workpiece surface in measuring point P1 in the applicate (for _MVAR=106 only)
_STA1	REAL	Setpoint angle about 1st axis of the plane
_INCA	REAL	Setpoint angle about 2nd axis of the plane
_MD	0, 1	0: positive measuring direction 1: negative measuring direction (for _MVAR=100106 only)
_ID	REAL, >0	Distance between measuring points P1 and P2 in the 1st axis of the plane (abscissa)
_SETV[0]	REAL, >0	Distance between measuring points P1 and P3 in the 2nd axis of the plane (ordinate)
_KNUM	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (Individual values: see Parameter description section "Description of the most important defining parameters", Parameter _KNUM)

The following additional parameters are also valid:

_VMS, _CORA, _TSA, _FA, _PRNUM, _EVNUM and _NMSP

_CORA only relevant for monodirectional probe.

With _TSA, the difference of the angle is monitored and this value is additionally traversed to _STA1 with intermediate positioning at an angle. _TSA has the dimension unit degrees in this case!

See also

Variable measuring velocity: _VMS (Page 76)

Offset angle position: _CORA (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

5.7.3.2 Programming example 1

2-angle measurement with CYCLE998

(determining an oblique plane in space)

The task is to check the angular position of a machined oblique surface on a workpiece.

The result is taken from the result parameters _OVR[ ] for evaluation.

A measuring point 1 (P1) must be selected where P2 in the ordinate (with G17: Y axis) has the same value as P1 and the abscissa value (_ID) is positive. P3 must still have the same value in the abscissa (X axis in G17) as P1. The ordinate value (_SETV[0]) must be positive.

Positioning in the applicate must be performed as far as possible parallel with the oblique plane (set angle).

The machined oblique plane has set angle about Y: 12 degrees (_INCA) and about X: 8 degrees (_STA1), maximum deviation _TSA= 5 degrees.

Workpiece probe 1, used as tool **T9, D1**, is to be used.

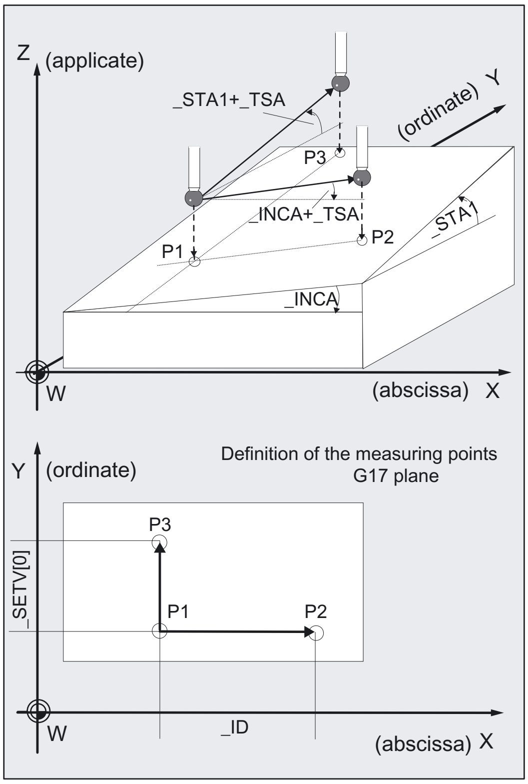
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.




```
%_N_INCLINEDMEAS_MPF
N10 G54 G17 G90 T9 D1                  ;Select T No. probe
N20 M6                                 ;Activate offsets
N30 X70 Y-10                           ;Position probe in X/Y plane above
                                       ;measuring point
N40 Z40                                ;Position Z axis at measuring point level
                                       ;and select tool offset
N60 _MVAR=106 _SETV[0]=30 _ID=40       ;Set parameters for measuring cycle call
_KNUM=0 _RA=0 _STA1=8 _INCA=12 _TSA=5
_PRNUM=1 _VMS=0 _NMSP=1 _FA=5 _EVNUM=0
N520 CYCLE998                          ;Measuring cycle for measuring the oblique
                                       ;plane
N530 G0 Z160                           ;Traverse up Z axis
N540 M30                               ;End of program
```

Explanation of example

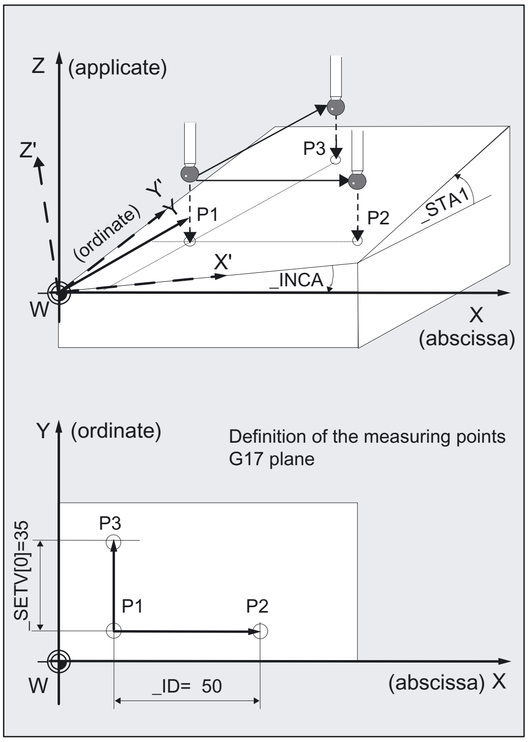
Both measured angles are entered in result field _OVR[ ]. A ZO correction is not applied (_KNUM=0).

5.7.3.3 Programming example 2

Orientation of an oblique workpiece surface for remachining using CYCLE800

Initial state

- The workpiece is clamped on the swivel table (swiveling workpiece holder) and aligned roughly paraxially to the machine axes.
- The swivel table is in its home position.
- The probe is in inserted as T9 and positioned in JOG approximately 20 mm above the front left corner of the workpiece to be set up.
- The scratch function is used to define the zero point of the ZO G56 at which the 2-angle measurement is to be performed and the G17 machining plane is defined as X0 Y0 Z20.



Exercise

Remachining will be performed with G57 active. The workpiece should be aligned so that for G17, the tool is located vertically on the previously inclined surface, the workpiece zero (G57) is the left-hand corner and the workpiece edges run in parallel to axes X and Y (G57). `CYCLE978` should be used to set the 3 edges. To determine the angle, `CYCLE998` (1 and 2 angle measurement).

```
%_N_PLANE_SETUP_MPF
N500 G56 G17 G90                        ;Select ZO and machining plane
N505 T9 D1                              ;Select probe
N506 M6                                 ;Activate tool compensation for probe
N510                                    ;Align swivel table
CYCLE800(1,"",0,57,0,0,0,0,0,0,0,0,
0,-1)
N520 $P_UIFR[4] = $P_UIFR[3]            ;Copy the data of ZO memory G56 to G57
                                        ;
```

`N530 G1 F500 X20 Y25`	`;Approach of the 1st MP for` `;2 angle measurement in the plane`
`N540 Z40`	`;Positioning height in Z, in which all 3 MPs` `;can be approached`

`N550 _VMS=0 _PRNUM=1 _TSA=20 _EVNUM=0`
`_NMSP=1 _FA=40 _STA1=0 _INCA=0`
`_MVAR=100106 _MD=1 _ID=50 _SETV[0]=35`
`_KNUM=4`
	`Measuring velocity 300 mm/min, data field 1`
	`;for probe, safe area 20°,`
	`;without empirical value, number of`
	`measurements`
	`;at same position =1, measurement path 40`
	`mm,`
	`;angles 1 and 2 = 0, 2 angle measurement`
	`with`
	`;paraxial positioning, measurement`
	`;in minus direction,`
	`:distance in X between MP1 and MP2 50 mm,`
	`;distance in Y between MP1 and MP3 35 mm,`
	`;ZO correction in G57`

`N560 CYCLE998`	`;Call measuring cycle`
`N570 G57`	`;Activate ZO G57`

`N580`
`CYCLE800(1,"",0,57,0,0,0,0,0,0,0,0,0,-`
`1)`
	`;Align swivel table, probe is`
	`;perpendicular above oblique surface`

`N590 X20 Y25`	`;Approach 1st MP in the plane`
`N600 Z20`	`;Lower in Z' about 20 mm above surface`

`N610 _MVAR=100 _SETVAL=0 _MA=3 _TSA=10`
`_FA=20 _KNUM=4`
	`;ZO determination on surface, setpoint 0,`
	`;meas. axis Z', safe area 10 mm,`
	`;meas. path 20 mm before and after expected`
	`;switching position, ZO correction in G57`

`N620 CYCLE978`	`;ZO determination on surface in Z' axis for` `;setting the zero in Z'`
`N625 G57`	`;Activate the changed` `;zero offset`
`N630 X20 Y-20`	`;Place in plane before the front edge`
`N640 Z-5`	`;Lower in Z' direction to align` `;the front edge in the X' direction`

`N650 _MVAR=105 _MA=102 _SETVAL=0 _RA=0`
`_STA1=0`
	`;Angle measurement measuring axis Y',`
	`displacement in`
	`;X' axis, distance between ;measuring points`
	`;50 mm offset in the ;rotation part of the`
	`;ZO memory G57, set ;angle between`
	`;edge and X' direction 0`

`N660 CYCLE998`	`;Angle measurement by measuring in Y' and`
	`;displacement between the 2 measuring`
	`;points`
	`;in ;X' with offset in G57`

`N665 G57`	`;Activate the changed ZO G57`
`N680 X20 Y-20`	
`N690 Z-5`	`;Position at measuring height before ;the` `front edge`

`N700 _MVAR=100 _MA=2 _SETVAL=0 _FA=10`	`;ZO determination on surface, meas. in`
	`;Y' direction, measurement path 10 mm in`
	`;front of to 10 mm behind expected edge`

```
N710 CYCLE978                       ;ZO determination on surface with meas.
                                    ;in +Y' direction and ZO in G57 for
                                    ;setting the zero in Y'
N720 G57                            ;Activate the changed ZO G57
N730 X-20 Y-20
N740 Y25                            ;Place in front of the left edge
N750 _MA=1                          ;Measure in +X'
N760 CYCLE978                       ;ZO determination on surface, measurement
                                    ;in ;+X' direction, and ZO correction in G57
                                    ;memory
                                    . Measurement path 10 mm in front of
                                    ;up to 10 mm behind expected edge to
                                    ;set zero in X‛
N770 G57                            ;Activate the changed ZO G57
N780 Z20                            ;Raise in Z
.                                   ;The oblique surface is now completely set
.                                   up
.
N1000 M2                            ;End of program
```

Comment about CYCLE800

The swivel cycle CYCLE800 is used to measure and operate on any surface by converting the active workpiece zero and the active tool offset to the oblique surface in the cycle by calling the relevant NC functions, taking account of the kinematic chain of the machine, and positioning the rotary axes.

Cycle CYCLE800 is not part of the "measuring cycle package" but of the "standard cycles".

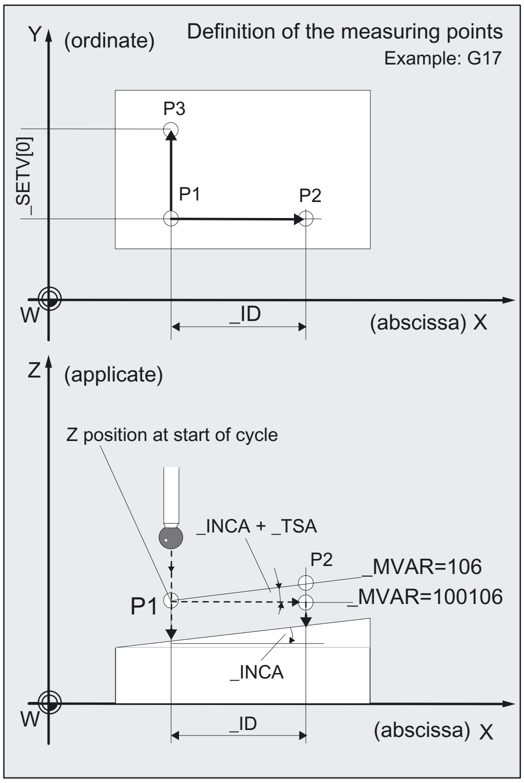
Explanation of example

- CYCLE998 (2 angle measurement) measures the oblique workpiece surface and an offset is entered in the rotation part of the ZO memory G57.
- After CYCLE800 has been called, axes X, Y, and Z and the rotary axes involved are positioned such that the probe is perpendicular above the oblique workpiece surface.
- Subsequent measurement with ZO in the –Z' direction with CYCLE978 zeroes the workpiece surface in the Z' direction.
- Determining the angular position of the front workpiece edge with respect to the X' direction and offset in the ZO memory G57 with CYCLE998 aligns the front edge paraxially with the X' direction.
- Then the workpiece zero is precisely defined in the plane by measuring with the ZO in the +X' direction and +Y' direction with CYCLE978.
- After that, remachining can begin on the setup surface.

5.7.3.4 Operational sequence

Position before measuring cycle call

Before the cycle is called, the probe must be positioned over the 1st measuring point (P1) in the plane and at the appropriate depth in the applicate. The measuring axis is always the applicate. Measuring point P1 must be selected in the plane such that _ID and _SETV[0] result in positive values.



Procedure for variant "intermediate positioning at an angle" (MVAR=106):

After completion of the measurement in P1 the probe is positioned at P2 in the abscissa and applicate (X and Z in G17) taking angle _INCA and maximum deviation in _TSA into account. After the measurement has been performed in P2, repositioning to P1 is performed by the same path. Then the probe is positioned from P1 to P3 in the ordinate and applicate (Y and Z in G17) taking account of angle _STA1 and maximum deviation in _TSA and then measured.

Procedure for variant "intermediate positioning parallel to axis" (MVAR=100106):

Positioning from P1 to P2 is performed in the abscissa, from P1 to P3 in the ordinate.

It must also be possible to reach P2 and P3 from starting position P1 in the applicate (in Z in G17) without collision.

Position after end of measuring cycle

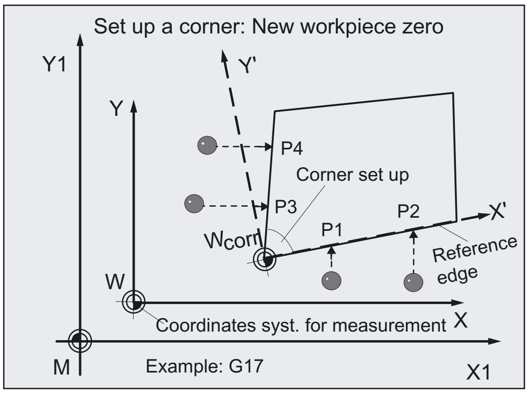
After completion of the measuring operation, the probe will always be amount _FA (MVAR=106) above the 3rd measuring point in the applicate or, if _ MVAR= 100106, at the initial height (positioning height).

5.8 CYCLE961 workpiece: Setup inside and outside corner

5.8.1 Function overview

Function

The cycle can measure the **position of an internal or external corner** of a workpiece in the selected plane with different measuring variants. The position of this corner can also be used as the workpiece zero in a defined zero offset (ZO).



In certain measuring variants an additional offset can be defined.

The measurements are performed with different specified values depending on the measuring variant used:

Specification of distances and angles

- The workpiece is a rectangle:

  3-point measurement
- Unknown workpiece geometry:

  4-point measurement

Specification of 4 points

- Unknown workpiece geometry:

  4-point measurement

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

When using the cycle on a turning machine: set type 5xy and _CBIT[14]=0.

Compensation of the zero offset

The ZO correction is applied in the **coarse offset**. If a fine offset is available (MD18600: MM_FRAME_FINE_TRANS=1), it is reset.

If _KNUM=0, there is no zero offset (ZO).

When _KNUM 0, the corresponding ZO for the abscissa and ordinate is calculated in such a way that the calculated corner point becomes the workpiece zero. The rotary component for the applicate (rotation about Z for G17) is offset in such a way that the workpiece coordinate system lies in the plane parallel to the reference edge.

Workpiece measuring probe type that can be used

Multidirectional probe (_PRNUM=xy)

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

Programming

```
CYCLE961
```

Measuring variants

Measuring cycle CYCLE961 permits the following measuring variants, which are specified via parameter _MVAR.

Value	Measuring variant
105	Setting-up an internal corner of a square/rectangle, specifying the angle and distances
106	Setting-up an external corner of a square/rectangle, specifying the angle and distances
107	Set up internal corner, specify angle and distances
108	Set up external corner, specify angle and distances
117	Set up internal corner, specify 4 points
118	Set up external corner, specify 4 points

Result parameters

Measuring cycle `CYCLE961` makes the following values available as results in the GUD5 data block:

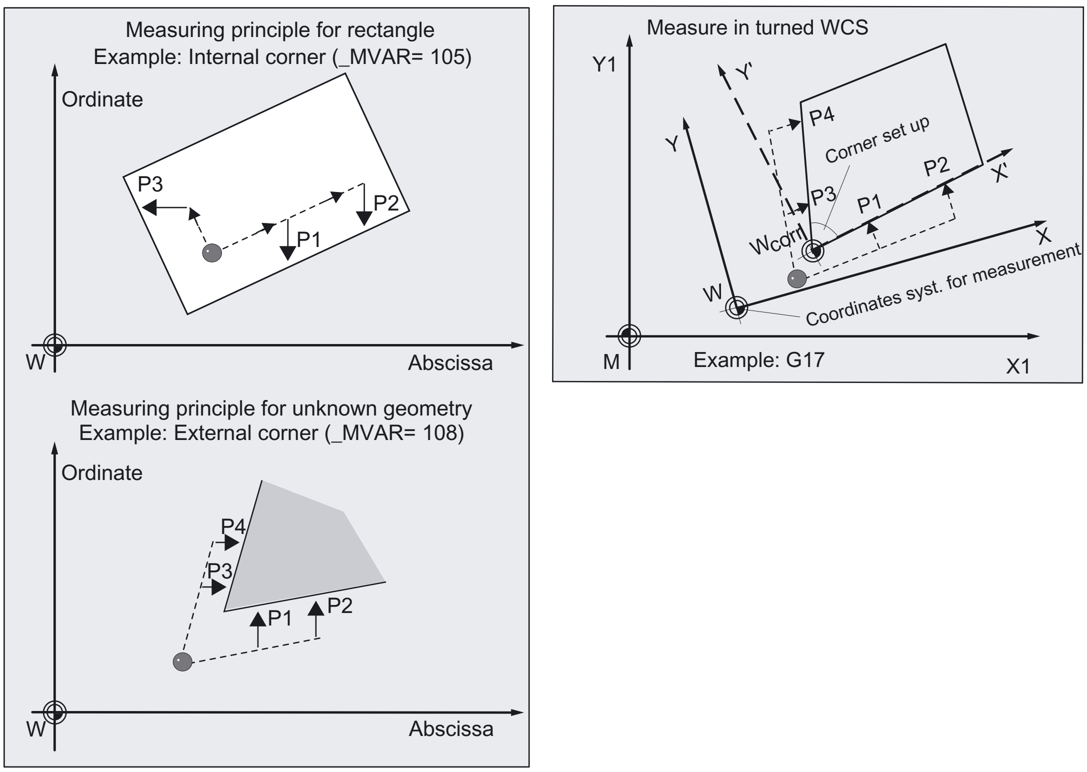
Parameter	Data type	Result
`_OVR [4]`	REAL	Angle to abscissa axis) in the workpiece coordinate system (WCS)
`_OVR [5]`	REAL	Actual value for corner point in abscissa in WCS
`_OVR [6]`	REAL	Actual value for corner point in abscissa in WCS
`_OVR [20]`	REAL	Angle to abscissa axis in the workpiece coordinate system (WCS)1)
`_OVR [21]`	REAL	Actual value for corner point in abscissa in MCS1)
`_OVR [22]`	REAL	Actual value for corner point in ordinate in MCS1)
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [3]`	INTEGER	Measuring variant
`_OVI [5]`	INTEGER	Probe number
`_OVI [9]`	INTEGER	Alarm number
1) Transformation deactivated, otherwise basic coordinate system		

5.8.2 Setting up a corner with definition of distances and angles

5.8.2.1 General information

Function

Using this measuring cycle and the **_MVAR=105, _MVAR=106** measuring variants, the internal and external corner of a **rectangle** can be measured and set up while using the **_MVAR=107, _MVAR=108** measuring variants, the internal and external corner of an **unknown workpiece geometry** can be measured and set up.



The cycle approaches either 3 (for a rectangle) or 4 measuring points (if workpiece geometry is not known) and calculates the point of intersection of the resulting straight lines and the angle of rotation to the positive abscissa axis of the current plane. If the workpiece geometry is known (rectangle), the corner to be calculated can be offset.

The result, the position of the corner, is stored as an absolute value in the specified ZO (offset and rotation) and in the result parameters _OVR[ ].

The measuring points are derived from the specified angle and distances. Measurement is performed paraxially to the existing workpiece coordinate system (WCS).

Note

When **setting up the internal corner,** the cycle only traverses in the plane at measuring height.

When **setting up the external corner**, the corner can either be **passed over** using the shortest path (lift in applicate) or **traveled around** in the plane.

Parameter

Parameter	Data type	Meaning
`_MVAR`	105	Set up internal corner of a rectangle (geometry known, 3 measuring points)
	106	Set up external corner of a rectangle (geometry known, 3 measuring points)
	107	Set up internal corner (geometry unknown, 4 measuring points)
	108	Set up external corner (geometry unknown, 4 measuring points)
`_FA`	REAL	Measuring path, only included if _FA larger than internally calculated
`_KNUM`	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (Individual values: see Parameter description section "Description of the most important defining parameters"., Parameter _KNUM)
`_STA1`	REAL	Approx. angle of posit. direction of the abscissa with respect to reference edge of the workpiece **in MCS**1) (accuracy: <10 degrees): • Negative value in clockwise direction • Positive value in counterclockwise direction
`_INCA`	REAL	Approximate angle between reference edge and 2nd edge of workpiece (precision: <10 degrees): • Negative value in clockwise direction • Positive value in counterclockwise direction
`_ID`	REAL	Incremental retraction of applicate when measuring external corner, used to travel around the corner, especially `_ID=0`: The corner is traveled around – not passed over.
`_SETV[0]`	REAL, >0	Distance between starting point and measuring point 2 in direction _STA1 (P1 is at _SETV[0] / 2)
`_SETV[1]`	REAL, >0	Distance between starting point and measuring point 4 in direction STA1+ INCA (P3 is at _SETV[1] / 2)
For measuring variants 105 and 106 only (rectangle):		
`_SETV[2]`	REAL	Offset of zero offset WCS (corrected) in abscissa
`_SETV[3]`	REAL	Offset of zero offset WCS (corrected) in ordinate

Parameter	Data type	Meaning	
`_SETV[4]`	REAL	Selection of offset:	
		Values:	1: Measured corner entered as zero point
			2: Measured corner is entered as zero point in abscissa offset by _SETV[2]
			3: Measured corner is entered as zero point in both axes offset by _SETV[2] (abscissa) and _SETV[3] (ordinate) .
			4: Measured corner is entered as zero point in ordinate offset by _SETV[3].
1) Transformation deactivated, otherwise basic coordinate system.			

The following additional parameters are also valid:

`_VMS, _PRNUM and _NMSP.`

See also

Variable measuring velocity: _VMS (Page 76)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

5.8.2.2 Programming example

Determination of the coordinates of an external corner of a workpiece

The coordinates of the external corner of a workpiece with unknown geometry are to be determined.

Zero offset G55 is to be corrected in such a way that this corner is workpiece zero for G55.

The reference edge lies approximately at _STA1=-35 and the 2nd edge approximately at _INCA= 80 degrees in addition. The distance to measuring points 2 and 4 is 100 mm.

The corner is to be passed over from P1 to P3 at distance _ID= 30 mm above measuring height.

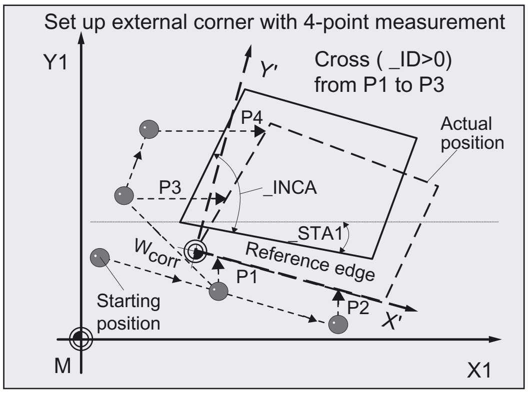
The starting point opposite the corner that is to be set up is reached before the measuring cycle is called.

Workpiece probe 1, used as tool **T9, D1**, is to be used.

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000



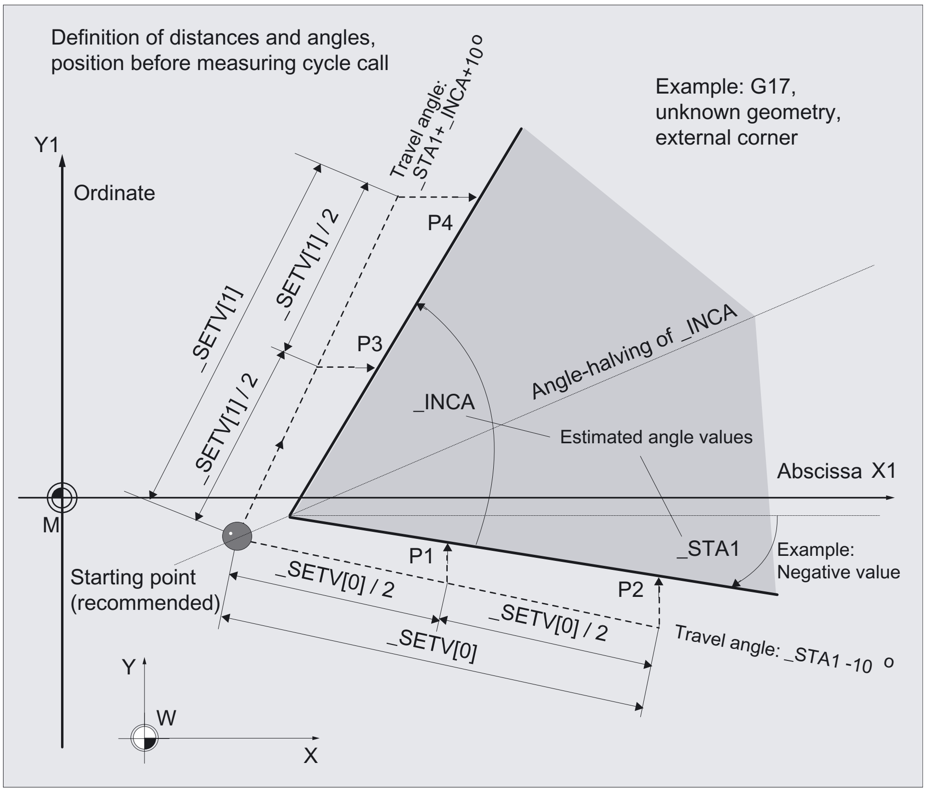
Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.

```
%_N_CORNER_SETUP_MPF
N10 G500 G17 G90 T9 D1                 ;Select probe, offset active
N20 _PRNUM=1 _VMS=0 _NMSP=1            ;The probe is in the start position,
N21 _MVAR=108 _FA=20 _KNUM=2 _STA1=-35 ;set parameters, e.g. by moving in JOG
_INCA=80 _ID=30 _SETV[0]=100           ;CYCLE961
_SETV[1]=100
N30 CYCLE961
N40 G55                                ;Call corrected ZO G55
N100 M2
```

5.8.2.3 Operational sequence

Defining distances and angles



Position before measuring cycle call

The probe is positioned at measuring depth opposite the corner to be measured. It must be possible to approach the measuring points from here without collision. The measuring points are derived from the programmed distance between the starting point and

_SETVAL[0] (measuring point 2) or

_SETVAL[1] (meas. point 4) in direction of angle _STA1, _INCA.

The starting points for measuring point 1 and 3 are each located at half the distance.

Measurement is performed paraxially with the existing workpiece coordinate system.

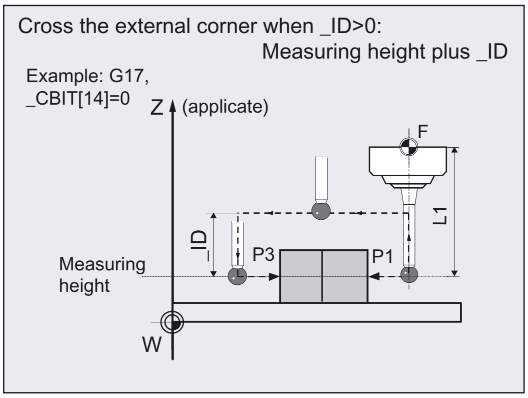
_STA1 refers to the machine coordinate system.

The measuring cycle generates the required traversing blocks and performs the measurements at the measuring points.

During travel an additional tolerance angle of 10 degrees is added to the programmed angles in the cycle.

First measuring point P 2, then P 1, P 3, and depending on parameterization, P 4 is approached.

Traversing between P 1 and P 3 on outside edge:



- _ID=0:

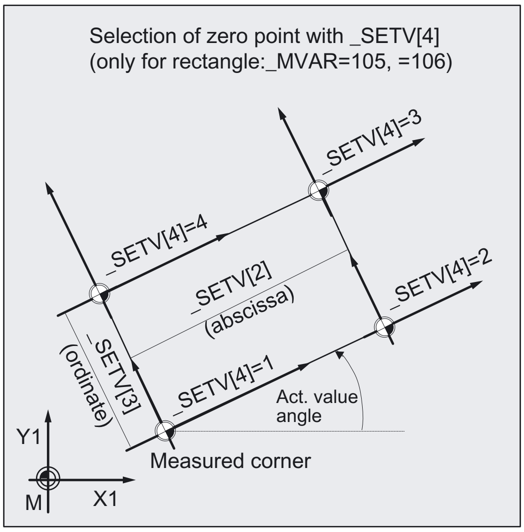
  The corner is traveled around.
- _ID>0:

  For P 1, after the measurement, is raised by _ID in the applicate and P 3 is approached via corner.

Position after end of measuring cycle

The probe is again positioned at the starting point (at measuring depth opposite the measured corner).

Selection of offset with _SETV[4]



With measuring variants MVAR=105, =106 (rectangle) the measured corner can be selected offset as workpiece zero.

The offset is specified in _SETV[2] (abscissa) and _SETV[3] (ordinate).

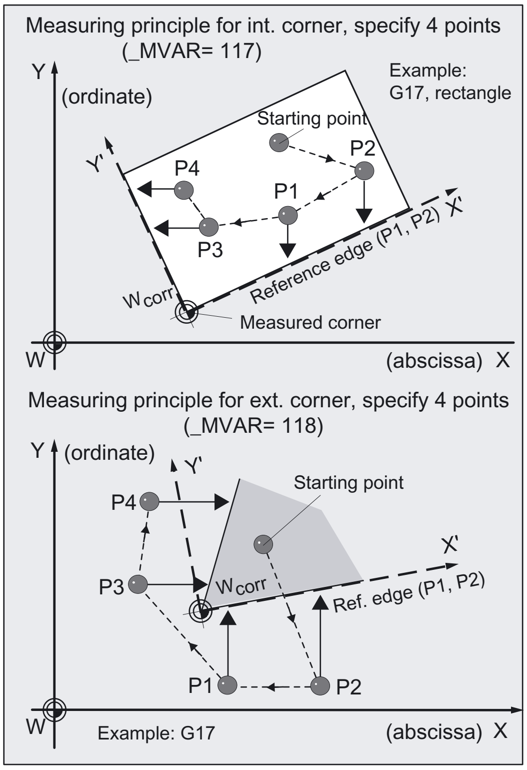
_SETV[4] can assume values 1 to 4.

5.8.3 Setting up a corner with 4 points

5.8.3.1 General information

Function

Using this measuring cycle and the **_MVAR=117, _MVAR=118** measuring variants, the internal and external corner of an **unknown workpiece geometry** can be measured and set up.



One after the other, points **P2**, P1, P3, P4 are traversed in the cycle with positioning feedrate at positioning height. At each of these points the probe is lowered to measuring depth and then traversed at measuring feedrate parallel to the axis against the workpiece corner.

The cycle uses the relative positions of points P1 to P4 to determine the approach directions and the measuring axis. The cycle calculates the corner point and the angle between the reference edge and the positive abscissa axis of the current plane from the results of measurement.

The **angle** is calculated by measuring **P2 and P1** (reference edge).

The position of corner, corner point coordinates, and rotation are stored in result parameter _OVR[ ].

If _KNUM>0, absolute correction to the coarse offset in the specified ZO (translation and rotation) is performed.

The measuring points are derived from the specified 4 points. Measurement is performed paraxially to the existing workpiece coordinate system (WCS).

Parameter

Parameter	Data type	Meaning
`_MVAR`	117	Set up internal corner, specify 4 points
	118	Set up external corner, specify 4 points
`_FA`	REAL	Measurement path
`_KNUM`	0, >0	0: without automatic ZO correction >0: with automatic ZO correction (Individual values: see Parameter description section "Description of the most important defining parameters"., Parameter _KNUM)
`_ID`	REAL	Incremental infeed in applicate for measuring depth
`_SETV[0]`	REAL	Abscissa P1 in active WCS
`_SETV[1]`	REAL	Ordinate P1 in active WCS
`_SETV[2]`	REAL	Abscissa P2 in active WCS
`_SETV[3]`	REAL	Ordinate P2 in active WCS
`_SETV[4]`	REAL	Abscissa P3 in active WCS
`_SETV[5]`	REAL	Ordinate P3 in active WCS
`_SETV[6]`	REAL	Abscissa P4 in active WCS
`_SETV[7]`	REAL	Ordinate P4 in active WCS

The following additional parameters are also valid:
`_VMS, _PRNUM, and _NMSP.`

See also

Variable measuring velocity: _VMS (Page 76)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

5.8.3.2 Programming example

Determination of coordinates of the corner of a workpiece with subsequent ZO offset

The coordinates of the corner of a workpiece are to be determined by outside measurement. ZO G55 must be corrected in such a way that the corner point is workpiece zero when G55 is selected.

Measurement is performed in plane G17 with active G54. The values in mm of the coordinates of points P1…P4 from which the workpiece can be approached parallel to the axis are:

- P1.x=50 P1.y=20
- P2.x=150 P2.y=20
- P3.x=15 P3.y=40
- P4.x=15 P4.y=80

The probe is to be positioned at a height of 100 mm. The measuring depth is 60 mm lower.

The workpiece corner is expected to be at a distance less than 200 mm at each point (_FA=100 [mm]).

Workpiece probe 1, used as tool **T9, D1**, is to be used.

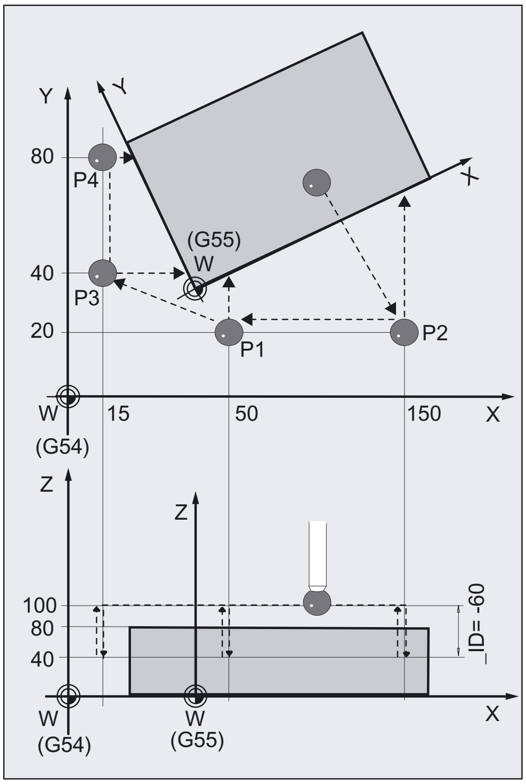
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.

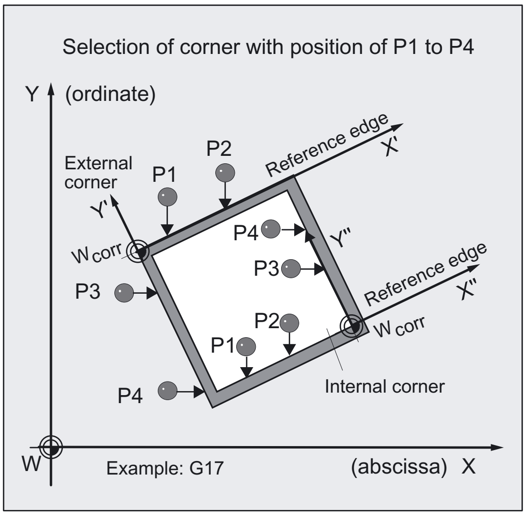


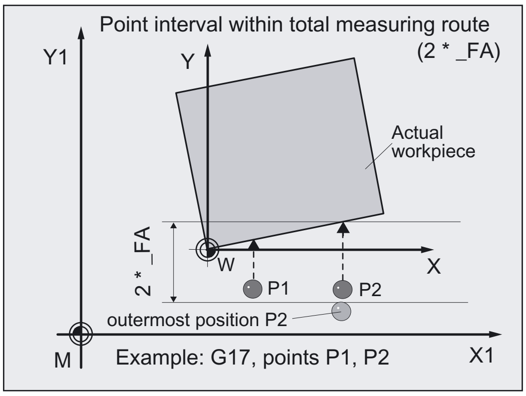
```
%_N_CORNER_SETUP_1_MPF
N10 G54 G17 G90 T9 D1                  ;Select ZO, plane, probe, …
N20 G0 Z100                            ;Position probe at positioning height
N30 X100 Y70                           ;Position probe in X/Y plane above
                                       ;workpiece
N50 _MVAR=118 _SETV[0]=50 _SETV[1]=20  ;Measuring variant for external corner
_SETV[2]=150 _SETV[3]=20 _SETV[4]=15   ;coordinates of P1 to P4
_SETV[5]=40 _SETV[6]=15 _SETV[7]=80    ;Measurement path 100 mm to expected edge
_ID=-60                                ;(max. measurement path =200 mm)
N51 _VMS=0 _NMSP=1 _PRNUM=1 _FA=100
_KNUM=2
N60 CYCLE961                           ; Cycle call
N70 G55                                ;Call corrected ZO G55
N80 G0 X0 Y0                           ;Position probe in X/Y plane above
                                       ;corner (new zero point)
N100 M2                                ;End of program
```

5.8.3.3 Operational sequence

Defining the 4 points

The position of points P1 and P2 in relation to each other determines the direction of the abscissa axis (X axis in G17) of the new coordinate system. A negative offset between P1 and P2 in the abscissa (X axis in G17) results in an additional rotation about 180°!





The position of the corner is selected with all 4 points. So for a rectangle, for example, different corners can be selected as the zero point depending on whether measuring variant internal or external corner is applied.

The individual points or _FA must be selected such that the contour is reached within a

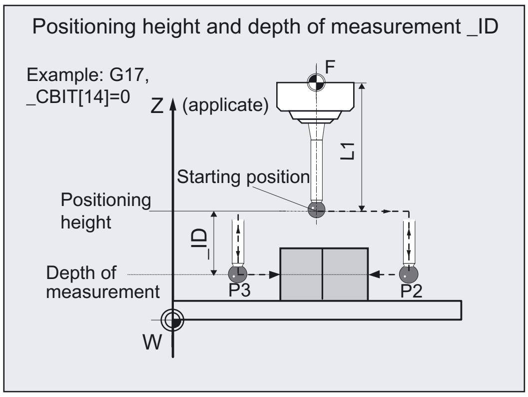
Total measuring path: 2 · _FA in mm

is reached.

Otherwise, no measurement will be performed.

A minimum total measurement path of 2 · 20 mm is produced within a cycle.

Position before measuring cycle call



The probe is above the workpiece at positioning height. It must be possible to reach all points without collision.

The measuring cycle generates the traversing blocks and performs the measurements at the measuring points from points P1 to P4. The measuring depth is derived from the positioning height lowered by the value in **_ID** (negative prefix). After measurement at one point the probe is again raised to positioning height and traversed to the next point and then lowered again to measuring depth.

Point **P2** is approached first, followed by P1, P3, and P4.

Position after end of measuring cycle

The probe is at the positioning height at point P4.

5.9 CYCLE997 workpiece: Measuring a sphere and ZO determination

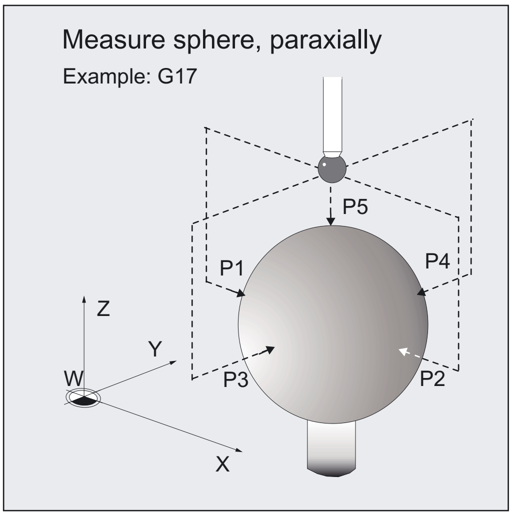
5.9.1 Function overview

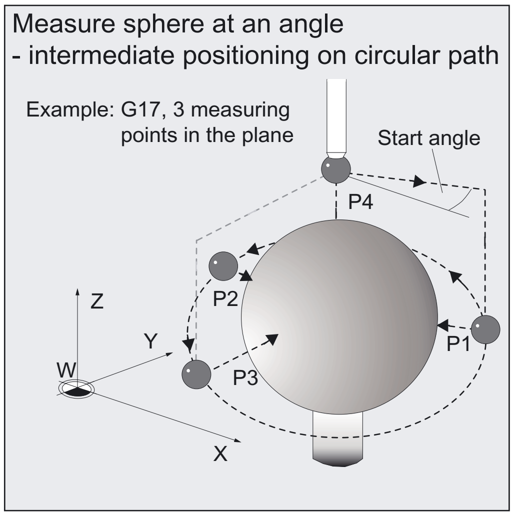
Function

With measuring cycle `CYCLE997`, different measuring variants can be used to measure

- a sphere or
- 3 equal sized spheres, fixed to a common base (workpiece),

.





Measurements can be performed **paraxially** with the workpiece coordinates system (WCS) **or at an angle** in the plane.

The center point (position of sphere) is derived from 4 or 5 measuring points around the circumference with a known diameter. With an additional measurement the diameter can also be determined.

Intermediate positioning for measuring points P1 to P3 and P4 (determining circle in plane) is performed with measuring variant "at an angle" on a circular path, otherwise parallel with the axis.

Positioning in the infeed axis and between the spheres is always a linear movement.

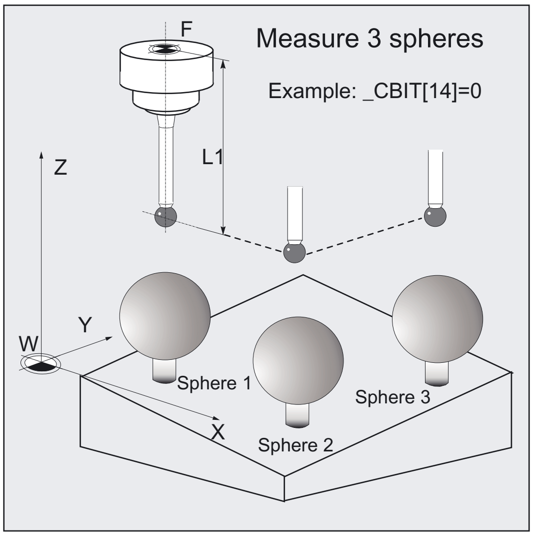
`CYCLE997` can measure the sphere and in addition automatically correct a **zero offset (ZO)** on the basis of the position of the center of the sphere.

With "Measure 3 spheres" the angles in space of the sphere grouping can also be determined.

The target of the ZO compensation can be selected with _KNUM.

Workpiece measuring probe type that can be used

Multidirectional probe (_PRNUM=xy)



Measurement is performed in all three coordinate axes.

Different lengths can be specified for the probe in _CBIT[14]:

- _CBIT[14]=0: L1 referred to the probe ball center
- _CBIT[14]=1: L1 referred to circumference of probe ball center

In measurement the same setting as for calibration of the workpiece probe must be used.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane, orientation of the spindle in the plane and measuring velocity are the same for both measurement and calibration. Deviations can cause additional measuring errors.

Prerequisite

The probe must be called as a tool with a tool length offset.

Tool type, preferably: 710

For "Measuring at an angle" (_MVAR=xx1109) the probe must have been calibrated with "Determine active probe ball diameter".

Calibration with an additional "Determine position deviation" improves the measuring precision.

In ZO (frame) the approximate values for the position of the spheres in offset and rotation are entered and activated.

Only small deviations are expected.

The sphere diameter must be much larger than the probe ball diameter.

Important

The user must select measuring points for the particular measuring variant such that during measurement or intermediate positioning a collision with a sphere fixture or other obstacle is ruled out.

Programming

```
CYCLE997
```

Measuring variants

Measuring cycle CYCLE997 permits the following measuring variants which are specified via parameter _MVAR.

Digit							Measuring variant
7	6	5	4	3	2	1	
				1		9	Measuring a sphere and ZO determination
					0		No measurement repetition
					1		With measurement repetition (with derived values)
			0				Measurement paraxial (to axes of the WCS)
			1				measurement at an angle (intermediate positioning on circular path)
		0					Measure 1 sphere
		1					Measure 3 spheres
	0		1				3 circular measuring points (for "Measuring at an angle" only)
	1		1				4 circular measuring points (for "Measuring at an angle" only)
0							Without diameter determination (ball diameter known)
1							With diameter determination

Result parameters

Measuring cycle `CYCLE997` makes the following values available as results in the GUD5 data block::

Parameter	Data type	Result
`_OVR [0]`	REAL	Setpoint sphere diameter, 1st sphere
`_OVR [1]`	REAL	Setpoint center point coordinate abscissa 1st sphere
`_OVR [2]`	REAL	Setpoint center point coordinate ordinate 1st sphere
`_OVR [3]`	REAL	Setpoint center point coordinate applicate 1st sphere
`_OVR [4]`	REAL	Actual value sphere diameter 1st sphere
`_OVR [5]`	REAL	Actual value center point coordinate abscissa 1st sphere
`_OVR [6]`	REAL	Actual value center point coordinate ordinate 1st sphere
`_OVR [7]`	REAL	Actual value center point coordinate applicate 1st sphere
`_OVR [8]`	REAL	Difference sphere diameter 1st sphere
`_OVR [9]`	REAL	Different center point coordinate abscissa 1st sphere

Parameter	Data type	Result
_OVR [10]	REAL	Difference center point coordinate ordinate 1st sphere
_OVR [11]	REAL	Difference center point coordinate applicate 1st sphere
_OVR [12]	REAL	Actual value sphere diameter 2nd sphere 1)
_OVR [13]	REAL	Actual value of center point coordinates for abscissa 2nd sphere 1)
_OVR [14]	REAL	Actual value of center point coordinates for ordinate 2nd sphere 1)
_OVR [15]	REAL	Actual value of center point coordinates for applicate 2nd sphere 1)
_OVR [16]	REAL	Difference for sphere diameter 2nd sphere 1)
_OVR [17]	REAL	Difference for center point coordinates for abscissa 2nd sphere 1)
_OVR [18]	REAL	Difference for center point coordinates for ordinate 2nd sphere 1)
_OVR [19]	REAL	Difference for center point coordinates for applicate 2nd sphere 1)
_OVR [20]	REAL	Actual value sphere diameter 3rd sphere 1)
_OVR [21]	REAL	Actual value of center point coordinates for abscissa 3rd sphere 1)
_OVR [22]	REAL	Actual value of center point coordinates for ordinate 3rd sphere 1)
_OVR [23]	REAL	Actual value of center point coordinates for applicate 3rd sphere 1)
_OVR [24]	REAL	Difference for sphere diameter 3rd sphere 1)
_OVR [25]	REAL	Difference for center point coordinates for abscissa 3rd sphere 1)
_OVR [26]	REAL	Difference for center point coordinates for ordinate 3rd sphere 1)
_OVR [27]	REAL	Difference for center point coordinates for applicate 3rd sphere 1)
_OVR [28]	REAL	Safe area
_OVI [0]	INTEGER	ZO number
_OVI [2]	INTEGER	Measuring cycle number = 997
_OVI [5]	INTEGER	Probe number
_OVI [9]	INTEGER	Alarm number
_OVI [11]	INTEGER	Status offset request
_OVI [12]	INTEGER	Additional error information on alarm output, internal measurement evaluation
1) for measuring variants _MVAR=x1x1x9, only, measure 3 spheres		

Parameter

Parameter	Data type	Meaning
_SETVAL	REAL	Setpoint sphere diameter
_SETV[0]	REAL	Setpoint center abscissa – 1st sphere
_SETV[1]	REAL	Setpoint center ordinate – 1st sphere
_SETV[2]	REAL	Setpoint center applicate – 1st sphere
_SETV[3]	REAL	Setpoint center abscissa – 2nd sphere 1)
_SETV[4]	REAL	Setpoint center ordinate – 2nd sphere 1)
_SETV[5]	REAL	Setpoint center applicate – 2nd sphere 1)
_SETV[6]	REAL	Setpoint center abscissa – 3rd sphere 1)
_SETV[7]	REAL	Setpoint center ordinate – 3rd sphere 1)
_SETV[8]	REAL	Setpoint center applicate – 3rd sphere 1)

Parameter	Data type	Meaning
_RF	REAL	Velocity for intermediate paths on circular path (G2 or G3) (for _MVAR=xx11x9, – "Measuring at an angle" only)
_KNUM	0, >0	0: without automatic ZO compensation >0: with automatic ZO compensation (Individual values: see Parameter description section "Description of the most important defining parameters"., Parameter _KNUM)
_STA1	REAL	Starting angle (for _MVAR=xx11x9, – "Measuring at an angle" only)
_INCA	REAL	Stepping angle (for _MVAR=xx11x9, – "Measuring at an angle" only)
_TNVL	REAL	Limit value for distortion of triangle (sum of deviations) ZO is only corrected if the calculated distortion is below this limit value. (for _MVAR=x1x1x9 – "Measuring 3 spheres" and _KNUM>0 only)
1) for measuring variant _MVAR=x1x1x9, only, measure 3 spheres		

The following additional parameters are also valid:

_FA, _TSA, _VMS, _PRNUM and _NMSP

See also

Measurement path: _FA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Variable measuring velocity: _VMS (Page 76)

Probe type, probe number: _PRNUM (Page 79)

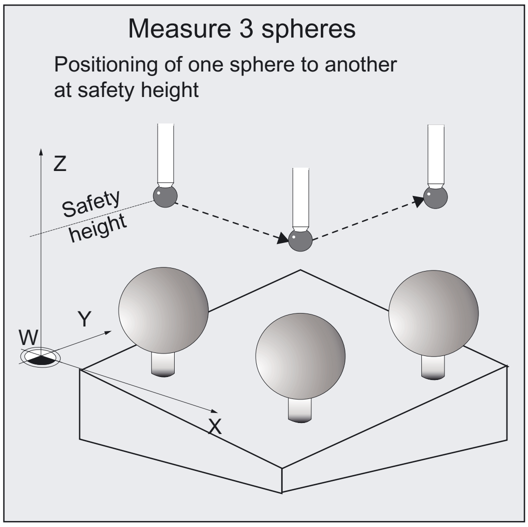
Multiple measurement at the same location: _NMSP (Page 81)

5.9.2 Measurement and ZO determination

5.9.2.1 General information

Measurement and calculation strategy

At the beginning of the cycle the probe must be in the infeed axis at safety height. It must be possible to reach all spheres from here without collision.



The cycle starts with measurement of the 1st sphere. Active G17 to G19 defines the plane with abscissa, ordinate. The applicate is the infeed axis.

4 or 3 measuring points are approached at the height of the center point setpoint of the applicate. The actual center point of the circle in the plane is calculated internally from these measured values (center of sphere in plane). For measurement "at an angle" the auxiliary cycle `CYCLE116` is used for calculation.

The last measuring point is located exactly above the calculated sphere center in the plane and is approached using the applicate as the measuring axis.

The actual **sphere center point** in abscissa, ordinate, applicate is calculated from all these measuring point.

If measuring variant "Measuring 3 spheres" is selected with _MVAR, these spheres are then measured in the order sphere 2, sphere 3 in the same way.

Selecting the measuring variant

With variant "Measure at angle" (_MVAR=0x1109) fast calculation of the sphere position is possible if the sphere diameter is known (low number of measuring points and few intermediate positioning actions)

"Paraxial measurement" (_MVAR=0x0109) always requires 5 measuring points with more intermediate positioning actions.

In both types of measurement it is possible to **repeat measurement** with the located sphere center point (_MVAR=xxx119). Repeating measurement improves the measuring result.

It is also possible to calculate the **sphere diameter** (_MVAR=10xx1x9). In this case an additional measurement is taken parallel to the axis in the plus direction of the abscissa at the height of the sphere center calculated in the first measurement. Calculation of the sphere diameter and measurement repetition can be combined (_MVAR=10xx119). Here the diameter is calculated after each position measurement.

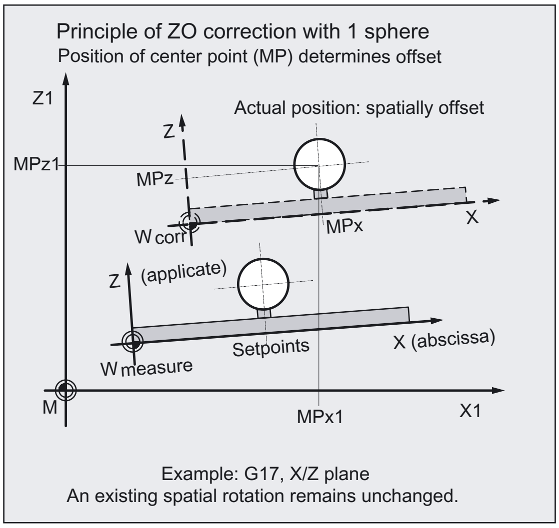
Safe area

All setpoint/actual differences are checked for compliance with the safe area (parameter _TSA). If this value is exceeded, alarm message "61303 safe area exceeded" appears and an NC-RESET is needed.

Measurement is then canceled.

If _CBIT[0]=1 the measurement is first repeated.

ZO compensation during measurement of one sphere only (_MVAR=x0x1x9):



The actual value/setpoint differences of the center point coordinates are included the calculation of the translatory component of the ZO. The offset acts such that the calculated sphere center point in the offset ZO includes the specified setpoint position (workpiece coordinates, three axes).

The offset is applied to the ZO number as defined in _KNUM. When KNUM=0, there is no offset. No scaling factors must be active in the ZOs / frames.

Settings in _CHBIT[21]:

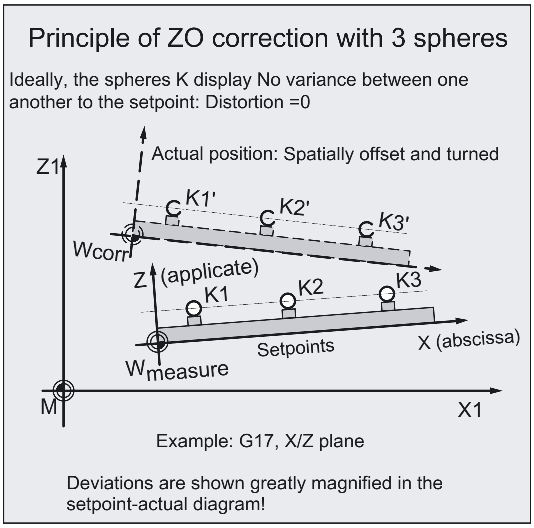
You can set whether a ZO compensation should be FINE or COARSE in the translation component.

- _CHBIT[21]=0:

  Offset is additive in FINE (if FINE is available as set in the MD, otherwise in COARSE).
- _CHBIT[21]=1:

  Offset is COARSE, FINE is included in calculation and then reset (if FINE is available as set in the MD).

ZO compensation during measurement of 3 spheres (_MVAR=x1x109):



Compensation of the entire active frame with its translational and rotary components is performed after 3 spheres have been measured with cycle `CYCLE119` (see following section).

No mirroring or scaling factor may be active.

The offset acts such that the triangle formed by the 3 sphere center points includes the specified setpoint center positions (workpiece coordinates). The sum of the deviations of the spheres in relation to each other (distortion) must lie within the value in `_TNVL`. Otherwise no offset is performed and an alarm is output.

Offset compensation is always performed in COARSE (as described for _CHBIT[21]=1).

Note

In this measuring variant (Measure 3 spheres) compensation in an NCU-global basic frame is not possible (_KNUM=1051 to 1066). This frame has no rotation component.

5.9.2.2 Operational sequence

Position before measuring cycle call

Before measuring cycle CYCLE997 is called the probe must be positioned at safety height above the set sphere center point (setpoints in _SETV[...]) of the 1st sphere.

General

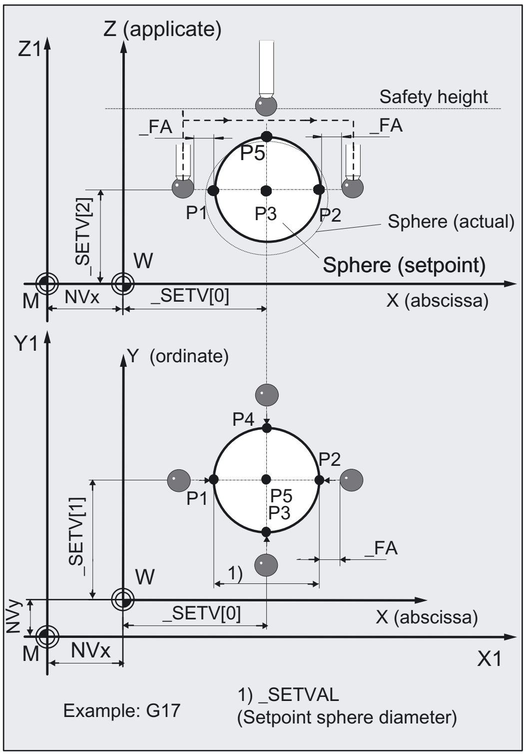
The measuring cycle generates the travel movements for approaching the measuring points itself and executes the measurements according to the selected measuring variant.

Note

The value selected for parameter _FA should be so large that all spheres can be reached within total measurement path 2 · _FA.

Otherwise, no measurement will be performed or they will be incomplete.

Next process for measuring variant "Paraxial measurement" (_MVAR=x01x9):



All intermediate positioning actions and measurement movements are paraxial with the active workpiece coordinate system. The measuring points are approached at distance _FA from the sphere lateral surface (setpoint sphere diameter). Measuring point P1 is approached first. After positioning in the abscissa, ordinate, the applicate is lowered to the height of the center point setpoint and the 1st measurement is taken Then P2 to P4 are approached and measured parallel to the axis.

P2 is approached via positioning of the applicate at distance _FA above the sphere (setpoint diameter) and lowering to measuring height again (setpoint center point of applicate). P3 and P4 are approached in the same way.

P3 and P4 lie at the center derived from P1 and P2 (actual value center point of abscissa).

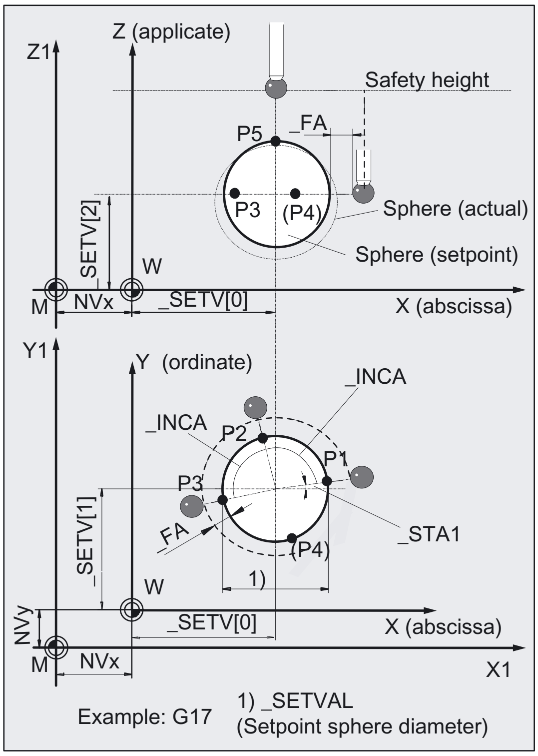
The applicate is positioned from P4 to a distance _FA above the sphere and then approached in the abscissa, ordinate of the calculated actual value point (P5). The last measurement is taken: in the minus direction of the applicate.

After this measurement, the applicate is positioned to safety height (height as beginning of the cycle).

When 3 spheres are measured, the abscissa, ordinate are positioned toward the **set center point of the next sphere**. Procedure continues as above.

No sphere fixture or other obstacle must be located in this entire traversing range. It may be necessary to select this measuring variant with intermediate positioning on a circular path (_MVAR=xx1109). The position and number of measuring points is then variable.

Next process for measuring variant "Measurement at an angle" (_MVAR=x11x9):



With _STA1 (starting angle) the angle position of P1 is defined, with _INCA, the incremental angle after P2 and then after P3. If the measuring variant is selected with 4 measuring points on a circle (_MVAR=1x1109), _INCA is also valid from P3 to P4.

The measuring points are approached at distance _FA from the sphere lateral surface (setpoint sphere diameter). Measuring point P1 is approached first. After joint positioning of abscissa and ordinate, the applicate is lowered to the height of the center point setpoint of the applicate and the 1st measurement is taken radially in the direction center point setpont abscissa/ordinate.

Then P2 to P3 and P4 are measured on a circular path with feedrate _RF and measured in the same way as P1.

The applicate is positioned from P4 or P3 to a distance _FA above the sphere and then approached in the abscissa and ordinate of the calculated actual value point (P5). The last measurement is taken: in the minus direction of the applicate.

After this measurement, the applicate is positioned to safety height (height as beginning of the cycle).

When 3 spheres are measured the abscissa and ordinate are positioned simultaneously toward measuring point P1 of the next sphere and continued as described above.

No sphere fixture or other obstacle must be located in this entire traversing range.

The sum of the starting angle _STA1 and all incremental angles _INCA may not exceed 360 degrees.

Position after end of measuring cycle

At the end of the cycle the probe is located above the first calculated actual center point of the 3rd or only sphere at safety height (height same as at beginning of cycle).

5.9.3 Programming example CYCLE997

Determining positional deviations in space

Three spheres each with a diameter of 50 mm are measured. Sphere center points 1 to 3 are expected for (X,Y,Z)=(100, 100, 100), (600, 100, 100) and (1100, 1100, 100).

ZO compensation of the active frame is to be performed in accordance with the measured values. The exact diameter of the sphere is known.

A measured sphere lateral surface with a maximum deviation of ± 5 mm is expected
(--> _FA=5).

Fixture of workpiece (ZO) with G54: NVx, NVy, NVz

Workpiece probe 1, used as tool **T9, D1**,is to be used.

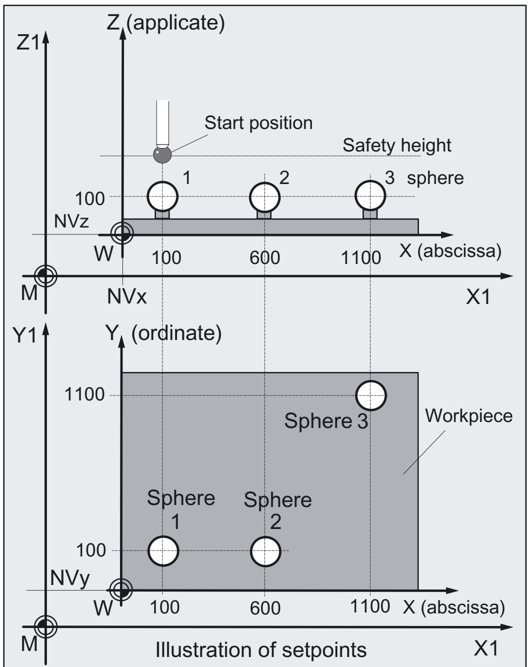
The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

Careful when positioning! Radius R in length (L1) is ignored.



In its actual position, the workpiece with 3 spheres clamped in a spatially offset and turned position. The variances are measured and the ZO corrected.

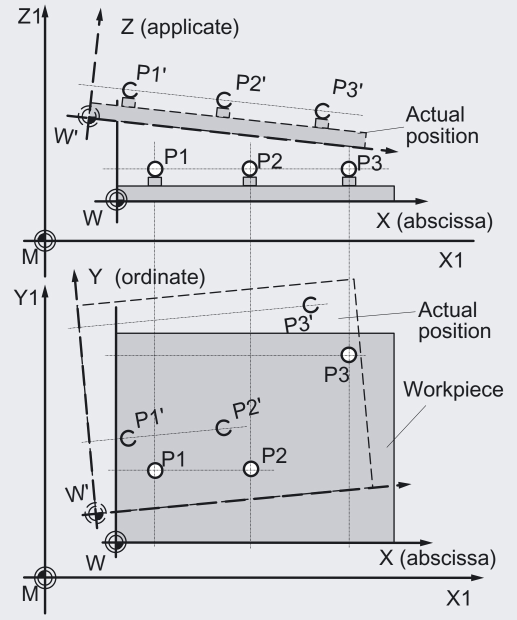
```
%_N_ DETERMINE_KS _MPF
N10 G17 G54                           ;X-Y plane, active ZO
N20 T20 D1                            ;Select and activate
                                      ;probe with tool offset D1 (M6)
N30 G0 G90 Z200                       ;Approach position Z at safety height
N40 X100 Y100                         ;Approach position X, Y of 1st sphere
N50 _SETVAL=50                        ;Set setpoint parameters for measuring cycle
_SETV[0]=SET(100,100,100, 600, 100,   call
100,1100, 1100, 100)                  ;
N60 _MVAR=010109 _KNUM=9999 _TNVL=1.2 ;Measure 3 spheres parallel to axis
                                      ;Offset in active frame,
                                      ;The offset is applied only if
                                      ;calculated distortion is less than 1.2 mm
N70 _VMS=200 _NMSP=1 _FA=5 _PRNUM=1   ;Measuring velocity 200 mm/min
                                      ;Measurement at same measuring point
                                      ;Measurement path 5 mm in front of to 5 mm
                                      behind
                                      ;setpoint position (sphere lateral surface),
                                      ;Probe array _WP[0.0....9]
N100 CYCLE997                         ;Call measuring cycle
...
N200 M2                               ;End of program
```

5.9.4 CYCLE119: Arithmetic cycle for determining position in space

5.9.4.1 General information

Function

This auxiliary cycle calculates the deviations in position and angle to the active frame from 3 defined setpoint positions in space (reference triangle) and 3 actual positions, and corrects a selected frame if necessary.



3 linked points P1 to P3 (triangle) are positioned spatially offset and turned: P1', P2', P3'

CYCLE119 is called as a subroutine by measuring cycle CYCLE997.

To allow this cycle to be used universally, its data are transferred via parameters.

Programming

```
CYCLE119(_SETPOINT,_MEASPOINT,_ALARM,_RES,_REFRAME,_COR,_RESLIM)
```

Parameter

<table>
<tr><th>Input data</th><th>Data type</th><th colspan="2">Meaning</th></tr>
<tr><td>_SETPOINT[3,3]</td><td>REAL</td><td colspan="2">Field for 3 setpoint positions in the sequence 1st, 2nd, 3rd, geometry axis (X, Y, Z)
These points are the reference triangle.</td></tr>
<tr><td>_MEASPOINT[3,3]</td><td>REAL</td><td colspan="2">Field for 3 setpoint positions measured in the sequence 1st, 2nd, 3rd, geometry axis (X, Y, Z). This is the real position in space of the described triangle.</td></tr>
<tr><td rowspan="7">_COR</td><td rowspan="7">INTEGER</td><td colspan="2">Offset</td></tr>
<tr><td rowspan="6">Values :</td><td>0: No compensation</td></tr>
<tr><td>1...99: ZO compensation in G54...G57, G505..G599</td></tr>
<tr><td>1000: ZO compensation of last active channel basic frame according to MD 28081</td></tr>
<tr><td>1011 to 1026: ZO compensation in channel basic frame</td></tr>
<tr><td>2000: ZO compensation in scratch system frame $P_SETFR</td></tr>
<tr><td>9999: ZO compensation in active frame, settable frame G54...G57, G505...G599 and/or with G500 in last active basic frame according to $P_CHBFRMASK</td></tr>
<tr><td>_RESLIM</td><td>REAL</td><td colspan="2">Limit value for distortion (only relevant, if _COR >0)
If _RES is below this limit value, OZ is corrected,
otherwise an alarm is output.</td></tr>
</table>

The results of calculation are stored in these transfer parameters.

<table>
<tr><th>Output data</th><th>Data type</th><th colspan="2">Meaning</th></tr>
<tr><td>_ALARM</td><td>INTEGER</td><td colspan="2">Cycle alarm number for feedback
(transfer value must be 0 on cycle call).</td></tr>
<tr><td rowspan="3">_RES</td><td rowspan="3">REAL</td><td colspan="2">Result of calculation</td></tr>
<tr><td rowspan="2">Values :</td><td>< 0: No frame was calculated An alarm (_ALARM > 0) is returned.</td></tr>
<tr><td>≧0: Calculation was successful. The size of the value a measure of the distortion of the triangle, for example, by measurement inaccuracies. It is the sum of the variances of the individual points in mm.</td></tr>
<tr><td>_REFRAME</td><td>FRAME</td><td colspan="2">Result frame, difference from actual frame
If this result frame is linked to the active frame, the measured triangle position is given the desired
setpoint position (workpiece coordinates).</td></tr>
</table>

Note

Correction

The frame to be corrected must not contain any mirroring or scaling factors. If no channel basic frame exists for G500, a cycle alarm (_ALARM>0) is output.

The new frame data with renewed programming of the G command of the associated settable frame is activated (G500, G54 to …) outside this cycle by the user.

5.9.4.2 Programming example

CYCLE119 application:

```
%_N_ Check _MPF
;Calculate new frame according to transferred points and correct in active frame
;Apply (_COR=9999) if distortion is _RES < 1.2 mm:
DEF REAL
_SETPOINT[3,3],_MEASPOINT[3,3]
DEF REAL _RES, _RESLIMIT
DEF INT _ALARM
DEF FRAME _REFRAME
N10 G17 G54 T1 D1
N20 _SETPOINT[0,0]=SET(10,0,0)          ;Setpoint coordinates 1st point (X1,Y1,Z1)
N30 _SETPOINT[1,0]=SET(0,20,0)          ;Setpoint coordinates 2nd point (X2,Y2,Z2)
N40 _SETPOINT[2,0]=SET(0,0,30)          ;Setpoint coordinates 3rd point (X3,Y3,Z3)
;Program section for determining actual workpiece coordinates of the 3 points:
...
;Assignment of derived values:
N100 _MEASPOINT[0,0]=SET(11,0,0)        ;Actual value coordinates 1st point
                                        (X1,Y1,Z1)
N110 _MEASPOINT[1,0]=SET(1,20,0)        ;Actual value coordinates 2nd point
                                        (X2,Y2,Z2)
N120 _MEASPOINT[2,0]=SET(1,0,30)        ;Actual value coordinates 3rd point
                                        (X3,Y3,Z3)
;Calculation with compensation in G54:
N200 CYCLE119(_SETPOINT,_MEASPOINT,
_ALARM,_RES,_REFRAME,9999,1.2)
IF (_ALARM==0) GOTOF _OKAY
MSG ("Error: " <<_ALARM)
M0                                      ;Alarm occurred
GOTOF _END
_OKAY: G54                              ;Activate corrected frame (ZO)
N400 G0 X... Y... Z...                  ;Traverse in corrected frame
...
N500 _END: M2
```

5.10 CYCLE996 workpiece: Measure kinematics

5.10.1 General

Function

Note

The "Measure kinematics" function is an option and is available from measuring cycles SW 7.5 onwards!

With the "Measure kinematics" function, it is possible to calculate the geometric vectors used to define the 5-axis transformation (TRAORI and TCARR) by measuring the position of the ball in space.

The measurement is essentially carried out by means of workpiece probes, which scan three positions of a measuring ball on each rotary axis. The ball positions can be defined in accordance with user specifications so that they correspond to the geometric ratios on the machine. The only way of setting the ball positions is to reposition the rotary axis that is to be measured in each case.

Aside from the basic mechanics of the machine, no specific knowledge is required to use CYCLE996. No dimension drawings or machine location diagrams are necessary to carry out measuring.

References: /PGZ/ Programming Manual Cycles, CYCLE800

Application range

The "Measure kinematics" function (CYCLE996) can be used to determine the data that is relevant to transformations in the case of kinematic transformations that involve rotary axes (TRAORI, TCARR).

Options:

- Redetermination of swivel data records
  - Machine startup
  - Use of swivel-mounted workholders as TCARR
- Checking swivel data records
  - Service following collisions
  - Checking the kinematics during the machining process

Kinematics with manual axes (manually adjustable rotary tables, swivel-mounted workholders) can be measured in the same way as kinematics with NC-controlled rotary axes.

When CYCLE996 is started, a swivel data record with basic data (for kinematics type, see Programming Manual Cycles CYCLE800) must be parameterized. The measurement itself must be carried out without an active kinematic transformation.

Requirements

The following requirements must be met in order to use CYCLE996 (Measure kinematics):

- SIEMENS measuring cycles package is installed
- Workpiece probe is calibrated
- Calibration ball is mounted
- Oriented tool carrier is initialized (MD 18088: MM_NUM_TOOL_CARRIER > 0)
- The basic geometry of the machine (X, Y, Z) is rectangular and referenced

  The right angle refers to the workpiece spindle and should be preferably checked using a test mandrel.
- Defined position of the rotary axes involved in the transformation
- Defined traverse directions in compliance with the standard of all axes involved in the transformation according to ISO 841-2001 and/or DIN 66217 (righthand rule)

5.10.2 Measurement procedure

5.10.2.1 Proceed as follows

The "Measure kinematics" function involving the use of CYCLE996 is implemented by means of the following basic procedure:

1. Measure a rotary axis
2. Measure a second rotary axis (if this exists)
3. Calculate the swivel data records (calculate kinematics)
4. The calculated data is activated automatically or with the aid of the user

The user (preferably the machine manufacturer) should ensure compliance with the specified sequence.

If the position of the calibration ball within the machine can be specified as an inherent part of the design, then it will be possible to store the entire kinematic measurement process (carried out using CYCLE996) as a part program, which is extremely advantageous. As a result, the user can carry out measurement of the kinematics under a set of predefined conditions at any given point in time.

5.10.2.2 Measuring an individual rotary axis

Process

The following steps must be carried out in order to measure a rotary axis:

- Mount the calibration ball on the machine table (user)
- Define and approach the three ball positions with the rotary axis that is to be measured (user)
- Specify and approach the three ball positions with the probe in a linear movement/in linear movements (user)
- Using CYCLE996, scan all three ball positions of the calibration ball with the probe.

Mounting the calibration ball

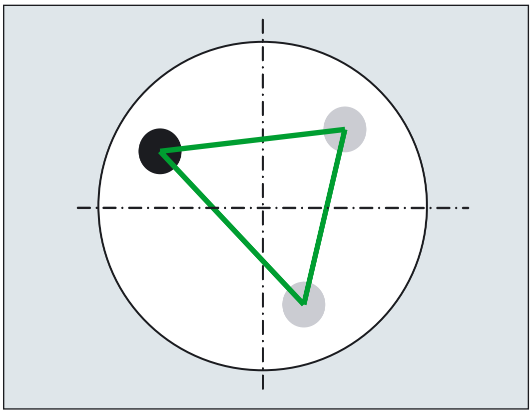
In the case of machinery, the calibration ball is to be installed on the machine table.

In order to measure swivel data records for swivel-mounted workholders, the ball must be incorporated into the appropriate workholder. In all cases it must be ensured that the probe can approach and bypass the mounted calibration ball without collision in all the selected rotary axis positions.

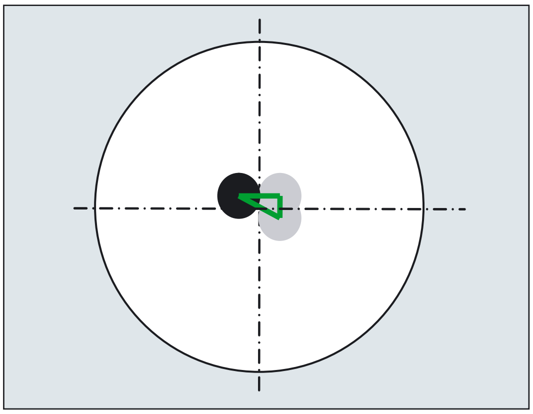
Considering the need to avoid collisions, the calibration ball should be mounted as far as possible from the center of rotation of the rotary axis that is to be measured.

If the three ball positions result in too small a triangle, this will negatively affect the accuracy of the procedure:

Calibration ball mounted sufficiently far from the center of rotation; large triangle can be clamped



Calibration ball mounted too near the center of rotation; clamped triangle is too small



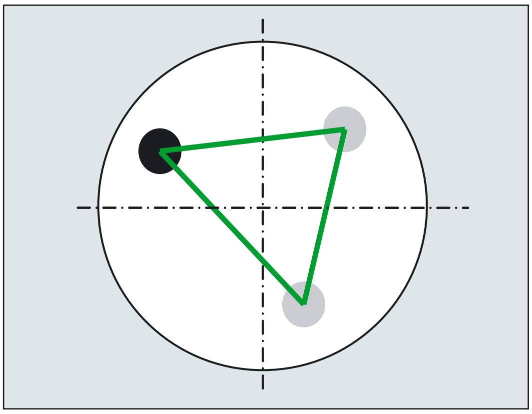
Note

While measuring a rotary axis, the mechanical hold-down of the calibration ball must not be altered. It is only with table and mixed kinematics that different calibration ball mounting positions are permissible for the purpose of measuring the first and subsequent rotary axes.

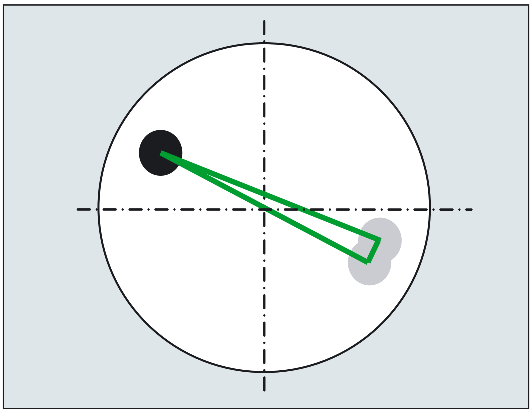
Defining the rotary axis positions

Three measuring positions (ball position) must be defined for each rotary axis. Please note that the positions of the ball in space (resulting from the three defined rotary axis positions) should lead to as large a triangle as possible being clamped.

Rotary axis positions sufficiently far away from one another; large triangle clamped



Rotary axis positions poorly selected; clamped triangle is too small

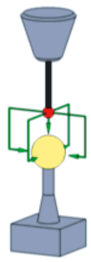


Approaching the ball position

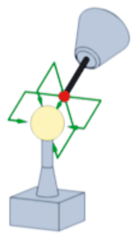
First of all, the probe must be positioned above the calibration ball at each of the three rotary axis positions defined by the user. The position must only be approached by traversing the linear axes (X, Y, Z). The positions themselves must be entered (set up) by the user. They should be determined manually using an active probe.

When selecting approach positions, please bear in mind that, within the context of automatic calibration ball scanning, the probe always moves in its preferred direction. Particularly where head and mixed kinematics are concerned, the starting point should be selected in a way that ensures alignment of the probe with the center point of the calibration ball in the approach position.

Starting point selected directly above the calibration ball



Starting point selected laterally above the calibration ball



Note

If the machine does not proceed as expected when the calibration ball is being scanned, the basic orientation and travel direction of the rotary axes should be checked (has DIN conformity been maintained when defining the axes?)

5.10.2.3 Measuring an individual ball position

Once the probe has been positioned in accordance with user specifications above the ball, either manually or by the part program (starting point of CYCLE996), the calibration ball is scanned by calling CYCLE996 and the current ball position is measured.

To this end, the user should parameterize and call CYCLE996 separately for each ball position.

5.10.2.4 Calculating and activating the swivel data records

After measuring the three ball positions that are required in each case for all the relevant rotary axes, the entire set of swivel data records can be calculated by means of CYCLE996. CYCLE996 should be parameterized and called for this purpose.

The swivel data records calculated using CYCLE996 can be activated as follows:

- Automatically or
- Manually

Activating tolerance limits when parameterizing CYCLE996 (compare output values and calculated values), allows conclusions to be drawn as regards unusual changes in the mechanical kinematic chain. The unintentional automatic overwriting of output values can be avoided by adjusting the tolerance limits.

⚠ CAUTION
The rotary axis vectors V1/V2 (orientation of the rotary axes) are never automatically overwritten.

Primarily, the calculated rotary axis vectors enable an assessment to be made regarding the mechanical desired/actual state of the kinematics. Depending on the kinematics configuration, even the smallest and corrected deviations in the position of the rotary axis vectors can result in large compensating movements.

5.10.3 Example of the procedure to measure the kinematics (CYCLE996)

By way of illustration, the BC table kinematics measurement process (both rotary axes move the workpiece) is described below:

- The two rotary axes can only be adjusted mechanically (workholder with orientation capability)
- The computed values are archived in TCARR data.

General procedure

- Create/check TCARR data:
  MD 18088 MM_NUM_TOOL_CARRIER > = 1?
- Mount calibration ball on the clamping device
- Load and activate the probe in the spindle
- Calibrate the probe using CYCLE976 or "Calibrate probe". Measure in JOG mode

Procedure for approaching positions

- Rotary axis 1
  - 1. Measurement P1
    - Manufacturer initial state, 1st rotary axis (B axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
  - 2. Measurement P2
    - Repositioning of 1st rotary axis (B axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
  - 3. Measurement P3
    - Repositioning of 1st rotary axis (B axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
- Rotary axis 2
  - 1. Measurement P1
    - Manufacturer initial state, 2nd rotary axis (C axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
  - 2. Measurement P2
    - Repositioning of 2nd rotary axis (C axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
  - 3. Measurement P3
    - Repositioning of 2nd rotary axis (C axis)
    - Positioning probe over calibration ball
    - Ball measurement using CYCLE996
    - Probe retraction
- Calculating measurement results using CYCLE996

5.10.4 Activation of the function

The screen form for CYCLE996 ("Measure kinematics") is activated via the global GUD6 variable _MZ_MASK[8] = 1

as follows:

Commis-sioning	⇒	>	⇒	Measuring cycles	⇒	Automatic measuring

5.10.5 Measuring kinematics

Starting from the kinematics initial state, the relevant rotary axes are measured individually.

Process

- Rotary axes 1 or 2 can be measured in any order. If the machine kinematics only have one rotary axis, this is measured as rotary axis 1. During the measurement procedure, no 5-axis transformations (TCARR or TRAORI) are active.
- The basic data for the kinematics are always the data of the tool carrier with orientation capability. If a dynamic 5-axis transformation is to be supported, it is preferable to use transformation type 72 (vectors from TCARR data).
- The linear and rotary axes must be prepositioned on the starting positions P1 to P3 (see programming example) before measuring cycle CYCLE996 is called in the NC program. The starting position is automatically accepted in CYCLE996 as the position setpoint for the "Measure ball" function.
- In each of the ball (rotary axis) positions selected, measuring is performed in accordance with the parameters and by calling CYCLE996.
- The kinematics are calculated via a separate, parameterized call of CYCLE996.
- The measuring results are written to the result parameter (OVR parameter) after the 3rd measurement has been completed and the CYCLE996 setting "Calculate kinematics" (refer to _MVAR). When the "Enter vectors" function is selected (refer to _MVAR, _TNUM), then data is output to the swivel data record that has been set-up (TCARR, TRAORI(1)).
- A protocol file with the measurement results in an appropriate data format (machine data or TCARR data) can be optionally output.

5.10.6 Programming via a screen form

5.10.6.1 General

Call "Measure kinematics" function - CYCLE996

Enter "Program" operating area in the part program editor

Press the following softkeys:

>	⇒	MEASURE MILLING	⇒	MEASURE WORKPIECE	⇒	>>	⇒	Kinematics

CYCLE996 screen forms

Two screen forms are offered for CYCLE996:

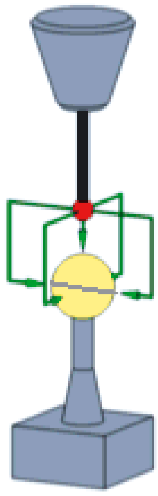
- "1st, 2nd, 3rd measurement" screen form
- "Calculate kinematics" screen form

Vertical softkey (VSK) functions:

Swivel data

The swivel data can be selected in accordance with the "Swivel cycle" startup menu (see Programming Manual Cycles CYCLE800). This enables the user to check the data of the selected swivel data record, or enter the basic kinematics data.

CYCLE996 has to be called three times in order to complete the entire measuring and vector calculation process for one rotary axis. Between cycle calls, the user must reposition the rotary axis to be measured. Any rotary axis that is not being measured must not be repositioned during the measurement procedure. The linear axes are positioned on the starting positions P1, P2, P3.



The probe must be able to reach the ball equator of the calibration ball.

The 1st measurement must take place in the kinematics initial state.

If a rotary axis rotates parallel to the spindle without offset in a head kinematics (fork head), the 1st measurement can be made with spring-loaded probe. The rotary axis that is not to be measured is not in the initial position of the kinematics.

1st measu rement P1	Call 1st measurement
2nd measu rement P2	Call 2nd measurement
3rd measu rement P3	Call 3rd measurement

Kinematics calculating

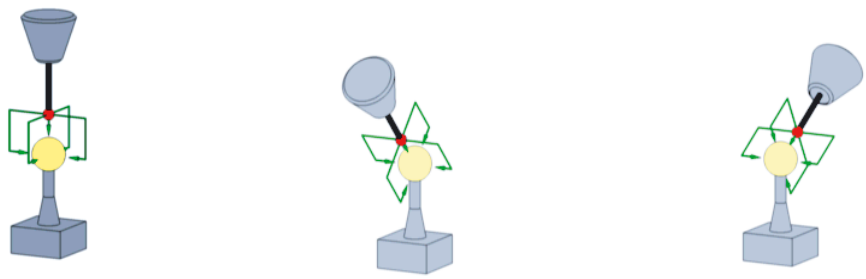
At the end of the 3rd measurement, a call calculates the vectors of the measured rotary axes. The prerequisite for this is that all three measurements have been carried out for the rotary axis concerned, and that the corresponding measurement results (center points of the calibration ball) have been saved. The vectors of the machine kinematics are then calculated in full when both rotary axes have been measured. The measurement counter, parameter OVR[40], is displayed in the result bit or in the protocol.

For "1st, 2nd, 3rd measurement" or "Calculate kinematics" coding, see parameter _MVAR.

The help displays show the three starting positions (P1, P2, P3) of the probe, based on the kinematics type of the swivel data record.

Measurement for kinematics with swivel head:

1. Measurement P1 (initial state) | 2. Measurement P2 | 3. Measurement P3

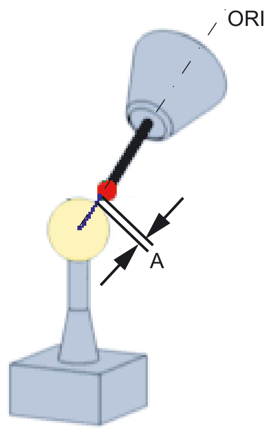


With the 2nd and 3rd measurements, the rotary axis to be measured is rotated around the largest possible angle. The position of the calibration ball must be stationary during measurement (1st, 2nd, 3rd).

Start position

The starting position of the probe must be approached by the user or from the user program (see example program).

The probe must be prepositioned in the direction of the tool orientation (ORI) above the highest point of the calibration ball (probe aligned with ball center point). After approaching the starting position, the distance (D) from the calibration ball should be as short as possible.



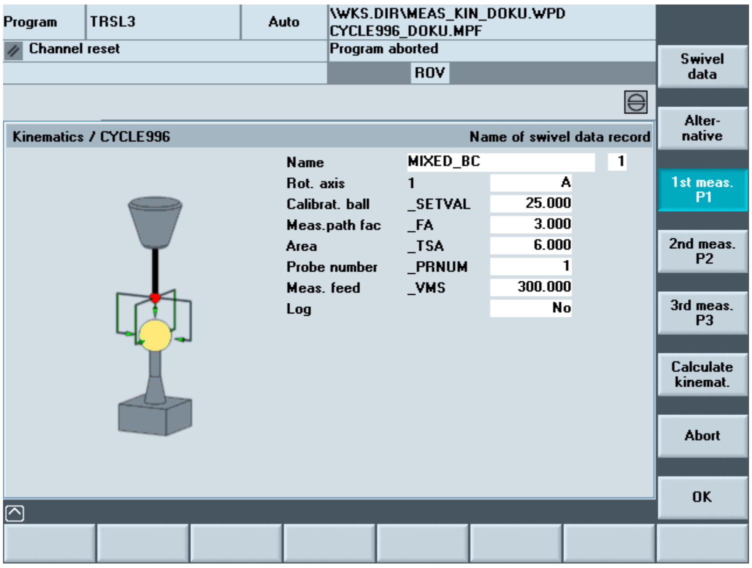
Note

Measure kinematics is also possible with active 5-axis transformation (TRAORI).

As a prerequisite for Measure kinematics with active TRAORI, the vectors of the 5-axis transformation must be roughly set. The positions for measuring the kinematics are approached in the user program with active transformation. During the actual measurement with the calibration ball, CYCLE996 switches off the transformation and switches it on again after the measurement.

5.10.6.2 Parameters of "1st, 2nd, 3rd measurement" screen form

Screen form



Name (Name/number of the swivel data record)

Select the swivel data records set in MD 18088: MM_NUM_TOOL_CARRIER The basic kinematics data can be entered with VSK1 "Swivel data".

Parameter: `_TNUM`

Rotary axis (Name of rotary axis 1 or 2)

Select the name of the rotary axis of the swivel data record ($TC_CARR35/36).

Parameter: `_MVAR`

Measuring angle (Measuring angle with manual or semi-automatic rotary axes)

The entry field is only displayed if manual or semi-automatic rotary axes are declared in the swivel data record→ see $TC_CARR37.

Parameters:

- `_SETV[3]` with rotary axis 1
- `_SETV[4]` with rotary axis 2 or with swivel head with manual rotary axes

Calibration ball (Calibration ball diameter)

Parameter: `_SETVAL`

Measurement path (Measurement path factor)

Parameter: `_FA`

`_FA` should be selected to be greater than the mechanical clearance (A) when pre-positioning the probe.

Range (Safe area)

Parameter: `_TSA`

Probe number (Number of probe field)

Parameter: `_PRNUM`

Measuring feedrate (Measuring feedrate)

Input field for the measuring feedrate

Parameter: `_VMS`

Protocol file (Measurement data protocol file)

Selection:

- No (default)
- yes

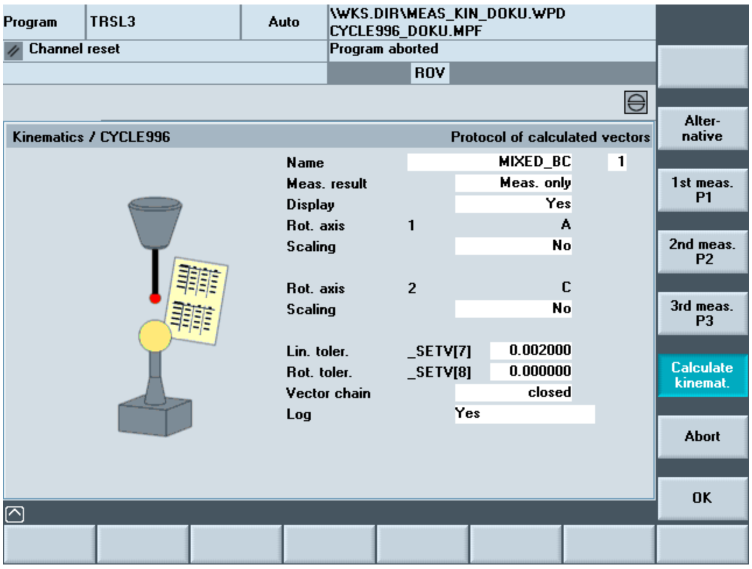
The protocol file is saved in the current NC data path (or workpiece) in which the measurement program is running. The file name is the same as that of the swivel data record plus "_M1". If the file name already exists, M1 is incremented (up to M99).

If the protocol file is activated, the intermediate results, i.e., the three center points of the calibration ball (corresponding to 1st, 2nd and 3rd measurements) are logged.

The user is responsible for all protocol file operations (deleting, unloading, saving, etc.)

5.10.6.3 Parameters of "Calculate kinematics" screen form

Pressing VSK6, "Calculate kinematics" displays the following screen form:



Name (Name/number of the swivel data record)

Select the swivel data records set in MD 18088: MM_NUM_TOOL_CARRIER

Parameter: `_TNUM`

Measuring result

Selection:

- Measure only (only "Measure" and "Calculate vectors")
- Enter ("Measure", "Calculate vectors" and "Enter vectors in swivel data record")

For coding, see `_MVAR`

The result parameters from _OVR[1] are calculated in both selections.

The "Enter" option is only displayed when the manufacturer password is set. When the option to "Enter" vectors is selected, the linear vectors (offset vectors) are entered in the swivel data record. If input fields of the tolerance values are not equal to zero and these are overwritten after measurement, then the linear vectors are not automatically entered.

⚠ CAUTION
Rotary axis vectors V1 and V2 are not entered automatically.

Observe the machine manufacturer's instructions!

Result bit

Selection:

- No (no result bit)
- Yes (result bit of calculated vectors)
- Yes, can be edited (result bit and offset of calculated vectors)
  - Only when manufacturer password and measuring result selection are "entered".
  - If necessary, the user can round off the calculated vectors before accepting the data

For the result bit, see Section "Result bit".

The following displays - "Rotary axis", "Normalizing" and, where applicable, "Position value" - are all functionally associated with one another.

Rotary axis

Displays the name of rotary axis 1/rotary axis 2 (if this exists) of the measured kinematics.

Normalizing (Normalizing the vertice of the calculated vectors)

"Normalizing" refers to setting a component of a linear vector to a preferred value of a linear axis position (in X, Y or Z). Using normalizing, kinematic vectors that have been determined can be calculated with reference to mechanical fixed positions specific for a machine (e.g. Z position of the table surface). This allows comparable swivel data records to be written to within a machine series. The measured kinematic data are therefore independent of mechanically specified measuring conditions (mounting position of the calibration ball). The measured rotary axis vectors are taken into account in scaling.

Example:

Z component of the linear vector of rotary axis C is always referred to the upper edge of the table at Z = 0.

i.e., rotary axis C/normalizing Z/position value 0

Selection:

- No (default) (no normalizing)
- Z, Y, X (normalizing of axes X, Y, or Z in line with an assigned position value)

For coding, see `_MVAR`

Position value (Normalizing position value)

Entry field can only be seen if "Normalizing" is shown on Z, Y, X.

Parameter:

- Rotary axis 1 normalizing `_SETV[5]`
- Rotary axis 2 normalizing `_SETV[6]`

Tolerance lin (Tolerance value of offset vectors I1 to I4)

The tolerance parameters should enable the user to make a "good" or "bad" assessment when the kinematics are measured. The prerequisite for this is that kinematics vectors have already been correctly entered. The tolerance values and the extensive normalizing associated with them must be specified by the machine manufacturer.

Parameter: `_SETV[7]`

Tolerance red (Tolerance value of rotary axis vectors V1, V2)

Parameter: `_SETV[8]`

Effect of the tolerance parameters:

1. Tolerance value = 0 -> no effect
2. Tolerance value <> 0 and tolerance exceeded → Cancel alarm 62430, 62431 with display of the 1st value and parameter ($TC_CARR1, etc.) that has been exceeded.

If the result bit is active, the fields are displayed in which the tolerance value was found to be exceeded on comparison of the $TC_CARR parameter and the _OVR result parameter.

Observe the machine manufacturer's instructions!

Protocol file (Protocol file for the calculated kinematics vectors)

Selection:

- No
- yes
- Yes, TRAORI(1);

The protocol file is saved in the current NC data path (or workpiece) in which the measurement program is running. The file name of the protocol file is generated from the name of the swivel data record and a counting index:

→ e.g. swivel data name generated from $TC_TCARR[x] = "SWIVEL"

Name of protocol file: "SCHWENK_M1.MPF"

If the file name already exists, M1 is incremented (up to M99). Once there are 99 protocol files, the process starts again from protocol file "_M1". The user is responsible for all protocol file operations.

The protocol file contains the syntax of the swivel data record parameters

→ e.g. $TC_CARR1[1]=-426.708853 $TC_CARR2[1]=-855.050806 … ;I1xyz.

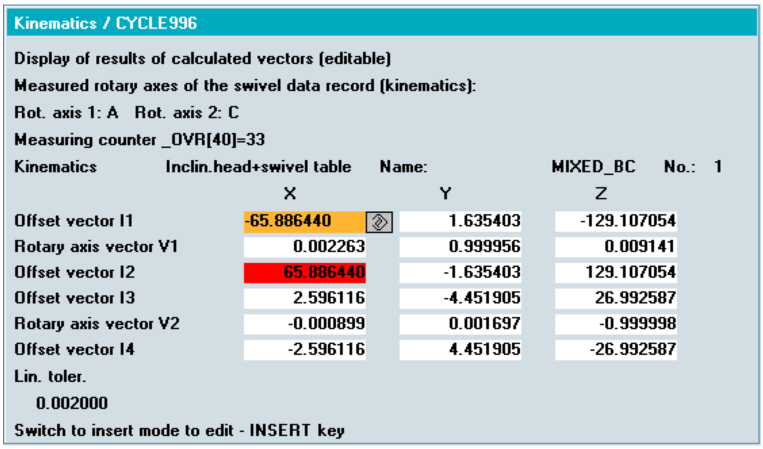
In the settings "Yes, TRAORI(1)", a protocol file with the corresponding TRAORI machine data is generated.

For coding, see `_MVAR`

5.10.6.4 Result bit

If the "Calculate kinematics" selection is active, a result bit can be selected in the screen form for CYCLE996 as follows:

- No: After calculating/measuring, the results are not displayed.
- Yes: After calculation/measuring, the message display appears; the individual values on this display cannot be edited.
- Yes, editable: The result parameters can be changed (and potentially rounded off).



If the tolerance parameters <> 0, the relevant fields are displayed in red when they are exceeded (comparison from $TC_CARR1...with _OVR[1...]).

The calculated/measured _OVR-Parameter are always displayed in the result bit.

5.10.7 Programming using parameters

5.10.7.1 Programming using parameters

CYCLE996 programming with "1st, 2nd, 3rd measurement"

```
_MVAR, _TNUM, _SETVAL, _FA, _TSA, _VMS, _PRNUM, _SETV[3], _SETV[4]
CYCLE996
```

CYCLE997 is called internally within CYCLE996 for the purpose of measuring the calibration ball. Parameters `_SETVAL, _FA, _TSA, _VMS` and `_PRNUM` feed CYCLE997.

CYCLE996 programming with "Calculate kinematics"

```
_MVAR, _TNUM, _SETV[5], _SETV[6], _SETV[7], _SETV[8]
CYCLE996
```

Basic kinematics data

The functionality of CYCLE996 requires the NCK function "Tool carrier with orientation capability (TCARR)" (see also Programming Manual Cycles CYCLE800).

The number of tool carriers with orientation capability must be entered in machine data MD 18088: MM_NUM_TOOL_CARRIER.

If the dynamic 5-axis transformation (TRAORI) is also to be set (or is the only function to be set), MD 24x00 $MC_TRAFO_TYPE_x = 72 (x = 1...8) should ideally be set, as should the number of the TOOLCARR swivel data record to be used in MD 24582 TRAFO5_TCARR_NO_1.

The following basic kinematics data must be known at the start of CYCLE996:

It is entered in either the "Swivel cycle" startup menu (CYCLE800) or in the screen form for the 1st measurement (SK swivel data record).

- Kinematics type: Swivel head ("T"), swivel table ("P") or mixed kinematics ("M")
- Name of swivel data record
- Approximate rotary axis vector V1xyz of rotary axis 1 (e.g, axis B swivels around Y V1 = 0, 1, 0)
- Approximate rotary axis vector V2xyz of rotary axis 2 (if this exists) (e.g, axis C swivels around Z V2 = 0, 0, 1)
- Name of rotary axes
- Mode of rotary axes: automatic (NC rotary axes), manual or semi-automatic
- Travel range of rotary axes

"1st, 2nd, 3rd measurement" parameters

Parameter	Value/data type	Meaning
_MVAR	Decimal 1...9	"Measure kinematics" mode (see the following measurement variants)
_TNUM	INTEGER	Number of swivel data record
_SETVAL	REAL	Diameter of the calibration ball
_FA	REAL	Measurement path factor
_TSA	REAL	Safe area
_VMS	REAL	Measuring feedrate
_PRNUM	INTEGER	Number of probe (probe field)
_SETV[3]	REAL	Position value of rotary axis 1 (manual or semi-automatic)
_SETV[4]	REAL	Position value of rotary axis 2 (manual or semi-automatic)

"Calculate kinematics"parameters

Parameter	Value/data type	Meaning
_MVAR	Decimal 1...9	"Measure kinematics" mode (see the following measurement variants)
_TNUM	INTEGER	Number of swivel data record
_SETV[5]	REAL	Position value for normalizing rotary axis 1
_SETV[6]	REAL	Position value for normalizing rotary axis 2
_SETV[7]	REAL	Tolerance value of offset vectors I1...I4
_SETV[8]	REAL	Tolerance value of rotary axis vectors V1, V2

Measurement variants

Measuring cycle CYCLE996 permits the following measurement variants, which are specified via parameter _MVAR.

- "1st, 2nd, 3rd measurement" _MVAR

9 8 7 6 5 4 3 2 1

_MVAR

Digit	Value	Meaning
1	1	1. Measurement
	2	2. Measurement
	3	3. Measurement
2	9	Identification of "Measure kinematics" function - CYCLE996
5		Measuring axis measurement result
	1	Rotary axis 1
	2	Rotary axis 2
8		Protocol file
	0	No
	1	Yes

- "Calculate kinematics" _MVAR

9 8 7 6 5 4 3 2 1

_MVAR

Digit	Value	Meaning
1	4	Calculate kinematics
2	9	Identification of "Measure kinematics" function - CYCLE996
3		Measuring result
	0	Measuring only
	1	Measure + enter vectors
4		Result bit
	0	No
	1	Yes
	2	Yes, vectors editable
5		Vector chain
	0	Vector chain closed
	3	Vector chain open
6		Axis number for normalizing rotary axis 1
	0	No normalizing
	1	X axis normalizing
	2	Y axis normalizing
	3	Z axis normalizing
7		Axis number for normalizing rotary axis 2
	0	No normalizing
	1	X axis normalizing
	2	Y axis normalizing
	3	Z axis normalizing
8		Protocol file
	0	No
	1	Yes (protocol format as $TC_CARR-Parameter)
	2	Yes, TRAORI (1) (protocol format as $TC_CARR-Parameter and as TRAORI machine data)

5.10.7.2 Result parameters, intermediate results

Result parameters

When "**Measure kinematics**" is selected and both rotary axes (_OVR[40] = 33) are measured, the CYCLE996 measuring cycle makes the following values available as results in data block GUD5:

Parameter	Data type	Result
_OVR[1]	REAL	Offset vector I1 $TC_CARR1[n], X component
_OVR[2]	REAL	Offset vector I1 $TC_CARR2[n], Y component
_OVR[3]	REAL	Offset vector I1 $TC_CARR3[n], Z component
_OVR[4]	REAL	Offset vector I2 $TC_CARR4[n], X component
_OVR[5]	REAL	Offset vector I2 $TC_CARR5[n], Y component
_OVR[6]	REAL	Offset vector I2 $TC_CARR6[n], Z component
_OVR[7]	REAL	Rotary axis vector V1 $TC_CARR7[n], X component
_OVR [8]	REAL	Rotary axis vector V1 $TC_CARR8[n], Y component
_OVR [9]	REAL	Rotary axis vector V1 $TC_CARR9[n], Z component
_OVR[10]	REAL	Rotary axis vector V2 $TC_CARR10[n], X component
_OVR[11]	REAL	Rotary axis vector V2 $TC_CARR11[n], Y component
_OVR [12]	REAL	Rotary axis vector V2 $TC_CARR12[n], Z component
_OVR[15]	REAL	Offset vector I3 $TC_CARR15[n], X component
_OVR[16]	REAL	Offset vector I3 $TC_CARR16[n], Y component
_OVR [17]	REAL	Offset vector I3 $TC_CARR17[n], Z component
_OVR [18]	REAL	Offset vector I4 $TC_CARR18[n], X component
_OVR [19]	REAL	Offset vector I4 $TC_CARR19[n], Y component
_OVR [20]	REAL	Offset vector I4 $TC_CARR20[n], Z component
_OVI [2]	INTEGER	Measuring cycle number = 996
_OVI [3]	INTEGER	Measurement variant (_MVAR)
_OVI [8]	INTEGER	Number of swivel data record (_TNUM)
_OVI [9]	INTEGER	Alarm number

Measurement results (calculated vectors) depend on the type of kinematics

Head kinematics		
I1 $TC_CARR1...3[n]	Corresponds to	_OVR[1]..._OVR[3]
I2 $TC_CARR4...6[n]		_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
		_OVR[18]..._OVR[20] = 0
Closure of the I1 = -(I3+I2) vector chain; for fixed-mounted machine kinematics		

Table kinematics		
I2 $TC_CARR4...6[n]	Corresponds to	_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
I4 $TC_CARR18...20[n]		_OVR[18]..._OVR[20]
		_OVR[1]..._OVR[3] = 0
Closure of the I4 = -(I3+I2) vector chain; for fixed-mounted machine kinematics		

Mixed kinematics		
I1 $TC_CARR1...3[n]	Corresponds to	_OVR[1]..._OVR[3]
I2 $TC_CARR4...6[n]		_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]		_OVR[15]..._OVR[17]
I4 $TC_CARR18...20[n]		_OVR[18]..._OVR[20]
Closure of the I1 = -I2 I4 = -I3 vector chain; for fixed-mounted machine kinematics		

The result parameters that are not calculated = 0

Intermediate results _OVR[32] to _OVR[71]

Intermediate results (center point of the calibration ball XYZ) and the status are saved in the fields from _OVR[33...].

Parameters	Data type	Result
`_OVR[32,33,34]`	REAL	Linear vectors of 1st rotary axis are not normalized
`_OVR[35,36,37]`	REAL	Linear vectors of 2nd rotary axis are not normalized
The linear vectors are assigned to the concrete vectors of the kinematics (I1, I2, etc.) in accordance with the normalizing process.		
`_OVR [40]`	REAL	Measurement counter x0 = 1st measurement of 1st rotary axis begun x1 = 1st measurement of 1st rotary axis OK x2 = 2nd measurement of 1st rotary axis OK x3 = 3rd measurement of 1st rotary axis OK 0x = 1st measurement of 2nd rotary axis begun 1x = 1st measurement of 2nd rotary axis OK 2x = 2nd measurement of 2nd rotary axis OK 3x = 3rd measurement of 2nd rotary axis OK 33 = Both rotary axes measured

Parameters	Data type	Result
_OVR[41,42,43]	REAL	1. Measurement of 1st rotary axis
_OVR[44,45,46]	REAL	2. Measurement of 1st rotary axis
_OVR[47,48,49]	REAL	3. Measurement of 1st rotary axis
_OVR[51,52,53]	REAL	1. Measurement of 2nd rotary axis
_OVR[54,55,56]	REAL	2. Measurement of 2nd rotary axis
_OVR[57,58,59]	REAL	3. Measurement of 2nd rotary axis
When the 1st measurement is begun, the intermediate results (ball center points) of the rotary axis are deleted. 1st measurement of 1st rotary axis → Delete _OVR[41] ... _OVR[49] 1st measurement of 2nd rotary axis → Delete _OVR[51] ... _OVR[59]		
_OVR[60,61,62]	REAL	Actual value of rotary axis 1 for 1st, 2nd, 3rd measurement
_OVR[63,64,65]	REAL	Actual value of rotary axis 2 for 1st, 2nd, 3rd measurement
_OVR[66,67,68]	REAL	Rotary axis vectors V1xyz
_OVR [69,70,71]	REAL	Rotary axis vectors V2xyz

5.10.8 Programmable adjustable parameters

The following parameters should be programmed in the main program for "Measure kinematics" with CYCLE996:

_CHBIT[25]

- 0 = Only enter calculated offset vectors when the operator has acknowledged M0 with NC Start.
- 1 = Enter calculated offset vectors immediately (no M0)
  - For Calculate kinematics and measurement variant "Enter measuring result".
  - Only when the tolerance of the offset vectors has not been exceeded in the calculation.

_CHBIT[26]

- 0 = Measurement with the calibration ball parallel to the axis
- 1 = Measurement with the calibration ball at an angle

  With this variant, the kinematics can be measured, e.g. at 90 degree positions, without the shank of the calibration ball mechanically preventing the measurement.

  The starting angle, parameter _STA1, must be specified externally in the main program. Value range of the starting angle _STA1, 0 to 360 degrees.

  The leading angle _INCA is equal to 90 degrees.

  Parameter _SPEED[1] is used as feedrate on the circular path.

  See also Programming Manual, Measuring cycles: Measure ball CYCLE997

_TNVL

Limit angle, distortion of triangle when calculating kinematics [degrees].

Parameter _TNVL is used to monitor the distortion of the measurement triangle. Suitable values for parameter _TNVL are 20 to 45 degrees.

If the distortion of the triangle is outside of parameter _TNVL, error 61430 "Calculation of the kinematics vectors not performed -> Error code: %4" is displayed.

Programming example

_CHBIT[25]=0 _CHBIT[26]=1 _STA1=45 _TNVL=20
…
CYCLE996(…)

5.10.9 Programming example

```
%_N_HEAD_BC_MPF
;$PATH=/_N_WKS_DIR/_N_ HEAD_BC_WPD
;Measure kinematics
;Starting positions for HEAD_BC (swivel head)
;Calibration ball D = 25mm
;P1...P3 rotary axis 1
;P4...P6 rotary axis 2
;P1,P4 kinematics initial state

DEF REAL _P1[5]=SET(27.5,-184.5,22.5,0,0)            ;P1 xyz 1.RA 2.RA
DEF REAL _P2[5]=SET(83,-108,22.5,45,0)               ;P2 xyz 1.RA 2.RA
DEF REAL _P3[5]=SET(-65,-200,22.5,-45,0)             ;P3 xyz 1.RA 2.RA
DEF REAL _P4[5]=SET(27.5,-184.5,22.5,0,0)            ;P4 xyz 1.RA 2.RA
DEF REAL _P5[5]=SET(124,-184.5,-17,0,45)             ;P5 xyz 1.RA 2.RA
DEF REAL _P6[5]=SET(-68.8,-184.5,-17,0,-45)          ;P6 xyz 1.RA 2.RA
T99 D1                                               ;3D probe
G500
CYCLE800()
TRAFOOF
IF (NOT $P_SEARCH)                                   ;If no block search
_OVR[40]=0                                           ;reset measurement counter to
ENDIF                                                zero
;--------------------- 1. measurement of rotary axis 1
G0 Z100                                            ;Safely retract axis Z
BB=_P1[3] CC=_P1[4]                                ;kinematics initial state
X=_P1[0] Y=_P1[1] Z=_P1[2]
_MVAR=10010091 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
```

```
;--------------------- 2. measurement of rotary axis 1
G0 Z100
BB=_P2[3] CC=_P2[4]
X=_P2[0] Y=_P2[1] Z=_P2[2]
_MVAR=10092 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
;--------------------- 3. measurement of rotary axis 1
G0 Z100
BB=_P3[3] CC=_P3[4]
X=_P3[0]
Y=_P3[1] Z=_P3[2]
_MVAR=10093 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
;====================== 1. measurement of rotary axis 2
G0 Z100
BB=_P4[3] CC=_P4[4]
X=_P4[0]
Y=_P4[1] Z=_P4[2]
_MVAR=20091 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
;--------------------- 2. measurement of rotary axis 2
G0 Z100
BB=_P5[3] CC=_P5[4]
X=_P5[0]
Y=_P5[1] Z=_P5[2]
_MVAR=20092 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
;--------------------- 3. measurement of rotary axis 2
G0 Z100
BB=_P6[3] CC=_P6[4]
X=_P6[0]
Y=_P6[1] Z=_P6[2]
_MVAR=20093 _TNUM=1 _SETVAL=25.000 _FA=3.000 _TSA=6.000 _VMS=500.000 _PRNUM=1
_SETV[3]=0.000 _SETV[4]=0.000
CYCLE996
M0
;-------------------- Calculate kinematics; no normalizing
_MVAR=20001194 _TNUM=1 _SETV[5]=0.000 _SETV[6]=0.000 _SETV[7]=100.000000
_SETV[8]=10.000000
CYCLE996
MSG("Kinematics measurement, 1st rotary axis OK")
M0
M02
```

6 Measuring Cycles for Turning Machines

6.1 General prerequisites

6.1.1 General information

The measuring cycles below are intended for use on turning machines.

To be able to run the measuring cycles described in this Chapter, the following programs must be stored in the part program memory of the control.

Note

As of HMI sl software version 2.6

The GUD parameters are stored in the machine or setting data.

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used up to and including measuring cycles version 7.5, compared to the machine and setting data as of measuring cycles version 2.6, is included in appendices A1, A2 and A3.

6.1.2 Overview of measuring cycles

Cycle	Function
CYCLE973	Calibrate workpiece probe in the reference groove or on surface
CYCLE974	1-point measurement with automatic tool offset or ZO determination
CYCLE982	Calibrate tool probe, measure turning and milling tools
CYCLE994	2-point measurement on diameter with automatic tool offset

6.1.3 Overview of the auxiliary programs required

Cycle	Function
CYCLE102	Measurement result display selection
CYCLE109	Internal subroutine: Data transfer
CYCLE110	Internal subroutine: Plausibility checks
CYCLE111	Internal subroutine: Measuring functions
CYCLE114	Internal subroutine (tool offset)
CYCLE115	Internal subroutine (ZO compensation)
CYCLE117	Internal subroutine: Measuring functions
CYCLE118	Format real values: Log

See also

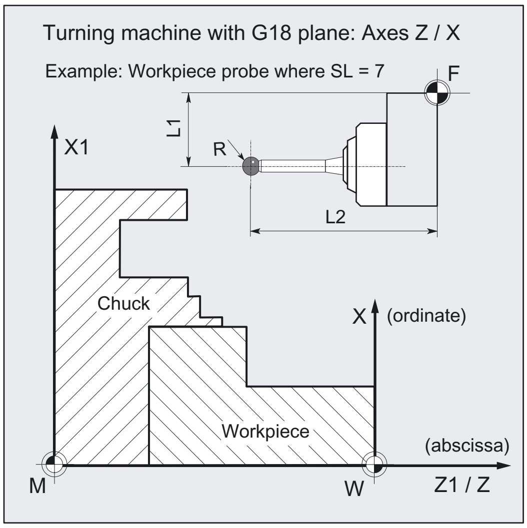
Comparison of GUD parameters up to measuring cycles version 7.5 and GUD parameters as of measuring cycles version 2.6, with reference to measuring function. (Page 413)

GUD variables that can no longer be used (Page 418)

Changes to names of cycle programs and GUD modules (Page 420)

6.1.4 Call and return conditions

- D compensation with the data of the calibration tool or the workpiece probe or the tool to be measured must be activated in accordance with the measuring variant before a measuring cycle is called.
- The permissible tool type for the workpiece probe is type 5xy with cutting edge positions SL 5 to 8. Lengths refer to the center of the probe ball.
- No scaling factors <>1 must be active in the frames. Mirroring is permissible in the workpiece measuring cycles except for calibration (condition: MD 10610: MIRROR_REF_AX =0).
- The G functions active before the measuring cycle call are reactivated at the end of the cycle.



Plane definition

The measuring cycles work internally with the abscissa and ordinate of the current plane G17 to G19.

The default setting for turning machines is **G18**.

Note

Spindle

Spindle commands in the measuring cycles always refer to the active **master spindle** of the control.

When using measuring cycles on machines with several spindles, the spindle concerned before the cycle call must be defined as the master spindle.

References: /PG/ "Programming Guide: Fundamentals"

6.2 CYCLE982 Tool: Measure turning tools

6.2.1 Function overview

Function

The CYCLE982 cycles each implement the

- **Calibration of a tool probe**

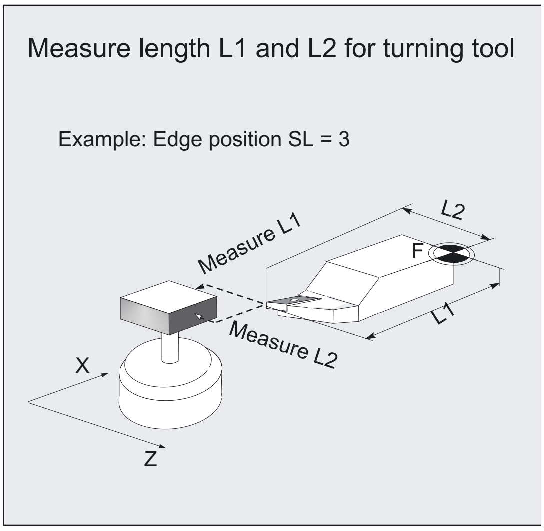
and

- **Measuring turning tools**

(machine-related, probe arrays _TP[ ]).

Tool lengths
L1, L2 of turning tools with cutting edge positions SL = 1 to 8 are measured.

It is only possible to measure tools with one calibrated tool probe.



Programming

```
CYCLE982
```

Note

Tolerance parameters _TSA, _TDIF and _TZL must be entered taking into account machine data

- MD 20360 TOOL_PARAMETER_DEF_MASK bit0 and bit1

in conjunction with the offset target

- geometry and wear.

Measuring variants

The CYCLE982 measuring cycles permit the following measurement variants which are specified via parameter _MVAR.

Value	Measuring variant
0	Calibrate tool probe (machine-related)
1	Measure tool (machine-related)

Result parameters

The CYCLE982 measuring cycles return the following values in the data block GUD5 for the measurement variant **calibration**:

Parameter	Data type	Result
`_OVR [8]`	REAL	Trigger point in minus direction, actual value, abscissa
`_OVR[10]`	REAL	Trigger point in plus direction, actual value, abscissa
`_OVR [12]`	REAL	Trigger point in minus direction, actual value, ordinate
`_OVR [14]`	REAL	Trigger point in plus direction, actual value, ordinate
`_OVR [9]`	REAL	Trigger point in minus direction, difference, abscissa
`_OVR[11]`	REAL	Trigger point in plus direction, difference, abscissa
`_OVR [13]`	REAL	Trigger point in minus direction, difference, ordinate
`_OVR[15]`	REAL	Trigger point in plus direction, difference, ordinate
`_OVR [27]`	REAL	Zero offset area
`_OVR [28]`	REAL	Safe area
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [3]`	INTEGER	Measuring variant
`_OVI [5]`	INTEGER	Probe number
`_OVI [9]`	INTEGER	Alarm number

The CYCLE982 measuring cycles return the following values in the data block GUD5 for the measurement variant **tool measurement**:

Parameter	Data type	Result
`_OVR [8]`	REAL	Actual value length L1
`_OVR [9]`	REAL	Difference length L1
`_OVR[10]`	REAL	Actual value length L2
`_OVR[11]`	REAL	Difference length L2
`_OVR [27]`	REAL	Zero offset area
`_OVR [28]`	REAL	Safe area
`_OVR [29]`	REAL	Permissible dimensional difference
`_OVR [30]`	REAL	Empirical value
`_OVI [0]`	INTEGER	D number
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [3]`	INTEGER	Measuring variant
`_OVI [5]`	INTEGER	Probe number
`_OVI [7]`	INTEGER	Empirical value memory number
`_OVI [8]`	INTEGER	Tool number
`_OVI [9]`	INTEGER	Alarm number

6.2.2 Calibrate tool probe (machine-related)

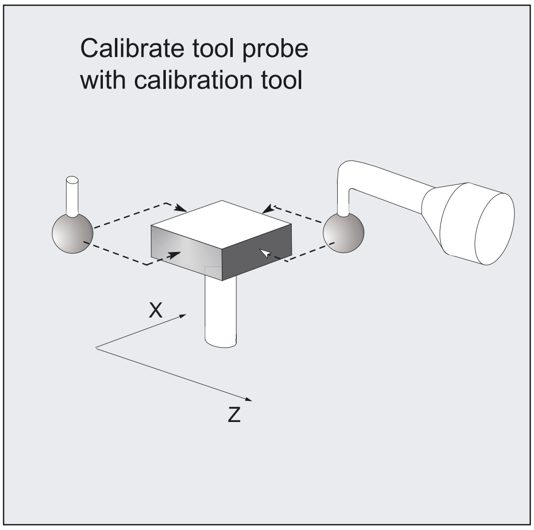
Function

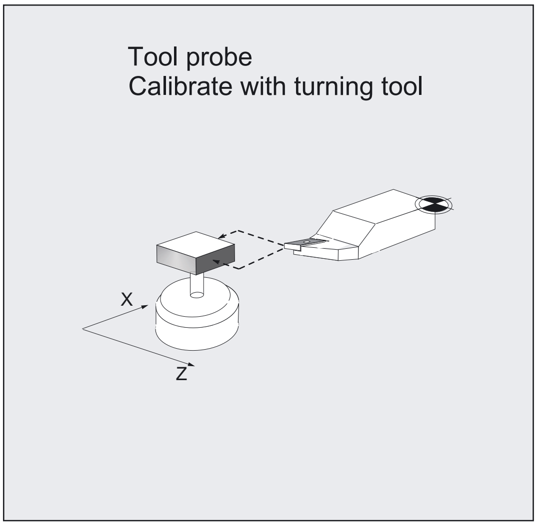
The cycle uses the calibration tool to ascertain the current distance dimensions between the **machine zero** and the probe trigger point and automatically loads them into the appropriate data area in data block GUD6 (_TP [ ]fields).

Values are corrected without empirical and mean values.

Note

If no special calibration tool is available, a turning tool can be used instead for calibration of 2 sides of the probe (see Chapter "Determining dimensions of calibration").





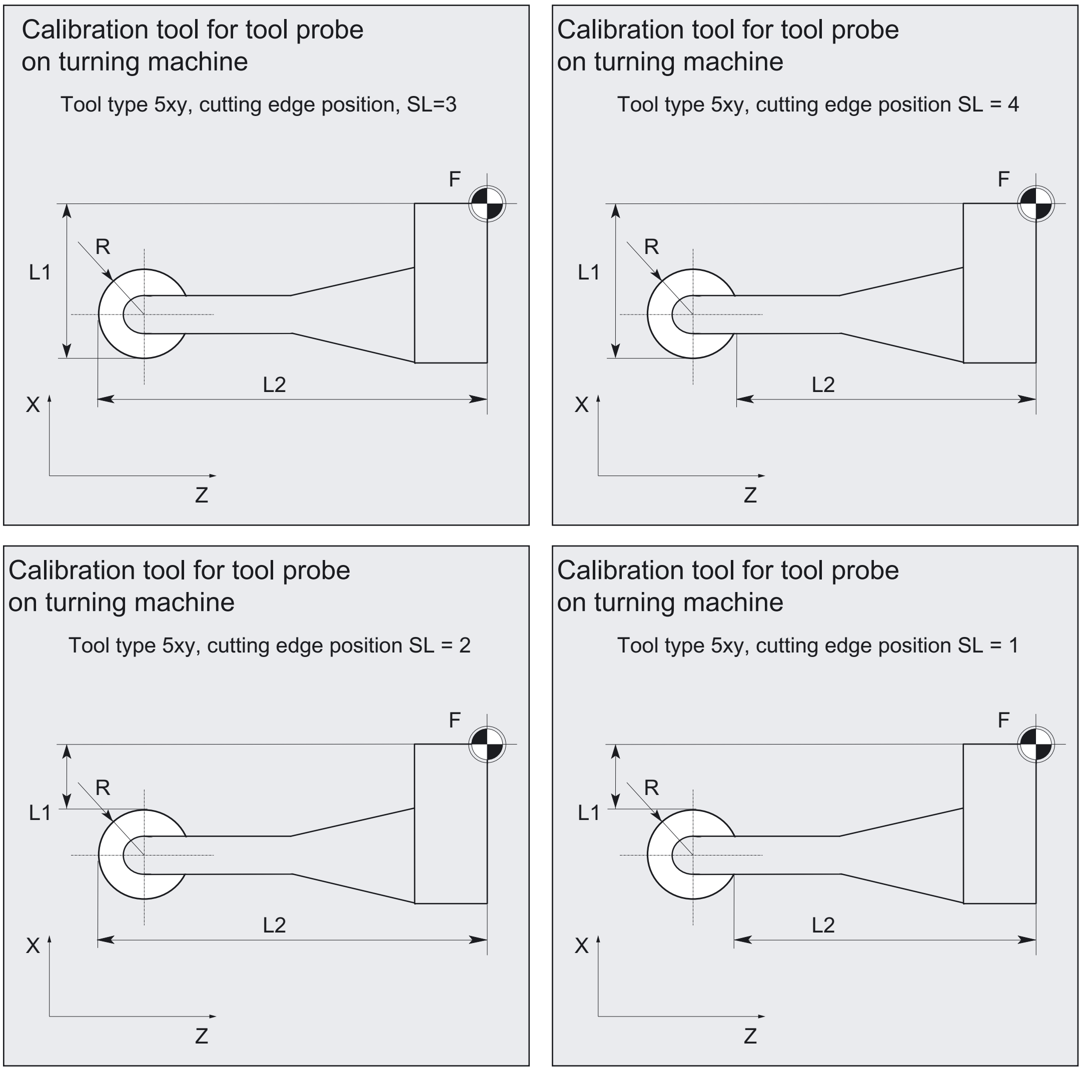
Requirement

Since no specific tool type is available for the calibration tool, the 8th digit of _MVAR indicates whether a calibration or turning tool is to be used for calibration (see CYCLE982, measuring variants).

Lengths 1 and 2 and the radius of the calibration/turning tool must be known exactly and stored in a tool offset data block.

This tool offset must be active when the measuring cycle is called. A turning tool must be specified as the tool type (type 5xy). Calibration is possible with cutting edge positions SL1, SL2, SL3 or SL4.

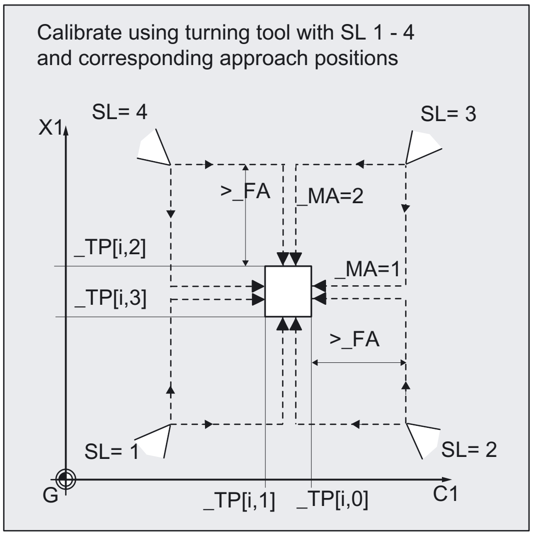
1. Calibrate with calibration tool



The calibration tool is shaped (bent) in such a way that the probe can be calibrated on all 4 sides with it.

2. Calibrate with turning tool

When a turning tool is used for calibration, the probe can only be calibrated on 2 sides (see figure below).



Requirement

The lateral surfaces of the probe cube must be aligned parallel to the machine axes Z1, X1 (abscissa and ordinate). The approximate coordinates of the tool probe PRNUM with respect to the machine zero must be entered in array _TP[_PRNUM-1,0] to _TP[_PRNUM-1,3].

These values are used for automatic approach of the probe with the calibration tool and their absolute value must not deviate from the actual value by more than the value in parameter _TSA. The probe must also be reached within the total measurement path 2 · _FA.

parameters

parameters	Value/data type	Description
`_MVAR`	0 10000000	Calibrate tool probe (machine-related) with calibration tool Calibrate tool probe (machine-related) with turning tool
`_MA`	1, 2	Measuring axis
`_PRNUM`	INTEGER	Probe number

Additional parameters `_VMS`, `_TZL`, `_TSA`, `_FA` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

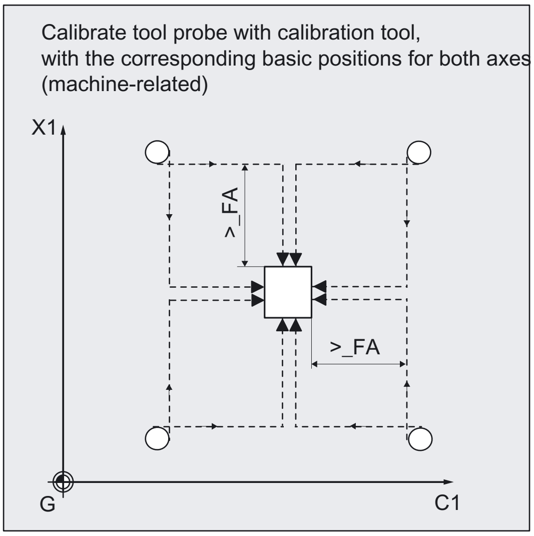
Multiple measurement at the same location: _NMSP (Page 81)

Sequence

Position before measuring cycle call

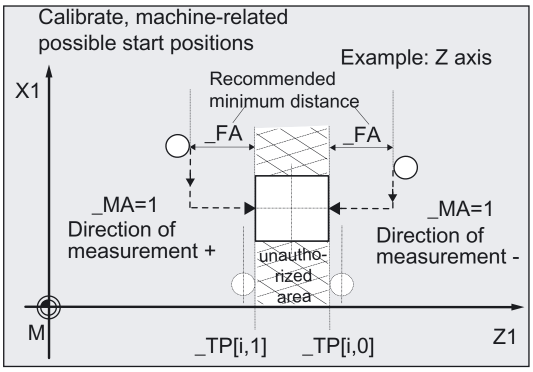
The calibration tool must be prepositioned as shown in the figure.

The measuring cycle calculates the center of the probe and the approach paths automatically and generates the necessary traverse blocks.



Position after measuring-cycle call

On completion of calibration, the calibration tool is _FA from the measuring surface.



Programming example

Calibrate tool probe (machine-related)

Tool probe 1 is stationary but provides a switching signal. The calibration tool is inserted in the turret as tool T7.

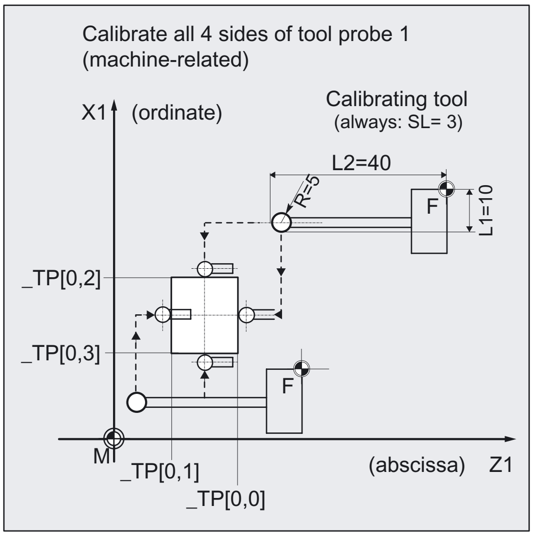
Values of the calibration tool T7 D1:

Tool type (DP1):	500
Cutting edge length (DP2):	3
Length 1 - geometry (DP3).	L1 = 10
Length 2 - geometry (DP4):	L2 = 40
Radius - geometry (DP6):	R = 5

This radius must be taken into account in selecting the starting position for calibration of _TP[0,1], _TP [0,3] (increase distance from probe by 2 × R).

Values of tool probe 1 in data block GUD6 which were determined manually to 5 mm accuracy beforehand (relative to the machine zero):

_TP[0.0] = 50, _TP[0.1] = 20
_TP[0.2] = 70, _TP[0.3] = 40



To obtain a minimum measurement path of 1 mm, the measurement path is programmed with _FA = 1+5= 6 mm (max. total measurement path = 12 mm).

```
%_N_CALIBRATE_MTT_MPF
N05 G94 G90 DIAMOF
N10 T7 D1                                  ;Calibration tool
N15 G0 SUPA Z300 X240                      ;Starting position in minus X direction,
                                           ;procedure when ZO is deactivated
N20 _TZL=0.001 _PRNUM=1 _VMS=0 _NMSP=1     ;Parameters for calibration cycle
N21 _MVAR=0 _MA=2 _TSA=5 _FA=6
N30 CYCLE982                               ;Calibration in minus X direction
N35 G0 SUPA Z60                            ;Approach new starting position
N38 _MA=1                                  ;Select another measuring axis
N40 CYCLE982                               ;Calibration in minus Z direction
N45 G0 SUPA X20                            ;Approach new starting position
N48 _MA=2
N50 CYCLE982                               ;Calibration in plus X direction
N55 G0 SUPA Z0                             ;Approach new starting position
N58 _MA=1
N60 CYCLE982                               ;Calibration in plus Z direction
N65 G0 SUPA X240                           ;Approach change position in each axis
N70 SUPA Z300
N99 M2
```

6.2.3 Determining dimensions of calibration

Function

If no special calibration tool is available, a turning tool with cutting edge position SL=3 can be used instead for calibration of two sides of the probe (_TP[i,0], _TP[i,2]).

With the following procedure it is possible to determine the dimensions as the calibration tool.

Example: X axis, probe PRNUM=1 (_TP[0,2])

1. Approximate probe data in the data block GUD6: Parameters _TP[0,0]..._TP[0,3]
2. Measure the turning tool at the presetting location.
3. Enter all tool data in the tool offset (incl. e.g.: L1 = 60.000) and use the tool in the revolver.
4. Machine a test part (turn to X dimension), e.g.:
   setpoint diameter: 200.000 mm
   Actual diameter: 200.100 mm.
5. Adapting tool correction (L1 = 59.950).
6. Finish-turn the test part again, e.g.:
   setpoint diameter: 195.000 mm
   Actual diameter: 195.000 mm,
   setpoint must be equal to the actual value, then:
7. Calibrate tool probe in X axis
   (see sample program in section "Calibrate tool probe (machine-related)").
8. Measure tool (see section "Measure turning tool (machine-related)")
   The aim is to determine value L1 = 59.950 (see Item 5.).

Another tool can then be measured and used as the calibration tool. Calibrate the probe; the subsequent tool measurement must result in the same tool length.

6.2.4 Measure turning tool (machine-related)

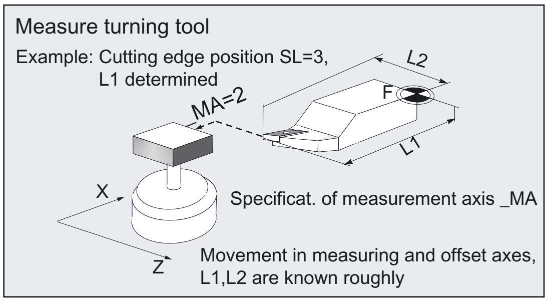
Function

The cycle determines the new tool length (L1 or L2) and checks whether the difference from the old tool length can be corrected within a defined tolerance range:

Upper limits: Safe area _TSA and dimensional deviation check _TDIF

Lower limit: Zero offset range _TZL

If this range is not violated, the new tool length is accepted, otherwise an alarm is output. Violation of the lower limit is not corrected.



Compensation strategy

The tool measuring cycle is provided for various applications:

- **Initial measurement of a tool**(_CHBIT[3]=0):

  The tool offset values in geometry and wear are replaced.

  The offset is applied in the geometry component of the length.

  The wear component is deleted.
- **Remeasurement of a tool** (_CHBIT[3]=1):

  The resulting difference is calculated into the wear component (length).

Empirical values may optionally be included. The mean value is not calculated.

Prerequisite

The tool probe must be calibrated.

The approximate tool dimensions must be entered in the tool offset data:

Tool type 5xy, cutting edge position, tool nose radius,

length 1, length 2.

The tool to be measured must be active with its tool offset values when the cycle is called.

Parameter

Parameter	Value	Meaning
_MVAR	1	Measure tool (machine-related)
_MA	1, 2	Measuring axis

Additional parameters _VMS, _TZL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM and _NMSP also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

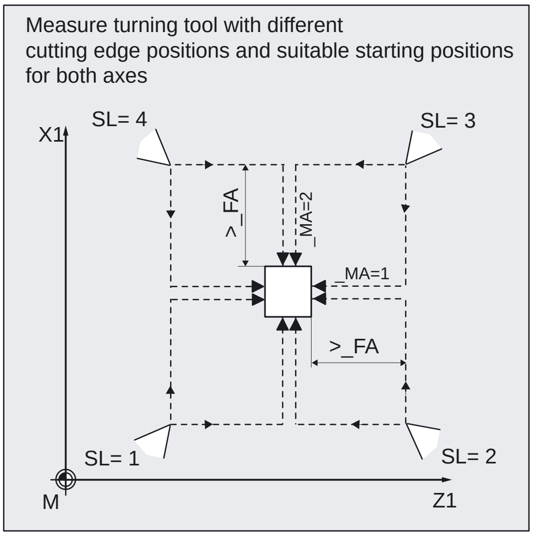
Sequence

Position before measuring cycle call

Before the cycle is called, the tool must be moved to the tool tip starting position, as shown in the figure.

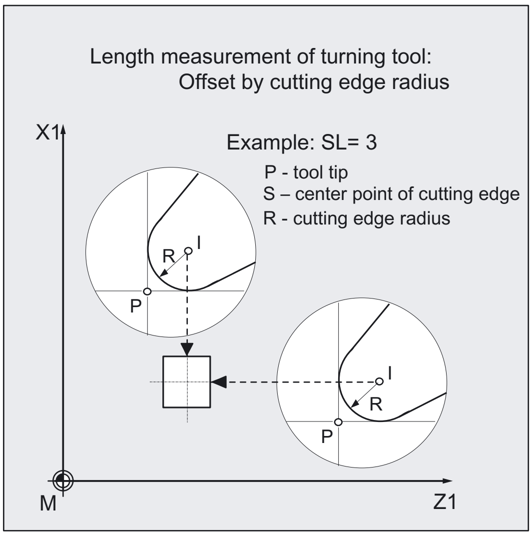
The measuring cycle calculates the center of the probe and the associated approach paths automatically. The necessary traverse blocks are generated.

The tool nose center (S) is positioned at the center of the probe.



Position after measuring-cycle call

On completion of the cycle, the tool nose is positioned facing the measuring surface and _FA from it.

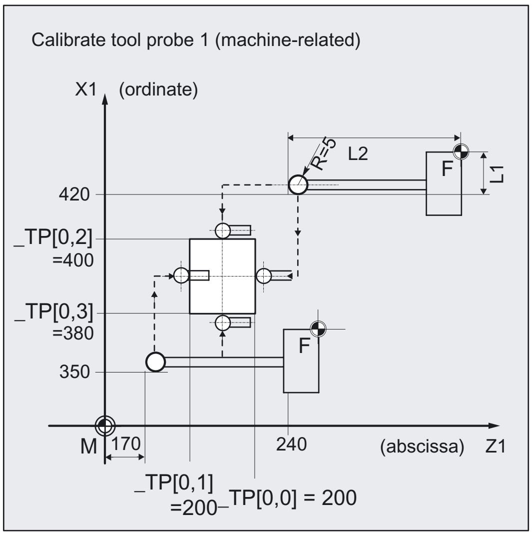


Programming example

Calibrating the tool probe with subsequent measurement of turning tool (machine-related)

Calibration tool T7, D1 is to be used to calibrate all 4 sides of probe 1. After that, turning tool T3, D1 is to be remeasured in both lengths L1 and L2 (wear calculation).

The dimensions of the calibration tool T7 are in lengths L1, L2 and the radius R = 5.0 mm are known precisely and entered in offset field D1.
The cutting edge position is SL = 3.



The default values of probe 1 as applied in data block GUD6 with a tolerance of approx. 1 mm:

_TP[0,0] = 220

_TP[0,1] = 200

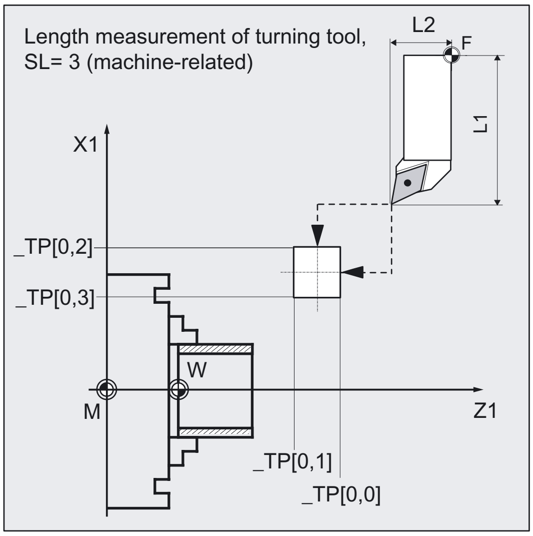
_TP[0,2] = 400

_TP[0,3] = 380

After calibration, the measured value (calibration value) is set.

The lengths for the tool to be measured T3, D1 are known, remeasurement in wear:

Tool type (DP1):	500
Cutting edge length (DP2):	3
Length 1 - geometry (DP3):	L1 = 100.654
Length 2 - geometry (DP4):	L2 = 60.321
Radius (DP6):	R = 2.000
Length 1 - wear (DP12):	0
Length 2 - wear (DP13):	0




```
%_N_T3_MEAS_MPF
;Calibration:
N10 G0 G18 G94 G90 DIAMOF
N20 T7 D1                                ;Call calibration tool
N30 SUPA Z240 X420                       ;Starting position for calibration
N40 _TZL=0.001 _PRNUM=1 _VMS=0 _NMSP=1   ;Parameter definition
N50 _MVAR=0 _FA=1 _TSA=1 _MA=2
N60 CYCLE982                             ;Calibration in minus X direction
N70 G0 SUPA Z240                         ;New starting position
N80 _MA=1                                ;Set other measuring axis (Z)
N90 CYCLE982                             ;Calibration in minus Z direction
N100 G0 SUPA X350                        ;New starting position
N110_MA=2                                ;Set other measuring axis (X)
N120 CYCLE982                            ;Calibration in plus X direction
N130 G0 SUPA Z170                        ;New starting position
N140 _MA=1                               ;Set other measuring axis (Z)
N150 CYCLE982                            ;Calibration in plus Z direction
N160 G0 SUPA X350                        ;Go to tool change position in each
                                         axis
N170 SUPA Z520                           ;Traverse
N180 SUPA X420

;Measurement:
N200 T3 D1                               ;Selection of the tool to be measured
N210 G0 SUPA Z240 X420                   ;Starting position for measurement
N220 _MVAR=1 _MA=2 _TDIF=0.8             ;Change of parameter definition for
                                         ;measurement, otherwise calibration
```

```
N230 _CHBIT[3]=1              ;Offset in wear (remeasuring)
N240 CYCLE982                 ;Tool measurement in minus X direction
                              (L1)
N250 G0 SUPA Z240             ;New starting position
N260 _MA=1                    ;Set other measuring axis (Z)
N270 CYCLE982                 ;Tool measurement in minus Z direction
                              (L2)
N280 G0 SUPA X420             ;Retraction axis by axis
N290 SUPA Z520
N300 M2
```

Explanation N10 to N180, calibrate

The "tip" of the calibration tool T7 is positioned in measuring axis X from the starting position at distance _FA=1 mm (dimension → with reference to the radius) before the probe. In axis Z, the probe tip center is centered with respect to the probe.

The measuring process is initiated in the negative X direction (_MA=2, starting position) with measuring velocity 150 mm/min (_VMS=0, _FA=1). The switching signal is expected by the probe 1 (_PRNUM=1) within a distance of 2 · _FA=2 mm. Otherwise, an alarm will be triggered.

Measurement is performed once (_NMSP=1). After successful measurement, the "tip" of T7 is _FA=1 mm in front of the probe in the X direction.

The calculated probe value is entered in _TP[0,2]. Calibration with the measuring process has been completed in minus X.

Calibration is then performed in the other measuring directions/axes.

Explanation N200 to N300, measure

The probe is completely calibrated.

The "nose" of the turning tool T3 is positioned in measuring axis X from the starting position at distance _FA=1 mm (dimension → with reference to the radius) in front of the probe. In axis Z, the center of the cutting edge is centered with respect to the probe. If the cutting edge radius =0, it is the tool nose.

The measuring process is initiated in the negative X direction (_MA=2, starting position) with measuring velocity 150 mm/min (_VMS=0, _FA=1). The switching signal is expected by the probe 1 (_PRNUM=1) within a distance of 2 · _FA = 2 mm. Otherwise, an alarm will be triggered.

Measurement is performed once (_NMSP=1). After successful measurement, the "tip" of T3 is _FA=1 mm in front of the probe in the X direction.

The calculated length difference of L1 (tool type 5xy, _MA=2, _MVAR=1) is summated and entered in D1 from T3 in the wear (_CHBIT[3]=1).

Measurement and wear offset are then performed in L2 in the minus Z direction.

Recommended parameters

The following parameters are recommended so that this programming example runs reliably:

- Calibration:

  _TZL=0.001 zero offset area
  _TSA=1 safe area
  _FA=1 measurement path

- First-time measurement of a tool:

  _TZL=0.001 zero offset area
  _TDIF=3 dimension difference check
  _TSA=3 safe area
  _FA=3 measurement path

- Remeasure the tool:

  _TZL=0.001 zero offset area
  _TDIF=0.3 dimension difference check
  _TSA=1 safe area
  _FA=1 measurement path

6.3 CYCLE982 tool: Measure turning and milling tools

6.3.1 Function overview

Function

Cycle CYCLE982 permits

- calibration of a tool probe,
- measurement of tool lengths L1 and L2 for turning tools with cutting edge positions 1 to 8,
- the tool lengths for milling tools and drills on turning machines,
- the radius for milling tools.

NC software of at least SW 5 is needed for measuring milling cutters/drills.

Programming

```
CYCLE982
```

Note

Tolerance parameters _TSA, _TDIF and _TZL must be entered taking into account machine data

- MD 20360 TOOL_PARAMETER_DEF_MASK bit0 and bit1

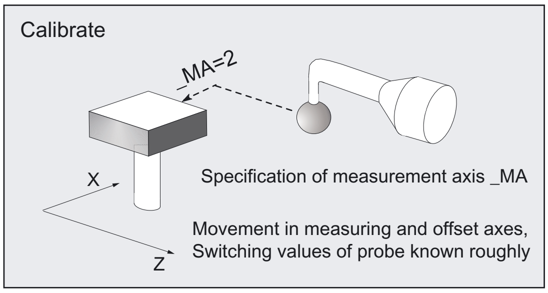
in conjunction with the offset target

- geometry and wear.

The following measurement and calibration tasks are supported by CYCLE982:

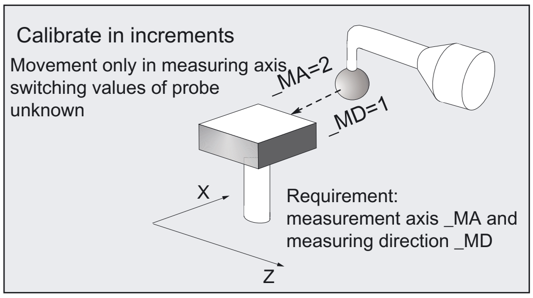
- **Calibrate** as preparation for measurement/automatic measurement

The 4 switching positions of the probe are roughly known and entered in the array of the associated tool probe. Positioning of the calibration tool with respect to the probe is performed in the cycle. It is only possible to determine the switching position that is in the measuring axis _MA and measuring direction according to starting position.



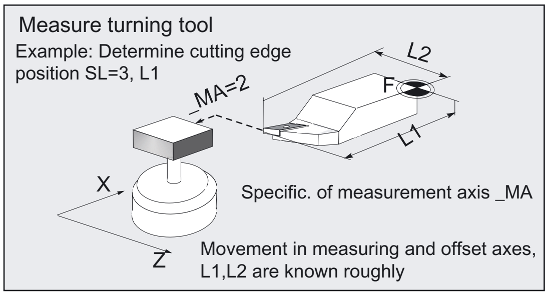
- **Calibrate in increments** as preparation for incremental measurement

The switching positions of the probe are not known. The calibration tool must have been positioned in front of the probe manually (in JOG mode) before the cycle is called. It is only possible to determine the switching position that is in the measuring axis _MA and the stated measuring direction _MD. Only the probe switching position in which the axis and direction will subsequently be measured incrementally have to be calibrated.



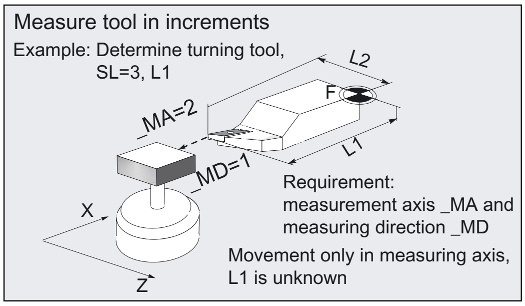
- **Measuring**

Only measured values that are in the measurement axis _MA can be calculated. The geometry of the tool to be measured is roughly known and entered in the tool offset. Positioning of the tool with respect to the calibrated probe is performed in the cycle. The geometry must be determined precisely or wear (initial measurement or remeasurement of a tool).



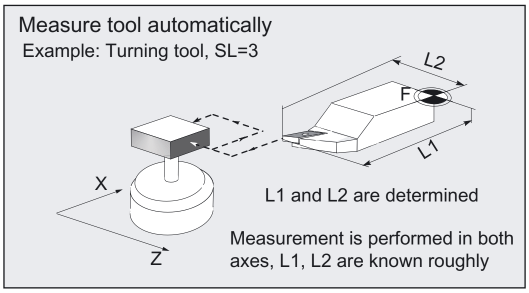
- **Incremental measurement**

The geometry of the tool to be measured is not known. The tool must have been positioned in front of the probe manually before the cycle is called. The geometry is to be determined exactly. Only one measured value that is in the measurement axis _MA can be calculated. The cycle approaches the probe in the measuring axis in the specified measuring direction _MD.



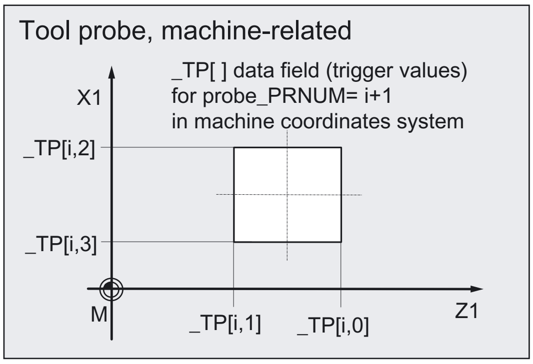
- **Automatic measurement**

  All values that can be determined are determined automatically according to the active tool type. The geometry of the tool to be measured is roughly known and entered in the tool offset. Positioning of the tool with respect to the calibrated probe is performed in the cycle. The geometry must be determined precisely or wear (initial measurement or remeasurement of a tool).



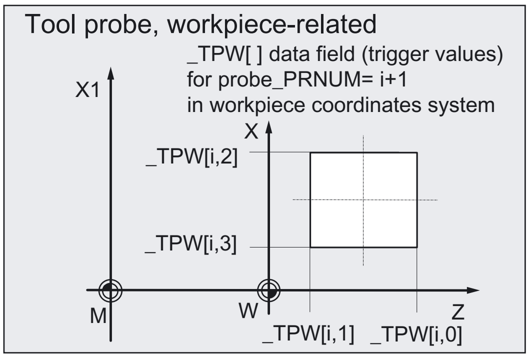
- **Machine-related measurement, calibration**

  The switching positions of the tool probe refer to the machine zero. The data field for the tool probe _PRNUM is used: **_TP**[PRNUM-1,...].



- **Machine-related measurement, calibration**

  The switching positions of the tool probe refer to the workpiece zero. The data field for the tool probe _PRNUM is used: **_TPW**[PRNUM-1,...].



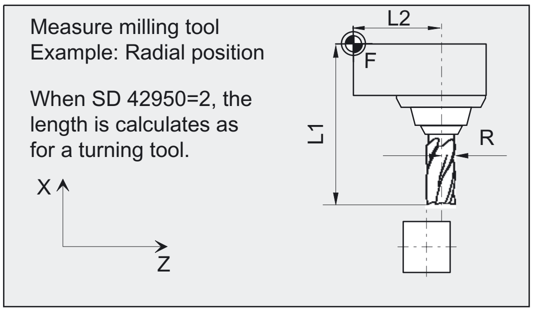
Special aspects with milling tools

The tool length correction is specific to the turning machine (SD 42950:TOOL_LENGTH_TYPE=2). The length assignment (L1, L2) is performed like for a turning tool.

Measurement is possible with a rotating (M3, M4) or with a stationary milling spindle (M5). If the milling spindle is stationary, it is positioned at the specified starting angle _STA1 at the beginning. For simple measuring tasks, this positioning with _STA1 can be suppressed _CHBIT[20]=1). If suppression is active, measurement not requiring an SPOS-capable milling spindle is possible.

To measure a second cutting edge, you can select "measurement with reversal". This involves calculating the mean value over both measured values.

Not all functions are available. Certain functions require a certain SW software version of the measuring cycles and NCK. This information is given with each function.



Note

Measuring drills

If the length of the drill (L2 for G18, radial position and/or L1 for G18, axial position) is measuring by approaching the probe from the side, ensure that for the drill to be measured, the probe is not deflected in the area of the twist groove or in the area of its drill tip. If this is not possible using the "Measurement" or "Automatic measurement" measuring processing, the "Incremental measurement" measuring variant should be used.

The drill radius must have been previously entered in the tool correction for this measurement variant, otherwise an alarm is triggered.

Note

Turning machines with Y axis

Before CYCLE982 is called, the Y axis (applicate in G18) must be put in a position corresponding to the center of the probing surface of the tool probe in this axis.

The Y axis is not positioned in the cycle itself.

Measuring variants

Measuring cycle CYCLE982 permits the following measuring variants which are specified via parameter _MVAR.

Digit								Meaning
8	7	6	5	4	3	2	1	
								Calibrating tool probes
0 1							0 0	With calibration tool ; with turning tool
							1	**Measure turning and milling tool/drill**, Measurement axis in _MA (is specified for Turning tools: Cutting edge position 1...8, Milling tools: Points 3 to 5 in _MVAR)
							2	**Automatic measurement** (determine both lengths, for milling cutter, the radius tool.) The following is specified: Turning tools: Of edge positions 1...8, Milling tools: Points 3 to 5 in _MVAR)
						0		Machine-related[1)]
						1		Workpiece-related
								Significance for measuring milling tools only, also automatically:
					0			Measurement without reversal
					1			Measurement with reversal
								Significance for measuring milling tools only, also automatically:
				0 0			1 2	Only correct length (for measuring only) or Measure milling cutter automatically
				1			1	Only correct radius (for measuring only)
				2			1	Only length and radius (for measuring only, not for measuring in increments)
				3			2	Measure upper tool edge automatically: Correct length and radius, travel round measuring cube opposite starting position side (for automatic measurement only, e.g.: groove mill)
				4			2	Measure upper tool edge automatically: Correct length and radius, measuring direction for determining length opposite to traversing direction, measuring sequence as for _MVAR=x3x02 but with different traversing motion (for automatic measurement only, e.g.: groove mill)
1) Tool measurement and calibration are undertaken in the basic coordinates system (machine coordinates system with kinematics transformation switched off).								

Digit								Meaning
8	7	6	5	4	3	2	1	*Significance for measuring milling tools only, also automatically:*
			0					Axial position of milling tool/drill (radius in ordinate, for G18: X axis, SD 42950: value = 2)
			1					Radial position of milling tool/drill (radius in abscissa, for G18: Z axis, SD 42950: value = 2)
		0						Measurement and calibration
								Incremental calibration
0		1					0	With calibration tool
1		1					0	; with turning tool
								or
		1					1	Incremental measurement (limited variants, no automatic measurement)

- The following measuring variants are not possible for incremental measurement:

  1xxxx2; 102xx1; 112xx1
- The following measuring variants are permitted if _CHBIT[20]=1 (suppression of the starting angle position with _STA1) on a milling tool:

  xxx0x1 (with x: 0 or 1, no other values)
- A measuring variant can also be impermissible if it cannot be performed with the specified measuring axis _MA, e.g. determining the milling cutter radius. However, with this position of the milling cutter it is not in the measuring axis.

Result parameters

The measuring cycle CYCLE982 returns the following values in the data block GUD5 for the measuring variant calibration:

Parameter	Data type	Result
`_OVR [8]`	REAL	Trigger point in minus direction, actual value, abscissa
`_OVR [10]`	REAL	Trigger point in plus direction, actual value, abscissa
`_OVR [12]`	REAL	Trigger point in minus direction, actual value, ordinate
`_OVR [14]`	REAL	Trigger point in plus direction, actual value, ordinate
`_OVR [9]`	REAL	Trigger point in minus direction, difference, abscissa
`_OVR [11]`	REAL	Trigger point in plus direction, difference, abscissa
`_OVR [13]`	REAL	Trigger point in minus direction, difference, ordinate
`_OVR [15]`	REAL	Trigger point in plus direction, difference, ordinate
`_OVR [27]`	REAL	Zero offset area
`_OVR [28]`	REAL	Safe area
`_OVI [2]`	INTEGER	Measuring cycle number
`_OVI [3]`	INTEGER	Measuring variant
`_OVI [5]`	INTEGER	Probe number
`_OVI [9]`	INTEGER	Alarm number

Measuring cycle CYCLE982 returns the following values in the data block GUD5 for tool measurement:

Parameter	Data type	Result
_OVR [8]	REAL	Actual value length L1
_OVR [9]	REAL	Difference length L1
_OVR [10]	REAL	Actual value length L2
_OVR [11]	REAL	Difference length L2
_OVR [12]	REAL	Actual value for radius
_OVR [13]	REAL	Difference for radius
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29]	REAL	Permissible dimensional difference
_OVR [30]	REAL	Empirical value
_OVI [0]	INTEGER	D number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [3]	INTEGER	Measuring variant
_OVI [5]	INTEGER	Probe number
_OVI [7]	INTEGER	Empirical value memory
_OVI [8]	INTEGER	T number
_OVI [9]	INTEGER	Alarm number

Note

Tool types

During measurement or calibration, the tool type (tool parameter DP1 in the tool offset data) of the active tool is evaluated.

Type 5xy: Turning tool or calibrating tool

Type 1xy: Milling tool

Type 2xy: Drill

Use of tool types 711 to 799 is also possible. These are treated as a milling tool (type 1xy).

Drills (type 2xy), with SD 42950: TOOL_LENGTH_TYPE=0 can be gauged (refer to Chapter "Measuring drills – special applications"). Otherwise this is only possible for drills and milling tools with SD 42950: TOOL_LENGTH_TYPE=2.

6.3.2 Calibrating tool probes

Function

- **Calibrating tool probes - machine-related**

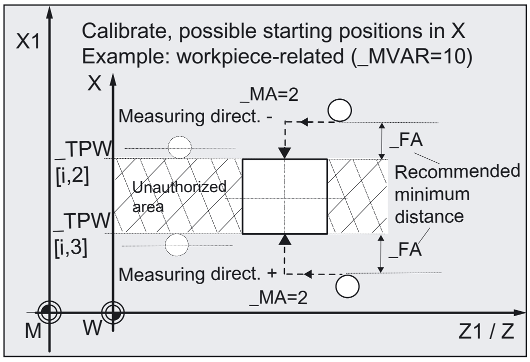
  Measuring variant **_MVAR=0** permits machine-related calibration of a tool probe with a calibrating tool.

  This variant is already described in detail section "Calibrate tool probe automatically (machine-related)".

- **Calibrate tool probe, workpiece-related**

  Measuring variant **_MVAR=10** permits calibration of a tool probe relative to the calibration tool relative to the workpiece.

  The switching positions of the tool probe refer to the workpiece zero. The data field for the tool probe _PRNUM is used: _TPW[PRNUM-1,...].



Transformations can be activated in workpiece-related measurement, calibration.

The requirements and procedures are as for machine-related calibration (see "Calibrate tool probe automatically (machine-related)").

parameters

parameters	Value/data type	Description
`_MVAR`	0 10000000 10 10000010	Calibrate tool probe (machine-related) with calibration tool Calibrate tool probe (machine-related) with turning tool Calibrate tool probe (workpiece-related) with calibration tool Calibrate tool probe (workpiece-related) with turning tool
`_MA`	1, 2	Measuring axis
`_PRNUM`	INTEGER	Probe number

Additional parameters `_VMS`, `_TZL`, `_TSA`, `_FA` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

Programming example

Calibrate tool probe (workpiece-related)

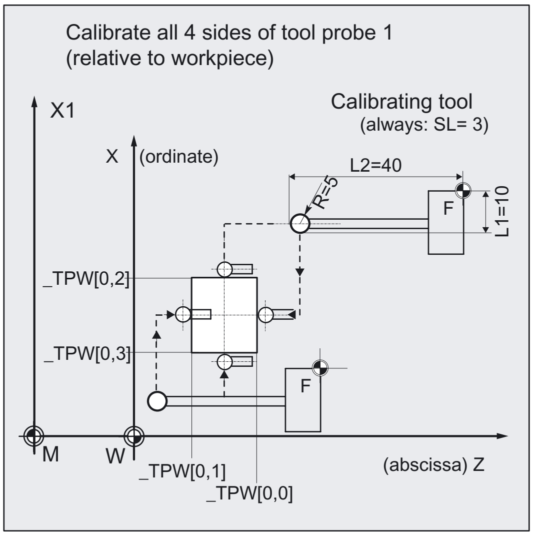
Tool probe 1 is in the machining area and is oriented parallel to the axis of the workpiece coordinate system.

The calibration tool is inserted in the turret as tool T7.

Values of the calibration tool T7 D1:

Tool type (DP1):	500
Cutting edge position (DP2):	3
Length 1 - geometry (DP3):	L1 = 10
Length 2 - geometry (DP4):	L2 = 40
Radius - geometry (DP6):	R = 5

This radius must be taken into account when selecting the starting position for calibration of _TPW[0,1], _TPW[0,3] (increase distance from probe by 2 × R).



Values of the settable ZO G54:

Displacement: X = 0, Z = 60.000 mm, no rotation

Values of tool probe 1 in data block GUD6 which were determined manually to 5 mm accuracy beforehand (relative to the workpiece zero):

_TPW[0,0] = 50
_TPW[0,1] = 20
_TPW[0,2] = 70
_TPW[0,3] = 40

To obtain a minimum measurement path of 1 mm, the measurement path is programmed with _FA = 1+5= 6 mm (max. total measurement path = 12 mm).

```
%_N_CALIBRATE_MTT_WCS_MPF
N05 G54 G94 G90 DIAMOF
N10 T7 D1                                ;Calibration tool
N15 G0 Z100 X120                         ;Starting position in minus X
                                         direction,
                                         ;procedure when ZO is activated
N20 _TZL=0.001 _PRNUM=1 _VMS=0 _NMSP=1   ;Parameters for calibration cycle
N21 _MVAR=10 _MA=2 _TSA=5 _FA=6
N30 CYCLE982                             ;Calibration in minus X direction
N35 G0 Z80                               ;Approach new starting position
N38 _MA=1                                ;Select another measuring axis
N40 CYCLE982                             ;Calibration in minus Z direction
N45 G0 X10                               ;Approach new starting position
N48 _MA=2
N50 CYCLE982                             ;Calibration in plus X direction
N55 G0 Z-10                              ;Approach new starting position
N58 _MA=1
N60 CYCLE982                             ;Calibration in plus Z direction
N65 G0 X10                               ;Approach start position in each
                                         axis
N70 Z100
N80 X120
N100 M2                                  ;End of program
```

Explanation of example

The calibration tool moves out of the starting position of N15 (X120, Z100) in Z to the center of the probe with its "tool tip". An offset is applied to compensate for the calibration tool radius. This places the radius center point in the center of the probe. The tool tip position is shown: Z30 ((_TPW[0,0] + (_TPW[0,1]) / 2 -R = (50+20) / 2 -5=30)). This is followed by traversal in measuring axis X (_MA=2, G18) to position X76 (_TPW[0,2] + _FA = 70 + 6 = 76). This is where actual calibration (like measurement) starts in the minus X direction. At the end the calibration tool is again at position X76.

The new trigger values in minus X are stored in the data of tool probe 1 (_PRNUM=1) _TP[0,2] if they deviate by more than 0.001 mm (_TZL=0.001) from the old values. Deviations of up to 5 mm (_TSA=5) are permissible.

After that, the sides in the minus Z direction, plus X direction, and plus Z direction are approached, calibrated, and the values entered in array _TPW[0,...].

6.3.3 Measuring tool

Function

This cycle and its various measuring variants are for measuring:

_MVAR=1: Turning tools (machine-related)

This variant is described in detail section "Measure turning tool (machine-related)".

_MVAR=11: Turning tools (workpiece-related)

_MVAR=xxx01: Milling tools, drills (machine-related)

_MVAR=xxx11: Milling tools, drills (workpiece-related)

Workpiece-related or machine-related measurement require an appropriately calibrated tool probe (see section "Calibrating tool probes" or "Calibrating tool probes (machine-related)").

These measuring variants can only determine offset values that are in the measurement axis _MA.

The cycle determines the new tool length (L1 or L2), for milling tools the radius too, and checks whether the difference from the old tool length can be corrected within a defined tolerance range:

Upper limits: Safe area _TSA and dimensional deviation check _TDIF,

Lower limit: Zero offset range _TZL.

If this range is not violated, the new tool length is accepted, otherwise an alarm is output. Violation of the lower limit is not corrected.

Compensation strategy

The tool measuring cycle is provided for various applications:

- Initial measurement of a tool(_CHBIT[3]=0):
  - The tool offset values in geometry and wear are replaced.
  - The offset is applied in the geometry component of the length.
  - The wear component is deleted.
- Remeasurement of a tool (_CHBIT[3]=1):

  The resulting difference is calculated into the wear component (radius or length).

Empirical values may optionally be included. The mean value is not calculated.

If _CHBIT[20]=1, positioning of the milling spindle at the value of _STA1 can be suppressed.

That is possible with the following milling cutter measuring variants:

_MVAR=xxx001 (with x: 0 or 1, no other values).

Prerequisite

The tool probe must be calibrated.

The approximate tool dimensions must be entered in the tool offset data:

Tool type, cutting edge position on turning tools, radius, length 1, length 2.

The tool to be measured must be active with its tool offset values when the cycle is called.

For a **milling cutter**, the setting data SD 42950: TOOL_LENGTH_TYPE = 2 must be set (length calculation as for turning tool). For milling tools, the tool spindle must be declared the master spindle.

For a **drill**, SD 42950: TOOL_LENGTH_TYPE = 0 is also possible (refer to Chapter "Measuring drills – special applications").

parameters

parameters	Value/data type	Description
`_MVAR`	1 or xxx01 11 or xxx11	Measure tool (machine-related) Measure tool (workpiece-related) More precise parameterization for milling tools is entered in the 3rd to 5th digits of _MVAR.
`_MA`	1, 2	Measuring axis
`_STA1`	REAL	For milling tools: Start angle
`_CORA`	REAL	For milling tools: Correction angle setting after reversal (for measurement with reversal only _MVAR=xx1x1)

Additional parameters `_VMS, _TZL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

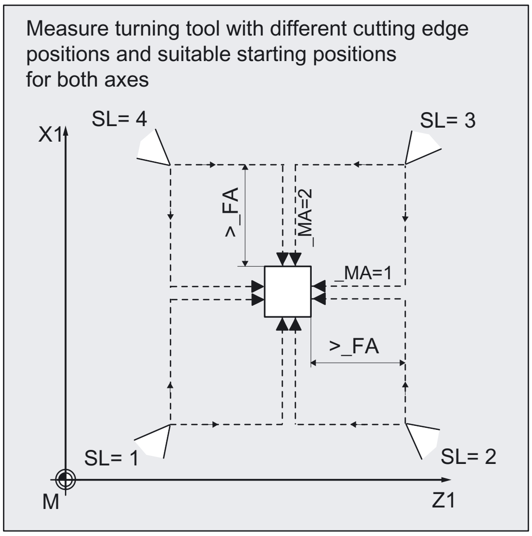
Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Sequence

Position before measuring cycle call

Before the cycle is called, the tool must be moved to the starting position, as shown in the diagram for turning tools. The measuring cycle then calculates the approach position automatically. This position determines the measuring direction in the measuring axis _MA. For milling tools, the measuring point on the tool is determined by entered lengths 1 and 2 (please note: SD 42950: TOOL_LENGTH_TYPE). If the radius value is not equal to zero, this is also a determining factor. The measuring point is then located on the side which the measuring probe faces (+R or –R). The axial or radial position of the tool must be specified (_MVAR). This starting position must ensure collision-free approach.



In the case of milling tools, length and radius can be selected as an alternative to length only to determine the cutter radius.

For length and radius, two measuring points are required. These are approached from different sides of the measuring probe. First the measuring point facing the measuring probe at the starting point is approached. Then, after travel round the probe (in the direction of the starting point), the 2nd measuring point is measured in the opposite direction. If the spindle is stationary (M5) and measurement without reversal is selected, the 2nd measurement is performed with a spindle rotation of 180 degrees. The same cutting edge used for the 1st measurement is now used.

The L1 or L2 offset values and the cutter radius are calculated from these two measurements.

Measurement with reversal can be selected separately with _MVAR: First the measuring point is measured in the selected axis and in a milling spindle position according to starting angle _STA1. Then the tool (spindle) is turned 180 degrees and measured again. The average value is the measured value. Measurement with reversal causes a second measurement at each measuring point P with a spindle rotation through 180 degrees from the starting angle.
The offset angle entered in _CORA is summated to these 180 degrees. That enables selection of a certain 2nd milling cutting edge that is offset from the 1st cutting edge by precisely 180 degrees. Measurement with reversal permits measurement of two cutting edges of one tool. The mean value is the offset value.

If _CHBIT[20]=1, selected measuring variants are possible for a milling cutter without taking the starting angle _STA1 into account (see Subsection "Milling cutter: Suppression of start angle positioning _STA1").

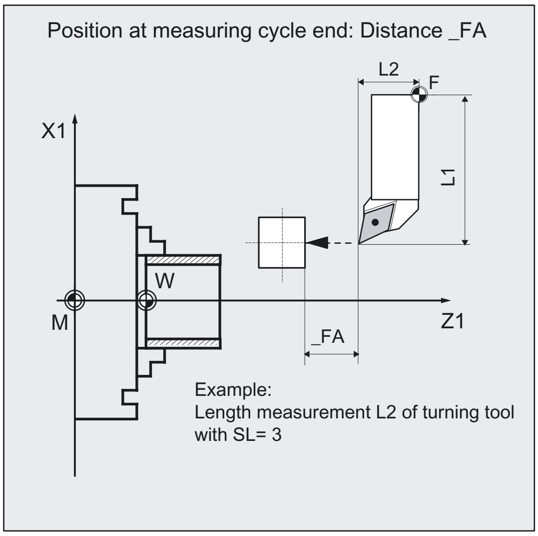
Note

Measurement with rotating spindle

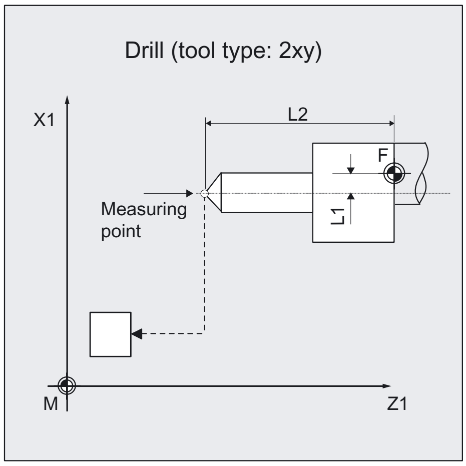
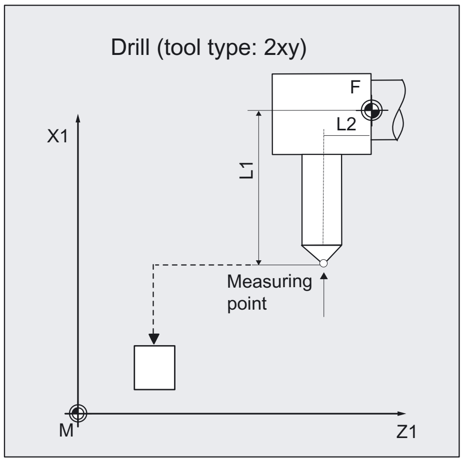
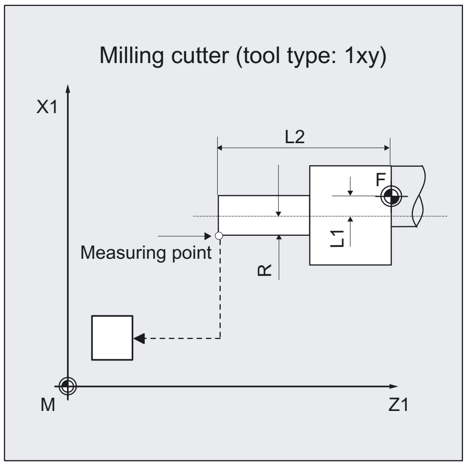
If selection of a certain miller cutting edge is not possible, it is possible to measure with a rotating spindle. The user must then program the direction of rotation, speed, and feedrate very carefully before calling up CYCLE982 to prevent damage to the probe. A low speed and feedrate must be selected.

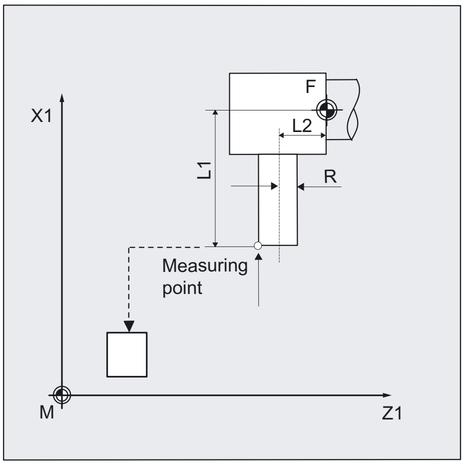
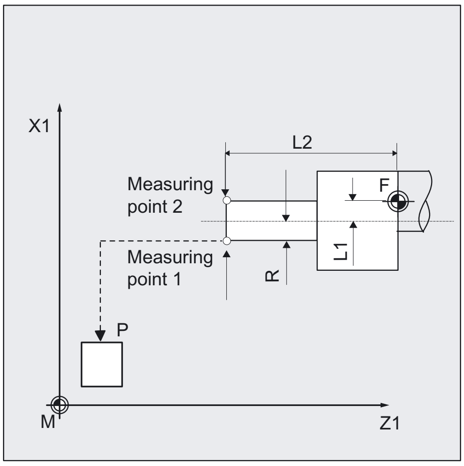
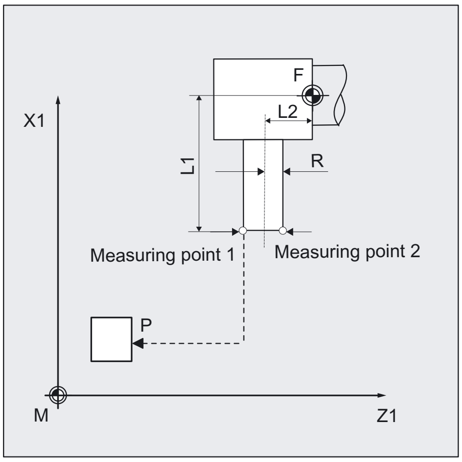
Position after end of measuring cycle

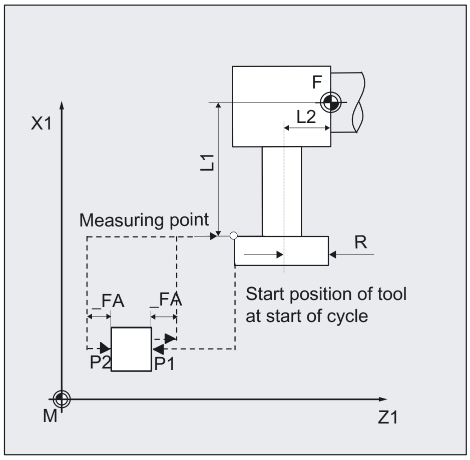
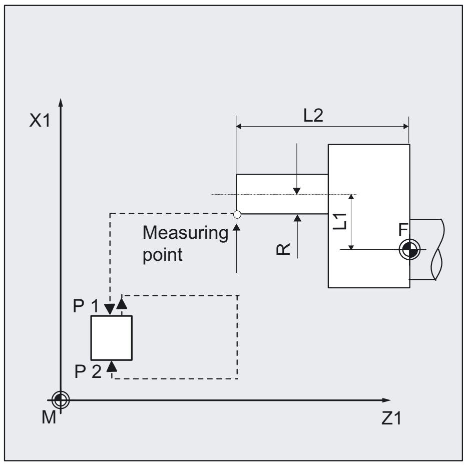
On completion of the cycle, the tool nose is positioned facing the last measuring surface and _FA from it.

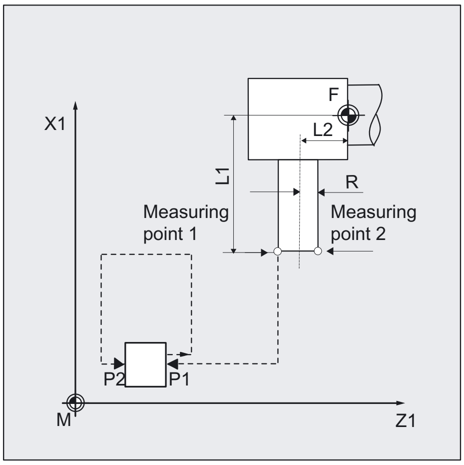
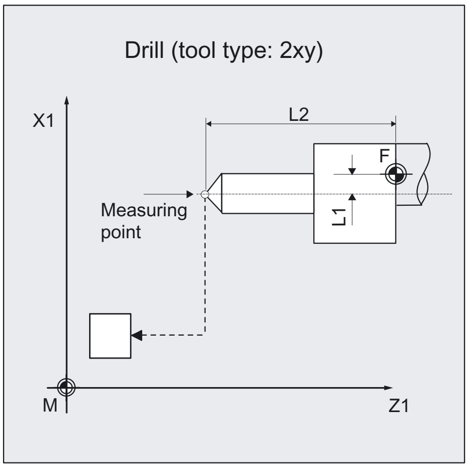


Examples of measuring variants

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example: **Axial position,** R=0, Measuring without reversal, calculate length only _MVAR=1 _MA=1	L1=... L2=... R=0	L2	
Example: **Radial position,** R=0, Measuring without reversal, calculate length only _MVAR=10001 _MA=2	L1=... L2=... R=0	L1	
Example: **Axial position,** R ≠ 0, Measuring without reversal, calculate length only _MVAR=1 _MA=1	L1=... L2=... R=...	L2	

<table>
<tr><th>Measuring variant</th><th>Specified geometry</th><th>Offset applied in</th><th>Milling tools, drills</th></tr>
<tr><td>Example:
Radial position,
R ≠ 0,
Measuring without reversal,
calculate length only
_MVAR=10001
_MA=2</td><td>L1=...
L2=...
R=...</td><td>L1</td><td>
</td></tr>
<tr><td>Example:
Axial position,
R ≠ 0,
measuring with reversal,
calculate radius only
_MVAR=1101
_MA=2
L1 must be known</td><td>L1=...
L2=...
R=...</td><td>R
R=ABS(P – L1)</td><td>
</td></tr>
<tr><td>Example:
Radial position,
R ≠ 0,
measuring with reversal,
calculate length only
_MVAR=10101
_MA=1
R must be known</td><td>L1=...
L2=...
R=...</td><td>L2
L2=(P - R)
Or other measuring direction:
L2=(P + R)</td><td>
</td></tr>
</table>

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example: **Radial position,** R ≠ 0, Measuring without reversal, calculate length and radius, 2 measuring points necessary _MVAR=12001 _MA=1	L1=... L2=... R=...	L2 R L2=(P1 + P2)/2 R= ABS(P1-P2)/2	
Notes: On starting, the measuring point must be outside the measurement cube coordinates in both coordinates. On the opposite side of the measuring cube (P2) measurement is performed with a rotated spindle (by 180 degrees). The same cutting edge is then measured. This only happens if the spindle is stationary and without reversal. In this example, L1 refers to the upper cutting edge. If L1 is to be calculated in another measurement, the starting position must be below the measuring cube.			
Example: **Axial position,** R ≠ 0, Measuring without reversal, calculate length and radius, 2 measuring points necessary _MVAR=2001 _MA=2 P2 is measured with a rotated spindle (by 180 degrees), if measurement is performed with a stationary spindle.	L1=-.. L2=... R=...	L1 R L1=(P1 + P2)/2 R= ABS(P1-P2)/2	

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example: **Radial position,** R ≠ 0, Measurement with reversal at each measuring point, calculate length and radius, 2 measuring points necessary (4 measurements) **_MVAR=12101** **_MA=1**	L1=... L2=... R=...	L2 R L2=(P1 + P2)/2 R= ABS(P1-P2)/2	
Example: **Axial position,** R=0, Measuring without reversal, calculate length only **_MVAR=1** **_MA=1**	L1=... L2=... R=0	L2	

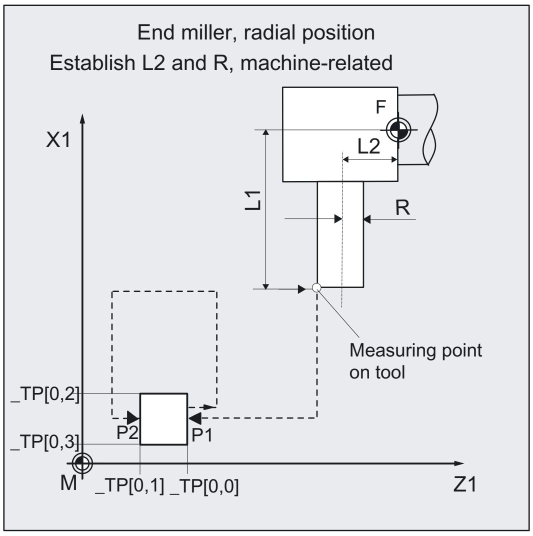
Programming example

Measure milling tool in the radial position (machine-related)

For the end miller T3, D1 should be determined in the radial position when first measuring length L2 and radius R. Measurements will be without reversal. The cutting edge to be measured is in the milling spindle position 15 degrees.

The lengths and radius of tool T3 to be measured are roughly known and entered in offset field D1:

Tool type (DP1):	120
Cutting edge position (DP2):	
Length 1 - geometry (DP3):	L1 = 60
Length 2 - geometry (DP4):	L2 = 10
Radius - geometry (DP6):	R = 14



Deviations from this value of less then 2.5 mm are expected.

The probe to be used is tool probe 1. This probe has already been completely calibrated (machine-related). The precise values are entered in array _TP[0,...] and are approximately:

_TP[0,0]=220, _TP[0,1]=200

_TP[0,2]=400, _TP[0,3]=380.

```
%_N_T3_MEAS_FR_MPF
N1 G0 G18 G90 G94 DIAMOF
N100 T3 D1                                    ;Selection of the tool to be
                                              measured
N110 G0 SUPA Z285 X450                        ;Start position for measuring
                                              ;procedure without ZO
N120 _TZL=0.001 _TSA=3 _FA=3 _PRNUM=1         ;Change of parameter definition for
_VMS=0 _NMSP=1                                ;measurement, otherwise calibration

N121 _MA=1 _TDIF=2.5 _MVAR=12001 _STA1=15
N130 _CHBIT[3]=0                              ;Offset in the geometry
N131 _CHBIT[20]=0                             ;Do not suppress _STA1
N140 CYCLE982                                 ;Tool measurement L2, R
N180 G0 SUPA X450                             ;Retraction axis by axis
N190 SUPA Z285
N200 M2                                       ;End of program
```

Explanation of example

The spindle is positioned at 15 degrees with SPOS. Measuring point P1 is approached first. The measuring process is initiated in the negative Z direction (_MA=1, starting position) with measuring velocity 300 mm/min (_VMS=0, _FA>1). The switching signal is expected by the probe 1 (_PRNUM=1) within a distance of 2 **x** _FA=2 mm. Otherwise, an alarm will be triggered. Measurement is performed once (_NMSP=1). After successful measurement, tool T3 is _FA=3 mm + tool radius in front of the probe.

The probe is then traveled around as shown in the figure. On the opposite side of the probe (P2) measurement is performed with a rotated spindle (by 180 degrees). The same cutting edge is then measured. Measurement is performed with the spindle stopped and without reversal. After successful measurement, tool T3 is _FA=3 mm + tool radius in front of the probe. The spindle remains in this position.

The radius and length L2 are determined precisely and tool parameters DP6 and DP4 of T3, D1 are entered. The values in result parameter array OVR[ ] are also entered.

In block N180, N190, the tool returns to the starting position and the program then ends.

6.3.4 Automatic tool measurement

Function

This cycle and its various measuring variants are for measuring tools **automatically**:

_MVAR=2: Turning tools (machine-related)

_MVAR=12: Turning tools (workpiece-related)

_MVAR=xxx02: Milling tools, drills (machine-related)

_MVAR=xxx12: Milling tools, drills (workpiece-related)

Workpiece-related or machine-related measurement require an appropriately calibrated tool probe (see section "Calibrating tool probes" or "Calibrate tool probe automatically (machine related)").

With milling tools/drills, the measurement is further specified in the 3rd to 5th digits of parameter _MVAR. Here, SD 42950: TOOL_LENGTH_TYPE must be = 2

The function is as for non-automatic measurement.

In automatic measurement, all offsets are determined. These are then defined with the tool type:

- **Turning tool:**
  - Both lengths (2 measurements),
  - for cutting edge positions SL = 5, 6, 7, and 8, only one length (1 measurement)
- **Drill:**

  Length according to axial or radial position (1 measurement)
- **Milling cutter:**

  both lengths and radius (4 measurements), if the radius is specified as R=0, only both lengths are established (2 measurements).

The calculated offsets are entered in the active D number of the active tool. The offset strategy is defined via _CHBIT[3] as for measurement.

The measuring cycle generates the approach blocks to the probe and the transverse motions to measure length 1, length 2 and for the milling cutter, the radius too. A correctly selected start position is needed.

Prerequisite

As for non-automatic tool measurement

Parameter

Parameter	Value/data type	Meaning
`_MVAR`	2 or xxx02 12 or xxx12	Measure tool automatically (machine-related) Measure tool automatically (workpiece-related) More precise parameterization for milling tools is entered in the 3rd to 5th digits of _MVAR.
`_MA`	1, 2	Measuring axis
`_STA1`	REAL	For milling tools: Start angle
`_CORA`	REAL	For milling tools: Correction angle setting after reversal (for measurement with reversal only _MVAR=xx1x1)

Additional parameters `_VMS`, `_TZL`, `_TDIF`, `_TSA`, `_FA`, `_PRNUM`, `_EVNUM` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

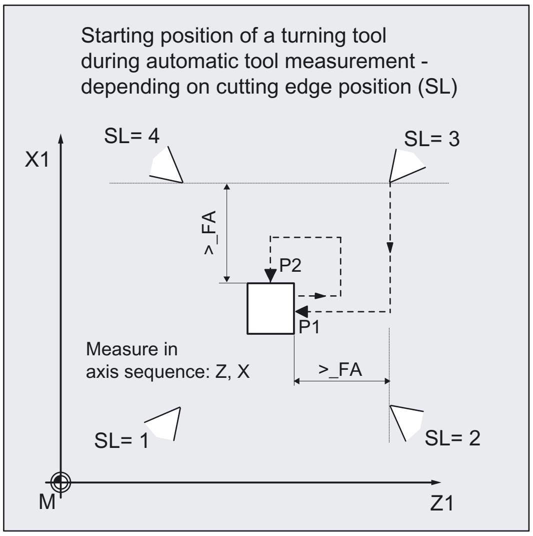
Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Sequence

Position before measuring cycle call

Before the cycle is called, the tool must be moved to the starting position, as shown in the diagram for turning tools. The measuring cycle then calculates the approach position automatically. First the length (P1) in the abscissa (Z axis for G18) and then (P2) in the ordinate (X axis for G18) is measured. For turning tools, the measuring probe travels round the measuring cube at distance _FA.

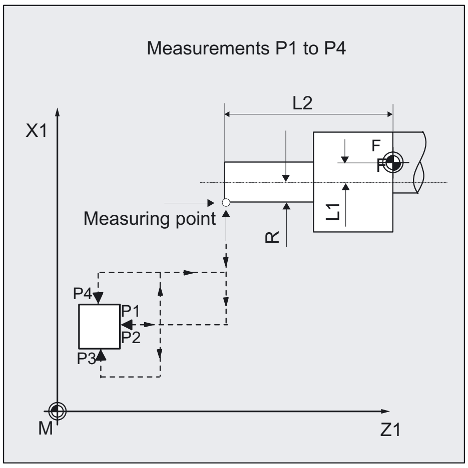
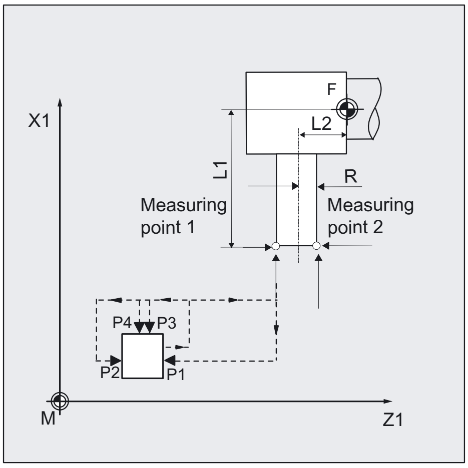


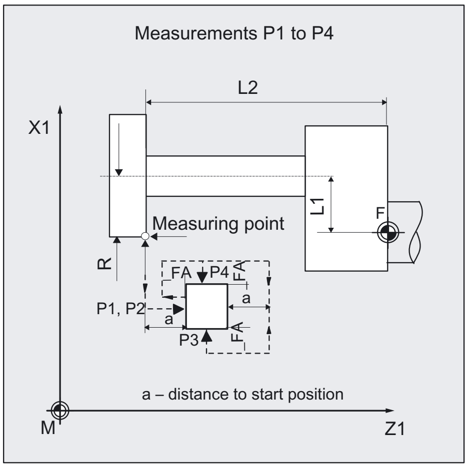
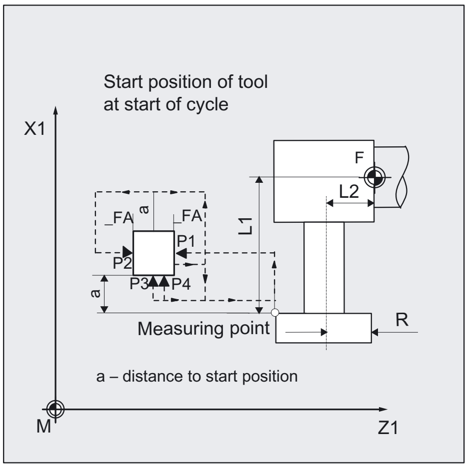
For milling tools, the measuring points on the tool are determined by entered lengths 1 and 2 (please note: SD 42950). If the radius value is not equal to zero, this is also a determining factor. The axial or radial position of the tool must be specified in _MVAR, and the starting position approached accordingly. First, the values in the abscissa (Z axis for G18) are measured. Measurement with reversal can be selected separately with _MVAR. The probe travels round the measuring cube at distance _FA or according to the starting point coordinate (see figs.).

Position after end of measuring cycle

When the cycle is complete, the tool nose is again located at the starting point. A movement to this point is automatically generated in the cycle.

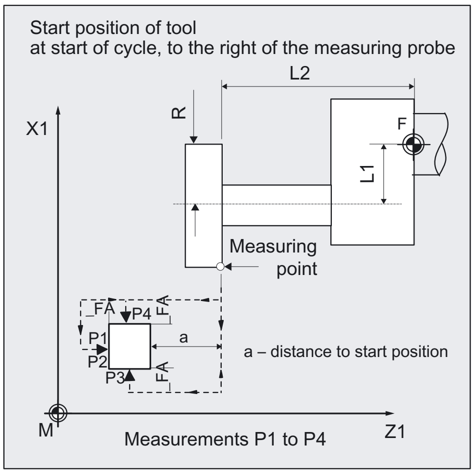
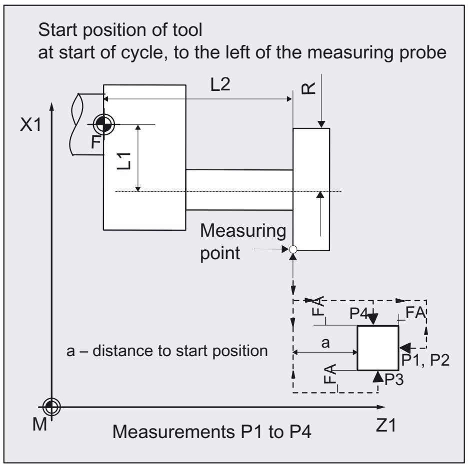
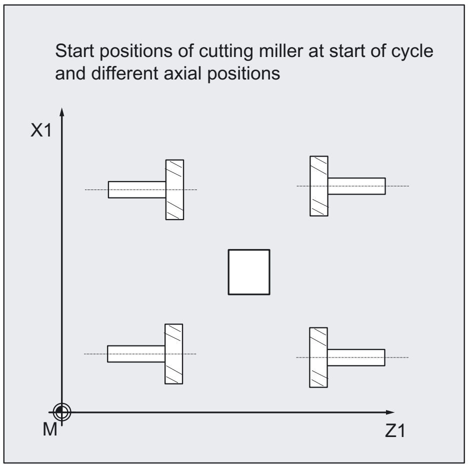
Examples of measuring variants

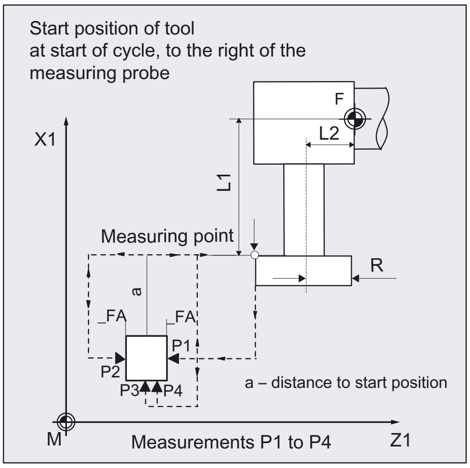
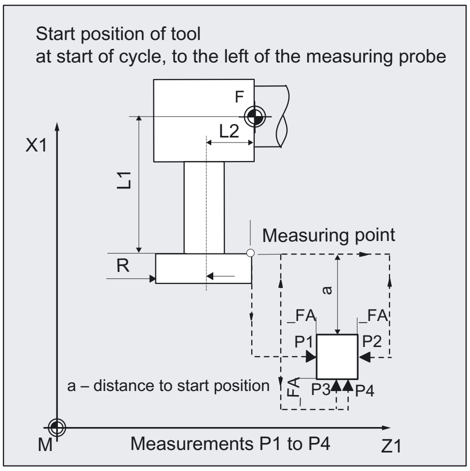
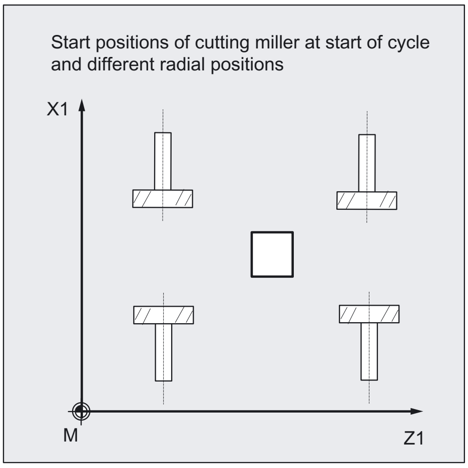
<table>
<tr><th>Measuring variant</th><th>Specified geometry</th><th>Offset applied in</th><th>Milling tools</th></tr>
<tr><td>Example 1:
Axial position,
R ≠ 0,
Measuring without reversal,
spindle stationary,
4 measurements necessary
_MVAR=2</td><td>L1=...
L2=...
R=...</td><td>L1
L2
R
L1=
(P3x + P4x)/2
L2=
(P1z + P2z)/2
R=ABS(P3x-P4x)/2</td><td>
</td></tr>
<tr><td colspan="4">Note on example 1, process:
P1 is approached with the starting angle position _STA1 of the milling spindle and measured. As the spindle is stationary (M5) and reversal measurement is not selected, the spindle is rotated by 180 degrees and the same cutting edge is measured again after it has been positioned in the center of the measuring cube. The mean value of both measurements is L2.
Then P3 is approached and measured, after that the spindle is again rotated by 180 degrees and P4 is measured. L1 and R are calculated from these two measurements. The probe is then retracted to the starting point in axis sequence abscissa/ordinate.</td></tr>
<tr><td>Example 2:
Radial position,
R ≠ 0
measuring with reversal,
8 measurements necessary (P1 to P4 each with reversal)
_MVAR=10102</td><td>L1=...
L2=...
R=...</td><td>L1
L2
R
L1=
(P3x + P4x)/2
L2=
(P1z + P2z)/2
R=ABS(P1z-P2z)/2</td><td>
</td></tr>
</table>

Measuring variant	Specified geometry	Offset applied in	Milling tools
Example 3: **Axial position,** R ≠ 0, Measuring without reversal, 4 measurements necessary **_MVAR=3002** The probe travels around the measuring cube opposite the starting position side.	L1=... L2=... R=...	L1 L2 R L1= (P3x + P4x)/2 L2= (P1z + P2z)/2 R=ABS(P3x-P4x)/2	
Note on example 3: Length measurements for L2 (P1, P2) are performed here at the same measuring point 1, without rotating the spindle by 180 degrees. The same cutting edge is always measured (starting angle _STA1).			
Example 4: **Radial position,** R ≠ 0 Measuring without reversal, 4 measurements necessary **_MVAR=13002** The probe travels around the measuring cube opposite the starting position side.	L1=... L2=... R=...	L1 L2 R L1= (P3x + P4x)/2 L2= (P1z + P2z)/2 R=ABS(P1z-P2z)/2	
Note on example 4: Length measurements for L1 (P3, P4) are performed here at the same measuring point 1, without rotating the spindle by 180 degrees. The same cutting edge is always measured (starting angle _STA1).			

For measuring variants _MVAR=0x3xx2 and _MVAR=0x4xx2 (measure upper cutting edge automatically), the cutting mill must have suitable geometric dimension (end mill/cutter radius) for approaching the center of the probe with the cutting edge without collision.

No check is made for suitability of the milling cutter for this measuring variant. It is up to the user to ensure this.

Measuring variant	Specified geometry	Offset applied in	Milling tools
Example 5: Axial position, R ≠ 0, Measuring without reversal, 4 measurements necessary _MVAR=4002 Direction of measurement for determining length L2 opposite to traversing direction, measuring procedure as for _MVAR=x3002 but with different traversing motion **Notes:** Length measurements for L2 (P1, P2) are performed here at the same measuring point – without rotating the spindle by 180 degrees. The same cutting edge is always measured (starting angle _STA1). The width of the milling tool must be considered when selecting the starting position or dimension a!	L1=... L2=... R=...	L1 L2 R L1=(P3x + P4x)/2 L2=(P1z + P2z)/2 R= ABS(P3x-P4x)/2	  

Measuring variant	Specified geometry	Offset applied in	Milling tools
Example 6: Radial position, R ≠ 0, Measuring without reversal, 4 measurements necessary _MVAR=14002 Direction of measurement for determining length L1 opposite to traversing direction, measuring procedure as for _MVAR=x13002 but with different traversing motion **Notes:** Length measurements for L1 (P3, P4) are performed here at the same measuring point – without rotating the spindle by 180 degrees. The same cutting edge is always measured (starting angle _STA1). The width of the milling tool must be considered when selecting the starting position or dimension a!	L1=... L2=... R=...	L1 L2 R L1=(P3x + P4x)/2 L2=(P1z + P2z)/2 R= ABS(P3z-P4z)/2	  

6.3.5 Incremental calibration

Function

A tool probe can be calibrated with measuring variant

_MVAR=100000 (machine related) or

_MVAR=100010 (workpiece-related)

incrementally with a calibration tool.

The switching positions of the probe are not known. The values entered in the array of the probe are not evaluated. The calibration tool must have been positioned in front of the probe manually (in JOG mode) before the cycle is called.

The cycle uses the calibration tool to ascertain the current distance dimensions between the zero and the probe trigger point and automatically loads them into the appropriate data area in data block GUD6 (field _TP [ ] or _TPW[ ]).

Values are corrected without empirical and mean values.

Prerequisite

The lateral surfaces of the tool probe must be aligned parallel to the relevant axes (machine or workpiece coordinate system in abscissa and ordinate).

Since no specific tool type is available for the calibration tool, the 8th digit of _MVAR indicates whether a calibration or turning tool is to be used for calibration (see CYCLE982, measuring variants).

Length 1 and 2 and the radius of the calibration tool must be known exactly and stored in a tool offset data block.

This tool offset must be active when the cycle is called. A turning tool must be specified as the tool type (type 5xy). Calibration is possible with cutting edge positions SL1, SL2, SL3 or SL4.

Before CYCLE982 starts, the position of the calibration tool (tool tip) must be such that it causes the probe to switch in the specified direction _MD for the measuring axis _MA within path 2 × _FA.

Careful when positioning manually!

Damage to the probe must be prevented.

Parameter

Parameter	Value	Description
_MVAR	100000	Calibrate tool probe incrementally (machine-related) with calibration tool
	10100000	Calibrate tool probe incrementally (machine-related) with turning tool
	100010	Calibrate tool probe incrementally (workpiece-related) with calibration tool
	10100010	Calibrate tool probe incrementally (workpiece-related) with turning tool
_MA	1, 2	Measuring axis
_MD	0, 1	Measuring direction: 0 - positive, 1 - negative

Additional parameters `_VMS`, `_FA`, `_PRNUM` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Multiple measurement at the same location: _NMSP (Page 81)

Sequence

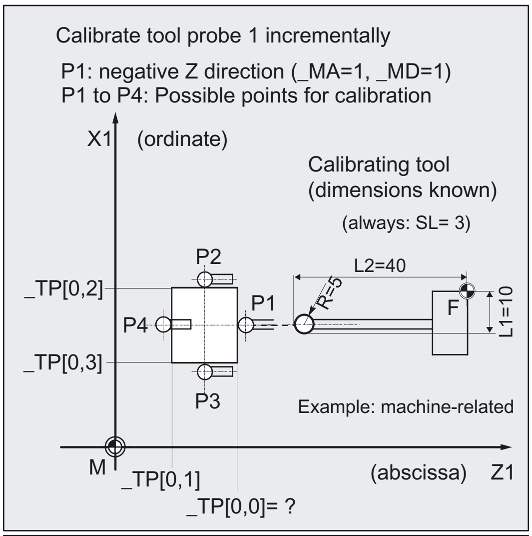
Position before measuring cycle call

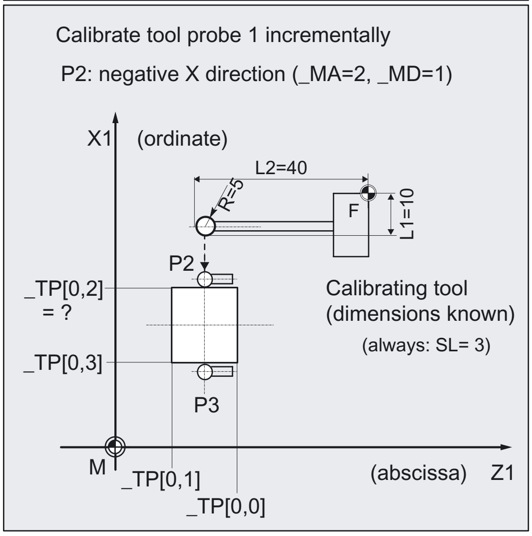
The calibration tool must be prepositioned as shown in the figure:

The "tip" of the calibration tool in the **measuring axis** _MA within distance 2 · _FA **in front of** the measuring surface.

The center of the calibration tool tip in the **other axis** (offset axis) must be in the center of the probe.

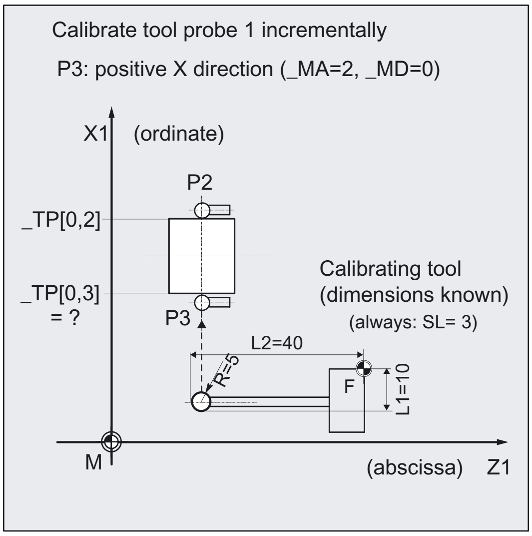
The measuring cycle starts measuring in the specified axis (_MA) and measuring direction (_MD) immediately on starting.





Position after end of measuring cycle

When the calibration procedure is completed the calibration tool is positioned on the starting position again.



Comments

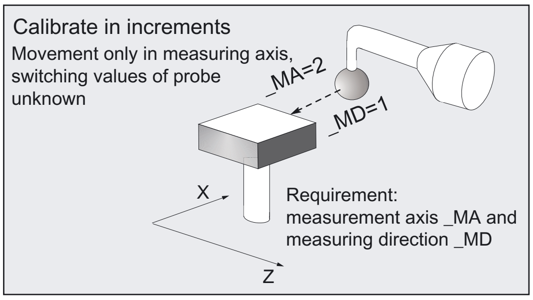
A special tool is used as the calibration tool and is entered as a turning tool (5xy) with cutting edge. Calibration is possible with cutting edge positions SL1, SL2, SL3 or SL4. It is usually shaped (bent) such that it is also possible to approach point P4 for calibration (_MA=1, _MD=0). Calibration tool: See section "Calibrate tool probe (machine-related)".

However, it is not necessary to calibrate all 4 sides for **incremental** measurement. The side that is used for incremental measurement is sufficient. That does not apply to automatic measurement. Here all 4 points must be calibrated or values entered for automatic central positioning of the tool to be measured.

Programming example

Calibrate tool probe incrementally

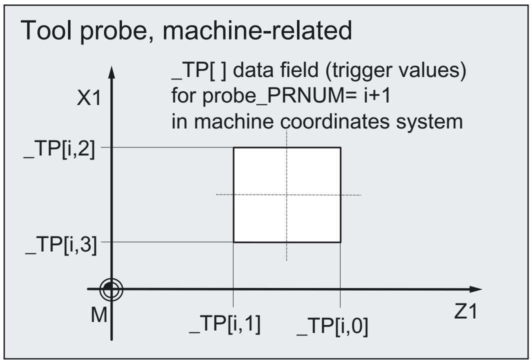
Tool probe 1 is in the machining area and is oriented parallel to the axis of the machine. Calibration is to be performed in the minus X direction and incrementally.



The calibration tool is inserted in the turret as tool T7.

Values of the calibration tool T7 D1:

Tool type (DP1):	500
Cutting edge position (DP2):	3
Length 1 - geometry (DP3):	L1 = 10
Length 2 - geometry (DP4):	L2 = 40
Radius - geometry (DP6):	R = 5



Values of tool probe 1 in data block GUD6 before calibration:

_TP[0,0] = ?, _TP[0,1] = ?

_TP[0,2] = ?, _TP[0,3] = ?

```
%_N_INCR_CALIBRATE_MPF
N10 T7 D1 G94                                ;Calibration tool is active,
                                             ;start position is taken up
N20 _MVAR=100000 _MA=2 _MD=1 _FA=20 _PRNUM=1 ;Parameters for calibration cycle
_VMS=0 _NMSP=1
N30 CYCLE982                                 ;Calibration in minus X direction
N99 M2
```

Explanation of example

Before the program is started, the "tip" of the calibration tool T7 is in measuring axis X in a range 2 · _FA=40 (dimension with reference to radius) in front of the probe. In axis Z, the probe tip center is centered with respect to the probe.

When CYCLE982 is started, measurement starts in the negative X direction (_MA=2, MD=1) with measuring velocity 300 mm/min (_VMS=0, _FA>1). The switching signal is expected by the probe 1 (_PRNUM=1) within a distance of 2 · _FA=40 mm. Otherwise, an alarm will be triggered. Measurement is performed once (_NMSP=1).

After successful measurement, the "tip" of T7 is in the starting position again.

The calculated probe value is entered in _TP[0,2]. Calibration with the measuring process has been completed in minus X.

6.3.6 Incremental measurement

Function

This cycle and its various measuring variants are for measuring tools **incrementally**:

_MVAR=100001: Turning tools (machine-related)

_MVAR=100011: Turning tools (workpiece-related)

_MVAR=1xxx01: Milling tools, drills (machine-related)

_MVAR=1xxx11: Milling tools, drills (workpiece-related).

Workpiece-related or machine-related measurement require an appropriately calibrated tool probe (see Subsection "Incremental calibrating").

With milling tools/drills, the measurement is further specified in the 3rd to 5th digits of parameter _MVAR.

It is possible to measure single tool lengths, or alternatively for milling tools the cutter radius.

The calculated offsets are entered in the active D number. The offset is entered in the **geometry data** and the wear data are reset (irrespective of _CHBIT[3]).

Only the offset value that is in the measuring axis _MA and measuring direction _MD can be determined in a measurement.

If _CHBIT[20]=1, positioning of the milling spindle at the value of _STA1 can be suppressed (see Subsection "Milling tool": Suppression of start angle positioning _STA1").

This is possible for milling cutter measuring variants:

_MVAR= xxx001 (where x : 0 or 1, no other values).

Requirements

For incremental measurement, the tool probe must be calibrated in the measuring axis and direction in which measuring will be performed.

The tool T to be measured must be called with tool offset (D number).

The tool type is entered in the offset data.

For a **milling cutter**, setting data SD 42950: TOOL_LENGTH_TYPE = 2 must be set (length calculation as for turning tool).

For milling tools, the tool spindle must be declared the master spindle. For a **drill**, SD 42950: TOOL_LENGTH_TYPE = 0 is also possible (refer to Chapter "Measuring drills – special applications").

parameters

parameters	Value/data type	Meaning
`_MVAR`	1xxx01 1xxx11	Measure a tool incrementally – machine-related Measure a tool incrementally – workpiece-related More precise parameterization for milling tools/drills is entered in the 3rd to 5th digits of _MVAR.
`_MA`	1, 2	Measuring axis
`_MD`	0, 1	Measuring direction: 0 - positive, 1 - negative
`_STA1`	REAL	Only for milling tools and if _CHBIT[20]=0: Starting angle of the milling spindle
`_CORA`	REAL	Only for milling tools and measurement with reversal: Offset angle position of the milling spindle after reversal

Additional parameters `_VMS`, `_FA`, `_PRNUM` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

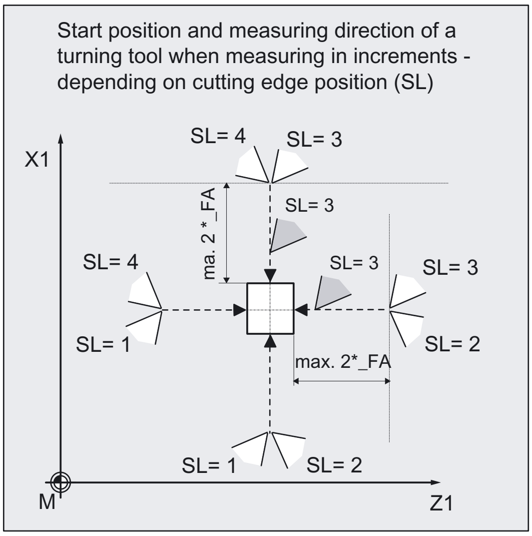
Multiple measurement at the same location: _NMSP (Page 81)

Sequence

Position before measuring cycle call

Before the cycle is called, the tool must be moved to the starting position, as is shown in the diagram for **turning tools**, e.g.: with traversal in JOG:

The "tip" of the calibration tool in the **measuring axis** _MA within distance 2 · _FA **in front of** the measuring surface. The center of the cutting edge radius on the turning tool in the **other axis**is in the center of the probe. If the cutting edge radius =0, it is the tool nose.



For **milling tools** the axial or radial position of the tool must be specified in _MVAR; as with **Measure with reversal:**

First the measuring point is measured in the selected axis and in a milling spindle position according to starting angle _STA1. The tool (milling spindle) is then rotated through 180 degrees plus the value in _CORA and measured again. The average value is the measured value.

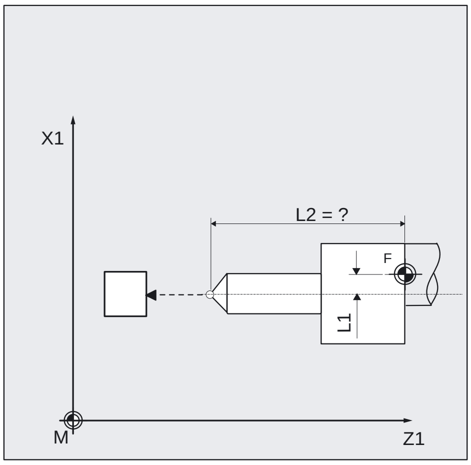
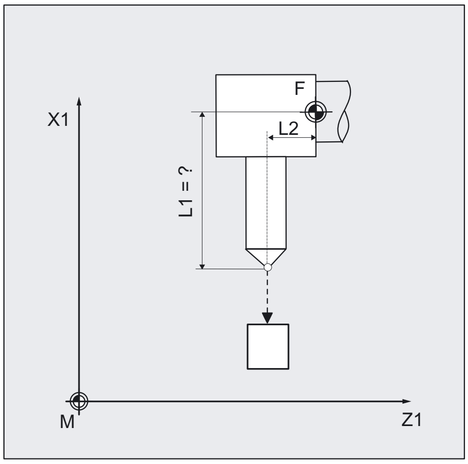
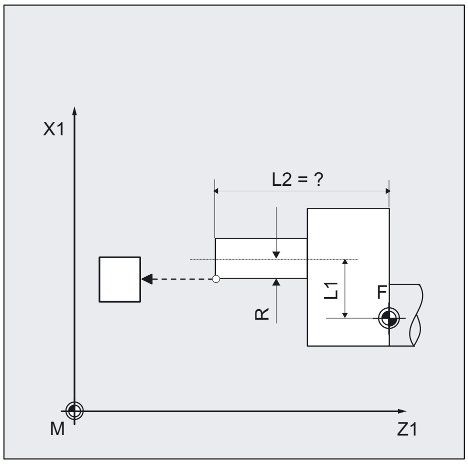
If the milling spindle is activated when the cycle is started, measurement will be performed with a **rotating spindle**. In that case, the user must exercise special care when selecting the speed, direction of rotation, and feedrate!

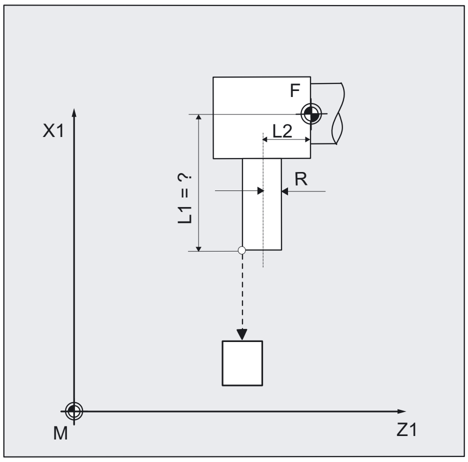
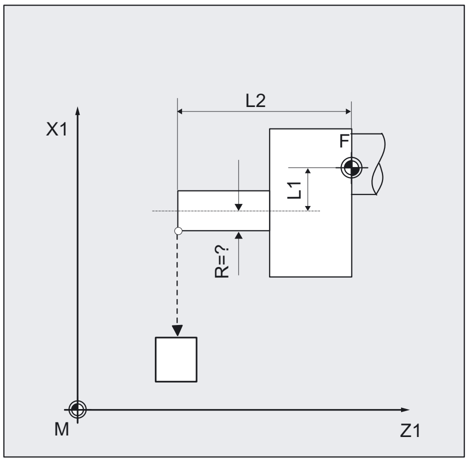
If _CHBIT[20]=1, selected measuring variants are possible for a milling cutter without taking the starting angle _STA1 into account (see Subsection "Milling cutter: Suppression of start angle positioning _STA1").

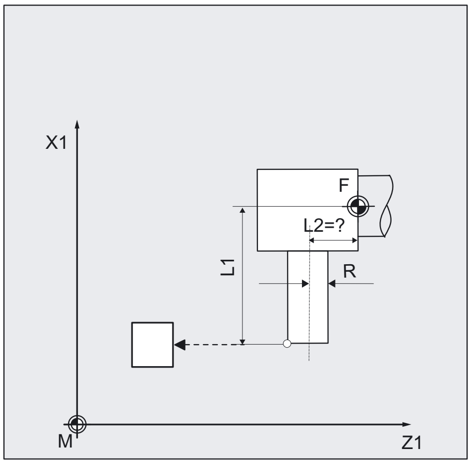
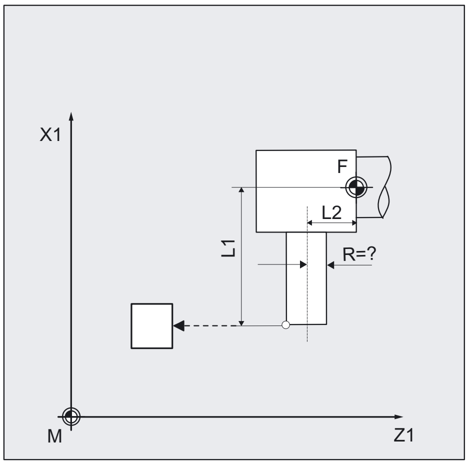
Position after end of measuring cycle

When the cycle is complete, the tool nose is again located at the starting position.

Examples of measuring variant

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example 1: **Axial position,** Drill, R=0, incremental measurement without reversal, calculation of the length in Z **_MVAR=100001** **_MA=1** Always position the drill tip in the center of the probe!	L1=... L2=... R=0	L2	
Example 2: **Radial position,** Drill, R=0 Measuring without reversal, calculation of the length in X **_MVAR=110001** **_MA=2**	L1=... L2=... R=0	L1	
Example 3: **Axial position,** Milling cutter, R ≠ 0, Measuring without reversal, calculation of the length in Z **_MVAR=100001** **_MA=1**	L1= -... L2=... R=...	L2	

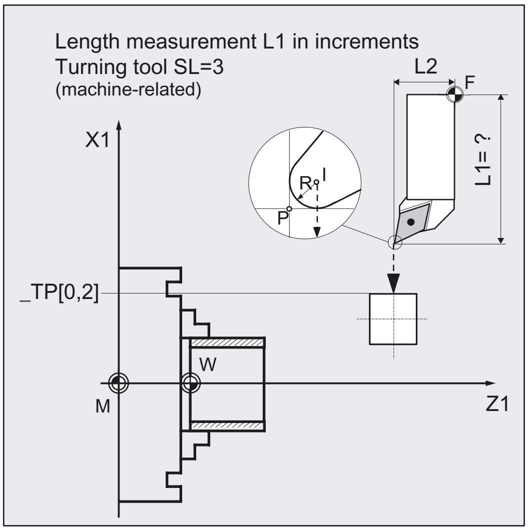
Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example 4: **Radial position,** Milling cutter, R ≠ 0, Measuring without reversal, calculation of the length in X _MVAR=110001 _MA=2	L1=... L2=... R=...	L1	
Example 5: **Axial position,** Milling cutter, R ≠ 0, measuring with reversal, calculate radius _MVAR=101101 _MA=2 In this case, L1 must be known.	L1=.... L2=... R=...	R	

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example 6: **Radial position,** Milling cutter, R ≠ 0, measuring with reversal, calculation of the length in Z **_MVAR=110101** **_MA=1** In this case, R must be known.	L1=... L2=... R=...	L2	
Example 7: **Radial position,** Milling cutter, R ≠ 0, measuring with reversal, calculate radius **_MVAR=111101** **_MA=1** In this case, L2 must be known.	L1=... L2=... R=...	R	

Programming example

With the turning tool T3, D1 with SL=3, length L1 is to be determined **incrementally** and machine-related.

The probe to be used is tool probe 1. This probe is already calibrated in the minus X direction (machine-related). The precise values are entered in probe array _TP[0,2].




```
%_N_INCR_MEAS_MPF
N10 T3 D1 G94                                        ;Turning tool T3 is active,
                                                     ;Starting position reached
N20 _MVAR=100001 _MA=2 _FA=20 _MD=1 _PRNUM=1 _VMS=0  ;Parameters for the measuring
_NMSP=1                                              cycle
N30 CYCLE982                                         ;Measurement in minus X
                                                     direction
N99 M2
```

Explanation of example

The probe has been calibrated in minus X.

Before the program is started, the "tip" of the tool T3 is in measuring axis X in a range 2 × _FA=40 mm (dimension with reference to radius) in front of the probe. In axis Z, the center of the cutting edge is centered with respect to the probe. If the cutting edge radius =0, it is the tool nose.

When CYCLE982 is started, measurement starts in the negative X direction (_MA=2, MD=1) with measuring velocity 300 mm/min (_VMS=0, _FA>1). The switching signal is expected by the probe 1 (_PRNUM=1) within a distance of 2 x _FA = 40 mm. Otherwise, an alarm will be triggered. Measurement is performed once (_NMSP=1).

After successful measurement, the "tip" of T3 is in the starting position again.

The calculated length L1 (tool type 5xy, _MA=2, _MVAR=xx**0**xxx) is entered in D1 of T3 in the geometry. The associated wear component is reset.

6.3.7 Milling tool: Suppression of start angle positioning _STA1

Function

To apply the angular position of the milling spindle (cutting edge of the miller contacting the probe) unchanged in the cycle and thus suppress the starting angle positioning with the value in _STA1, you can set **_CHBIT[20]=1** .

However, this only permits simple milling cutter measuring variants that do not have to use the starting angle in _STA1, e.g.: no 2nd measurement or no re-positioning after measurement with reversal. Otherwise milling cutter measuring variants are possible that are also permitted for incremental measurement.

If the machine does not feature an SPOS-capable milling spindle, it is also possible to measure milling cutters with these measuring variants and _CHBIT[20]=1.

Permissible measuring variants with milling cutter and _CHBIT[20]=1:
xxx0x1 (with x : 0 or 1, no other values)

Other measuring variants with a miller will be rejected with an alarm message.

For measurement with rotating spindle and _CHBIT[20]=1, only these measuring variants are permitted. Measurement with reversal is not permitted.

6.3.8 Measuring drills - Special applications

Prerequisite

The tool probe has been calibrated with **G18** active as is usual for turning tools.

Function

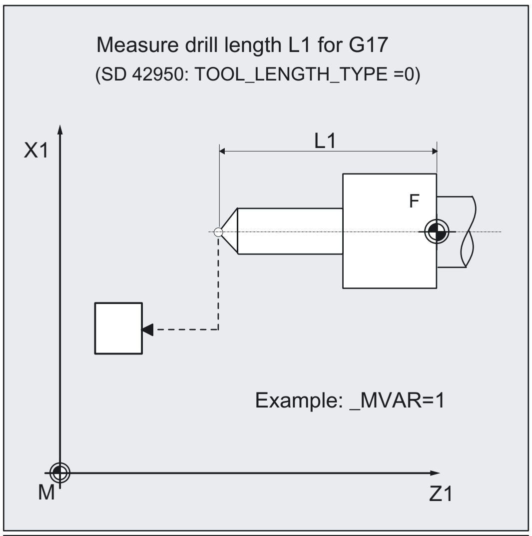
If **drills** are used on lathes with a length correction (offset) as for milling machines (SD 42950: TOOL_LENGTH_TYPE=0), then a drill can also be measured (gauged) in this application.

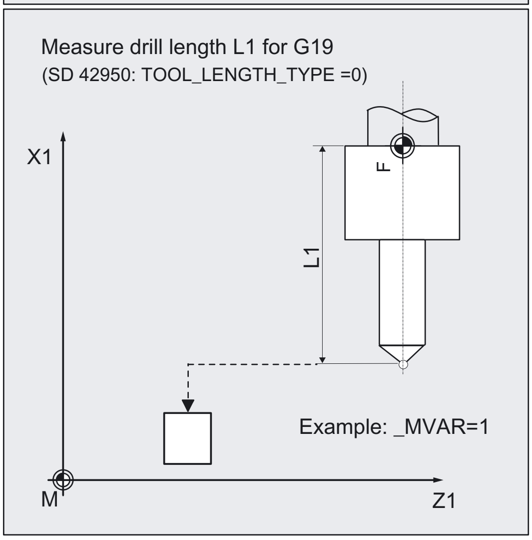
Length L1 is always calculated in the applicate (tool offset axis) of the current plane G17 to G19. This also characterizes the position of the tool. The usual position definition in _MVAR (5th digit) is no longer relevant and is ignored.

G17: L1 in Z axis (corresponds to axial position)

G18: L1 in Y axis (no turning machine application)

G19: L1 in X axis (corresponds to radial position)





Length L1 is determined if the following conditions are satisfied:

- the active tool is of type 2xy (drill)
- SD 42950: TOOL_LENGTH_TYPE=0

- G17 or G19 are active and
- A measuring variant is set:
  - _MVAR=1: Measuring (relative to the machine)
  - _MVAR=11: Measuring (relative to the workpiece)
  - _MVAR=1000x1: Incremental measuring (relative to the machine or workpiece)

A measuring axis specified in _MA is ignored. The 3rd axis (applicate) is used within the cycle. Otherwise the description of the measuring variant applies.

6.3.9 Measuring a tool with orientational tool carriers - 90° multiples of tool position (measuring cycle release SW 6.3 and higher)

6.3.9.1 Overview of the functions

The functionality is designed for a specific configuration on turning machines (turning/milling machines). As well as the linear axes (Z and X) and main spindle, the turning machines must have swivel axis about Y with accompanying tool spindle. The swivel axis can be used to align the tool on the X/Z level.

Requirement

- The lateral surfaces of the tool probe must be aligned parallel to the relevant axes (machine or workpiece coordinate system in abscissa and ordinate). The tool probe must be calibrated in the measuring axis and direction in which measuring will be performed.
- The tool to be measured must be called with tool offset.
- When measuring drilling and milling tools, the setting data

  SD42950: TOOL_LENGTH_TYPE must = 2,

  i.e., lengths are assigned to the axes in the same way as on turning tools. The active level must be G18.

Function

For the orientational tool carrier to be taken into account in measuring cycle CYCLE982, the _CBIT[7] must be set.

_CBIT[7] = 1	Support by means of orientational tool carrier, positioned probes/tools

It is possible to measure a tool (turning, milling and drilling tools) with orientational tool carriers for 90° multiples of the tool positions. This is monitored within the cycle.

The measuring variants Measure, Automatic Measure and Incremental Measure are supported for turning, milling and drilling tools.

Tools can be measured in relation to the workpiece and in relation to the machine.

The measuring cycle parameters for the individual measuring variants are set in the same way as when the tool carrier is in its basic position.

Sequence

Before CYCLE 982 is called, the tool must be aligned in the same way as it will eventually be measured.

Preferably, tool alignment should be performed with CYCLE800 (see Programming Manual "Cycles", function "Tool alignment").

Please note that the measuring cycle assumes that the tool has been aligned in advance.

From the position adopted by the tool, it must be possible to approach the probe in X, Z via the measuring cycle.

The measuring procedure that follows is the same as for the measuring variants when the tool carrier is in its basic position.

6.3.9.2 Measuring turning tools - 90° multiples of the tool position

Requirement

When measuring turning tools with orientational tool carriers, the cutting edge position of the tool must be entered in the tool offset in accordance with the **basic position of the tool carrier**.

Programming example

Measuring the turning tool automatically (machine-related, measuring cycle release SW 7.3 and higher)

Approximate values for the lengths and radius of tool T1 are known and entered in offset field D1. The cutting edge position in the tool offset must be entered in accordance with the basic position of the tool carrier; in this case, cutting edge position 3.

The tool should be measured in cutting edge position 4; the tool is aligned in relation to this.

Values of the turning tool T1 D1:

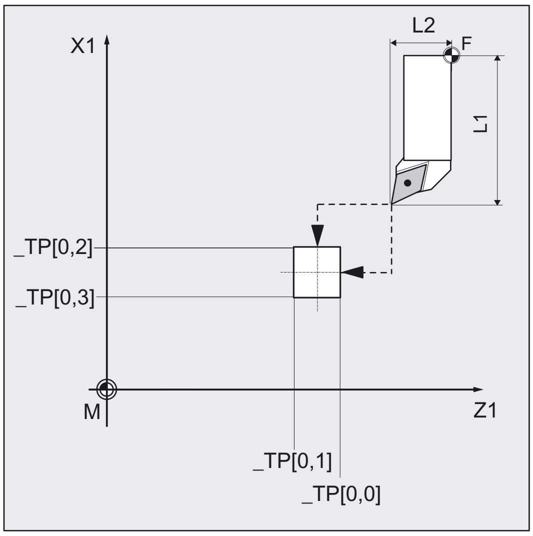
Tool type (DP1):	500
Cutting edge length (DP2):	3
Length 1 - geometry (DP3):	L1 = 10
Length 2 - geometry (DP4):	L2 = 40
Radius - geometry (DP6):	R = 0.5

Deviations from this value of less then 2.5 mm are expected.

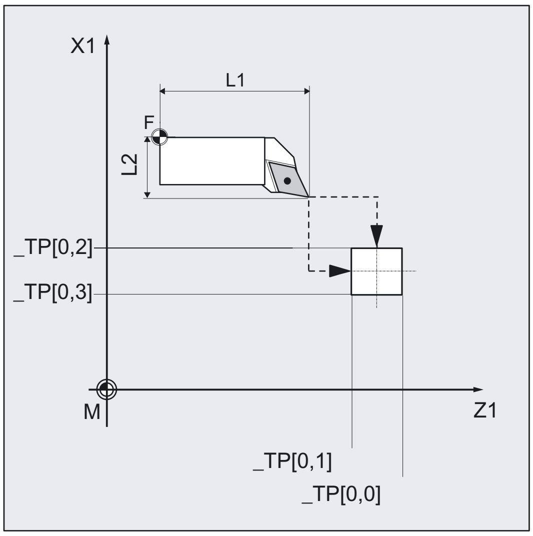
The probe to be used is tool probe 1. This probe has already been completely calibrated (machine-related). The precise values are entered in data field _TP[0,...] and are:

_TP[0.0] = 220, _TP[0.1] = 200
_TP[0.2] = 400, _TP[0.3] = 380

Basic position of the tool carrier:
Turning tool Cutting edge position 3



Aligned tool:
Turning tool Cutting edge position 4



```
%_N_AUTO_DREH_MPF
;$PATH=/_N_WKS_DIR/_N_WZ_MESSEN_WPD
N10 G0 G18 G40 G90 G94 DIAMOF
N20 _CHBIT[3]=0                                 ;Offset in the geometry
N30 T1 D1                                       ;Selection of the tool to be
                                                measured
N40 SUPA Z285 X450                              ;Starting position for alignment
N50 CYCLE800(0,"TURN",200,57,0,0,0,0,90,0,0,0,0,1,0) ;Tool alignment
N60 SUPA Z120 X450                              ;Starting position for measurement
N70 _MVAR=2 _ID=0 _PRNUM=1 _FA=3 _TSA=3
_TDIF=2 _TZL=0 _VMS=0 _NMSP=1 _EVNUM=0
N80 CYCLE982                                    ;Measure tool L1 and L2
N90 M30
```

Explanation of example

After approaching the starting position for alignment, the tool is aligned with CYCLE800 (see Programming Manual "Cycles", function "Tool alignment"). This changes the cutting edge position from 3 (basic position of tool carrier) to 4. The change in cutting position is detected within the cycle, i.e., no data entries need to be made. Following alignment, the starting position for measurement is approached. The measuring procedure and the offset strategy that follow are the same as for the measuring variants when the tool carrier is in its basic position.

6.3.9.3 Measuring milling/drilling tools - 90° multiples of the tool position

Requirement

When measuring drilling and milling tools, the setting data

SD42950: TOOL_LENGTH_TYPE must = 2

i.e., lengths are assigned to the axes in the same way as on turning tools. The active level must be G18.

Programming example

Measure milling tool (workpiece-related)

The lengths and radius of tool T10 to be measured are known and entered in offset field D1. When the tool carrier is in its basic position, the position of the milling tool is radial. The length L1 of the tool needs to be adjusted in the axial position (offset in wear); for this purpose, the tool is aligned axially using CYCLE800 (see Programming Manual "Cycles", function "Tool alignment").

Values of the turning tool T10 D1:

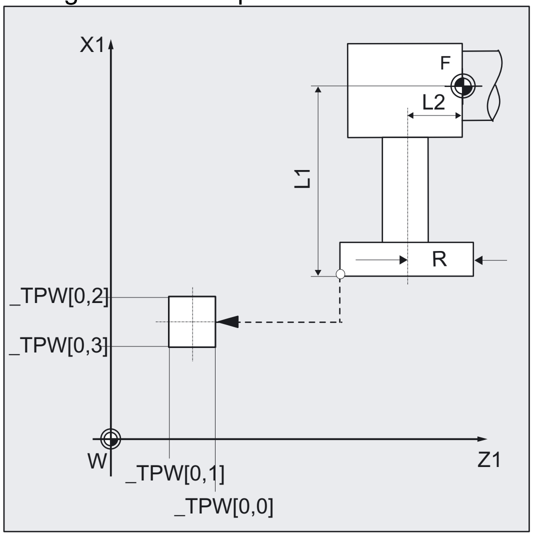
Tool type (DP1):	120
Cutting edge length (DP2):	
Length 1 - geometry (DP3):	L1 = 60
Length 2 - geometry (DP4):	L2 = 10
Radius - geometry (DP6):	R = 20
Length 1 - wear (DP12):	0
Length 2 - wear (DP12):	0

Deviations from this value of less then 2.5 mm are expected.

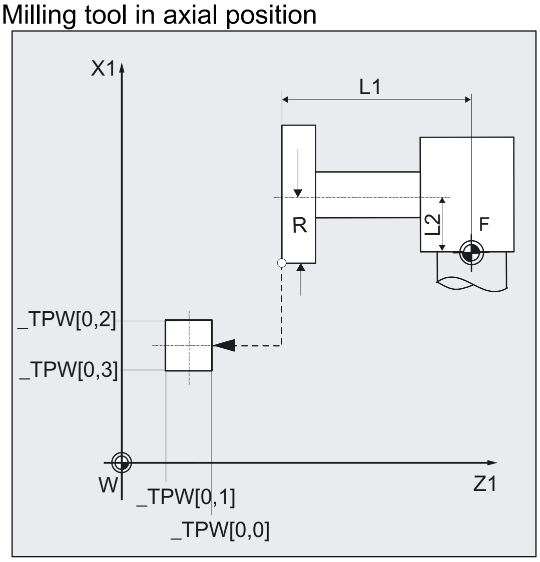
The probe to be used is tool probe 1. This probe has already been completely calibrated (workpiece-related). The precise values are entered in data field _TPW[0,...] and are:

_TPW[0.0] = 100, _TPW[0.1] = 60
_TPW[0.2] = 120, _TPW[0.3] = 80

Basic position of the tool carrier:
Milling tool in radial position



Aligned tool:
Milling tool in axial position



```
%_N_MESSEN_FW_MPF
;$PATH=/_N_WKS_DIR/_N_WZ_MESSEN_WPD
N10 G0 G54 G18 G40 G90 G94 DIAMOF
N20 _CHBIT[3]=1                               ;Offset in wear
N30 T10 D1                                    ;Selection of the tool to be
                                              measured
N40 Z200 X200                                 ;Starting position for alignment
N50 CYCLE800(0,"TURN",300,57,0,0,0,0,-        ;Align tool
90,0,0,0,0,-1,)
N60 Z200 X200                                 ;Starting position for measurement
N70 _MVAR=11 _ID=0 _PRNUM=1 _FA=3 _TSA=3
_TDIF=2 _TZL=0 _VMS=0 _NMSP=1 _EVNUM=0
N80 CYCLE982                                  ;Measure tool L1
N90 M30
```

Explanation of example

After approaching the starting position for alignment, the tool is aligned with CYCLE800 (see Programming Manual "Cycles", function "Tool alignment"). The tool is aligned from the radial tool position when the tool carrier is in its basic position to an axial position. Following alignment, the starting position for measurement is approached. The measuring procedure and the offset strategy that follow are the same as for the measuring variants when the tool carrier is in its basic position.

Note

The following measuring variants are not supported when using an orientational tool carrier:

- Automatic measurement of milling tools, particularly of the upper cutting edge
  - _MVAR=x3xx2 and
  - _MVAR=x4xx2.

When this measuring variant is used, alarm 61307: "Incorrect measuring variant" is output.

6.4 CYCLE973 Calibrating workpiece probes

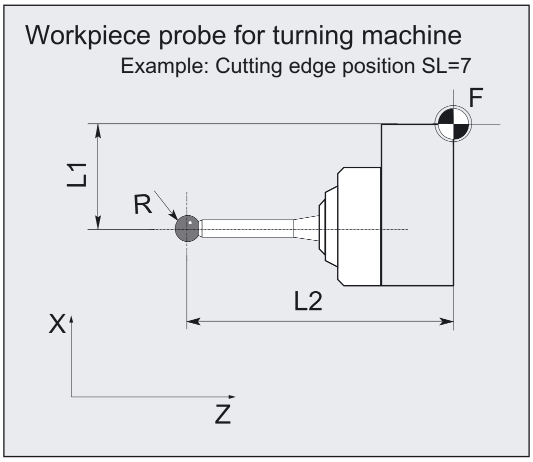
6.4.1 Function overview

Function

This cycle can calibrate a workpiece probe with various cutting edge positions in a

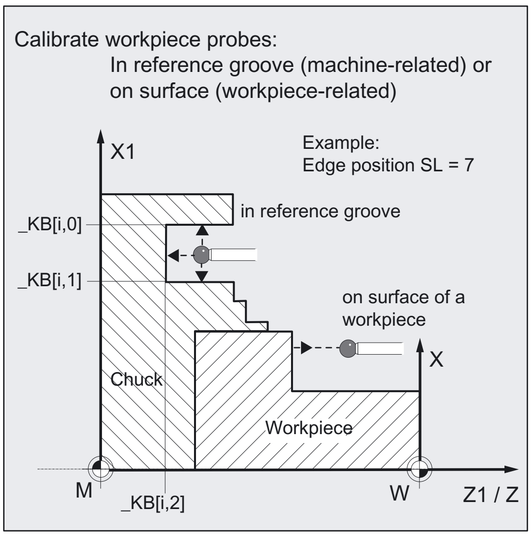
- **reference groove** or on a
- **surface.**

The surface for calibration on a "surface" is workpiece-related. It is only possible to calibrate in the selected axis and direction (perpendicular in front of the surface).



Calibration in a "reference groove" is relative to the machine. In this case, calibration is possible in one cycle call in both axis directions.

It is additionally possible select determining the position deviation of the probe in the idle position or determining the active probe ball diameter. The workpiece probe can only have cutting edge positions SL=7 or SL=8.



Calibration principle

The switching position of the workpiece probe in an axis is calculated into the measuring probe length. The trigger values calculated in this way (relative to ball center) is then entered in the corresponding array _WP[ ] of array GUD6.DEF for the associated probe **_PRNUM** (_WP[_PRNUM-1,...]).

For a complete description of the array _WP[ ] of a workpiece probe, refer to Chapter "Data description", "Central values".

Programming

```
CYCLE973
```

Measuring variants

Measuring cycle CYCLE973 permits the following calibration variants which are specified via parameter _MVAR.

Digit					Significance
5	4	3	2	1	
-	-	-	-	0	**Calibration on surface** (workpiece-related)
			1	3	**Calibrate in groove** (machine-related)
0			1	3	Without determining position deviation of probe
1			1	3	With determining position deviation of probe
	1		1	3	1 axis direction (specify meas. axis _MA and axis direction _MD)
	2		1	3	2 axis directions (specify measuring axis _MA)
		0	1	3	Without determining diameter of probe ball
		1	1	3	Determining diameter of probe ball

Note

When _MVAR=x1x13 calibration is only performed in one direction. It is not possible to determine position deviation or calculate probe ball.

Tolerance parameters _TSA and _TZL must be entered taking into account machine data

- MD 20360 TOOL_PARAMETER_DEF_MASK bit0 and bit1

in conjunction with the offset target

- geometry and wear.

.

Result parameters

Measuring cycle CYCLE973 returns the following values in block GUD5 for **calibration**:

Parameters	Data type	Result
_OVR [4]	REAL	Actual value probe ball diameter
_OVR [5]	REAL	Difference probe ball diameter
_OVR [8]	REAL	Trigger point in minus direction, actual value, abscissa
_OVR [10]	REAL	Trigger point in plus direction, actual value, abscissa
_OVR [12]	REAL	Trigger point in minus direction, actual value, ordinate
_OVR [14]	REAL	Trigger point in plus direction, actual value, ordinate
_OVR [9]	REAL	Trigger point in minus direction, difference, abscissa
_OVR [11]	REAL	Trigger point in plus direction, difference, abscissa
_OVR [13]	REAL	Trigger point in minus direction, difference, ordinate
_OVR [15]	REAL	Trigger point in plus direction, difference, ordinate
_OVR [20]	REAL	Positional deviation abscissa
_OVR [21]	REAL	Positional deviation ordinate
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVI [2]	INTEGER	Measuring cycle number
_OVI [5]	INTEGER	Probe number
_OVI [9]	INTEGER	Alarm number

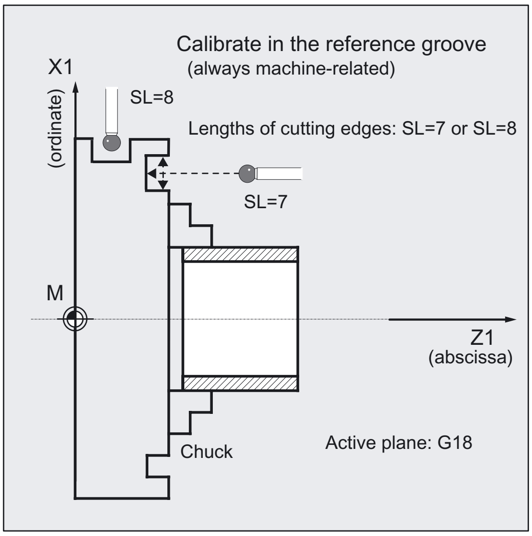
6.4.2 Calibrating in the reference groove

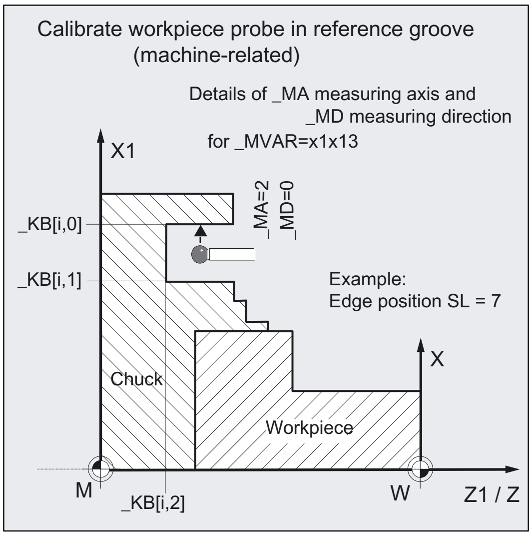
6.4.2.1 General information

Function

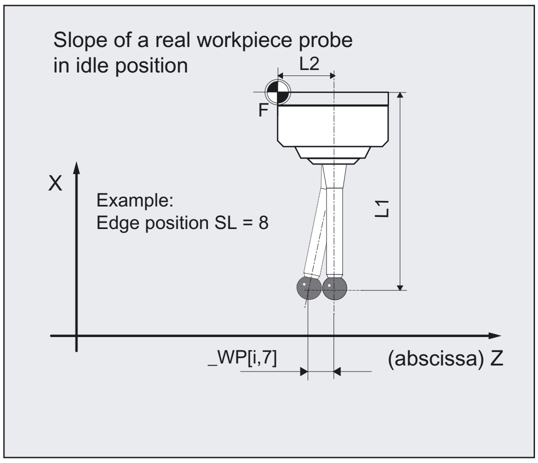
With this measuring cycle and the **_MVAR=xxx13** measuring variant, it is possible to calibrate a workpiece probe with cutting edge position SL=7 or SL=8 in a **reference groove** machine-related in the axes of the plane (abscissa, ordinate).

Calibration is possible in one direction (_MVAR=x1x13) or in both directions of an axis (_MVAR=x2x13).





It is also possible to calibrate the position deviation of the probe and the active diameter of the probe ball in both directions.



The workpiece probe calibrated is selected with _PRNUM. The associated array _WP[ ] in data block GUD6.DEF is _WP[_PRNUM-1,...] (for a detailed description of the array, refer to Chapter "Data description", "Central values").

The reference groove is selected with _CALNUM. The associated array _KB[ ] in data block GUD6.DEF is _KB[_CALNUM-1,...].

Prerequisite

The dimensions of the reference groove must already be stored in array _KB[ ] of data block GUD6.DEF for the groove selected via _CALNUM.

The workpiece probe must be called as a tool with a tool offset.

Parameter

Parameter						Data type	Meaning
`_MVAR`							Calibration variant
				1	3	Calibrate in groove (machine-related)	
	0			1	3	Without determining position deviation of probe	
	1			1	3	With determining position deviation of probe	
		1		1	3	1 axis direction (specify meas. axis _MA and axis direction _MD)	
		2		1	3	2 axis directions (specify measuring axis _MA)	
			0	1	3	Without determining diameter of probe ball	
			1	1	3	Determining diameter of probe ball	
`_MA`			1, 2				Measuring axis
`_MD`			0 positive axis direction 1 negative axis direction				Measuring direction (for _MVAR=x1x13 only)
`_CALNUM`						INTEGER	Number of reference groove (calibration groove)
`_PRNUM`						INTEGER	Probe number

Additional parameters `_VMS`, `_TZL`, `_TSA`, `_FA` and `_NMSP` also apply.

Note

When _MVAR=x1x13 calibration is only performed in one direction. It is not possible to determine position deviation or calculate probe ball.

NOTICE

The first time calibration is performed the default setting in the array of the probe is still "0". For that reason _TSA> probe ball radius must be programmed to avoid alarm "Safe area violated".

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

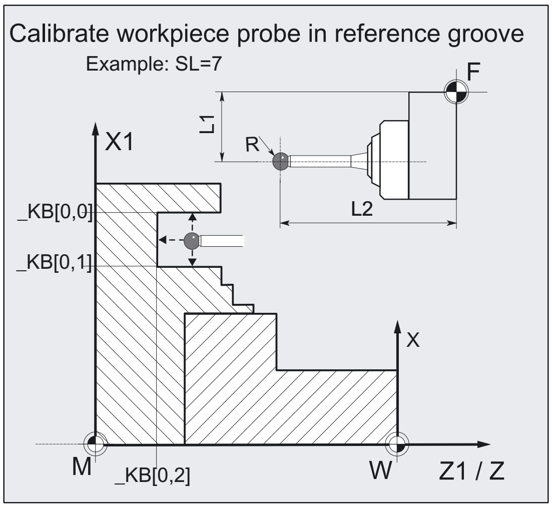
6.4.2.2 Programming example

Calibrate workpiece probe in reference groove

The workpiece probe 1 with cutting edge position SL=7 is to be calibrated in reference groove 1 in both axes and in both directions in X. The probe is inserted as tool T8, D1.

Probe lengths L1 and L2 always refer to the probe ball center and must be entered in the tool offset memory before the measuring cycle is called, T8, D1:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



The data for reference groove 1 have already been entered:

_KB[0,0] = 60.123, _KB[0,1] = 50.054,
_KB[0,2] = 15.021

```
%_N_CALIBRATE_IN_GROOVE_MPF
N10 T8 D1                                          ;Tool offset of the probe
N20 G0 SUPA G90 DIAMOF Z125 X95                    ;Position in front of cycle call
                                                   ;(start position),
                                                   ;position without ZO
N30 _TZL=0 _TSA=1 _VMS=0 _NMSP=1 _FA=3 _PRNUM=1  ;Set parameters for calibration,
N31 _MVAR=13 _MA=1 _MD=1 _CALNUM=1               ;minus Z-direction
N40 CYCLE973                                       ; Cycle call
N50 _MVAR=02013 _MA=2                              ;In X axis, both directions
N60 CYCLE973                                       ; Cycle call
N70 G0 SUPA Z125                                   ;Retraction in Z
N80 SUPA X95                                       ;Retraction in X
N100 M2                                            ;End of program
```

Explanation of example

The cycle automatically approaches reference groove 1 from the starting position and performs calibration in both axes and in the X axis in a double cycle call. The new trigger values are stored in the data of the workpiece probe 1 _WP[0,1], _WP[0,3], _WP[0,4].

At the end, result array _OVR[ ] contains the values of the 2nd cycle call.

6.4.2.3 Operational sequence

Position before measuring cycle call

The starting point must be selected such that the selected workpiece probe can be positioned in the cycle into the reference groove selected via _CALNUM by the shortest path with paraxial collision-free movements in accordance with the active cutting edge position.

Position after end of measuring cycle

On completion of calibration, the probe is positioned facing the calibration surface at distance _FA.

6.4.3 Calibration on surface

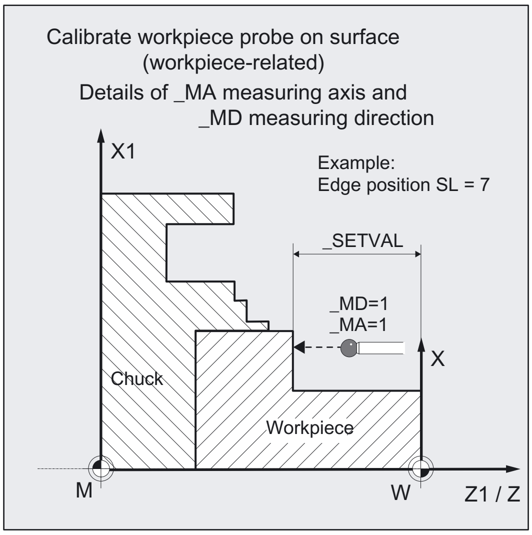
6.4.3.1 General information

Function

With this measuring cycle and the **_MVAR=0** measuring variant, it is possible to calibrate a workpiece probe with cutting edge positions SL=5 to 8 on a surface (workpiece-related) and therefore determine the probe trigger points.

The position of the surfaces is defined in workpiece coordinates in _SETVAL.

The workpiece probe calibrated is selected with _PRNUM. The associated array _WP[ ] in data block GUD6.DEF is _WP[_PRNUM-1,...].



Prerequisite

The surface must be parallel to an axis of the workpiece coordinate system and have low surface roughness.

The workpiece probe is called as a tool with tool offset and positioned opposite the calibration surface. 5xy should be entered as the tool type.

Parameter

Parameter	Data type	Meaning
_MVAR	0	Calibration on surface (workpiece-related)
_SETVAL	REAL	Setpoint referred to the workpiece zero, for facing axis in the diameter (DIAMON)
_MA	1, 2, 3[1)]	Measuring axis
_MD	0 positive axis direction 1 negative axis direction	Measuring direction
_PRNUM	INT	Probe number
1) It is also possible to calibrate in the 3rd axis (Y in G18), provided that this axis exists.		

Additional parameters `_VMS`, `_TZL`, `_TSA`, `_FA` and `_NMSP` also apply.

NOTICE
The first time calibration is performed the default setting in the array of the probe is still "0". For that reason _TSA> probe ball radius must be programmed to avoid alarm "Safe area violated".

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Multiple measurement at the same location: _NMSP (Page 81)

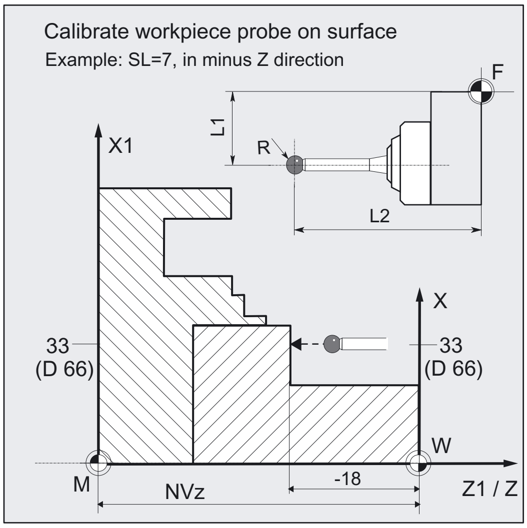
6.4.3.2 Programming example

Calibration of probe 1 on a surface

Workpiece probe 1 with cutting edge position SL=7 is to be calibrated on surface Z=-18 mm in direction minus Z. The probe is inserted as tool T9, D1.

Probe lengths L1 and L2 always refer to the probe ball center and must be entered in the tool offset memory before the measuring cycle is called, T9, D1:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



Zero offset, with settable ZO G54: NVz

```
%_N_CALIBRATE_IN_Z_MPF
N10 G54 G90 G0 X66 Z90 T9 D1 DIAMON          ;Activate ZO, select the tool offset
                                             ;of probe
                                             ;Position before cycle call
N20 _MVAR=0 _SETVAL=-18 _MA=1 _MD=1 _TZL=0   ;Set parameters for calibration in
_TSA=1 _PRNUM=1 _VMS=0 _NMSP=1 _FA=3         minus
                                             ;Z-direction, _SETVAL is negative!
N30 CYCLE973                                 ; Cycle call
N40 G0 Z90                                   ;Retraction in Z
N50 X146                                     ;Retraction in X
N100 M2                                      ;End of program
```

Explanation of example

The surface with position Z=-18 is approached in the Z axis in the minus direction (_SETVAL=-18, _MA=1, _MD=1).

Actual calibration starts _FA=3 mm in front of the surface. The workpiece probe is then calibrated and ends up facing the surface again at distance _FA from it. The new trigger value in minus Z is entered in the data of probe 1 _WP[0,1] and in the result field _OVR[ ].

The original position is approached in block N40, N50.

6.4.3.3 Operational sequence

Position before measuring cycle call

The starting point must be a position facing the calibration surface.

Position after end of measuring cycle

On completion of calibration, the probe is positioned facing the calibration surface at distance _FA.

6.5 CYCLE974 workpiece: 1-point measurement

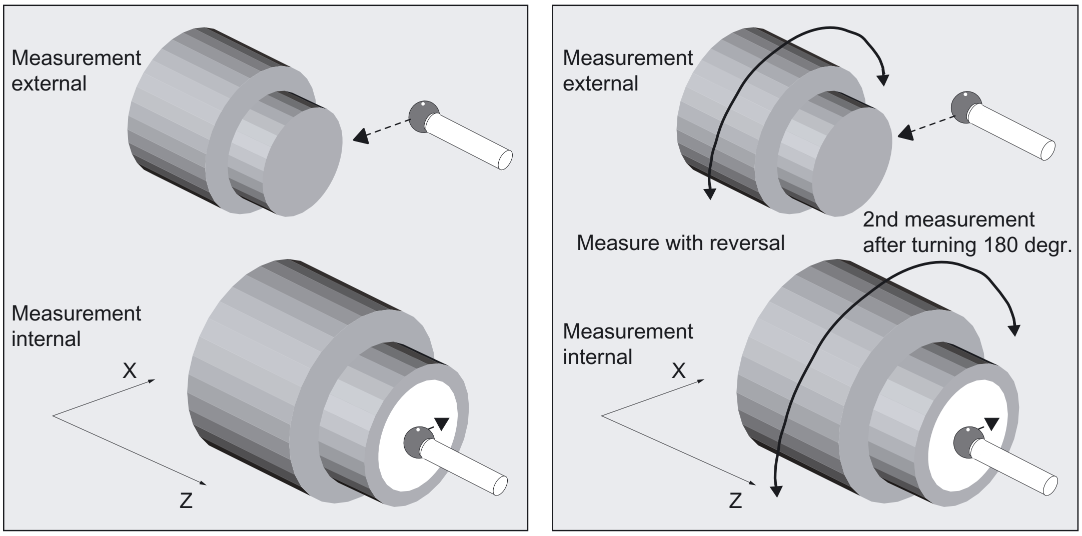
6.5.1 Function overview

Function

This measuring cycle can be used in various measurement variants to determine workpiece dimensions in a 1-point measurement.

It is also possible to determine a zero offset (ZO) or an automatic tool offset.

- 1-point measurement and ZO determination
- 1-point measurement and tool offset
- 1-point measurement with reversal and tool offset



The measuring cycle determines the actual value of the workpiece with respect to the workpiece zero in the selected measuring axis _MA and calculates the difference from a defined setpoint (setpoint-actual value).

An empirical value stored in data block GUD5 can be included. For variants "with tool offset" it is also possible to calculate a mean value over several parts.

The cycle checks that a set tolerance range for the measured deviation is not violated and automatically corrects the ZO memory or tool offset memory selected in _KNUM. If KNUM=0, there is no offset.

Programming

```
CYCLE974
```

Note

Tolerance parameters _TSA, _TDIF, _TZL, _TMV, _TLL and _TUL must be entered taking into account machine data

- MD 20360 TOOL_PARAMETER_DEF_MASK bit0 and bit1

in conjunction with the offset target

- geometry and wear.

.

Prerequisite

The probe must be calibrated in the measuring direction and as a tool with tool offset. The tool type is 5xy.

The cutting edge position can be 5 to 8 and must be suitable for the measurement task.

Measuring variants

Measuring cycle CYCLE974 permits the following measuring variants that are specified in parameter _MVAR.

Value	Significance
0	1-point measurement and tool offset
100	1-point measurement and ZO determination
1000	1-point measurement with reversal and tool offset

Result parameters

Depending on the measuring variant, measuring cycle CYCLE974 returns the following result values in the GUD5 block:

Parameters	Data type	Result
_OVR [0]	REAL	Setpoint value for measuring axis
_OVR [1]	REAL	Setpoint in abscissa → only when _MA=1
_OVR [2]	REAL	Setpoint in ordinate → only when _MA=2
_OVR [3]	REAL	Setpoint in applicate → only when _MA=3
_OVR [4]	REAL	Actual value for measuring axis
_OVR [5]	REAL	Actual value in abscissa → only when _MA=1
_OVR [6]	REAL	Actual value in ordinate → only when _MA=2
_OVR [7]	REAL	Actual value in applicate → only when _MA=3
_OVR [8] 1)	REAL	Upper tolerance limit for measuring axis
_OVR [12] 1)	REAL	Lower tolerance limit for measuring axis
_OVR [16]	REAL	Difference for measuring axis
_OVR [17]	REAL	Difference in abscissa → only when _MA=1
_OVR [18]	REAL	Difference in ordinate → only when _MA=2
_OVR [19]	REAL	Difference in applicate → only when _MA=3
_OVR [20] 1)3)	REAL	Compensation value
_OVR [27] 1)	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29] 1)	REAL	Dimensional difference
_OVR [30]	REAL	Empirical value
_OVR [31] 1)	REAL	Mean value
_OVI [0]	INTEGER	D number or ZO number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [4] 1)	INTEGER	Weighting factor
_OVI [5]	INTEGER	Probe number
_OVI [6] 1)	INTEGER	Mean value memory number
_OVI [7]	INTEGER	Empirical value memory number
_OVI [8]	INTEGER	Tool number
_OVI [9]	INTEGER	Alarm number
_OVI [11] 2)	INTEGER	Status offset request

1) for workpiece measurement with tool offset only

2) For ZO correction only

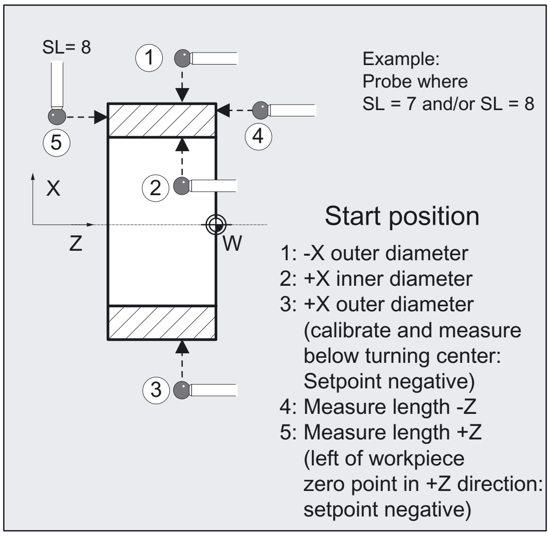
3) For "tool offset" the offset value always appears as a radius dimension in _OVR[20].

Starting positions for various measuring tasks

The starting positions before cycle call depend on the measuring task, the value of the setpoint _SETVAL, the measuring axes, and the cutting edge position (SL) of the workpiece probe.

The probe must be positioned facing the point to be measured and is reached by traversing measuring axis _MA in the setpoint direction in the measuring cycle. The setpoint (position of the point) is defined by parameter _SETVAL.

Measurement is possible parallel to and in the direction of the axes permitted by the "cutting edge position" of the workpiece probe inserted.



6.5.2 1-point measurement and ZO determination

6.5.2.1 General information

Function

With this measuring cycle and the **_MVAR=100** measuring variant, the actual value of a workpiece is determined with reference to the workpiece zero in the selected measuring axis _MA. An empirical value from data block GUD5 can be included with the correct sign.

The zero offset (ZO) is applied in such a way that the actual value adopts the required setpoint (_SETVAL) in the workpiece coordinate system when the corrected ZO (frame) is used. Mirroring can be active in a frame of the frame sequence. Dimension factors must never be active. The ZO to be corrected is specified in coded form with variable _KNUM >0.

The ZO can be specified and corrected by various methods, e.g. in various settable frames, in various basic frames, system frames, fine offset, or coarse offset, etc.

For detailed information on specifying _KNUM for the zero offset: see section "Description of the most important defining parameters".

Prerequisite

If necessary, the workpiece must be positioned in the correct angular spindle position with SPOS before the cycle is called.

Parameter

Parameter	Data type	Meaning
`_MVAR`	100	1-point measurement and ZO determination
`_SETVAL`	REAL 1)	Setpoint, with reference to the workpiece zero
`_MA`	1, 2, 3 1)	Measuring axis
`_KNUM`	0, >0	0: No automatic ZO correction >0: With automatic ZO correction (individual values: see section "Description of the most important defining parameters", Parameter _KNUM)
1) Measurement in the 3rd axis of the plane (with G18 in Y) is also possible, provided this axis exists. Moreover, for measurement in the 3rd axis of the plane with active G18 (measurement in the Y axis), the same setpoint parameterization can be used as for measurement in the X axis (facing axis), if _CHBIT[19]=1 is set in block GUD6. The offset is then stored in the X-component of the selected ZO memory.		

Additional parameters `_VMS`, `_TSA`, `_FA`, `_PRNUM`, `_EVNUM` and `_NMSP` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

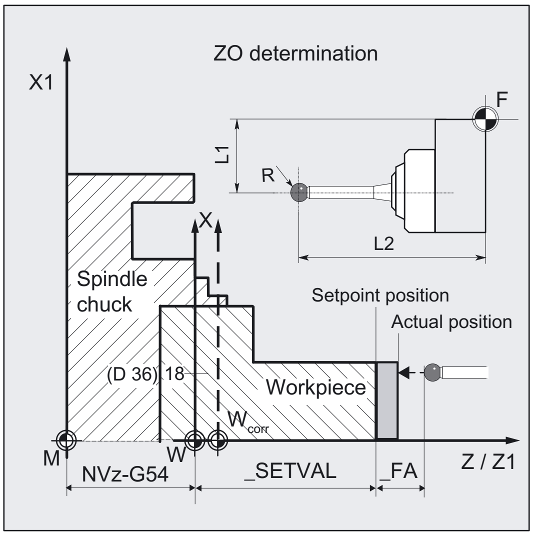
6.5.2.2 Programming example

ZO calculation at a workpiece

The intention is to determine the zero offset in the Z axis on a clamped workpiece with workpiece probe 1, inserted as tool T8, D1. The position determined should retain the value 60 mm in the new workpiece with G54. Measurement is also performed with G54.

The probe is already calibrated and the tool data are entered in T8, D1:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



Zero offset, with settable ZO G54: NVz

```
%_N_ZO_DETERMINING_1_MPF
N10 G54 G90 G18 DIAMON T8 D1                  ;Call ZO, tool = probe
N20 G0 X36 Z100                               ;Starting position before cycle call
N30 _MVAR=100 _SETVAL=60 _MA=1 _TSA=1 _KNUM=1 ;Parameters for cycle call
_EVNUM=0 _PRNUM=1 _VMS=0 _NMSP=1 _FA=1
N40 CYCLE974                                  ;Measurement in the Z-direction
N50 G0 Z100                                   ;Retraction in Z
N60 X114                                      ;Retraction in X
N100 M2                                       ;End of program
```

Note

If parameter _VMS has value 0, the default value of the measuring cycle is used for the variable measuring velocity:

if _FA=1: 150 mm/min

if _FA>1: 300 mm/min

(see section "Description of the most important defining parameters")

6.5.2.3 Operational sequence

Position before measuring cycle call

The probe must be positioned opposite the surface to be measured.

Position after end of measuring cycle

On completion of measurement, the probe is positioned facing the measuring surface at distance _FA.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration. If the probe is used in the spindle for a powered tool, the spindle orientation must also be considered. Deviations can cause additional measuring errors.

6.5.3 1-point measurement and tool offset

6.5.3.1 General information

Function

With this measuring cycle and the **_MVAR=0** measuring variant, the actual value of a workpiece is determined with reference to the workpiece zero in the selected measuring axis.

An offset can also be determined for a tool depending on that. This tool is specified in **_TNUM** and **_TNAME**. The D number and type of offset are specified in coded form in variable **_KNUM**.

Extended tool offset is also possible. With this function a tool from a particular stored tool environment **_TENV**, and additive, setup offsets can be corrected by specifying the DL number in **_DLNUM**.

Detailed information on the parameters: see section "Description of the most important defining parameters".

Empirical values and mean values

An empirical value stored in data block GUD5 in array _EV[ ] can be included in calculation of the result after measurement is completed. Optionally, averaging is performed over a number of parts (array _MV[ ]) and the tolerance bands are checked.

Both are activated in _EVNUM (see Section "Description of the most important defining parameters").

Prerequisite

If necessary, the workpiece must be positioned in the correct angular spindle position with SPOS before the cycle is called.

Parameter

Parameters	Data type	Meaning
`_MVAR`	0	1-point measurement and tool offset
`_SETVAL`	REAL2)	Setpoint (according to drawing) (in the case of facing axis (X) and diameter programming, this is a diameter dimension)
`_MA`	1, 2, 31)	Measuring axis
`_KNUM`	0, >0	0: Without automatic tool offset >0: With automatic tool offset (individual values: see section "Description of the most important defining parameters", Parameter _KNUM)
`_TNUM`	INTEGER, ≥0	Tool number for automatic tool offset
`_TNAME`	STRING[32]	Tool name for automatic tool offset (alternative to _TNUM with tool management active)
`_DLNUM`	INTEGER, ≥0	DL number for additive and setup offset
`_TENV`	STRING[32]	Name of tool environment for automatic tool offset

1) Measurement in the 3rd axis of the plane (with G18 in Y) is also possible, provided this axis exists.

2) By setting _CHBIT[19]=1 in the GUD6 block, the same parameterization regarding the setpoint can be used when measuring in the Y axis (3rd axis of the plane) for active G18 as when measuring in the X axis (transverse axis). In this case, the tool offset is also applied to L1 (effective length in X) if nothing different is specified by _KNUM.

Additional parameters `_VMS, _TZL, _TMV, _TUL, TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP` and `_K` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

6.5.3.2 Programming example

1-point measurements at outside and inside diameters with tool offsets

An outside diameter with tool T7, D1 and an inside diameter with tool T8, D1 has been machines on a workpiece. The set diameters have the dimensions shown in the figure.

If the absolute value of the difference determined is >0.002 mm, the length (in measuring axis _MA) of the tool is to be automatically offset in the wear. The maximum permissible deviation is taken as max. 0.5 mm. Max. 0.04 mm is permissible. To obtain a minimum measuring path of 0.5 mm, the measuring path is programmed as _FA=0.5+0.5=1 mm (max. total measuring path = 2 mm).

The offset must take the empirical value in memory _EV[12] into consideration for T 7, or _EV[13] for T 8. Mean value calculation _MV[12] or _MV[13] and inclusion in calculation are also to be used. This tool offset will therefore affect the production of the next workpieces or possible remachining.

Clamping for workpiece:

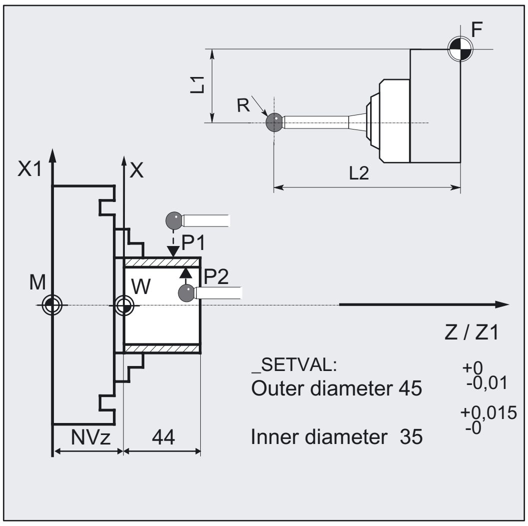
Zero offset, with settable ZO G54: NVz

Workpiece probe 1, used as tool **T9, D1,** is to be used.

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



```
%_N_ONE_POINT_MEAS_MPF
N10 G54 G18 G90 T9 D1 DIAMON                    ;Call ZO, tool = probe
N20 G0 Z30 X90                                  ;Preposition probe
N25 _CHBIT[4]=1                                 ;With mean value calculation
N30 _TZL=0.002 _TMV=0.005 _TDIF=0.04 _TSA=0.5   ;Parameters for cycle call
_PRNUM=1 _VMS=0 _NMSP=1 _FA=1
N31 _MVAR=0 _SETVAL=45 _TUL=0 _TLL=-0.01
_TNUM=7 _KNUM=1 _EVNUM=13 _K=2 _MA=2
N40 CYCLE974                                    ;Measurement on the outside diameter
N50 G0 Z60                                      ;Place probe facing P2
N60 X0
N70 Z40
N80 _SETVAL=35 _TUL=0.015 _TLL=0 _TNUM=8
_EVNUM=14
N90 CYCLE974                                    ;Measurement on the inside diameter
N100 G0 Z110                                    ;Retraction in Z
N110 X90                                        ;Retraction in X
N200 M2                                         ;End of program
```

Explanation of example

Measurement of outside diameter and offset T7

The difference calculated from the actual value and setpoint is compensated for by the empirical value in the empirical value memory _EV[12] and compared with the tolerance parameter:

- If it is more than 0.5 mm (_TSA), alarm "Safe area violated" is output and program execution cannot be continued.
- If it is more than 0.04 mm (_TDIF), no compensation is performed and alarm "Permissible dimensional difference exceeded" is output and the program continues.
- If values _TUL= -0.01, _TLL=0 are violated upward or downward, the length of T7 D1 is compensated 100% by this difference. Alarm "Oversize" or "Undersize" is displayed and the program is continued.
- If 0.005 mm (_TMV) is exceeded, the length in T7 D1 is compensated 100% by this difference.
- If it is less than 0.005 mm (_TMV), the mean value is calculated (only if _CHBIT[4]=1! with mean value memory) with the mean value in mean value memory _MV[12] and by including weighting factor (_K=2).
  - If the mean value obtained is >0.002 (_TZL), the reduced compensation of the length 1 for T7 D1 is the mean value/2 and the mean value is deleted in _MV[12].
  - - If the mean value is <0.002 (_TZL), there is no offset but it is stored in the mean value memory _MV[12] if mean value storage (_CHBIT[4]=1) is active.

The results are entered in result array _OVR[ ]. The wear of the length 1 of T7, D1 is included if a change is necessary.

Measurement of inside diameter and offset T8

Procedure as described for "Measurement output diameter".

Offset of T8 with appropriate modified values _EV[13], _MV[13] (EVNUM=14), _TUL, _TLL, _SETVAL.

Note

The values of the workpiece tolerance parameters _TUL, _TLL were selected asymmetrically in the example. The result is then made symmetrical (see Section "Tolerance parameters: _TZL, _TMV, _TUL, TLL, _TDIF and _TSA").

6.5.3.3 Operational sequence

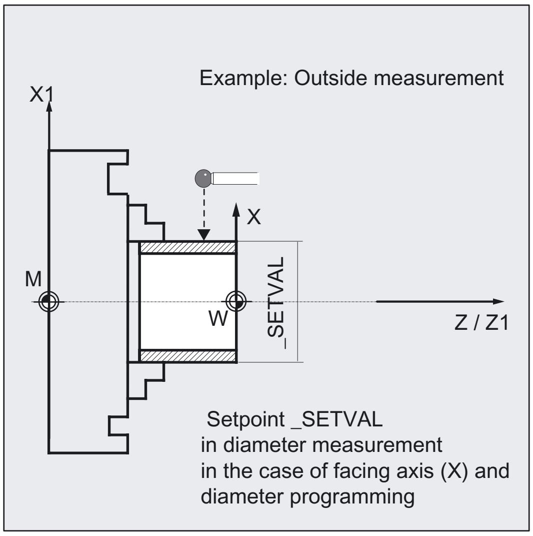
Position before measuring cycle call

The probe must be positioned opposite the surface to be measured.

Position after end of measuring cycle

On completion of measurement, the probe is positioned facing the measuring surface at distance _FA.

NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration. If the probe is used in the spindle for a powered tool, the spindle orientation must also be considered. Deviations can cause additional measuring errors.



6.5.4 1-point measurement with reversal and tool offset

6.5.4.1 General information

Function

With this measuring cycle and the **_MVAR=1000** measuring variant, the workpiece actual value is ascertained with reference to the workpiece zero in the measuring axis by acquiring two opposite points on the diameter.

Before taking the first measurement, the workpiece is positioned at the angular position programmed in parameter **_STA1** with SPOS and the 180° reversal is automatically generated by the cycle before the second measurement.

The mean value is calculated from both measured values.

Otherwise, the same conditions and tool offset options apply as for measuring variant _MVAR=10 "1-point measurement and tool offset".

Parameter

Parameter	Data type	Meaning
`_MVAR`	1000	1-point measurement with reversal and tool offset
`_SETVAL`	REAL 2)	Setpoint (according to drawing) (in the case of facing axis (X) and DIAMON , this is a diameter dimension)
`_MA`	1, 2, 3 1)	Measuring axis
`_STA1`	REAL, >=0	Starting angle (spindle position)
`_KNUM`	0, >0	0: Without automatic tool offset >0: With automatic tool offset (individual values: See Section 2.3, parameter _KNUM)
`_TNUM`	INTEGER, ≥0	Tool number for automatic tool offset
`_TNAME`	STRING[32]	Tool name for automatic tool offset (alternative to _TNUM with tool management active)
`_DLNUM`	INTEGER, ≥0	DL number for additive and setup offset
`_TENV`	STRING[32]	Name of tool environment for automatic tool offset
1) Measurement in the 3rd axis of the plane (with G18 in Y) is also possible, provided this axis exists. 2) By setting _CHBIT[19]=1 in the GUD6 block, the same parameterization regarding the setpoint can be used when measuring in the Y axis (3rd axis of the plane) for active G18 as when measuring in the X axis (transverse axis). In this case, the tool offset is also applied to L1 (effective length in X) unless specified otherwise using _KNUM.		

The additional parameters `_VMS, _TZL, _TMV, _TUL, TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP` and `_K` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

6.5.4.2 Programming example

1-point measurement at outside diameter, measuring with reversal

An outside diameter with tool T7, D1 has been machined on a workpiece. The set diameter has the dimension shown in the figure.

This outside diameter is to be measured with reversal. The spindle is SPOS-capable.

If the absolute value of the difference determined is >0.002, the length (in measuring axis _MA) of the tool is to be automatically offset in the wear.

The maximum permissible deviation is taken as max. 1 mm. Max. 0.4 mm is permissible.

To obtain a minimum measuring path of 1 mm, the measuring path is programmed as _FA=1+1=2 mm (max. total measuring path = 4 mm).

The offset is not to consider an empirical value and no mean value is calculated or used.

Clamping for workpiece:

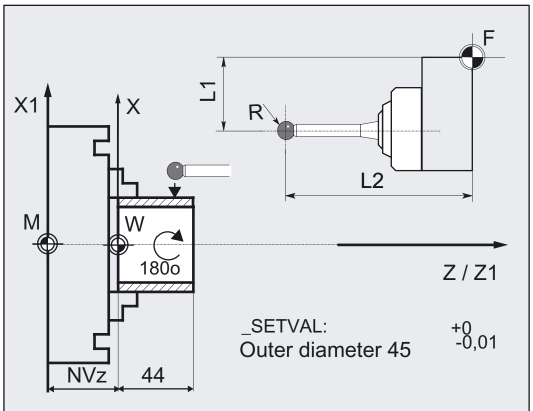
Zero offset, with settable ZO G54: NVz

Workpiece probe 1, used as tool **T9, D1,** is to be used.

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T9, D1 in the tool offset memory:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



Outside measurement with spindle reversal

```
%_N_REVERSALMEAS_MPF
N10 G54 G90 G18 T9 D1 DIAMON                    ;Call ZO, tool = probe
N20 G0 Z30 X90                                  ;Preposition probe
N30 _MVAR=1000 _SETVAL=45 _TUL=0 _TLL=-0.01     ;Parameters for cycle call
_MA=2 _STA1=0 _KNUM=1 _TNUM=7 _EVNUM=0
_TZL=0.002 _TDIF=0.4 _TSA=1 _PRNUM=1 _VMS=0
_NMSP=1 _FA=2
N40 CYCLE974                                    ;Measuring cycle call
N50 G0 Z110                                     ;Retraction in Z
N60 X90                                         ;Retraction in X
N100 M2                                         ;End of program
```

Note

The values of the workpiece tolerance parameters _TUL, _TLL were selected asymmetrically in the example. The result is then made symmetrical (see Section "Tolerance parameters: _TZL, _TMV, _TUL, TLL, _TDIF and _TSA").

6.6 CYCLE994 workpiece: 2-point measurement

6.6.1 Function overview

6.6.1.1 General information

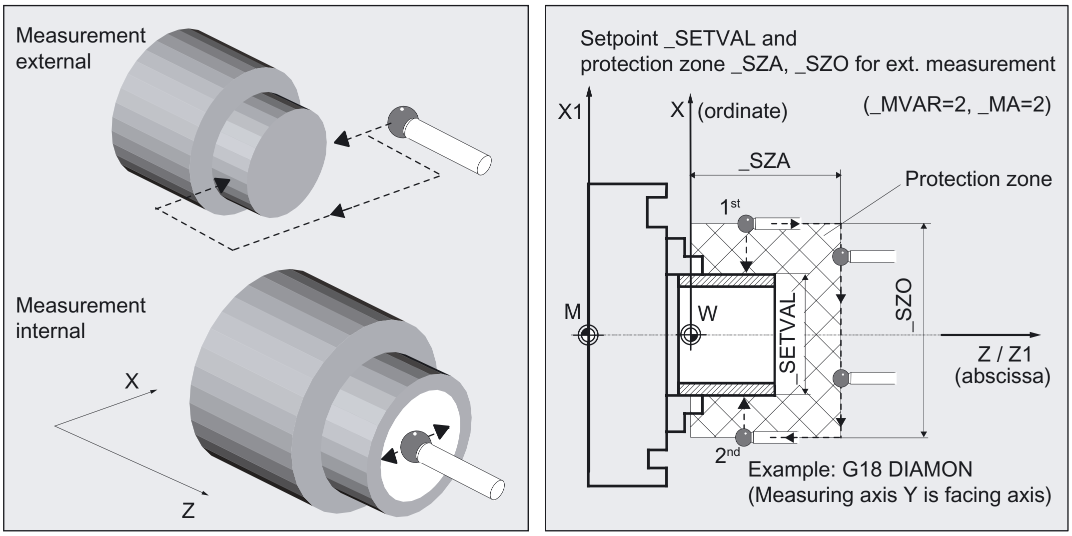
Function

This measuring cycle can be used to determine workpiece dimensions in 2-point measurements with various measuring variants.

Automatic **tool offset**is also possible.

The measuring cycle determines the actual value of the workpiece with respect to the workpiece zero in the selected measuring axis _MA and calculates the difference from a defined setpoint (setpoint-actual value). An empirical value stored in data block GUD5 can be included. It is also possible to calculate a mean value over several parts.

The cycle checks that a set tolerance range for the measured deviation is not violated and automatically corrects the tool offset memory selected in _KNUM. If KNUM=0, there is no offset.



Two opposite measuring points in measuring axis _MA are approached symmetrically to the workpiece zero at the distance of the setpoint _SETVAL.

Order: 1. measuring point positive, 2nd measuring point negative.

A safety zone is programmed in parameters _SZA and _SZO. This is considered in traversal with the measuring variant. The probe ball radius must also be considered by the user.

Programming

```
CYCLE994
```

Note

Tolerance parameters _TSA, _TDIF, _TZL, _TMV, _TLL and _TUL must be entered taking into account machine data

- MD 20360 TOOL_PARAMETER_DEF_MASK bit0 and bit1

in conjunction with the offset target

- geometry and wear.

.

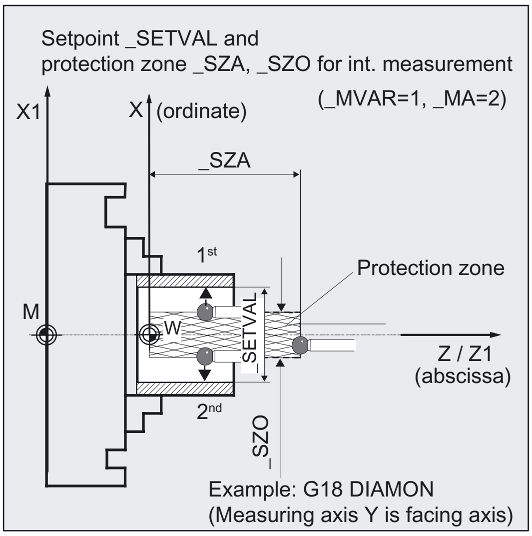
Prerequisite

The probe must be calibrated in the measuring direction (if _CHBIT[7] = 0) and called as a tool with tool offset. The tool type is 5xy. The cutting edge position can be 5 to 8 and must be suitable for the measurement task. The measuring cycle can be used for measurement **without** previous **calibration**.

Instead of the trigger values in _WP[ ], the probe ball diameter entered in the probe array _PRNUM (_WP[_PRNUM-1,0]) is used in the calculation.

The function is controlled via bit:

- _CHBIT[7]=1: Probe not calibrated, (without use of the trigger values), use of the probe ball diameter _WP[_PRNUM-1,**0**])
- _CHBIT[7]=0: Probe is calibrated, use of trigger values in _WP[_PRNUM-1,...])



Tool offset

An offset can be applied for the tool that machined the workpiece. This tool is specified in _TNUM and _TNAME. The D number and type of offset are specified in coded form in variable _KNUM.

Extended tool offset is also possible. With this function a tool from a particular stored tool environment _TENV, and additive, setup offsets can be corrected by specifying the DL number in _DLNUM.

Detailed information on the parameters: see section "Description of the most important defining parameters".

Empirical values and mean values

An empirical value stored in data block GUD5 in array _EV[ ] can be included in calculation of the result after measurement is completed.

Optionally, averaging is performed over a number of parts (array _MV[ ]) and the tolerance bands are checked.

Both are activated in _EVNUM (see Section "Description of the most important defining parameters").

Measuring variants

Measuring cycle CYCLE994 permits the following measuring variants that are specified in parameter _MVAR.

Value	Meaning
1	2-point inside measurement with programmed safety zone
2	2-point measurement: • Outside measurement with programmed safety zone • Inside measurement without safety zone

Result parameters

The measuring cycle CYCLE994 supplies the following values as results in the GUD5 block:

Parameter	Data type	Result
_OVR [0]	REAL	Setpoint diameter or setpoint as radius dimension (note _MA)
_OVR [1]	REAL	Setpoint for diameter/radius in abscissa → only when _MA=1
_OVR [2]	REAL	Setpoint for diameter/radius in ordinate → only when _MA=2
_OVR [3]	REAL	Setpoint for diameter/radius in applicate → only when _MA=3
_OVR [4]	REAL	Actual value for diameter/radius
_OVR [5]	REAL	Actual value for diameter/radius in abscissa → only when _MA=1
_OVR [6]	REAL	Actual value for diameter/radius in ordinate → only when _MA=2
_OVR [7]	REAL	Actual value for diameter/radius in applicate → only when _MA=3
_OVR [8]	REAL	Upper Tolerance limit for diameter/radius
_OVR [12]	REAL	Lower tolerance limit for diameter/radius
_OVR [16]	REAL	Difference for diameter
_OVR [17]	REAL	Difference for diameter/radius in abscissa → only when _MA=1
_OVR [18]	REAL	Difference for diameter/radius in ordinate → only when _MA=2
_OVR [19]	REAL	Difference for diameter/radius in applicate → only when _MA=3
_OVR [20] 1)	REAL	Compensation value
_OVR [27]	REAL	Zero offset area
_OVR [28]	REAL	Safe area
_OVR [29]	REAL	Dimensional difference
_OVR [30]	REAL	Empirical value
_OVR [31]	REAL	Mean value
_OVI [0]	INTEGER	D number
_OVI [2]	INTEGER	Measuring cycle number
_OVI [4]	INTEGER	Weighting factor
_OVI [5]	INTEGER	Probe number
_OVI [6]	INTEGER	Mean value memory number
_OVI [7]	INTEGER	Empirical value memory number
_OVI [8]	INTEGER	Tool number
_OVI [9]	INTEGER	Alarm number
1) For "tool offset" the offset value always appears in _OVR[20] as a radius dimension, regardless of DIAMON or DIAMOF.		

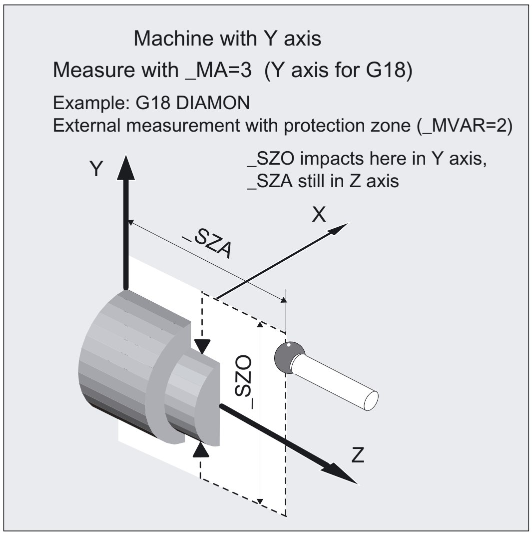
When measuring in the traverse axis and for diameter programming (DIAMON), all of the dimensioned parameters are diameter dimensions, otherwise radius dimensions.

Parameter

Parameter	Data type	Meaning
_MVAR	1 or 2	1: Inside measurement, 2-point measurement with safety zone 2: 2-point measurement, safety zone only for outside measurement
_SETVAL	REAL2)	Setpoint If measurement is made in the transverse axis and diameter programming (DIAMON) is active, then _SETVAL is a diameter dimension, otherwise a radius dimension around the workpiece zero.
_MA	1, 2, 31)	Measuring axis
_SZA	REAL	Protection zone at the workpiece in the abscissa2) If the abscissa is a transverse axis and diameter programming (DIAMON) is active, then _SZA is a diameter dimension, otherwise a radius dimension around the workpiece zero.
_SZO	REAL	Protection zone at the workpiece in the ordinate2) If the ordinate is a transverse axis and diameter programming (DIAMON) is active, then _SZO is a diameter dimension, otherwise a radius dimension around the workpiece zero.
_KNUM	0, > 0	0: Without automatic tool offset >0: with automatic tool offset (individual values: See Section 2.3, parameter _KNUM)
_TNUM	INTEGER, ≥0	Tool number for automatic tool offset
_TNAME	STRING[32]	Tool name for automatic tool offset (alternative to _TNUM with tool management active)
_DLNUM	INTEGER, ≥0	DL number for additive and setup offset
_TENV	STRING[32]	Name of tool environment for automatic tool offset

1) Measurement in the 3rd axis of the plane is also possible, provided this axis exists (_MA=3: if G18 is in the Y axis).

2) For measurement in the 3rd axis (in G18 in Y _SZO applies in this axis. _SZA still applies in the 1st axis in the plane (Z axis in G18). Travel around is performed in the 1st axis of the plane (Z axis in G18). Setting _CHBIT[19]=1 in block GUD6 enables the same setpoint and safety zone parameterization to be used for measurement in the 3rd axis (measurement in the Y axis) with active G18 as for measurement in the X axis (facing axis). The tool offset is then also in L1 if not specified differently in _KNUM.



Additional parameters `_VMS, _TZL, _TMV, _TUL _TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP` and `_K` also apply.

See also

Defining parameters (Page 63)

Result parameters (Page 65)

Variable measuring velocity: _VMS (Page 76)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 77)

Measurement path: _FA (Page 78)

Probe type, probe number: _PRNUM (Page 79)

Empirical value, mean value: _EVNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 81)

Weighting factor for mean value calculation: _K (Page 81)

6.6.1.2 Programming example

Two-point measurement, outside and inside

An outside diameter with tool T8, D1 and an inside diameter with tool T9, D1 has been machines on a workpiece. The set diameters have the dimensions shown in the figure.

If the absolute value of the difference determined is >0.002 mm, the length (in measuring axis _MA) of the tool is to be automatically offset in the wear. The maximum permissible deviation is taken as max. 0.5 mm. Max. 0.04 mm is permissible. To obtain a minimum measuring path of 0.5 mm, the measuring path is programmed as _FA= 0.5+0.5=1 mm (max. total measuring path = 2 mm).

The offset must take the empirical value in memory _EV[2] into consideration for T 8, or _EV[3] for T 9. Mean value calculation _MV[2] or _MV[3] and inclusion in calculation are also to be used. This tool offsets will therefore affect the production of the next workpieces or possible remachining.

Clamping for workpiece:

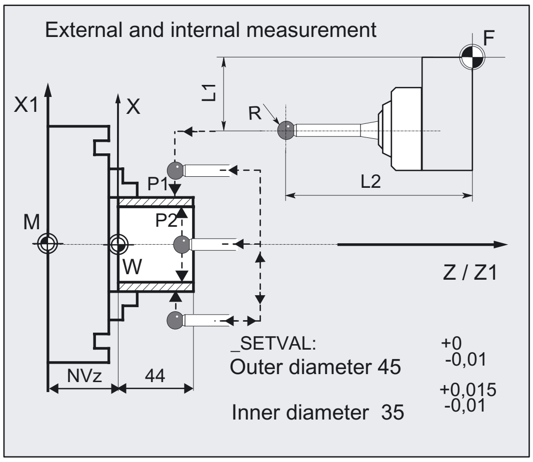
Zero offset, with settable ZO G54: NVz

Workpiece probe 1, used as tool **T1, D1,** is to be used.

The probe is already calibrated. Arrays for workpiece probe 1: _WP[0, ...]

The following is entered under T1, D1 in the tool offset memory:

Tool type (DP1):	580
Cutting edge position (DP2):	7
Length 1 - geometry (DP3):	L1 = 40.123
Length 2 - geometry (DP4):	L2 = 100.456
Radius - geometry (DP6):	3.000



```
%_N_TWO_POINT_MEAS_MPF
N10 T1 D1 DIAMON                              ;Call tool = probe (MT)
N20 G0 G54 Z30 X60                            ;ZO selection,
                                              ;Position probe facing P1
N25 _CHBIT[4]=1 _CHBIT[7]=0                   ;With mean value calc., calibrated MT
N30 _TLL=-0.01 _MA=2 _SZA=55 _SZO=55          ;Parameter assignment for 1st cycle
_KNUM=1 _K=3 _TZL=0.002 _TMV=0.005            call
_TDIF=0.04 _TSA=0.5 _VMS=0 _NMSP=1 _FA=1      ;(outside measurement)
_MVAR=2
N31 _SETVAL=45 _TUL=0 _TNUM=8 _EVNUM=3
N40 CYCLE994                                  ;2-point measurement outside
                                              ;with protection zone (P1)
N50 G0 Z55                                    ;Position probe facing P2
N60 X20
N70 Z30
N80 _SETVAL=35 _TUL=0.015 _TNUM=9 _EVNUM=4    ;Parameter change for 2nd cycle call
                                              ;(inside measurement)
N90 CYCLE994                                  ;2-point measurement inside
                                              ;without protection zone (P2)
N100 G0 Z110                                  ;Retraction in Z
N110 X60                                      ;Retraction in X
N200 M2                                       ;End of program
```

Explanation of example

Measurement of outside diameter and offset T8

The difference calculated from the actual value and setpoint is compensated for by the empirical value in the empirical value memory _EV[2] and compared with the tolerance parameter:

- If it is more than 0.5 mm (_TSA), alarm "Safe area violated" is output and program execution cannot be continued.
- If it is more than 0.04 mm (_TDIF), no compensation is performed and alarm "Permissible dimensional difference exceeded" is output and the program continues.
- If values _TUL= -0.01, _TLL=0 are violated upward or downward, the length of T8 D1 is compensated 100% by this difference. Alarm "Oversize" or "Undersize" is displayed and the program is continued.
- If 0.005 mm (_TMV) is exceeded, the length in T8 D1 is compensated 100% by this difference.
- If it is less than 0.005 mm (_TMV), the mean value is calculated (only if _CHBIT[4]=1! with mean value memory) with the mean value in mean value memory _MV[2] and by including weighting factor (_K=3).
  - If the mean value obtained is >0.002 (_TZL), the reduced compensation of the length 1 for T8 D1 is the mean value/2 and the mean value is deleted in _MV[2].
  - - If the mean value is <0.002 (_TZL), there is no offset but it is stored in the mean value memory _MV[2] if mean value storage (_CHBIT[4]=1) is active.

The results are entered in result field _OVR[ ]. The wear of the length L1 (KNUM=1, _MA=2) of T8, D1 is included if a change is necessary.

Measurement of inside diameter and offset T9

Procedure as described for "Measurement output diameter".

Offset of T8 with appropriate modified values _EV[3], _MV[3] (EVNUM=4), _TUL, _SETVAL.

Note

The values of the workpiece tolerance parameters _TUL, _TLL were selected asymmetrically in the example. The result is then made symmetrical (see Section "Tolerance parameters: _TZL, _TMV, _TUL, TLL, _TDIF and _TSA").

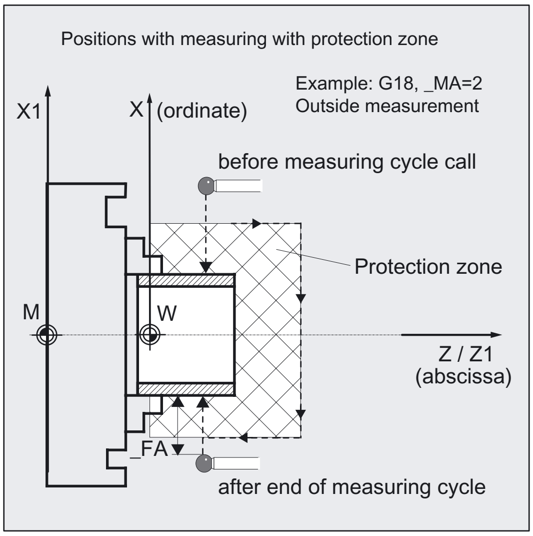
6.6.1.3 Operational sequence

Position before measuring cycle call

The probe must be positioned opposite the **positive** measuring point.

Position after end of measuring cycle

After the end of measurement, the probe is facing the **negative** measuring point at distance _FA.



NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration. If the probe is used in the spindle for a powered tool, the spindle orientation must also be considered. Deviations can cause additional measuring errors.

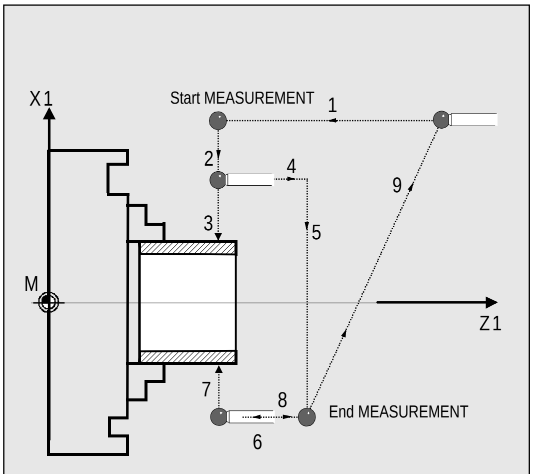
Procedure for outside measurement with _MVAR=2, _MA=2:

(safety zone _SZA, _SZO active)

1: Approach path outside diameter (user)

2 to 7: Traverse paths generated by the cycle for measuring on the outside diameter taking the safety zone _SZA, _SZO (4 to 6) into account

8 to 9: Retraction to the original point (user)



2-point measurement, external

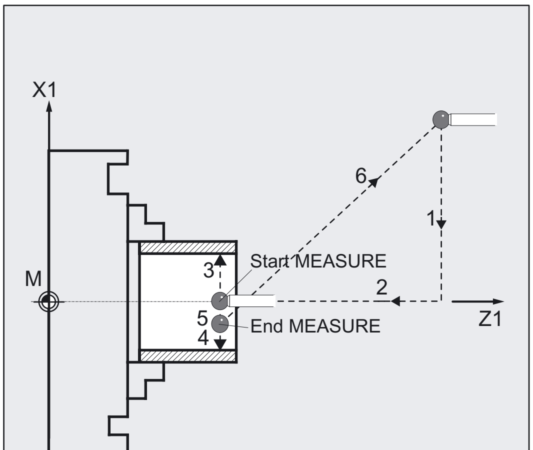
Procedure for inside measurement with _MVAR=2, _MA=2:

(no safety zone active)

1, 2: Approach paths inside diameter (user)

3 to 5: Traverse paths generated by the cycle for measuring on the inside diameter

6: Retraction paths to the original point (user)



2-point measurement inside

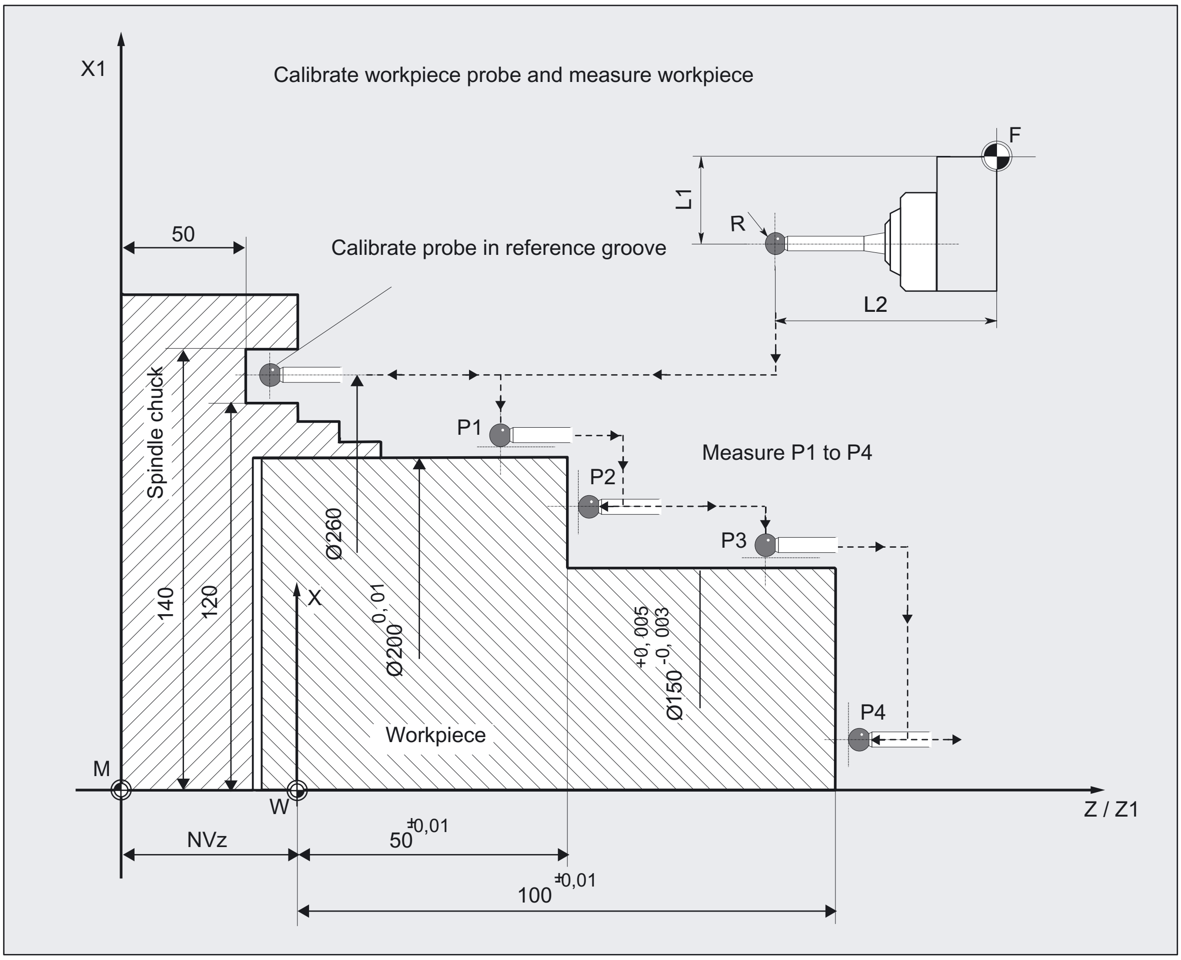
6.7 Complex example for tool measurement

Exercise

The workpiece shown in the figure is to be measured with workpiece probe 1 with cutting edge position 7, inserted as tool T8, D1, in **CYCLE974**.

This tool master is previously calibrated with **CYCLE973** in reference groove 1 in both axes in the negative direction.

Measuring points P1 to P4 were machined with different tools T1 D1 to T4 D1. These tools are to be automatically corrected in the length (according to measuring axis _MA) without empirical and mean values.



Calibration with workpiece probe CYCLE973, measurement of workpiece with CYCLE974

```
%_N_PART_1_MEAS_MPF
N10 T8 D1 DIAMON                         ;Select tool = probe
N20 SUPA G0 X300 Z150                    ;Approach starting position in X and Z, from
                                         ;which it is possible to approach the reference groove
                                         ;for calibration without collision
N30 _MVAR=13 _MA=1 _MD=1 _CALNUM=1 _TZL=0 ;Parameters for calibration in ref.
_TSA=1 _PRNUM=1 _VMS=0 _NMSP=1 _FA=1     groove
N40 CYCLE973                             ;Calibrate probe in the minus Z direction
N50 _MA=2                                ;Another measuring axis
N60 CYCLE973                             ;Calibrate probe in the minus X direction
N70 G54 G0 Z40                           ;Select work offset, traverse to measuring
                                         ;point in the Z axis
N80 X220                                 ;Position probe facing P 1
N100 _TUL=0 _TLL=-0.01 _TZL=0.002        ;Define parameters for measurement
_EVNUM=0 _TDIF=0.2 _TSA=0.3 _PRNUM=1
_MVAR=0 _SETVAL=200 _MA=2 _TNUM=1 _KNUM=1
N110 CYCLE974                            ;Measure P1
N120 G0 Z70                              ;Position probe facing P2
N130 X175
N140 _MA=1 _SETVAL=50 _TUL=0.01 _TNUM=2  ;Define parameters for measurement in
_KNUM=1                                  ;another axis
N150 CYCLE974                            ;Measure P2
N160 G0 Z80                              ;Position probe opposite P3
N170 _MA=2 _SETVAL=150 _TUL=0.005        ;Change parameters for measurement
_TLL=-0.003 _TNUM=3 _KNUM=1
N180 CYCLE974                            ;Measure P3
N190 G0 Z110                             ;Position probe opposite P4
N200 X50
N210 _MA=1 _SETVAL=100 _TUL=0.01         ;Change parameters for measurement
_TLL=-0.01 _TNUM=4 _KNUM=1
N220 CYCLE974                            ;Measure P4
N230 G0 SUPA Z250                        ;Retraction in Z
N240 SUPA X280                           ;Retraction in X
N300 M2                                  ;End of program
```

7 Miscellaneous functions

7.1 Log measurement results

Note

As of HMI sl software version 2.6

The "Log" function is not available in SINUMERIK HMI sl SW 2.6.

7.2 Measuring cycle support in the program editor

The program editor offers extended measuring cycle support for inserting measuring cycle calls into the program.

Prerequisite

Hardware TCU or PCU.

Function

This measuring cycle support provides the following functionality:

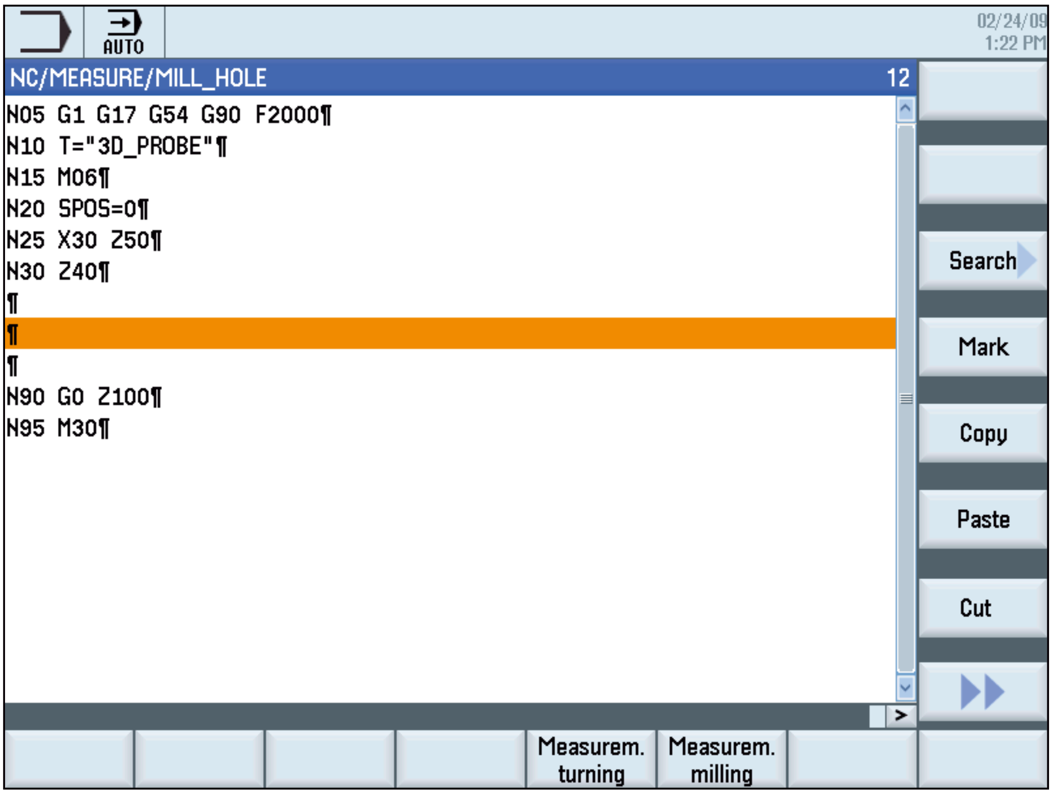
- Measuring cycle selection via softkeys
- Input screen forms for parameter assignment with help displays
- Retranslatable program code is generated from the individual screen forms.

7.2.1 Menus, explanation of the cycles

7.2.1.1 General information

Explanation

The input screens for the measuring cycles are selected depending on the technology being used via horizontal softkeys.

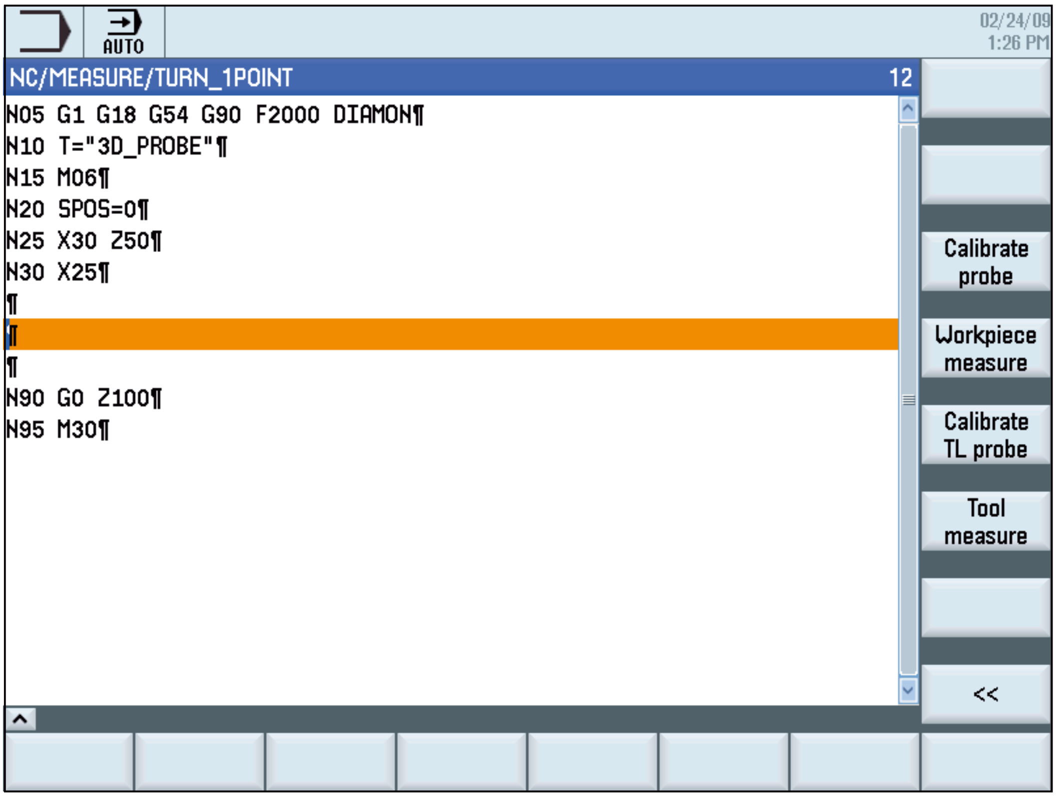


Measure turning — Input screen forms for measuring cycles for turning technology.

Measure milling — Input screen forms for measuring cycles for milling technology.

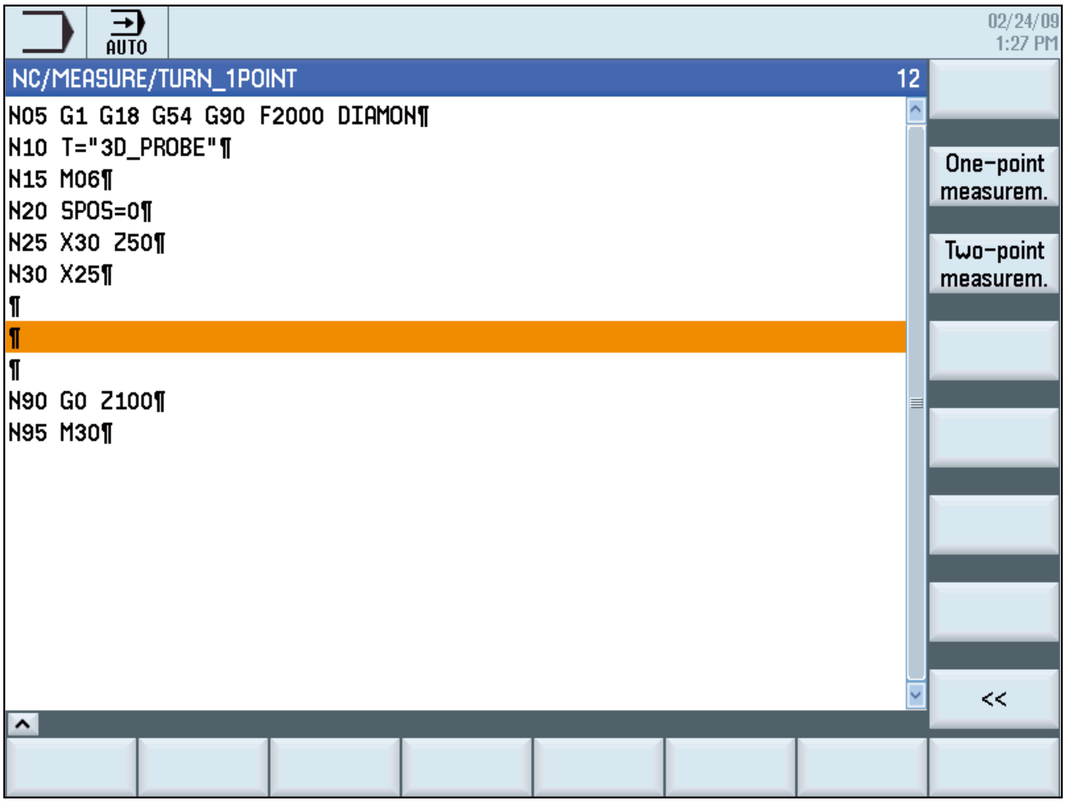
7.2.1.2 Softkey bars for turning

Vertical softkey menu for turning technology

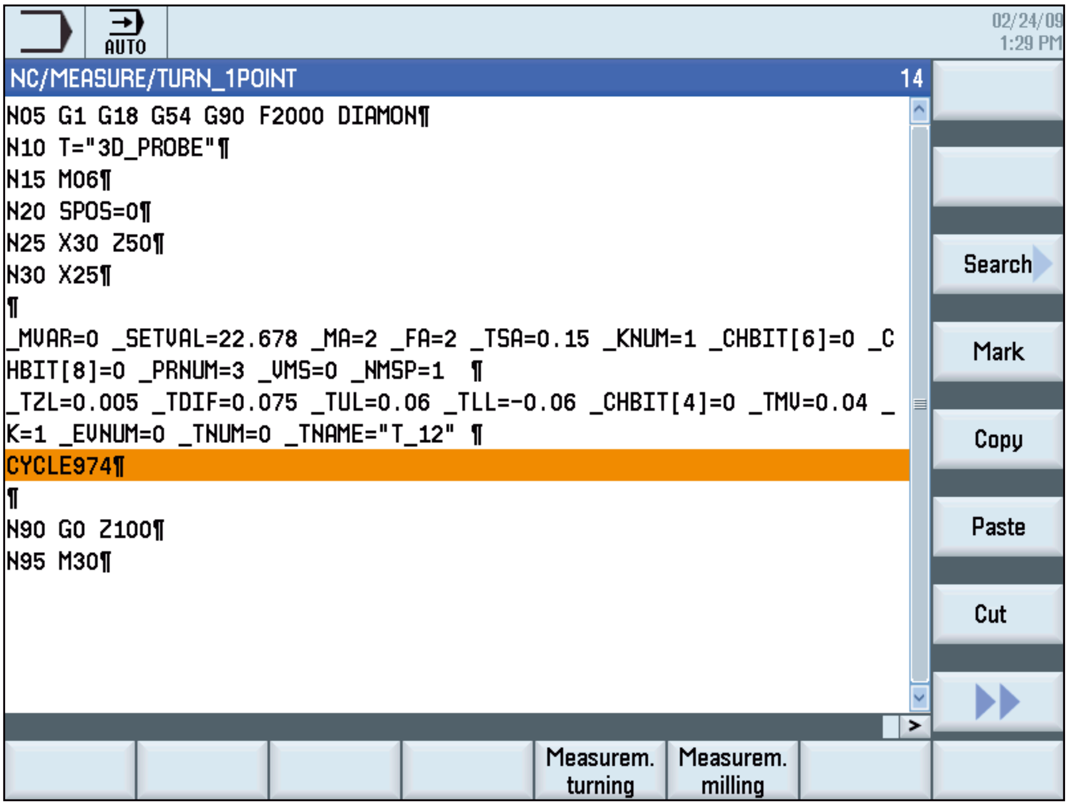


Measurem. probe calibr.	Call screen form for CYCLE973 Calibrate workpiece probe for turning machines.
Measure workpiece	Call new vertical softkey menu for "measure workpiece".
Tool probe calibr.	Call screen form for CYCLE982 Calibrate tool probe for turning machines.
Measure tool	Call screen form for CYCLE982 Gauge turning and milling tools for turning machines
<<	Back

Vertical softkey menu for measure workpiece, turning

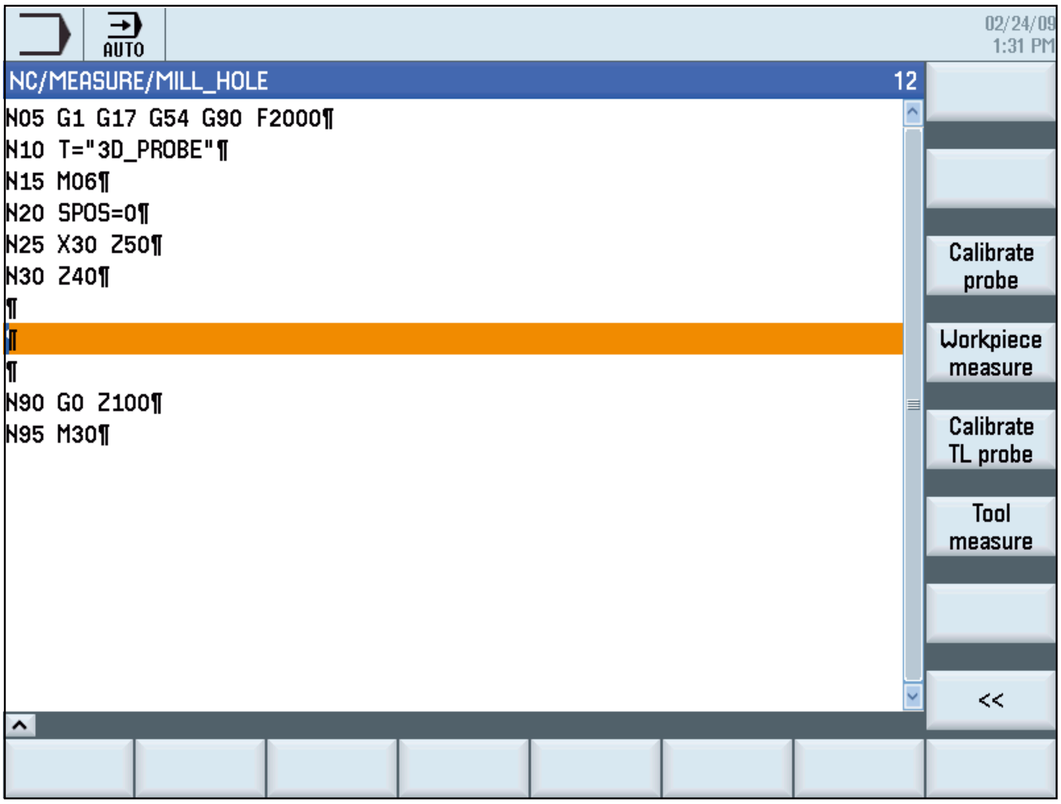


Single point measurem.	Call screen form Workpiece measurement for turning machines CYCLE974 1 point measurement.
Two point measurem.	Call screen form Workpiece measurement for turning machines CYCLE994 2-point measurement.
<<	Back to selection menu turning.


AUTO
02/24/09
1:29 PM
NC/MEASURE/TURN_1POINT
14
N05 G1 G18 G54 G90 F2000 DIAMON¶
N10 T="3D_PROBE"¶
N15 M06¶
N20 SPOS=0¶
N25 X30 Z50¶
N30 X25¶
¶
_MVAR=0 _SETVAL=22.678 _MA=2 _FA=2 _TSA=0.15 _KNUM=1 _CHBIT[6]=0 _C
HBIT[8]=0 _PRNUM=3 _VMS=0 _NMSP=1 ¶
_TZL=0.005 _TDIF=0.075 _TUL=0.06 _TLL=-0.06 _CHBIT[4]=0 _TMV=0.04 _
K=1 _EVNUM=0 _TNUM=0 _TNAME="T_12" ¶
CYCLE974¶
¶
N90 G0 Z100¶
N95 M30¶
Search
Mark
Copy
Paste
Cut
Measurem. turning
Measurem. milling

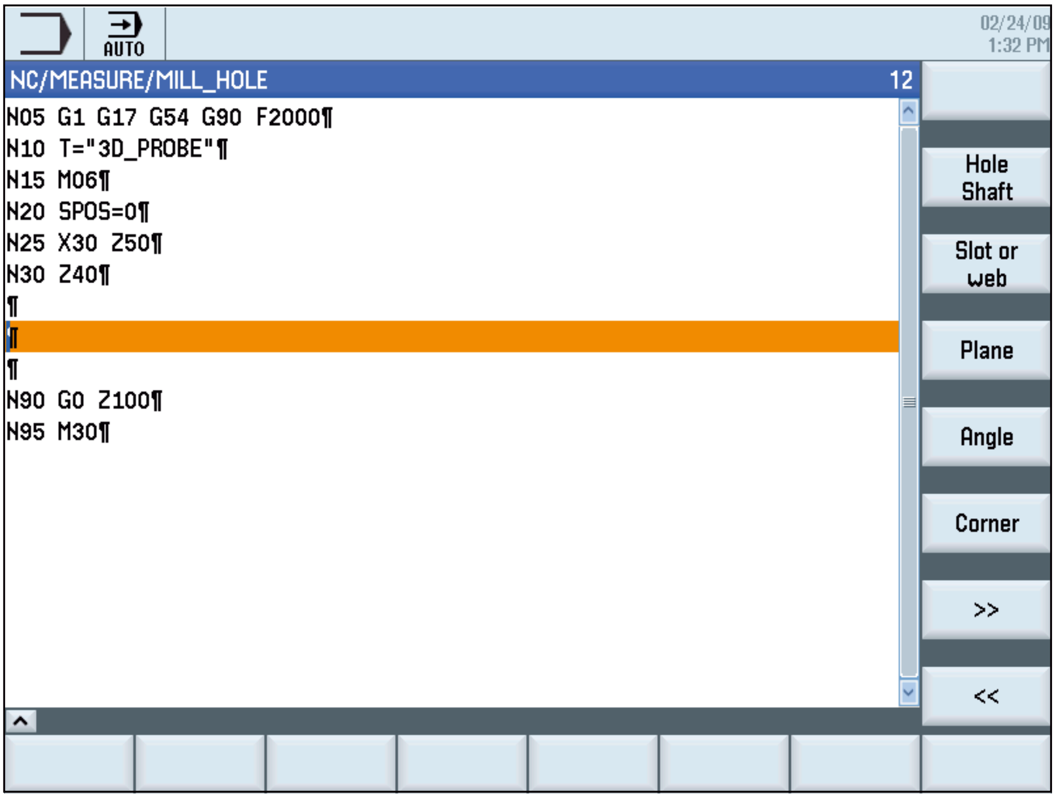
7.2.1.3 Softkey bars for milling

Vertical softkey menu for milling technology



Measurem. probe calibr.	Call screen form for CYCLE976 Calibrate workpiece probe for milling machines.
Measure workpiece	Call new vertical softkey menu for selection "measure workpiece".
Tool probe calibr.	Call screen form for CYCLE971 Calibrate tool probe for milling machines.
Measure tool	Call screen form for CYCLE971 Gauge milling tools on milling machines.
<<	Back

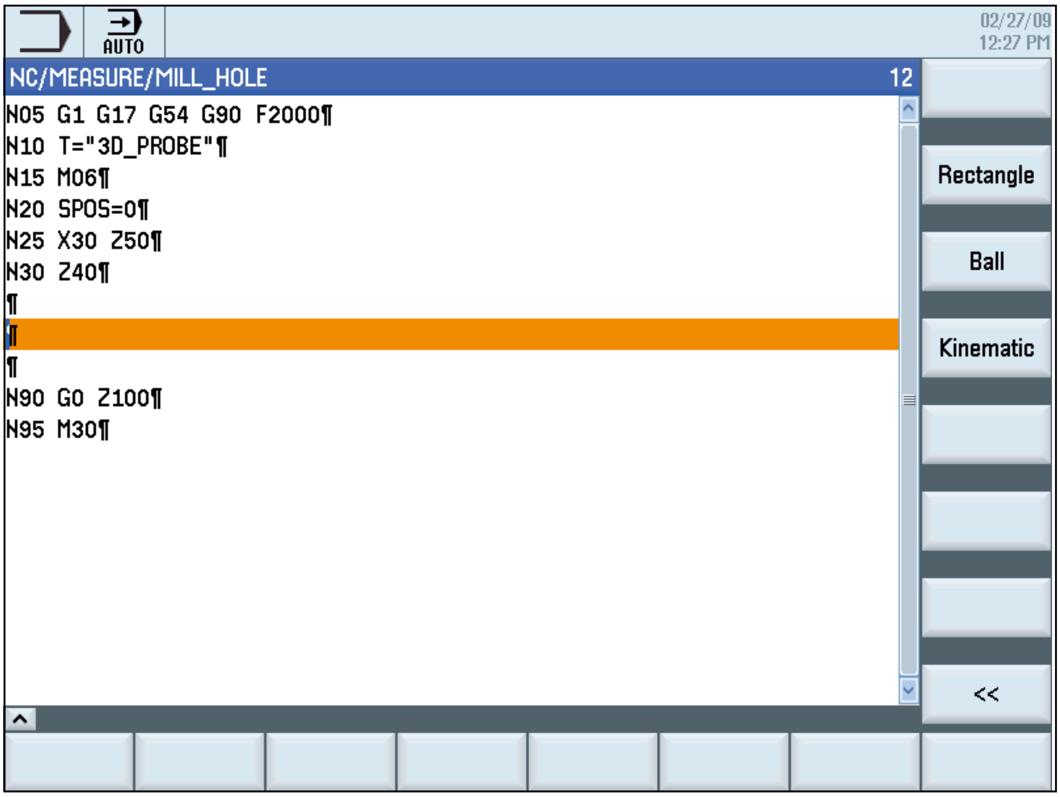
Vertical softkey menu for workpiece measuring, milling



Hole shaft	Call screen form for workpiece measurement for milling machines CYCLE977/CYCLE979 hole/shaft. Hole/shaft and paraxial/at an angle switchover are performed in the screen form.
Groove web	Call screen form for workpiece measurement for milling machines CYCLE977/CYCLE979 groove/web. Slot/web and paraxial/at an angle switchover are performed in the screen form.
Area	Call screen form for workpiece measurement for milling machines CYCLE978 1-point measurement.
Angle	Call screen form for zero measurement for milling machines CYCLE998 angle measurement 1 angle/2 angle switchover is performed in the screen form.
Corner	Call screen form automatic setup corner internal/external CYCLE961. Switchover between corner setup specifying distances and angle or points is performed within the form.
>>	Call vertical advancement menu.

<<	Back to selection menu milling.

Vertical advancement menu for workpiece measurement milling

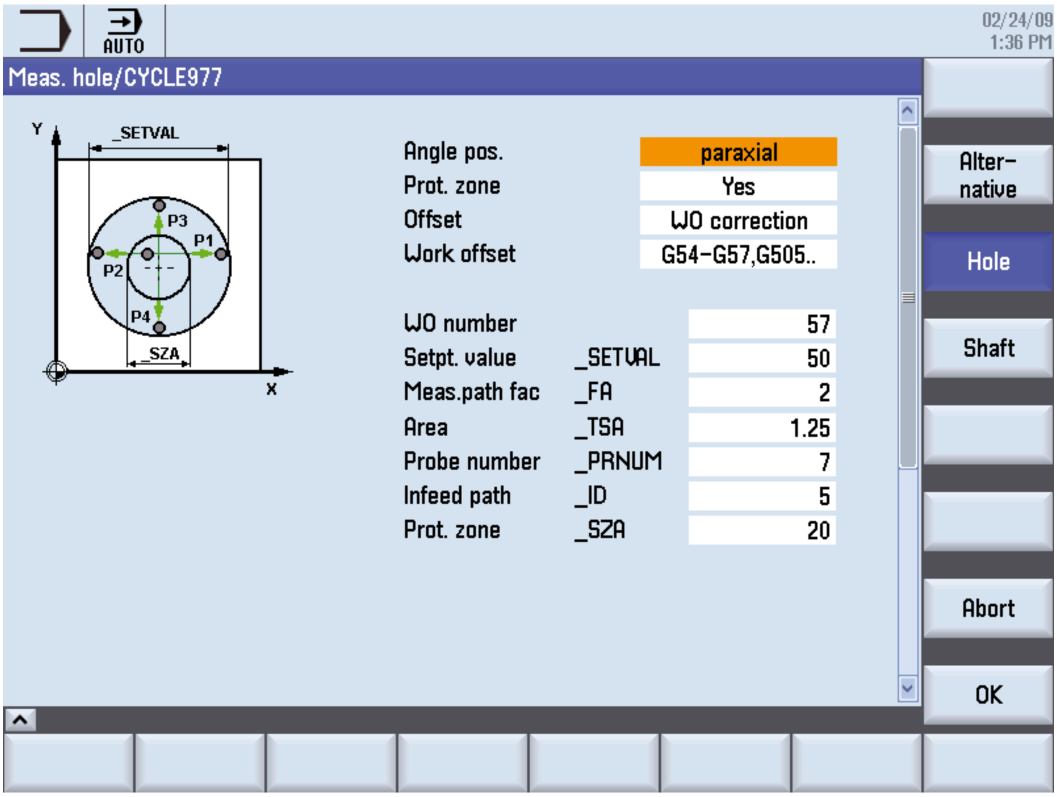


Rectangle	Call screen form for workpiece measurement for milling machines CYCLE977 rectangle internal/external.
Sphere	Call screen for workpiece measurement for milling machines CYCLE997, measure ball and ZO determination.
Kinematics	Call screen "Measure Kinematics" for milling machines Cycle996, measure ball positions and determine geometric vectors for transformations.
<<	Back to selection list measure workpiece milling.

7.2.1.4 Programming example

```
;Measuring a hole parallel to the axis
; with protection zone
;(generated with measuring cycle support)
N100 G17 G0 G90 Z20 F2000 S500 M3
N110 T=7 M6                                         ;Insert probe
N120 X50 Y50                                        ;Position probe in X/Y
                                                    plane;on hole center
                                                    point;position
N130 Z20                                            ;Position Z axis in hole;
                                                    Position at measuring height
;
;The following is the NC code generated by the measuring cycle support
N130 _MVAR=1001 _SETVAL=100.000 _PRNUM=101          ;Call measuring cycle
 _KNUM=2002 _FA=2 _TSA=0.23
 _VMS=0 _NMSP=1 _ID=-20.000 _SZA=50.000
 _CORA=0.03 _TZL=0.01 _TDIF=0.2 _TUL=0.065
 _TLL=-0.065 _CHBIT[4]=0 _K=1 _EVNUM=2
 -TNUM=1 CYCLE977
;end of NC code generated by measuring cycle support
...
N200 M30                                            ;End of program
```

Input screen for measuring a hole, parallel with the axis, with protection zone (CYCLE977)



7.2.2 Presetting measuring cycle support in HMI sl

For descriptions of the default settings for measuring cycle support for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter Configuring cycles; Configuring measuring cycles and measuring functions

7.3 Measuring result screens

Function

Measurement result displays will be shown automatically during measuring cycle runtime if _CHBIT[10]=1. If _CHBIT[10]=0 (default setting), the measurement result displays are now shown.

Depending on the setting in _CHBIT[11] and _CHBIT[18]

- the measurement result displays are automatically deselected at the end of measuring cycle (_CHBIT[11]=0, _CHBIT[18]=0)

  or
- the measurement result displays must be acknowledged with the NC start key (_CHBIT[11]=1, _CHBIT[18]=0). In this case, the measuring cycle outputs the message:

  "Please acknowledge measurement result screen with NC start"

  or
- The measurement result displays are retained until the next measuring cycle call (_CHBIT[11]=0, _CHBIT[18]=1).

The measuring cycles can display different measuring result screens depending on the measuring variant:

- Calibrating tool probes
- Measuring the tool
- Calibrating workpiece probes
- Workpiece measurement

Display result displays

The result displays contain the following data:

Calibrating tool probes

- Measuring cycle and measuring variant
- Trigger values of axis directions and differences
- Probe number
- Safe area

Measuring the tool

- Measuring cycle and measuring variant
- Actual values and differences for tool offsets
- Safe area and permissible dimensional difference
- T-, D-number

Calibrating workpiece probes

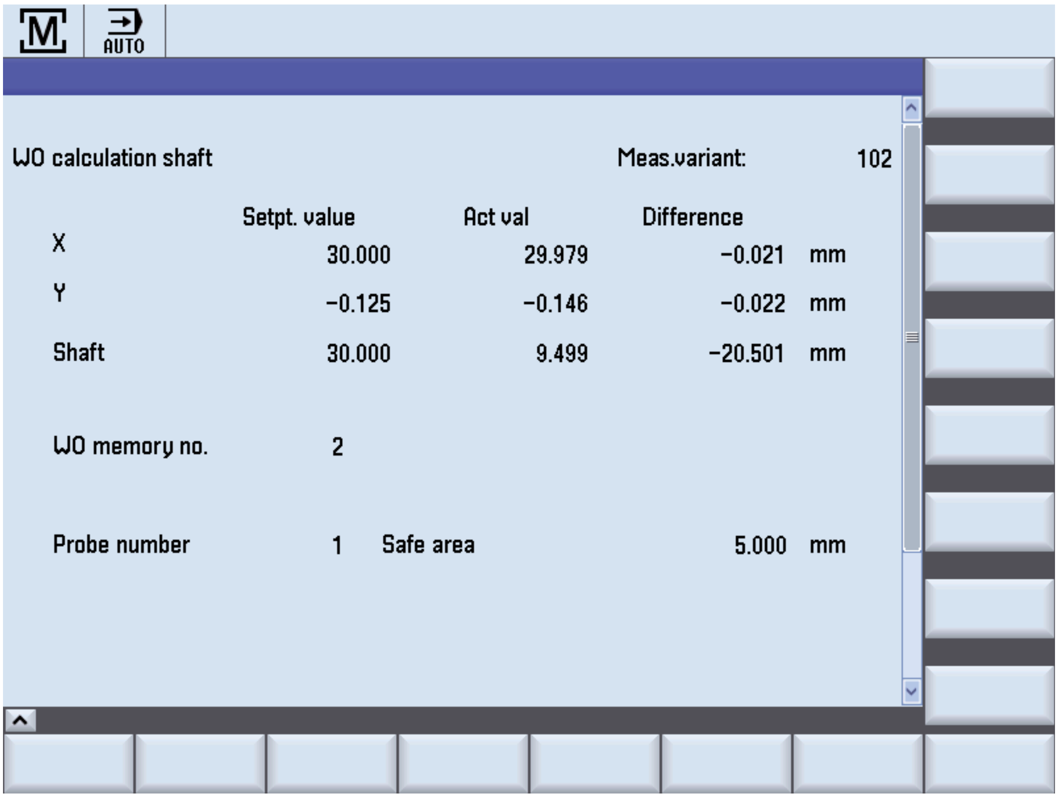
- Measuring cycle and measuring variant
- Trigger values of axis directions and differences

- Positional deviation during calibration in the plane
- Probe number
- Safe area

Workpiece measurement

- Measuring cycle and measuring variant
- Setpoints, actual values and their differences
- Tolerance upper and lower limits (for tool offset)
- Compensation value
- Probe number
- Safe area and permissible dimensional difference
- T number, D number, and DL number or ZO memory number for automatic offset

Example of measurement result display



8 Hardware/software

8.1 Hardware prerequisites for HMI sl

For descriptions of the hardware prerequisites for measuring cycles for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

8.2 Software prerequisites for HMI sl

For descriptions of the software prerequisites for measuring cycles for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

8.3 Function check for HMI sl

For descriptions of the function check for measuring cycles for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

Data description 9

9.1 Machine data for machine cycle runs

For descriptions of the machine data for the sequence of measuring cycles for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

Note

As of HMI sl software version 2.6

The GUD parameters are stored in the machine or setting data.

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used up to and including measuring cycles version 7.5, compared to the machine and setting data as of measuring cycles version 2.6, is included in appendices A1, A2 and A3.

9.2 Cycle data

9.2.1 Data blocks for measuring cycles

9.2.1.1 General information

The measuring cycle data are stored in two separate definition blocks:

- GUD5.DEF: Data block for measuring cycle users
- GUD6.DEF: Data module for machine manufacturers

Note

As of HMI sl software version 2.6

The GUD parameters are stored in the machine or setting data.

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used up to and including measuring cycles version 7.5, compared to the machine and setting data as of measuring cycles version 2.6, is included in appendices A1, A2 and A3.

9.2.1.2 Data block GUD5.DEF

The input and output parameters for measuring cycles are stored in the data block GUD5.DEF; their status flags and arrays for the empirical and mean values are also defined here.

The sizes of the fields for the empirical and mean values must also be configured by the machine manufacturer at measuring cycle start-up.

The preset values, however, are defined by the measuring cycle operator.

In the as-delivered state, for example, the following settings are active:

Data arrays	Data type	Meaning
_EV[20]	REAL	Number of empirical values
_MV[20]	REAL	Number of mean values

9.2.1.3 Data block GUD6.DEF

The general, global, and channel-specific measuring cycle data are configured in the GUD6.DEF data block.

This block is supplied with the measuring cycles in its standard configuration and must be adapted to the specific requirements of the machine by the machine manufacturer.

In the as-delivered state, the following settings are active:

Global data	Data type	Meaning	
_TP[3,10]	REAL	3 arrays for tool probes, machine-related	
_WP[3,11]	REAL	3 arrays for workpiece probes	
_KB[3,7]	REAL	3 arrays for gauging blocks	
_TPW[3,10]	REAL	3 data arrays for tool probes, machine-related	
_CM[9]=(100,1000,1, 0.005,20,4,10,0,0.5)	REAL	Only active if _CBIT[12]=0 Monitoring data for tool measurement with rotating spindle and cyclic calculation with CYCLE971: • max. peripheral speed 100 m/min • max. speed 1000 rev/min • F_{min} = 1mm/min • measuring accuracy 0.005 mm • F_{max} for probing 20 mm/min • direction of rotation M4 • probing twice with feed factor 10 on first probing _CM[8] only active if _CBIT[7]=1 Tolerance parameter for tool measurement with orientational tool carriers - 90° multiples of the tool positions with CYCLE982 • Field for tolerance parameter of rotary axis positions deviation: 0.5 degrees	
_MFS[6]	REAL	Only active if _CBIT[12]=1 Speed and feed set by user during tool measurement with rotating spindle	
_CBIT[16]=(0,0,0,1,0,0, 0,0,1,0,0,0,0,0,0,0)	BOOL	Values	Central bits
		[0]: 0:	Measurement repetition after violation of dimensional difference and safe area
		[1]: 0:	No M0 on measurement repeat
		[2]: 0:	No M0 on "oversize", "undersize", "dim. difference"
		[3]: 1:	Metric basic system
		[4]: 0:	Internal data item
		[5]: 0:	Tool measurement and calibration with CYCLE982 are undertaken in the basic coordinates system (machine coordinates system with kinematics transformation is switched off)
		[6]: 0:	Logging with information about the measuring cycle and measuring variant
		[7]: 0:	No support for orientational tool carriers
		[8]: 1:	Offset for mono probe setting with _CORA
		[9]: 0:	Log OFF
		[10]: 0:	Internal data item
		[11]: 0:	Use of standard log header
		[12]: 0:	Internal cycle calculation of speed and feedrate during tool measurement with rotating spindle
		[13]: 0:	Without deleting fields _TP[ ], _TPW[ ], _WP[ ], _KB[ ], _EV[ ] and _MV[ ]
		[14]: 0:	Length of workpiece probe relative to center of probe ball
		[15]: 0:	Internal data item

<table>
<tr><th>Global data</th><th>Data type</th><th colspan="2">Meaning</th></tr>
<tr><td>_SI[3]=("","6","")</td><td>STRING[8]</td><td colspan="2">Central strings (system information)
• Internal data item
• software version of the control
• Internal data item</td></tr>
<tr><td>_PROTNAME[2]</td><td>STRING[32]</td><td colspan="2">• name of main program the log is from,
• name of log file</td></tr>
<tr><td>_HEADLINE[10]</td><td>STRING[80]</td><td colspan="2">Strings for log header</td></tr>
<tr><td>_PROTFORM[6]=(60,80, 1,3,1,12),</td><td>INTEGER</td><td colspan="2">Log formatting
• 60 lines per page
• 80 characters per line
• first page number is 1
• number of header lines is 3
• number of value lines in the log is 1
• number of characters per column is 12</td></tr>
<tr><td>_PROTSYM[2]=(";","#")</td><td>CHAR</td><td colspan="2">• Separator in the log is ";"
• Special character for identification of tolerance limits being exceeded is "#"</td></tr>
<tr><td rowspan="4">_PROTVAL[13]</td><td rowspan="4">STRING[100]</td><td>Values</td><td>Title line in log;
Specification of the values to be logged</td></tr>
<tr><td>0...1:</td><td>two title lines</td></tr>
<tr><td>2...5:</td><td>up to 4 value lines</td></tr>
<tr><td>6...12:</td><td>internal fields</td></tr>
<tr><td>_PMI[4]</td><td>INTEGER</td><td colspan="2">Field for internal flags for logging</td></tr>
<tr><td>_SP_B[20]</td><td>INTEGER</td><td colspan="2">Variable column width</td></tr>
<tr><td>_TXT[100]</td><td>STRING[12]</td><td colspan="2">Field for formatted strings</td></tr>
<tr><td>_DIGIT=3</td><td>INTEGER</td><td colspan="2">Number of decimal places is 3</td></tr>
<tr><td>_MZ_MASK[20] =(1,0,0,0,0,0,0,0)</td><td>INTEGER</td><td colspan="2">Setting data for measuring cycle support
• generation of a direct measuring cycle call
• without extended ZO/tool offset
• without input field for measuring speed and measuring feed
• without empirical values
• without mean value calculation
• workpiece probe is a multidirectional probe
• Internal data item
• cycle-internal calculation of feedrate and spindle rotation for tool measurement with rotating spindle (CYCLE971)</td></tr>
</table>

Channel-specific data	Data type	Meaning	
_EVMVNUM[2]=(20,20)	INTEGER	Number of empirical values and mean values • 20 memories for empirical values • 20 memories for mean values	
_SPEED[4] =(50,1000,1000,900),	REAL	Traversing velocities for intermediate positioning • 50% rapid traverse velocity • positioning feedrate in the plane 1000 mm/min • positioning feedrate in infeed axis 1000 mm/min • fast measurement feedrate 900 mm/min	
_CHBIT[30] =(0,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0)	BOOL	Values	
		[0]: 0:	Measuring input 1 for connecting a workpiece probe
		[1]: 1:	Measuring input 2 for connecting a tool probe
		[2]: 1:	Collision monitoring active for traversing blocks generated by measuring cycles
		[3]: 0:	Tool data are entered into the geometry memory when the tool is measured
		[4]: 0:	No mean value storage
		[5]: 0:	The empirical value is subtracted from the measured actual value
		[6]: 0:	When measuring workpieces with automatic tool offset, an additive offset/correction is made in the wear memory
		[7]: 0:	CYCLE994 uses the trigger values for offset
		[8]: 0:	When measuring workpieces with automatic tool offset, an additive offset is made in the total offset
		[9]: 0:	Internal data item
		[10]: 0:	No measurement result display
		[11]: 0:	Measurement result display is deselected at the end of cycle
		[12]: 0:	Internal data item
		[13]: 0:	No coupling of the spindle position with coordinate rotation in the plane
		[14]: 0:	Spindle positioning acc. to default
		[15]: 0:	Up to 5 measurement attempts
		[16]: 0:	retraction from meas. point at same velocity as intermediate positioning
		[17]: 0:	Measurement feed only defined by _VMS
		[18]: 0:	Automatic de-selection of the measuring result screen with cycle end
		[19]: 0:	Normal handling of the Y axis for rotating meas. cycles
		[20]: 0:	Spindle positioning with measurement with CYCLE982
		[21]: 0:	Internal data item
		[22]: 0:	Last measurement at reduced speed for tool measurement with rotating spindle (CYCLE971)
		[23]: 0:	Internal data item
		[24]: 1:	Metric basic system
		[25...29]: 0:	Internal data item

Channel-specific data	Data type	Meaning
_TP_CF=0	INTEGER	No tool probe manufacturer specified (type)
_MT_COMP=0	INTEGER	No additional offset of the measurement result display on tool measurement with rotating spindle (CYCLE971)
_MT_EC_R[6,5]=(0,...,0)	REAL	User-defined array for offsetting the measurement result on tool radius measurement and rotating spindle (CYCLE971)
_MT_EC_L[6,5]=(0,...,0	REAL	User-defined array for offsetting the measurement result on tool length measurement and rotating spindle (CYCLE971)
_JM_I[10]= (0,1,1,17,100,0,0,0,0,0)	INTEGER	INTEGER value field for JOG measurement • no set array number for probes like in ShopMill • number of array for workpiece probe is 1 • number of array for tool probe is 1 • working plane for measurement in JOG is G17 • active ZO number on measurement in JOG is 0 (G500)
_JM_B[10]= (0,1,0,0,0,0,0,0,0,0)	BOOL	BOOL value field for JOG measurement • offset in geometry on tool measurement • 1 measurement attempt • retraction from meas. point at same velocity as intermediate positioning • no fast measurement feed
_MC_MTL[3]= (33.3,33.3,33.3)	INTEGER	Probe offset during sphere measuring (only relevant in CYCLE997 for the measurement variant with "determining the sphere diameter") Ratio between the tracer length/pin-sphere (ball) radius ($TC_DP6) Pre-assignment (default) for 3 measuring probes: 100/3 If this variable is not available, then the trigger values are not corrected. [Array index]: _PRNUM-1
_MC_SIMSIM=1	INTEGER	0: Skip measuring cycles during simulation 1: Run measuring cycles during simulation
_MC_SIMDIFF=0	REAL	Value for simulated measuring difference

9.2.2 Data adjustment to a specific machine

For adapting the data to a specific machine, see the following:

References:

Commissioning Manual SINUMERIK 840D sl base software and HMI sl;

Book HMI sl (IM9), chapter on measuring cycles

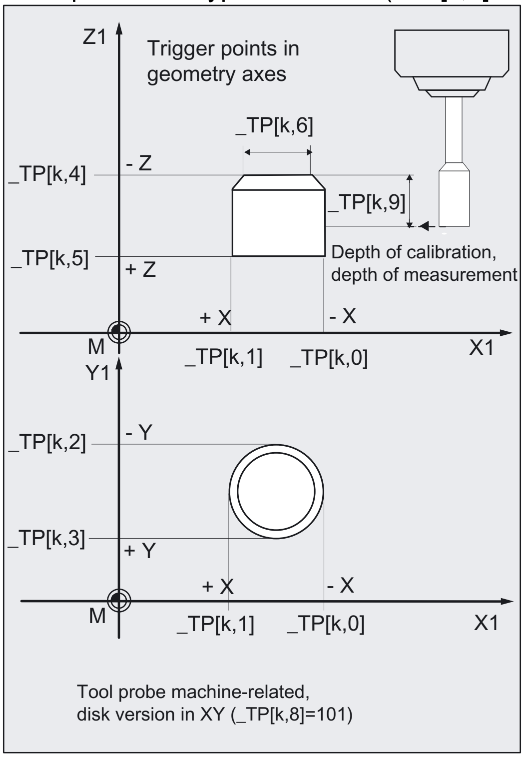
9.2.3 Central values

Data block GUD6.DEF

<table>
<tr><td></td><td colspan="5">_TP[ ]
Array for tool probes (machine-related)</td></tr>
<tr><td colspan="2"></td><td colspan="2">Min. input limit: -</td><td colspan="2">Max. input limit: -</td></tr>
<tr><td colspan="3">Changes valid after value assignment</td><td>Protection level: -</td><td colspan="2">Units: -</td></tr>
<tr><td colspan="4">Data type:REAL</td><td colspan="2">Applies as of SW SW 3.2</td></tr>
<tr><td rowspan="24">Significance:</td><td colspan="3">Index "k" stands for the number of the current data field (_PRNUM-1)</td><td colspan="2">Preset default</td></tr>
<tr><td colspan="3">Assignment for milling</td><td colspan="2"></td></tr>
<tr><td>_TP[k,0]</td><td>Trigger point in minus direction</td><td>X (1st geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,1]</td><td>Trigger point in plus direction</td><td>X (1st geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,2]</td><td>Trigger point in minus direction</td><td>Y (2nd geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,3]</td><td>Trigger point in plus direction</td><td>Y (2nd geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,4]</td><td>Trigger point in minus direction</td><td>Z (3rd geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,5]</td><td>Trigger point in plus direction</td><td>Z (3rd geometry axis)</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,6]</td><td colspan="2">Edge length/disk diameter</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,7]</td><td colspan="2">Axes and directions for "automatic calibration"</td><td colspan="2">133</td></tr>
<tr><td rowspan="4">_TP[k,8]</td><td rowspan="4">Probe type</td><td>0: Cube</td><td colspan="2" rowspan="4">0</td></tr>
<tr><td>101: disk in XY</td></tr>
<tr><td>201: disk in ZX</td></tr>
<tr><td>301: disk in YZ</td></tr>
<tr><td>_TP[k,9]</td><td colspan="2">Distance between upper edge of tool probe and lower edge of tool probe (= depth of calibration, depth of measuring for milling cutter radius)</td><td colspan="2">2</td></tr>
<tr><td colspan="3">Assignment for turning (probe type: primarily cube)</td><td colspan="2"></td></tr>
<tr><td>_TP[k,0]</td><td colspan="2">Trigger point in minus direction of abscissa</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,1]</td><td colspan="2">Trigger point in plus direction of abscissa</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,2]</td><td colspan="2">Trigger point in minus direction of ordinate</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,3]</td><td colspan="2">Trigger point in plus direction of ordinate</td><td colspan="2">0</td></tr>
<tr><td>_TP[k,4] to
_TP[k,9]</td><td colspan="2">irrelevant</td><td colspan="2">0</td></tr>
</table>

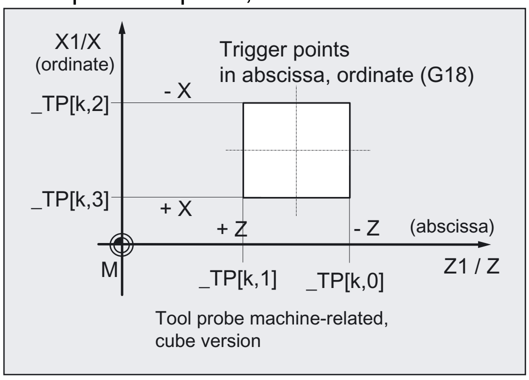
- **Tool probe on milling machine**

  Example: Probe type disk in XY (_TP[k,8]=101)



- **Tool probe on turning machine**

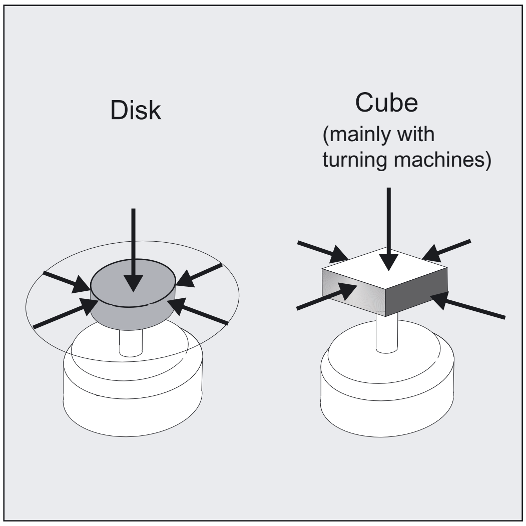
  Example: G18 plane, values machine-related



	_TPW[ ] Array for tool probes (workpiece-related)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type:REAL				Applies as of SW SW 6.3
Significance:	Index "k" stands for the number of the current data field (_PRNUM-1)			Preset default
	Assignment for milling			
	_TPW[k,0]	Trigger point in minus direction	**X** (1st geometry axis)	0
	_TPW[k,1]	Trigger point in plus direction	**X** (1st geometry axis)	0
	_TPW[k,2]	Trigger point in minus direction	**Y** (2nd geometry axis)	0
	_TPW[k,3]	Trigger point in plus direction	**Y** (2nd geometry axis)	0
	_TPW[k,4]	Trigger point in minus direction	**Z** (3rd geometry axis)	0
	_TPW[k,5]	Trigger point in plus direction	**Z** (3rd geometry axis)	0
	_TPW[k,6]	Edge length/disk diameter		0
	_TPW[k,7]	Axes and directions for "automatic calibration"		133
	_TPW[k,8]	Probe type	0: Cube 101: disk in XY 201: disk in ZX 301: disk in YZ	0
	_TPW[k,9]	Distance between upper edge of tool probe and lower edge of tool probe (= depth of calibration, depth of measuring for milling cutter radius)		2
	Assignment for turning (probe type: primarily cube)			
	_TPW[k,0]	Trigger point in minus direction of abscissa		0
	_TPW[k,1]	Trigger point in plus direction of abscissa		0
	_TPW[k,2]	Trigger point in minus direction of ordinate		0
	_TPW[k,3]	Trigger point in plus direction of ordinate		0
	_TPW[k,4] to _TPW[k,9]	irrelevant		0

For illustration, see analogous explanation of _TP[ ]

Tool probe types

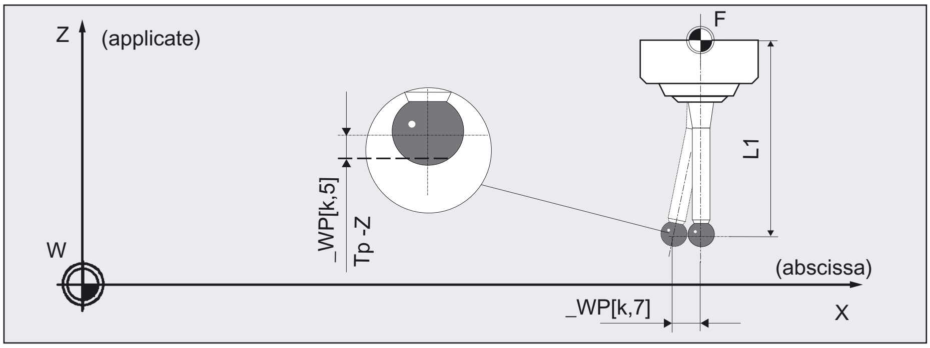


	_WP[ ] Workpiece probe		
	Min. input limit: -		Max. input limit: -
Changes valid after value assignment		Protection level: -	Units: -
Data type:REAL			Applies as of SW SW 3.2
Significance:	Index "k" stands for the number of the current data field (_PRNUM-1)		Preset default
	_WP[k,0]	active ball diameter of the workpiece probe	0
	_WP[k,1]	Trigger point in minus direction of abscissa	0
	_WP[k,2]	Trigger point in plus direction of abscissa	0
	_WP[k,3]	Trigger point in minus direction of ordinate	0
	_WP[k,4]	Trigger point in plus direction of ordinate	0
	_WP[k,5]	Trigger point in minus direction of applicate	0
	_WP[k,6]	Trigger point in plus direction of applicate	0
	_WP[k,7]	Positional deviation abscissa (skew)	0
	_WP[k,8]	Positional deviation ordinate (skew)	0
	_WP[k,9]	Calibration status, coded	0
	_WP[k,10]	Calibration status, coded	0

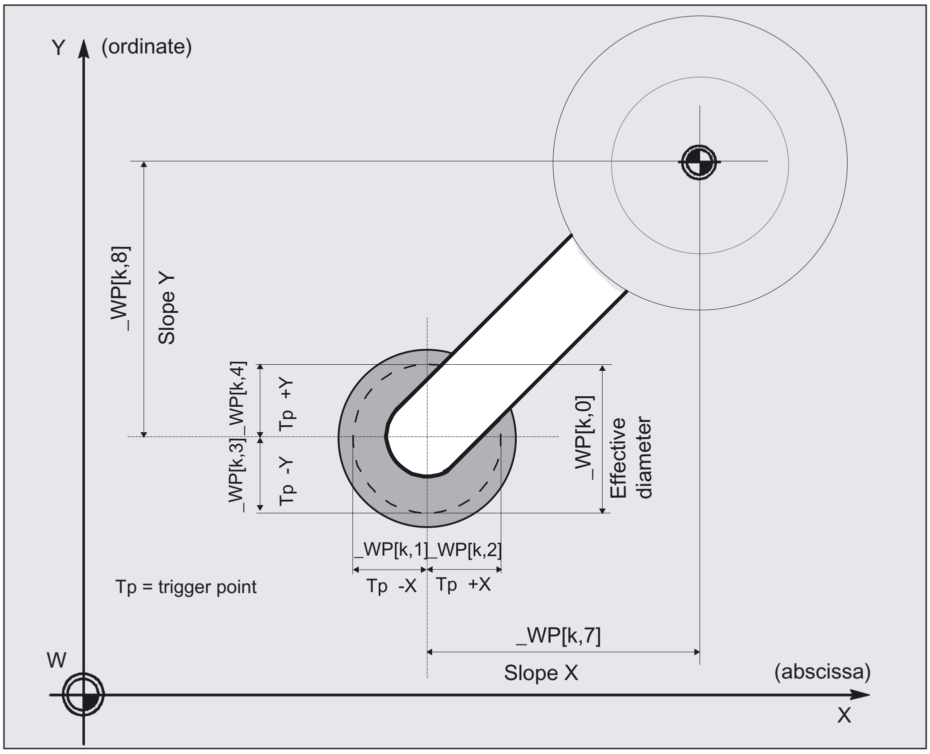
Overview of workpiece probe data

Example: G17, milling, _CBIT[14]=0

Position deviation of a real probe in rest position and trigger point Tp in –Z



Position deviation and trigger points Tp in X and Y (magnified illustration):

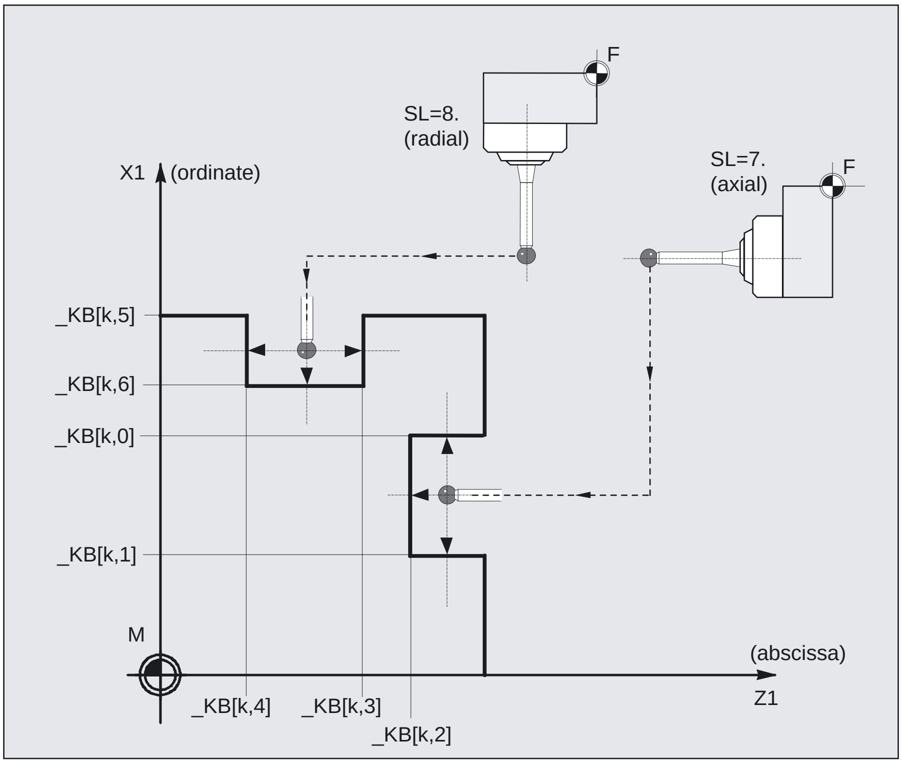


	_KB[ ] Gauging block (pair of reference grooves)		
	Min. input limit: -		Max. input limit: -
Changes valid after value assignment		Protection level: -	Unit: -
Data type REAL			Applies as of SW SW 3.2

Significance:	Index "k" stands for the number of the current data field (_CALNUM-1)		Preset default
	Reference groove for calibration of a workpiece probe with cutting edge position **SL=7** (tool type: 5xy)		
	_KB[k,0]	Groove edge in plus direction, ordinate	0
	_KB[k,1]	Groove edge in minus direction, ordinate	0
	_KB[k,2]	Groove base in abscissa	0
	Reference groove for calibration of a workpiece probe with cutting edge position **SL=8** (tool type: 5xy)		
	_KB[k,3]	Groove edge in plus direction, abscissa	0
	_KB[k,4]	Groove edge in minus direction, abscissa	0
	_KB[k,5]	Upper edge groove in ordinate	0
	_KB[k,6]	Groove base in ordinate	0
	Note: The values of the grooves are always machine-related and radius dimensions. Both grooves have the same depth.		

Overview of reference groove pairs for calibration (for turning only)

The representation refers to the working plane defined by G18.



For tool measurement with CYCLE971 only

	_CM[ ] Monitoring functions for tool measurement with rotating spindle, only active if _CBIT[12]=0			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Unit: -
Data type REAL				Applies as of SW SW 4.3
Significance:	CYCLE971: _CM[0]…_CM[7] Monitoring functions for tool measurement with rotating spindle, only active if _CBIT[12]=0			Preset default
	_CM[0]	Max. permissible peripheral speed [m/min]/[feet/min]		100 [m/min]
	_CM[1]	Max. permissible speed [rpm]		1000 [RPM]
	_CM[2]	Minimum feedrate for 1st probing operation [mm/min]/[inch/min]		1 [mm/min]
	_CM[3]	Required measuring accuracy [mm]/[inch]		0.005 [mm]
	_CM[4]	Max. permissible feedrate for probing [mm/min]/[inch/min]		20 [mm/min]
	_CM[5]	Direction of spindle rotation		4
	_CM[6]	Feed factor 1		10
	_CM[7]	Feed factor 2		0
	CYCLE982: _CM[8], only active if _CBIT[7]=1 Tolerance parameter for tool measurement with orientational tool carrier - 90° multiples of the tool positions Under some circumstances, the actual angular position of the axes can deviate from the programmed value; it is for this reason that this tolerance variable has been introduced.			
	_CM[8]	Field for tolerance parameter of rotary axis positions:		0.5 degrees

For tool measurement with CYCLE971 only

	_MFS[ ] Feeds and speeds for tool measurement with rotating spindle, only active if _CBIT[12]=1			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Unit: -
Data type REAL				Applies as of SW SW 4.3
Significance:				Preset default
	_MFS[0]	Speed 1st probing		0
	_MFS[1]	Feed 1st probing		0
	_MFS[2]	Speed 2nd probing		0
	_MFS[3]	Feed 2nd probing		0
	_MFS[4]	Speed 3rd probing		0
	_MFS[5]	Feed 3rd probing		0

9.2.4 Central bits

9.2.4.1 In data block GUD6.DEF

	_CBIT[ ] Central bits		
	Min. input limit: 0		Max. input limit: 1
Changes valid after value assignment		Protection level: -	Units: -
Data type BOOLEAN			
Significance:			Preset default
	_CBIT[0]	Measurement repetition after violation of dimensional difference and safe area 0: no measurement repetition 1: measurement repeat, up to 4	0
	_CBIT[1]	Alarm and M0 for measurement repeat with _CBIT[0]=1 0: no alarm, no M0 generated 1: M0 and an alarm are generated before each repeat	0
	_CBIT[2]	M0 for tolerance alarms "oversize", "undersize", "permissible dimensional difference exceeded" 0: no generation of M0 for the above alarms 1: generation of M0 for the above alarms	0
	_CBIT[3]	currently not assigned	0
	_CBIT[4]	currently not assigned	
	_CBIT[5]	Tool measurement and calibration in the WCS in CYCLE982 0: machine-related measurement and calibration 1: workpiece-related measurement and calibration **Note:** In both cases, the _TP[ ] field of the probe is used. A function switchover using _MVAR is available.	0
	_CBIT[6]	Logging without output of the measuring cycle name and measurement variant 0: Measuring cycle name and measuring variant will be output. 1: These outputs will be suppressed.	0
	_CBIT[7]	Support for orientational tool carriers 0: No support for orientational tool carriers 1: Support for probes and/or tools positioned using orientational tool carriers	0
	_CBIT[8]	Offset of mono probe position 0: No offset 1: If the workpiece measuring probe is a mono probe, its position (spindle position) is corrected by the angular value in _CORA.	1
	_CBIT[9]	Assigned internally	0
	_CBIT[10]	currently not assigned	0
	_CBIT[11]	Selection of log header for logging 0: Standard 1: user-defined	0

	_CBIT[ ] Central bits		
	_CBIT[12]	Feed and speed in CYCLE971 0: calculation by measuring cycle itself 1: set by user in array _MFS[ ]	0
	_CBIT[13]	Deletion of values from the measuring cycle arrays in GUD6 0: No deletion 1: delete _TP[ ], _TPW[ ], _WP[ ], _KB[ ], _EV[ ], _MV[ ], _CBIT[13]	0
	_CBIT[14]	Length reference of the workpiece probe in milling measuring cycles 0: length relative to probe ball center 1: length ref. to ball circumference	0
	_CBIT[15]	Transfer of workpiece probe data into the tool offset in CYCLE976 0: No acceptance 1: result of probe ball calculation on **calibration** will be entered in the geometry memory of the workpiece probe (radius)	0
	_CBIT[16]	Calibration monitoring for "Measuring in automatic mode" can be activated/deactivated with this! 0: No calibration monitoring 1: Calibration monitoring active	1

9.2.4.2 Detailed description

Measurement repetition after violation of dimensional difference and safe area

_CBIT[0]=0:	When the parameters for the dimensional difference (_TDIF) and safe area (_TSA) are exceeded, the measurement is not repeated. An appropriate alarm is displayed.
_CBIT[0]=1:	When the parameters for the dimensional difference (_TDIF) and safe area (_TSA) are exceeded, a measurement is repeated. An alarm is also displayed in the repeat measurements if **_CBIT[1]** is set.

Alarm and M0 for measurement repeat with _CBIT[0]=1

_CBIT[1]=0:	no alarm, no measurement repetitions in M0
_CBIT[1]=1:	If the limits of the parameters for the dimensional difference and safe area are exceeded, M0 is generated and the repeat measurement must be started with NC-START. An alarm that does not have to be acknowledged is displayed in the alarm line.

M0 for tolerance alarms "oversize", "undersize", or "permissible dimensional difference exceeded"

_CBIT[2]=0:	When the alarms "oversize", "undersize", or "permissible dimensional difference exceeded" occur, no M0 is generated.
_CBIT[2]=1:	M0 is generated when these alarms occur.

Tool measurement and calibration in the WCS in CYCLE982

_CBIT[5]=0:	The tool is measured and the tool measuring probe is calibrated in the machine coordinate system. The tool probe data are stored in the _TP[ ] field.
_CBIT[5]=1:	The tool can be measured and the tool probe calibrated in the active WCS. In this case, when calibrating and measuring, the same prerequisites must exist regarding the actual WCS. This means that tools with active transformation can also be measured, e.g. TRAANG. Notice: When calibrating and measuring, the _TP[ ] field is also used here.

Note

A function switchover using _MVAR is available. A separate tool probe array is used there, the _TPW[ ] field, for calibration/measurement in the WCS.

Logging without output of the measuring cycle name and measurement variant

_CBIT[6]=0:	When logging, the measuring cycle name and the measuring variant are written into the log.
_CBIT[6]=1:	When logging, the measuring cycle name and the measuring variant are not output into the log.

Support for turning machines with orientational tool carriers

_CBIT[7]=0:	No support for orientational tool carriers.
_CBIT[7]=1:	Support for a probe or tool positioned using orientational tool carrier (kinematics type "T"), with reference to the special carrier positions 0°, 90°, 180° and 270°.

Offset for mono probe setting

_CBIT[8]=0:	No compensation
_CBIT[8]=1:	If the workpiece measuring probe is a mono probe, its position (spindle position) is corrected by the angular value in _CORA.

Selection of log header for logging

_CBIT[11]=0:	The standard log header is used.
_CBIT[11]=1:	A user-defined log header is used.

Feed and speed in CYCLE971

_CBIT[12]=0:	When measuring milling tools with the spindle rotating, the measuring cycle calculates the feed and speed.
_CBIT[12]=1:	The user enters the feed and speed in data field (data array) _MFS[ ].

Deletion of values from the measuring cycle arrays in GUD6

_CBIT[13]=0:	No deletion
_CBIT[13]=1:	For the following measuring cycle call, the data fields (data arrays) _TP[ ], _TPW[ ], _WP[ ], _KB[ ], _EV[ ], _MV[ ] and _CBIT[13] are set to zero.

Length reference of the workpiece probe in milling measuring cycles

_CBIT[14]=0:	The length 1 of the measuring probe referred to the center of the probe sphere (ball) should be entered into the tool offset..
_CBIT[14]=1:	The length 1 of the measuring probe referred to the circumference of the probe sphere (ball) should be entered into the tool offset..

Transfer of workpiece probe data into the tool offset in CYCLE976

_CBIT[15]=0:	No transfer
_CBIT[15]=1:	When using the "Calibrate with probe sphere calculation" measurement variant, the determined "effective probe sphere diameter" (_WP[k,0]) converted as a radius value, is entered into the radius geometry memory of the active workpiece measuring probe as the tool offset.

Activate calibration monitoring during "Measuring in automatic mode"

_CBIT[16]=0:	No calibration monitoring
_CBIT[16]=1:	Calibration monitoring active The monitoring checks whether the calibration plane, mono/multi probe calibration or calibration at the probe center point/probe end point between calibrating and measuring is identical. Note: When measuring cycles are called up from "Measuring in JOG" or "ShopMill", these monitoring checks are always active and cannot be deactivated.

9.2.5 Channel-oriented values

Data block GUD5.DEF

	_EV[ ] Empirical values			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type:REAL				
Significance:	Index "k" stands for the number of the current array -1			Preset default
	_EV[k]	Number of empirical values		0

	_MV[ ] Mean values			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type:REAL				
Significance:	Index “k” stands for the number of the current array			Preset default
	_MV[k]	Number of empirical values		0

Data block GUD6.DEF

	_EVMVNUM[ ] Number of empirical values and mean values			
		Min. input limit: 0		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type:INTEGER				
Significance:				Preset default
	_EVMVNUM[0]	Number of empirical values		20
	_EVMVNUM[1]	Number of mean values		20

	_ SPEED[ ] Traversing velocities for intermediate positioning		
	Min. input limit: 0		Max. input limit: -
Changes valid after value assignment		Protection level: -	Units: -
Data type:REAL			
Significance:			Preset default
	_SPEED[0]	Interim positioning in measuring cycle with rapid traverse velocity as % during inactive collision monitoring (values between 1 and 100)	50 %
	_SPEED[1]	Interim positioning in measuring cycle in the plane with collision monitoring active	1000 [mm/min]
	_SPEED[2]	Interim positioning in measuring cycle with positioning in the feed axis with collision monitoring active	1000 [mm/min]
	_SPEED[3]	Fast measuring feed	900 [mm/min]
	Note: If necessary, adjust values to the probe and machine used. Values that are too high can result in probe damage!		

Explanations relating to SPEED[ ]

Traverse velocities for intermediate positioning _SPEED[0] to [2]

Intermediate positions before the actual measuring block are calculated in the measuring cycles. This positions can

- be approached **with collision monitoring** (_CHBIT[2]=1, default)

  or

- **without collision monitoring** (_CHBIT[2]=0).

The appropriate velocities are used for approach as specified in these settings:

- **With collision monitoring (_CHBIT[2]=1):**

  With **_SPEED[1]** the feedrate is applied to traversing in the plane and with _SPEED[2] to traversing in the infeed axis (applicate).

  If the probe switches while approaching these intermediate positions, the movement is interrupted and the alarm "probe collision" is issued.

- **Without collision monitoring (_CHBIT[2]=0):**

  The intermediate positions are approached with the **percentage maximum axis velocity** (rapid traverse) specified in **_SPEED[0]**. With _SPEED[0]=0 and _SPEED[0]=100 the maximum axis velocity applies.

CAUTION
The user must ensure that collisions are ruled out.

Measuring feed _VMS, fast measuring feed _SPEED[3]

Measurement is performed with the measuring feed of _VMS.

- If _VMS=0 and _FA=1: 150 mm/min
- If _VMS=0 and _FA>1: 300 mm/min

If **_CHBIT[17]=1** and **_FA>1** probing is performed twice. The **fast measuring feed _SPEED[3]** is used for the first probing. After the probe has switched, it is retracted by 2 mm. This is followed by actual measurement with the feedrate programmed in _VMS.

Measurement retraction velocity

Retraction from the measuring point is usually performed with the same speed (_SPEED[1], [2]) or percentage of the rapid traverse as approach to the intermediate position (see above).

However, while **collision monitoring** (_CHBIT[2]=1) is active, it is possible with **CHBIT[16]=1** to switch to the percentage of rapid traverse in **_SPEED[0]**.

	_TP_CF Tool probe type (manufacturer)		
		Min. input limit: 0	Max. input limit: 2
Changes valid after value assignment		Protection level: -	Units: -
Data type INTEGER			
Significance:	Applies to tool measurement with rotating spindle (CYCLE971 only)		Preset default
	0	No data	0
	1	TT130 (Heidenhain)	
	2	TS27R (Renishaw)	

	_MT_COMP Measurement result offset for tool measurement with rotating spindle (CYCLE971 only)		
		Min. input limit: 0	Max. input limit: 2
Changes valid after value assignment		Protection level: -	Units: -
Data type INTEGER			
Significance:			Preset default
	0	No compensation	0
	1	cycle-internal offset (only active if _TP_CF<>0)	
	2	offset via user-defined offset table	

	_MT_EC_R[6,5] Offset table for measurement result offset for tool radius measurement with rotating spindle (CYCLE971 only)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: mm
Data type:REAL				
Significance:	Measurement result offset for tool measurement with rotating spindle (CYCLE971 only)			Preset default
	_MT_EC_R[0,1]..._MT_EC_R[0,4] 4 tool radii from small to large are specified			
	_MT_EC_R[1,0]..._MT_EC_R[5,0] 5 peripheral velocities from low to high are specified			
	_MT_EC_R[i,k] where i=1...5, k=1...4			20 offset values
	When _MT_COMP=2, actual radius = measured radius - _MT_EC_R[i,k] when i=1...5 next lowest table value for circumference speed and K=1...4 next lowest table value for tool radius			

	_MT_ EC_L[6,5] Offset table for measurement result offset for tool length measurement with rotating spindle (CYCLE971 only)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: mm
Data type:REAL				
Significance:	Measurement result offset for tool measurement with rotating spindle (CYCLE971 only)			Preset default
	_MT_EC_L[0,1]..._MT_EC_L[0,4] 4 tool lengths from small to large are specified			
	_MT_EC_L[1,0]..._MT_EC_L[5,0] 5 peripheral velocities from low to high are specified			
	_MT_EC_L[i,k] where i=1...5, k=1...4			20 offset values
	When _MT_COMP=2, actual length = measured length - _MT_EC_R[i,k] when i=1...5 next lowest table value for circumference speed and K=1...4 next lowest table value for tool radius			

9.2.6 Channel-oriented bits

9.2.6.1 In data block GUD6.DEF

	_CHBIT Channel bits		
		Min. input limit: -	Max. input limit: -
Changes valid after value assignment		Protection level: -	Units: -
Data type BOOLEAN			
Significance:			Preset default
	_CHBIT[0]	Measurement input for workpiece measurement 0: measurement input 1 1: measurement input 2	0
	CHBIT[1]	Measurement input for tool measurement: 0: measurement input 1 1: measurement input 2	1
	_CHBIT[2]	Collision monitoring for intermediate positioning 0: OFF 1: ON	1
	_CHBIT[3]	Tool offset mode with tool measurement 0: first-time measurement (determining geometry) 1: remeasuring (determining wear)	0
	_CHBIT[4]	Mean value for workpiece measurement with automatic tool correction (_EVNUM>0) 0: no mean value derivation over several parts 1: with mean value formation and calculation	0
	_CHBIT[5]	Inclusion of empirical value (_EVNUM>0) 0: subtraction of actual value 1: addition to actual value	0
	_CHBIT[6]	Tool offset mode for workpiece measurement with automatic tool offset 0: Offset in wear 1: offset in geometry, delete wear For additive and setup offset and _CHBIT[8]=0: 0: Offset in additive offset 1: offset in set-up offset, delete additive offset	0
	_CHBIT[7]	Measured value offset in CYCLE994 0: use of trigger values of the probe _WP[k,1] ... 1: use of the active ball diameter of the probe _WP[k,0]	0
	_CHBIT[8]	Offset mode for workpiece measurement with automatic tool offset 0: additive, setup offset according to _CHBIT[6] 1: offset additive in set-up offset, irrespective of _CHBIT[6]	0
	_CHBIT[9]	currently not assigned	0

	_CHBIT Channel bits		
	_CHBIT[10]	Measuring result display 0: OFF 1: ON	0
	_CHBIT[11]	Acknowledgment measurement result screen with NC start 0: OFF (If _CHBIT[18]=0, the display is automatically deselected at end of cycle.) 1: ON (M0 is generated in the cycle.)	0
	_CHBIT[12]	currently not assigned	0
	_CHBIT[13]	Coupling spindle position with coordinate rotation in active plane for workpiece measurement with multi probe 0: OFF 1: ON	0
	_CHBIT[14]	Adapt spindle positioning, if _CHBIT[13]=1 0: Following standard 1: adapted angle values	0
	_CHBIT[15]	Number of measurements on failure to switch 0: up to 5 measurements 1: only 1 measurement	0
	_CHBIT[16]	Retraction velocity from the measuring point 0: velocity as for intermediate positioning 1: with percentage of rapid traverse velocity (_SPEED[0]) (only active with collision monitoring ON: _CHBIT[2]=1)	0
	_CHBIT[17]	Feed during measurement 0: with feed in _VMS 1: During 1st measurement feed in _SPEED[3] During 2nd measurement with feed in _VMS	0
	_CHBIT[18]	Static measurement result display 0: effect as set in _CHBIT[11] 1: only active if _CHBIT[11]=0: Measuring result display remains until next measuring cycle is called	0
	_CHBIT[19]	**Only active for CYCLE974 or CYCLE994!** Special treatment of Y axis with G18 0: No special treatment 1: setpoint setting and parameterization (_SETVAL, _TUL, _TLL, SZO) for the Y axis (applicate) as for the parameterization of the ordinate (X axis). The tool offset is applied in the length that is active in the ordinate (X axis) (usually L1), as long as no other length has been set in _KNUM. The ZO compensation is applied in the specified ZO memory in the ordinate component (X axis).	0
	_CHBIT[20]	**Only active for CYCLE982!** Measuring milling tools Suppression of the starting angle positioning _STA1 0: suppression OFF 1: suppression ON	0

	_CHBIT Channel bits		
	_CHBIT[21]	**Only active for CYCLE974, CYCLE977, CYCLE978, CYCLE979, CYCLE997!** ZO compensation mode 0: offset additive in FINE 1: offset in COARSE, delete FINE	0
	_CHBIT[22]	**Only active for CYCLE971!** with rotating spindle and multiple measurement with rotating spindle and multiple measurement 0: last measurement with reduced speed at _CBIT[12] = 0 1: no speed reduction	0
	_CHBIT[23]	**Only active for CYCLE982!** Recoding of tool point direction during tool measurement 0: No recoding 1: internal recoding (tool point direction mirroring about X)	0

9.2.6.2 Detailed description

Measurement input for workpiece measurement

_CHBIT[0]=0:	Meas. input 1 is used for workpc. measurement.
_CHBIT[0]=1:	Meas. input 2 is used for workpc. measurement.

Measurement input for tool measurement:

_CHBIT[1]=0:	Meas. input 1 is used for tool measurement.
_CHBIT[1]=1:	Meas. input 2 is used for tool measurement.

Collision monitoring for intermediate positioning

_CHBIT[2]=0:	OFF
_CHBIT[2]=1:	ON Intermediate positions that are calculated and approached by the measuring cycles are interrupted as soon as the measuring probe supplies a switching signal. When aborted/interrupted (collision), an alarm message is generated.

Tool offset mode with tool measurement

_CHBIT[3]=0:	First-time measurement The determined tool data (length and radius) are written into the geometry data of the tool. The wear is deleted.
_CHBIT[3]=1:	Remeasurement The difference that is determined is entered into the appropriate wear data of the tool. The geometry data remains unchanged.

Mean value for workpiece measurement with automatic tool correction (_EVNUM >0)

_CHBIT[4]=0:	no mean value derivation over several parts For the formula used to calculate the mean value, 0 is used as the old mean value. The calculated mean value is not saved.
_CHBIT[4]=1:	When calculating the mean value, the value from the mean value memory _MV[ ] programmed using _EVNUM, is used for the calculation and then the new mean value is saved in this mean value memory.

Inclusion of empirical value (_EVNUM >0)

_CHBIT[5]=0:	The empirical value _EV[ ] is subtracted from the measured actual value.
_CHBIT[5]=1:	The empirical value _EV[ ] is added to the measured actual value.

Tool offset mode for workpiece measurement with automatic tool offset

_CHBIT[6]=0:	The determined offset value is added in the **wear** memory (length and radius) of the specified tool and is incorporated in the D number specified using _KNUM .
_CHBIT[6]=1:	The length and the radius of the specified tool is corrected by the determined offset value and entered into the appropriate **geometry** memory. The corresponding wear memory is calculated and then set to zero.

An offset in the set-up/additive offset can also be programmed, if these are set up. The type of calculation is also defined by **_CHBIT[6]** and also **_CHBIT[8]**:

_CHBIT[6] = 0: _CHBIT[8] = 0:	The offset value calculated is included (added) in the corresponding total offset value memory.
_CHBIT[6] = 1: _CHBIT[8] = 0:	The offset value calculated is included in the set-up offset memory taking the corresponding total offset value memory into account and the total offset memory is deleted.
_CHBIT[8]=1:	Independent of _CHBIT[6], the determined offset value is additively incorporated into the appropriate setting-up offset memory.

Measured value offset in CYCLE994

_CHBIT[7]=0:	In order to determine the actual value, the **trigger values** of the measuring probe, saved in the _WP[_PRNUM-1,1...4) are used.
_CHBIT[7]=1:	In order to determine the actual value, the effective **diameter** of the measuring probe, saved in the _WP[_PRNUM-1,0] is used.

Offset mode for workpiece measurement with automatic tool offset

_CHBIT[8]=0:	Explanation --> see _CHBIT[6]
_CHBIT[8]=1:	Explanation --> see _CHBIT[6]

Measuring result display

_CHBIT[10]=0:	OFF
_CHBIT[10]=1:	ON After measuring or calibrating, a measurement result screen is automatically displayed.

Acknowledgment measurement result screen with NC start

_CHBIT[11]=0:	The measurement result screen is automatically de-selected at the end of the cycle. Also _CHBIT[18] must be =0, otherwise the effect as described for **_CHBIT[18]=**1 is obtained.
_CHBIT[11]=1:	After the measurement result screen is displayed, the cycle generates M0. The measurement cycle is continued and the screen is de-selected after the NC start.

Static measurement result display

_CHBIT[18]=0:	Effect is defined by **_CHBIT[11]**.
_CHBIT[18]=1:	The measurement result screen display is kept until the next measuring cycle is called. NC program processing is not interrupted. **_CHBIT[10]** must be set, _CHBIT[11] must be 0!

Coupling spindle position with coordinate rotation in active plane for workpiece measurement with multi probe

_CHBIT[13]=0:	OFF There is no coupling between the spindle position and active coordinate rotation in the plane.
_CHBIT[13]=1:	ON When multi-probes are being used, the spindle is positioned depending on the active coordinate rotation in the plane (rotation around the applicate (feed axis)) so that the same positions of the probe sphere are probed when calibrating and measuring. Note: Pay attention to _CHBIT[14]!

NOTICE

If additional rotations are active in the other planes/axes, then this function is not effective!

The coupling between the coordinate rotation and spindle position is generally not executed:

- Rotations around abscissa or ordinates between calibrating and measuring are not identical
- There is no position-controlled machining spindle
- Monoprobes are used (_PRNUM = x1xx)

Adapt spindle positioning, if _CHBIT[13]=1

_CHBIT[14]=0:	Spindle positioning is undertaken acc. to the default. Angle of coordinate rotation in the plane 0°: Spindle positioning 0° Angle of coordinate rotation in the plane 90°: Spindle positioning 270°
_CHBIT[14]=1:	Spindle positioning is undertaken in reverse. Angle of coordinate rotation in the plane 0°: Spindle positioning 0° Angle of coordinate rotation in the plane 90°: Spindle positioning 90°

Note

A coordinate rotation in the active plane is:

- one rotation around the Z axis with G17,
- one rotation around the Y axis with G18 or
- one rotation around the X axis with G19.

Number of measurements on failure to switch

_CHBIT[15]=0:	A max. of 5 measuring attempts are undertaken before the fault "measuring sensor does not switch" is generated.
_CHBIT[15]=1:	After **one** unsuccessful measurement attempt, the fault "measuring sensor does not switch" is generated.

Retraction velocity from the measuring point

_CHBIT[16]=0:	The retraction from the measuring point is realized with the same velocity as for an intermediate positioning operation.
_CHBIT[16]=1:	The retraction velocity is realized with the percentage rapid traverse velocity, defined in SPEED[0] and is only effective when collision monitoring is active (_CHBIT[2]=1).

Feed during measurement

_CHBIT[17]=0:	Measurement is performed with the feed programmed in _VMS. Note peculiarities with _VMS=0!
_CHBIT[17]=1:	Initially, the axis traverses with the measuring feed _SPEED[3], after switching, there is a retraction of 2 mm from the measuring position and the actual measurement starts with the feed from _VMS. Measurement with the feed from _SPEED[3] is only realized for a measurement distance/travel > 2 mm

Static measurement result display

_CHBIT[18]=0:	For explanation, see _CHBIT[10], _CHBIT[11]
_CHBIT[18]=1:	For explanation, see _CHBIT[10], _CHBIT[11]

Special treatment of Y axis with G18in CYCLE974 or CYCLE994

_CHBIT[19]=0:	No special treatment for Y axis (applicate)
_CHBIT[19]=1:	setpoint setting and parameterization (SETVAL, _TUL, _TLL, SZO) for the Y axis (applicate) as for the parameterization of the ordinate (X axis). The tool offset is applied to the length that is active in the ordinate (X axis) (usually L1), as long as other lengths are not specified by _KNUM. The ZO compensation is applied in the specified ZO memory in the ordinate component (X axis).

Suppression of the starting angle positioning _STA1 in CYCLE982

_CHBIT[20]=0:	For certain measuring variants, the milling spindle is positioned with _STA1.
_CHBIT[20]=1:	When measuring milling tools, for basic measuring variants, it is possible to suppress positioning of the milling spindle to the value of the starting angle _STA1. This is possible for the following measuring variants to measure milling tools: _MVAR=xxx001 (with x: 0 or 1, no other values)

ZO compensation mode in CYCLE974, CYCLE977, CYCLE978, CYCLE979, CYCLE997

_CHBIT[21]=0:	The offset is applied additively in FINE, if MD 18600: MM_FRAME_FINE_TRANS=1, otherwise in COARSE.
_CHBIT[21]=1:	The offset is applied in COARSE. FINE is taken into account and is then subsequently deleted.

Speed reduction in tool measurement in CYCLE971

_CHBIT[22]=0:	When measuring tools with rotating spindle and when the speed (_CBIT[12]=0) is calculated in the cycle, for multiple measurements, the last measurement is carried out at a reduced speed.
_CHBIT[22]=1:	For multiple measurements with the spindle rotating and calculation in the cycle, the speed remains constant.

Recoding of tool point direction during tool measurement in CYCLE982

_CHBIT[23]=0:	Standard setting, no recoding
_CHBIT[23]=1:	Internal recoding, tool point direction mirroring about X axis (tool revolver -180 degrees, Z not mirrored)

9.3 Data for measuring in JOG

For descriptions of the data for measuring in JOG for the measuring cycle runs for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

10 Start-up (hardware)

For descriptions of the commissioning of measuring cycles for HMI as of software version 2.6, see:

References:
Commissioning Manual SINUMERIK 840d HMI sl base software and HMI sl;

Book HMI sl (IM9)

Chapter on measuring cycles

11 Alarm, error, and system messages

11.1 General notes

If faulty states are detected in the measuring cycles, an alarm is generated and execution of the measuring cycle is aborted.

In addition, the measuring cycles issue messages in the dialog line of the PLC. These message will not interrupt the program execution.

11.2 Error rectification in the measuring cycles

Alarms with numbers between 61000 and 62999 are generated in the measuring cycles. This range of numbers, in turn, is divided again with regard to alarm responses and cancel criteria.

The error text that is displayed together with the alarm number gives you more detailed information on the error cause.

Alarm number	Clearing criterion	Alarm Response
61000 ... 61999	NC_RESET	Block preparation in the NC is aborted
62000 ... 62999	Clear key	Program execution is not interrupted; display only.

11.3 Overview of measuring cycle alarms

The measuring cycle alarms are listed below:

References: /DA/ Diagnostics Manual

Appendix A

A.1 Comparison of GUD parameters up to measuring cycles version 7.5 and GUD parameters as of measuring cycles version 2.6, with reference to measuring function.

You can make specific machine and setting data for each item of cycle data, machine data or setting data.

The following prefixes are defined:

- §SNS_... Generally applicable setting data
- §SCS_... Channel-specific setting data
- §MNS_... Generally applicable machine data
- $MCS_... Channel-specific machine data

The GUD parameters contained in the following tables show the contents of the GUD modules GUD5, GUD6 and GUD7_MC, and are available in appendices A1, A2 and A3 as displayed here. The modules GUD5, GUD6 and GUD7_MC no longer exist.

GUD up to Version 7.5	MD/SD as of Version 2.6
_TP[x,0]	SD54625 $SNS_MEA_TP_TRIG_MINUS_DIR_AX1[x]
_TP[x,1]	SD54626 $SNS_MEA_TP_TRIG_PLUS_DIR_AX1[x]
_TP[x,2]	SD54627 $SNS_MEA_TP_TRIG_MINUS_DIR_AX2[x]
_TP[x,3]	SD54628 $SNS_MEA_TP_TRIG_PLUS_DIR_AX2[x]
_TP[x,4]	SD54629 $SNS_MEA_TP_TRIG_MINUS_DIR_AX3[x]
_TP[x,5]	SD54630 $SNS_MEA_TP_TRIG_PLUS_DIR_AX3[x]
_TP[x,6]	SD54631 $SNS_MEA_TP_EDGE_DISK_SIZE[x]
_TP[x,7]	SD54632 $SNS_MEA_TP_AX_DIR_AUTO_CAL[x]
_TP[x,8]	SD54633 $SNS_MEA_TP_TYPE[x]
_TP[x,9]	SD54634 $SNS_MEA_TP_CAL_MEASURE_DEPTH[x]
_WP[x,0]	SD54600 $SNS_MEA_WP_BALL_DIAM[x]
_WP[x,1]	SD54601 $SNS_MEA_WP_TRIG_MINUS_DIR_AX1[x]
_WP[x,2]	SD54602 $SNS_MEA_WP_TRIG_PLUS_DIR_AX1[x]
_WP[x,3]	SD54603 $SNS_MEA_WP_TRIG_MINUS_DIR_AX2[x]
_WP[x,4]	SD54604 $SNS_MEA_WP_TRIG_PLUS_DIR_AX2[x]
_WP[x,5]	SD54605 $SNS_MEA_WP_TRIG_MINUS_DIR_AX3[x]
_WP[x,6]	SD54606 $SNS_MEA_WP_TRIG_PLUS_DIR_AX3[x]
_WP[x,7]	SD54607 $SNS_MEA_WP_POS_DEV_AX1[x]
_WP[x,8]	SD54608 $SNS_MEA_WP_POS_DEV_AX2[x]
_WP[x,9]	SD54609 $SNS_MEA_WP_STATUS_RT[x]
_WP[x,10]	SD54610 $SNS_MEA_WP_STATUS_GEN[x]

GUD up to Version 7.5	MD/SD as of Version 2.6
_KB[x,0]	SD54621 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX2[x]
_KB[x,1]	SD54622 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX2[x]
_KB[x,2]	SD54615 $SNS_MEA_CAL_EDGE_BASE_AX1[x]
_KB[x,3]	SD54617 $SNS_MEA_CAL_EDGE_PLUS_DIR_AX1[x]
_KB[x,4]	SD54618 $SNS_MEA_CAL_EDGE_MINUS_DIR_AX1[x]
_KB[x,5]	SD54620 $SNS_MEA_CAL_EDGE_UPPER_AX2[x]
_KB[x,6]	SD54619 $SNS_MEA_CAL_EDGE_BASE_AX2[x]
_TPW[x,1]	SD54641 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX1[x]
_TPW[x,2]	SD54642 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX2[x]
_TPW[x,3]	SD54643 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX2[x]
_TPW[x,4]	SD54644 $SNS_MEA_TPW_TRIG_MINUS_DIR_AX3[x]
_TPW[x,5]	SD54645 $SNS_MEA_TPW_TRIG_PLUS_DIR_AX3[x]
_TPW[x,6]	SD54646 $SNS_MEA_TPW_EDGE_DISK_SIZE[x]
_TPW[x,7]	SD54647 $SNS_MEA_TPW_AX_DIR_AUTO_CAL[x]
_TPW[x,8]	SD54648 $SNS_MEA_TPW_TYPE[x]
_TWP[x,9]	SD54649 $SNS_MEA_TPW_CAL_MEASURE_DEPTH[x]
_CM[0]	SD54670 $SNS_MEA_CM_MAX_PERI_SPEED[0]
_CM[1]	SD54671 $SNS_MEA_CM_MAX_REVOLUTIONS[0]
_CM[4]	SD54672 $SNS_MEA_CM_MAX_FEEDRATE[0]
_CM[2]	SD54673 $SNS_MEA_CM_MIN_FEEDRATE[0]
_CM[5]]	SD54674 $SNS_MEA_CM_SPIND_ROT_DIR[0
_CM[6]	SD54675 $SNS_MEA_CM_FEEDFACTOR_1[0]
_CM[7]	SD54676 $SNS_MEA_CM_FEEDFACTOR_2[0]
_CM[3]	SD54677 $SNS_MEA_CM_MEASURING_ACCURACY[0]
_CM[8]	MD51618 $MNS_MEA_CM_ROT_AX_POS_TOL[0]
_CBIT[0]SD54655	$SNS_MEA_REPEAT_ACTIVE
_CBIT[1]	SD54656 $SNS_MEA_REPEAT_WITH_M0
_CBIT[2]	SD54657 $SNS_MEA_TOL_ALARM_SET_M0
_CBIT[3]	No function is assigned to this GUD.
_CBIT[4]	No function is assigned to this GUD.
_CBIT[5]	SD54659 $SNS_MEA_TOOL_MEASURE_RELATE
_CBIT[6]	No function is assigned to this GUD.
_CBIT[7]	MD51610 $MNS_MEA_TOOLCARR_ENABLE
_CBIT[8]	MD51612 $MNS_MEA_MONO_COR_POS_ACTIVE
_CBIT[9]	No function is assigned to this GUD.
_CBIT[10]	No function is assigned to this GUD.
_CBIT[11]	No function is assigned to this GUD.

GUD up to Version 7.5	MD/SD as of Version 2.6
_CBIT[12]	Can be used but is not a new MD/SD!
_CBIT[13]	No function is assigned to this GUD.
_CBIT[14]	MD51614 $MNS_MEA_PROBE_LENGTH_RELATE
_CBIT[15]	SD54660 $SNS_MEA_PROBE_BALL_RAD_IN_TOA
_CBIT[16]	MD51616 $MNS_MEA_CAL_MONITORING
_CHBIT[0]	MD51606 $MNS_MEA_INPUT_PIECE_PROBE[0]
_CHBIT[1]	MD51607 $MNS_MEA_INPUT_TOOL_PROBE[0]
_CHBIT[2]	SD55600 $SCS_MEA_COLLISION_MONITORING
_CHBIT[3]	Can be used but is not a new MD/SD!
_CHBIT[4]	Can be used but is not a new MD/SD!
_CHBIT[5]	Can be used but is not a new MD/SD!
_CHBIT[6]	Can be used but is not a new MD/SD!
_CHBIT[7]	Can be used but is not a new MD/SD!
_CHBIT[8]	Can be used but is not a new MD/SD!
_CHBIT[9]	No function is assigned to this GUD.
_CHBIT[10]	SD $SCS_MEA_RESULT_DISPLAY
_CHBIT[11]	Can be used but is not a new MD/SD!
_CHBIT[12]	No function is assigned to this GUD.
_CHBIT[13]	SD55602 $SCS_MEA_COUPL_SPIND_COORD
_CHBIT[14]	SD55604 $SCS_MEA_SPIND_MOVE_DIR
_CHBIT[15]	SD55606 $SCS_MEA_NUM_OF_MEASURE
_CHBIT[16]	SD55608 $SCS_MEA_RETRACTION_FEED
_CHBIT[17]	SD55610 $SCS_MEA_FEED_TYP
_CHBIT[18]	Can be used but is not a new MD/SD!
_CHBIT[19]	MD52605 $MCS_MEA_TURN_CYC_SPECIAL_MODE
_CHBIT[20]	Can be used but is not a new MD/SD!
_CHBIT[21]	Can be used but is not a new MD/SD!
_CHBIT[22]	Can be used but is not a new MD/SD!
_CHBIT[23]	Can be used but is not a new MD/SD!
_CHBIT[24]	No function is assigned to this GUD.
_EVMVNUM[0]	SD55622 $SCS_MEA_EMPIRIC_VALUE
_EVMVNUM[1]	SD55624 $SCS_MEA_AVERAGE_VALUE
_EV[n]	SD55623 $SCS_MEA_EMPIRIC_VALUE[n]
_MV[n	SD55625 $SCS_MEA_AVERAGE_VALUE[n]
_SPEED[0]	SD55630 $SCS_MEA_FEED_RAPID_IN_PERCENT
_SPEED[1]	SD55631 $SCS_MEA_FEED_PLANE_VALUE
_SPEED[2]	SD55632 $SCS_MEA_FEED_FEEDAX_VALUE
_SPEED[3]	SD55633 $SCS_MEA_FEED_FAST_MEASURE

GUD up to Version 7.5	MD/SD as of Version 2.6
_TP_CF	SD54690 $SNS_MEA_T_PROBE_MANUFACTURER
_MT_COMP	SD54691 $SNS_MEA_T_PROBE_OFFSET
_MT_EC_R[1.5]	SD54695 $SNS_MEA_RESULT_OFFSET_TAB_RAD1[0...4]
_MT_EC_R[2.5]	SD54696 $SNS_MEA_RESULT_OFFSET_TAB_RAD2[0...4]
_MT_EC_R[3.5]	SD54697 $SNS_MEA_RESULT_OFFSET_TAB_RAD3[0...4]
_MT_EC_R[4.5]	SD54698 $SNS_MEA_RESULT_OFFSET_TAB_RAD4[0...4]
_MT_EC_R[5.5]	SD54699 $SNS_MEA_RESULT_OFFSET_TAB_RAD5[0...4]
_MT_EC_R[6.5]	SD54700 $SNS_MEA_RESULT_OFFSET_TAB_RAD6[0...4]
_MT_EC_L[1.5]	SD54705 $SNS_MEA_RESULT_OFFSET_TAB_LEN1[0...4]
_MT_EC_L[2.5]	SD54706 $SNS_MEA_RESULT_OFFSET_TAB_ LEN2[0...4]
_MT_EC_L[3.5]	SD54707 $SNS_MEA_RESULT_OFFSET_TAB_ LEN3[0...4]
_MT_EC_L[4.5]	SD54708 $SNS_MEA_RESULT_OFFSET_TAB_ LEN4[0...4]
_MT_EC_L[5.5]	SD54709 $SNS_MEA_RESULT_OFFSET_TAB_ LEN5[0...4]
_MT_EC_L[6.5]	SD54710 $SNS_MEA_RESULT_OFFSET_TAB_ LEN6[0...4]
_MFS[0 ... 5]	Can be used but is not a new MD/SD!
_MZ_MASK[0 ... 7]	Can be used but is not a new MD/SD!
_MVAR	Can be used but is not a new MD/SD!
_MA	Can be used but is not a new MD/SD!
_SETVA	Can be used but is not a new MD/SD!
_SETV[0 ... 9]	Can be used but is not a new MD/SD!
_ID	Can be used but is not a new MD/SD!
_TNUM	Can be used but is not a new MD/SD!
_TNAME	Can be used but is not a new MD/SD!
_TUL	Can be used but is not a new MD/SD!
_TLL	Can be used but is not a new MD/SD!
_KNUM	Can be used but is not a new MD/SD!
_RA	Can be used but is not a new MD/SD!
_MD	Can be used but is not a new MD/SD!
_SZA	Can be used but is not a new MD/SD!
_SZO	Can be used but is not a new MD/SD!
_CPA	Can be used but is not a new MD/SD!
_CPO	Can be used but is not a new MD/SD!
_STA1	Can be used but is not a new MD/SD!
_INCA	Can be used but is not a new MD/SD!
_RF	Can be used but is not a new MD/SD!
_CORA	Can be used but is not a new MD/SD!
_VMS	Can be used but is not a new MD/SD!
_FA	Can be used but is not a new MD/SD!

GUD up to Version 7.5	MD/SD as of Version 2.6
_NMSP	Can be used but is not a new MD/SD!
_PRNUM	Can be used but is not a new MD/SD!
_EVNUM	Can be used but is not a new MD/SD!
_TZL	Can be used but is not a new MD/SD!
_TMV	Can be used but is not a new MD/SD!
_TDIF	Can be used but is not a new MD/SD!
_TSA	Can be used but is not a new MD/SD!
_K	Can be used but is not a new MD/SD!
_CALNUM	Can be used but is not a new MD/SD!

See also

General information (Page 91)

Overview of the auxiliary programs required (Page 261)

General information (Page 378)

Overview of measuring cycle parameters (Page 421)

A.2 GUD variables that can no longer be used

The following GUD variables can generally no longer be programmed as of measuring cycles version 2.6! If machine or setting data is assigned to a GUD variable, only this data should be used!

GUD up to Version 7.5	MD/SD as of Version 2.6
_CVAL[0]	
_CVAL[1]	
_CVAL[2]	
_CVAL[3]	
_PROTNAME	
_HEADLINE	
_PROTFORM	
_PROTSYM	
_PROTVAL	
_PMI	
_SP_B	
_TXT	
_DIGIT	
_SI[n]	
_SM_R[n]	
_SM_I[n]	
_SM_B[n]	
_SH_I[n]	
_SH_B[n]	
_JM_I[n]	
_M_TNIC	
_JM_B[0]	
_JM_B[1]	SD55761 $SCS_J_MEA_SET_NUM_OF_ATTEMPTS
_JM_B[2]	SD55762 $SCS_J_MEA_SET_RETRAC_MODE
_JM_B[3]	SD55763 $SCS_J_MEA_SET_FEED_MODE
_JM_B[4]	
_JM_B[5]	
_JM_B[6]	
_SMI_I[2]	SD54691 $SNS_MEA_T_PROBE_OFFSET
_SMI_I[3]	SD54690 $SNS_MEA_T_PROBE_MANUFACTURER
E_MESS_IS_METRIC	
E_MESS_IS_METRIC_SPEZ_VAR	

GUD up to Version 7.5	MD/SD as of Version 2.6
E_MESS_MS_IN	MD51606 $MNS_MEA_INPUT_PIECE_PROBE[0]
E_MESS_MT_IN	MD51607 $MNS_MEA_INPUT_TOOL_PROBE[0]
E_MESS_D	MD51750 $MNS_J_MEA_M_DIST
E_MESS_D_M	MD51751 $MNS_J_MEA_M_DIST_MANUELL
E_MESS_D_L	MD51752 $MNS_J_MEA_M_DIST_TOOL_LENGTH
E_MESS_D_R	MD51753 $MNS_J_MEA_M_DIST_TOOL_RADIUS
E_MESS_FM	MD51755 $MNS_J_MEA_MEASURING_FEED
E_MESS_F	MD51757 $MNS_J_MEA_COLL_MONIT_FEED
E_MESS_FZ	MD51758 $MNS_J_MEA_COLL_MONIT_POS_FEED
E_MESS_CAL_D[3]	MD51770 $MNS_J_MEA_CAL_RING_DIAM
E_MESS_CAL_L[3]	MD51772 $MNS_J_MEA_CAL_HEIGHT_FEEDAX
E_MESS_MT_TYP[3]	MD51774 $MNS_J_MEA_T_PROBE_TYPE
E_MESS_MT_AX[3]	MD51776 $MNS_J_MEA_T_PROBE_ALLOW_AX_DIR
E_MESS_MT_DL[3]	MD51778 $MNS_J_MEA_T_PROBE_DIAM_LENGTH
E_MESS_MT_DR[3]	MD51780 $MNS_J_MEA_T_PROBE_DIAM_RAD
E_MESS_MT_DZ[3]	MD51782 $MNS_J_MEA_T_PROBE_T_EDGE_DIST
E_MESS_MT_DIR[3]	MD51784 $MNS_J_MEA_T_PROBE_T_EDGE_DIST
E_MESS_MT_D	MD51786 $MNS_J_MEA_T_PROBE_MEASURE_DIST
E_MESS_MT_FM	MD51787 $MNS_J_MEA_T_PROBE_MEASURE_FEED
E_MESS_MT_CF	SD54690 $SNS_MEA_T_PROBE_MANUFACTURER
E_MESS_MT_COMP	SD54691 $SNS_MEA_T_PROBE_OFFSET
E_MESS_SETT[0]	SD55770 $SCS_J_MEA_SET_COUPL_SP_COORD
E_MESS_SETT[1]	SD55771 $SCS_J_MEA_SET_CAL_MODE
E_MESS_MS_SOUTH	MD51614 $MNS_MEA_PROBE_LENGTH_RELATE
E_MESS_MS_MONO	SD55772 $SCS_J_MEA_SET_CAL_MODE
_MC_SIMSIM	SD55618 $SCS_MEA_SIM_ENABLE
_MC_SIMDIFF	SD55619 $SCS_MEA_SIM_MEASURE_DIFF

See also

General information (Page 91)
Overview of the auxiliary programs required (Page 261)
General information (Page 378)
Overview of measuring cycle parameters (Page 421)

A.3 Changes to names of cycle programs and GUD modules

The following measuring programs have been renamed or deleted from measuring cycle version 2.6:

Cycle Name of GUD up to Version 7.5	Cycle Name as of Version 2.6
CYC_JMC	Cycle131
CYC_JMA	Cycle132
Cycle198	CUST_MEACYC
Cycle199	CUST_MEACYC
Cycle100	Program is no longer available.
Cycle101	Program is no longer available.
Cycle105	Program is no longer available.
Cycle106	Program is no longer available.
Cycle107	Program is no longer available.
Cycle108	Program is no longer available.
Cycle113	Program is no longer available.
Cycle118	Program is no longer available.
Cycle972	Program is no longer available.
E_SP_NPV	Program is no longer available.
CYC_JM	Program is no longer available.
GUD5	Module no longer available.
GUD6	Module no longer available.
GUD7	Module no longer available.
GUD7_MC	Module no longer available.

See also

General information (Page 91)

Overview of the auxiliary programs required (Page 261)

General information (Page 378)

Overview of measuring cycle parameters (Page 421)

A.4 Overview of measuring cycle parameters

Parameter definition

Illustration in the table (cell)	Meaning
	Parameter must be defined and/or the parameter's definition depends on the measuring variant, other parameters or the machine configuration.
----	Parameter is not used in the cycle

The measuring cycle data are defined in the data blocks:

- GUD5.DEF
- GUD6.DEF

Note

As of HMI sl software version 2.6

The GUD parameters are stored in the machine or setting data.

A correspondence/assignment list of the measuring cycle GUD parameters, GUD modules and measuring programs used until now, compared to the new machine and setting data, is included in appendices A1, A2 and A3.

Overview

CYCLE961		Workpiece measurements					
Parameter GUD5	Type	Automatic setup of inside and outside corner for G17: in XY plane for G18: in ZX plane for G19: in YZ plane					
		Specifying distances and angles				Specifying 4 points	
		Corner inside	Corner outside	Corner inside	Corner outside	Corner inside	Corner outside
		3 measuring points		4 measuring points			
_CALNUM	INT	----	----	----	----	----	----
_CORA	REAL	----	----	----	----	----	----
_CPA	REAL	----	----	----	----	----	----
_CPO	REAL	----	----	----	----	----	----
_EVNUM	INT	----	----	----	----	----	----
_FA	REAL >0	Measurement path in mm					
		Only included if calculated larger than internal value					

CYCLE961		Workpiece measurements					
_ID	REAL	----	Retraction in infeed axis, incremental for overtravel of corner if _ID=0 travels around the corner	----	Retraction in infeed axis, incremental for overtravel of corner if _ID=0 travels around the corner	Infeed of positioning depth to measuring depth (incremental)	
_INCA	REAL 179.5 ..179.5 degrees	Angle from 1st edge to 2nd edge of the workpiece (clockwise negative)				----	----
_K	INT	----	----	----	----	----	----
_KNUM	INT >=0	Without/with automatic offset of the ZO memory 0: Without offset					
		1...99: automatic offset in ZO G54...G57 G505...G599 **1000:** automatic offset in basic frame G500 **1011...1026:** automatic ZO correction in 1st to 16th basic frame **2000:** automatic ZO in system frame					
_MA	INT	----	----	----	----	----	----
_MD	INT	----	----	----	----	----	----
_MVAR	INT >0	Measuring variant					
		105	106	107	108	117	118
_NMSP	INT >0	Number of measurements at the same location					
_PRNUM	INT >0	Probe number (number of the data field assigned to the workpiece probe GUD6:_WP[_PRNUM-1])					
_RA	INT	----	----	----	----	----	----
_RF	REAL	----	----	----	----	----	----
_SETVAL	REAL	----	----	----	----	----	----
_SETV[0]	REAL	Distance between starting point and measuring point 2 (positive only)				Coordinates of point P1 in the active workpiece coordinate system (abscissa)	
_SETV[1]	REAL	Distance between starting point and measuring point 4 (positive only)				Coordinates of point P1 in the active workpiece coordinate system (ordinate)	
_SETV[2]	REAL	Distance between measured and required corner point in abscissa only active if _SETV[4]>1		----	----	Coordinates of point P2 in the active workpiece coordinate system (abscissa)	
_SETV[3]	REAL	Distance between measured and required corner point in ordinate only active if _SETV[4]>1		----	----	Coordinates of point P2 in the active workpiece coordinate system (ordinate)	

CYCLE961		Workpiece measurements					
_SETV[4]	REAL	1: Measured corner 2: Offset in abscissa 3: Offset in abscissa and ordinate 4: Offset in ordinate		----	----	Coordinates of point P3 in the active workpiece coordinate system (abscissa)	
_SETV[5]	REAL	----	----	----	----	Coordinates of point P3 in the active workpiece coordinate system (ordinate)	
_SETV[6]	REAL	----	----		----	Coordinates of point P4 in the active workpiece coordinate system (abscissa)	
_SETV[7]	REAL	----	----	----	----	Coordinates of point P4 in the active workpiece coordinate system (ordinate)	
_STA1	REAL 0...360 degrees	Approx. angle of posit. direction of the abscissa with respect to 1st edge of the workpiece (reference edge), clockwise negative				----	----
_SZA	REAL	----	----	----	----	----	----
_SZO	REAL	----	----	----	----	----	----
_TDIF	REAL	----	----	----	----	----	----
_TMV	REAL	----	----	----	----	----	----
_TNAME	STRING[ ]	----	----	----	----	----	----
_TNUM	INT	----	----	----	----	----	----
_TUL	REAL	----	----	----	----	----	----
_TLL	REAL	----	----	----	----	----	----
_TSA	REAL	----	----	----	----	----	----
_TZL	REAL	----	----	----	----	----	----
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))					

See also

Comparison of GUD parameters up to measuring cycles version 7.5 and GUD parameters as of measuring cycles version 2.6, with reference to measuring function. (Page 413)

GUD variables that can no longer be used (Page 418)

Changes to names of cycle programs and GUD modules (Page 420)

CYCLE971		Tool measurement of milling tools on milling machines			
Parameter GUD5	Type	**Possible axes** Abscissa (_MA=1) / ordinate (_MA=2) / applicate (_MA=3) for G17: X=1 / Y=2 / Z=3 for G18: Z=1 / X=2 / Y=3 for G19: Y=1 / Z=2 / X=3			
		Calibrating tool probe		Measuring tool	
		Machine-related	Workpiece-related	Machine-related	Workpiece-related
`_CALNUM`	INT	----	----	----	----
`_CORA`	REAL	----	----	----	----
`_CPA`	REAL	----	----	----	----
`_CPO`	REAL	----	----	----	----
`_EVNUM`	INT	----	----	Empirical value memory number number of data field **GUD5:_EV[_EVNUM-1]**	
`_FA`	REAL >0	Measurement path in mm			
		For incremental calibration, the direction of travel is specified by the sign of _FA.		----	
`_ID`	REAL >=0	----	----	Normally 0, on multiple cutters the offset between the highest point of the cutting edge and the length for radius measurement (or the radius for length measurement).	
`_INCA`	REAL			----	----
`_K`	INT	----	----	----	----
`_KNUM`	INT	----	----	----	----
`_MA`	INT	Measuring axis 1...3			
		1: calibration in +/- direction in 1 (abscissa) 2: calibration in +/- direction in 2 (ordinate) 3: calibration in +/- direction in 3 (applicate) Also possible for calibration in plane: 102: a) Calculation of center in 1(abscissa) b) Calibrate in 2 (ordinate) 201: a) Calculation of center in 2 (ordinate) b) Calibrate in 1 (abscissa) **not for incremental calibration!**		1: Meas. of radius in direction 1 (abscissa) 2: Meas. of radius in direction 2 (ordinate) 3: Meas. of length at center point of the tool probe 103: Meas. of the length, offset about radius 1 (abscissa) 203: Meas. of the length, offset about radius 2 (ordinate)	
`_MD`	INT	----	----	----	----

CYCLE971		Tool measurement of milling tools on milling machines			
_MVAR	INT >0	Measuring variant			
		Calibration in measurement axis acc. to previous positioning on center of measurement cube		Measure of length of radius with motionless spindle	
		0	10	1	11
		Incremental calibration, traverse motion in measuring axis only		Measurement with rotating spindle; direction of rotation before cycle call, if spindle is already rotating. For motionless spindle direction in **_CM[5]**	
		10000	10010	2	12
		from meas. cycles SW 6.3: Calibrate automatically		----	----
		100000	100010	----	----
_NMSP	INT >0	Number of measurements at the same location			
_PRNUM	INT >0	Tool probe number (number of the data field assigned to the workpiece probe **GUD6:**			
		_TP[_PRNUM-1,i])	**_TPW[_PRNUM-1,i]**	**_TP[_PRNUM-1,i])**	**_TPW[_PRNUM-1,i]**
_RA	INT	----	----	----	----
_RF	REAL	----	----	----	----
_SETVAL	REAL	----	----	----	----
_SETV[8]	REAL	----	----		
_STA1	REAL 0...360 degrees	----	----	----	----
_SZA	REAL	----	----	----	----
_SZO	REAL	----	----	----	----
_TDIF	REAL	----	----	Dimension difference check	
_TMV	REAL	----	----	----	----
_TNAME	STRING [32]	----	----	----	----
_TNUM	INT	----	----	----	----
_TUL	REAL	----	----	----	----
_TLL	REAL	----	----	----	----
_TSA	REAL	Safe area			
_TZL	REAL	Zero offset area			
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))			
_CM[ ] GUD6- data	REAL	----		Cycle-internal calculation of **S, F** from monitoring data in **_CM[ ]** **Only active if _CBIT[12]=0**	
_MFS[ ] GUD6- data	REAL	----		Specification of **S, F** by user in **_MFS[ ]** Only active if _CBIT[12]=1	

<table>
<tr><th colspan="2">CYCLE973</th><th colspan="4">Workpiece measurements</th></tr>
<tr><td rowspan="4">Parameter
GUD5</td><td rowspan="4">Type</td><td colspan="4">Possible axes
Abscissa (_MA=1) / ordinate (_MA=2) / applicate (_MA=3)
for G17: X=1 / Y=2 / Z=3
for G18: Z=1 / X=2 / Y=3
for G19: Y=1 / Z=2 / X=3</td></tr>
<tr><td colspan="4">Calibrating tool probes</td></tr>
<tr><td colspan="2">Machine-related</td><td colspan="2">Workpiece-related</td></tr>
<tr><td colspan="2">Reference groove</td><td colspan="2">Area</td></tr>
<tr><td>_CALNUM</td><td>INT</td><td colspan="2">Number of the gauging block
(number of the data field assigned
GUD6: _KB[_CALNUM-1])</td><td colspan="2">----</td></tr>
<tr><td>_CORA</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_CPA</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_CPO</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_EVNUM</td><td>INT</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_FA</td><td>REAL
>0</td><td colspan="4">Measurement path in mm</td></tr>
<tr><td>_ID</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_INCA</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_K</td><td>INT</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_KNUM</td><td>INT</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_MA</td><td>INT</td><td colspan="2">Measuring axis 1...2</td><td colspan="2">Measuring axis 1...3</td></tr>
<tr><td>_MD</td><td>INT</td><td colspan="4">Measuring direction (0 = positive / 1 = negative)</td></tr>
<tr><td rowspan="3">_MVAR</td><td rowspan="3">INT
>0</td><td colspan="4">Measuring variant</td></tr>
<tr><td colspan="2">xxx13</td><td colspan="2">0</td></tr>
<tr><td colspan="2">5 4 3 2 1
Digits 2 1: 1 3 Reference groove
Digit 3: 0 Not incl. probe ball in calculation
1 Including probe ball in calculation (for calibration in groove only)
Digit 4: 1 1 axis direction (specify measuring axis and axis direction)
2 2 axis directions (specify measuring axis)
Digit 5: 0 Without position calculation
1 With position calibration (for calibration in groove only)</td><td colspan="2">Area</td></tr>
<tr><td>_NMSP</td><td>INT
>0</td><td colspan="4">Number of measurements at the same location</td></tr>
<tr><td>_PRNUM</td><td>INT
>0</td><td colspan="4">Tool probe number
(number of the data field assigned to the tool probe
GUD6:_TP[_PRNUM-1])</td></tr>
<tr><td></td><td></td><td>_TP[_PRNUM-1,i])</td><td>_TPW[_PRNUM-1,i]</td><td>_TP[_PRNUM-1,i])</td><td>_TPW[_PRNUM-1,i]</td></tr>
<tr><td>_RA</td><td>INT</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_RF</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_SETVAL</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_SETV[8]</td><td>REAL</td><td colspan="2">----</td><td colspan="2">Calibration setpoint</td></tr>
</table>

CYCLE973		Workpiece measurements	
`_STA1`	REAL	----	----
`_SZA`	REAL	----	----
`_SZO`	REAL	----	----
`_TDIF`	REAL	----	----
`_TMV`	REAL	----	----
`_TNAME`	STRING [32]	----	----
`_TNUM`	INT	----	----
`_TUL`	REAL	----	----
`_TLL`	REAL	----	----
`_TSA`	REAL	Safe area	
`_TZL`	REAL	Zero offset area	
`_VMS`	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))	

CYCLE974 CYCLE994		Workpiece measurements			
Parameter GUD5	Type	Possible axes Abscissa (_MA=1) / ordinate (_MA=2) / applicate (_MA=3) for G17: X=1 / Y=2 / Z=3 for G18: Z=1 / X=2 / Y=3 for G19: Y=1 / Z=2 / X=3			
		Measuring with automatic ZO correction	Measuring with automatic tool offset		
		CYCLE974	CYCLE974		CYCLE994
		1 point	1 point	1 point with reversal	2 point with reversal
`_CALNUM`	INT	----	----	----	
`_CORA`	REAL	----	----	----	----
`_CPA`	REAL	----	----	----	
`_CPO`	REAL	----	----	----	----
`_EVNUM`	INT >=0	Empirical value memory number number of data field GUD5:_EV[_EVNUM-1]			
		----	Mean value memory number number of data field GUD5:_MV[_EVNUM-1] Only active if GUD6:_CHBIT[4]=1		
`_FA`	REAL >0	Measurement path in mm			
`_ID`	REAL	----	----	----	----
`_INCA`	REAL	----	----	----	----
`_K`	INT	----	Weighting factor k for mean value calculation		

CYCLE974 CYCLE994		Workpiece measurements			
_KNUM	INT >=0	without/with automatic offset of the ZO memory 0: Without offset	without / with automatic tool offset (D number) 0: without tool offset		
		1...99 automatic offset in ZO G54...G57 G505...G599 **1000** automatic offset in basic frame G500 **1011...1026** automatic ZO correction in 1st to 16th channel basic frame **1051...1066** automatic ZO correction in 1st to 16th global basic frame **2000** automatic ZO correction in system frame **9999** automatic ZO correction in active frame G54...G57,G505...G599 or with active G500 in the last active channel-specific basic frame	Normal D number structure 7 6 5 4 3 2 1 D number 0/1 Length correction in the measuring axis or set-up and/or additive correction 2 Radius correction or correction and/or additive correction 0 Correction normal 1 Correction inverted 0 Correction relates to 4th position 1 Correction of L1 2 Correction of L2 3 Correction of L3 4 Radius correction 0 Correction in length/radius 1 Correction in setup and/or additive correction 2 Correction in length and/or radius acc. to _TENV 3 Correction in setup and/or additive correction acc. to _TENV		Flat D number structure 9 8 7 6 5 4 3 2 1 D number 0/1 Length correction in the measuring axis or set-up and/or additive correction 2 Radius correction or correction and/or additive correction 0 correction normal 1 correction inverted 0 Correction relates to 6th position 1 Correction of L1 2 Correction of L2 3 Correction of L3 4 Radius correction 0 Correction in length/radius 1 Correction in setup and/or additive correction 2 Correction in length and/or radius acc. to _TENV 3 Correction in setup and/or additive correction acc. to _TENV
_MA	INT	Measuring axis 1...3			
_MD	INT	----	----	----	----
_MVAR	INT >0	Measuring variant			
		100	0	1000	1 2
_NMSP	INT >0	Number of measurements at the same location			
_PRNUM	INT >0	Workpiece probe number (number of the data field assigned to the workpiece probe GUD6:_WP[_PRNUM-1])			
_RA	INT	----	----	----	----
_RF	REAL	----	----	----	----
_SETVAL	REAL	Setpoint	Setpoint (according to drawing)		
_SETV[8]	REAL	----	----	----	----
_STA1	REAL	----	----	Start angle	----
_SZA	REAL	----	----	----	----

CYCLE974 CYCLE994		Workpiece measurements			
_SZO	REAL	----	----	----	----
_TDIF	REAL	----	Dimension difference check		
_TMV	REAL	----	Tool name (alternative for "_TNUM" if tool management active)		
_TNAME	STRING [32]	----	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)		
_TNUM	INT	----	Tool number for automatic tool offset		
_TUL	REAL	----	Offset range with mean value calculation only active if GUD6:_CHBIT[4]=1		
_TLL	REAL	----	Upper tolerance limit (according to drawing)		
_TSA	REAL	Safe area			
_TZL	REAL		Zero offset area		
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))			

CYCLE976		Workpiece measurements		
Parameter GUD5	Type	Possible axes Abscissa (_MA=1) / ordinate (_MA=2) / applicate (_MA=3) for G17: X=1 / Y=2 / Z=3 for G18: Z=1 / X=2 / Y=3 for G19: Y=1 / Z=2 / X=3		
		Calibrating workpiece probes		
		Hole with known center	Hole with unknown center	Area
_CALNUM	INT	----	----	----
_CORA	REAL	Offset angular position (only active if mono probe)		
_CPA	REAL	----	----	----
_CPO	REAL	----	----	----
_EVNUM	INT	----	----	----
_FA	REAL >0	Measurement path in mm		
_ID	REAL	----	----	----
_INCA	REAL	----	----	----
_K	INT	----	----	----
_KNUM	INT	----	----	----
_MA	INT	Measuring axis		
_MD	INT	Measuring direction (0 = positive / 1 = negative)		
_MVAR	INT >0	Measuring variant		
		xxxx01	xxxx08	x0000

CYCLE976		Workpiece measurements		
		Calibrate in the plane 6 5 4 3 2 1 1 Calibrate in hole with unknown center 8 Calibrate in hole with unknown center 0 0 Not including probe ball in calculation 1 Including probe ball in calculation 0 4 axis directions 1 axis direction (specify measuring axis and axis direction) 2 2 axis directions (specify measuring axis) 0 Without position calculation 1 With position calculation 0 Paraxial calibration (in the plane) 1 Calibrate at any angle (in the plane)		Calibration on surface _MVAR=0 Calibration on surface _MVAR=10000 calibration on surface with calculation of the probe length only permissible with _MA=3!
`_NMSP`	INT >0	Number of measurements at the same location		
`_PRNUM`	INT >0	Probe type/workpiece probe number 3 2 1 2-digit number Calibrate 2-digit number in hole with unknown center 1 Mono probe 0 Multi probe (number of the data field assigned to the workpiece probe GUD6:_WP[_PRNUM(2-digit)-1])		
`_RA`	INT	----		----
`_RF`	REAL	----		----
`_SETVAL`	REAL	Calibration setpoint		
`_SETV[8]`	REAL	----		
`_STA1`	REAL	Start angle		----
`_SZA`	REAL	----		
`_SZO`	REAL	----		
`_TDIF`	REAL	----	----	----
`_TMV`	REAL	----	----	----
`_TNAME`	STRING [ ]	----	----	----
`_TNUM`	INT	----	----	----
`_TUL`	REAL	----	----	----
`_TLL`	REAL	----	----	----
`_TSA`	REAL	Safe area		
`_TZL`	REAL	Zero offset area		
`_VMS`	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))		

CYCLE977		Workpiece measurements							
Parameter GUD5	Type	Possible measuring axes Abscissa (_MA=1) / ordinate (_MA=2) for G17: X=1 / Y=2 for G18: Z=1 / X=2 for G19: Y=1 / Z=2							
		Measuring with automatic tool offset				Measuring with automatic ZO correction			
		Hole	Shaft	Groove	Web	Hole	Shaft	Gro ove	Web
`_CALNUM`	INT	----	----	----	----	----	----	----	----
`_CORA`	REAL	Offset angular position (only active if mono probe)							
`_CPA`	REAL	----	----	----	----	----	----	----	----
`_CPO`	REAL	----	----	----	----	----	----	----	----
`_EVNUM`	INT	Empirical value memory number number of data field GUD5:_EV[_EVNUM-1]				----			
		Mean value memory number number of data field GUD5:_MV[_EVNUM-1] Only active if GUD6:_CHBIT[4]=1				----	----	----	----
`_FA`	REAL >0	Measurement path in mm							
`_ID`	REAL	Infeed applicate							
`_INCA`	REAL 0...360 degrees	----	----	----	----	----	----	----	----
`_K`	INT	----	----	----	----	----	----	----	----

CYCLE977		Workpiece measurements							
_KNUM	INT >=0	without / with automatic tool offset (D number) 0 without tool offset				without/with automatic offset of the ZO memory 0 without offset			
		Normal D number structure		Flat D number structure					
		7 6 5 4 3 2 1 3 2 1: D number[1)] 4: 0/1 Length correction in the measuring axis or set-up and/or additive correction; 2 Radius correction or correction and/or additive correction 5: 0 Correction normal; 1 Correction inverted 6: 0 Correction relates to 4th position; 1 Correction of L1; 2 Correction of L2; 3 Correction of L3; 4 Radius correction 7: 0 Correction in length/radius; 1 Correction in setup and/or additive correction; 2 Correction in length and/or radius acc. to _TENV; 3 Correction in setup and/or additive correction acc. to _TENV 1) if MD 18105 <=9 single-digit, >9<1000, three-digit D number		9 8 7 6 5 4 3 2 1 5 4 3 2 1: D number[2)] 6: 0/1 Length correction in the measuring axis or set-up and/or additive correction; 2 Radius correction or correction and/or additive correction 7: 0 Correction normal; 1 Correction inverted 8: 0 Correction relates to 6th position; 1 Correction of L1; 2 Correction of L2; 3 Correction of L3; 4 Radius correction 9: 0 Correction in length/radius; 1 Correction in setup and/or additive correction; 2 Correction in length and/or radius acc. to _TENV; 3 Correction in setup and/or additive correction acc. to _TENV 2) if MD 18105 >999 also valid for normal D number structure		**1...99** automatic correction in ZO G54...G57 G505...G599 **1000** automatic correction in basic frame G500 **1011...1026** automatic ZO correction in 1st to 16th channel basic frame **1051...1066** automatic ZO correction in 1st to 16th global basic frame **2000** automatic ZO correction in system frame **9999** automatic ZO correction in active frame G54...G57, G505...G599 or with active G500 in the last active channel-specific basic frame			
_MA	INT	----	----	Measuring axis 1...2		----	----	Measuring axis 1...2	
_MD	INT	----	----	----	----	----	----	----	
_MVAR	INT >0	Measuring variant 1xxx measurement traveling around or taking account of a safety zone							
		1	2	3	4	101	102	103	104
_NMSP	INT >0	Number of measurements at the same location							
_PRNUM	INT >0	Probe type/workpiece probe number 3 2 1 2 1: 2-digit number Calibrate 2-digit number in hole with unknown center 3: 1 Mono probe 0 Multi probe (number of the data field assigned to the workpiece probe **GUD6:_WP[_PRNUM(2-digit)-1])**							
_RA	INT	----	----	----	----	----	----	----	----
_RF	REAL	----	----	----	----	----	----	----	----
_SETVAL	REAL	Setpoint (according to drawing)				Setpoint			
_SETV[8]	REAL	----	----	----	----	----	----	----	----
_STA1	REAL 0...360 degrees	----	----		----	----	----	----	----
_SZA	REAL	Protection zone in abscissa (only for _MVAR=1xxx)							

CYCLE977		Workpiece measurements				
_SZO	REAL	Protection zone in ordinate (only for _MVAR=1xxx)				
_TDIF	REAL	Dimension difference check	----	----	----	----
_TMV	REAL	Offset range with mean value calculation	----	----	----	----
_TNAME	STRING[ ]	Tool name (alternative for "_TNUM" if tool management active)	----	----	----	----
_TENV	STRING[ ]	Name of tool surroundings for automatic tool offset				
_TNUM	INT	Tool number for automatic tool offset	----	----	----	----
_TUL	REAL	Upper tolerance limit (according to drawing)	----	----	----	----
_TLL	REAL	Lower tolerance limit (according to drawing)	----	----	----	----
_TSA	REAL	Safe area				
_TZL	REAL	Zero offset area	----	----	----	----
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))				

CYCLE978		Workpiece measurements	
Parameter GUD5	Type	**Possible measuring axes** **Abscissa (_MA=1) / ordinate (_MA=2)** **for G17: X=1 / Y=2** **for G18: Z=1 / X=2** **for G19: Y=1 / Z=2**	
		Measuring with automatic tool offset	**Measuring with automatic ZO correction**
_CALNUM	INT	----	----
_CORA	REAL 0...359.5	Offset angular position only active if mono probe	
_CPA	REAL	----	----
_CPO	REAL	----	----
_EVNUM	INT >=0	Empirical value memory number number of data field GUD5:_EV[_EVNUM-1]	
		Mean value memory number number of data field GUD5:_MV[_EVNUM-1] Only active if GUD6:_CHBIT[4]=1	----
_FA	REAL >0	Measurement path in mm	
_ID	REAL	----	----
_INCA	REAL	----	----
_K	INT	Weighting factor k for mean value calculation	----

<table>
<tr><th colspan="2">CYCLE978</th><th colspan="4">Workpiece measurements</th></tr>
<tr><td rowspan="2">_KNUM</td><td rowspan="2">INT</td><td colspan="3">without / with automatic tool offset (D number)
0 without tool offset

Normal D number structure | Flat D number structure</td><td>without/with automatic offset of the ZO memory
0 without offset</td></tr>
<tr><td colspan="2">7 6 5 4 3 2 1
D number[1)]
0/1 Length correction in the measuring axis or set-up and/or additive correction
2 Radius correction or correction and/or additive correction
0 Correction normal
1 Correction inverted
0 Correction relates to 4th position
1 Correction of L1
2 Correction of L2
3 Correction of L3
4 Radius correction
0 Correction in length/radius
1 Correction in setup and/or additive correction
2 Correction in length and/or radius acc. to _TENV
3 Correction in setup and/or additive correction acc. to _TENV
1) if MD 18105 <=9 single-digit, >9<1000, three-digit D number</td><td>9 8 7 6 5 4 3 2 1
D number[2)]
0/1 Length correction in the measuring axis or set-up and/or additive correction
2 Radius correction or correction and/or additive correction
0 Correction normal
1 Correction inverted
0 Correction relates to 6th position
1 Correction of L1
2 Correction of L2
3 Correction of L3
4 Radius correction
0 Correction in length/radius
1 Correction in setup and/or additive correction
2 Correction in length and/or radius acc. to _TENV
3 Correction in setup and/or additive correction acc. to _TENV
2) if MD 18105 >999 also valid for normal D number structure</td><td>1...99
automatic correction in ZO G54...G57 G505...G599
1000
automatic correction in basic frame G500
1011...1026
automatic ZO correction in 1st to 16th channel basic frame
1051...1066
automatic ZO correction in 1st to 16th global basic frame
2000
automatic ZO correction in system frame
9999
automatic ZO correction in active frame G54...G57,G505...G599 or with active G500 in the last active channel-specific basic frame</td></tr>
<tr><td>_MA</td><td>INT</td><td colspan="4">Measuring axis 1...3</td></tr>
<tr><td>_MD</td><td>INT</td><td colspan="3">----</td><td>----</td></tr>
<tr><td rowspan="3">_MVAR</td><td rowspan="3">INT
>=0</td><td colspan="4">Measuring variant</td></tr>
<tr><td colspan="3">0</td><td>100</td></tr>
<tr><td colspan="3">1000
(Difference measurement not with mono probe)</td><td>1100 (Difference measurement not with mono probe)</td></tr>
<tr><td>_NMSP</td><td>INT</td><td colspan="4">Number of measurements at the same location</td></tr>
<tr><td>_PRNUM</td><td>INT
>0</td><td colspan="4">Probe type/workpiece probe number
3 2 1
2-digit number
Calibrate 2-digit number in hole with unknown center
1 Mono probe
0 Multi probe
(number of the data field assigned to the tool probe
GUD6:_WP[_PRNUM(2-digit)-1])</td></tr>
<tr><td>_RA</td><td>INT</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_RF</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_SETVAL</td><td>REAL</td><td colspan="2">Setpoint (acc. to drawing)</td><td colspan="2">Setpoint</td></tr>
<tr><td>_STA1</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_SZA</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_SZO</td><td>REAL</td><td colspan="2">----</td><td colspan="2">----</td></tr>
<tr><td>_TDIF</td><td>REAL</td><td colspan="2">Dimension difference check</td><td colspan="2">----</td></tr>
</table>

CYCLE978		Workpiece measurements	
_TMV	REAL	Offset range with mean value calculation only active if GUD6:_CHBIT[4]=1	----
_TNAME	STRING [ ]	Tool name (alternative for "_TNUM" if tool management active)	----
_TENV	STRING [ ]	Name of tool surroundings for automatic tool offset	----
_TNUM	INT	Tool number for automatic tool offset	----
_TUL	REAL	Upper tolerance limit (according to drawing)	----
_TLL	REAL	Lower tolerance limit (according to drawing)	----
_TSA	REAL	Safe area	
_TZL	REAL	Zero offset area	
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))	

CYCLE979		Workpiece measurements							
Parameter GUD5	Type	Possible measurements G17: X-Y plane G18: Z-X plane G19: Y-Z plane							
		Measuring with automatic tool offset				Measuring with automatic ZO correction			
		Hole	Shaft	Groove	Web	Hole	Shaft	Groo ve	Web
_CALNUM	INT	----	----	----	----	----	----	----	----
_CORA	REAL	Offset angular position (only active if mono probe)							
_CPA	REAL	Center abscissa (with reference to the workpiece zero)							
_CPO	REAL	Center ordinate (with reference to the workpiece zero)							
_EVNUM	INT	Empirical value memory number number of data field GUD5:_EV[_EVNUM-1]				----			
		Mean value memory number number of data field GUD5:_MV[_EVNUM-1] Only active if GUD6:_CHBIT[4]=1				----	----	----	----
_FA	REAL >0	Measurement path in mm							
_ID	REAL	----	----	----	Infeed applicate	----	----	----	Infeed applicate
_INCA	REAL 0...360 degrees	Incrementing angle		----	----	Incrementing angle		----	----
_K	INT	Weighting factor k for mean value calculation				----	----	----	----

CYCLE979		Workpiece measurements							
_KNUM	INT >=0	without / with automatic tool offset (D number) 0 without tool offset				without/with automatic offset of the ZO memory 0 without offset			
		Normal D number structure		Flat D number structure					
		7 6 5 4 3 2 1 3 2 1: D number[1)] 4: 0/1 Length correction in the measuring axis or set-up and/or additive correction 2 Radius correction or correction and/or additive correction 5: 0 Correction normal 1 Correction inverted 6: 0 Correction relates to 4th position 1 Correction of L1 2 Correction of L2 3 Correction of L3 4 Radius correction 7: 0 Correction in length/radius 1 Correction in setup and/or additive correction 2 Correction in length and/or radius acc. to _TENV 3 Correction in setup and/or additive correction acc. to _TENV 1) if MD 18105 <=9 single-digit, >9<1000, three-digit D number		9 8 7 6 5 4 3 2 1 5 4 3 2 1: D number[2)] 6: 0/1 Length correction in the measuring axis or set-up and/or additive correction 2 Radius correction or correction and/or additive correction 7: 0 Correction normal 1 Correction inverted 8: 0 Correction relates to 6th position 1 Correction of L1 2 Correction of L2 3 Correction of L3 4 Radius correction 9: 0 Correction in length/radius 1 Correction in setup and/or additive correction 2 Correction in length and/or radius acc. to _TENV 3 Correction in setup and/or additive correction acc. to _TENV 2) if MD 18105 >999 also valid for normal D number structure		**1...99** automatic correction in ZO G54...G57 G505...G599 **1000** automatic correction in basic frame G500 **1011...1026** automatic ZO correction in 1st to 16th channel basic frame **1051...1066** automatic ZO correction in 1st to 16th global basic frame **2000** automatic ZO correction in system frame **9999** automatic ZO correction in active frame G54...G57, G505...G599 or with active G500 in the last active channel-specific basic frame			
_MA	INT	----	----			----	----		
_MD	INT	----	----	----	----	----	----	----	
_MVAR	INT >0	Measuring variant 1xxx measurement traveling around or taking account of a safety zone							
		1	2	3	4	101	102	103	104
_NMSP	INT >0	Number of measurements at the same location							
_PRNUM	INT >0	Number of measuring points/probe type/workpiece probe number 4 3 2 1 2 1: 2-digit number Calibrate 2-digit number in hole with unknown 3: 1 Mono probe 0 Multi probe 4: 0 3 Measuring points 1 4 Measuring points (number of the data field assigned to the workpiece probe GUD6:_WP[_PRNUM(2-digit)-1])							
_RA	INT	----	----	----	----	----	----	----	----
_RF	REAL	Velocity for circular interpolation		----	----	Velocity for circular interpolation		----	----
_SETVAL	REAL	Setpoint (according to drawing)				Setpoint			
_SETV[8]	REAL	----	----	----	----	----	----	----	----
_STA1	REAL 0...360 degrees	Start angle							

CYCLE979		Workpiece measurements							
_SZA	REAL	----	----	----	----	----	----	----	----
_SZO	REAL	----	----	----	----	----	----	----	----
_TDIF	REAL	Dimension difference check				----	----	----	----
_TMV	REAL	Offset range with mean value calculation only active if GUD6:_CHBIT[4]=1				----	----	----	----
_TNAME	STRING[ ]	Tool name (alternative for "_TNUM" if tool management active)				----	----	----	----
_TENV	STRING[ ]	Name of tool surroundings for automatic tool offset				----	----	----	----
_TNUM	INT	Tool number for automatic tool offset				----	----	----	----
_TUL	REAL	Upper tolerance limit (according to drawing)				----	----	----	----
_TLL	REAL	Lower tolerance limit (according to drawing)				----	----	----	----
_TSA	REAL	Safe area							
_TZL	REAL	Zero offset area				----	----	----	----
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))							

CYCLE982		Workpiece measurements					
Parameter GUD5	Type	Possible measuring axes Abscissa (_MA=1) / ordinate (_MA=2) for G17: X=1 / Y=2 for G18: Z=1 / X=2 for G19: Y=1 / Z=2					
		Calibrating tool probe		Measuring tool		Automatic tool measurement	
		Machine-related	Workpiece-related	Machine-related	Workpiece-related	Machine-related	Workpiece-related
_CORA	REAL 0...359.5	----	----	Offset angle after reversal when measuring milling tools			
_CPA	REAL	----	----	----	----	----	
_CPO	REAL	----	----	----	----	----	----
_EVNUM	INT, ≥0	----	----	Empirical value memory number number of data field GUD5:_EV[_EVNUM-1]			
_FA	REAL >0	Measurement path in mm					
_ID	REAL	----		----		----	
_INCA	REAL 0...360 degrees	----		----		----	
_K	INT	----		----		----	
_KNUM	INT	----		----		----	
_MA	INT	----		----		----	
_MD	INT	----		----		----	

CYCLE982		Workpiece measurements					
_MVAR	INT >0	Measuring variant					
		0	10	xxxx01	xxxx11	xxxx02	xxxx12
		8 7 6 5 4 3 2 1 1st digit: 0 Calibrate 1 Measurement of turning (SL 1-8), milling and drilling tools Measuring axis in _MA 2nd digit: 2 Automatic measurement in abscissa and ordinate 0 Machine-related 0 Workpiece-related For milling tools only (also automatically), setting data SD42960 = 2! 3rd digit: 0 Measure without reversal 1 Measure with reversal 4th digit: 0 Measure: Only correct length if 1st digit = 1 1 Measure: Only correct length if 1st digit = 1 2 Measure: Correct length and radius if 1st digit = 1 3 Automatic measurement: Only correct length and radius if 1st digit = 2 Travel around toolsetter to starting position 4 Automatic measurement: Correct length and radius if 1st digit = 2 Measuring in opposite direction to approach 5th digit: 0 Axial position of milling tool/drill (radius in ordinate, at G18: X axis 1 Radial position of milling tool/drill (radius in abscissa, at G18: Z axis 6th digit: 0 Measure or calibrate 1 Measure or calibrate incrementally 7th digit: Reserved 8th digit: 0 Calibrate with calibration tool 1 Calibrate with turning tool					
_NMSP	INT >0	Number of measurements at the same location					
_PRNUM	INT >0	Tool probe number (number of the data field assigned to the workpiece probe GUD6:					
		_TP [_PRNUM-1,i]	_TPW [_PRNUM-1,i]	_TP [_PRNUM-1,i]	TPW [_PRNUM-1,i]	_TP [_PRNUM-1,i]	TPW [_PRNUM-1,i]
_RA	INT	----	----	----	----	----	----
_RF	REAL	----	----	----	----	----	----
_SETVAL	REAL	----	----	----	----	----	----
_SETV[8]	REAL	----	----	----	----	----	----
_STA1	REAL 0...360 degrees			Starting angle when measuring milling tools			
_SZA	REAL	----	----	----	----	----	----
_SZO	REAL	----	----	----	----	----	----
_TDIF	REAL >0	----	----	Dimension difference check			
_TMV	REAL	----	----	----	----	----	----
_TNAME	STRING[ ]	----	----	----	----	----	----
_TNUM	INT	----	----	----	----	----	----
_TUL	REAL	----	----	----	----	----	----
_TLL	REAL	----	----	----	----	----	----
_TSA	REAL	Safe area					

CYCLE982		Workpiece measurements
_TZL	REAL	Zero offset area
_VMS	REAL, ≥0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))

CYCLE996		Workpiece measurements	
Parameter GUD5	Type	Possible measurements G17: X-Y plane G18: Z-X plane G19: Y-Z plane	
		1st, 2nd, 3rd measurements	Calculate kinematics
_FA	REAL	Measuring distance factor → Transfer to CYCLE997	----
_MVAR	INT	Measuring variant	
		9 8 7 6 5 4 3 2 1 _MVAR 1 1. Measurement 2 2. Measurement 3 3. Measurement 9 Identification of "Measure kinematics" function - CYCLE996 Measuring axis measurement result 1 Rotary axis 1 2 Rotary axis 2 Protocol file 0 No 1 Yes	9 8 7 6 5 4 3 2 1 _MVAR 4 Calculate kinematics 9 Identification of "Measure kinematics" function - CYCLE996 Measuring result 0 Measuring only 1 Measure + enter vectors Result bit 0 No 1 Yes 2 Yes, vectors editable Vector chain 0 Vector chain closed 3 Vector chain open Axis number for normalizing rotary axis 1 0 No normalizing 1 X axis normalizing 2 Y axis normalizing 3 Z axis normalizing Axis number for normalizing rotary axis 2 0 No normalizing 1 X axis normalizing 2 Y axis normalizing 3 Z axis normalizing Protocol file 0 No 1 Yes (protocol format as $TC_CARR-Parameter) 2 Yes, TRAORI (1) (protocol format as $TC_CARR-Parameter and as TRAORI machine data)
_TNUM	INT	Number of swivel data record	
_SETVAL	REAL	Diameter of the calibration ball → Transfer to CYCLE997	----
_TSA	REAL	Confidence range → Transfer to CYCLE997	----
_VMS	REAL	Measuring feedrate	----
_PRNUM	INT	Number, probe (field) → Transfer to CYCLE997	----
_SETV[3]	REAL	Position value of rotary axis 1 (manual or semi-automatic)	----
_SETV[4]	REAL	Position value of rotary axis 2 (manual or semi-automatic)	----
_SETV[5]	REAL	----	Position value for normalizing rotary axis 1
_SETV[6]	REAL	----	Position value for normalizing rotary axis 2

CYCLE996		Workpiece measurements	
_SETV[7]	REAL	----	Tolerance value of offset vectors I1...I4
_SETV[8]	REAL	----	Tolerance value of rotary axis vectors V1, V2

CYCLE997		Workpiece measurements	
Parameter GUD5	Type	**Possible measurements** **G17: X-Y plane** **G18: Z-X plane** **G19: Y-Z plane**	
		Measuring with automatic ZO correction	
		1 sphere	**1 sphere**
_FA	REAL >0	Measurement path in mm	
_INCA	REAL	Incremental angle (for _MVAR=xx1109 only, measuring at an angle)	
_KNUM	INT	without/with automatic offset of the ZO memory **0** without offset	
		1..99 automatic offset in ZO G54...G57 G505...G599 **1000.** automatic offset in basic frame G500 **1011...1026** automatic ZO correction in 1st to 16th channel basic frame **1051...1066** automatic ZO correction in 1st to 16th global basic frame **2000** automatic ZO correction in system frame **9999** automatic ZO correction in active frame G54...G57,G505...G599 or with active G500 in the last active channel-specific basic frame	**1..99** automatic offset in ZO G54...G57 G505...G599 **1000** automatic offset in basic frame G500 **1011...1026** automatic ZO correction in 1st to 16th channel basic frame **2000** automatic ZO correction in system frame **9999** automatic ZO correction in active frame G54...G57,G505...G599 or with active G500 in the last active channel-specific basic frame

<table>
<tr><th colspan="2">CYCLE997</th><th colspan="2">Workpiece measurements</th></tr>
<tr><td rowspan="3">_MVAR</td><td rowspan="3">INT
>0</td><td colspan="2">Measuring variant</td></tr>
<tr><td>x0xxxx</td><td>x1xxxx</td></tr>
<tr><td colspan="2">7 6 5 4 3 2 1
109 Measure sphere and ZO determination without measurement repeat
119 Measure sphere and ZO determination with measurement repeat
0 Measurement paraxial (to axes of the WCS)
1 Measure at an angle (intermediate positioning on circular path)
0 Measure 1 sphere
1 Measure 3 spheres
01 3 meas. points for circle determination, for measuring at an angle only
10 4 meas. points for circle determination, for measuring at an angle only
0 Without diameter determination (sphere diameter known)
1 With diameter determination</td></tr>
<tr><td>_NMSP</td><td>INT
>0</td><td colspan="2">Number of measurements at the same location</td></tr>
<tr><td>_PRNUM</td><td>INT
>0</td><td colspan="2">Workpiece probe number (for multi probe only)
Values: 1 to maximum 99
(number of the data field assigned to the workpiece probe
GUD6:_WP[_PRNUM–1]</td></tr>
<tr><td>_RF</td><td>REAL</td><td colspan="2">Velocity for intermediate paths on circular path (G2 or G3)
(or _MVAR=xx1109 only, measuring at an angle)</td></tr>
<tr><td>_SETV[8]</td><td>REAL</td><td colspan="2">Setpoints, center point of the spheres (balls)</td></tr>
<tr><td>_STA1</td><td>REAL</td><td colspan="2">Starting angle (for _MVAR=xx1109 only, measuring at an angle)</td></tr>
<tr><td>_TNVL</td><td>REAL</td><td>----</td><td>Limit for triangle distortion
(for _MVAR=x1x109 only, measure 3 spheres and ZO correction)</td></tr>
<tr><td>_TSA</td><td>REAL</td><td colspan="2">Safe area</td></tr>
<tr><td>_VMS</td><td>REAL
>=0</td><td colspan="2">Variable measuring velocity
(for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))</td></tr>
</table>

<table>
<tr><th colspan="2">CYCLE998</th><th colspan="2">Workpiece measurements</th></tr>
<tr><td rowspan="3">Parameter
GUD5</td><td rowspan="3">Type</td><td colspan="2">Possible measuring axes
Abscissa (_MA=1) / ordinate (_MA=2) / applicate (_MA=3)
for G17: X=1 / Y=2 / Z=3
for G18: Z=1 / X=2 / Y=3
for G19: Y=1 / Z=2 / X=3</td></tr>
<tr><td colspan="2">Measuring with automatic ZO correction</td></tr>
<tr><td>1 angle</td><td>1 angle</td></tr>
<tr><td>_CALNUM</td><td>INT</td><td colspan="2">----</td></tr>
<tr><td>_CORA</td><td>REAL
0...359.5</td><td colspan="2">Offset angular position
(only active if mono probe)</td></tr>
<tr><td>_CPA</td><td>REAL</td><td colspan="2">----</td></tr>
<tr><td>_CPO</td><td>REAL</td><td colspan="2">----</td></tr>
<tr><td>_EVNUM</td><td>INT</td><td colspan="2">----</td></tr>
<tr><td>_FA</td><td>REAL
>0</td><td colspan="2">Measurement path in mm</td></tr>
</table>

CYCLE998		Workpiece measurements	
_ID	REAL	Distance between measuring points P1 and P2 in offset axis	Distance between measuring points P1 and P2 in abscissa
_INCA	REAL	----	Setpoint or angle in ordinate
_K	INT	----	
_KNUM	INT	without/with automatic offset of the ZO memory 0 without offset	
		1...99	automatic offset in ZO G54...G57 G505...G599
		1000	automatic offset in basic frame G500
		1011...1026	automatic ZO correction in 1st to 16th basic frame
		2000	automatic ZO in system frame
		9999	automatic ZO correction in active frame G54...G57, G505...G599 or with active G500 in the last active channel-specific basic frame
_MA	INT >0	Offset axis/measuring axis 102: Offset axis 301: Measuring axis	----
_MD	INT	for _MVAR=1xx10x only	for _MVAR=1xx10x only
_MVAR	INT >0	Measuring variant	
		105	106
		1105 (Difference measurement not with mono probe)	----
_NMSP	INT	Number of measurements at the same location	
_PRNUM	INT >0	Probe type/workpiece probe number 3 2 1 2-digit number Calibrate 2-digit number in hole with unknown center 1 Mono probe 0 Multi probe (number of the data field assigned to the workpiece probe GUD6:_WP[_PRNUM(2-digit)-1])	
_RA	INT	_RA=0: coordinate system is rotated _RA>0: Number of round axis in which the correction is undertaken	----
_RF	REAL	----	----
_SETVAL	REAL	Setpoint at measuring point 1 in the measuring axis (not for _MVAR 1xx10x)	Setpoint at measuring point P1 in the applicate (not for _MVAR 1xx10x)
_SETV[0]	REAL	----	Distance between measuring points P1 and P3 in ordinate
_STA1	REAL	Setpoint angle	Setpoint for angle about the abscissa
_SZA	REAL	----	
_SZO	REAL	----	
_TDIF	REAL	----	

CYCLE998		Workpiece measurements
_TMV	REAL	----
_TNAME	STRING [ ]	----
_TNUM	INT	----
_TUL	REAL	----
_TLL	REAL	----
_TSA	REAL	Safe area angle
_TZL	REAL	----
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))

Result parameters calibration										
						CYCLE:	971	982	973	976
GUD5	Data type	Meaning								
_OVR [0]	REAL						----	----	----	----
_OVR [1]	REAL						----	----	----	----
_OVR [2]	REAL						----	----	----	----
_OVR [3]	REAL						----	----	----	----
_OVR [4]	REAL	Actual value	Probe ball diameter				----	----		
_OVR [5]	REAL	Difference	Probe ball diameter				----	----		
_OVR [6]	REAL	Center of hole				Abscissa	----	----	----	
_OVR [7]	REAL	Center of hole				Ordinate	----	----	----	
_OVR [8]	REAL	Trigger point	Minus	Direction	Actual value	Abscissa				
_OVR [9]	REAL	Trigger point	Minus	Direction	Difference	Abscissa				
_OVR [10]	REAL	Trigger point	Plus	Direction	Actual value	Abscissa				
_OVR [11]	REAL	Trigger point	Plus	Direction	Difference	Abscissa				
_OVR [12]	REAL	Trigger point	Minus	Direction	Actual value	Ordinate				
_OVR [13]	REAL	Trigger point	Minus	Direction	Difference	Ordinate				
_OVR [14]	REAL	Trigger point	Plus	Direction	Actual value	Ordinate				
_OVR [15]	REAL	Trigger point	Plus	Direction	Difference	Ordinate				
_OVR [16]	REAL	Trigger point	Minus	Direction	Actual value	Applicate		----	----	
_OVR [17]	REAL	Trigger point	Minus	Direction	Difference	Applicate		----	----	
_OVR [18]	REAL	Trigger point	Plus	Direction	Actual value	Applicate		----	----	
_OVR [19]	REAL	Trigger point	Plus	Direction	Difference	Applicate		----	----	
_OVR [20]	REAL	Positional deviation				Abscissa	----	----		
_OVR [21]	REAL	Positional deviation				Ordinate	----	----		
_OVR [22]	REAL	Probe length of the workpiece probe					----	----	----	
_OVR [23]	REAL						----	----	----	----

Result parameters calibration						
		CYCLE:	971	982	973	976
GUD5	Data type	Meaning				
`_OVR [24]`	REAL	Angle at which the trigger points were determined	----	----	----	
`_OVR [25]`	REAL		----	----	----	----
`_OVR [26]`	REAL		----	----	----	----
`_OVR [27]`	REAL	Zero offset area				
`_OVR [28]`	REAL	Safe area				
`_OVR [29]`	REAL		----	----	----	----
`_OVI [0]`	INT		----	----	----	----
`_OVI [1]`	INT		----	----	----	----
`_OVI [2]`	INT	Measuring cycle number				
`_OVI [3]`	INT	Measurement variant			----	----
`_OVI [4]`	INT			----	----	----
`_OVI [5]`	INT	Probe number				
`_OVI [6]`	INT		----	----	----	----
`_OVI [7]`	INT		----	----	----	----
`_OVI [8]`	INT		----	----	----	----
`_OVI [9]`	INT	Alarm number				

Result parameters measurement (turning machines)					
GUD5	Data type	Meaning	CYCLE974	CYCLE994	CYCLE982
`_OVR [0]`	REAL	Setpoint	Measuring axis	Diameter/radius	----
`_OVR [1]`	REAL	Setpoint	Abscissa	Abscissa	----
`_OVR[2]`	REAL	Setpoint	Ordinate	Ordinate	----
`_OVR[3]`	REAL	Setpoint	Applicate	Applicate	----
`_OVR[4]`	REAL	Actual value	Measuring axis	Diameter/radius	----
`_OVR[5]`	REAL	Actual value	Abscissa	Abscissa	----
`_OVR[6]`	REAL	Actual value	Ordinate	Ordinate	----
`_OVR[7]`	REAL	Actual value	Applicate	Applicate	----
`_OVR[8]`	REAL	Tolerance top limit 1)	Measuring axis	Diameter/radius	----
		Actual value	----	----	Length L1
`_OVR[9]`	REAL	Difference	----	----	Length L1
`_OVR[10]`	REAL	Actual value	----	----	Length L2
`_OVR[11]`	REAL	Difference	----	----	Length L2
`_OVR[12]`	REAL	Tolerance lower limit 1)	Measuring axis	Diameter/radius	----
		Actual value	----	----	Radius only CYCLE982
`_OVR[13]`	REAL	Difference	----	----	Radius only CYCLE982
`_OVR[14]`	REAL		----	----	----

Result parameters measurement (turning machines)					
GUD5	Data type	Meaning	CYCLE974	CYCLE994	CYCLE982
_OVR[15]	REAL		----	----	----
_OVR[16]	REAL	Difference	Measuring axis	Diameter/radius	----
_OVR[17]	REAL	Difference	Abscissa	Abscissa	----
_OVR[18]	REAL	Difference	Ordinate	Ordinate	----
_OVR[19]	REAL	Difference	Applicate	Applicate	----
_OVR[20]	REAL	Compensation value			
_OVR[21]	REAL		----	----	----
_OVR[22]	REAL		----	----	----
_OVR[23]	REAL		----	----	----
_OVR[24]	REAL		----	----	----
_OVR[25]	REAL		----	----	----
_OVR[26]	REAL		----	----	----
_OVR[27]	REAL	Zero offset range1)			
_OVR[28]	REAL	Safe area			
_OVR[29]	REAL	Permissible dimension difference1)			
_OVR [30]	REAL	Empirical value			
_OVR [31]	REAL	Mean value1)			----
_OVI [0]	INT	D number / ZO number			----
_OVI [1]	INT		----	----	----
_OVI [2]	INT	Measuring cycle number			
_OVI [3]	INT	Measurement variant	----	----	----
_OVI [4]	INT	Weighting factor1)			----
_OVI [5]	INT	Probe number			
_OVI [6]	INT	Mean value memory no. 1)			----
_OVI [7]	INT	Empirical value memory no.			----
_OVI [8]	INT	Tool number			
_OVI [9]	INT	Alarm number			
_OVI [11]	INT	Status offset request2)	----	----	----
_OVI [12]	INT	Internal error number	----	----	----
1) for automatic tool offset only 2) for automatic ZO correction only					

Result parameters measurement (milling and machining centers)						
GUD5	Type	Meaning	CYCLE961	CYCLE997	CYCLE998	
					1 angle	2 angle
_OVR [0]	REAL	Setpoint	----	Sphere diameter 1st sphere	Angle	Angle about abscissa
_OVR [1]	REAL	Setpoint	----	Center point coordinates for abscissa 1st sphere	----	Angle about ordinate

Result parameters measurement (milling and machining centers)						
GUD5	Type	Meaning	CYCLE961	CYCLE997	CYCLE998	
					1 angle	2 angle
_OVR [2]	REAL	Setpoint	----	Center point coordinates for ordinate 1st sphere	----	----
_OVR [3]	REAL	Setpoint	----	Center point coordinates for applicate 1st sphere	----	----
_OVR [4]	REAL	Actual value	Angle with abscissa axis (WCS)	Sphere diameter 1st sphere	Angle	Angle about abscissa
_OVR [5]	REAL	Actual value	Corner point in abscissa (WCS)	Center point coordinates for abscissa 1st sphere	----	Angle about ordinate
_OVR [6]	REAL	Actual value	Corner point in ordinate (WCS)	Center point coordinates for ordinate 1st sphere	----	----
_OVR [7]	REAL	Actual value	----	Center point coordinates for applicate 1st sphere	----	----
_OVR [8]	REAL	Difference	----	Sphere diameter 1st sphere	----	----
_OVR [9]	REAL	Difference	----	Center point coordinates for abscissa 1st sphere		
_OVR [10]	REAL	Difference	----	Center point coordinates for ordinate 1st sphere		
_OVR [11]	REAL	Difference	----	Center point coordinates for applicate 1st sphere		
_OVR [12]	REAL	Actual value	----	Sphere diameter 2nd sphere [1)]	----	
_OVR [13]	REAL	Actual value	----	Center point coordinates for abscissa 2nd sphere[1)]	----	
_OVR [14]	REAL	Actual value	----	Center point coordinates for ordinate 2nd sphere[1)]	----	
_OVR [15]	REAL	Actual value	----	Center point coordinates for applicate 2nd sphere[1)]	----	
_OVR [16]	REAL	Difference	----	Sphere diameter 2nd sphere [1)]	Angle	Angle about abscissa
_OVR [17]	REAL	Difference	----	Center point coordinates for abscissa 2nd sphere[1)]	----	Angle about ordinate
_OVR [18]	REAL	Difference	----	Center point coordinates for ordinate 2nd sphere[1)]	----	----
_OVR [19]	REAL	Difference	----	Center point coordinates for applicate 2nd sphere[1)]	----	----
_OVR [20]	REAL	Actual value	Angle with abscissa axis (MCS)	Sphere diameter 3rd sphere[1)]	----	----
		Compensation value	----	----	Angle	----
_OVR [21]	REAL	Actual value	Corner point in abscissa (MCS)	Center point coordinates for abscissa 3rd sphere[1)]	----	----
		Compensation value	----	----		Angle about abscissa

Result parameters measurement (milling and machining centers)						
GUD5	Type	Meaning	CYCLE961	CYCLE997	CYCLE998	
					1 angle	2 angle
_OVR [22]	REAL	Actual value	Corner point in ordinate (MCS)	Center point coordinates for ordinate 3rd sphere 1)	----	----
		Compensation value	----	----		Angle about ordinate
_OVR [23]	REAL	Actual value	----	Center point coordinates for applicate 3rd sphere 1)	----	----
		Compensation value	----	----	----	Angle about applicate
_OVR [24]	REAL	Difference	----	Sphere diameter 3rd sphere 1)	----	----
_OVR [25]	REAL	Difference	----	Center point coordinates for abscissa 3rd sphere 1)	----	----
_OVR [26]	REAL	Difference	----	Center point coordinates for ordinate 3rd sphere 1)	----	----
_OVR [27]	REAL	Difference	----	Center point coordinates for applicate 3rd sphere 1)	----	----
_OVR [28]	REAL	Safe area	----			
_OVR [30]	REAL	Empirical value	----	----		
_OVR [31]	REAL	Mean value	----	----	----	----
			----	----	----	----
_OVI [0]	INT	ZO number	----			
_OVI [1]	INT		----	----	----	----
_OVI [2]	INT	Measuring cycle number				
_OVI [3]	INT	Measuring variant		----	----	----
_OVI [4]	INT	Weighting factor	----	----	----	----
_OVI [5]	INT	Probe no.				
_OVI [6]	INT	mean value memory number	----	----	----	----
_OVI [7]	INT	Empirical value memory number	----	----		
_OVI [8]	INT	Tool number	----	----	----	----
_OVI [9]	INT	Alarm number				
_OVI[10			----			
_OVI [11]	INT	Status offset request	----			
_OVI12]	INT	internal error no.	----	Internal measurement evaluation	----	----
1) for measuring variants _MVAR=x1x109 only, measure 3 spheres						

Result parameters measurement (milling and machining centers)						
GUD5	Type	Meaning	CYCLE977		CYCLE978	CYCLE979
			_MVAR=xxx1 to _MVAR=xxx4	_MVAR=xxx5 _MVAR=xxx6		
`_OVR [0]`	REAL	Setpoint	Hole	----	Measuring axis	Hole
			Shaft	----		Shaft
			Groove	----		Groove
			Web	----		Web
		Setpoint rectangle length	----	Abscissa	----	----
`_OVR [1]`	REAL	Setpoint center point/center	Abscissa	----	Abscissa	Abscissa
		Setpoint rectangle length	----	Ordinate	----	----
`_OVR [2]`	REAL	Setpoint center point/center	Ordinate	----	Ordinate	Ordinate
		Setpoint for rectangle center point	----	Abscissa	----	----
`_OVR [3]`	REAL	Setpoint	----	----	Applicate	----
		Setpoint for rectangle center point	----	Ordinate	----	----
`_OVR [4]`	REAL	Actual value for diameter/width	Hole	----	Measuring axis	Hole
			Shaft	----		Shaft
			Groove	----		Groove
			Web	----		Web
		Actual value rectangle length	----	Abscissa	----	----
`_OVR [5]`	REAL	Actual value center point/center	Abscissa	----	----	Abscissa
		Actual value rectangle length	----	Ordinate	----	----
`_OVR [6]`	REAL	Actual value	Ordinate	----	----	Ordinate
		Actual value rectangle center point	----	Abscissa	----	----
`_OVR [7]`	REAL	Actual value	----	----	----	----
		Actual value rectangle center point	----	Ordinate	----	----
`_OVR [8]` [1)]	REAL	Upper tolerance limit diameter/width	Hole	----	Measuring axis	Hole
			Shaft	----		Shaft
			Groove	----		Groove
			Web	----		Web
		Upper tolerance limit rectangle length	----	Abscissa	----	----
`_OVR [9]` [1)]	REAL	Upper tolerance limit rectangle length	----	Ordinate	----	----
`_OVR [10]`	REAL		----	----	----	----
`_OVR [11]`	REAL		----	----	----	----

Result parameters measurement (milling and machining centers)						
			CYCLE977		CYCLE978	CYCLE979
_OVR [12] 1)	REAL	Lower tolerance limit diameter/width	Hole	----	Measuring axis	Hole
			Shaft	----		Shaft
			Groove	----		Groove
			Web	----		Web
		Lower tolerance limit rectangle length	----	Abscissa	----	----
_OVR [13] 1)	REAL	Lower tolerance limit rectangle length	----	Ordinate	----	----
_OVR [14]	REAL		----	----	----	----
_OVR [15]	REAL		----	----	----	----
_OVR [16]	REAL	Difference diameter/width	Hole	----	Measuring axis	Hole
			Shaft	----		Shaft
			Groove	----		Groove
			Web	----		Web
		Difference rectangle length	----	Abscissa	----	----
_OVR [17] 1)	REAL	Difference center point/center	Abscissa	----	----	Abscissa
		Difference rectangle length	----	Ordinate	----	----
_OVR [18] 1)	REAL	Difference center point/center	Ordinate	----	----	Ordinate
		Difference of rectangle center point	----	Abscissa	----	----
_OVR [19] 1)	REAL	Difference of rectangle center point	----	Ordinate	----	----
_OVR [20] 1)	REAL	Compensation value	1)	1)	1)	1)
_OVR [21] 1)	REAL		----	----	----	----
_OVR [22] 1)	REAL		----	----	----	----
_OVR [23] 1)	REAL		----	----	----	----
_OVR [24] 1)	REAL		----	----	----	----
_OVR [25] 1)	REAL		----	----	----	----
_OVR [26] 1)	REAL		----	----	----	----
_OVR [27] 1)	REAL	Zero offset area	1)	1)	1)	1)
_OVR [28] 1)	REAL	Safe area				1)
_OVR [29] 1)	REAL	Permissible dimensional difference	1)	1)	1)	1)
_OVR [30] 1)	REAL	Empirical value	1)	1)		1)
_OVR [31] 1)	REAL	Mean value	1)	1)	1)	1)
_OVI [0] 1)	INT	D no./ZO no.				
_OVI [1] 1)	INT		----	----	----	----
_OVI [2] 1)	INT	Measuring cycle number				
_OVI [3] 1)	INT	Measuring variant				
_OVI [4] 1)	INT	Weighting factor	1)	1)	1)	1)

Result parameters measurement (milling and machining centers)						
			CYCLE977		CYCLE978	CYCLE979
_OVI [5] 1)	INT	Probe number				
_OVI [6] 1)	INT	Mean value memory number	1)	1)	1)	1)
_OVI [7] 1)	INT	Empirical value memory no.	1)	1)		1)
_OVI [8] 1)	INT	Tool number				
_OVI [9] 1)	INT	Alarm number				
_OVI [11] 1)	INT	Status offset request (for ZO compensation only)				
_OVI12] 1)	INT		----	----	----	----
_OVI13] 1)	INT	DL number (from measuring cycles SW 6.3)	1)	1)	1)	1)
1) for workpiece measurement with tool offset only						

Result parameters measurement (milling and machining centers, CYCLE996)		
GUD5	Type	Meaning
_OVR [0]	REAL	----
_OVR[1]	REAL	Offset vector I1 $TC_CARR1[n], X component
_OVR[2]	REAL	Offset vector I1 $TC_CARR2[n], Y component
_OVR[3]	REAL	Offset vector I1 $TC_CARR3[n], Z component
_OVR[4]	REAL	Offset vector I2 $TC_CARR4[n], X component
_OVR[5]	REAL	Offset vector I2 $TC_CARR5[n], Y component
_OVR[6]	REAL	Offset vector I2 $TC_CARR6[n], Z component
_OVR[7]	REAL	Rotary axis vector V1 $TC_CARR7[n], X component
_OVR [8]	REAL	Rotary axis vector V1 $TC_CARR8[n], Y component
_OVR [9]	REAL	Rotary axis vector V1 $TC_CARR9[n], Z component
_OVR[10]	REAL	Rotary axis vector V2 $TC_CARR10[n], X component
_OVR[11]	REAL	Rotary axis vector V2 $TC_CARR11[n], Y component
_OVR [12]	REAL	Rotary axis vector V2 $TC_CARR12[n], Z component
_OVR[15]	REAL	Offset vector I3 $TC_CARR15[n], X component
_OVR[16]	REAL	Offset vector I3 $TC_CARR16[n], Y component
_OVR [17]	REAL	Offset vector I3 $TC_CARR17[n], Z component
_OVR [18]	REAL	Offset vector I4 $TC_CARR18[n], X component
_OVR [19]	REAL	Offset vector I4 $TC_CARR19[n], Y component
_OVR [20]	REAL	Offset vector I4 $TC_CARR20[n], Z component
_OVI [0]	INT	----
_OVI [1]	INT	----
_OVI [2]	INT	Measuring cycle number = 996
_OVI [3]	INT	Measurement variant (_MVAR)
_OVI [4]	INT	----

Result parameters measurement (milling and machining centers, CYCLE996)		
GUD5	Type	Meaning
_OVI [5]	INT	----
_OVI [6]	INT	----
_OVI [7]	INT	----
_OVI [8]	INT	Number of swivel data record (_TNUM)
_OVI [9]	INT	Alarm number

NC machine data					
MD number	Identifier	Description	Max. input value	Default value	Value for meas. cycles
10132	MMC-CMD-TIMEOUT	Monitoring time for MMC command in part program	100	1	3
11420	LEN_PROTOCOL_FILE	File size for log files	100	1	5
13200	MEAS_PROBE_LOW_ACTIV	Switching characteristics of probe 0= 0V → 24V; 1= 24V → 0V	TRUE	0	0
18118	MM_NUM_GUD_MODULES	Number of data blocks	9	7	7
18120	MM_NUM_GUD_NAMES_NCK	Number of GUD variable names in the control	plus	10	30
18130	MM_NUM_GUD_NAMES_CHAN	Number of GUD variable names per channel	plus	40	130
18150	MM_GUD_VALUES_MEM	Memory for values of the GUD variables	plus0	12/16 1)	28/32 1)
18170	MM_NUM_MAX_FUNC_NAMES	No. of miscellaneous functions (cycles, DRAM)	plus	40	70
18180	MM_NUM_MAX_FUNC_PARAM	No. of miscellaneous functions (cycles, DRAM)	plus	300	600
28020	MM_NUM_LUD_NAMES_TOTAL	Number of LUD variables in total (in all program levels)	plus	200	200
28040	MM_NUM_LUD_VALUES_MEM	Memory for values of the LUD variables	plus	12/25 1)	14/27 1)
28082	MM_SYSTEM_FRAME_MASK (as from measuring cycle SW 6)	Channel-specific system frames	7FH	21H	21H (Bit0, 5=1)
1) for hardware NCU 3					

NC machine data for measuring in JOG					
11602	ASUP_START_MASK	Ignore stop conditions for ASUB	3	0	1, 3 Bit0=1
11604	ASUP_START_PRIO_LEVEL	Priority for "ASUP_START_MASK effective"	64H	0	From 1 to 64H
20110	RESET_MODE_MASK	Define control default setting after power-up and RESET	07FFFH	0	min. 4045H (Bit0, 2, 6, 14=1)
20112	START_MODE_MASK	Define control default setting after part program start	07FFFH	400H	400H (Bit6=0)

Cycle data The measuring cycle data are stored in blocks GUD5 and GUD6.			
Central values			
Block	Identifier	Description	As-delivered value
	_TP[ ]	Tool probe(machine-related)	
	Assignment for milling		
GUD6	_TP[k,0]	Trigger point in minus direction X (1st geometry axis)	0
GUD6	_TP[k,1]	Trigger point in plus direction X (1st geometry axis)	0
GUD6	_TP[k,2]	Trigger point in minus direction Y (2nd geometry axis)	0
GUD6	_TP[k,3]	Trigger point in plus direction Y (2nd geometry axis)	0
GUD6	_TP[k,4]	Trigger point in minus direction Z (3rd geometry axis)	0
GUD6	_TP[k,5]	Trigger point in plus direction Z (3rd geometry axis)	0
GUD6	_TP[k,6]	Edge length/disk diameter	0
GUD6	_TP[k,7]	Assigned internally	133
GUD6	_TP[k,8]	Probe type 0: Cube 101: Disk in XY 201: Disk in ZX 301: disk in YZ	0
GUD6	_TP[k,9]	Distance between upper edge of tool probe and lower edge of tool	2
	Assignment for turning		
GUD6	_TP[k,0]	Trigger point in minus direction, abscissa	0
GUD6	_TP[k,1]	Trigger point in plus direction, abscissa	0
GUD6	_TP[k,2]	Trigger point in minus direction, ordinate	0
GUD6	_TP[k,3]	Trigger point in plus direction, ordinate	0
GUD6	_TP[k,4]	irrelevant	0
	to		
GUD6	_TP[k,9]	irrelevant	0
	_TPW[ ]	Tool probe(workpiece-related)	

Cycle data The measuring cycle data are stored in blocks GUD5 and GUD6.			
Central values			
Block	Identifier	Description	As-delivered value
	Assignment for milling		
GUD6	_TPW[k,0]	Trigger point in minus direction X (1st geometry axis)	0
GUD6	_TPW[k,1]	Trigger point in plus direction X (1st geometry axis)	0
GUD6	_TPW[k,2]	Trigger point in minus direction Y (2nd geometry axis)	0
GUD6	_TPW[k,3]	Trigger point in plus direction Y (2nd geometry axis)	0
GUD6	_TPW[k,4]	Trigger point in minus direction Z (3rd geometry axis)	0
GUD6	_TPW[k,5]	Trigger point in plus direction Z (3rd geometry axis)	0
GUD6	_TPW[k,6]	Edge length/disk diameter	0
GUD6	_TPW[k,7]	Assigned internally	133
GUD6	_TPW[k,8]	Probe type 0: Cube 101: Disk in XY 201: Disk in ZX 301: disk in YZ	0
GUD6	_TPW[k,9]	Distance between upper edge of tool probe and lower edge of tool	2
	Assignment for turning		
GUD6	_TPW[k,0]	Trigger point in minus direction, abscissa	0
GUD6	_TPW[k,1]	Trigger point in plus direction, abscissa	0
GUD6	_TPW[k,2]	Trigger point in minus direction, ordinate	0
GUD6	_TPW[k,3]	Trigger point in plus direction, ordinate	0
GUD6	_TPW[k,4]	irrelevant	0
	to		
GUD6	_TPW[k,9]	irrelevant	0
	_WP[ ]	Workpiece probe	
GUD6	_WP[k,0]	Ball diameter	6
GUD6	_WP[k,1]	Trigger point in minus direction of abscissa	3
GUD6	_WP[k,2]	Trigger point in plus direction of abscissa	-3
GUD6	_WP[k,3]	Trigger point in minus direction of ordinate	3
GUD6	_WP[k,4]	Trigger point in plus direction of ordinate	-3
GUD6	_WP[k,5]	Trigger point in minus direction of applicate	3
GUD6	_WP[k,6]	Trigger point in plus direction of applicate	-3
GUD6	_WP[k,7]	Position deviation abscissa	0
GUD6	_WP[k,8]	Position deviation ordinate	0
GUD6	_WP[k,9]	Calibration status, coded	0
GUD6	_WP[k,10]	Calibration status, coded	0

Central values			
Block	**Identifier**	**Description**	**As-delivered value**
	_KB[ ]	**Gauging block**	
GUD6	_KB[k,0]	Groove edge in plus direction, ordinate	0
GUD6	_KB[k,1]	Groove edge in minus direction, ordinate	0
GUD6	_KB[k,2]	Groove base in abscissa	0
GUD6	_KB[k,3]	Groove edge in plus direction, abscissa	0
GUD6	_KB[k,4]	Groove edge in minus direction, abscissa	0
GUD6	_KB[k,5]	Upper edge groove in ordinate	0
GUD6	_KB[k,6]	Groove base in ordinate	0
	_CM[ ]	**Monitoring functions** **_CM[k,0] to _CM[k,7] only active if _CBIT[12] = 0** **_CM[k,8] only active if _CBIT[7]=1**	
GUD6	_CM[k,0]	Max. permissible peripheral speed [m/min]/[feet/min]	60
GUD6	_CM[k,1]	Max. permissible speed [rpm]	2000
GUD6	_CM[k,2]	Minimum feedrate for probing [mm/min]	1
GUD6	_CM[k,3]	Required measuring accuracy [mm]	0,005
GUD6	_CM[k,4]	Max. permissible feedrate for probing	20
GUD6	_CM[k,5]	Direction of spindle rotation	4
GUD6	_CM[k,6]	Feed factor 1	10
GUD6	_CM[k,7]	Feed factor 2	0
GUDS6	_CM[k,8]	Field for tolerance parameter of rotary axis positions	0.5
	_MFS[ ]	**Speed and feedrate _CBIT[12] = 1**	
GUD6	_MFS[k,0]	Speed 1st probing	0
GUD6	_MFS[k,1]	Feed 1st probing	0
GUD6	_MFS[k,2]	Speed 2nd probing	0
GUD6	_MFS[k,3]	Feed 2nd probing	0
GUD6	_MFS[k,4]	Speed 3rd probing	0
GUD6	_MFS[k,5]	Feed 3rd probing	0

Central bits			
Block	**Identifier**	**Description**	**As-delivered value**
	_CBIT[ ]	**Central bits**	
GUD6	_CBIT[0]	Measurement repetition after violation of dimensional difference and safe area 0: no measurement repeat 1: measurement repeat, up to 4	0
GUD6	_CBIT[1]	Alarm and M0 for measurement repeat with _CBIT[0]=1 0: no alarm, no M0 generated 1: M0 and an alarm are generated before each repeat	0

Central bits			
Block	**Identifier**	**Description**	**As-delivered value**
GUD6	_CBIT[2]	M0 for tolerance alarms "oversize", "undersize", "permissible dimensional difference exceeded" 0: no generation of M0 for the above alarms 1: generation of M0 for the above alarms	0
GUD6	_CBIT[3]	currently not assigned	0
GUD6	_CBIT[4]	currently not assigned	0
GUD6	_CBIT[5]	Tool measurement and calibration in the WCS in CYCLE982 (from measuring cycles SW 5.4) 0: machine-related measurement and calibration 1: workpiece-related measurement and calibration Note: In both cases, the _TP[ ] field of the probe is used. From measuring cycles SW 6.3, function switchover via _MVAR is available.	0
GUD6	_CBIT[6]	Logging without output of the measuring cycle name and measuring variant (from measuring cycles SW 6.2) 0: Measuring cycle name and measuring variant will be output. 1: These outputs will be suppressed.	0
GUD6	_CBIT[7]	currently not assigned	0
GUD6	_CBIT[8]	Offset of the mono probe setting 0: No compensation 1: offset of spindle by angle _CORA,	0
GUD6	_CBIT[9]	Assigned internally	0
GUD6	_CBIT[10]	currently not assigned	0
GUD6	_CBIT[11]	Selection of log header for logging 0: Standard 1: user-defined	0
GUD6	_CBIT[12]	Feed and speed in CYCLE971 0: calculation by measuring cycle itself 1: set by user in array _MFS[ ]	0
GUD6	_CBIT[13]	currently not assigned	0
GUD6	_CBIT[14]	Length reference of the workpiece probe in milling measuring cycles (from measuring cycles SW 4.5) 0: length relative to probe ball center 1: length relative to end	0
GUD6	_CBIT[15]	Transfer of workpiece probe data into the tool offset in CYCLE976 (from measuring cycles SW 4.5) 0: No transfer 1: result of probe ball calculation on calibration will be entered in the geometry memory of the workpiece probe (radius)	0

Channel-oriented values			
Block	**Identifier**	**Description**	**As-delivered value**
	_EVMVNUM	**Number of empirical values and mean values**	
GUD6	_EVMVNUM[0]	Number of empirical values	20
GUD6	_EVMVNUM[1]	Number of mean values	20
	_SPEED	**Traversing velocities for intermediate positioning**	
GUD6	_SPEED[0]	Max. rapid traverse in % (only active with collision monitoring switched off, max 100 %)	100
GUD6	_SPEED[1]	Positioning velocity in the plane with collision monitoring active	1000
GUD6	_SPEED[2]	Positioning velocity applicate	1000
GUD6	_SPEED[3]	Fast measuring feed	900
	_EV	**Empirical values**	
GUD5	_EV[x]	Empirical value	0
	_MV	**Mean values**	
GUD5	_MV[x]	Mean value	0

Channel-specific values (for measuring in JOG, GUD7_MC)			
Block	**Identifier**	**Description**	**As-delivered value**
GUD7	E_MESS_IS_METRIC E_MESS_IS_METRIC_SPEZ_VAR=1	All dimensioned data are metric	1
GUD7	E_MESS_MS_IN	Measurement input 1 for workpiece measurement	0
GUD7	E_MESS_MT_IN	Measurement input 2 for tool measurement	1
GUD7	E_MESS_D	Internal data item	5
GUD7	E_MESS_D_M	Measuring path for manual measuring [mm] (in front of and behind meas. point)	50
GUD7	E_MESS_D_L	Measuring path for length measurement [mm] (in front of and behind the measuring point) for tool measurement	2
GUD7	E_MESS_D_R	Measuring path for radius measurement [mm] (in front of and behind the measuring point) for tool measurement	1
GUD7	E_MESS_FM	Measuring feed [mm/rev]	300
GUD7	E_MESS_F	Plane feedrate for collision monitoring [mm/min]	2000
GUD7	E_MESS_FZ	Infeed feedrate for collision monitoring [mm/min]	2000
GUD7	E_MESS_CAL_D	Diameter, calibration ring	0
GUD7	E_MESS_CAL_L	Calibration dimension in the feed axis (referred to WCS)	0
GUD7	E_MESS_MAX_V	Max. peripheral speed for measuring with rotating spindle [m/min]	100
GUD7	E_MESS_MAX_S	Max. spindle speed for measuring with rotating spindle [rpm]	1000
GUD7	E_MESS_MAX_F	Max. feedrate for measuring with rotating spindle [mm/min]	20

Channel-specific values (for measuring in JOG, GUD7_MC)			
Block	Identifier	Description	As-delivered value
GUD7	E_MESS_MIN_F	Min. feed for measuring with rotating spindle for the 1st probing [mm/min]	1
GUD7	E_MESS_MIN_F_FAK1	On tool measurement with rotating spindle, traversal with 10 times measuring feed is performed in the 1st probing (limitation by E_MESS_MAX_F) [mm/min]	10
GUD7	E_MESS_MIN_F_FAK2	For tool measurement with rotating spindle, 2nd probing is performed with measuring feed. There is no 3rd probing [mm/min]	0
GUD7	E_MESS_MIN_D	Measuring accuracy for measuring with rotating spindle [mm/min]	0.01
GUD7	E_MESS_MS_MONO	Probe is treated as multi probe	0
GUD7	E_MESS_MS_SOUTH	Probe is used with reference to the probe sphere end	1
GUD7	E_MESS_MT_TYP[3]	Type of tool probe	0
GUD7	E_MESS_MT_AX[3]	Permissible axis directions for tool probe	133
GUD7	E_MESS_MT_DL[3] 1)	Diameter of tool probe for length measurement	0
GUD7	E_MESS_MT_DR[3] 1)	Diameter of tool probe for radius measurement	0
GUD7	E_MESS_MT_DZ[3]	Infeed for measurement tool probe diameter	2
GUD7	E_MESS_MT_DIR[3]	Approach direction in the plane tool probe	-1
GUD7	E_MESS_MT_D	Calibrate measurement path for tool probe and tool measurement with motionless spindle (before and after expected switching position)	10
GUD7	E_MESS_MT_FM	Calibrate measuring feed for tool probe and tool measurement with motionless spindle	100
GUD7	E_MESS_MT_CF	No tool probe make (manufacturer) specified	0
GUD7	E_MESS_MT_COMP	No offset of the measurement result on tool measurement with rotating spindle	0
GUD7	E_MESS[3]	Internal data item	
GUD7	E_MEAS	Internal data item	
GUD7	E_MESS_RETT	Internal data item	
GUD7	E_MESS_SETT[10]	Field for settings	
GUD7	E_MESS_AM	Internal data item	
1) During installation value input is mandatory here!			

Channel-oriented bits			
Block	**Identifier**	**Description**	**As-delivered value**
	_CHBIT	Channel bits	
GUD6	_CHBIT[0]	Measurement input for workpiece measurement 0: measurement input 1 1: measurement input 2	0
GUD6	_CHBIT[1]	Measurement input for tool measurement: 0: measurement input 1 1: measurement input 2	1
GUD6	_CHBIT[2]	Collision monitoring for intermediate positioning 0: OFF 1: ON	1
GUD6	_CHBIT[3]	Tool offset mode with tool measurement 0: first-time measurement (determining geometry) 1: remeasuring (determining wear)	0
GUD6	_CHBIT[4]	Mean value for workpiece measurement with automatic tool correction (_EVNUM>0) 0: no mean value derivation over several parts 1: with mean value formation and calculation	0
GUD6	_CHBIT[5]	Inclusion of empirical value (_EVNUM>0) 0: subtraction of actual value 1: addition to actual value	0
GUD6	_CHBIT[6]	Tool offset mode for workpiece measurement with automatic tool offset 0: Offset in wear 1: offset in geometry, delete wear From meas. cycles SW 6.3: For additive and setup offset and _CHBIT[8]=0: 0: offset in additive offset 1: offset in set-up offset, delete additive offset	0
GUD6	_CHBIT[7]	Measured value offset in CYCLE994 0: use of trigger values of the probe _WP[k,1] ... 1: use of the active ball diameter of the probe _WP[k,0]	0
GUD6	_CHBIT[8]	From meas. cycles SW 6.3: Offset mode for workpiece measurement with automatic tool offset 0: additive, setup offset according to _CHBIT[6] 1: offset additive in set-up offset, irrespective of _CHBIT[6]	0
GUD6	_CHBIT[9]	*currently not assigned*	0
GUD6	_CHBIT[10]	Measuring result display 0: OFF 1: ON	0

Channel-oriented bits			
Block	Identifier	Description	As-delivered value
	_CHBIT	Channel bits	
GUD6	_CHBIT[11]	Acknowledgment measurement result screen with NC start 0: OFF (If _CHBIT[18]=0, the display is automatically deselected at end of cycle.) 1: ON (M0 is generated in the cycle.)	0
GUD6	_CHBIT[12]	currently not assigned	0
GUD6	_CHBIT[13]	Coupling spindle position with coordinate rotation in active plane for workpiece measurement with multi probe 0: OFF 1: ON	0
GUD6	_CHBIT[14]	Adapt spindle positioning, if _CHBIT[13]=1 0: according to default 1: adapted angle values	0
GUD6	_CHBIT[15]	Number of measurements on failure to switch 0: up to 5 measurements 1: only 1 measurement	0
GUD6	_CHBIT[16]	Retraction velocity from the measuring point 0: velocity as for intermediate positioning 1: with percentage of rapid traverse velocity (_SPEED[0])(only active with collision monitoring ON) _CHBIT[2]=1)	0
GUD6	_CHBIT[17]	Feed during measurement 0: with feed in _VMS 1: During 1st measurement feed in _SPEED[3] During 2nd measurement with feed in _VMS	0
GUD6	_CHBIT[18]	Static measurement result display 0: effect as set in _CHBIT[11]. 1: only active if _CHBIT[11]=0: Measuring result display remains until next measuring cycle is called	0
GUD6	_CHBIT[19]	(CYCLE974 and CYCLE994 only): Special treatment of Y axis with G18 0: no special treatment 1: setpoint setting and parameterization (_SETVAL, _TUL, _TLL, SZO) for the Y axis (applicate) as for the parameterization of the ordinate (X axis). The tool offset is applied in the length that is active in the ordinate (X axis) (usually L1), as long as no other length has been set in _KNUM. The ZO compensation is applied in the specified ZO memory in the ordinate component (X axis).	0
GUD6	_CHBIT[20]	(CYCLE982 only): Suppression of the starting angle positioning _STA1 0: suppression OFF 1: suppression ON	0

Channel-oriented bits			
Block	**Identifier**	**Description**	**As-delivered value**
	_CHBIT	**Channel bits**	
GUD6	_CHBIT[21]	(CYCLE974, CYCLE977, CYCLE978, CYCLE979, CYCLE9997 only) Mode of ZO compensation 0: offset additive in FINE 1: offset in COARSE, delete FINE	0
GUD6	_CHBIT[22]	(CYCLE971 only): with rotating spindle and multiple measurement with rotating spindle and multiple measurement 0: last measurement with reduced speed if _CBIT[12]=0 1: no speed reduction	0
GUD6	_CHBIT[23]	From measuring cycles SW 6.3 (CYCLE982 only) Recoding of tool point direction during tool measurement 0: no recoding 1: internal recoding (tool point direction mirroring about X)	0

List of abbreviations

B

ASUB	Asynchronous subroutine
UI	User interface
CNC	Computerized Numerical Control Computerized numerical control
CPU	Central Processing Unit Central processing unit
DIN	Deutsche Industrie Norm (German Industry Standard)
DOS	Disk Operating System
DRF	Differential Resolver Function: Differential function for handwheel signaling
I/O	Input/Output
FM-NC	Function module - numerical control
GUD	Global User Data Global user data
IBN	Start up
JOG	JOGging: Setup mode
LUD	Local User Data
MD	Machine data
MCS	Machine coordinate system
MMC	Man-Machine Communication: User interface on numerical control systems for operator control, programming and simulation
MS	Microsoft (software manufacturer)
NC	Numerical Control: Numerical Control
NCK	Numerical Control Kernel: NC kernel with block preparation, traversing range, etc.
NCU	Numerical Control Unit: NCK hardware unit
ZO	Zero point offset
PCIN	Name of the SW for data exchange with the control
PG	Programming device
PLC	Programmable Logic Control Controller
Software	Software
TO	Tool Offset Tool offset
TOA	Tool Offset Active: Identifier (file type) for tool offsets
SR	Subprogram
V.24	Serial interface (definition of the exchange lines between DTE and DCE)
WCS	Workpiece coordinate system
TO	Tool offset

Parameter C

List of input/output variables for cycles

Name	Meaning in English	Meaning in German
_CALNUM	Calibration groove number	Number of the gauging block
_CBIT[30]	Central Bits	Field for NCK global bits
_CHBIT[16]	Channel Bits	Field for channel-specific bits
_CM[8]		Field: Monitoring functions for tool measurement with rotating spindle each with eight elements
_CORA	Correction angle position	Offset angle position
_CPA	Center point abscissa	Center point of abscissa
_CPO	Center point ordinate	Center point of ordinate
_CVAL[4]		Field: Number of elements each with e elements
_DIGIT		Number of decimal places
_DLNUM		DL number for setup or additive offset
_EV[20]		20 empirical value memories
_EVMVNUM[2]		Number of empirical values and mean values
_EVNUM		Number of empirical value memory
_FA	Factor for multipl. of measurem. path	Measurement path in mm
_HEADLINE[10]		10 strings for protocol headers
_ID	Infeed in applicate	Incremental infeed depth/offset
_INCA	Indexing angle	Following angle
_K	Weighting factor for averaging	Weighting factor
_KB[3,7]		Field: Gauging block data each with 7 elements
_KNUM		Compensation number
_MA	Number of measuring axis	Measuring axis
_MD	Measuring direction	Measuring direction
_MFS[ ]		Field: Feeds and speeds with measuring tools with rotating spindles each with 6 elements
_MV[20]		20 mean value memories
_MVAR	Measuring variant	Measuring variant
_NMSP	Number of measurements at same spot	Number of measurements at the same location
_OVI [20]		Field: Output values INT
_OVR [32]		Field: Output values REAL
_PRNUM	Probe type and probe number	Probe number
_PROTFORM[6]		Log formatting
_PROTNAME[2]		Name of log file
_PROTSYM[2]		Separator in the log
_PROTVAL[13]		Log header line
_RA	Number of rotary axis	Number

Name	Meaning in English	Meaning in German
_RF	Feedrate for circular interpolation	Feedrate in circular-path programming
_SETVAL	Setpoint value	Setpoint
_SETV[9]		Measure setpoints for square-rectangle
_SI[3]	System information	System information
_SPEED[4]		Field: Feed values
_STA1	Starting angle	Start angle
_SZA	Safety zone on workpiece abscissa	Protection zone in abscissa
_SZO	Safety zone on workpiece ordinate	Protection zone in ordinate
_TDIF	Tolerance dimensional difference check	Dimension difference check
_TENV		Name of tool environment
_TLL	Tolerance lower limit	Tolerance lower limit
_TMV		Mean value generation with compensation
_TNAME	Tool name	Tool name when using tool manager
_TNUM	Tnumber for automatic tool offset	T number
_TNVL		Limit value for distortion of triangle
_TP[3,10]		Field: Tool measuring probe data each with 6 elements
_TPW[3,10]		3 data arrays for tool probes, machine-related
_TSA	Tolerance safe area	Safe area
_TUL	Tolerance upper limit	Tolerance upper limit
_TZL	Tolerance zero offset range	Zero offset
_VMS	Variable measuring speed	Variable measuring speed
_WP[3,11]		Field: Workpiece measuring probe data each with 9 elements

D Feedback on the documentation

This document will be continuously improved with regard to its quality and ease of use. Please help us with this task by sending your comments and suggestions for improvement via e-mail or fax to:

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Suggestions and/or corrections

E Overview

Document Overview SINUMERIK 840D sl / 840Di sl

General Documentation

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Sales Brochure

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Catalog
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DOCONCD *)
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*) Recommended minimum scope of documentation

Glossary

Actual/set difference

Difference between measured and expected value.

Asynchronous subroutine

Part program that can be started asynchronously to (independently of) the current program status using an interrupt signal (e.g., "Rapid NC input" signal).

Blank measurement

The blank measurement ascertains the position, deviation, and zero offset of the workpiece in the result of a -> workpiece measurement.

Calibrating tool

Is a special tool (usually a cylindrical stylus), whose dimensions are known and that is used for precisely determining the distances between the machine zero and the probe trigger point (of the workpiece probe).

Calibration

During calibration, the trigger points of the probe are ascertained and stored in the measuring cycle data in block GUD6.

Collision monitoring

In the context of measuring cycles, this is a function that monitors all intermediate positions generated within the measuring cycle for the switching signal of the probe. When the probe switches, motion is stopped immediately and an alarm message is output.

Data blocks for measuring cycles

Data blocks GUD5.DEF, GUD6.DEF, GUD7DEF and GUD7.MC.DEF contain data required for configuration and execution of the measuring cycles.

These blocks must be loaded into the control during start-up. They must then be adapted according to the characteristics of the relevant machine by the machine manufacturer.

They are stored in the nonvolatile storage area of the control such that their setting values remain stored even when the control is switched off and on.

Delete distance-to-go

If a measuring point is to be approached, a traverse command is transmitted to the position control loop and the probe is moved towards the measuring point. A point behind the expected measuring point is defined as setpoint position. As soon as the probe makes contact, the actual axis value at the time the switching position is reached is measured and the drive is stopped. The remaining "distance-to-go" is deleted.

Differential measurement

Differential measurement means that the 1st measuring point is measured twice, once with a 180 degree spindle reversal (rotation of the probe), i.e. opposite the cycle start position and once with the spindle position assumed at the start of the cycle. This procedure allows uncalibrated probes to be used without imposing less stringent precision requirements!

Dimension difference check

Is a tolerance window. On reaching a limit (_TDIF) the tool will probably be worn and have to be replaced. The dimension difference check has no effect on generation of the compensation value.

Empirical value

The empirical values are used to suppress constant dimensional deviations that are not subject to a trend.

Log measurement results

Measurement results can optionally be logged in a file located in the part program memory. The log can be output from the control either via RS-232-C or on a diskette.

Mean value

The mean value calculation takes account of the trend of the dimensional deviations of a machining series. The -> weighting factor k from which the mean value is derived is selectable.

Mean value calculation alone is not enough to ensure constant machining quality. The measured dimensional deviation can be corrected for constant deviations without a trend by an -> empirical value.

Measure workpiece

For workpiece measurement, a measuring probe is moved up to the clamped workpiece in the same way as a tool. The flexibility of measuring cycles makes it possible to perform nearly all measurements required on a milling or turning machine.

Measurement path

Measurement path _FA defines the distance between the starting position and the expected switching position (setpoint) of the probe. Always specify _FA in mm.

Measurement result display

Measurement result displays can be shown automatically during measuring cycle runtime. Activation of this function depends on the settings in the measuring cycle data.

Measuring a workpiece at an angle

A measurement variant used to measure a drill-hole, shaft, groove, or web at random angles. The measurement path is traveled at a certain set angle defined in the WCS.

Measuring accuracy

The measurement accuracy that can be obtained is dependent on the following factors:

- Repeat accuracy of the machine
- Repeatability of the probe
- Resolution of the measuring system

The repeat accuracy of the controls for "on-the-fly measurement" is ±1 μm.

Measuring in JOG

It contains the following functions:

- Semi-automatic calculation of tool lengths and storage in tool offset memory
- Semi-automatic calculation and setting of reference points and storage in zero offset memory

The function is operated with softkeys and input displays.

Measuring tool

To perform tool measurement, the changed tool is moved up to the probe which is either permanently fixed or swiveled into the working range. The automatically derived tool geometry is entered in the relevant tool offset data record.

Measuring variant

The measuring variant of each measuring cycle is defined in parameter _MVAR. The parameter can have certain integer values for each measuring cycle, which are checked for validity within the cycle.

Measuring velocity

The measuring speed can be freely selected by means of parameter _VMS. The maximum measuring velocity must be selected to ensure safe deceleration within the measuring probe deflecting path.

Mono probe

A mono(directional) probe is a probe that can only deflect in one direction. It can only be used for workpiece measurement on milling machines and machining centers with slight limitations.

Multi probe

A multi(directional) probe is one that can deflect in three dimensions.

Multiple measurement at the same location

Parameter _NMSP can be used to determine the number of measurements at the same location. The actual/set difference is determined arithmetically.

Offset angle position

If a -> mono probe is used, the position of the probe can also be corrected for machine-specific reasons using the parameter _CORA.

Offset axis

With some measuring variants, for example, in CYCLE998, positioning in another axis that must be defined, also called offset axis can be performed between measurements in the measuring axis. This must be defined in parameter _MA with offset axis/measuring axis.

on-the-fly measurement

This method processes the probe signal directly in the NC.

Paraxial measurement

A measuring variant used for paraxial measurement of a workpieces, such as a drill-hole, shaft, rectangle, etc. The measuring path is traveled paraxially.

Positional deviation

The positional deviation (skew) describes the difference between the spindle center and the probe tip center ascertained by calibration. It is compensated for by the measuring cycles.

Probe ball diameter

The active diameter of the probe ball. It is ascertained during calibration and stored in the measuring cycle data.

Probe type

In order to measure tool and workpiece dimensions, a touch-trigger probe is required that supplies a constant signal (rather than a pulse) when deflected.

Probes are therefore classified in three groups according to the number of directions in which they can be deflected.

- Multidirectional
- Bidirectional
- Monodirectional (mono probe)

Reference groove

A groove located in the working area (permanent feature of the machine) whose precise position is known and that can be used to calibrate workpiece probes.

Safe area

The safe area _TSA does not affect the offset value; it is used for diagnosis. If this limit is reached, there is a defect in the probe or the set position is incorrect.

Setpoint

In the measuring procedure "inprocess measurement", a position is specified as the setpoint value for the cycle at which the signal of the touch-trigger probe is expected.

Tolerance bottom limit

When measuring a dimensional deviation as the lower tolerance limit (_TLL) ranging between "2/3 tolerance of workpiece" and "Dimensional difference control", this is regarded 100% as tool compensation. The previous average value is erased.

Tolerance top limit

When measuring a dimensional deviation as the upper tolerance limit (_TUL) ranging between "2/3 tolerance of workpiece" and "Dimensional difference control", this is regarded 100% as tool compensation. The previous average value is erased.

Tool environment

As from NCK SW 6.3, you can save the operating environment of a particular tool you are using. This is to allow you to correct the tool used to measure a workpiece taking into account the operating conditions (environment: G commands, setting data,...).

You then no longer have to specify the T, D, DL number in the offset explicitly. These are included in the stored tool environment. The name of a tool environment can have up to 32 characters.

Tool name

If tool management is active, the name of the tool can be entered in parameter _TNAME as an alternative to the -> tool number.

The tool number is derived from it within the cycle and entered in _TNUM.

Tool number

The parameter _TNUM contains the tool number of the tool to be automatically offset after workpiece measurement.

Trigger point

The trigger points of the probe are ascertained during calibration and stored in block GUD6 for the axis direction.

Variable measuring speed

The measuring velocity can be freely selected by means of _VMS. The maximum measuring velocity must be selected to ensure safe deceleration within the probe deflecting path. -> Measuring velocity

Weighting factor for mean value calculation

The weighting factor k can be applied to allow different weighting to be given to an individual measurement.

A new measurement result thus has only a limited effect on the new tool offset as a function of k.

Zero offset area

This tolerance range (lower limit _TZL) corresponds to the amount of maximum accidental dimensional deviations. If the absolute value of the actual/set difference is less than the zero offset range, the offset is not applied.

ZO determination

In the result of a measurement, the actual-setpoint value difference is stored in the data set of any settable zero offset.

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