SIEMENS

SINUMERIK 840D sl/840D/840Di sl

Measuring cycles

Programming Manual

Valid for

Controls
SINUMERIK 840D sl/840DE sl
SINUMERIK 840D powerline/840DE powerline
SINUMERIK 840Di sl/840DiE sl

Software	Version
NCU system software for 840D sl/840DE sl	1.5
HMI Advanced	7.5
with measuring cycles	7.5

01/2008
6FC5398-4BP20-1BA0

Safety Guidelines

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

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

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

⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

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.

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

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Prescribed Usage

Note the following:

⚠ WARNING
This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

Trademarks

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

Disclaimer of Liability

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

Preface

Structure of the documentation

The SINUMERIK documentation is organized in 3 parts:

- General Documentation
- User documentation
- Manufacturer/service documentation

A list of documents, updated on a monthly basis and indicating the available languages, is available on the Internet at:
http://www.siemens.com/motioncontrol
Select "Support" → "Technical Documentation" → "Overview of Documents".

The Internet version of the DOConCD (DOConWEB) is available at:
http://www.automation.siemens.com/doconweb

Information on the range of training courses and FAQs (frequently asked questions) are available in the Internet under:

http://www.siemens.com/motioncontrol and there under the menu item "Support"

Target group

This Manual is intended for machine-tool programmers.

Benefits

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

Standard scope

The functionality of the standard scope (measuring cycle release SW 6.3) is described in this programming manual. 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.

Technical Support

If you have any questions, please contact our Hotline:

Europe and Africa time zone

A&D Technical Support

Tel.: +49 (0) 180 / 5050 - 222

Fax: +49 (0) 180 / 5050 - 223

Internet: http://www.siemens.com/automation/support-request

Email: mailto:adsupport@siemens.com

Asia and Australia time zone

A&D Technical Support

Tel.: +86 1064 719 990

Fax: +86 1064 747 474

Internet: http://www.siemens.com/automation/support-request

Email: mailto:adsupport@siemens.com

America time zone

A&D Technical Support

Tel.: +1 423 262 2522

Fax: +1 423 262 2289

Internet: http://www.siemens.com/automation/support-request

Email: mailto:adsupport@siemens.com

Note

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

Enter http://www.siemens.com/automation/service&support

Questions on the manual

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

Fax: +49 (0) 9131 / 98 - 63315

Email: mailto:motioncontrol.docu@siemens.com

Fax form: See the reply form at the end of this publication

SINUMERIK Internet address

http://www.siemens.com/sinumerik

Validity

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

Measuring cycles, version 7.3.

Software versions stated in the programming manual refer to the 840D and their 810D equivalent, e.g. SW 5 (840D) corresponds to SW 3 (810D).

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.

Table of contents

General

<div align="right">1</div>

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**.
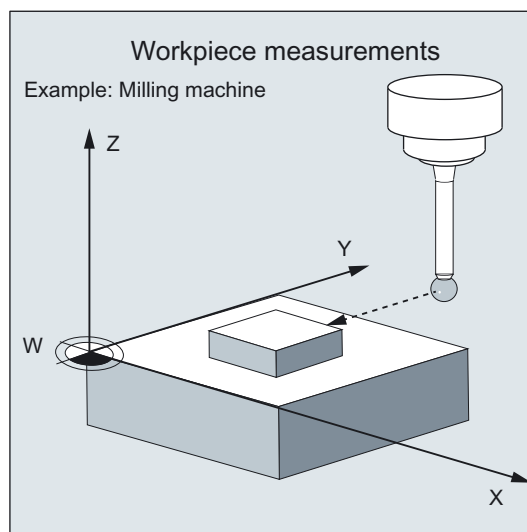
Workpiece measurements

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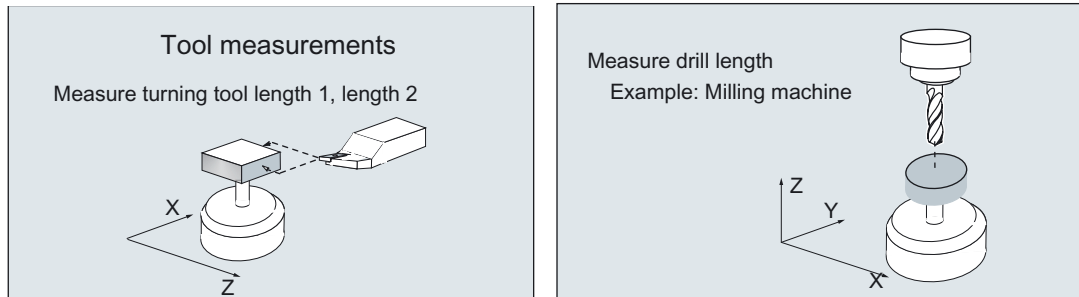
In tool measurement, the selected tool is moved up to the probe and the measured values are acquired. The probe is either in a fixed in position or is swung into the working area with a mechanism. The tool geometry measured is entered in the appropriate tool offset data set.

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 cycles, data blocks

The following have been loaded into the control and activated:

- The data blocks into the "Definitions" directory:
  - GUD5.DEF
  - GUD6.DEF and
  - GUD7.DEF (for measuring in JOG)
- The measuring cycles into the standard cycle directory.

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

An HMI/PCU is required for showing the measuring result displays and 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 on selection of "Simulation" 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.

Demo program for simulation on HMI Advanced

The measuring cycle software supplied includes programs for demonstrating how the measuring cycles work when simulating on HMI Advanced. The programs are divided into turning technology and milling technology. When a program is loaded, the "workpieces" are created whose directory contains all data and settings required for simulation.

Example 1: Measure hole (TESIM_977BO with CYCLE977, milling technology)
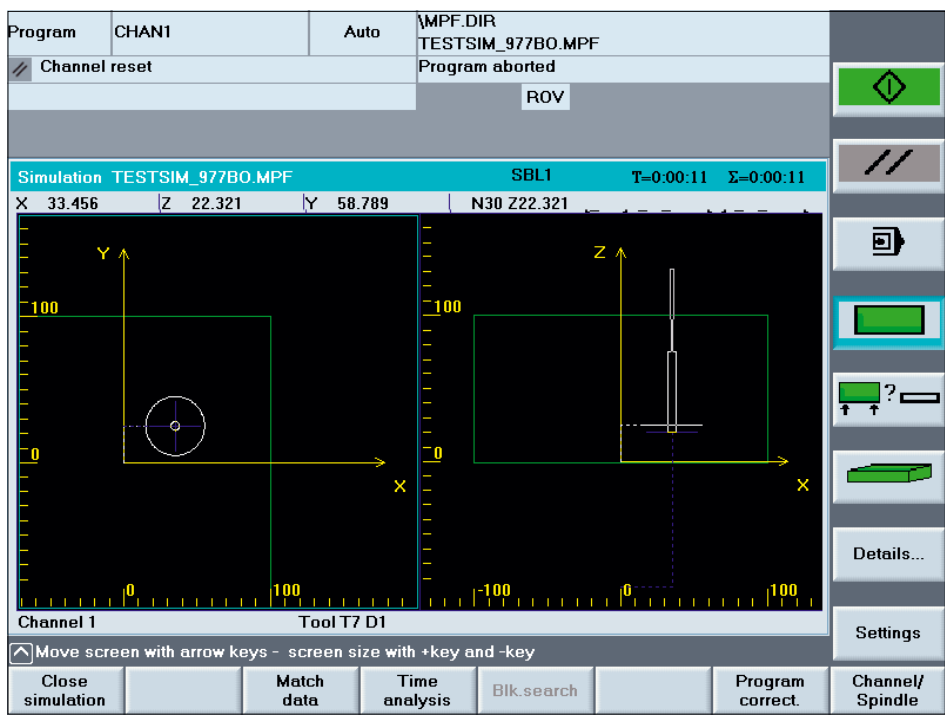
Example 2: Calibrate tool probe (TESIM_982MKS with CYCLE982, turning technology)
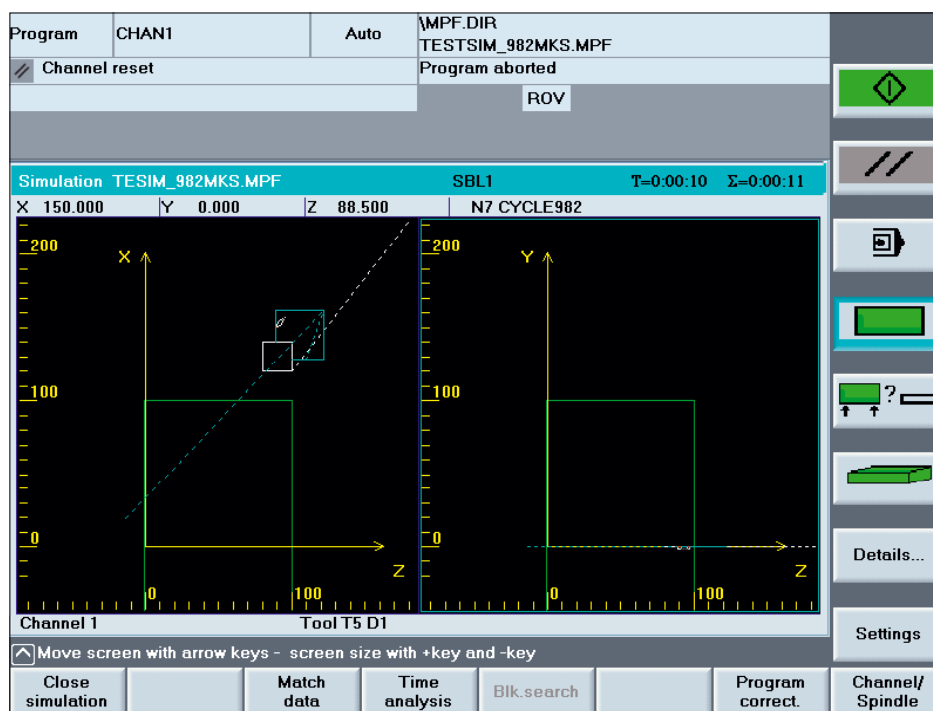
1.4 Reference points on the machine and workpiece

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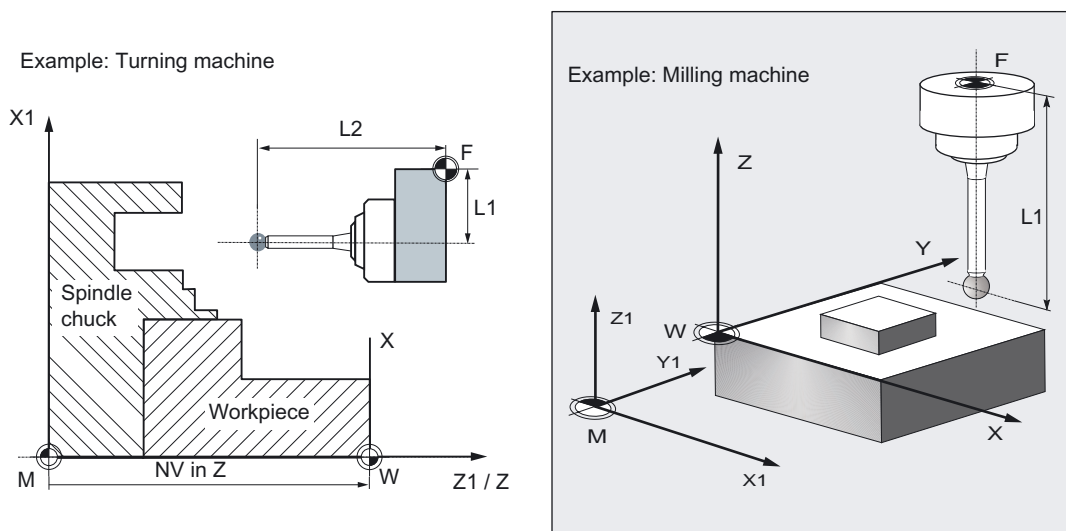
The position of tool reference point F in the machine coordinate system is displayed with machine zero M as the **machine actual value**.

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
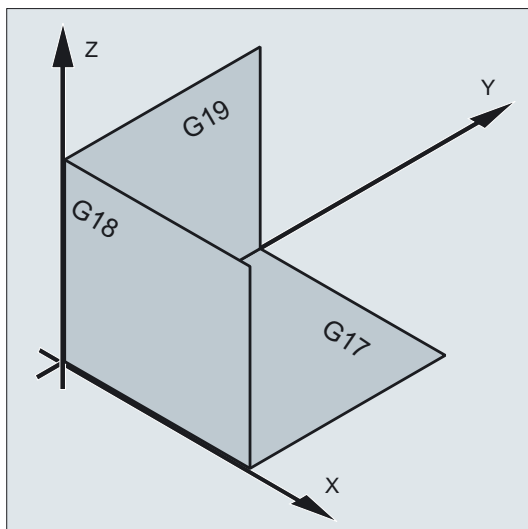
G17 plane

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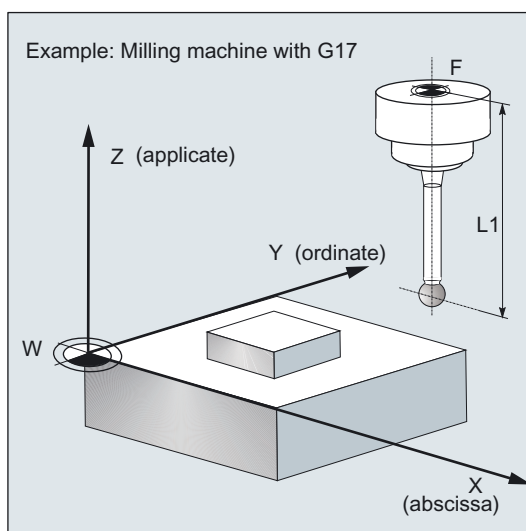
Turning
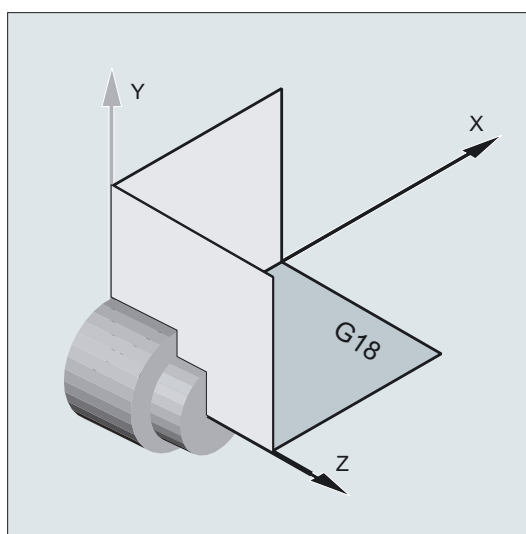
Turning machines generally only use axes Z and X and therefore:

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
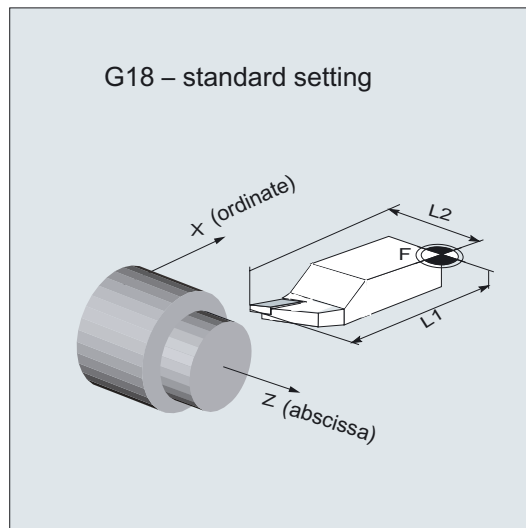
1.6 Probes that can be used

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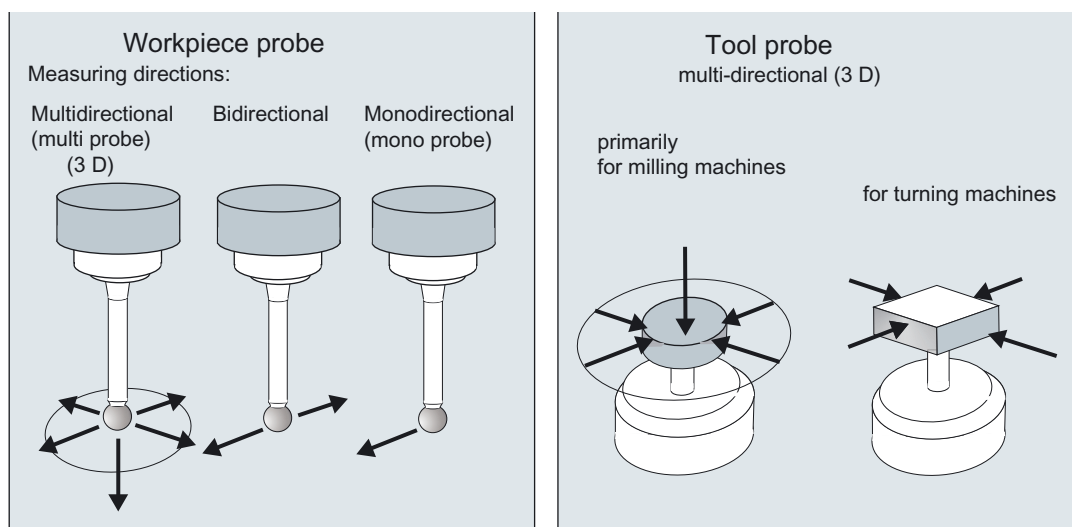
The probe type is defined by a parameter (_PRNUM) in measuring cycles (see Section 2.10).

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.
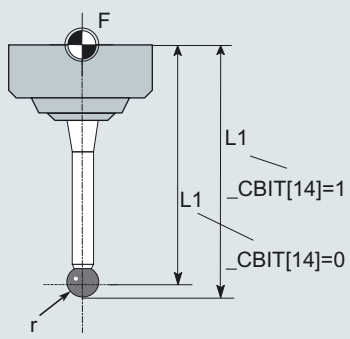
1.7   Probe, calibration body, calibration tool

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		Workpiece probe for milling machines, machining centers
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.
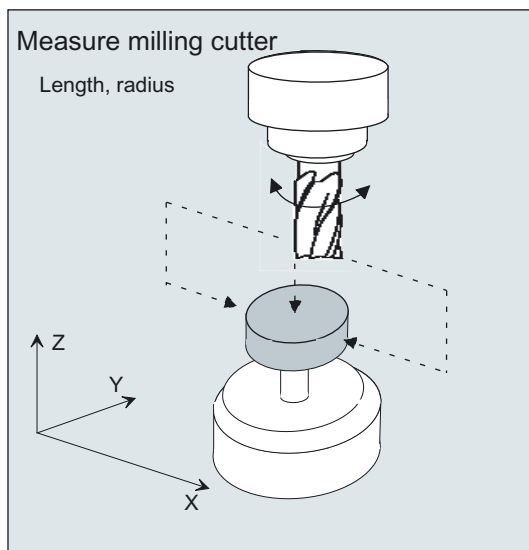
Approximate values must be entered here before calibration – if cycles are used in automatic mode. The cycle will then recognize the position of the probe.

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

Calibrate tool probes

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

Workpiece probe for turning machine
Example: Cutting edge position SL=7

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

Workpiece probe for turning machine
Example: Cutting edge position SL=8
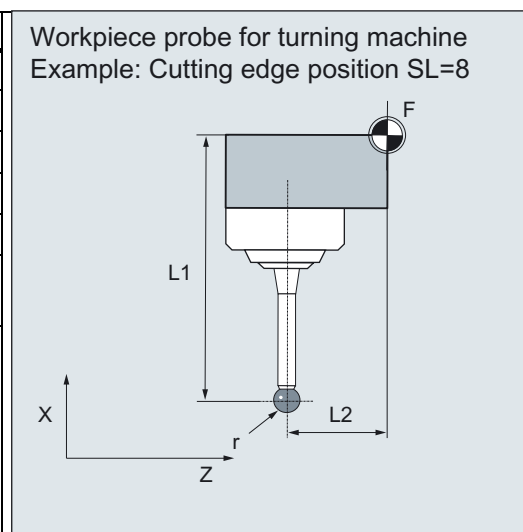
The wear and other tool parameters must be assigned the value 0.

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

Workpiece probe for turning machine

Cutting edge position SL=5

Cutting edge position SL=6
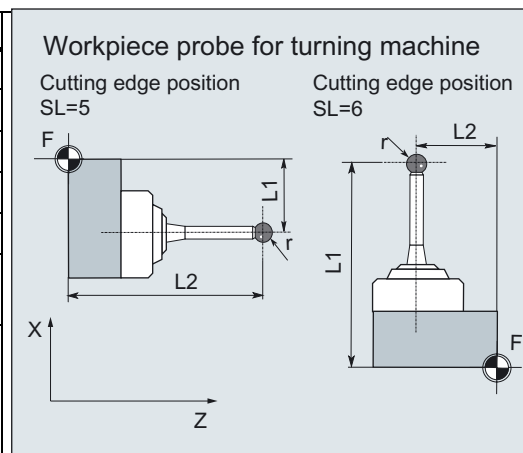
The wear and other tool parameters must be assigned the value 0.

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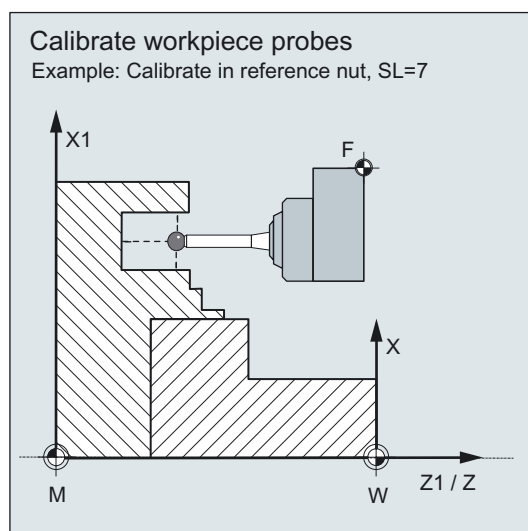
A probe must be calibrated before it can be used. During calibration the triggering points (switching points), positional deviation (skew), and precise ball radius of the workpiece probe are determined and then entered in special data fields _WP[ ] in data block GUD6.DEF.

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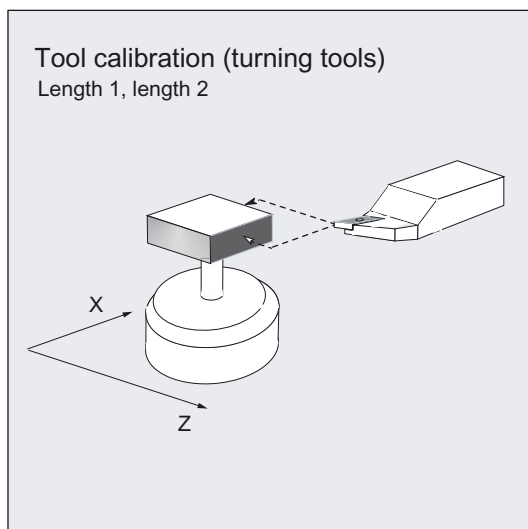
The tool probes have dedicated data fields _TP[ ] and _TPW[ ] in data block GUD6.DEF.

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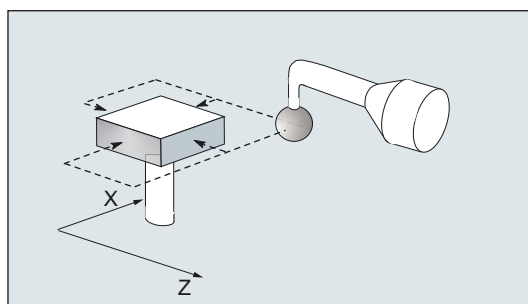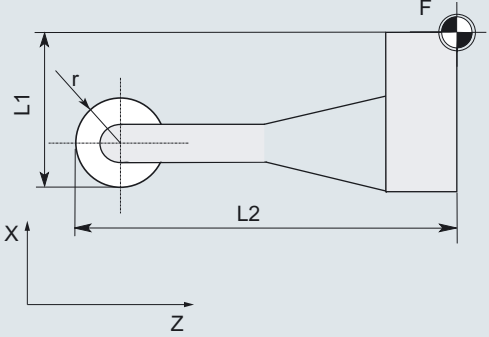
A probe must be calibrated before it can be used. Calibration involves precisely determining the triggering points (switching points) of the tool probe and entering them in special data fields.

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	Calibration tool for tool probe on turning machine
Cutting edge position (DP2):	3	
Length 1 - geometry:	L1	Tool type 5xy, cutting edge position, SL=3
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
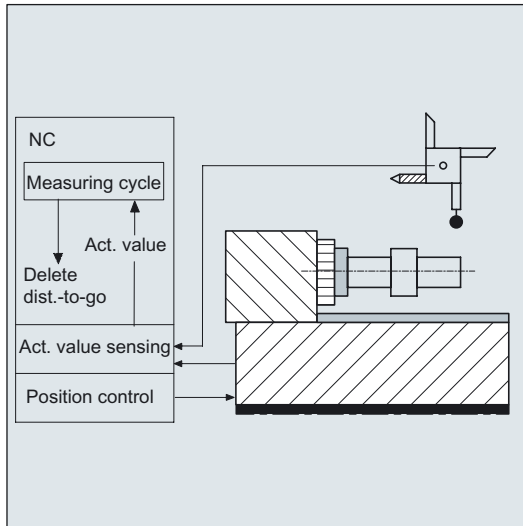
The principle of "on-the-fly" measurement is implemented in the SINUMERIK control. The probe signal is processed directly on the NC so that the delay when acquiring measured values is minimal. This permits a higher measuring speed for the prescribed measuring precision and time needed for measuring is 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
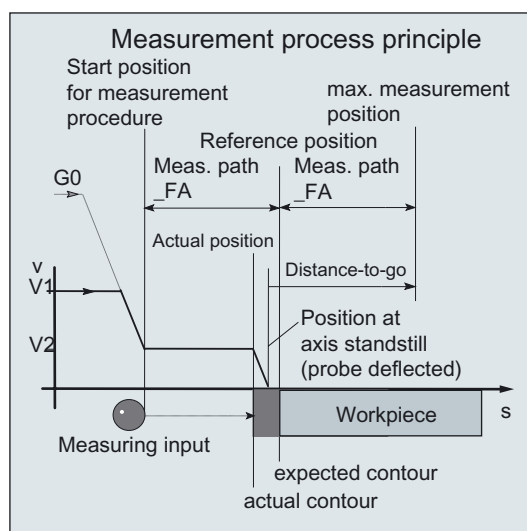
The procedure is described using the **workpiece measurement**. The procedure is the same for tool measurement. In this case, however, the tool is moved and the probe is fixed.

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

Position-time diagram at various measuring speeds following example of calculation
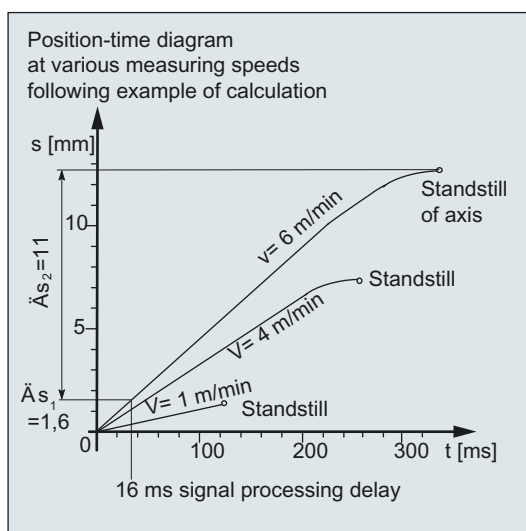
The deceleration path to be considered is calculated as follows:

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

$$\underbrace{}_{\Delta s_1}$$

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/s² 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:

$\Delta s = 6/ 1 = 6$ mm $\qquad$ Following error

$\Delta s2 = 1000 \cdot 0.01 / 2 + 6 = 11$ mm $\qquad$ axis-specific component

$\Delta s1 = 1000 \cdot 0.1 \cdot 0.016 = 1.6$ mm $\qquad$ 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
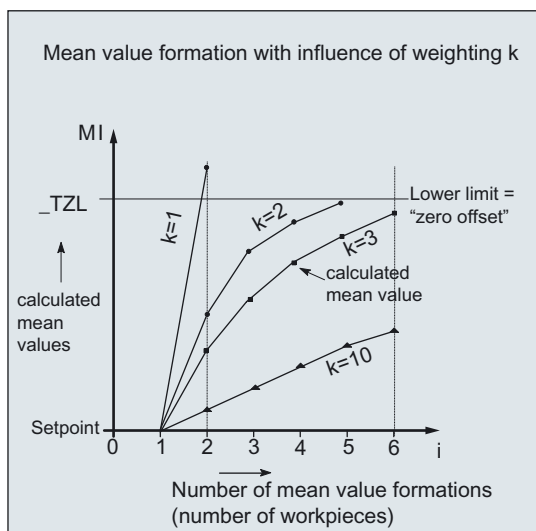
- The greater the value of k, the slower the formula will respond when major deviations occur in computation or counter compensation. At the same time, however, accidental scatter will be reduced as k increases.

- 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

i	Lower limit = 40 µm (_TZL = 0.04)			
	Di [µm]	Mi k = 3 [µm]	Mi k = 2 [µm]	
1st measurement	30	10	15	Characteristics of mean values with two different weighting factors
2nd measurement	50	23.3	32.5	
3rd measurement	60	35.5	46.2 ③	
4th measurement	20	30.3	10	
5th measurement	40	32.6	25	
6th measurement	50	38.4	37.5	
7th measurement	50	42.3 ①	43.75 ④	
8th measurement	30	10	15	
9th measurement	70	30	42.5 ⑤	
10th 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 measurement (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**
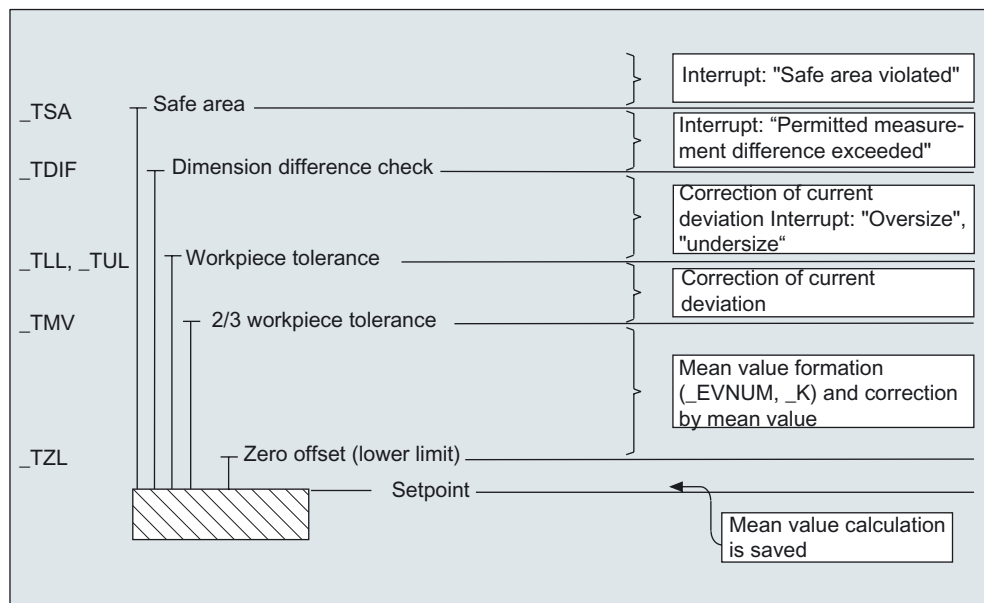
Note

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**

```
_TSA ─┬ Safe area ──────────────────────────┐}  ┌─────────────────────────────┐
      │                                         │ Interrupt: "Safe area violated" │
      │                                      }  └─────────────────────────────┘
      │                                         ┌─────────────────────────────┐
_TDIF │ ─┬ Dimension difference check ───────┤} │ Interrupt: "Permitted measure- │
      │  │                                       │ ment difference exceeded"      │
      │  │                                    }  └─────────────────────────────┘
      │  │                                       ┌─────────────────────────────┐
      │  │                                       │ Tool memory is corrected        │
_TZL  │  │ ─┬ Zero offset (lower limit) ──────┤} └─────────────────────────────┘
      │  │  │        ─ Setpoint ───────────────◄──────────────┐
   ┌──┴──┴──┴──┐                                ┌─────────────┴────┐
   │ ///////// │                                │ Tool memory       │
   └───────────┘                                │ unchanged         │
                                                 └──────────────────┘
```
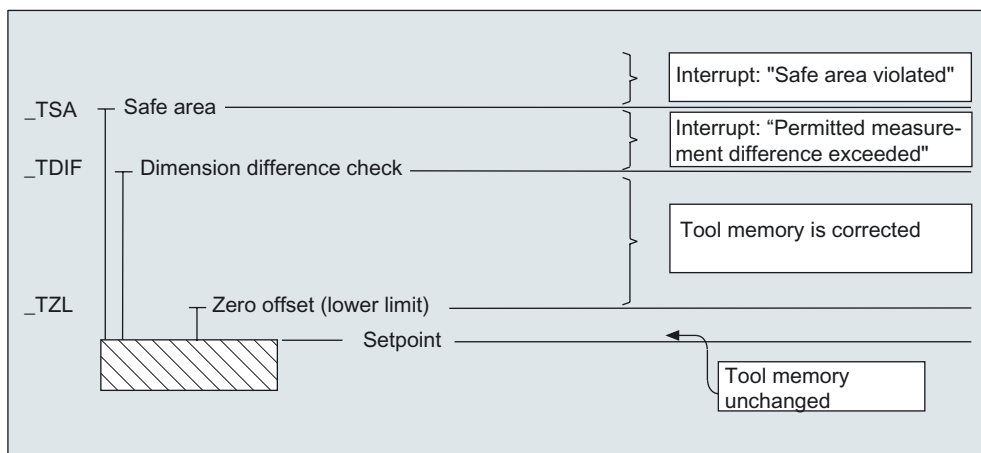
● **For workpiece measurement with zero offset**

```
_TSA ─┬ Safe area ──────────────────────────┐}  ┌─────────────────────────────┐
      │                                         │ Interrupt: "Safe area violated" │
      │                                      }  └─────────────────────────────┘
      │                                         ┌─────────────────────────────┐
      │                                         │ Correction of NV memory        │
      │          ─ Setpoint ─────────────────┤} └─────────────────────────────┘
   ┌──┴───────┐
   │ ///////// │
   └──────────┘
```

● **For workpiece probe calibration**

```
_TSA ─┬ Safe area ───────────────────────┐}  ┌─────────────────────────────┐
      │                                      │ Interrupt: "Safe area violated" │
      │                                   }  └─────────────────────────────┘
      │                                      ┌─────────────────────────────┐
      │                                      │ Workpiece probe data            │
      │                                      │ are corrected                   │
_TZL  │ ─┬ Zero offset (lower limit) ─────┤} └─────────────────────────────┘
      │  │        ─ Setpoint ──────────────◄──────────────┐
   ┌──┴──┴─────┐                             ┌────────────┴─────┐
   │ ///////// │                             │ Workpiece probe   │
   └───────────┘                             │ data unchanged    │
                                              └──────────────────┘
```
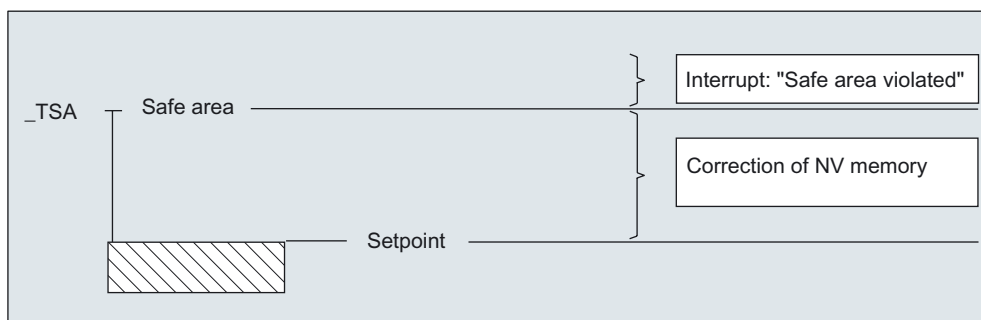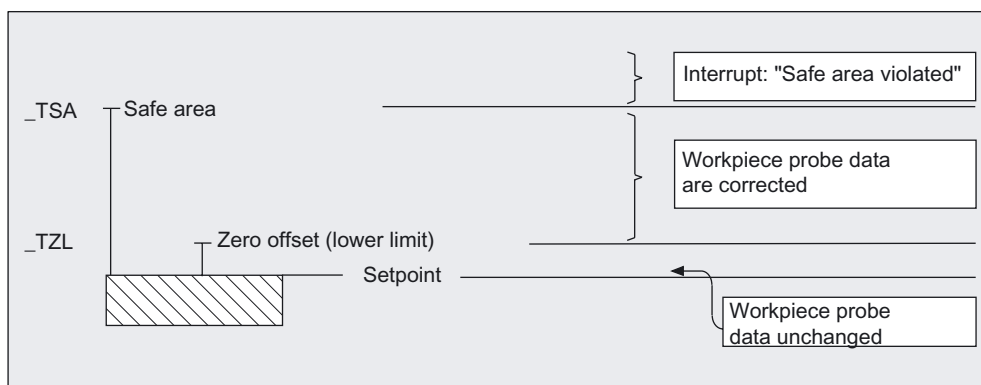
- **For tool probe calibration**
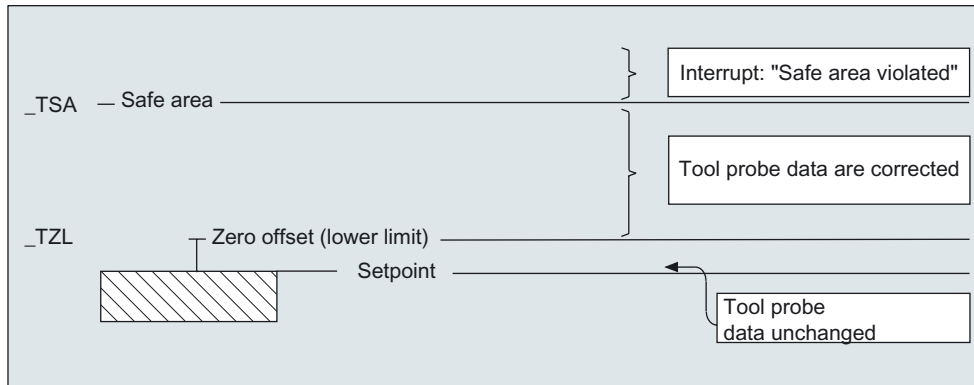
1.11 Effect of empirical value, mean value, and tolerance parameters

The following flowchart shows the effect of empirical value, mean value, and tolerance parameters on workpiece measurement with automatic tool offset.
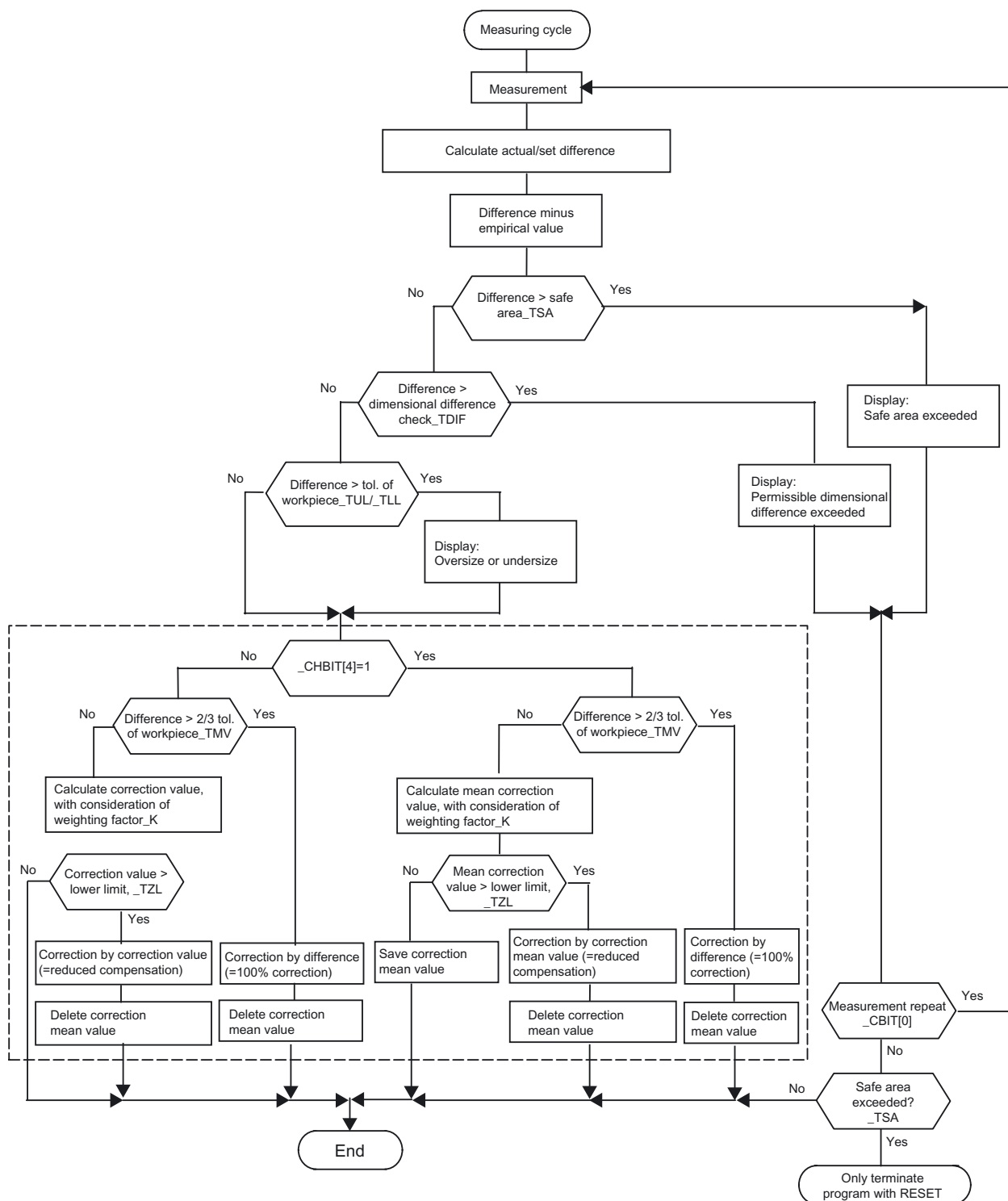
1.12 Overview of measuring cycle functions for milling technology

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
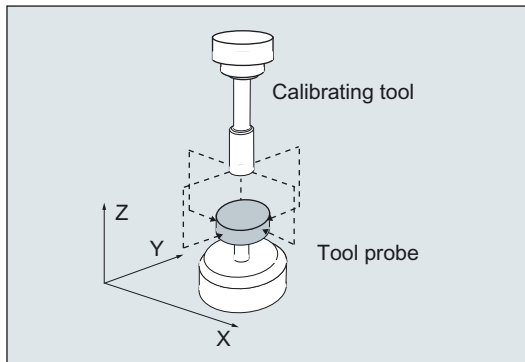
Result:

Probe switching point with reference to machine or workpiece zero.

Measuring tool
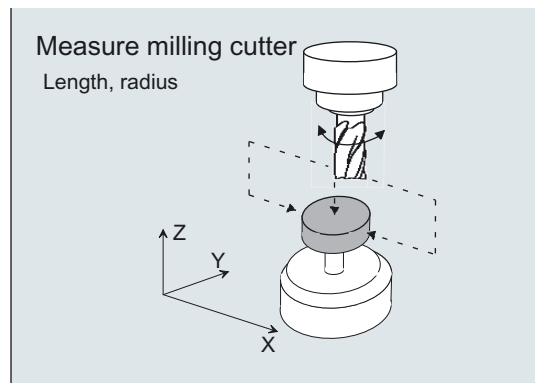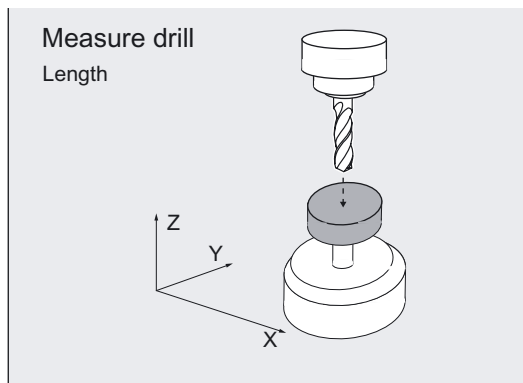
Result:

- 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.
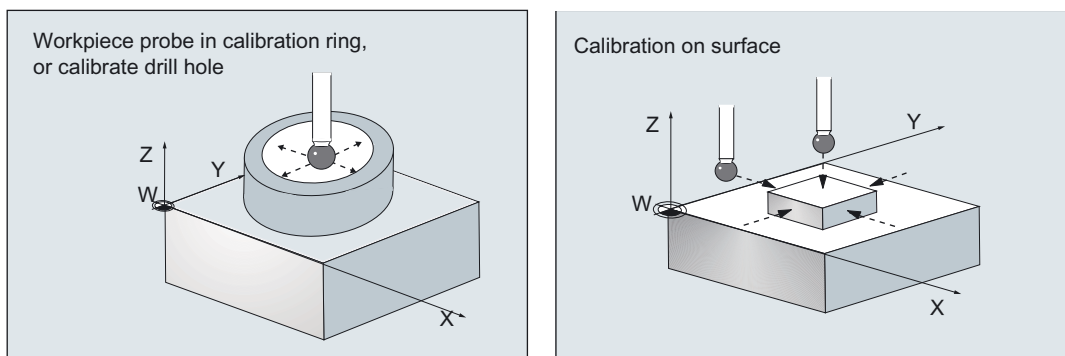
Result:

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
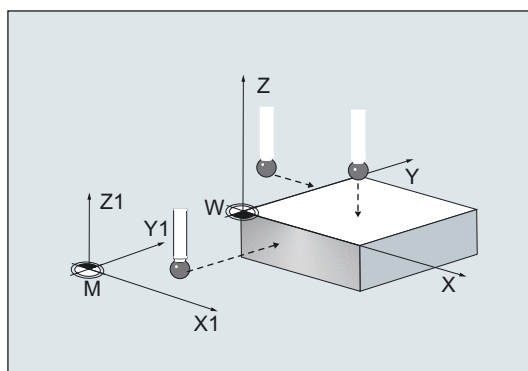
Result:

- Position
- Deviation
- Zero point offset

Workpiece measurement: 1-point measurement
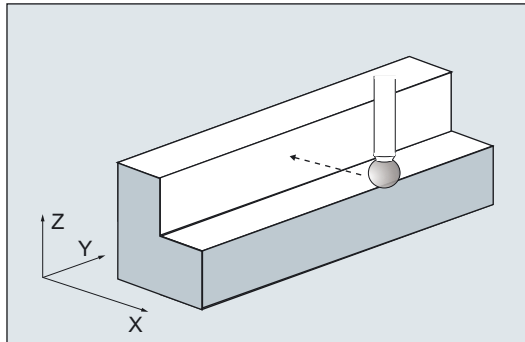
Result:

- 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
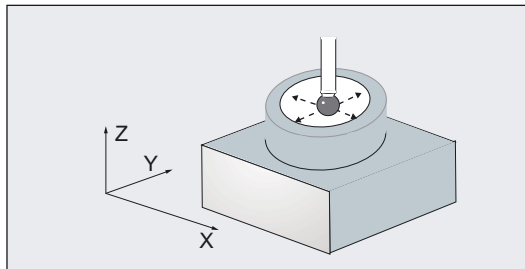
Result:

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

Workpiece measurement: Measuring a shaft
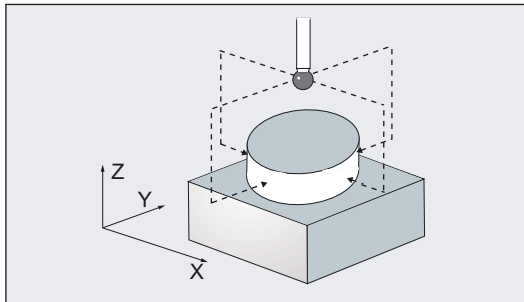
Result:

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

Workpiece measurement: Measuring a groove
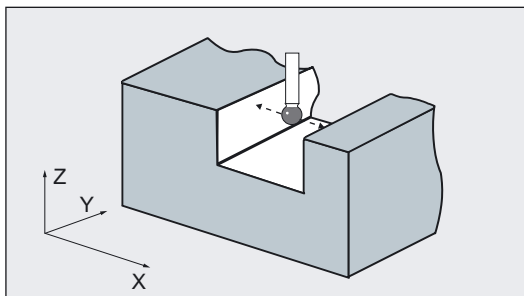
Result:

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

Workpiece measurement: Measuring a web
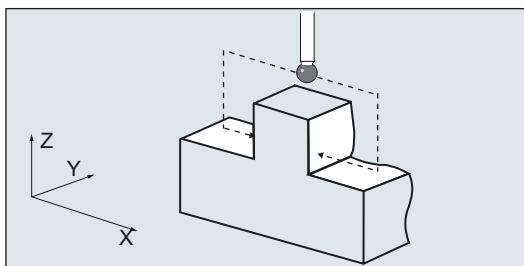
Result:

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

Workpiece measurement: Inside rectangle
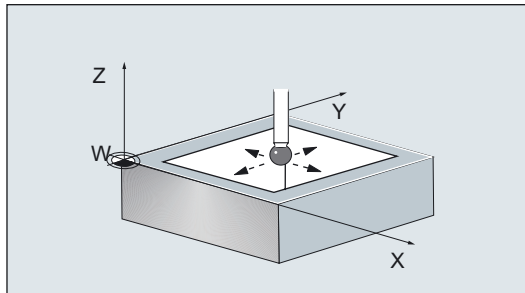
Result:

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

Workpiece measurement: Outside rectangle
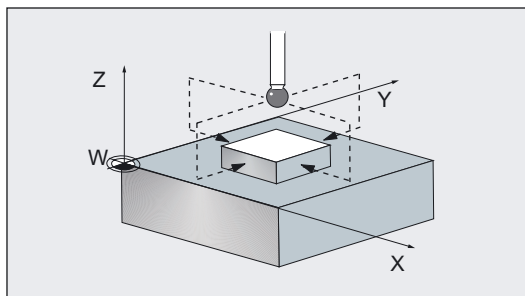
Result:

- 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
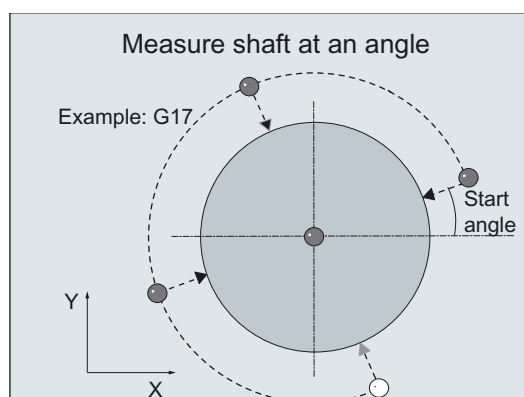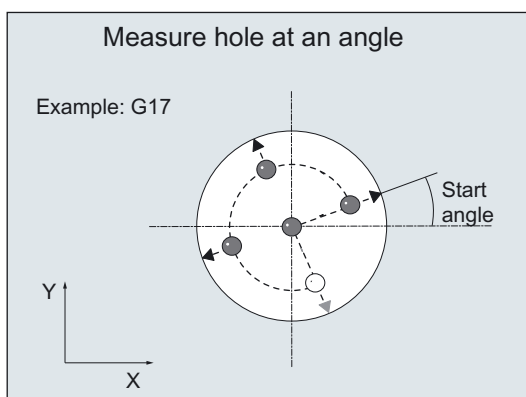
Result:

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

Two-point measurement at an angle
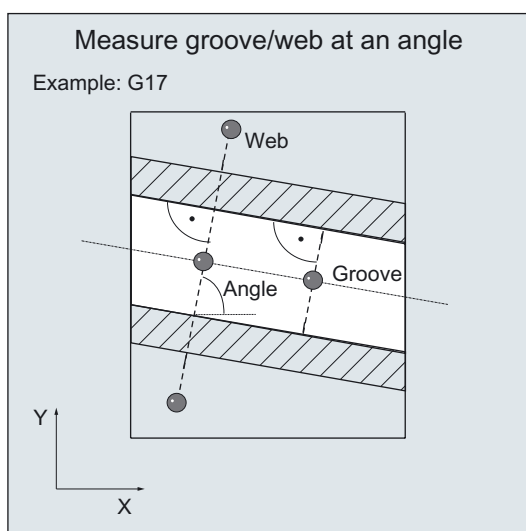
Result:

- 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
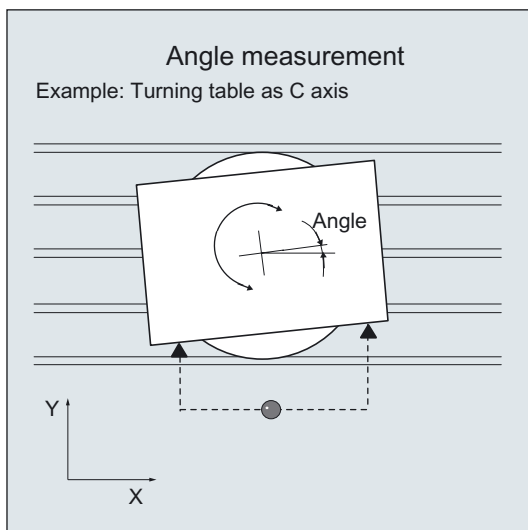
Result:

- Actual dimension: Angle
- Deviation: Zero point offset

Workpiece measurement: Two-angle measurement
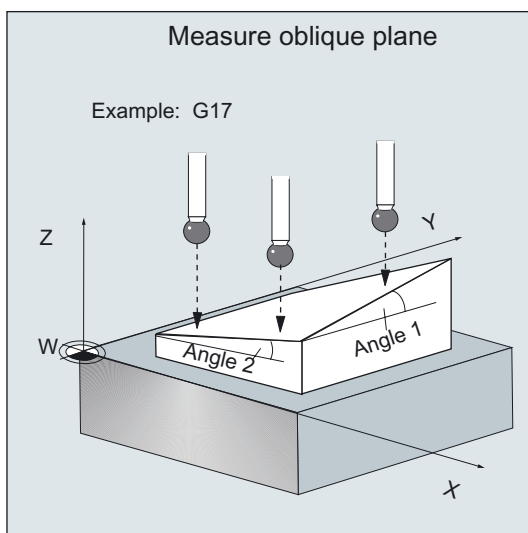
Result:

- 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
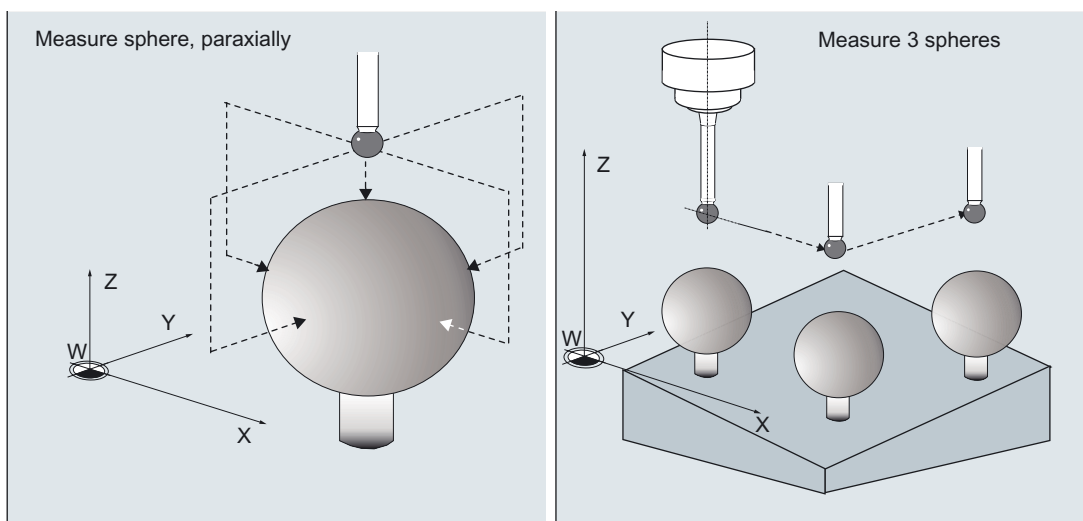
Result:

- 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
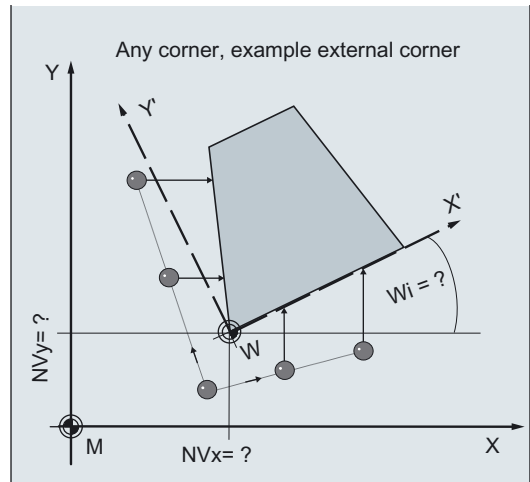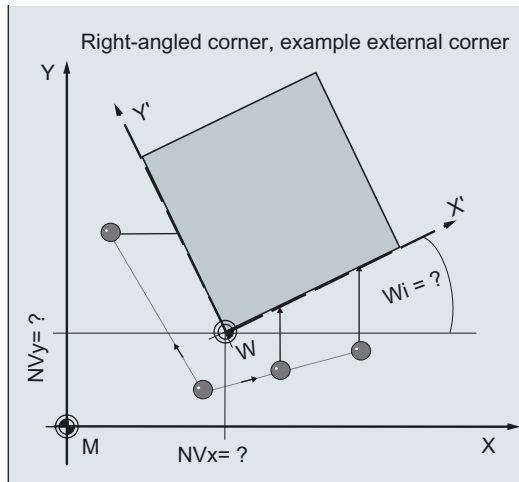
Result:

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

Measuring a corner, specifying 4 points
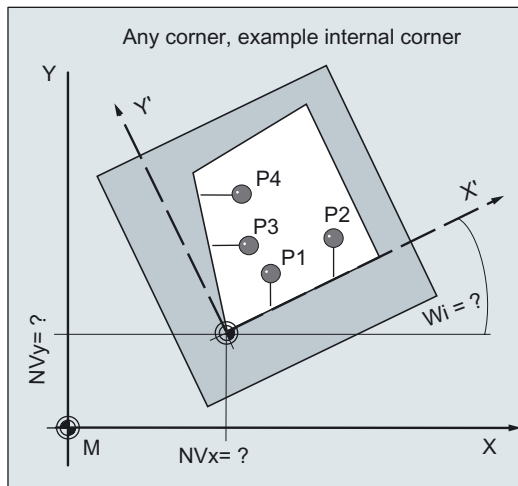
Result:

- 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
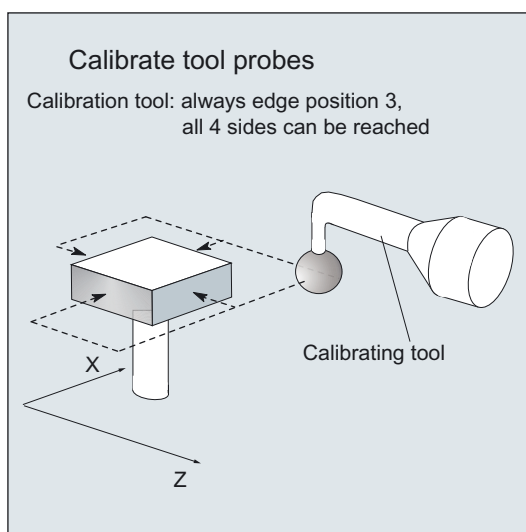
Result:

Probe switching point with reference to machine or workpiece zero

Measuring tool
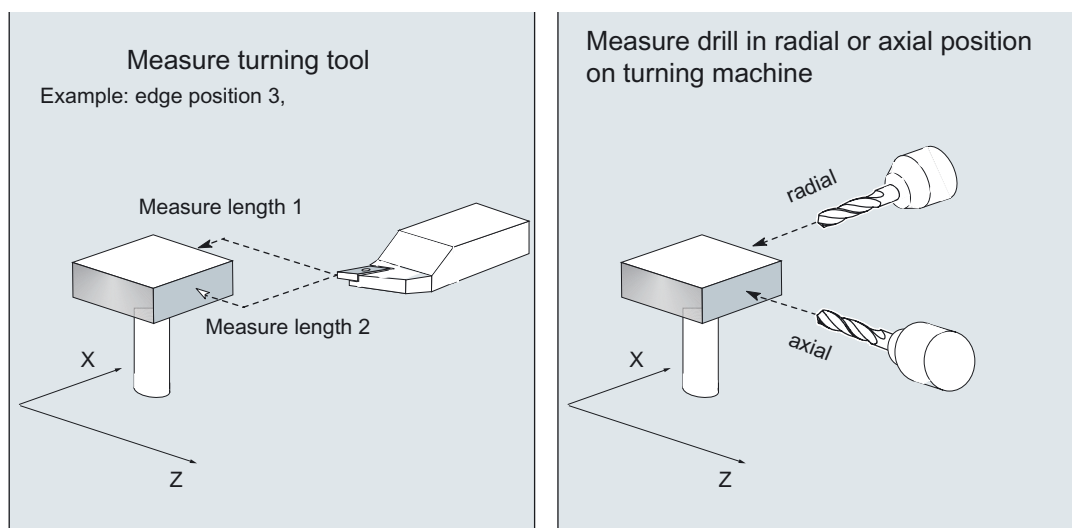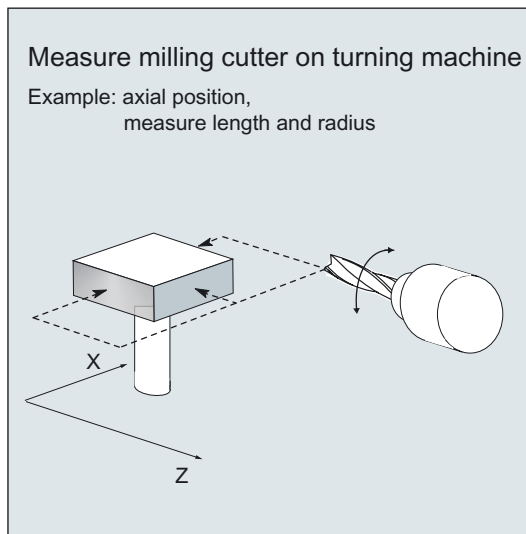
Result:

- 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.
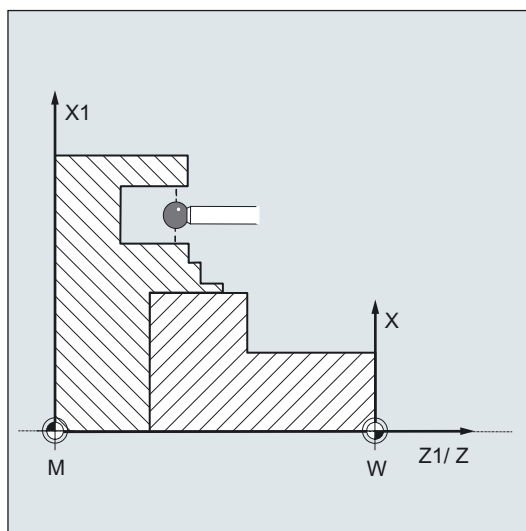
1.13.3 Measuring workpieces at lathes: 1-point measurement

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
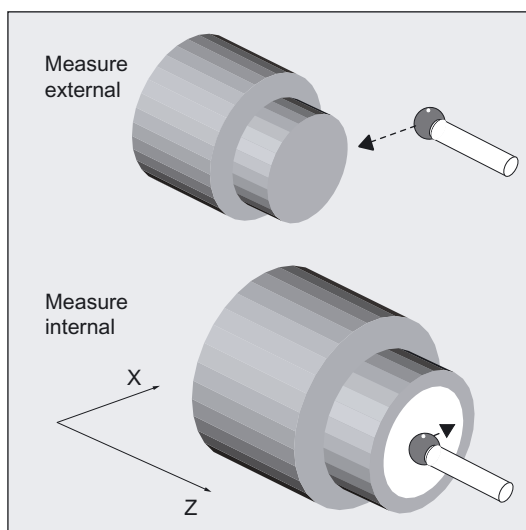
Result:

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

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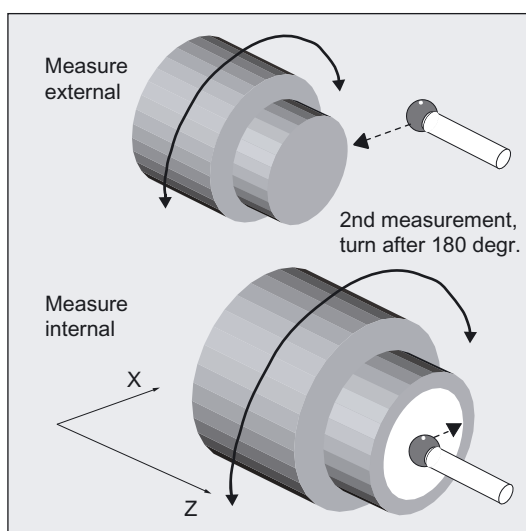
Result:

- 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
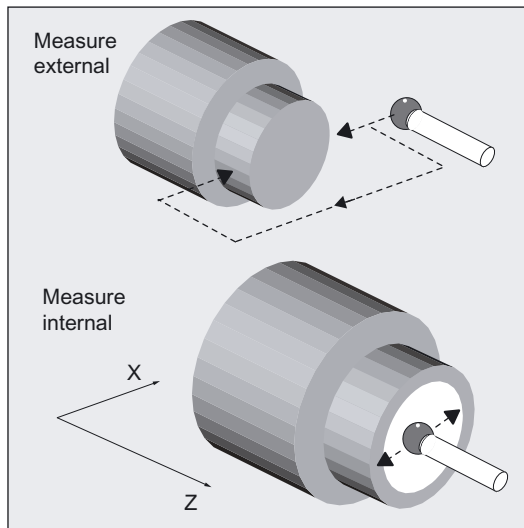
Result:

- Actual dimension: Diameter
- Deviation: Tool offset

Parameter description

<div style="text-align: right; font-size: 2em;">2</div>

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)

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. Local User Data (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
_TUL[1]	REAL	CHAN	1.0	Tolerance upper limit
_TLL[1]	REAL	CHAN	-1.0	Tolerance lower limit
_TDIF	REAL	CHAN	1.2	Dimension difference check
_TSA	REAL	CHAN	2	Safe area
_FA[2]	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
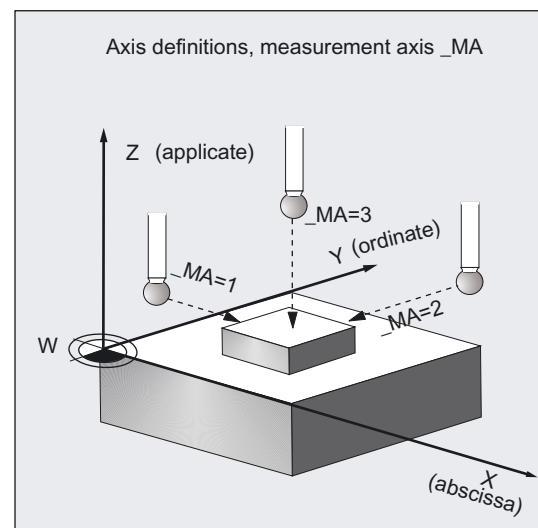
Axis definitions, measurement axis _MA

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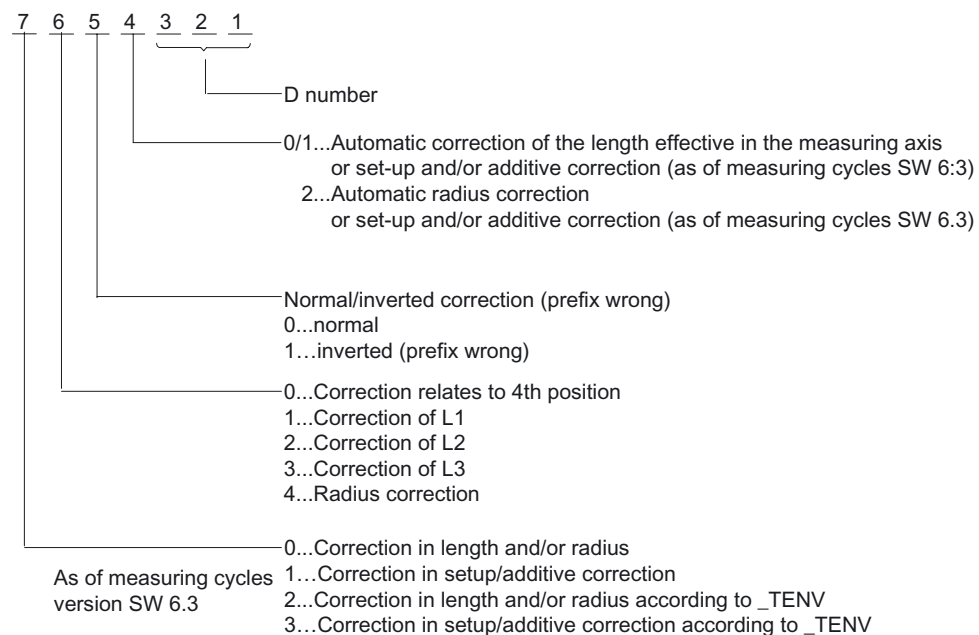
In the default setting, the D number has values between 0 and 9.

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 ^{3}1000 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.

```
9   8   7   6   5   4   3   2   1
│   │   │   │   └───┴───┴───┴───┘
│   │   │   │         └─────── D number
│   │   │   │
│   │   │   └── 0/1...Automatic correction of the length effective in the measuring axis
│   │   │              or set-up and/or additive correction (as of measuring cycles SW 6.3)
│   │   │        2...Radius correction
│   │   │              or set-up and/or additive correction (as of measuring cycles SW 6.3)
│   │   │
│   │   └── Normal/inverted correction (prefix wrong)
│   │       0...normal
│   │       1…inverted (prefix wrong)
│   │
│   └── 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 and/or radius
    1…Correction in setup/additive correction
    2...Correction in length and/or radius according to _TENV
    3…Correction in setup/additive correction according to _TENV
```

From measuring cycles SW 6.3:

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"

From measuring cycles SW 6.3 onwards, it is possible to correct a selected setup or additive offset in the measuring cycles when measuring workpieces with automatic tool offset using parameters _TNUM and _TNAME, _KNUM (D-number coded) and 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
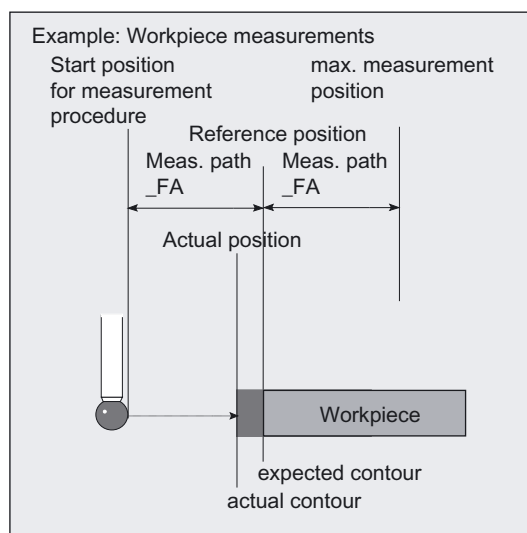
Measurement path _FA defines the distance between the **starting position** and the expected switching position (**setpoint**) of the probe. _FA is data type REAL with values >0.

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 information

- 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**.

- From measuring cycles SW 6.3, the data for the tool probes can be stored workpiece-specifically in 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").

Parameter

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
>0 to 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".

Measuring cycle help programs

<div align="right">

3

</div>

3.1 Package structure of the measuring cycles

Note

The machine data configuration and the software package version determine which programs can be used. It is also possible to partially define these programs in the global cycle data during start-up.

→ Please refer to data supplied by the machine manufacturer and Installation and Start-up Guide

General information

The measuring cycle package supplied consists of:

- Data blocks for defining the global measuring cycle data
- Measuring cycles
- Measuring cycle subroutines
- Convenience Functions

To ensure that the measuring cycles can be executed in the control, the data blocks must have been loaded into directory "Definitions" and the measuring cycles and measuring cycle subroutines must be stored in the part program memory.

Note

Please note that the control always requires a Power ON between loading and execution of the measuring cycles!

→ Please refer to the notes on installation in the Commissioning chapter!

Subpackages

In many applications, not all the measuring cycles are used on one machine. Instead, subpackages are used.

The following overview shows which subpackages are advisable and executable. This will help you to save memory.

Basic package		Supplementary package, measuring in JOG at milling machines

Measuring cycles, milling

Tool probe Calibrating + Measuring a tool	Workpiece probe Calibrating + Measure workpiece + ZO or TO Writing

			Semi-automatic calibration of the tool probe + Tool measuring + Calculating and setting the reference points

E_MS_CAL	E_MS_POC[2]	E_MT_CAL	CYC_JM
E_MS_CAN	E_MS_SPI[2]	E_MT_LEN	CYC_JMC
E_MS_HOL		E_MT_RAD	CYC_JMA[2]
E_MS_PIN		E_SP_NPV	

CYCLE971

CYCLE107[1]
CYCLE108[1]
CYCLE109
CYCLE110
CYCLE111
CYCLE198
CYCLE199

CYCLE961
CYCLE976
CYCLE977
CYCLE978
CYCLE979
CYCLE998
CYCLE997[2]
CYCLE996[3]

CYCLE107[1])
CYCLE108[1])
CYCLE109
CYCLE110
CYCLE111
CYCLE112
CYCLE114
CYCLE115
CYCLE116
CYCLE119[2]
CYCLE198
CYCLE199

+

Supplementary package, surface	Supplementary package, surface

Measurement result display selection

Activation: _CHBIT[10]=1

CYCLE102
CYCLE104

+

Logging in a file in the part program memory

Activation: CYCLE100

CYCLE100
CYCLE101
CYCLE105
CYCLE106
CYCLE113
CYCLE118

Basic package

Measuring cycles, turning

Tool probe Calibrating + Measuring a tool	Workpiece probe Calibrating + Measure workpiece + ZO or TO Writing

CYCLE972
CYCLE982
CYCLE107[1]
CYCLE108[1]
CYCLE109
CYCLE110
CYCLE111
CYCLE198
CYCLE199

CYCLE973

CYCLE974
CYCLE994

CYCLE107[1]
CYCLE108[1]
CYCLE109
CYCLE110
CYCLE111
CYCLE114
CYCLE115
CYCLE117
CYCLE198
CYCLE199

1) only up to measuring cycles – SW 6.2
2) from measuring cycles SW 6.3
3) from measuring cycles SW 7.5

3.2 Measuring cycle subroutines

3.2.1 Overview

General information

The measuring cycle subroutines are called directly by the cycles. With the exception of CYCLE100, CYCLE101, and CYCLE116, these subroutines cannot be executed by a direct call.

Programming

Cycle	Function		Note
CYCLE100	Activate logging		
CYCLE101	Deactivate logging		
CYCLE102	Measuring result display		
CYCLE103	Parameter setting in interactive mode		only up to measuring cycles SW 4.5
CYCLE104	Internal subroutine:	Measuring cycle interface	
CYCLE105	Internal subroutine:	Log	
CYCLE106	Internal subroutine:	Log	
CYCLE107	Output of measuring cycle messages		only up to measuring cycles SW 6.2
CYCLE108	Output of measuring cycle alarms		only up to measuring cycles SW 6.2
CYCLE109	Internal subroutine:	Data transfer	
CYCLE110	Internal subroutine:	Plausibility checks	
CYCLE111	Internal subroutine:	Measuring functions	
CYCLE112	Internal subroutine:	Measuring functions	
CYCLE113	Internal subroutine:	Log	
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	from meas. cycles - SW 6.3

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.
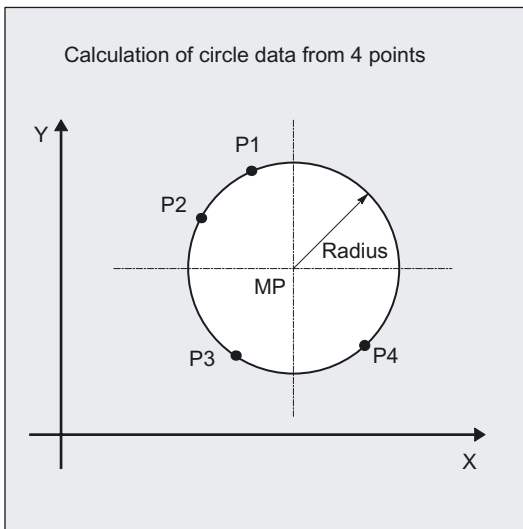
Programming

```
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).

3.3.2 CYCLE198: User program before undertaking measurement

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 CYCLE**977**
M17   ;end of cycle

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

3.3.3 CYCLE199: User program after undertaking measurement

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).

Measuring in JOG

4

4.1 Overview

General information

There are two types of measurement: **Workpiece measurement** and **tool measurement**. These measurements may be undertaken

- **automatically**

  (Cycles for automatic operations: refer to Milling technology chapter and Turning technology chapter) or

- **semi-automatically** in JOG mode.

The following chapter describes semi-automatic measurement for milling technology: **measuring in JOG**.

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.

General sequence

The required function is selected via softkeys on the HMI in JOG mode. Input displays are shown. These have to be completed via screen forms. This describes the measurement tasks and selects the offset.

The user must put the tool or probe into a permissible starting position for the measurement task, e.g. using the traverse keys or handwheel (manual traverse).

Once you have pressed the "NC start" key in JOG mode, the remaining sequence is automatic.

To cancel measurement, press "RESET".

NOTICE
Be sure to select the correct channel!
The "Measure in JOG" function is **channel-specific**.

Calling CYCLE198, CYCLE199

CYCLE198 and CYCLE199 are called before and after a measurement, see Measuring cycle user program chapter.

In addition, CYCLE199 is called on "Measure in JOG" after completion of complex measurements with several cycle calls, e.g. after "Center calculation from 3 holes/spigots with offset". CYCLE199 contains labels specially for the various complex measurements. Users can program their own special actions after the label in question.

Entry for "Measure in JOG" and selection is performed via the softkeys in the main screen of JOG mode:

Measure workpiece	Calculating and setting workpiece reference points or calibrating the workpiece probe.

or

Measure tool	Measurement of milling or drilling tools or calibration of tool probe.
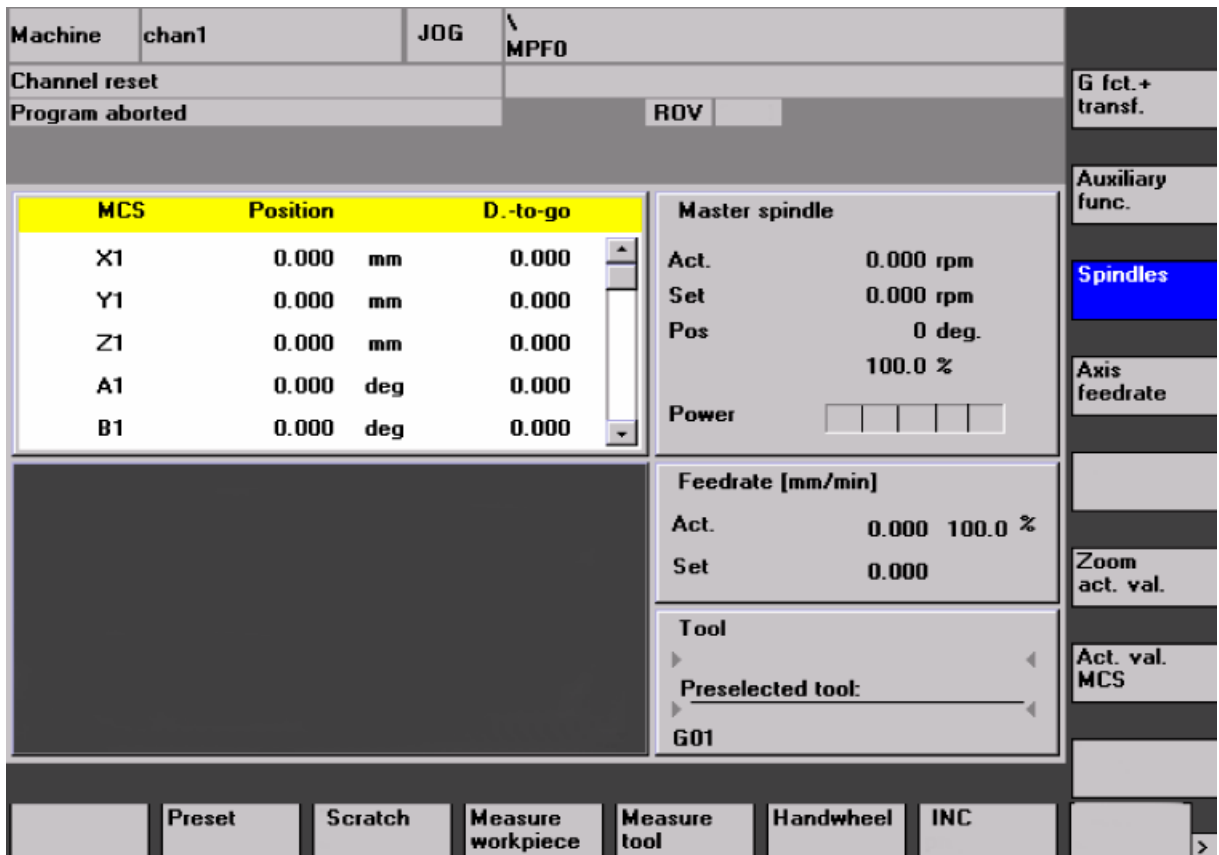
Requirements

The prerequisites for "Measuring in JOG" are detailed in Part 2 "Function description".

The following checklist is useful for determining whether the preconditions are fulfilled:

- **Machine**
  - All machine axes are designed in accordance with DIN 66217.
  - All 3 geometry axes are present according to MD 20050 AXCONF_GEOAX_ASSIGN_TAB.
  - Reference point approach was completed in all the required machine axes.
  - A touch-trigger workpiece probe (3D) is provided for acquiring workpiece dimensions, and a touch-trigger tool probe for acquiring tool dimensions.

- **PLC**

  810D, 840D, 840Di, 840D sl with HMI Advanced, with the option required:

  "Inter-modal actions" (ASUP's and synchronized actions in all modes)

- **General machine data for machine cycle runs**

  These machine data are described in the "Data description, general machine data for machine cycle runs" chapter.

- **Special machine data and other data for measuring in JOG**

  These special data and settings are described in the "Data description, data for measuring in JOG" chapter.

- **Interrupt for starting the ASUPs**

  As of PLC-SW 6.1, interrupt number 9 applies. 8 applies before this.

  This interrupt must not be used by any other application during "measuring in JOG".

- **Data blocks and measuring cycles in general**
  - The data blocks:

    GUD5.DEF and

    GUD6.DEF

    in directory DEFINE of the software supplied have been loaded into the control and activated (directory "Definitions" in the file system).
  - The measuring cycles in directory CYCLES of the software supplied have been loaded into the standard cycle directory of the control and a power-on has been performed.

- **Special files for measuring in JOG**
  - All files in directory JOG_MEAS\CYCLES of the software supplied have been loaded into the control via "Data in" and a power-on has been performed.
  - Data block GUD7_MC.DEF in directory JOG_MEAS\DEFINE of the software supplied has been adapted and loaded into the control.

    Data block GUD7.DEF has been activated.

Detailed function description:

See "Data description, data for measuring in JOG" chapter and information on upgrading measuring cycles in the "Commissioning" chapter and in the SIEMENSD.TXT file of the software supplied.

See also

> Modifying the GUD7 data block (Page 476)
>
> General information (Page 505)

4.2 Workpiece measurement

4.2.1 Overview

4.2.1.1 General information

> The "measure workpiece" function permits set-up of a workpiece clamped onto a machine table. Reference points on the workpiece are measured by means of workpiece probes, and necessary ZO compensation is calculated and set.
>
> For complete set-up, more than one call may be necessary (several axes, rotated clamping, see Section "Cascaded measurement").
>
> The workpiece probe can be calibrated.

4.2.1.2 Operational sequence

General procedure

1. The workpiece is clamped; the probe is in the spindle.
2. Pressing the "Measure workpiece" softkey displays the following softkey bar for selection:

3. The measurement task is selected by pressing the relevant softkeys.

4. The relevant input displays are shown. The input screen forms must be filled out.

5. Select the zero offset (ZO) to which the specified setpoint position refers and for which the offset is to apply.

6. Input of setpoints

   – e.g. approximate diameter for hole/spigot

   – e.g. specifying the set positions in the meas. axis (at edge)

   – e.g. specifying the center point (for hole/spigot) or the corner point

7. Select axis and axis direction for edge/corner.

8. For "NC start", measurement is started and completed with a preset measurement feed. The first traversing motion is used to correct the mechanical position deviation of the measuring probe, determined when calibrating, and is automatically executed by the system!

Internal sequence

After pressing "NC start", an automatically generated ASUB (/_N_SPF_DIR/_N_JM_MESS_SPF) is started to call up a measuring cycle with parameters, supplied from entries made in screen forms. This measuring cycle generates the measurement paths and intermediate positions as a function of the specified setpoints.

While the measuring cycle is running, the following settings, defined in the datablock GUD6, in the field _JM_I[ ] are effective:

- Zero point offset

- Working plane (G17...G19)

- the data field _WP[ ] assigned to the active measuring probe

The switching behavior parameters of the probe determined by calculating the probe are stored in this data field (data array) _WP[ ].

Zero offset

The translation offset and/or an offset for the rotation around the infeed axis in the selected ZO is applied based on the measuring results and the specified setpoint position, depending on the measurement task.

With the default setting (_JM_I[5]=0), the following offsets are possible:

- "Measuring Only" mode

  (no ZO correction, just display measurement results)

- "G54...G57, ..."

  (correction in settable ZO)

- "Basic reference"

  (offset in the system frame "set zero point" $P_SETFRAME)

In the extended correction selection (_JM_I[5]=1), the following options are available:

- Correction in any global basic frame of the frame chain active during measurement. Only possible if no rotation is measured:

  e.g. during "measure edge", "measure distance", "measure hole", and "measure spigot".

- Correction in any channel-specific basic frame of the frame chain active during measurement.

4.2.1.3   "Function interface of the measuring point softkeys (P1...P4)", in the PLC

General information

This function includes transfer of the status "n. measuring point completed and measure value saved" to the PLC interface. This has the same significance as activating a corresponding, vertical measuring point softkey (P1 … P4), after a successful measurement in one of the workpiece measuring variants from measuring in JOG.

The function "reject n. measurement → n. measuring point inactive" can be controlled from the PLC interface – equivalent to the same operator sequence at the HMI when measuring in JOG.

Description of the PLC user interface

- Signal flow: PLC → measuring in JOG (HMI)

Data	Description
DB19.DB43 Bit 0 = 1	Switches softkey "1st measuring point" inactive → reject measurement, The signal must be displayed on the HMI until DB19.DB43 Bit 4 = 0.
DB19.DB43 Bit 1 = 1	Switches softkey "2nd measuring point" inactive → reject measurement, The signal must be displayed on the HMI until DB19.DB43 Bit 5 = 0.
DB19.DB43 Bit 2 = 1	Switches softkey "3rd measuring point" inactive → reject measurement, The signal must be displayed on the HMI until DB19.DB43 Bit 6 = 0.
DB19.DB43 Bit 3 = 1	Switches softkey "4th measuring point" inactive → reject measurement, The signal must be displayed on the HMI until DB19.DB43 Bit 7 = 0.

- Signal flow: Measuring in JOG (HMI) → PLC

Data	Description
DB19.DB43 Bit 4 = 1	If softkey "1st measuring point" active and can be seen on the screen, Measuring 1st measuring point completed and measured value saved.
DB19.DB43 Bit 5 = 1	If softkey "2nd measuring point" active and can be seen on the screen, Measuring 2nd measuring point completed and measured value saved.
DB19.DB43 Bit 6 = 1	If softkey "3rd measuring point" active and can be seen on the screen, Measuring 3rd measuring point completed and measured value saved.
DB19.DB43 Bit 7 = 1	If softkey "4th measuring point" active and can be seen on the screen, Measuring 4th measuring point completed and measured value saved.

Example

The functionality shown can be used with a Siemens handheld unit (HHU) – when a measuring point has been successfully completed, an LED on the HHU keyboard is lit. The HHU key, assigned to this LED can then act from the sense as rejecting a measuring point.

The PLC user interface signals should be interlocked with the input and output signals of the HHU using the functionality of the PLC user program.

The use of an HHU should allow the process-related control of a measuring operation.

4.2.1.4 Measuring in JOG with active TRAORI

Operational sequence

The subsequent description refers to the following applications:

● Measuring in JOG, with active TRAORI and applied measuring probe.

● Measuring in JOG, in the rotated (swiveled) planes

1. TRAORI is active.

2. If a workpiece is measured and the measuring probe is not in the basic (initial) setting of the machine kinematics, then this must be communicated to the NCU as rotation in the active zero offset (ZO).

   – Example 1: The workpiece cannot be clamped to the machine by the longitudinal and transverse end. In this case, the workpiece coordinate system (WCS) must be rotated around Z through 90 degrees. Entry in the active ZO, rotation around Z.

   – Example 2: The hole to be measured is located on a vertical side of the workpiece. In this case, the WCS must be rotated around X or Y through 90 degrees. Entry in the active ZO rotation around X or Y.

3. Aligning the workpiece coordinate system (WCS) in the tool direction in MDA:

   G0 C3=1 (valid for G17 plane).

4. With NC start, traversing motion is initiated and the tool aligns itself in the rotated WCS in the Z axis.

   The vertical orientation to the XY plane is kept.

5. Approach the edge, corner,... to be measured

   If the edge, corner,… cannot be completely reached with the machine axes, the measuring probe can be advanced using the rotary axes.

   In this case, the WCS is not updated.

6. Start the measuring process!

From measuring cycles SW 6.3 onwards, the descriptive points 2. and 3. can also be executed with the functionality of "swivel in JOG".

Note

If the "swiveling" or 5-axis transformation (TRAORI) are used to align the measuring probe, then these must also be appropriately set-up in the machine!

Note the machine manufacturer's instructions.

Note

In general:
- The translation offset is applied in the coarse offset.
- Any fine offset is reset.

4.2.2 Calibrating the workpiece probe

4.2.2.1 General information

Prerequisite

The workpiece probe is the active tool in the spindle with activated tool offsets. The approximate length and the radius of the measuring probe sphere must be entered in the tool data.

An SPOS-capable spindle is required to calibrate the radius of the measuring probe sphere.

Calibration process

On milling machines and machining centers, the workpiece probe is inserted in the spindle. This can lead to measuring errors caused by the clamping tolerances of the probe in the spindle. The switching points (trigger points) of the measuring probe with reference to the spindle center must therefore be determined for each new probe inserted.

This is achieved with calibration by which the probe is calibrated in a hole or on a surface.

Note

The feedrate override should have the same value during calibration and measurement to reduce measurement inaccuracies.

Operation

After you have pressed the "probe calibration" softkey, a display image is shown, containing the following options:

- "Length" (calibrating the length of the probe at the surface)
- "Radius" (calibrating the radius of the measuring probe sphere in the hole)

The reference dimension for the diameter of the calibration hole and the height of the calibration surface to be specified can be pre-assigned using the following GUD parameters:

- E_MESS_CAL_D → diameter, calibration hole (calibration ring)
- E_MESS_CAL_L → calibration height in the feed axis (refer to WCS)

4.2.2.2   Calibrating probe length

General information

By selecting "length", it is possible to calibrate the probe in the infeed axis on a suitable and precisely known surface, e.g. on the workpiece. The precise length 1 (L1) of the prove is also determined and entered in the tool offset memory.

Note the setting of _CBIT[14]:

_CBIT[14]=0: L1 referred to ball center

_CBIT[14]=1: L1 ref. to ball circumference

Machine	CHAN1		Jog	MPF0			
⁄⁄ Channel reset				Program aborted			
					ROV		

Work	Position		Repos offset	Master spindle	S1	⊠	Length
X	-333.3333	mm	0.0000	Act.	0.000 rpm		
Y	-111.1111	mm	0.0000	Set	0.000 rpm		Radius
Z	222.2222	mm	0.0000	Pos.	0 deg.		
A	242.5183	deg	0.0000		100.0 %		
C	357.6571	deg	0.0000	Power	0%		

3D-probe calibration — Height of ref. piece

Z0   0.0000 mm

<<
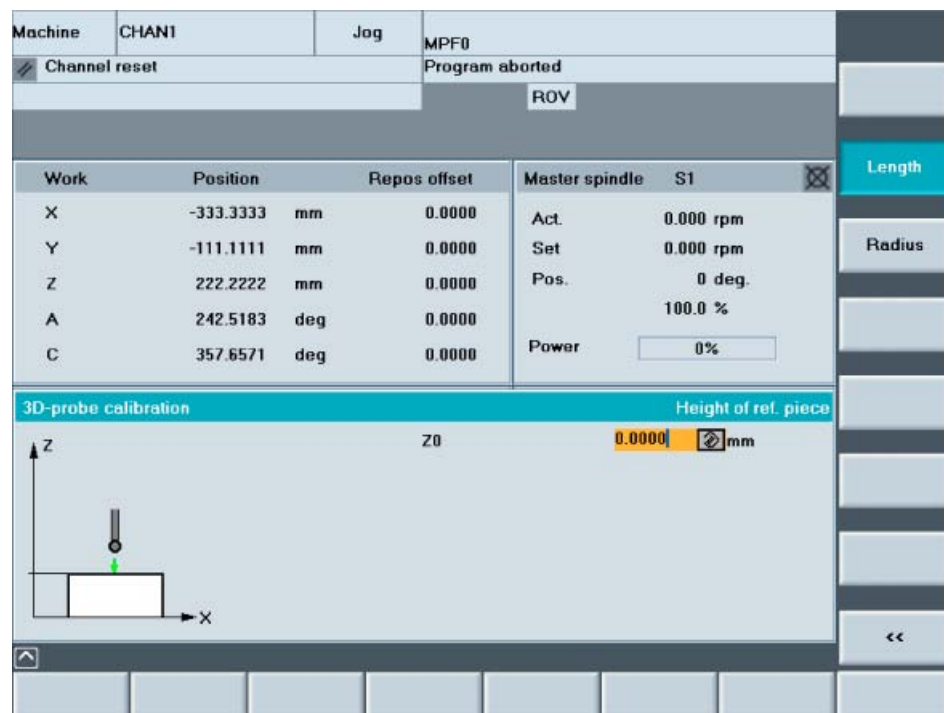
Approaching the calibration surface

The probe must be positioned opposite to the calibration surface of the reference or workpiece.

Enter details in input form

Enter the known dimension (workpiece coordinate) of the calibration surface, referred to the WCS active when calibrating.

Note the settings in data block GUD6:

* Active zero offset during measurement:

    Variable _JM_I_[4])

* Active working plane during measurement:

    Variable _JM_I_[3].

Result

Calibration is performed automatically as soon as you press "NC Start". Trigger value and length offset L1 are stored.

4.2.2.3 Calibrating probe radius

General information

With the "radius" selection, the probe can be calibrated in the axes of the working plane in a suitable hole (geometrical accuracy, low surface roughness) and precisely known diameter or in calibration ring.

Machine	CHAN1		Jog	MPF0				
Channel reset				Program aborted				
					ROV				

Work	Position		Repos offset	Master spindle	S1	
X	-333.3333	mm	0.0000	Act.	0.000 rpm	
Y	-111.1111	mm	0.0000	Set	0.000 rpm	
Z	222.2222	mm	0.0000	Pos.	0 deg.	
A	242.5183	deg	0.0000		100.0 %	
C	357.6571	deg	0.0000	Power	0%	

3D-probe calibration — Diameter ref. piece

D   50.0000 mm

Length

Radius

<<
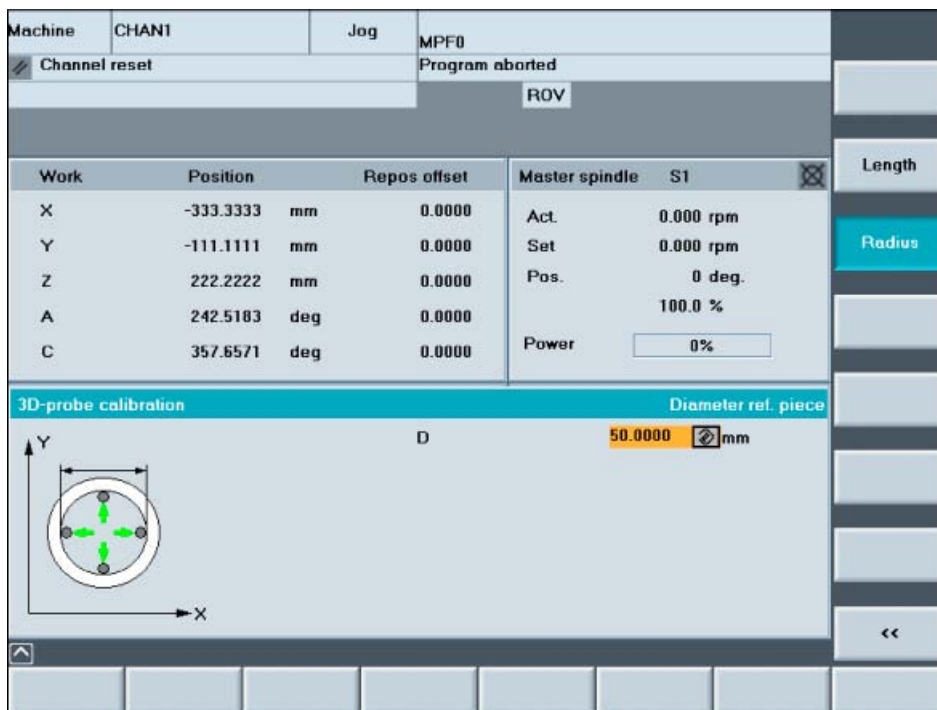
Approaching the calibration ring

Position the probe roughly in the hole center and at calibration depth.

Enter details in input form

Enter the known dimension of the calibration ring diameter.

Note the settings in data block GUD6:

- Active zero offset during measurement:

  Variable _JM_I_[4].

- Active working plane during measurement:

  Variable _JM_I_[3].

Result

Calibration is performed automatically as soon as you press "NC Start".

The precise position of the hole center is determined first. After that, in both axes of the plane and in each of the two directions, the 4 switching points within the hole are determined and stored as trigger values in the probe's array.

Note

If mono probes are used, no positional deviation is shown in "Measure in JOG"

The calibration variant used here, "Calibrate with unknown center point", does not provide the appropriate requirements. This means that the value "zero" is entered in the GUD6 parameters _WP[n,7] and _WP[n,8].

4.2.3 Measure edge

4.2.3.1 General information

Prerequisite

The workpiece probe is the active tool with activated tool offsets in the spindle and is already calibrated (refer to "Calibrating workpiece probe" chapter).

Selection display

After selecting "edge", a selection display is shown containing the following options:

- "Setting the edge"
- "Orienting the edge"
- "Distance 2 edges"

Machine	CHAN1		Jog	MPF0		
Channel reset				Program aborted		
				ROV		

Work	Position		Repos offset	Master spindle	S1	⊠
X	-333.3333	mm	0.0000	Act.	0.000 rpm	
Y	-111.1111	mm	0.0000	Set	0.000 rpm	
Z	222.2222	mm	0.0000	Pos.	0 deg.	
A	242.5183	deg	0.0000		100.0 %	
C	357.6571	deg	0.0000	Power	0%	

Workpiece measuring

— Set edge

— Orient edge

— Distance 2 edges

‹‹ — Back (to selection Measure workpiece)
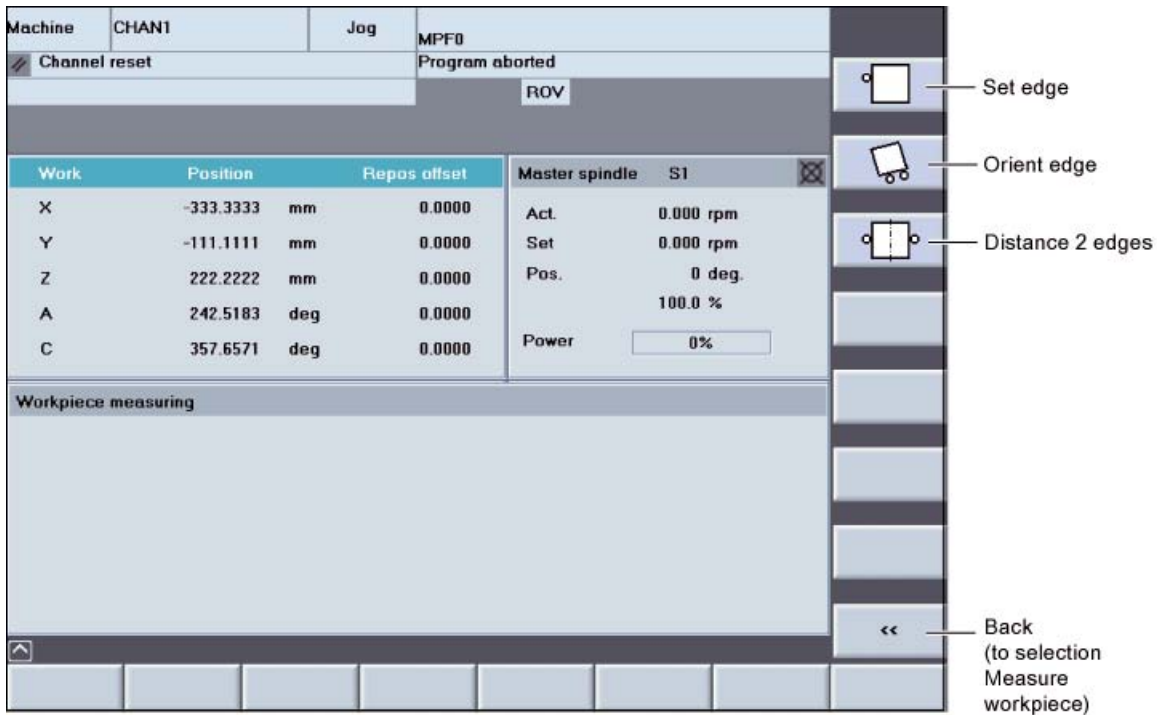
Note

Set the feedrate override to the same value as for calibration!

See also

Calibrating probe length (Page 99)

Calibrating probe radius (Page 100)

4.2.3.2   Setting the edge

This enable measurement of a reference point (paraxial edge) on a workpiece in one of the axes X, Y, or Z and setting as ZO (translation).

Approaching the workpiece

Position the probe in front of the edge.
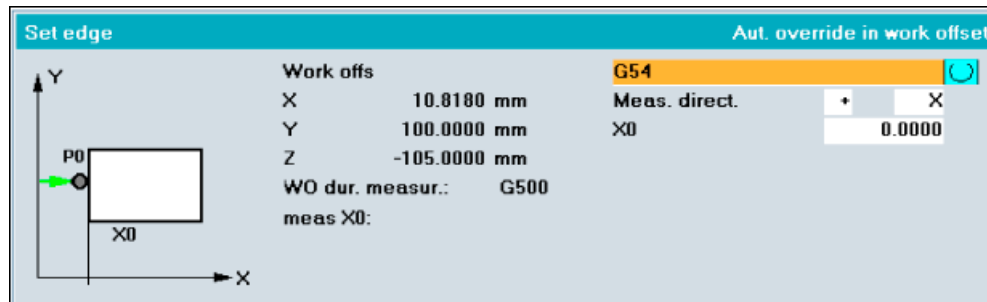
Enter details in input form

- Selection of the ZO.
- Select an axis and measuring direction.
- Enter the set position required for the reference point (edge) for the selected ZO.

Result

Measurement is performed automatically with the set measuring feed as soon as you press "NC Start". Measurement is followed by rapid-traverse retraction to the starting position. The offset is then automatically calculated. If the selected offset is the active ZO, then this is automatically activated.

Display and correction

After successful offset calculation, the frame components of the selected ZO are re-displayed along with the measured position of the edge in the measuring axis.

ZO correction is calculated in such a way that the measured edge assumes the required setpoint after activation of the selected ZO.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.3.3 Orienting the edge

By measuring two points on a straight workpiece edge, it is possible to determine the angle position of this edge with respect to a reference axis.

Orientation of the workpiece edge is possible by

- "Coordinate rotation" or
- Rotating the workpiece using a rotary table (specifying the rotary axis).

2 measuring points are possible, P1 and P2.

Approaching the workpiece

Position the probe in front of the edge, first at P1 and after completion of this measurement at P2.
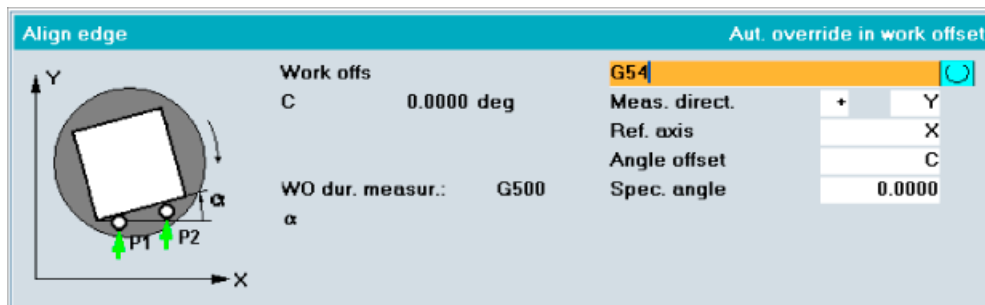
Enter details in input form

- Selection of the ZO.
- Select axis X, Y, or Z and measurement direction.
- Select reference axis for the angle.
- Select the required angle offset: Select "coordinate rotation" or the name of the rotary axis.
- When entering the "set angle", an orientation deviating from 0 degrees is possible.

Orienting the edge, rotating with rotary table

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". Measurement is followed by rapid-traverse retraction to the starting position.

After successful measurement, the measured value is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at measuring point **P2** and with softkey "P1 stored" switched active, pressing "NC Start" starts measurement of the 2nd measuring point in the selected measuring axis. After successful measurement, softkey "P2 stored" is activated, and the 2nd measured value is stored.

A vertical "Calculate" softkey is then displayed. After this softkey is pressed, then angle between the edge and the reference axis and the selected contour calculation is calculated.

When the "coordinate rotation" angular offset (correction) is selected, then the offset is also activated if it is the active ZO.

When the "rotary axis" angular offset is selected (name of the rotary axis), a help function for the user is displayed to activate the offset (refer to "Support of set-up in JOG" chapter).

Display and correction

After offset calculation has been completed, the frame components of the selected ZO are redisplayed along with the measured "alpha" angle.

In the case of ZO correction by "rotation of the workpiece coordinate system", the selected ZO is calculated such that the measured edge forms the required angle (set angle) with the selected reference axis after activation of the selected ZO.

In the case of ZO correction in a specified rotary axis, the difference in angle between the measured and desired angle is entered in the selected ZO (translation) of the specified rotary axis.

No check is made for correct assignment of the specified rotary axis!

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.3.4 Distance 2 edges

This means that the distance L of two edges parallel to an axis at a workpiece, e.g.: Slot, rib, or step, can be determined in one of the axes X, Y or Z and their center set as reference point in a ZO.

2 measuring points are possible, P1 and P2.

Approaching the workpiece

Position the probe in front of the edge, first at P1 and after completion of this measurement at P2.
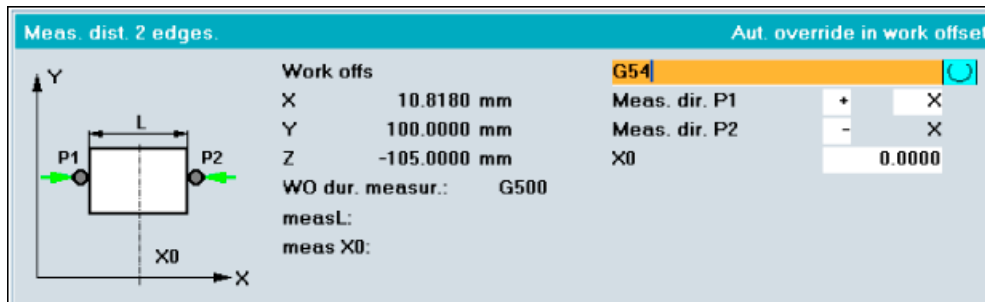
Enter details in input form

- Selection of the ZO.
- Select axis X, Y, or Z and measurement direction at P1.
- Select the measuring direction at P2.
- Enter the set position of the two edges for the selected ZO.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". After successful measurement, the measured value is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at measuring point **P2** and with softkey "P1 stored" switched active, pressing "NC Start" starts measurement of the 2nd measuring point P2 in the selected measuring axis. After successful measurement, softkey "P2 stored" is activated, and the 2nd measured value is stored.

A vertical "Calculate" softkey is then displayed. After this softkey is pressed, the distance and the distance center between the 2 measuring points in the selected measuring axis and the selected offset calculation are calculated. The offset is activated at the same time if it is the active ZO.

Display and correction

After the offset calculation has been successfully completed, the frame components of the selected ZO are re-displayed so that the calculated center of the measured edge distance after activating the selected ZO assumes the required setpoint position (e.g. X0) in the corrected workpiece coordinate system.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.4 Measuring corner

4.2.4.1 General information

Prerequisite

The workpiece probe is the active tool with activated tool offsets in the spindle and is already calibrated (refer to "Calibrating workpiece probe" chapter).

Selection display

After selecting "corner", a selection display is shown containing the following options:

- "right-angled corner"
- "any corner"
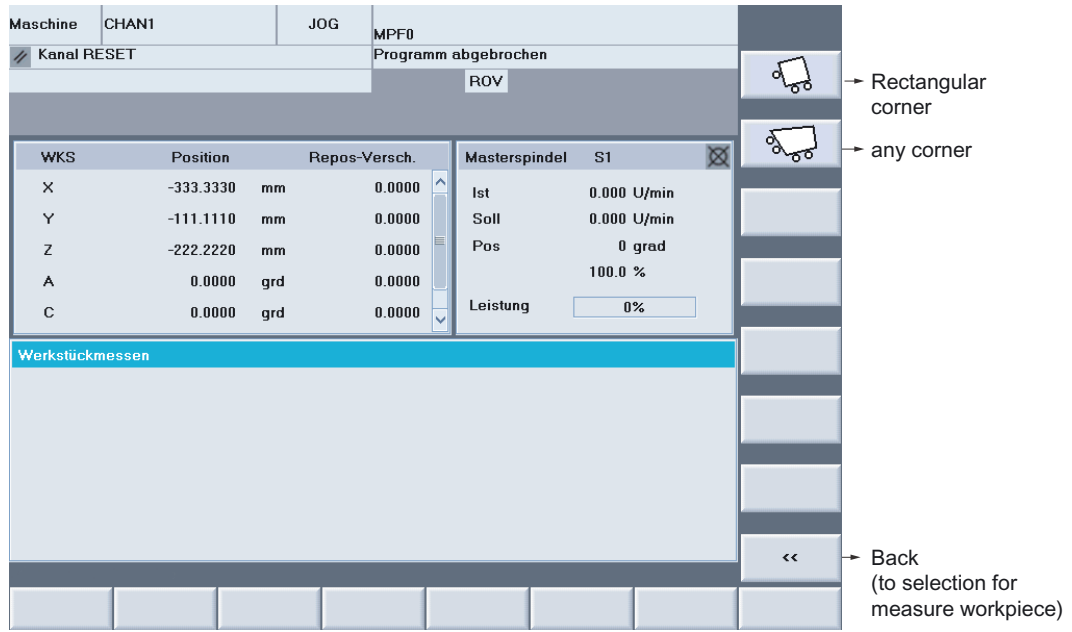
Note

Set the feedrate override to the same value as for calibration!

4.2.4.2 Right-angled corner

This permits measurement of a right-angled corner of a workpiece as the reference point in the axes of the working plane and setting it as the ZO (translation and rotation).

3 measuring points are required: P1, P2, and P3.

The 1st axis of the working plane functions as the reference axis (for G17: X axis). Edge P1, P2 functions as the reference edge on the workpiece. This edge is aligned parallel to the reference axis (G17: X axis).

Approaching the workpiece

Position the probe on the corner, first at P1 and after completion of this measurement at P2, and after completion of this measurement at P3 - to measuring depth in each case.
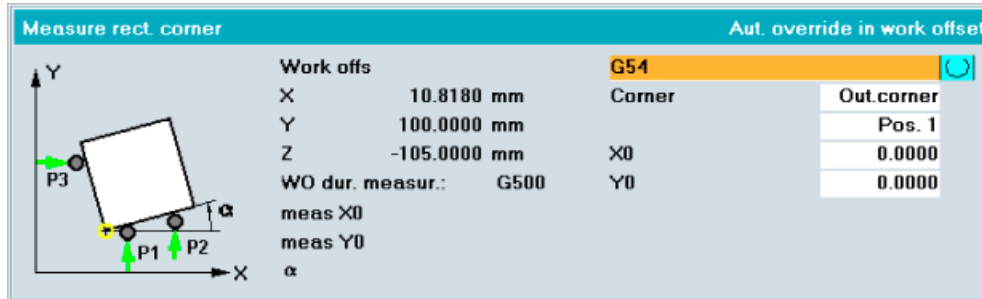
Enter details in input form

- Select of the ZO

- Select outside or inside corner

- Select the position of the corner

- Enter the set position required for the reference point P0 (corner) for the selected ZO in both axes.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". Measurement is performed in the axis and axis direction determined by the selected position. After successful measurement, the previously inactive softkey "P1 stored" is activated and the coordinates of the 1st measuring point **P1** is stored internally.

After manual positioning in front of the 2nd measuring point **P2**, measuring is performed automatically at this measuring point on pressing "NC start". Proceed in the same way for measuring point **P3**.

If all of the measuring points have been successfully completed and all "Px saved" softkeys activated, then a vertical "calculate" softkey is displayed. After this softkey has been pressed, the corner coordinates P0 and the offset are calculated. The offset is activated at the same time if it is the active ZO.

Display and correction

After successful calculation and offset application, the coordinates of the corner point determined are displayed in the WCS active during measurement. Display of the translation frame components of the selected ZO is updated.

If you have selected "Just measure", the corner point determined and the angle of the reference axis will only be displayed.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.4.3 Any corner

This permits measurement of a corner of a workpiece as the reference point in the axes of the working plane and setting it as the ZO (translation and rotation).

The corner does not have to be right-angled.

4 measuring points are required: P1, P2, P3, and P4.

The 1st axis of the working plane functions as the reference axis (for G17: X axis). Edge P1, P2 functions as the reference edge on the workpiece. This edge is aligned parallel to the reference axis (G17: X axis).

Approaching the workpiece

Position the probe on the corner, first at P1 and after completion of this measurement at P2, and after completion of this measurement at P3, etc.

Enter details in input form

- Select of the ZO
- Select outside or inside corner
- Select the position of the corner
- Enter the set position required for the reference point (corner) for the selected ZO in both axes.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start".

This is the same sequence as for "right-angled corner" but with 4 measuring points.

4.2.5 Measuring pocket, hole or spigot

4.2.5.1 General information

Prerequisite

The workpiece probe is the active tool with activated tool offsets in the spindle and is already calibrated (refer to "Calibrating workpiece probe" chapter).

Pocket/hole selection display

After selecting "pocket/hole", a selection display is shown containing the additional following options:

- "Rectangular pocket"
- "1 hole"
- "2 holes"
- "3 holes"
- "4 holes"

Spigot selection display

After selecting "spigot", a selection display is shown containing the additional following options:

- "Rectangular spigot"
- "1 circular spigot"
- "2 circular spigots"
- "3 circular spigots"
- "4 circular spigots"
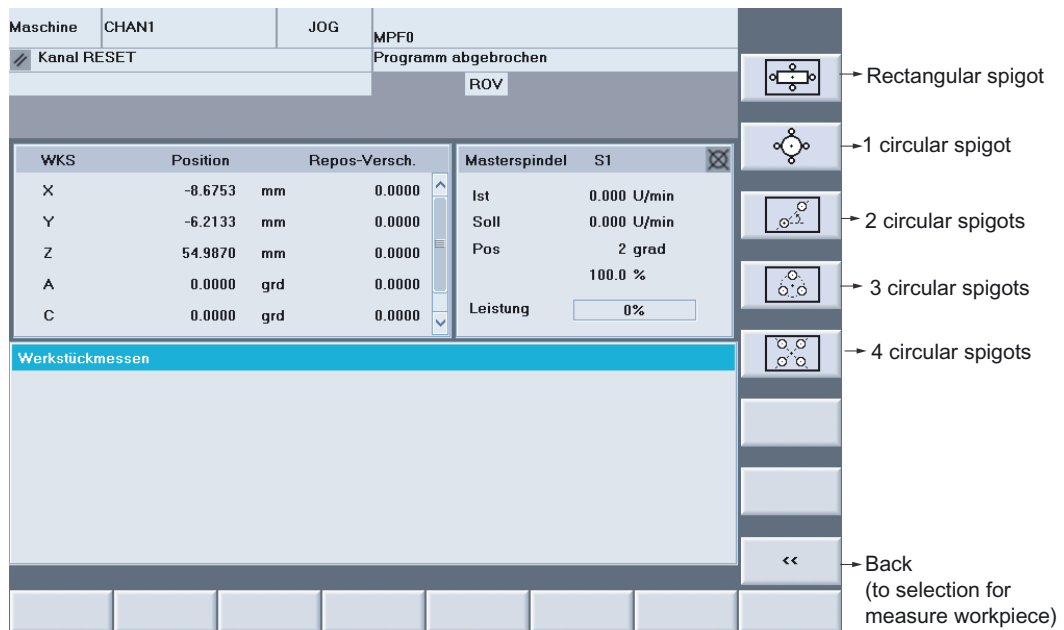
Note

Feed override

Set the feedrate override to the same value as for calibration!

4.2.5.2 Rectangular pocket or 1 hole or 1 spigot

It can be measured by selecting the **center** on the workpiece as the reference point and by setting as the ZO (translation) :
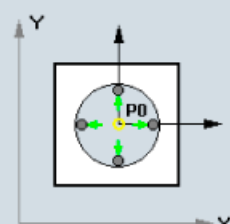
- A paraxial rectangular pocket or
- a hole or
- a paraxial rectangular spigot or
- a circular spigot

Measurement is performed in both axes of the working plane.

Approaching the workpiece
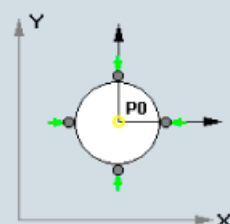
Position the probe roughly at measuring depth in the center of the pocket/hole, or in the case of spigots roughly in the center above the spigot.

Measure 1 hole		Aut. override in work offset
Y	Work offs	G54
	X 10.8180 mm	Diameter 50.0000
	Y 100.0000 mm	Contact angle 0.0000
P0	Z -105.0000 mm	X0 0.0000
	WO dur. measur.: G500	Y0 0.0000
	ø	
	meas X0:	
X	meas Y0:	
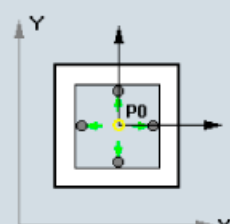
Measure 1 circ. spigot		Aut. override in work offset
Y	Work offs	G54
	X 10.8180 mm	Diameter 50.0000
	Y 100.0000 mm	DZ 7.0000
P0	Z -105.0000 mm	Contact angle 0.0000
	WO dur. measur.: G500	X0 0.0000
	ø	Y0 0.0000
	meas X0:	
X	meas Y0:	
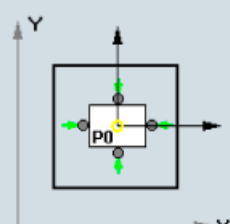
Measure rect. pocket		Aut. override in work offset
Y	Work offs	G54
	X 10.8180 mm	L 50.0000
	Y 100.0000 mm	W 35.0000
P0	Z -105.0000 mm	X0 0.0000
	WO dur. measur.: G500	Y0 0.0000
	meas L:	
	meas W:	
X		

Measure rect. spigot		Aut. override in work offset
Y	Work offs	G54
	X 10.8180 mm	L 50.0000
	Y 100.0000 mm	W 35.0000
	Z -105.0000 mm	DZ 7.0000
P0	WO dur. measur.: G500	X0 0.0000
	meas L:	Y0 0.0000
	meas W:	
X		

Enter details in input form

- Select of the ZO

- For rectangular pocket, rectangular spigot:

  Enter approx. length (1st axis of operating plane) and width W (2nd axis of operating plane).

- For hole, circular spigot:

  Enter the approximate diameter.

- For spigots only:

  Enter infeed value DZ (measuring depth as from starting position, value >0).

- For hole, circular spigot only:

  Enter the probing angle if measurement is not to be paraxial.

- Enter the set position required for the reference point P0 (center) for the selected ZO in both axes.

Result

Measurement is performed automatically as soon as you press "NC Start". The probe probes 4 points of the inside and outside wall in succession.

The offset is then automatically calculated. If the selected offset is the active ZO, then this is automatically activated.

Display and correction

After completion of calculation and offset, the diameter or width/length and the coordinates of the center P0 are displayed.

An offset is applied in the translation components of the selected ZO in both axes.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.

- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.5.3 2 holes or 2 circular spigots

This permits calculation of the basic rotation (rotation in the working plane) of the clamped workpiece.

This enables orientation by:

- "Coordinate rotation" or

- rotation of the workpiece with a rotary table (rotary axis).

For an angle offset by "coordinate rotation", it is possible to set the reference point for the calculated center of the 1st hole/spigot.

Measurement is performed in both axes of the working plane.

Approaching the workpiece

Position the probe roughly in the center of the 1st hole/spigot P1, after completion of this measurement in the rough center of the 2nd hole/spigot P2, for a hole to measuring depth in each case, for a spigot above the spigot.

Enter details in input form

- Select of the ZO

- Enter approximate diameter (hole/spigot).

  This must be selected such that it applies to all holes/spigots.

- For spigots only: Enter the infeed value DZ:

  (measuring depth as from starting position, value >0)

- Select the required angle offset:

  "Coordinate rotation" or axis name of the rotary axis

- Under the "set angle" input, an orientation deviating from 0 degrees with respect to the 1st axis of the working plane (e.g., G17: X axis) is possible.

- Only for offset type "coordinate rotation" and if "set P1" is selected:

  Enter the set position required for the reference point P1 (center of the 1st hole) for the selected ZO in both axes.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". The probe probes 4 points of the inside and outside wall in succession.

After successful measurement, the center is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at point **P2** and with softkey "P1 stored" switched active, pressing "NC start" starts measurement of the 2nd hole/spigot. After successful measurement, softkey "P2 stored" is activated, and the 2nd center is stored. If all of the measuring points have been successfully completed and all "Px saved" softkeys activated, then a vertical "calculate" softkey is displayed. After this softkey is pressed, "alpha" is calculated.

When the "coordinate rotation" angular offset (correction) is selected, then the offset is also activated if it is the active ZO.

When the "rotary axis" angular offset is selected (name of the rotary axis), a help function for the user is displayed to activate the offset.

Display and correction

After offset calculation has been completed, the frame components of the selected ZO are redisplayed along with the measured "alpha" angle and the coordinates of the reference point P1.

ZO correction is effected in such a way that the angle determined is in the required set rotation and point P1 is in the set position in the corrected workpiece coordinate system after activation of the selected ZO.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.5.4   3 holes or 3 circular spigots

This permits calculation of the reference point P0 and the "alpha" rotation of the clamped workpiece.

This enables orientation by coordinate rotation and setting the center P0 of the partial circle on which the 3 holes/spigots are located as the reference point.

Measurement is performed in both axes of the working plane.

Approaching the workpiece

Position the probe roughly in the center of the 1st hole/spigot P1, after completion of this measurement in the rough center of the 2nd hole/spigot P2, after completion of this measurement in the rough center of the 3rd hole/spigot P3, for a hole to measuring depth in each case, for a spigot above the spigot.

Enter details in input form

- Select of the ZO
- Enter approximate diameter (hole/spigot).

  This must be selected such that it applies to all holes/spigots.

- For spigots only: Enter the infeed value DZ:

  (measuring depth as from starting position, value >0).

- Enter the set position required for the reference point P0 (center of the partial circle of the 3 holes/spigots) for the selected ZO in both axes.

- If angle offset is selected:

  Under the "set angle" input, an orientation deviating from 0 degrees with respect to the 1st axis of the working plane (e.g., G17: X axis) is possible.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". The probe probes 4 points of the inside and outside wall in succession.

After successful measurement, the measured value is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at the next center P2 and with softkey "P1 stored" switched active, pressing "NC start" starts measurement for this hole/spigot.

The rest of the sequence is as for P1.

If all of the measuring points have been successfully completed and all "Px saved" softkeys activated, then a vertical "calculate" softkey is displayed. After this softkey is pressed, P0 and "alpha" are calculated.

When the "coordinate rotation" angular offset (correction) is selected, then the offset is also activated if it is the active ZO.

When the "rotary axis" angular offset is selected (name of the rotary axis), a help function for the user is displayed to activate the offset.

Display and correction

After offset calculation has been completed, the frame components of the selected ZO are redisplayed along with the measured "alpha" angle and the coordinates of the reference point P0.

ZO correction is effected in such a way that the "alpha" angle determined and point P0 are at the desired setpoints (translation and rotation) in the offset workpiece coordinate system after activation of the selected ZO.

Note
- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.5.5   4 holes or 4 circular spigots

This permits calculation of the reference point P0 and the "alpha" rotation of the clamped workpiece.

This permits orientation by coordinate rotation and setting point P0 (intersection point of the 2 straight lines, whose hole centers are connected diagonally) as the reference point.

Measurement is performed in both axes of the working plane.

Approaching the workpiece

Position the probe roughly in the center of the 1st hole/spigot P1, after completion of this measurement in the rough center of the 2nd hole/spigot P2, etc., for a hole to measuring depth in each case, for a spigot above the spigot.

Enter details in input form

- Select of the ZO

- Enter approximate diameter (hole/spigot).

  This must be selected such that it applies to all holes/spigots.

- For spigots only: Enter the infeed value (DZ)

  (measuring depth as from starting position, value >0)

- Enter the set position required for the reference point P0 (intersection point of the diagonals) for the selected ZO in both axes.

- If angle offset is selected:

  Under the "set angle" input, an orientation deviating from 0 degrees with respect to the 1st axis of the working plane (e.g., G17: X axis) is possible.

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". The probe probes 4 points of the inside and outside wall in succession.

After successful measurement, the measured value is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at the next center **P2** and with softkey "P1 stored" switched active, pressing "NC start" starts measurement for this hole/spigot.

The rest of the sequence is as for P1.

If all of the measuring points have been successfully completed and all "Px saved" softkeys activated, then a vertical "calculate" softkey is displayed. After this softkey is pressed, P0 and "alpha" are calculated.

When the "coordinate rotation" angular offset (correction) is selected, then the offset is also activated if it is the active ZO.

When the "rotary axis" angular offset is selected (name of the rotary axis), a help function for the user is displayed to activate the offset.

Display and correction

After offset calculation has been completed, the frame components of the selected ZO are redisplayed along with the measured "alpha" angle and the coordinates of the reference point P0.

ZO correction is effected in such a way that the "alpha" angle determined and point P0 are at the desired setpoints (translation and rotation) in the offset workpiece coordinate system after activation of the selected ZO.

Note
- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- **Support** for the user is featured for **activation of the zero offset** determined in JOG mode and for necessary probe reorientation. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.6   Align plane

4.2.6.1   General information

Prerequisite

The workpiece probe is the active tool with activated tool offsets in the spindle and is already calibrated (refer to "Calibrating workpiece probe" chapter).

Selection display

After selection of "orient plane", the following selection display is shown:
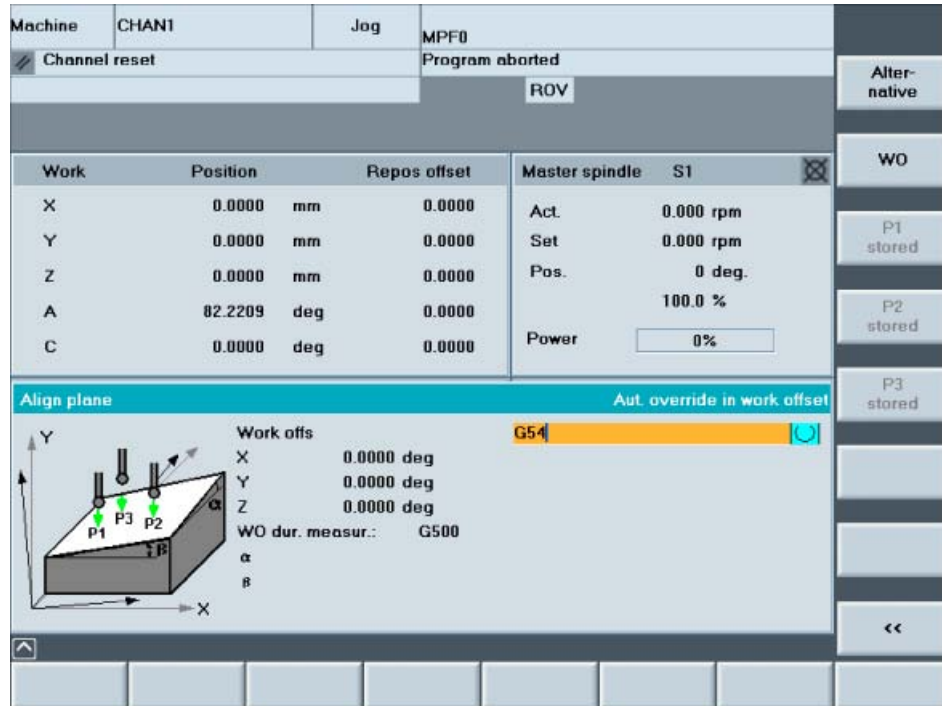
Note

Set the feedrate override to the same value as for calibration!

4.2.6.2 Measuring a plane that is oblique in space

That permits measurement of a workpiece plane that is oblique in space and determination of "alpha" and "beta" rotation.

That enables orthogonal orientation of the infeed axis with respect to this plane by coordinate rotation.

Measurement is performed in the infeed axis (3rd axis) at 3 different points in the working plane.

Approaching the workpiece

Position the probe above measuring point P1, after completion of this measurement above measuring point P2, after completion of this measurement above measuring point P3.

Enter details in input form

Select of the ZO

Result

Measurement is performed automatically at **P1** with the set measuring feed as soon as you press "NC Start". After successful measurement, the measured value is stored internally and the "P1 stored" softkey that was previously switched inactive is activated.

After manual positioning at the next measuring point **P2** and with softkey "P1 stored" switched active, pressing "NC start" starts measurement for this measuring point.

The rest of the sequence is as for P1.

If all of the measuring points have been successfully completed and all "Px saved" softkeys activated, then a vertical "calculate" softkey is displayed. After this softkey is pressed, "alpha" and "beta" are calculated.

Display and correction

After offset calculation has been completed, the frame components (rotation) of the selected ZO are redisplayed along with the measured "alpha" and "beta" angle.

ZO correction is performed in such a way that the plane with the calculated points P1 to P3 after activation of the selected ZO is parallel to the new working plane.

Note

- The rejection, repetition, and end of measurement are described in the "Reject, repeat, end of measurement" chapter.
- A **support function** is available to the user when **activating the determined ZO correction** in the JOG mode. This is shown right after the measurement and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

See also

Rejection and repetition of measurements (Page 122)

General information (Page 125)

4.2.7 Rejection, repetition, end of measurement

4.2.7.1 Rejection and repetition of measurements

The last measurement (Px) can be declared invalid any number of times by pressing the assigned softkey "Px stored"

. The softkey is then deactivated (grayed out).

Pressing "NC start" again repeats this measurement and the "Px stored" softkey is then reactivated (black text).

Example

Vertical softkeys P1 to P4 - inactive:

4.2.7.2 Terminating the measurement

If all "Px saved" softkeys are active, then a vertical "calculate" softkey is displayed.

When this softkey is pressed, the measuring points are finally confirmed/acknowledged and the translatory and rotary offset values are calculated. The result is immediately entered into the pre-selected "zero offset". If this is identical with "ZO when measuring", the offset values become immediately effective. This means that the measurements have been completed.

For offsets/corrections, that required e.g. a new alignment/orientation of the measuring probe or the rotary table, the user is provided with a support function to activate the determined ZO offset in the JOG mode. Once the "Calculate" softkey has been pressed, this is shown and is detailed in the Measuring workpieces chapter, "Support of set-up in JOG - after measurement".

The "Px stored" softkeys are then switched inactive and it is possible to start new measurement.

The number of softkeys Px is determined with the measurement task.

When the input screen form is exited, a measurement is also completed/interrupted.

Note

A mode change is only possible after exiting the operator area "measuring in JOG".

Example

Vertical softkeys P1 to P4 active,the "calculate" softkey is displayed:
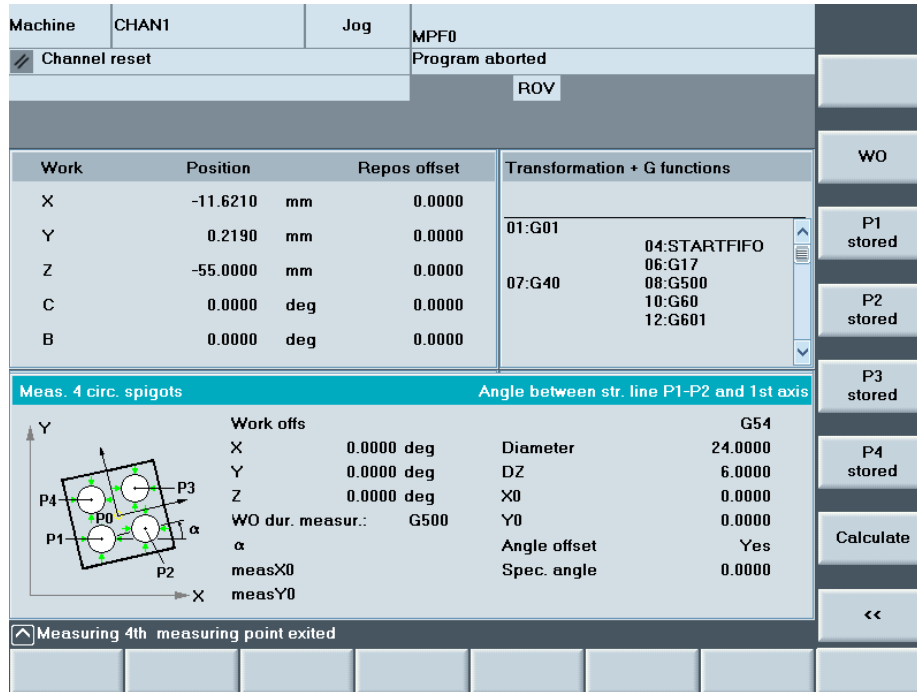
4.2.8 Cascaded measurement

Often, it is not possible to completely set-up a workpiece using just one single measurement; instead, a series of measurements has to be made. This results in certain interdependencies regarding the selected measuring series.

Example

- Orienting an oblique plane
- Orienting an edge, reference in X axis or
- Orienting an edge, reference in Y axis
- Setting a reference point in X, Y, Z

Zero offset

A zero offset can be applied after every measurement.

The "measuring in JOG" function supports activation of another or changed ZO in JOG mode by displaying an additional activation screen form with queries after measurement.

If so selected, the new zero offsets are activated and the probe possibly also re-oriented.

The changed zero offset is offered as the preferred setting for the next measurement. This setting can therefore deviate from the basic setting _JM_I[4] in data block GUD6.

4.2.9 Support of set-up in JOG - after measurement

4.2.9.1 General information

Compensation in the zero offset

After an offset has been applied in the selected zero offset by the measuring function, this ZO is activated in JOG mode and the probe possibly oriented in the new WCS, e.g. for the following measurements.

For "measuring in JOG", an offset in the active ZO (the ZO that applies during measurement) is preset. This ZO is updated after measurement and is therefore active.

This is sufficient in cases where translation offset of the workpiece coordinate system and / or rotation about the infeed axis has occurred.

Set-up in JOG.

Positioning of the rotary axes for orienting the workpiece after measurement or orienting the probe because of rotation about the axes of the working plane has so far only been possible in MDA or AUTOMATIC mode.

To support set-up in JOG after measurement, an additional **activation screen form is automatically shown afterward**, if at least one of the following reasons applies:

- Offset in a ZO **not** active during measurement.

- An offset causes rotation of the WCS about at least one **plane axis** following by a necessary reorientation of the probe.

- An offset demands **rotary axis positioning** for workpiece alignment without affecting the WCS.

The system detects whether the measuring probe must be aligned/oriented using the function "swiveling" or the 5-axis transformation (TRAORI). The relevant screen form is displayed.

If axial movements are required, the user is informed about this in the screen form. It is possible to decide whether pressing "NC start" will start the swivel cycle for orienting the probe or whether the selected rotary axis will move to orient the workpiece.

Note

Align probe

If the function "swiveling" or the 5-axis transformation (TRAORI) is used to align/orient the measuring probe, then this must also be set-up in the machine!

Note the machine manufacturer's instructions.

4.2.9.2   Example 1

Measurement

4 holes were measured. An offset is applied in a ZO that was not active during measurement. Reorientation of the probe is not necessary. The following selection display appears with information:

Machine	CHAN1		Jog	MPF0		
// Channel reset				Program aborted		Alter-native
				ROV		

Work	Position		Repos offset	Master spindle	S1	⊠	WO
X	1.3232	mm	0.0000	Act.	0.000 rpm		
Y	61.6800	mm	0.0000	Set	0.000 rpm		
Z	-55.0000	mm	0.0000	Pos.	11 deg.		
A	11.0000	deg	0.0000		100.0 %		
C	0.0000	deg	0.0000	Power	0%		

Measure 4 holes   You have corrected in an inactive WO!

Work offs	G54	Activate this
X	0.0000 deg	work offset? Yes ⭕
Y	0.0000 deg	The work is rotated
Z	8.6263 deg	round the tool axis!
WO dur. measur.:	G500	Please note when
α	8.6263	traversing in work!
meas X0:	22.5557	
meas Y0:	52.9536	

⌃ NV korrigiert, zum Aktivieren bitte NC-Start betätigen

Explanations on selection display

The display for the measurement function "measure 4 holes" is shown in the left part of the screen form. The display of the measurement result is also shown in the WCS that was active during measurement (G500) and display of the translation values of the offset ZO.

The operator is informed about the selection made in the selection field (yes) with a text or in an upper image line:

- **"You have applied an offset in a non-active ZO!"**

A message text also appears for the special case:

- **"The WCS is about the ...".**

An additional text is output on the HMI "dialog line with user information and instructions. It provides instructions on action to take:

- **"Please press NC start to activate!"**

After pressing "NC start", the ZO with the applied offset is activated. It is not necessary to traverse axes.

The previous measurement selection screen is then re-displayed. Measurement can be performed again.

To avoid activating the ZO with the applied offset, exit the display by pressing the softkey "<<" (return).

4.2.9.3 Example 2

Measurement

An oblique plane was measured. An offset is applied in a ZO that was not active during measurement. "Swiveling" is active. This requires re-orientation of the probe with respect to the plane via the swivel cycle.

The following selection display appears with information:
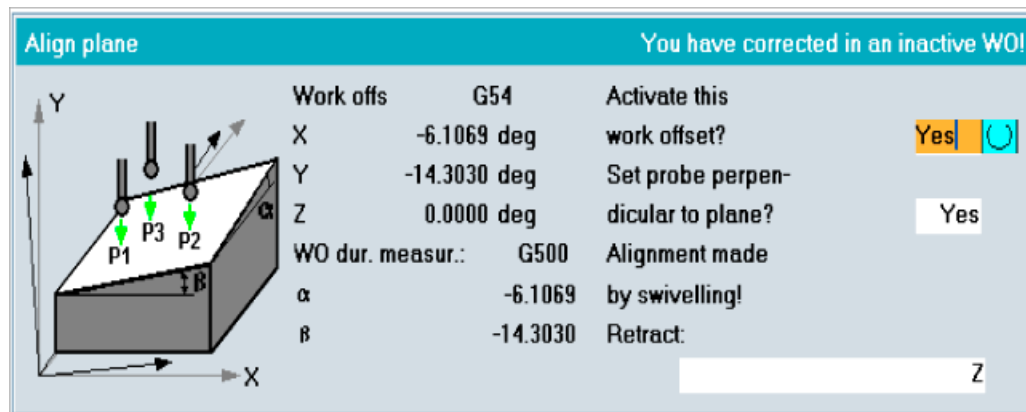
Explanations on selection display

The display for the measurement function "orient plane" is shown in the left part of the screen form. The display of the measurement result is also shown in the WCS that was active during measurement and display of the translation values of the offset ZO.

The operator is informed about the selection made in the selection field 1 (yes) with a text or in an upper image line:

- "You have applied an offset in a non-active ZO!"

Because of the answer with "yes" in toggle field 2, the text in the upper display line is changed to:

- "The new WCS has new orientation!"

With toggle field 3, retraction is supported.

If all screen forms have been filled out, a further text appears on a lower line of the display. It provides instructions on action to take:

- "Please press NC start to activate!"

After pressing "NC start", execution is performed according to the entries that the user made in the activation screen form:

- Activating the corrected ZO or

● Retracting the measuring probe and re-aligning/orienting it using the swivel cycle.

The previous measurement selection screen is then re-displayed.

After the plane has been successfully aligned/oriented, the workpiece can continue to be gauged with measuring "edge", "holes", "spigots" etc (see previous chapter).

To avoid activating the ZO with the applied offset, exit the selection display by pressing the softkey "<<" (return).

4.3 Measuring the tool

4.3.1 Overview of function and sequence

The "tool measurement" function permits the following functions.

- 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.

The tools are measured on the machine.

General sequence

When you press softkey "Measure tool", the following selection and more appears on the vertical softkey bar:

Length

Radius

Calibration probe

<< Back
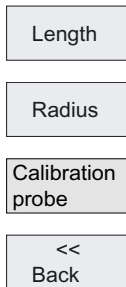
1. The measuring variant is selected and the input screen form is filled with values.
2. Position the tool near the tool measuring probe with the axis traverse keys.
3. "NC start" starts measurement and the remaining sequence with offset entry runs automatically.

4.3.2 Calibrating the tool probe

The function "Calibrate tool measuring probe" calculates the current distance (switching points) between the machine zero and the tool probe (calibration relative to machine) using a **calibration tool** and automatically writes them to a data storage area as trigger values.

The type 120 (end mill) can be defined as the tool type for the calibration tool. There is no special "calibration tool" type.

Prerequisite

- The tool probe is mounted in the machining space of the machine (usually on the machine table) and aligns with the machining axes (machine axes).
- All necessary data of the tool probe (form, dimensions, ...) are entered in the intended variables for "measuring in JOG" E_MESS_MT_... in data block GUD7 (see Data description chapter "Data for measuring in JOG").

- The precise length 1 and the radius of the calibration tool must be stored in a tool offset data set (geometry).
- The calibration tool is in the spindle and is activated with the offset data set.

Proceed as follows

Approaching the tool measuring probe

Position the calibration tool roughly over the center of the measuring surface of the tool probe.

Select the function with softkey

| Measure tool |

Continue with

| Calibration button |

In the input screen form, select the type of calibration by pressing the "alternative" softkey.

- Calibrate length only:
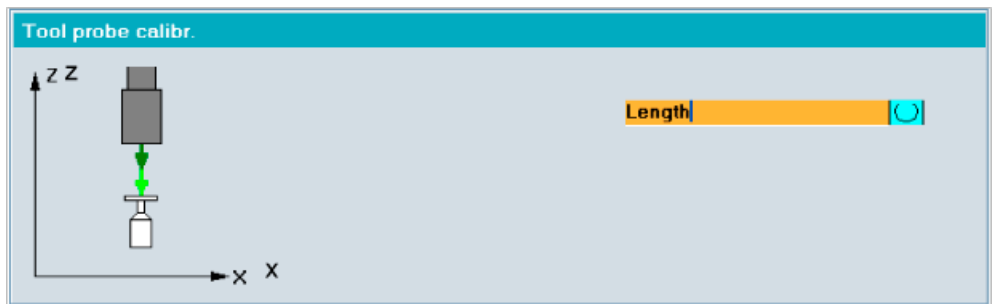
or

- Calibrate length and diameter:
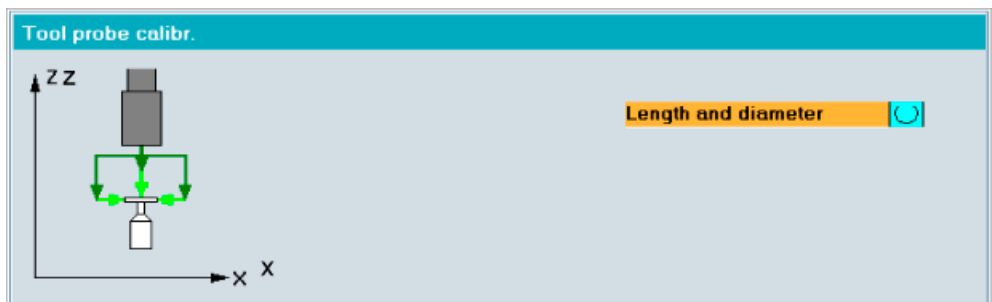
Result

On "NC start", calibration runs automatically with the measuring feed entered in _E_MESS_MT_FM in data block GUD7.

The current distance dimensions between the machine zero and tool probe (trigger points) are determined using the calibration tool and stored in a data area.

The tool probe is now prepared for measurement of tools.

4.3.3   Measuring milling or drilling tools

Prerequisite

- The specific GUD parameters used to measure tools are adapted to the real user conditions.
- The reference points have been approached.
- The tool probe is functional.
- The tool probe has been calibrated before measurement.
- The tool to be measured is located in the spindle and is activated.
- The tool offset data (length radius) are entered as approximate values and activated.

Measurement

This allows you to determine the tool length or radius of milling tools, or tool length of drills and then set the appropriate offset in the tool offset memory.

The tool offset mode for "measure in JOG" can be set via a variable in data block GUD6.

- _JM_B[0]=0: Offset in geometry component
- _JM_B[0]=1: Offset in wear component

For milling tools, cutting edges with a special shape, e.g. rounded cutting edges, can be taken into account with additional entries.

Measurement is performed with a motionless or rotating spindle.

- Radius measurement is performed with a rotation spindle.
- Length measurement is performed with a rotating spindle if the tool radius is greater than the upper radius of the too probe. Otherwise, measurement is with a motionless spindle.

Corresponding to the user specifications regarding the required measuring accuracy, it is possible that extremely small measurement feeds are applied. This is the reason that the tool gauging is automatically sub-divided into two measuring operations (corresponding to the default setting of E_MESS_... parameterization in GUD7_MC).

- The first measurement is always made from a starting position selected by the user with a high measurement velocity. This is used to detect the principle position of the tool to be gauged.
- The 2nd measurement is realized from an optimized position with a short measuring distance and a low measurement feed corresponding to the required measuring accuracy.

The number of probing operations, the required/specified measurement accuracy as well as various limit values can be adapted to the real conditions in the GUD parameters associated with tool measurement (E_MESS_...) (refer to Data description chapter, "Data for measuring in JOG").

Note

Mathematical connection between measuring accuracy and measuring feed

See Measuring cycles for milling and machining centers chapter, "Measurement and correction strategy".

Proceed as follows

Approaching the tool probe

Position the active tool:

- Over the measuring surface of the tool probe (for length measurement) or
- from the side over the measuring probe when measuring the radius

Select the function with softkey

| Measure tool | Continue with selection |

| Radius | The system displays: |

Or:
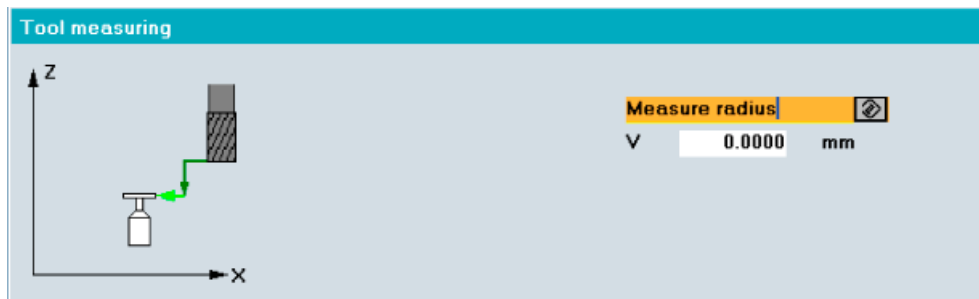
| Length | The system displays: |
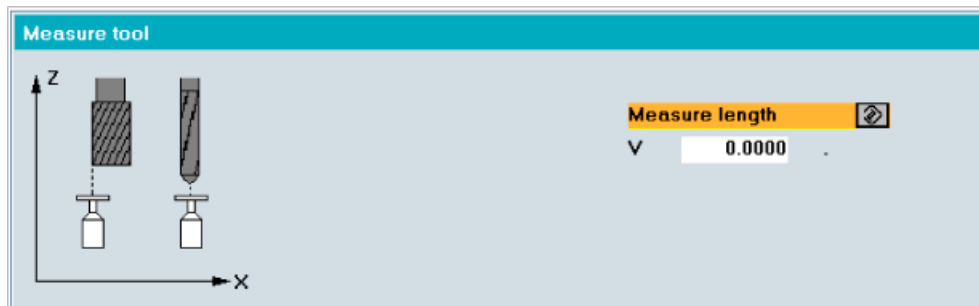
Length measurement of milling cutters

If the tool diameter (entered tool radius x 2) is greater than the entered upper diameter of the tool probe, the milling tool is placed in the center of the probe, offset by the tool radius and measured with rotating spindle (measuring the longest cutting edge).

Otherwise, the tool is placed in the center and measurement is performed with a motionless spindle.

Measurement of milling cutters with special cutting edge

If a cutting edge is rounded, for example, the tool must be measured with a probe offset. This offset (V) must be entered additionally for diameter determination.
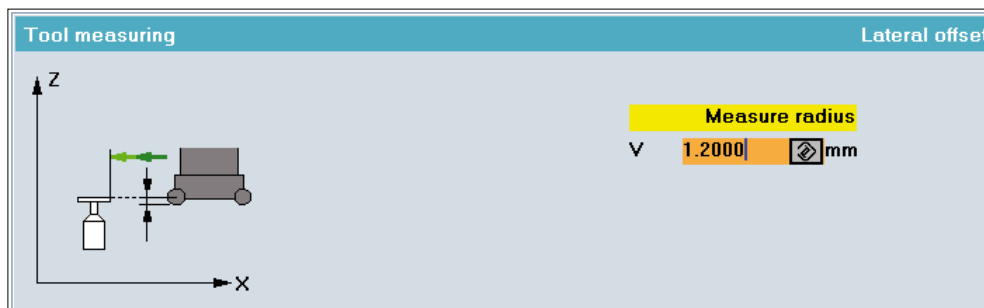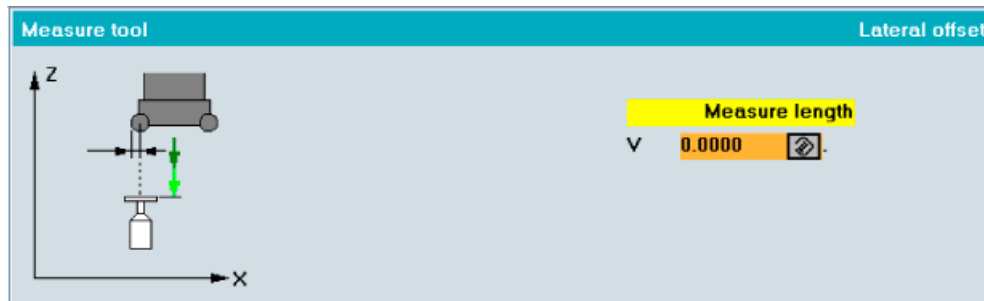
Enter details in input form

Enter offset (V, positive value) when required.

Result

Measurement is performed automatically as soon as you press "NC Start".

The tool offsets "radius" or "length 1" are calculated in and entered in the active tool offset data in accordance with the setting (in geometry or wear).

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

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
`CYCLE100`	Log ON
`CYCLE101`	Log OFF
`CYCLE102`	Measurement result display selection
`CYCLE103`	Preassignment of input data
`CYCLE104`	Internal subroutine: Measuring cycle interface
`CYCLE105`	Generate log contents
`CYCLE106`	Log sequential controller
`CYCLE107`	Output of message texts (up to measuring cycles SW 6.2)
`CYCLE108`	Output of alarm messages (up to measuring cycles SW 6.2)
`CYCLE109`	Internal subroutine: Data transfer
`CYCLE110`	Internal subroutine: Plausibility checks
`CYCLE111`	Internal subroutine: Measuring functions
`CYCLE112`	Internal subroutine: Measuring functions
`CYCLE113`	Internal subroutine: Log
`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.

Note

Measuring cycles from measuring cycles SW 6.2 and higher can only be used with NCK-SW 6.3 and higher.

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
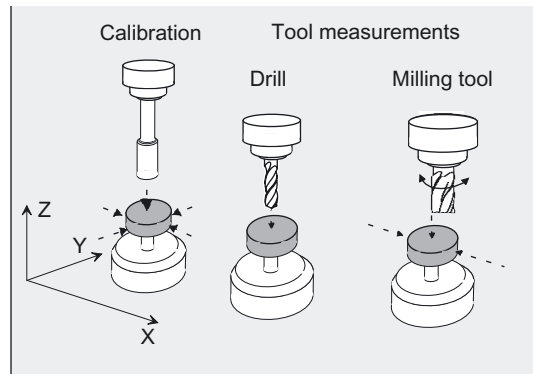
Programming

`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 probes (workpiece-related)[1]
11	Measure tool with motionless spindle (length or radius, workpiece-related)[1]
12	Measure tool with rotary spindle (length or radius, workpiece-related)[1]
10010	Calibrate tool probes in increments (workpiece-related)[1]
1) from meas. cycles SW 6.3	

Result parameters

The measuring cycle `CYCLE971` 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 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	Measuring 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**:

Parameter	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	Measuring 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].
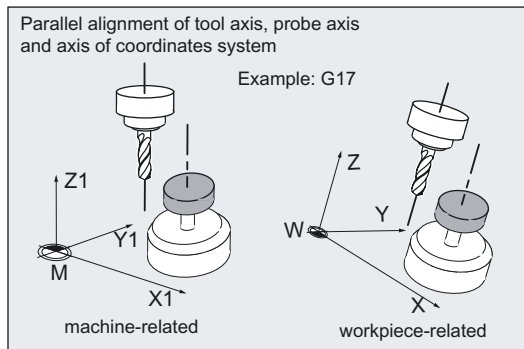
Tool measurement with motionless spindle

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	1st radius	2nd radius	3rd radius	4th radius
n = 1	1st peripheral speed	Compensation value for 1st radius/ 1st peripheral speed	Compensation value for 2nd radius/ 1st peripheral speed	Compensation value for 3rd radius/ 1st peripheral speed	Compensation value for 4th radius/ 1st peripheral speed
n = 2	2nd peripheral speed	Compensation value for 1st radius/ 2nd peripheral speed	Compensation value for 2nd radius/ 2nd peripheral speed	Compensation value for 3rd radius/ 2nd peripheral speed	Compensation value for 4th radius/ 2nd peripheral speed
n = 3	3rd peripheral speed	Compensation value for 1st radius/ 3rd peripheral speed	Compensation value for 2nd radius/ 3rd peripheral speed	Compensation value for 3rd radius/ 3rd peripheral speed	Compensation value for 4th radius/ 3rd peripheral speed

_MT_EC_R _MT_EC_L [n,m]	m = 0	m = 1	m = 2	m = 3	m = 4
n = 4	4th peripheral speed	Compensation value for 1st radius/ 4th peripheral speed	Compensation value for 2nd radius/ 4th peripheral speed	Compensation value for 3rd radius/ 4th peripheral speed	Compensation value for 4th radius/ 4th peripheral speed
n = 5	5th peripheral speed	Compensation value for 1st radius/ 5th peripheral speed	Compensation value for 2nd radius/ 5th peripheral speed	Compensation value for 3rd radius/ 5th peripheral speed	Compensation value for 4th radius/ 5th 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-related** calibration) 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	Calibrate tool probe (machine-related)
	10	Calibrate tool probe (workpiece-related)
	10000	Calibrate tool probes incrementally (machine-related)
	10010	Calibrate tool probe incrementally (workpiece-related)
_MA	1...3	Number of the measuring axis
	103, 203 102, 201	Number of the offset and measuring axis (not for _MVAR=10000 and _MVAR=10010)
_FA	>0	Measurement path
	<0	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 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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
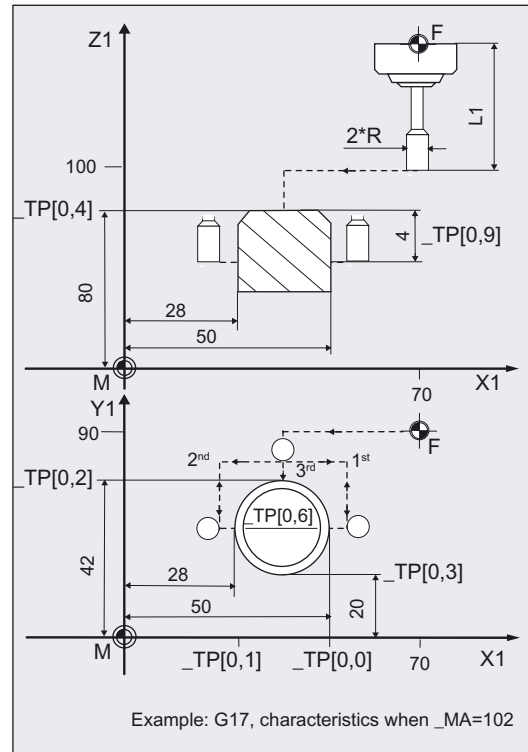
```
%_N_CALIBRATE_MTT_MPF
N05 G0 G17 G94 G90                    ;Machining plane, define feedrate type
N10 T7 D1                             ;Select calibration tool
N15 M6                                ;Change calibration tool and
                                      ;activate compensation
N30 SUPA 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
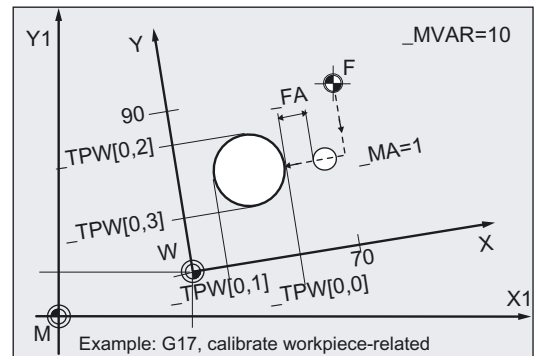
```
%_N_CALIBRATE_MTT_X_MPF
N05 G0 G17 G94 G54                        ;Define machining plane, zero offset and
                                          ;feed type
N10 T7 D1                                 ;Select calibration tool
N15 M6                                    ;Change calibration tool and
                                          ;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
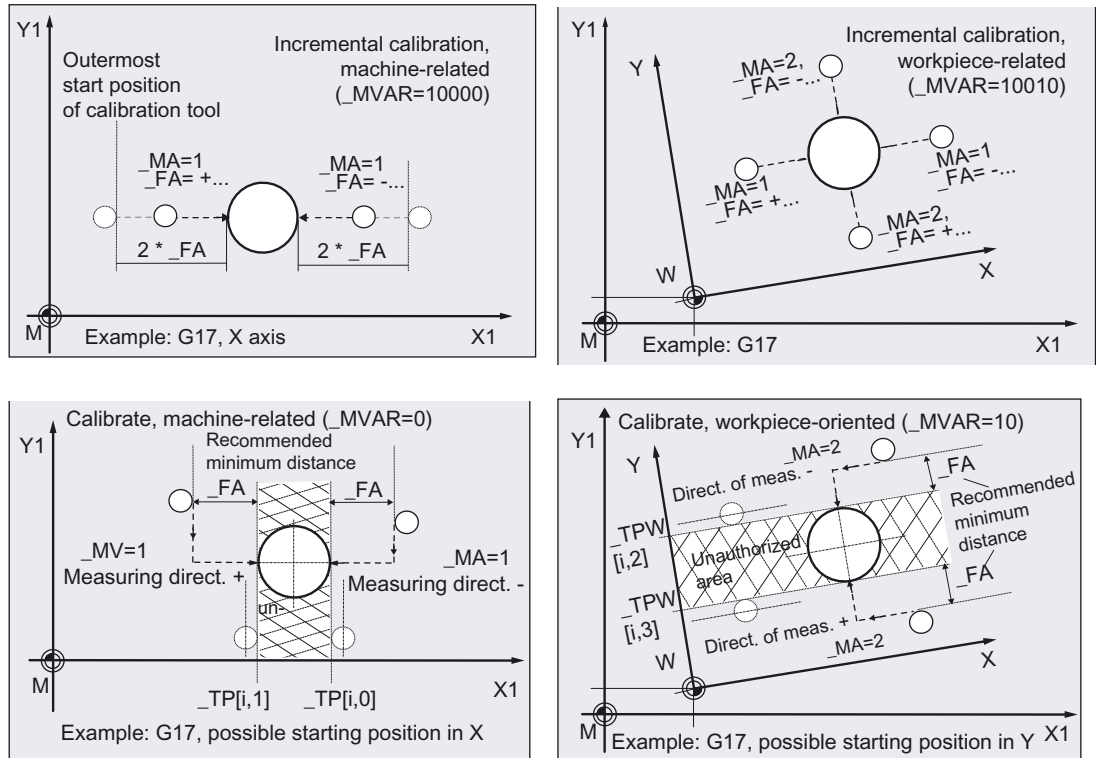
The calibration tool must be prepositioned as shown in the figure and for the selected variant. The tool must have reached a permissible starting position.

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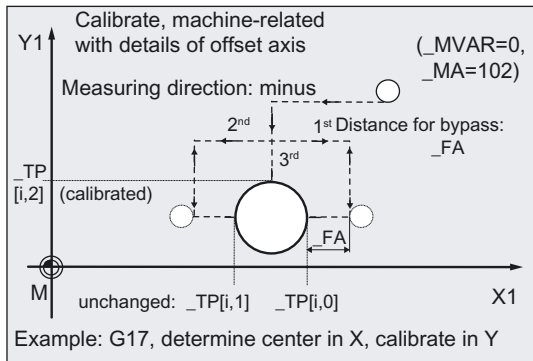
Additionally specifying the offset axis in _MA (_MA= 102 or _MA= 201) first causes the exact center of the tool probe to be detected in the offset axis before calibration takes place in the measuring axis.

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 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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)
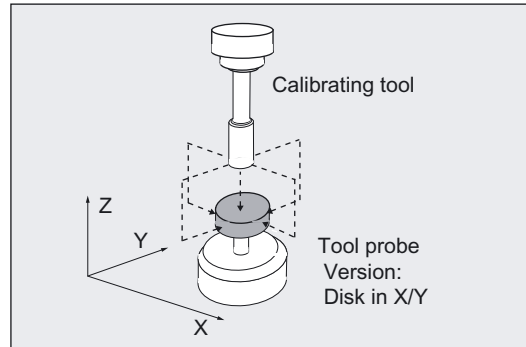
```
%_N_AUTO_CALIBRATE_MPF
N10 G17 G0 G90 G94
N20 T7 D1                              ;Preselect calibration tool
N30 M6                                 ;Change calibration tool and
                                       ;activate offset
N40 SUPA X39 Y31 Z100                  ;Take up start position
N20 _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
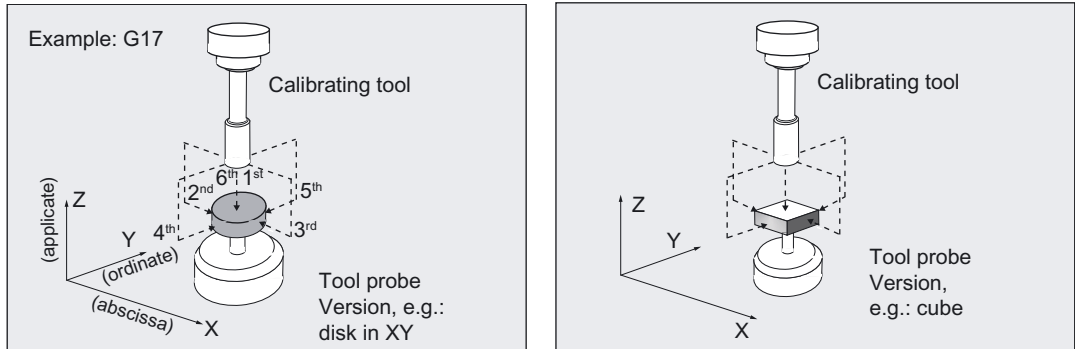
The position before measuring cycle call can be anywhere, but:

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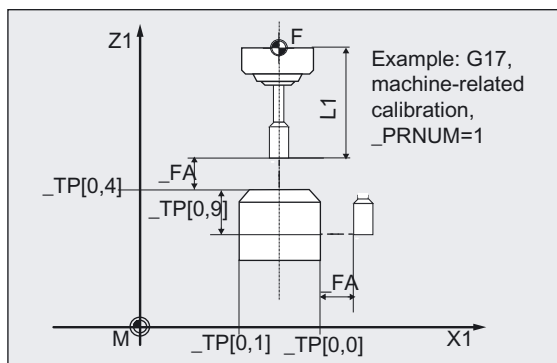
Calibration in the plus direction of the abscissa is performed after ascertaining the center of the probe in the ordinate. Additional movements are performed in the plane.

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	1st geometry axis (X)
	tens:	2nd geometry axis (Y)
	hundreds:	3rd 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

Parameter	Type	Meaning		
_CM[0]	REAL	Maximum permissible peripheral speed [m/min]/[feet/min] Default setting: 100 m/min		
_CM[1]	REAL	Maximum permissible speed for measuring with rotating spindle [rpm] (speed is automatically reduced if this is exceeded) Default setting: 1000 RPM		
_CM[2]	REAL	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		
_CM[3]	REAL	Required measuring accuracy [mm]/[inch] Is effective during last probing Default setting: 0.005 mm		
_CM[4]	REAL	Maximum feedrate for probing [mm/min]/[inch/min] Default setting: 20 mm/min		
_CM[5]	REAL	Direction of spindle rotation during measuring Default setting: 4 = M4		
_CM[6]	REAL	Feed factor 1		
		Values:	0: Probing just once with calculated feedrate (but at least value of _CM[2])	
			≥1: 1st probing with calculated feedrate (but at least value of _CM[2]) · Feed factor 1	
		Default setting: 10		
_CM[7]	REAL	Feed factor 2		
		Values:	0: 2nd probing with calculated feedrate (only active when _CM[6]>0)	
			≥1: 2. Probing action with calculated feed · Feed factor 2	
			3rd probing with calculated feed	
		Feed factor 2 should be smaller than feed factor 1. Default setting: 0		

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)

Length measurement: with or without offset
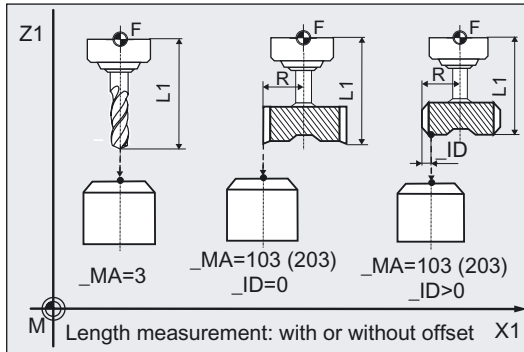
- **Radius measuring variants (milling tool) (**Example: G17, machine-related, _MA=1)

Radius measurement: with or without offset

Example: G17, possible starting position in X

Example: G17, possible starting position in Y
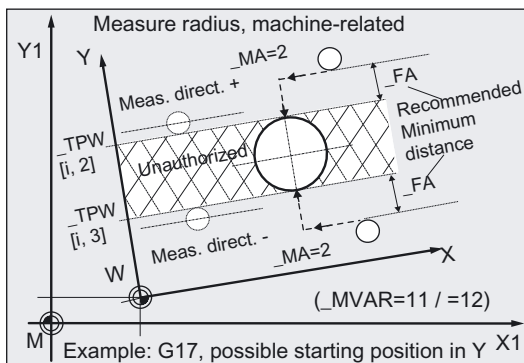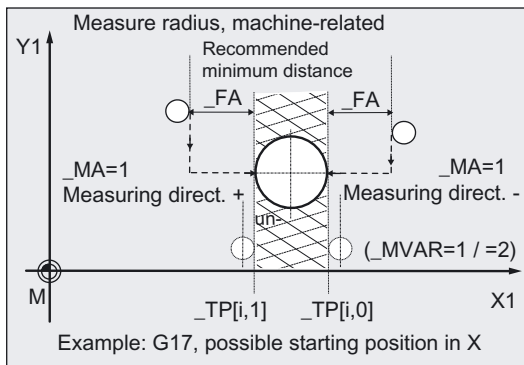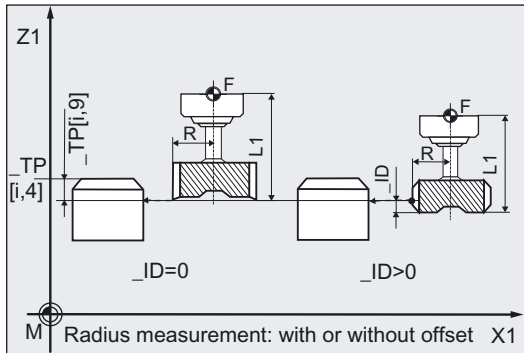
Note

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 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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"

Example: G17, measure tool length with _ID>0

```
%_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
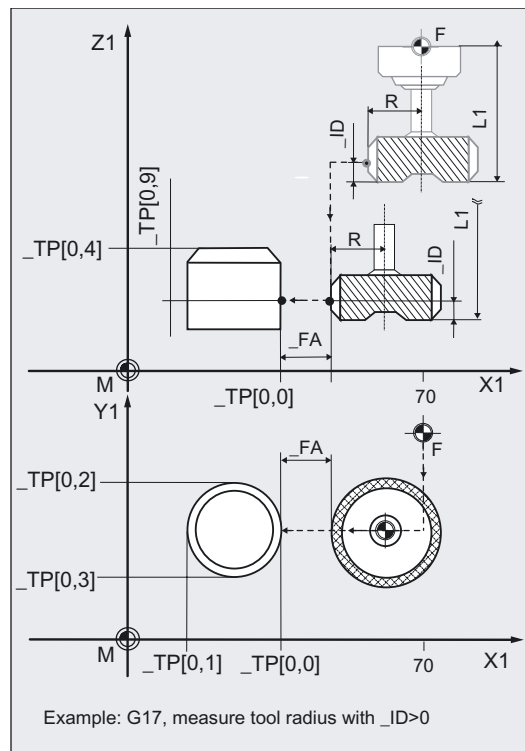
5.2.5.3   Programming example 2

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"

Measure radius, workpiece-related (_MVAR=2, _MA=1)
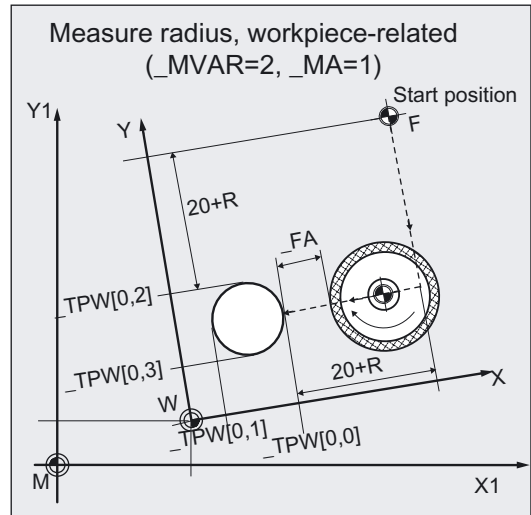
```
%_N_T4_MEASURE_MPF
N01 _PRNUM=1                                 ;Select tool probe 1
N02 G17 G54 G94 G90                          ;Plane, ZO, feedrate type, dimensioning
N05 T4 D1                                     ;Selection of the tool to be measured
N10 M6                                        ;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.
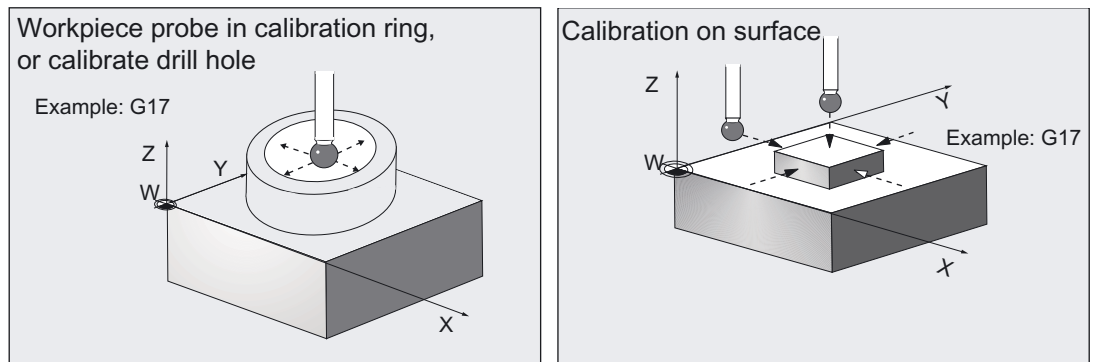
The probe trigger points must be determined in the axis directions that are dependent on:

- 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
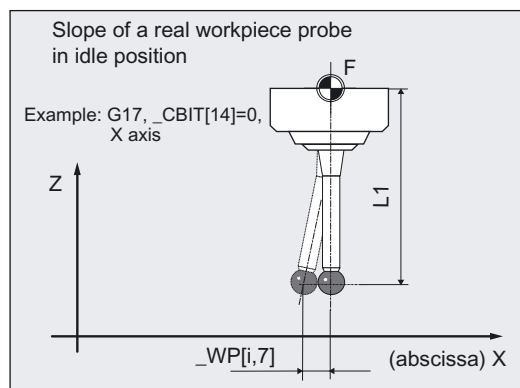
A real workpiece probe can deviate from its ideal vertical position even when not deflected. This positional deviation (skew) can be determined with measuring variants in this cycle and then entered in the intended array of the workpiece _WP[i, 7] for abscissa and _WP[i, 8] for ordinate (for detailed 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
_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.
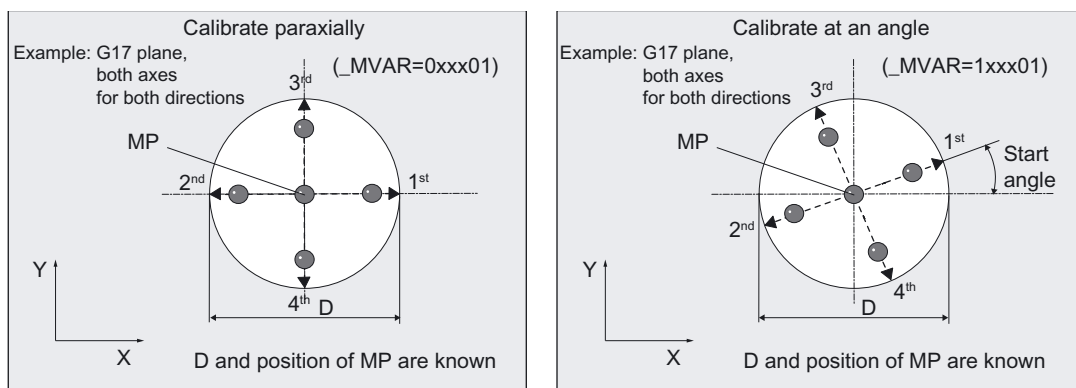
The center point (CP) of the hole and its diameter (D) must be known for this calibration variant!

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	Meas. axis, only for _MVAR= xx1x01
	1 negative axis direction	(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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Multiple measurement at the same location: _NMSP (Page 82)

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: _WP[2, ...]
(already contains
approximate values)

Calibrate in known hole
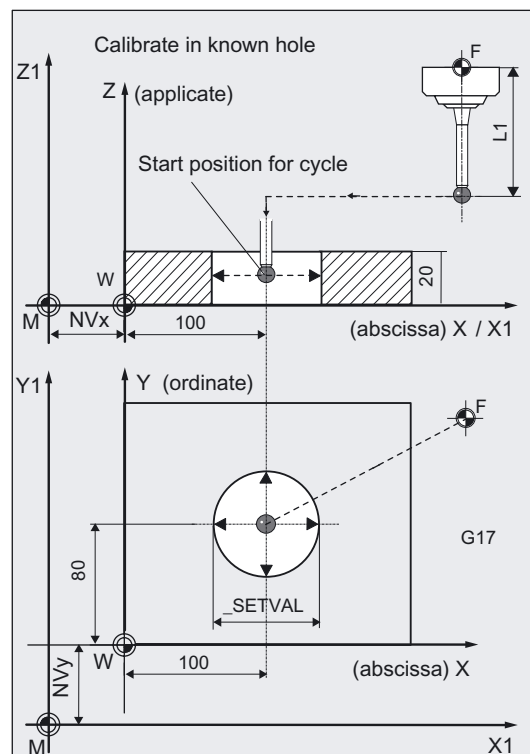
```
%_N_CALIBRATE_IN_X_Y_MPF
N10 G54 G90 G17 T9 D1              ;ZO selection, select probe as tool and
                                   ;operating plane
N20 M6                             ;Insert probe and activate tool offset
N30 G0 X100.000 Y80.000           ;Position probe at center of hole
N40 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.
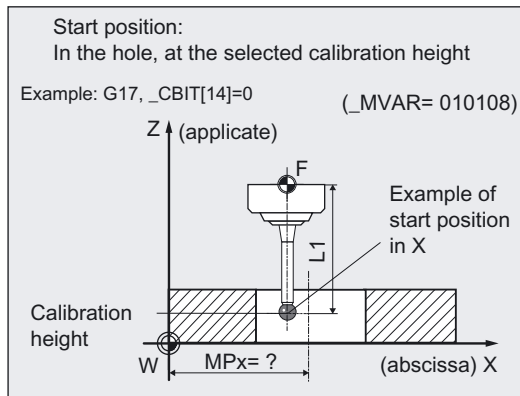
Axis sequence, axis direction sequence

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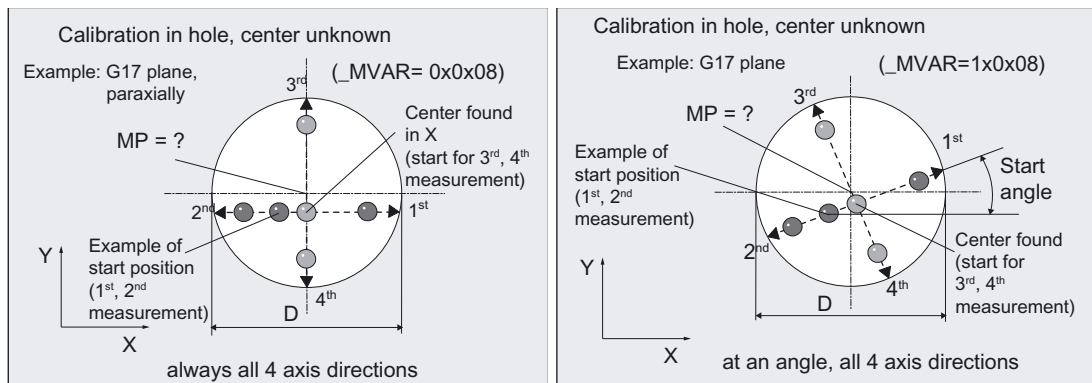
In this measuring variant first the hole center and then the positional deviation (skew) of the probe is calculated. Then the trigger points in all 4 axis directions on the plane are calculated.

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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Multiple measurement at the same location: _NMSP (Page 82)

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:   _WP[1, ...]
(already contains
approximate values)
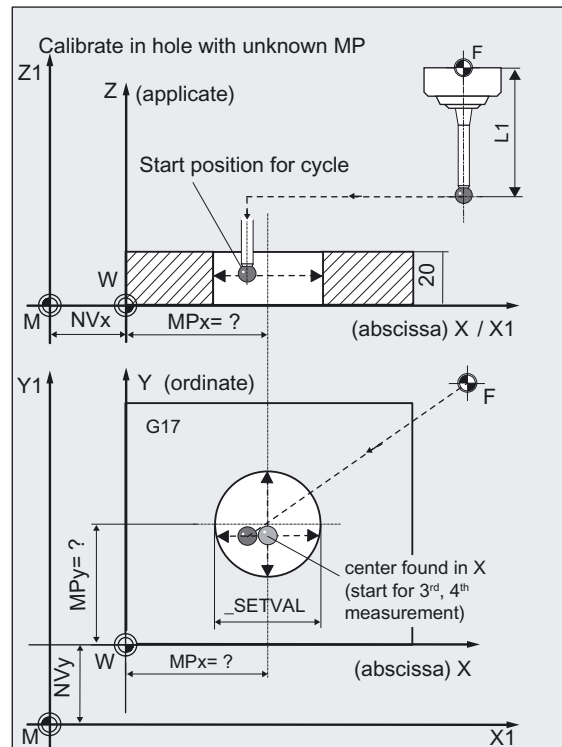
```
%_N_CALIBRATE2_IN_X_Y_MPF
N10 G54 G90 G17 T10 D1              ;ZO selection, select probe as tool and
                                   ;operating plane
N20 M6                             ;Insert probe and activate tool offset
                                   ;
N30 G0 X100 Y80                    ;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.
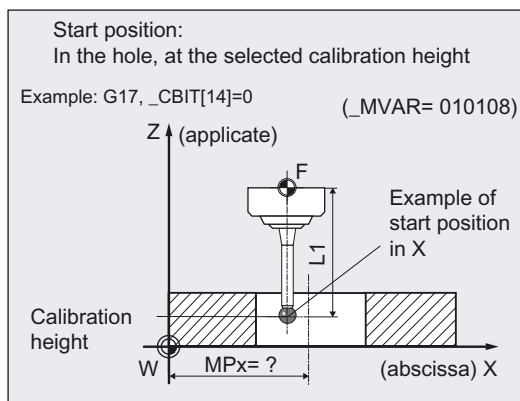
Axis sequence, axis direction sequence

- 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.
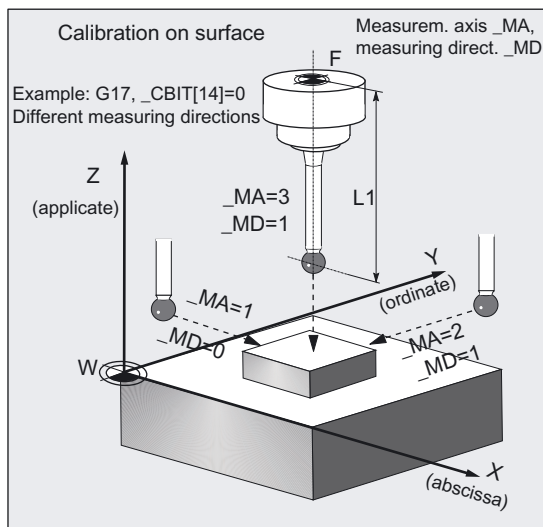
Prerequisite

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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Multiple measurement at the same location: _NMSP (Page 82)

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, ...]
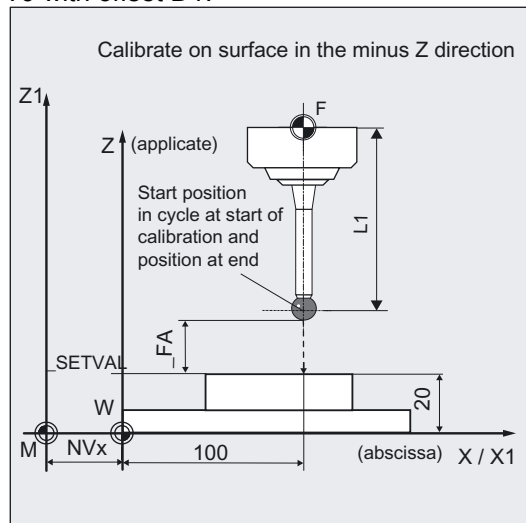
```
%_N_CALIBRATE_IN_Z_MPF
N10 G54 G90 G17 T9 D1                    ;ZO selection, select probe as tool and
                                         ;operating plane
N20 M6                                   ;Insert probe and activate tool offset
N30 G0 X100 Y80                          ;Position probe 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	Measuring direction
	1 negative axis 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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Multiple measurement at the same location: _NMSP (Page 82)

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, ...]

Calibrate on surface in the minus Z direction with specification of length L1   (_CBIT[14]=0)
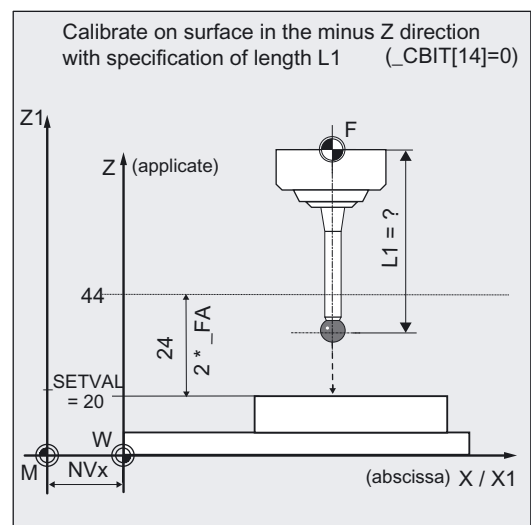
```
%_N_CALIBRATE_Z_L_MPF
N10 G54 G90 G17 T9 D1                    ;ZO selection, select probe as tool and
                                         ;operating plane
N20 M6                                   ;Insert probe and activate tool offset
; ...                                    ;The probe is prepositioned 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
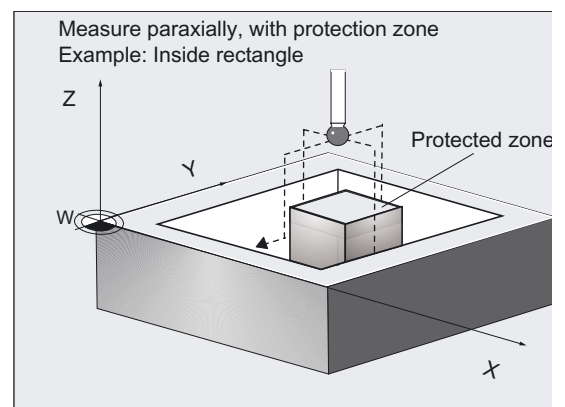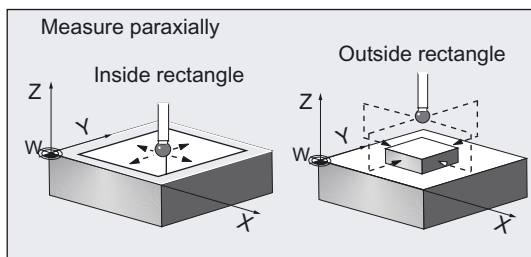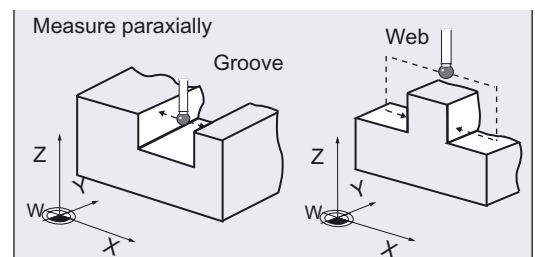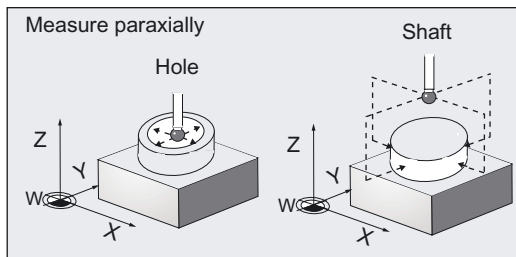
Measurement is performed paraxially to the workpiece coordinate system.

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

Measuring variants

Measuring cycle CYCLE977 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
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):

Parameter	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 (from measuring cycles SW 6.3)
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:

Parameter	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	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 (from measuring cycles SW 6.3)
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
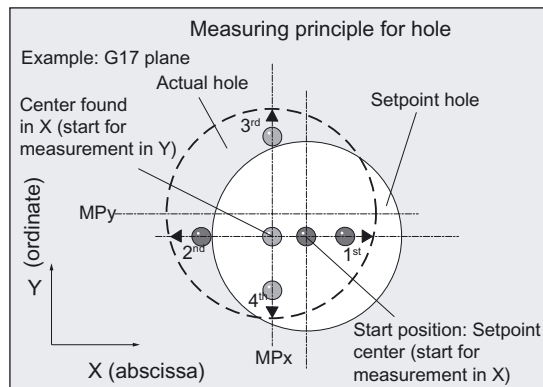
Two points each are measured in the abscissa and ordinate. The actual position of the center point (CP) in relation to workpiece zero is calculated from these four measured values. The actual diameter is calculated from the two points in the ordinate.

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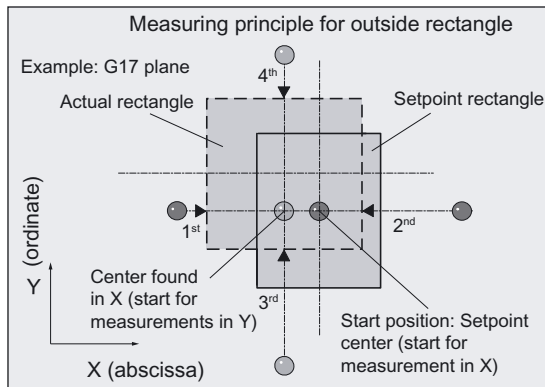
The rectangle lies parallel to the axes of the workpiece coordinate system.

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
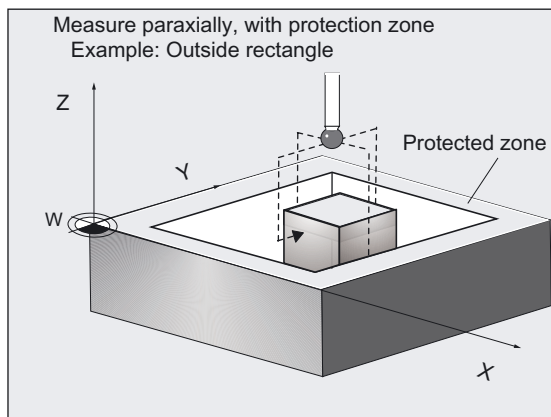
If required,

_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	Measure hole
	xxx2	Measure shaft
	xxx3	Measure groove
	xxx4	Measuring a web
	xxx5	Measure rectangle, inside
	xxx6	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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.
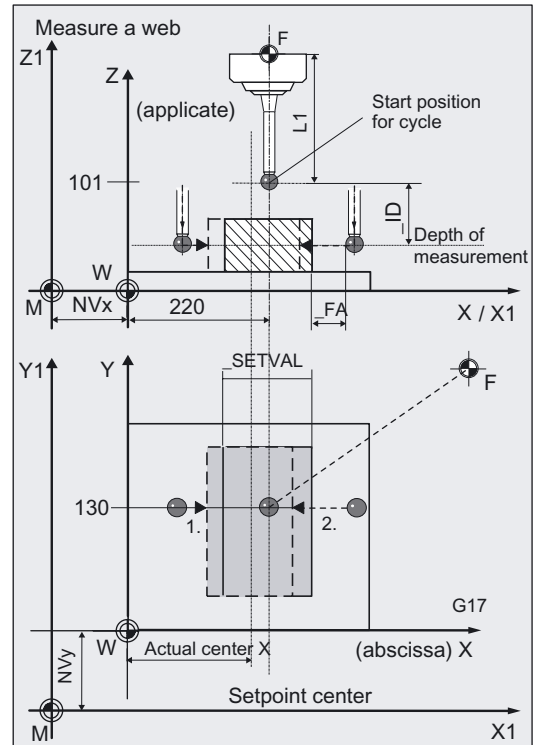

```
%_N_WEB_MEASURE_MPF
N10 G54 G17 G90 T9 D1                  ;ZO, select tool as probe ...
N20 M6                                 ;Insert probe,
                                       ;activate tool offset
N30 G0 X220 Y130                       ;Position probe in X/Y plane at setpoint web
                                       ;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]
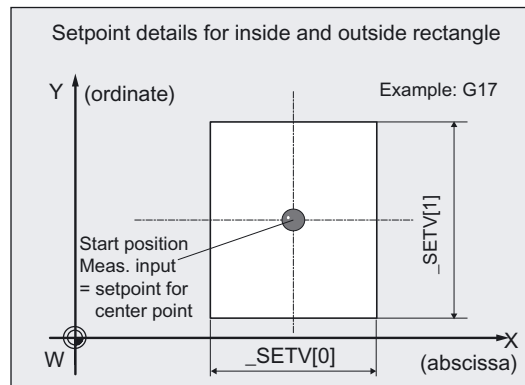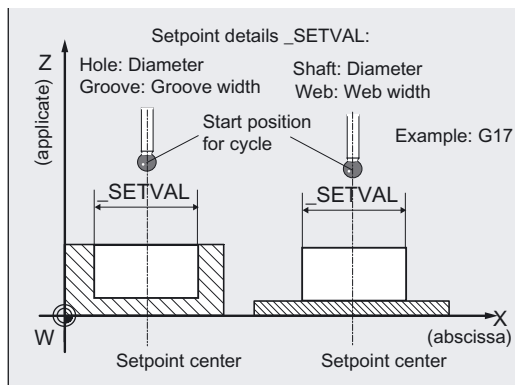
The position of the probe in the abscissa, ordinate at the beginning of a cycle is evaluated for the setpoint of the center point of a hole, shaft, or rectangle, or for the center of a groove, web.

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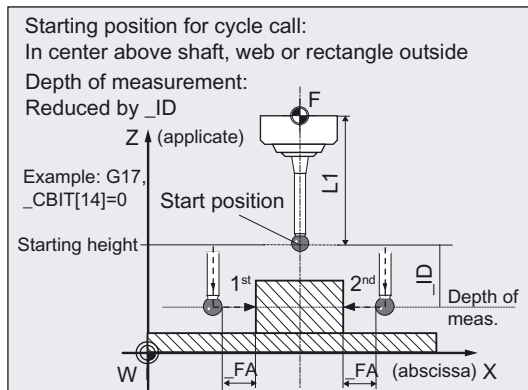
_MVAR	Pre-positioning	
	in the plane	in applicate
2/102	Shaft center point	Above shaft
4/104	Web center, meas. axis	Above web
6/106	Rectangle center point	Above rect.

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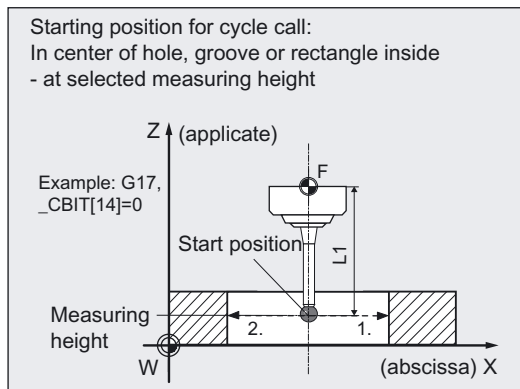
_MVAR	Pre-positioning	
	in the plane	in applicate
1/101	Hole center point	At meas. height
3/103	Groove center, meas. ax.	At meas. height
5/105	Rectangle center point	At meas. height

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
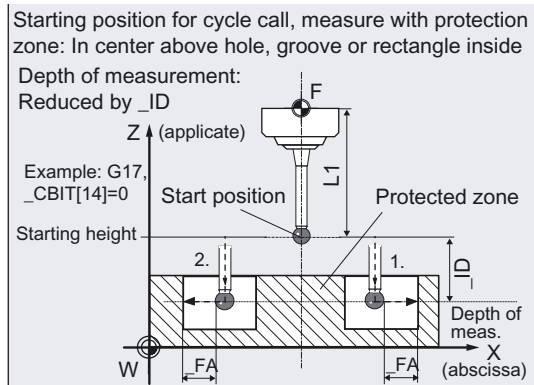
_MVAR	Pre-positioning	
	in the plane	in applicate
1001/1101	Hole center point	Above hole
1003 /1103	Groove center, meas. ax.	Above groove
1005/1105	Rectangle center point	Above rect.
1002 /1102	Shaft center point	Above shaft
1004/1104	Web center, meas. axis	Above web
1006 /1006	Rectangle center point	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
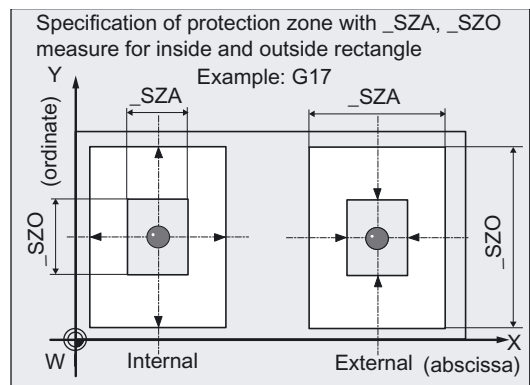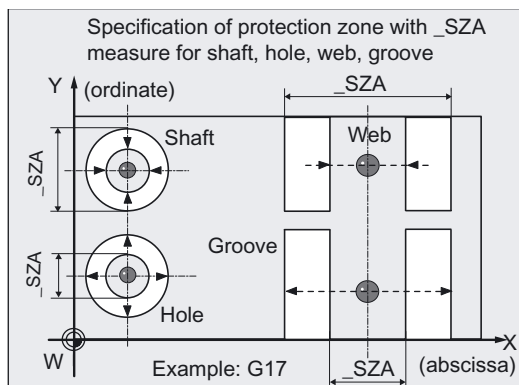
The safety zone (diameter or width) for shaft, hole, web, and groove is defined in _SZA.

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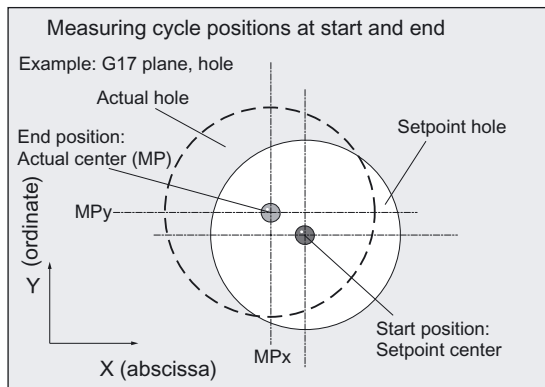
When measurement is complete the probe is positioned above the **calculated** center point or center at starting position height.

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 = x0xx
measuring variant, 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.

From measuring cycles SW 6.3, extended tool offset is available. 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 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.

Parameter

Parameter	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)
_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 (from measuring cycles SW 6.3)
_TENV	STRING[32]	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)

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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

Tool number and tool name: _TNUM and _TNAME (Page 70)

Offset number: _KNUM (Page 71)

Offset number _KNUM extended for tool offset: up to 9 digits (Page 73)

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.
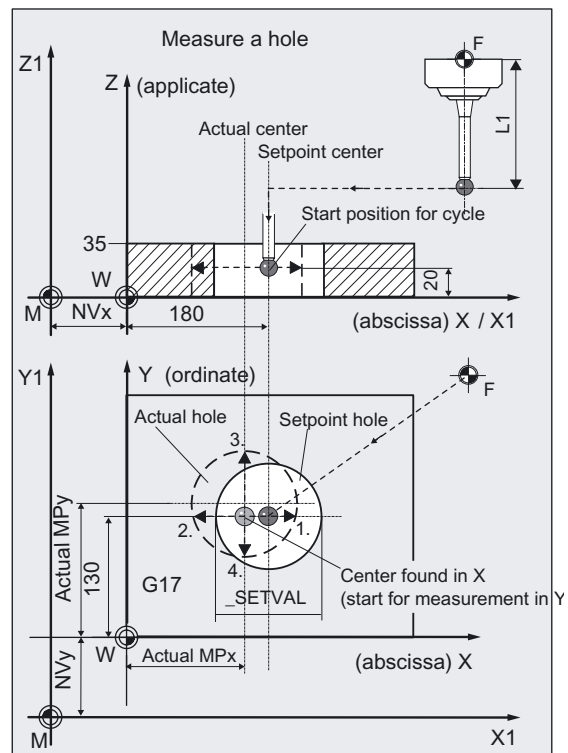
The hole was machined with milling tool **T20, D1** in the same environment as for measuring (G17, …) with circular milling.

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 corr.
	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 meas. 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 71)

Variable measuring velocity: _VMS (Page 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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 Figure

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.
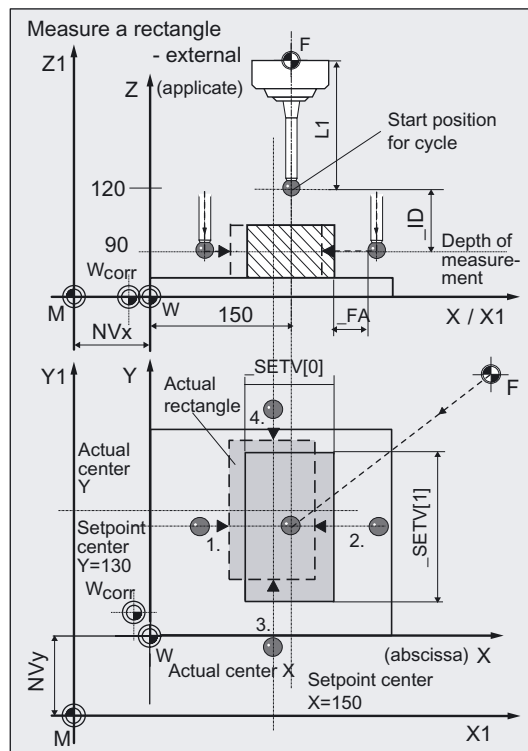
```
%_N_ZO_RECTANGLE_MPF
N10 G54 G17 G90 T9 D1                    ;ZO, select tool as probe ...
N20 M6                                   ;Insert probe,
                                         ;activate tool offset
N30 G0 X150 Y170                         ;Position probe in X/Y plane to
                                         ;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

Measuring variants

Measuring cycle CYCLE978 permits the following measuring variants which are specified via parameter _MVAR.

Value	Measuring 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:

Parameter	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	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

Parameter	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 (from measuring cycles SW 6.3)
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.
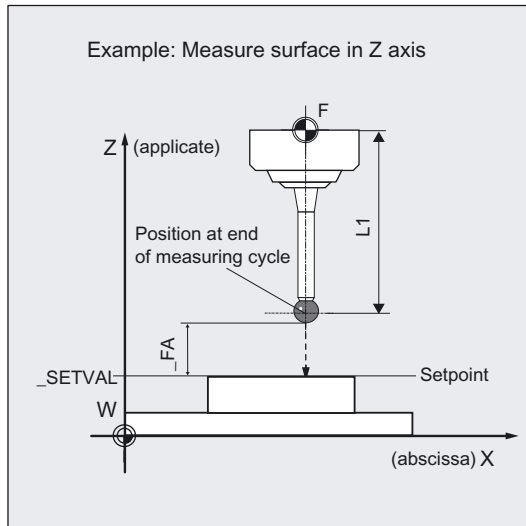
The absolute value of the positional deviation from the setpoint must not be greater than the measuring path _FA. Otherwise, no measurement will be performed.

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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.

Establishment of ZO – rectangular workpiece
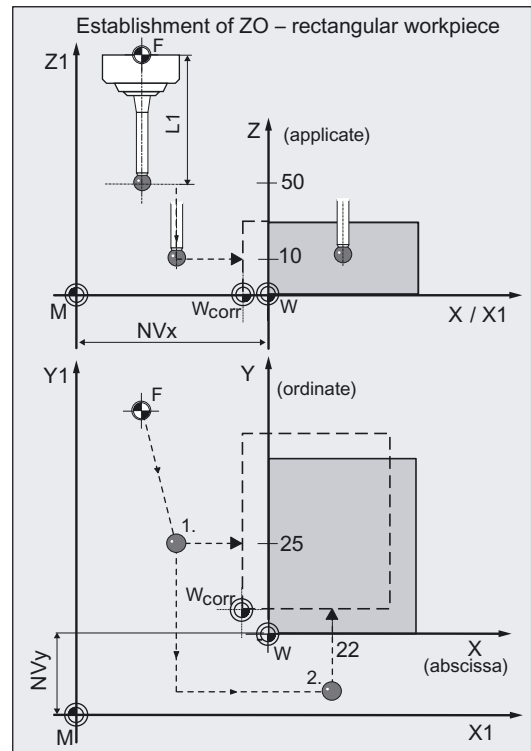
```
%_N_ZO_DETERMINING_1_MPF
N10 G54 G17 G90 T9 D1                        ;ZO, select tool as probe ...
N20 M6                                       ;Insert probe,
                                             ;activate tool offset
N30 G0 G90 X-20 Y25                          ;Position probe in X/Y plane 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=1000**
measuring 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`.

From measuring cycles SW 6.3, extended tool offset is available. 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 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").

Parameter

Parameter	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 (from measuring cycles SW 6.3)
`_TENV`	STRING[32]	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)

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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

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.

Machine surface along the Y axis

Tool T20 with D1

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.

Measure surface in X axis

```
%_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
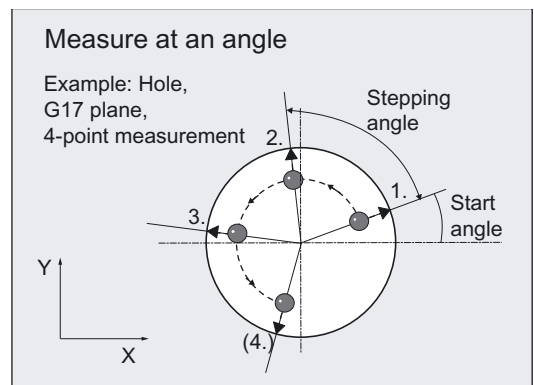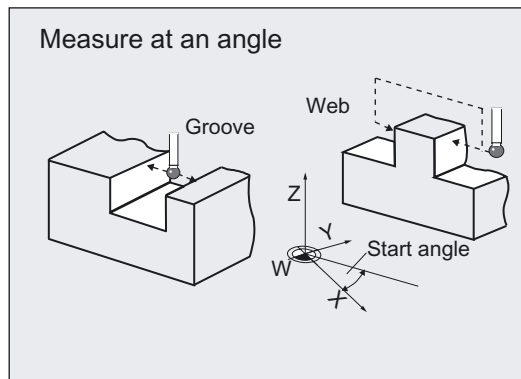
Measurement is performed at a specified starting angle to the abscissa of the workpiece coordinate system.

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 $\Rightarrow$ 3-point measurement

_PRNUM=1zxy $\Rightarrow$ 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 (from measuring cycles SW 6.3)
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.
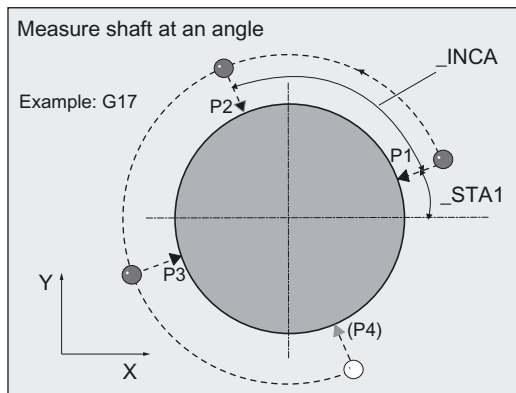
The position of the points is determined by starting angle _STA1, indexing angles _INCA, the diameter and the set center point.

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.
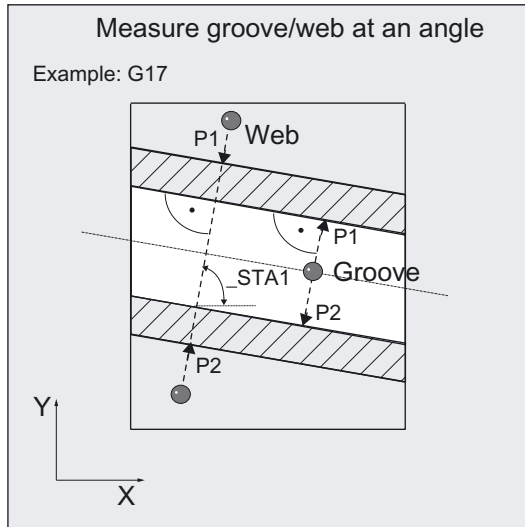
The actual value of the groove width and web width and the position of the groove center and web center in relation to workpiece zero are calculated from the measured values.

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

Setpoints using "Web" example
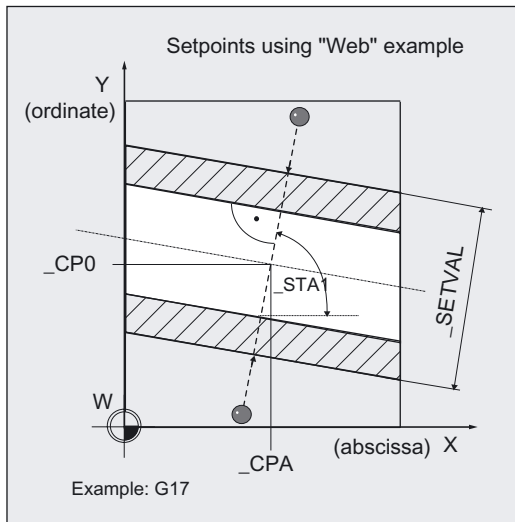
The setpoint for diameter or width is specified in **_SETVAL**.

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
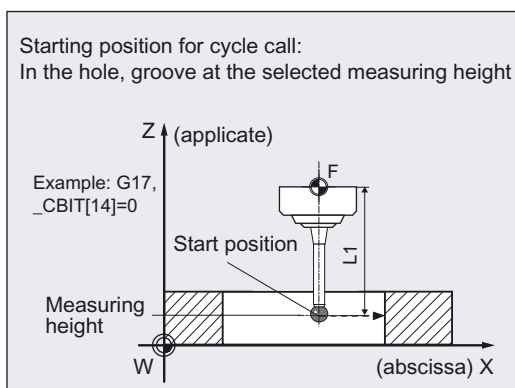
In all measuring variants the probe must be positioned at the required **measuring height** in the applicate (tool axis) close to the first measuring point P1.

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

Example: Hole G17 plane,
3-point measurement with _STA1, _INCA>0
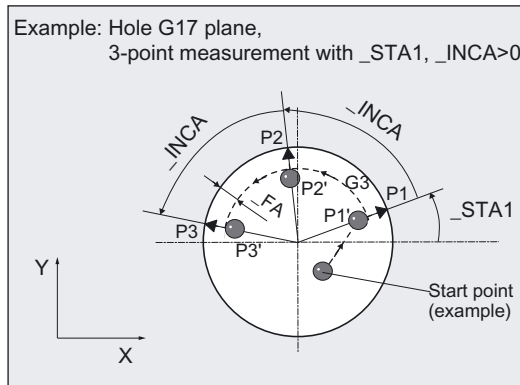
Note

When measuring circle segments of < 90 degrees, 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.
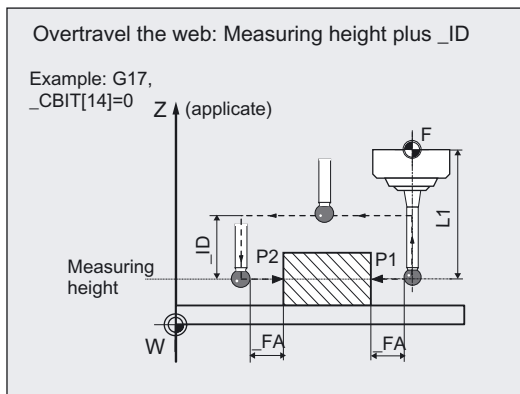
CAUTION
If _CBIT[14]=0, length 1 (L1) of the probe refers to the ball center. Radius R is then not taken into account in the length and must be included in _ID!

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.
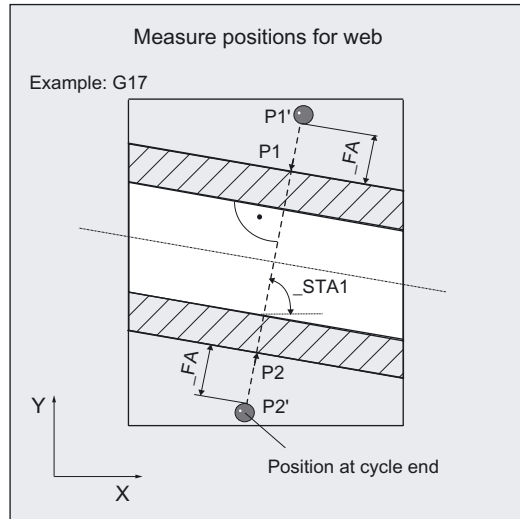
NOTICE
The range of positions of the center or diameter, or groove, web width, must be within the value specified in _FA for all workpieces to be measured.
Otherwise, there is danger of collision or the measurement cannot be performed!

5.6.3 Measuring and tool offset

5.6.3.1 General information

Function

Using this measuring cycle and various _MVAR=1...4
measuring 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.

From measuring cycles SW 6.3, extended tool offset is available. 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 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").

Parameter

Parameter	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 compensation
		(alternative for _TNUM if 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 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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

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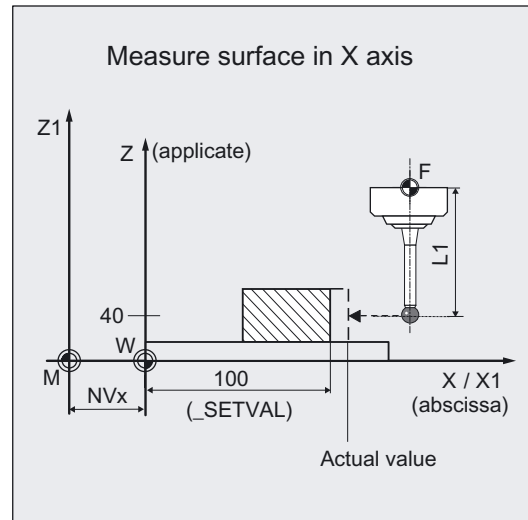
Tool type (DP1):	710
Length 1 - geometry (DP3):	L1 = 50.000
Radius - geometry (DP6):	R = 3.000

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.

Measure circle segment – semi-circle
Example: G17

```
%_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
_TSA=1 _PRNUM=1 _VMS=0 _NMSP=1 _FA=2 ;Three-point measurement with probe 1
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 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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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])

Measure groove and ZO correction
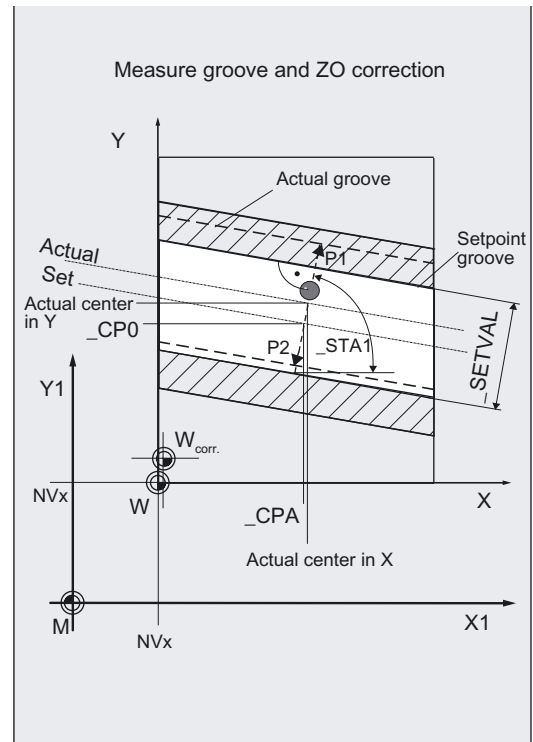
```
%_N_OFFSET_GROOVE_MPF
N10 G55 G17 G90 T9 D1                    ;ZO, select tool as probe ...
N20 M6                                   ;Insert probe,
                                         ;activate tool offset
N30 G0 X150 Y130                         ;Position probe in X/Y plane
                                         ;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:
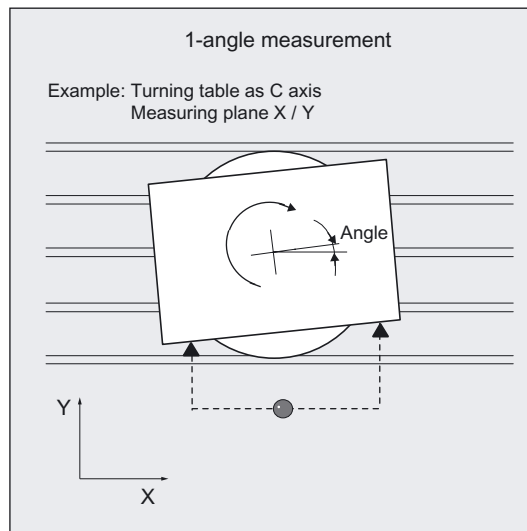
- When a workpiece is clamped rotated in the plane:

  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:

2-angle measurement
(Measuring a plane that is oblique in space)

Example: G17
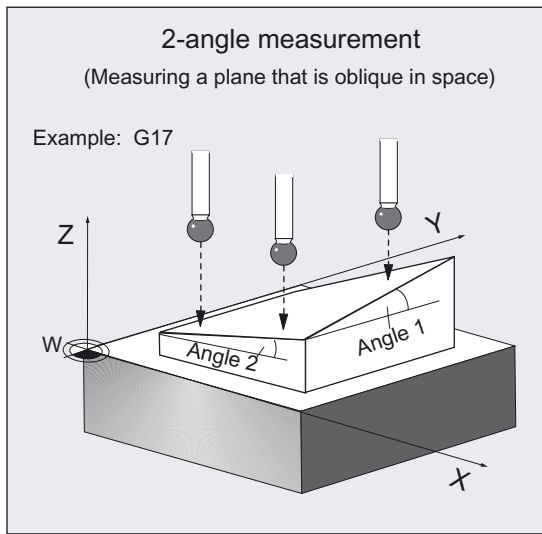
- If a workpiece has a plane that is inclined in space:

   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

Parameter	Data type	Result
_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.
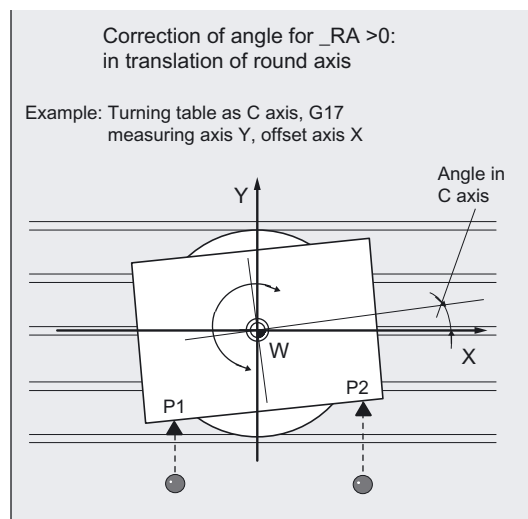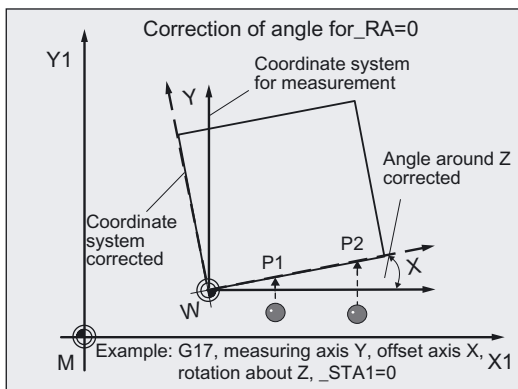
This can be used to determine and correct the rotation component in the zero offset (ZO, frame) of the workpiece in the plane.

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).

Parameter	Data type	Meaning
_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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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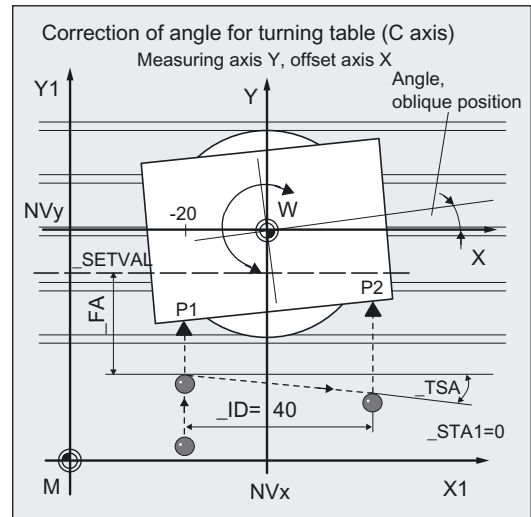
Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

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.
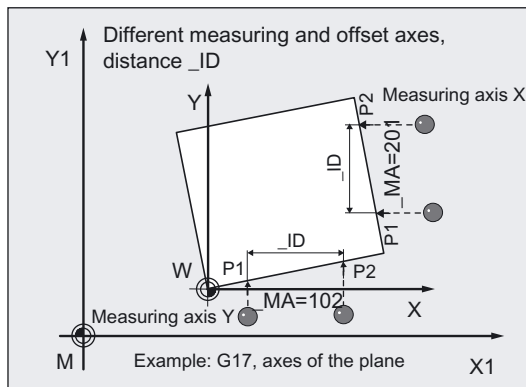
Distance of measuring point 1 to measuring point 2 in the offset axis: _ID

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.
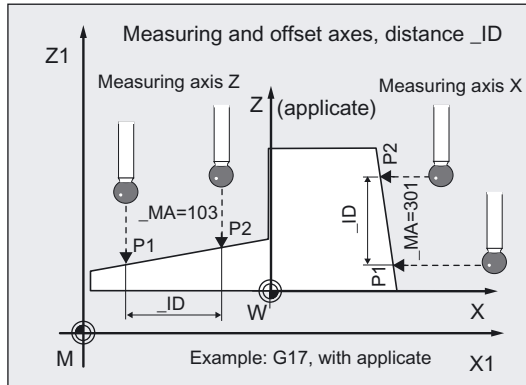
_STA1 set angle

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.
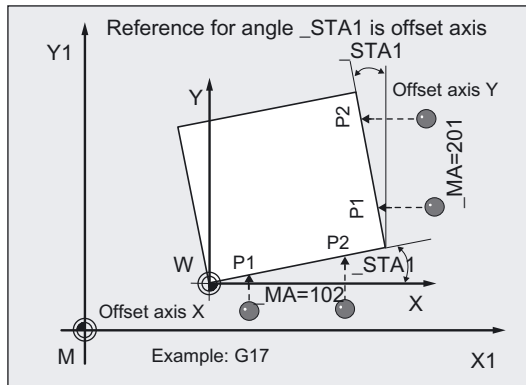
The set angle **_STA1** specifies the required angle between the edge and the positive direction of the offset axis. In the case of **_STA1=0**, the edge is aligned paraxially with regards to the offset axis after correction.

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
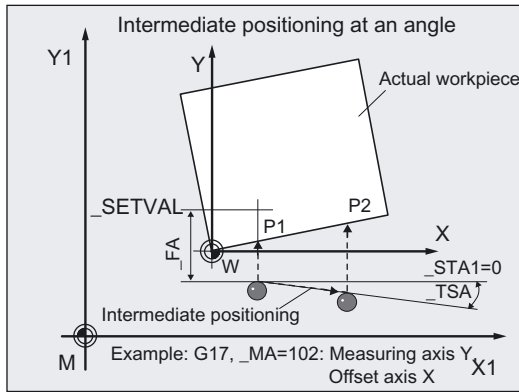
The probe is positioned with respect to the surface to be measured in such a way that during traversal of the measuring axis `_MA` specified in the direction of the setpoint **_SETVAL measuring point 1** on the surface will be reached.

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
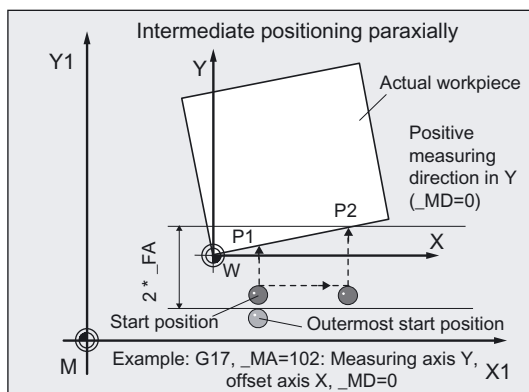
The probe is positioned with respect to the surface to be measured in such a way that during traversal in the specified measuring axis _MA and direction of the measurement in _MD both measuring points on the surface within the total measurement path: 2 · _FA in mm is reached.

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)

Parameter	Data type	Meaning
_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 77)

Offset angle position: _CORA (Page 78)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.

Definition of the measuring points
G17 plane
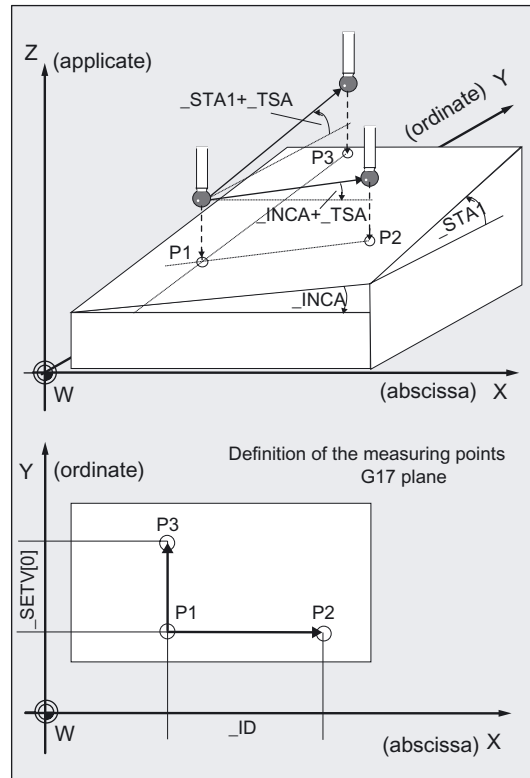
```
%_N_INCLINEDMEAS_MPF
N10 G54 G17 G90 T9 D1                    ;Select T No. probe
N20 M6                                   ;Activate offsets
N30 X70 Y-10                             ;Position probe in X/Y plane above
                                         ;measuring point
N40 Z40                                  ;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.

Definition of the measuring points G17 plane
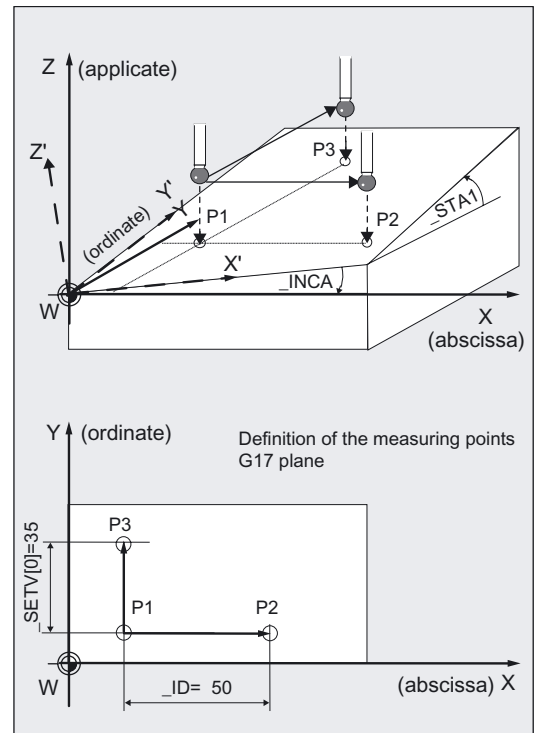
Exercise

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       ;Measuring velocity 300 mm/min, data field 1
_NMSP=1 _FA=40 _STA1=0 _INCA=0              ;for probe, safe area 20°,
_MVAR=100106 _MD=1 _ID=50 _SETV[0]=35      ;without empirical value, number of
_KNUM=4                                      ;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                                         ;Align swivel table, probe is
CYCLE800(1,"",0,57,0,0,0,0,0,0,0,0,0,-     ;perpendicular above oblique surface
1)
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      ;ZO determination on surface, setpoint 0,
_FA=20 _KNUM=4                              ;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    ;Angle measurement measuring axis Y',
_STA1=0                                   ;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.
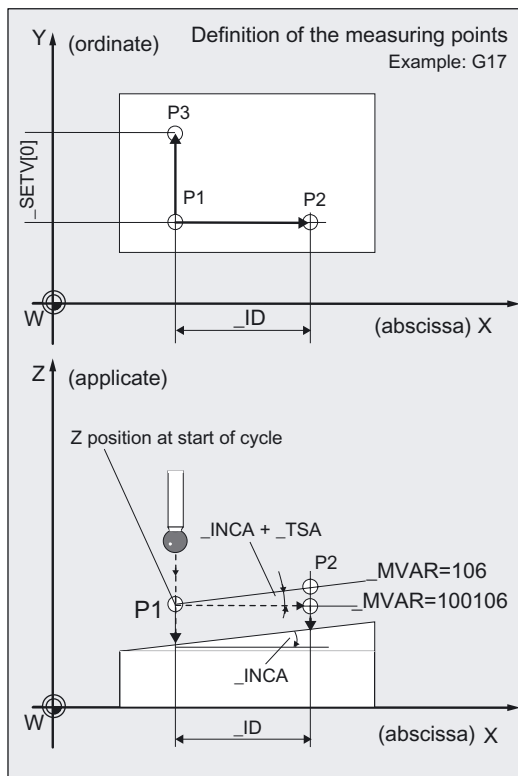
Procedure for variant "intermediate positioning at an angle" (MVAR=106):

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).
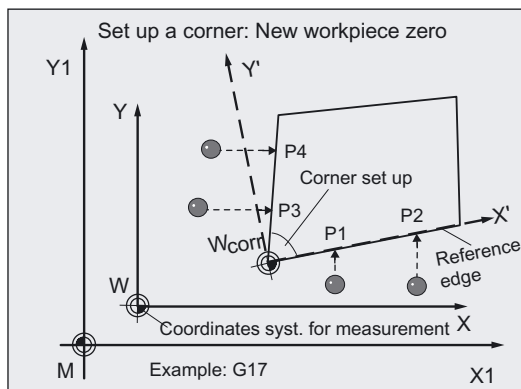
In certain measuring variants an additional offset can be defined.

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

Parameter	Data type	Result
_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 MCS[1]
_OVR [22]	REAL	Actual value for corner point in ordinate in MCS[1]
_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.

Measuring principle for rectangle
Example: Internal corner (_MVAR= 105)

Measure in turned WCS
Example: G17

Measuring principle for unknown geometry
Example: External corner (_MVAR= 108)
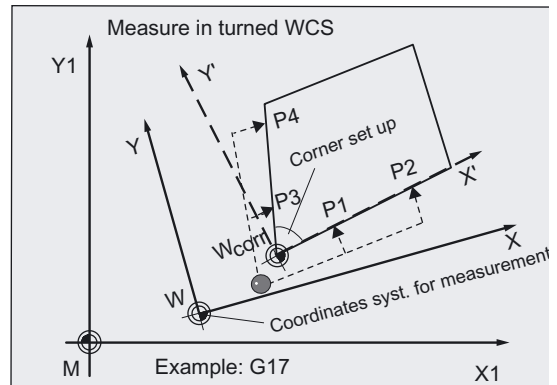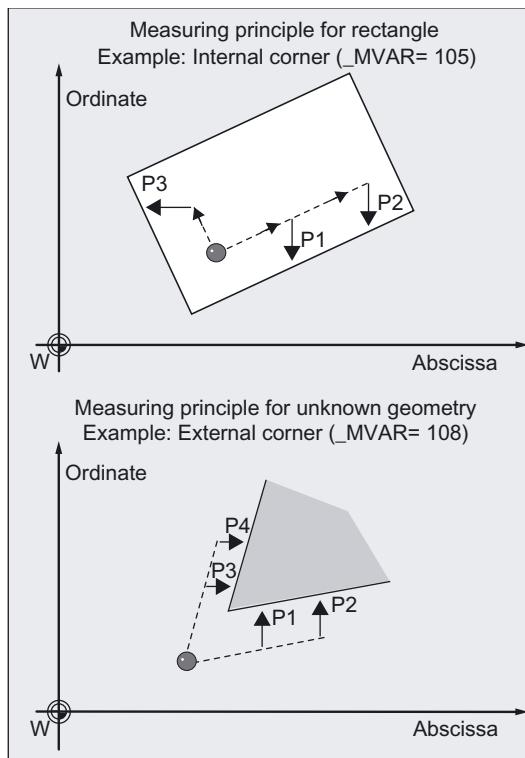
The cycle approaches either 3 (for a rectangle) or 4 measuring points (if workpiece geometry is not known) and calculates the point of intersection of the resulting straight lines and the angle of rotation to the positive abscissa axis of the current plane. If the workpiece geometry is known (rectangle), 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

Parameter	Data type	Meaning		
_SETV[3]	REAL	Offset of zero offset WCS (corrected) in ordinate		
_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 77)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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

Set up external corner with 4-point measurement
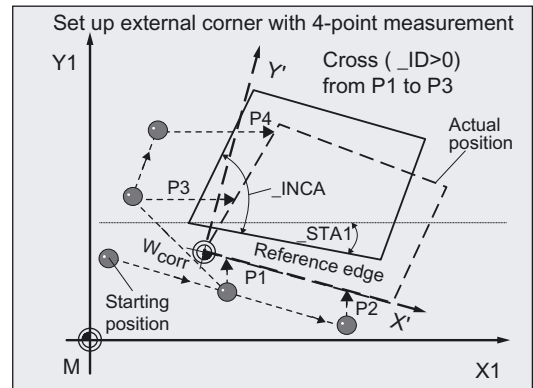
Length 1 (L1) must refer to the center of the probe ball (_CBIT[14]=0), as for calibration.

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
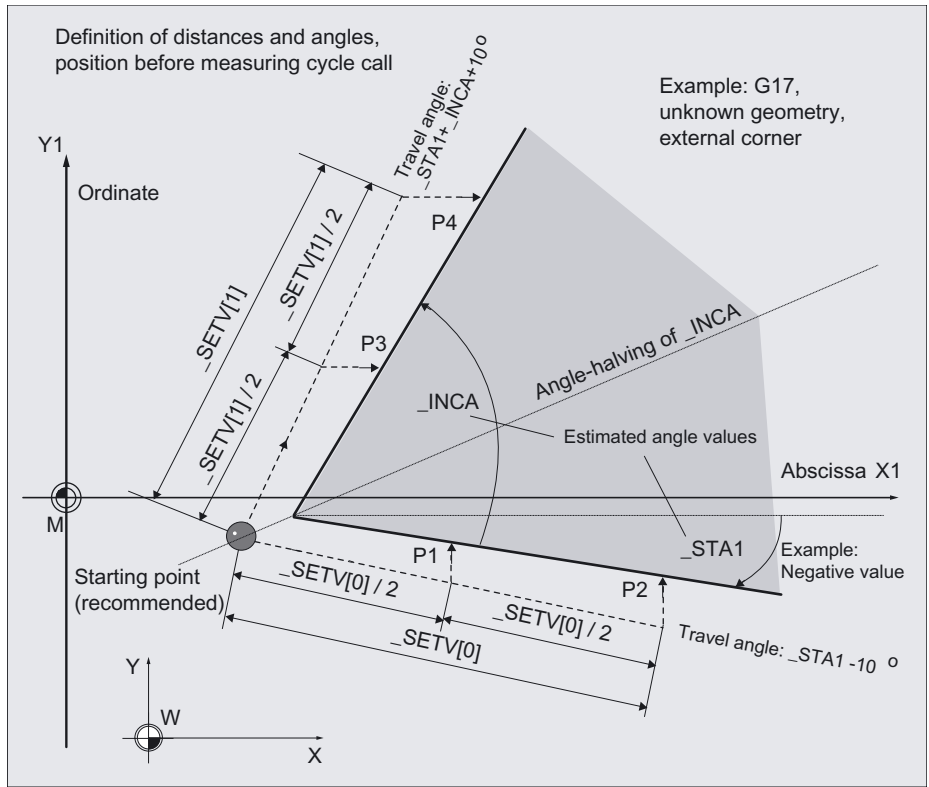
Position before measuring cycle call

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.
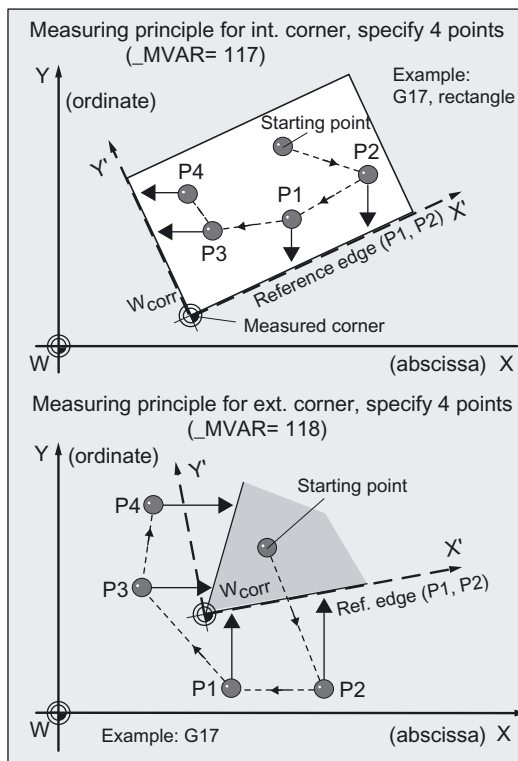
One after the other, points **P2**, P1, P3, P4 are traversed in the cycle with positioning feedrate at positioning height. At each of these points the probe is lowered to measuring depth and then traversed at measuring feedrate parallel to the axis against the workpiece corner.

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 77)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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.
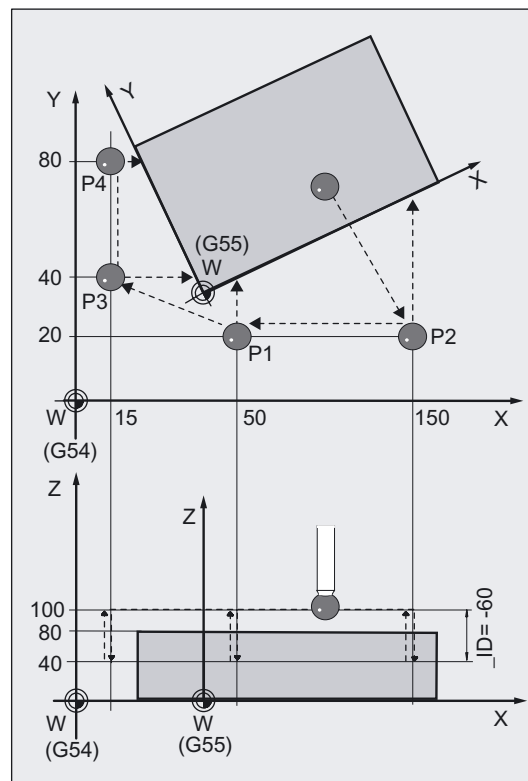

```
%_N_CORNER_SETUP_1_MPF
N10 G54 G17 G90 T9 D1                    ;Select ZO, plane, probe, …
N20 G0 Z100                              ;Position probe at positioning height
N30 X100 Y70                             ;Position probe in X/Y plane above
                                         ;workpiece
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°!
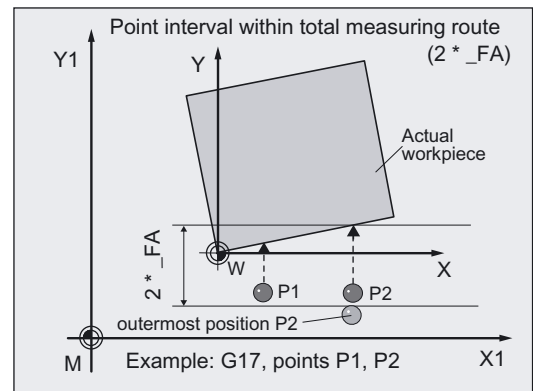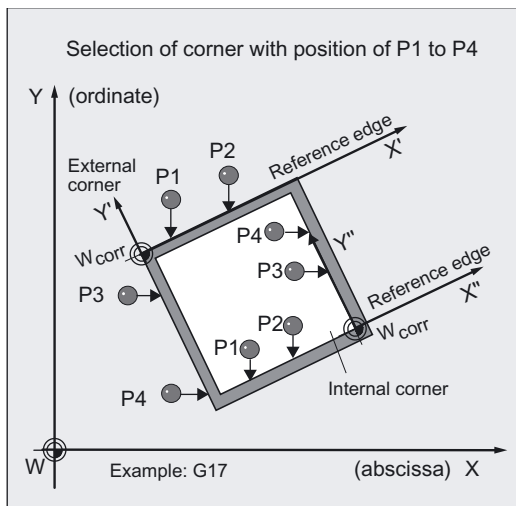
The position of the corner is selected with all 4 points. So for a rectangle, for example, different corners can be selected as the zero point depending on whether measuring variant internal or external corner is applied.

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
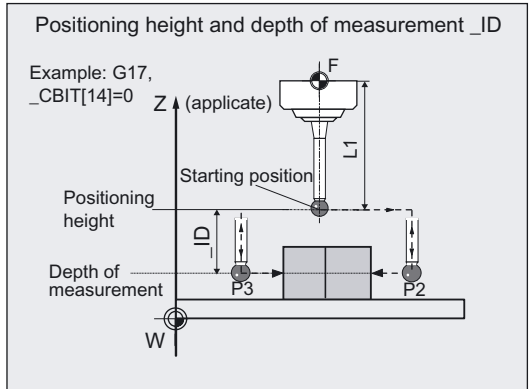
The probe is above the workpiece at positioning height. It must be possible to reach all points without collision.

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).
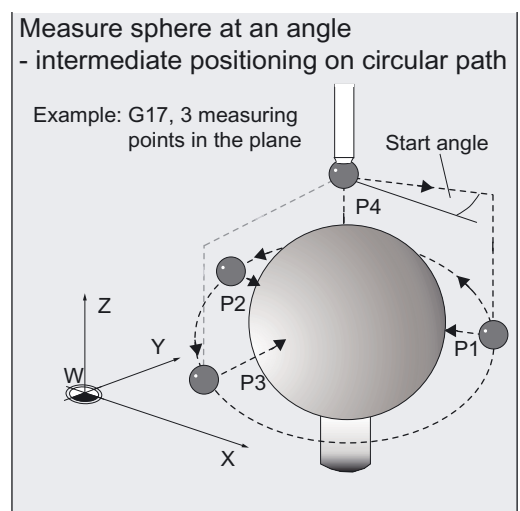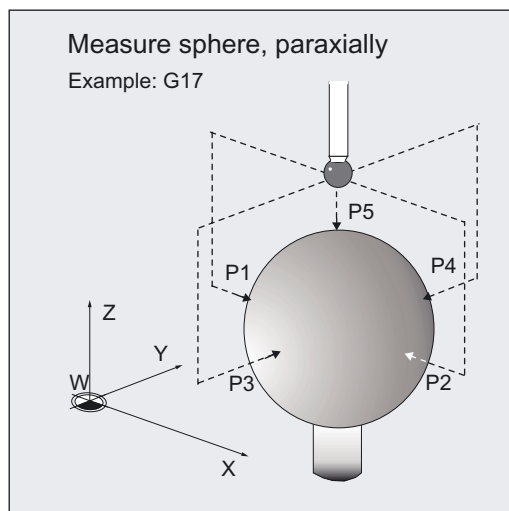
Measurements can be performed **paraxially** with the workpiece coordinates system (WCS) **or at an angle** in the plane.

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)
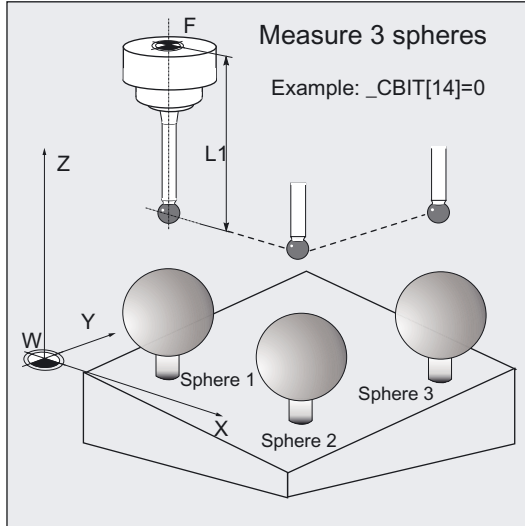
Measurement is performed in all three coordinate axes.

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
_OVR [10]	REAL	Difference center point coordinate ordinate 1st sphere

Parameter	Data type	Result
_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]
_RF	REAL	Velocity for intermediate paths on circular path (G2 or G3) (for _MVAR=xx11x9, – "Measuring at an angle" only)

Parameter	Data type	Meaning
_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 79)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Variable measuring velocity: _VMS (Page 77)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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.
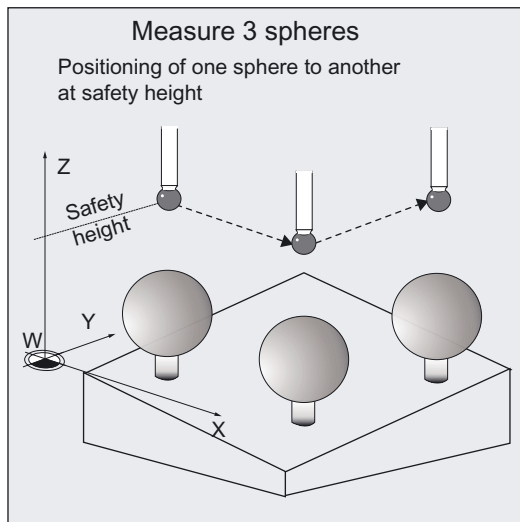
The cycle starts with measurement of the 1st sphere. Active G17 to G19 defines the plane with abscissa, ordinate. The applicate is the infeed axis.

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):

Principle of ZO correction with 1 sphere
Position of center point (MP) determines offset

Example: G17, X/Z plane
An existing spatial rotation remains unchanged.
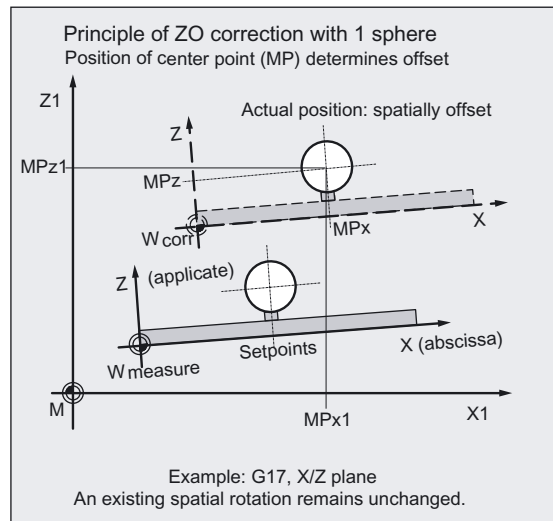
The actual value/setpoint differences of the center point coordinates are included the calculation of the translatory component of the ZO. The offset acts such that the calculated sphere center point in the offset ZO includes the specified setpoint position (workpiece coordinates, three axes).

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):

Principle of ZO correction with 3 spheres

Ideally, the spheres K display No variance between one another to the setpoint: Distortion =0

Actual position: Spatially offset and turned

Example: G17, X/Z plane

Deviations are shown greatly magnified in the setpoint-actual diagram!
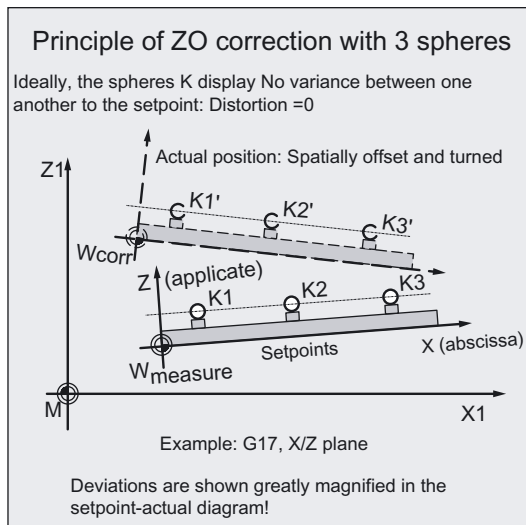
Compensation of the entire active frame with its translational and rotary components is performed after 3 spheres have been measured with cycle `CYCLE119` (see following section).

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):

Example: G17   1) _SETVAL
(Setpoint sphere diameter)
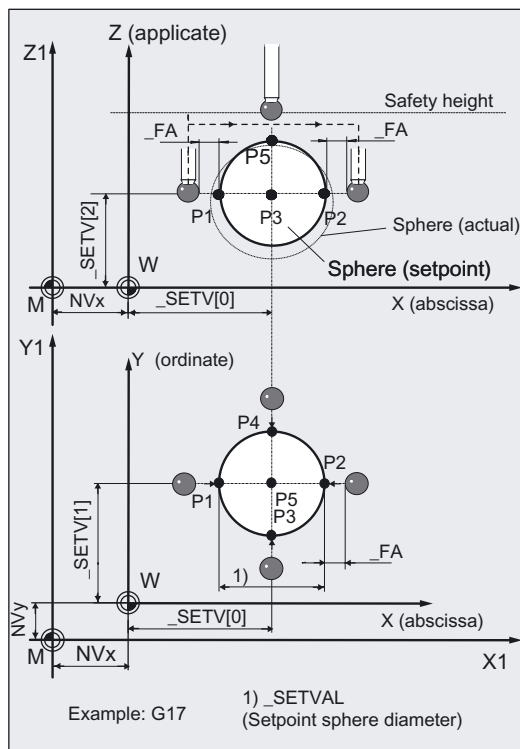
All intermediate positioning actions and measurement movements are paraxial with the active workpiece coordinate system. The measuring points are approached at distance _FA from the sphere lateral surface (setpoint sphere diameter). Measuring point P1 is approached first. After positioning in the abscissa, 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):
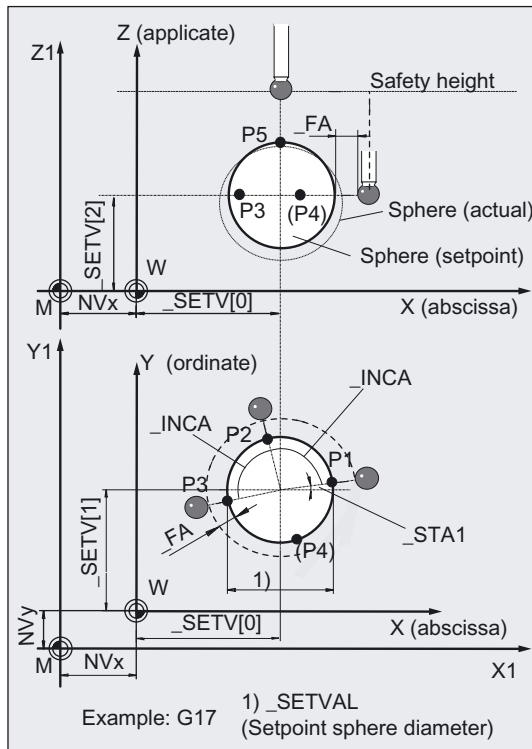
With _STA1 (starting angle) the angle position of P1 is defined, with _INCA, the incremental angle after P2 and then after P3. If the measuring variant is selected with 4 measuring points on a circle (_MVAR=1x1109), _INCA is also valid from P3 to P4.

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.
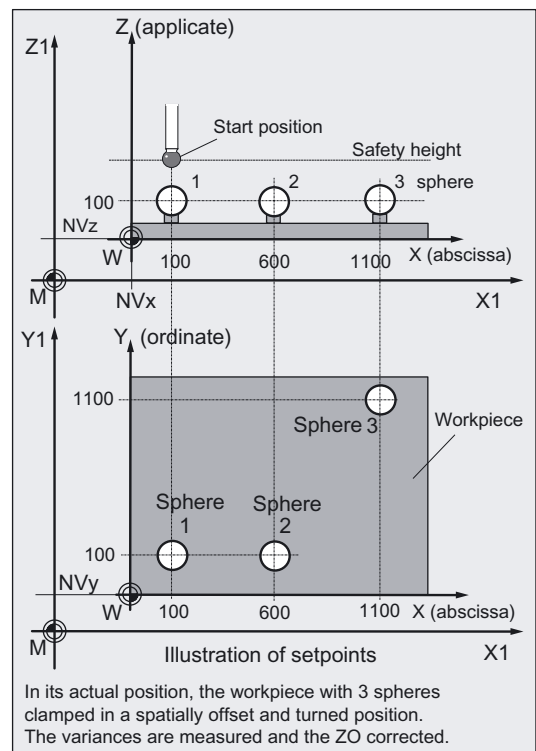
```
%_N_ DETERMINE_KS _MPF
N10 G17 G54                              ;X-Y plane, active ZO
N20 T20 D1                               ;Select and activate
                                         ;probe with tool offset D1 (M6)
N30 G0 G90 Z200                          ;Approach position Z at safety height
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'
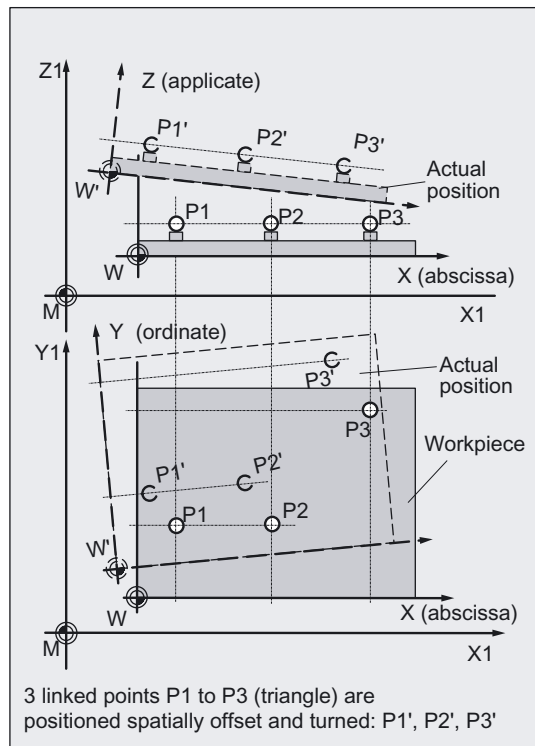
CYCLE119 is called as a subroutine by measuring cycle CYCLE997.

To allow this cycle to be used universally, its data are transferred via parameters.

Programming

```
CYCLE119(_SETPOINT,_MEASPOINT,_ALARM,_RES,_REFRAME,_COR,_RESLIM)
```

Parameter

Input data	Data type	Meaning		
_SETPOINT[3,3]	REAL	Field for 3 setpoint positions in the sequence 1st, 2nd, 3rd geometry axis (X, Y, Z)		
		These points are the reference triangle.		
_MEASPOINT[3,3]	REAL	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.		
_COR	INTEGER	Offset		
		Values:	0: No compensation	
			1...99: ZO compensation in G54...G57, G505..G599	
			1000: ZO compensation of last active channel basic frame according to MD 28081	
			1011 to 1026: ZO compensation in channel basic frame	
			2000: ZO compensation in scratch system frame $P_SETFR	
			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	
_RESLIM	REAL	Limit value for distortion (only relevant, if _COR >0) If _RES is below this limit value, OZ is corrected, otherwise an alarm is output.		

The results of calculation are stored in these transfer parameters.

Output data	Data type	Meaning	
_ALARM	INTEGER	Cycle alarm number for feedback	
		(transfer value must be 0 on cycle call).	
_RES	REAL	Result of calculation	
		Values:	< 0: No frame was calculated An alarm (_ALARM > 0) is returned.
			≧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.
_REFRAME	FRAME	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).	

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)

See also

Options (Page 432)

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
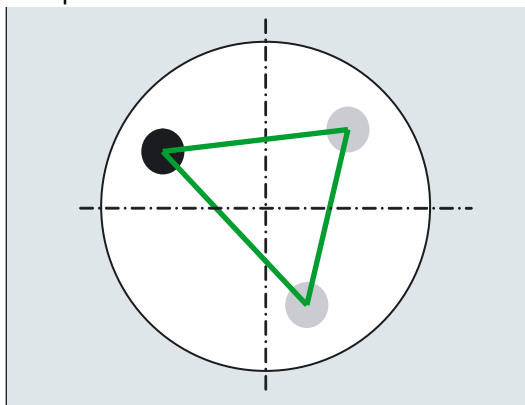
Calibration ball mounted too near the center of rotation; clamped triangle is too small
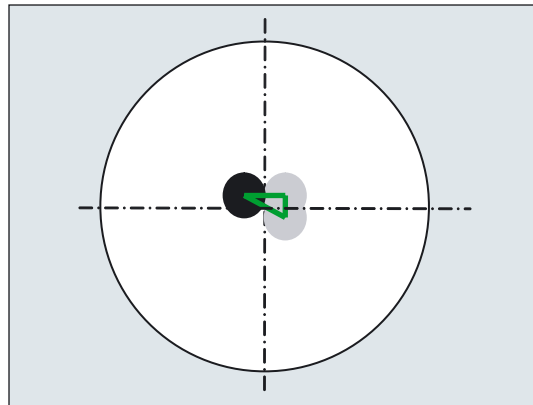
Note

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
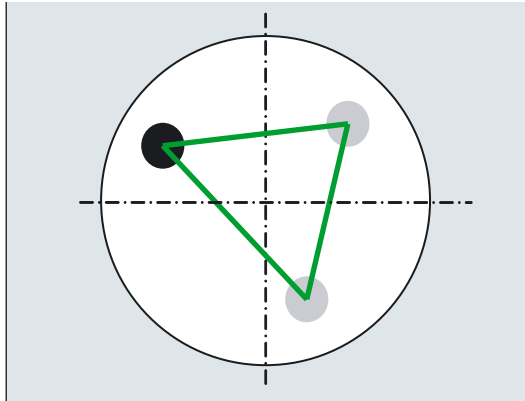
Rotary axis positions poorly selected; clamped triangle is too small
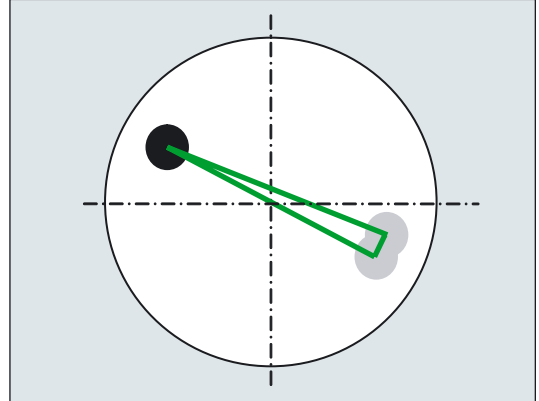
Approaching the ball position

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
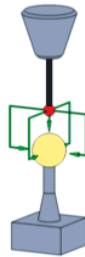
Starting point selected
laterally above the calibration ball
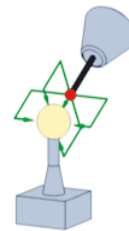
Note

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

1st measurement P1
- Manufacturer initial state, 1st rotary axis (B axis)
- Positioning probe over calibration ball
- Ball measurement using CYCLE996
- Probe retraction

2nd measurement P2
- Repositioning of 1st rotary axis (B axis)
- Positioning probe over calibration ball
- Ball measurement using CYCLE996
- Probe retraction

3rd measurement P3
- Repositioning of 1st rotary axis (B axis)
- Positioning probe over calibration ball
- Ball measurement using CYCLE996
- Probe retraction

Rotary axis 2

1st measurement P1
- Manufacturer initial state, 2nd rotary axis (C axis)
- Positioning probe over calibration ball
- Ball measurement using CYCLE996
- Probe retraction

2nd measurement P2
- Repositioning of 2nd rotary axis (C axis)
- Positioning probe over calibration ball
- Ball measurement using CYCLE996
- Probe retraction

3rd 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 |
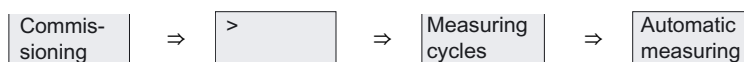
5.10.5 Measuring kinematics

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 |
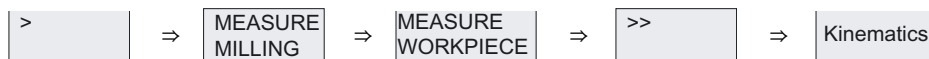
CYCLE996 screen forms

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 grants the user the possibility of checking the data of the selected swivel data record, or entering 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.

1st measure- ment P1

Call 1st measurement

2nd measure- ment P2

Call 2nd measurement

3rd measure- ment P3

Call 3rd measurement
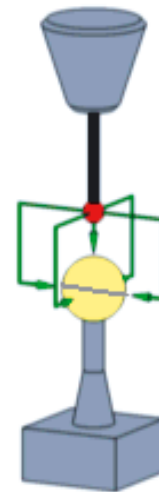
Kinematics calculating

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:

1st measurement P1 (initial state)   2nd measurement P2   3rd measurement P3
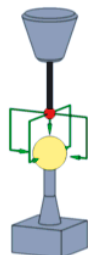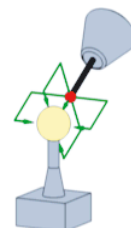
With the 2nd and 3rd measurements, the rotary axis to be measured is rotated around the largest possible angle. The position of the calibration ball must be stationary during measurement (1st, 2nd, 3rd).

Starting 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.
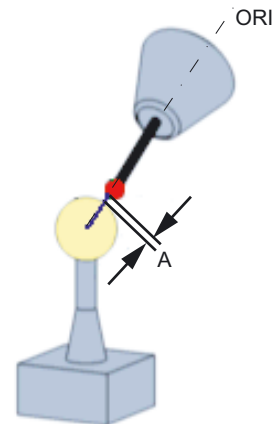
5.10.6.2 Parameters of "1st, 2nd, 3rd measurement" screen form

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:
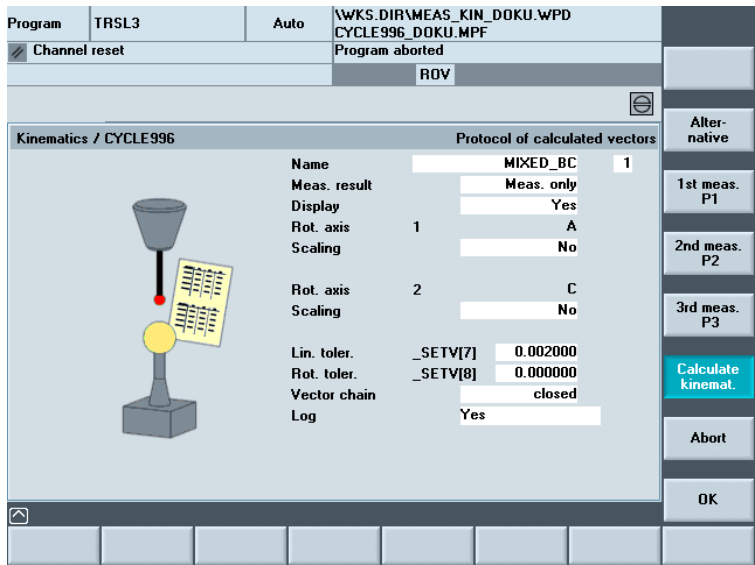
Name (Name/number of the swivel data record)

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).

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 … ;l1xyz.

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).

Kinematics / CYCLE996

Display of results of calculated vectors (editable)

Measured rotary axes of the swivel data record (kinematics):

Rot. axis 1: A   Rot. axis 2: C

Measuring counter _OVR[40]=33

Kinematics	Inclin.head+swivel table	Name:		MIXED_BC No.: 1
	X	Y	Z	
Offset vector l1	-65.886440	1.635403	-129.107054	
Rotary axis vector V1	0.002263	0.999956	0.009141	
Offset vector l2	65.886440	-1.635403	129.107054	
Offset vector l3	2.596116	-4.451905	26.992587	
Rotary axis vector V2	-0.000899	0.001697	-0.999998	
Offset vector l4	-2.596116	4.451905	-26.992587	

Lin. toler.
   0.002000

Switch to insert mode to edit - INSERT key

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
|   |   |     |  —— 1   1st measurement
|   |   |     |     2   2nd measurement
|   |   |     |     3   3rd 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
```

- "Calculate kinematics" _MVAR

```
9 8 7 6 5 4 3 2 1
| | | | | | | | |
| | | | | | | | |         _MVAR
| | | | | | | |—— 4       Calculate kinematics
| | | | | | | |_ _ _ _ _ _ _ _ _ _ _ _ _
| | | | | | |              Identification of "Measure
| | | | | | |—— 9         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)
```

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

Parameter	Data type	Result
_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]		_OVR[1]..._OVR[3]
I2 $TC_CARR4...6[n]	Corresponds to	_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]		_OVR[4]..._OVR[6]
I3 $TC_CARR15...17[n]	Corresponds to	_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]		_OVR[1]..._OVR[3]
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]
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
_OVR[41,42,43]	REAL	1st measurement of 1st rotary axis
_OVR[44,45,46]	REAL	2nd measurement of 1st rotary axis
_OVR[47,48,49]	REAL	3rd measurement of 1st rotary axis
_OVR[51,52,53]	REAL	1st measurement of 2nd rotary axis
_OVR[54,55,56]	REAL	2nd measurement of 2nd rotary axis
_OVR[57,58,59]	REAL	3rd 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[66,67,68]	REAL	Rotary axis vectors V1xyz
_OVR [69,70,71]	REAL	Rotary axis vectors V2xyz

5.10.8   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,-     ;P6 xyz 1.RA 2.RA
45)
T99 D1                                       ;3D probe
G500
CYCLE800()
TRAFOOF
IF (NOT $P_SEARCH)                           ;If no block search
_OVR[40]=0                                    ;reset measurement counter to zero
ENDIF
;-------------------- 1st 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
;-------------------- 2nd 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
;-------------------- 3rd 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
;===================== 1st 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
;-------------------- 2nd 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
;-------------------- 3rd 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
```

Measuring Cycles for Turning Machines

6

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.

6.1.2 Overview of measuring cycles

Cycle	Function
(CYCLE972)[1]	Calibrate tool probe, measure turning tools
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
1) CYCLE982 is the preferred cycle to use. CYCLE972 does not support graphic measuring cycles	

6.1.3 Overview of the auxiliary programs required

Cycle	Function
CYCLE100	Log ON
CYCLE101	Log OFF
CYCLE102	Measurement result display selection
CYCLE103	Preassignment of input data
CYCLE104	Internal subroutine: Measuring cycle interface
CYCLE105	Generate log contents: Log
CYCLE106	Logging the sequential controller Log
CYCLE107	Output of message texts (up to measuring cycles SW 6.2)
CYCLE108	Output of alarm messages (up to measuring cycles SW 6.2)
CYCLE109	Internal subroutine: Data transfer

Cycle	Function
CYCLE110	Internal subroutine: Plausibility checks
CYCLE111	Internal subroutine: Measuring functions
CYCLE113	Read system date and time Log
CYCLE114	Internal subroutine (tool offset)
CYCLE115	Internal subroutine (ZO compensation)
CYCLE117	Internal subroutine: Measuring functions
CYCLE118	Format real values: Log

The measuring cycle data are defined in the data blocks:

- **GUD5.DEF**

- **GUD6.DEF**

Note

The measuring cycles with measuring cycles SW 6.2 can only be used with NCK-SW 6.3 and higher.

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.
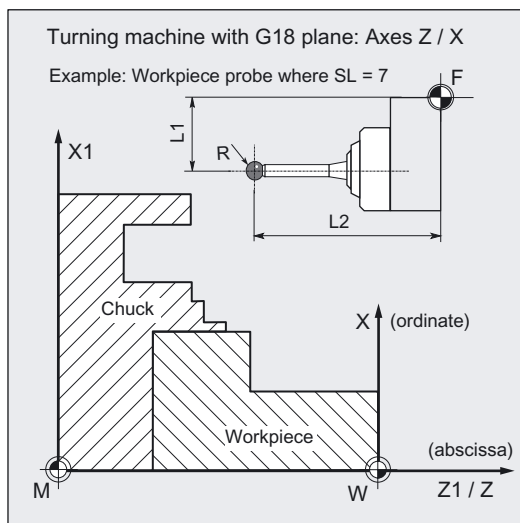
Plane definition

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, CYCLE972 Tool: Measure turning tools

6.2.1 Function overview

Function

Cycles CYCLE982, CYCLE972 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.

Measure length L1 and L2 for turning tool

Example: Edge position SL = 3
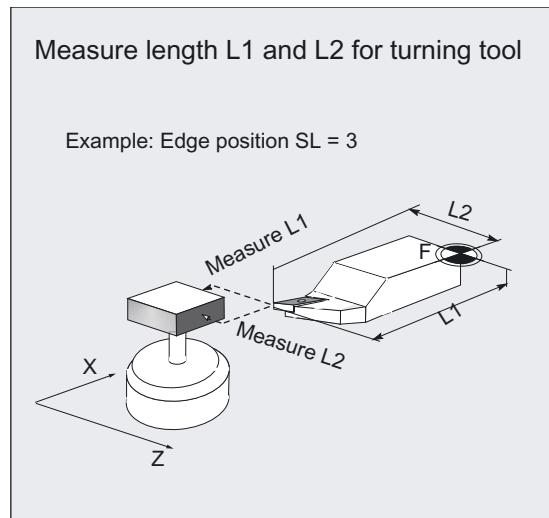
Programming

```
CYCLE982
CYCLE972
```

Note

CYCLE982 is the **preferred** cycle to use.

CYCLE972 does not provide graphics measuring cycle support.

Measuring cycle CYCLE982 provides extended measuring and calibration features over CYCLE972.

These variations are described in Section "CYCLE982: Tool: Measure turning and milling tools".

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

Measuring cycles CYCLE982, CYCLE972 permit the following measuring variants which are specified via parameter _MVAR.

Value	Measuring variant
0	Calibrate tool probe (machine-related)
1	Measure tool (machine-related)

Result parameters

Measuring cycles CYCLE982, CYCLE972 return the following values in data block GUD5 for 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 cycles CYCLE982, CYCLE972 return the following values in data block GUD5 for measuring 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

Parameter	Data type	Result
_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").
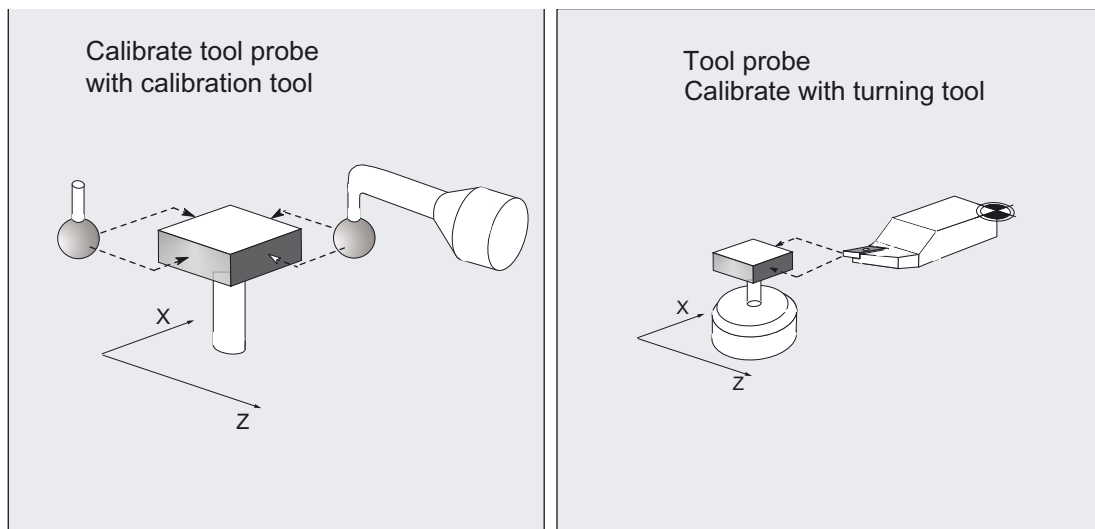
Requirement

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
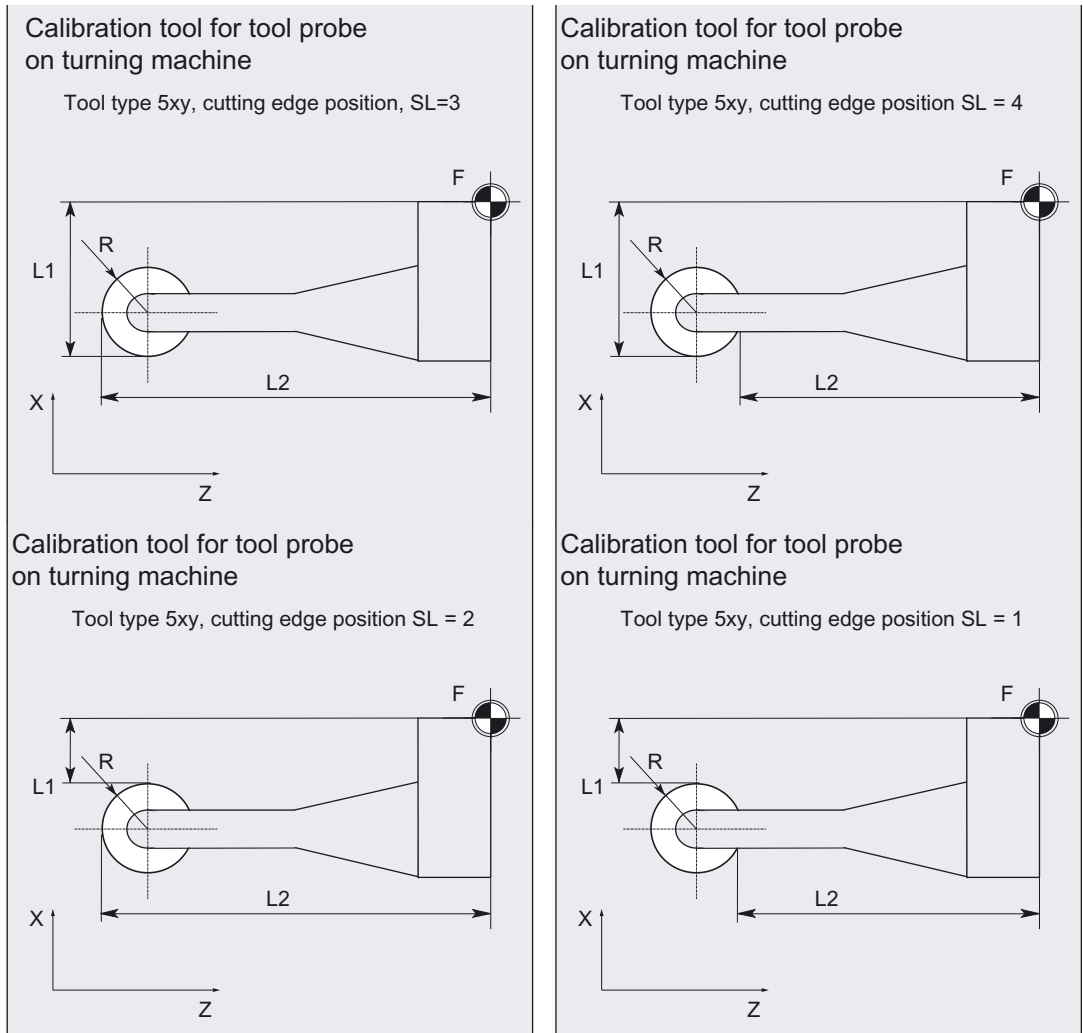
The calibration tool is shaped (bent) in such a way that the probe can be calibrated on all 4 sides with it.

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).
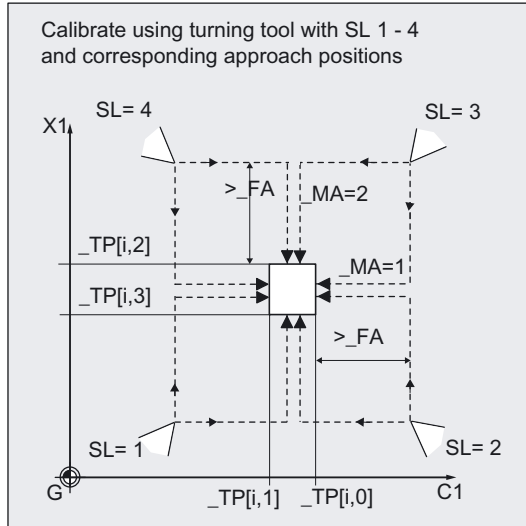
Requirement

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	Calibrate tool probe (machine-related) with calibration tool
	10000000	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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Multiple measurement at the same location: _NMSP (Page 82)

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.

Calibrate tool probe with calibration tool, with the corresponding basic positions for both axes (machine-related)
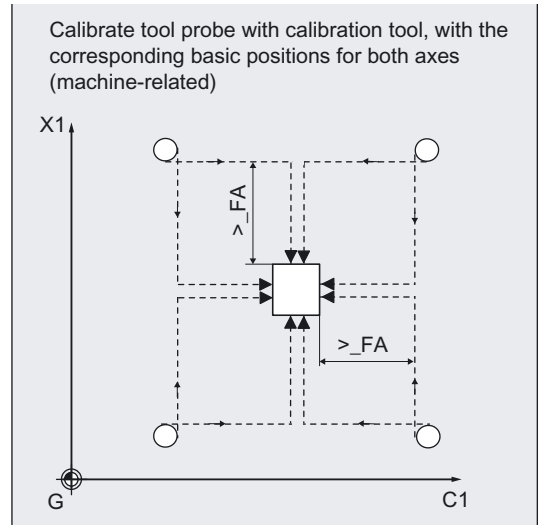
Position after measuring-cycle call

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

Calibrate, machine-related possible start positions
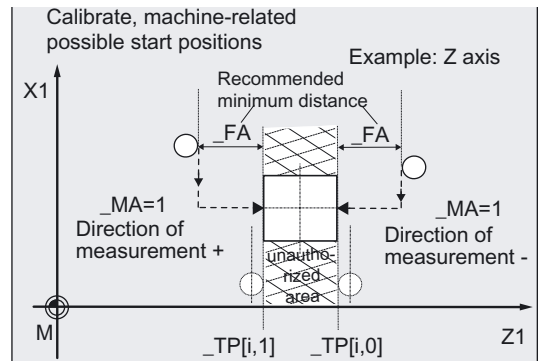
Programming example

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
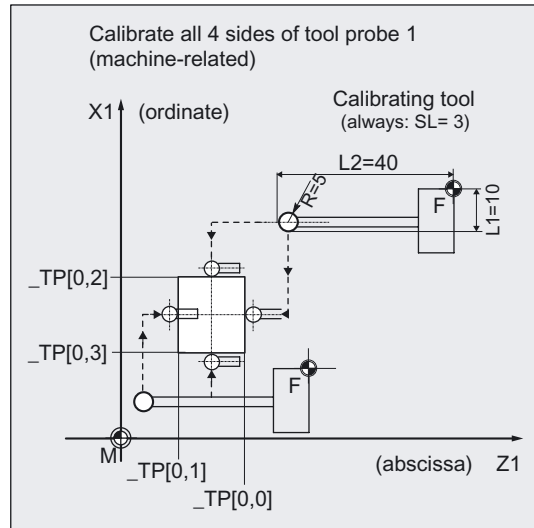
To obtain a minimum measurement path of 1 mm, the measurement path is programmed with _FA = 1+5= 6 mm (max. total measurement path = 12 mm).

```
%_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.

Measure turning tool
Example: Cutting edge position SL=3, L1 determined
MA=2
Specificat. of measurement axis _MA
Movement in measuring and offset axes, L1,L2 are known roughly

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.
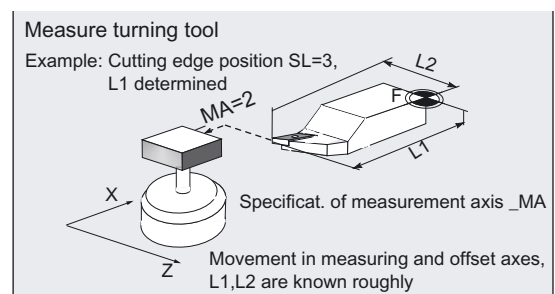
- **Remeasurement of a tool** (_CHBIT[3]=1):

  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 65)

Result parameters (Page 67)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.
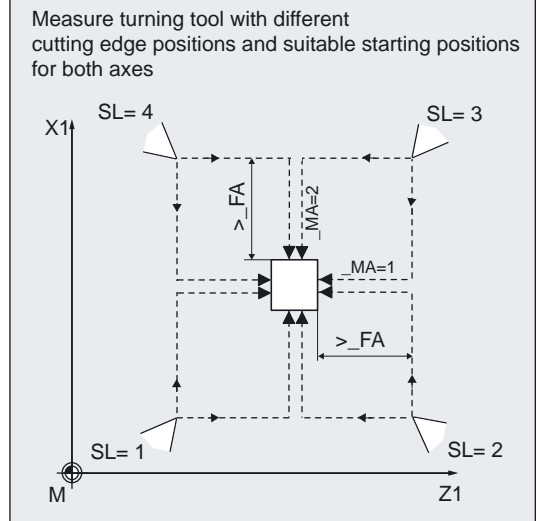
Measure turning tool with different cutting edge positions and suitable starting positions for both axes

Position after measuring-cycle call

On completion of the cycle, the tool nose is positioned facing the measuring surface and _FA from it.

Length measurement of turning tool:
Offset by cutting edge radius

Example: SL= 3
P - tool tip
S – center point of cutting edge
R - cutting edge radius
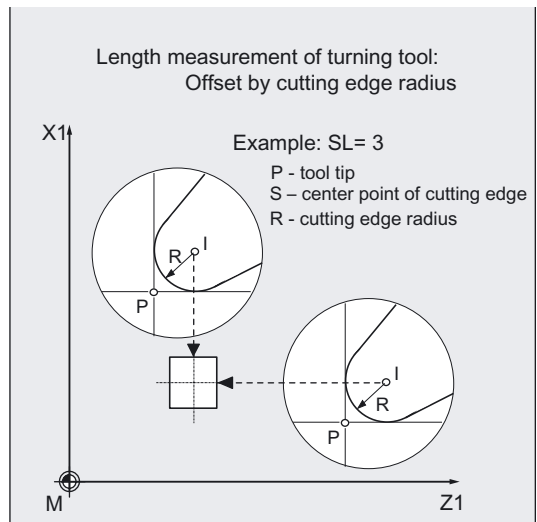
Programming example

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.

Calibrate tool probe 1 (machine-related)
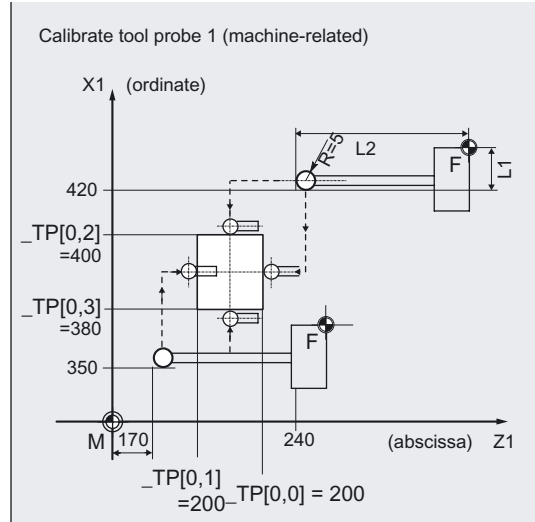
The default values of probe 1 as applied in data block GUD6 with a tolerance of approx. 1 mm:

_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

Length measurement of turning tool, SL= 3 (machine-related)
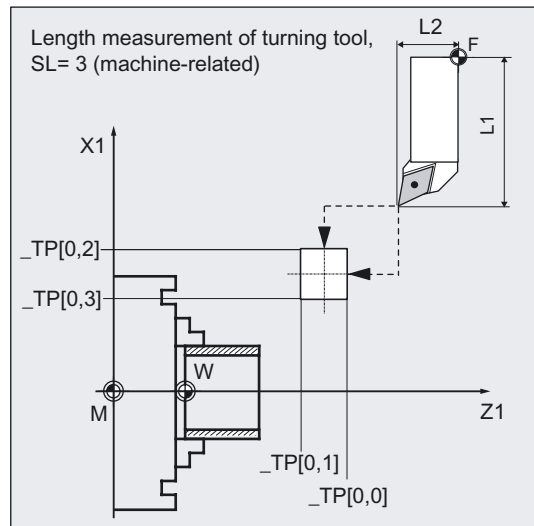
```
%_N_T3_MEAS_MPF
;Calibration:
N10 G0 G18 G94 G90 DIAMOF
N20 T7 D1                                ;Call calibration tool
N30 SUPA Z240 X420                       ;Starting position for calibration
N40 _TZL=0.001 _PRNUM=1 _VMS=0 _NMSP=1   ;Parameter definition
N50 _MVAR=0 _FA=1 _TSA=1 _MA=2
N60 CYCLE982                             ;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

_MA=2

X

Z

Specification of measurement axis _MA

Movement in measuring and offset axes, Switching values of probe known roughly
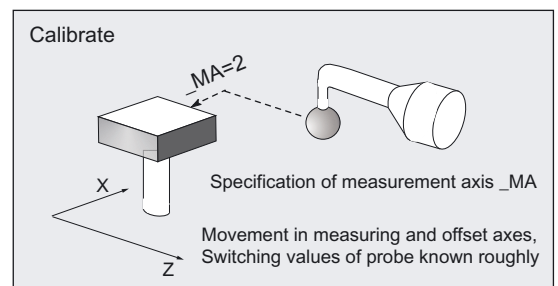
- **Calibrate in increments** as preparation for incremental measurement

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.

Calibrate in increments
Movement only in measuring axis switching values of probe unknown

_MA=2
_MD=1

X

Requirement: measurement axis _MA and measuring direction _MD

Z
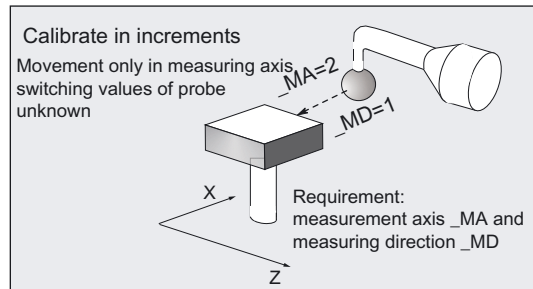
- **Measuring**

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).

Measure turning tool
Example: Determine cutting edge position SL=3, L1

_MA=2
L2
F
L1

X

Specific. of measurement axis _MA

Z

Movement in measuring and offset axes, L1,L2 are known roughly
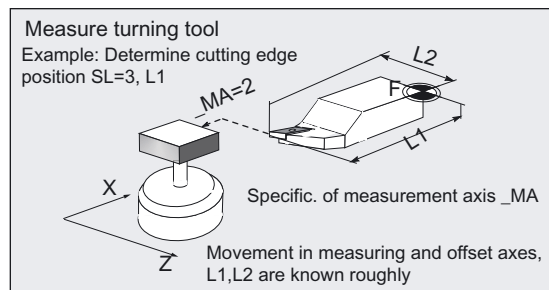
- **Incremental measurement**

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.

Measure tool in increments
Example: Determine turning tool, SL=3, L1

_MA=2
L2
F
L1

_MD=1

X

Requirement: measurement axis _MA and measuring direction _MD

Z

Movement only in measuring axis, L1 is unknown
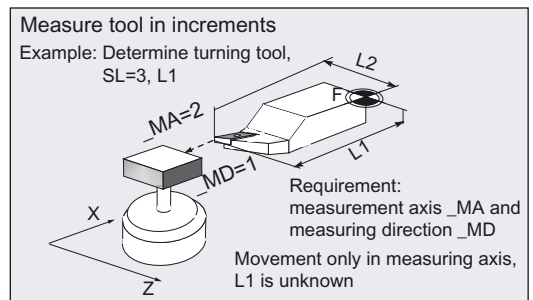
- **Automatic measurement**

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).

Measure tool automatically
Example: Turning tool, SL=3

L2
F
L1

X

L1 and L2 are determined

Z

Measurement is performed in both axes, L1, L2 are known roughly
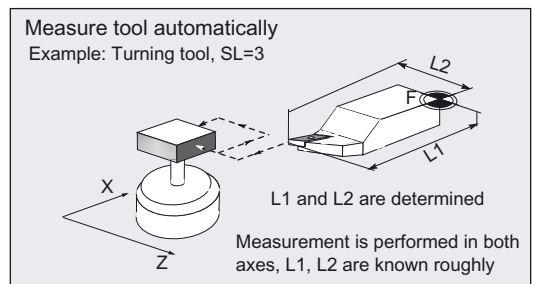
- **Machine-related measurement, calibration**

   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,...].
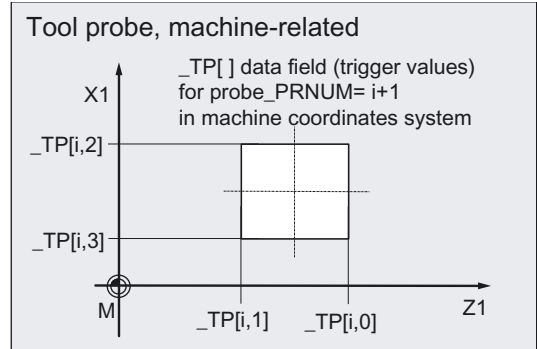
   Tool probe, machine-related

   _TP[ ] data field (trigger values) for probe_PRNUM= i+1 in machine coordinates system

- **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,...].

   Tool probe, workpiece-related

   _TPW[ ] data field (trigger values) for probe_PRNUM= i+1 in workpiece coordinates system
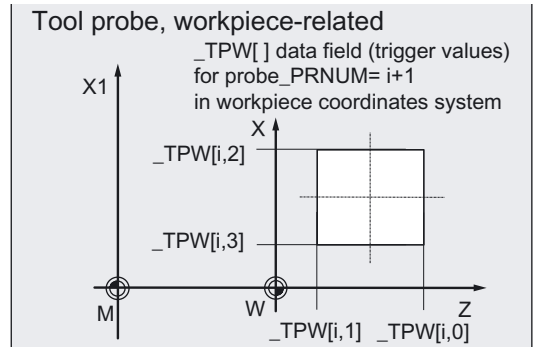
Special aspects with milling tools

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.

Measure milling tool
Example: Radial position

When SD 42950=2, the length is calculates as for a turning tool.
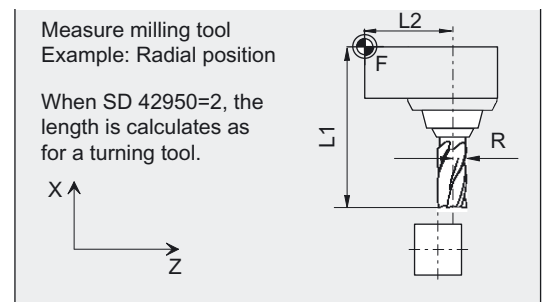
Note

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							0	With calibration tool
1							0	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

Digit								Meaning
								Significance for measuring milling tools only, also automatically:
				0			1	Only correct length (for measuring only) or
				0			2	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).								
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).

From measuring cycles SW 6.3, drill (type 2xy) also 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)".

- **Calibrating tool probes, workpiece-related** (measuring cycle release SW 6.3 and higher)

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,...].
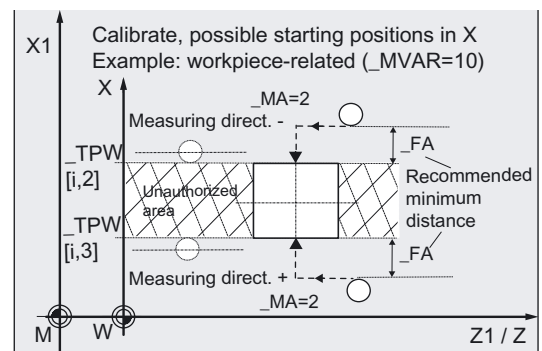
Transformations can be activated in workpiece-related measurement, calibration.

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	Calibrate tool probe (machine-related) with calibration tool
		Calibrate tool probe (machine-related) with turning tool
	10000000	Calibrate tool probe (workpiece-related) with calibration tool
		Calibrate tool probe (workpiece-related) with turning tool
	10	
	10000010	
_MA	1, 2	Measuring axis
_PRNUM	INTEGER	Probe number

Additional parameters `_VMS, _TZL, _TSA, _FA` and `_NMSP` also apply.

See also

Defining parameters (Page 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Multiple measurement at the same location: _NMSP (Page 82)

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:

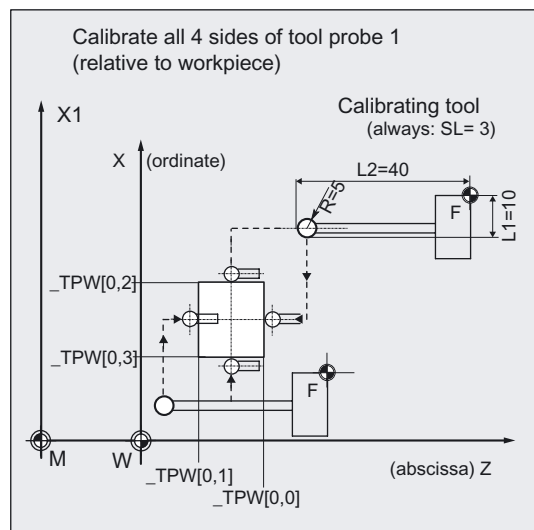|	
Tool type (DP1):	500
Cutting edge position (DP2):	3
Length 1 - geometry (DP3):	L1 = 10
Length 2 - geometry (DP4):	L2 = 40
Radius - geometry (DP6):	R = 5

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).

Calibrate all 4 sides of tool probe 1 (relative to workpiece)

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	Measure tool (machine-related)
	11 or xxx11	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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.

Measure turning tool with different cutting edge positions and suitable starting positions for both axes
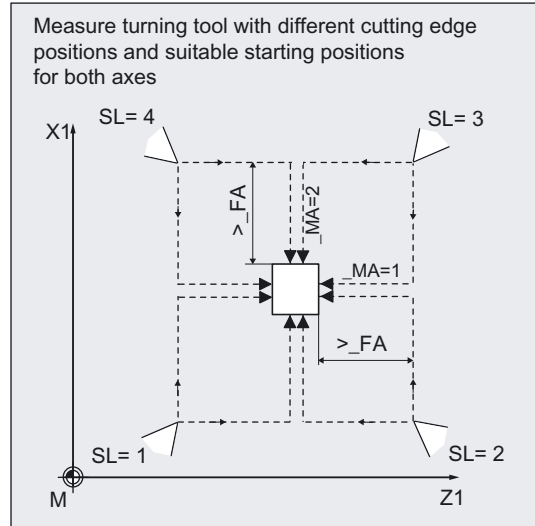
In the case of milling tools, length and radius can be selected as an alternative to length only to determine the cutter radius.

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").
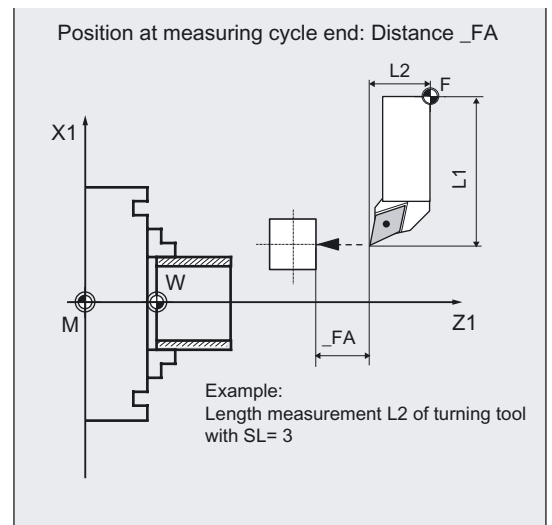

Note

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.

Position at measuring cycle end: Distance _FA
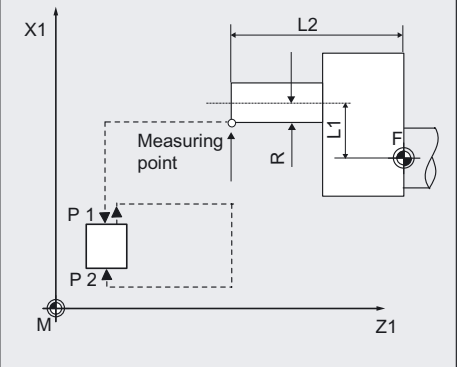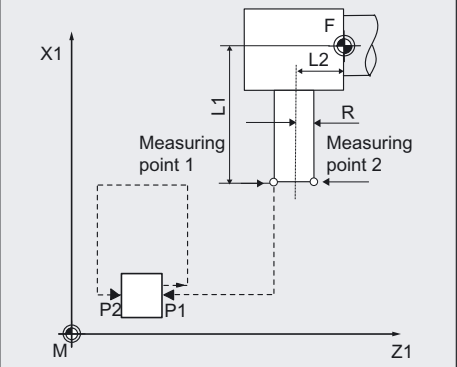
Example:
Length measurement L2 of turning tool with SL= 3

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	Drill (tool type: 2xy) Measuring point

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example: **Radial position,** R=0, Measuring without reversal, calculate length only **_MVAR=10001** **_MA=2**	L1=... L2=... R=0	L1	Drill (tool type: 2xy)
Example: **Axial position,** R ≠ 0, Measuring without reversal, calculate length only **_MVAR=1** **_MA=1**	L1=... L2=... R=...	L2	Milling cutter (tool type: 1xy)
Example: **Radial position,** R ≠ 0, Measuring without reversal, calculate length only **_MVAR=10001** **_MA=2**	L1=... L2=... R=...	L1	

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
Example: **Axial position,** R ≠ 0, measuring with reversal, calculate radius only **_MVAR=1101** **_MA=2** L1 must be known	L1=... L2=... R=...	R R=ABS(P – L1)	
Example: **Radial position,** R ≠ 0, measuring with reversal, calculate length only **_MVAR=10101** **_MA=1** R must be known	L1=... L2=... R=...	L2 L2=(P - R) Or other measuring direction: L2=(P + R)	
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	

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
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	
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	

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	Drill (tool type: 2xy) Measuring point

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
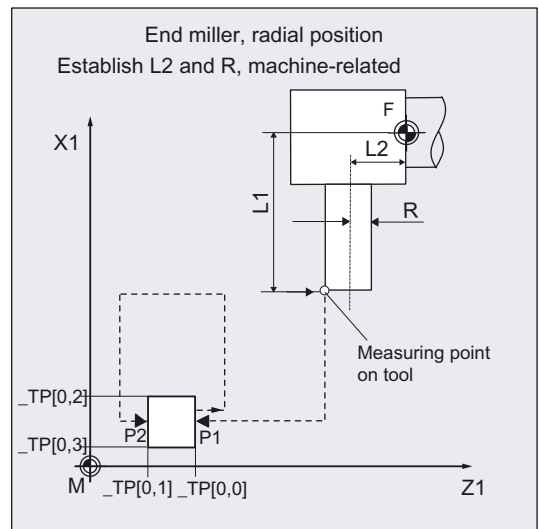
Deviations from this value of less then 2.5 mm are expected.

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	Measure tool automatically (machine-related)
	12 or xxx12	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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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.
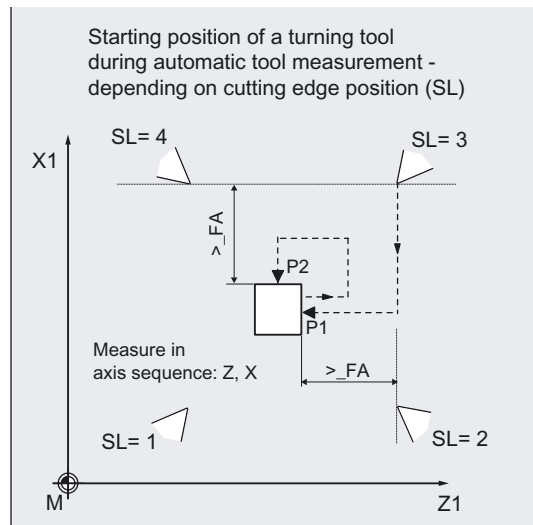
For milling tools, the measuring points on the tool are determined by entered lengths 1 and 2 (please note: SD 42950). If the radius value is not equal to zero, this is also a determining factor. The axial or radial position of the tool must be specified in _MVAR, and the starting position approached 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.).
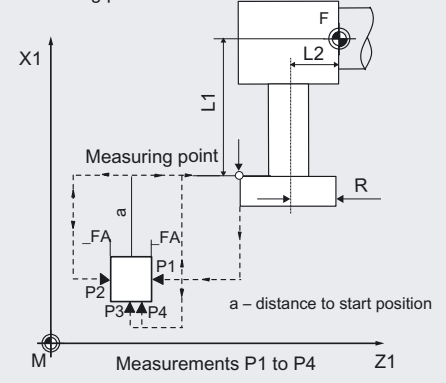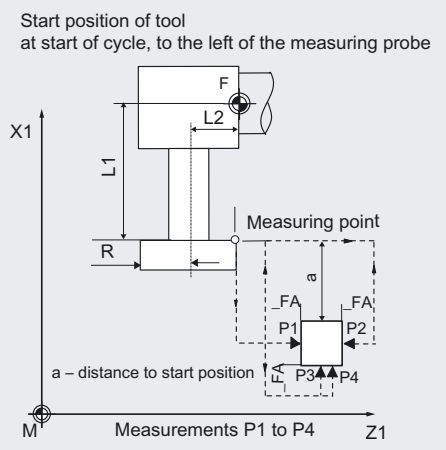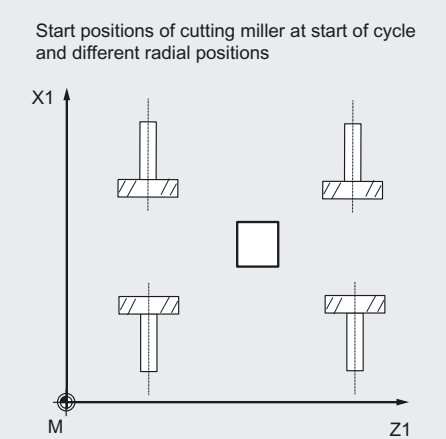
Position after end of measuring cycle

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

Measuring variant	Specified geometry	Offset applied in	Milling tools
Example 1: **Axial position,** R ≠ 0, Measuring without reversal, spindle stationary, 4 measurements necessary **_MVAR=2**	L1=... L2=... R=...	L1 L2 R L1= (P3x + P4x)/2 L2= (P1z + P2z)/2 R=ABS(P3x-P4x)/2	

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.

Measuring variant	Specified geometry	Offset applied in	Milling tools
Example 2: **Radial position,** R ≠ 0 measuring with reversal, 8 measurements necessary (P1 to P4 each with reversal) **_MVAR=10102**	L1=... L2=... R=...	L1 L2 R L1= (P3x + P4x)/2 L2= (P1z + P2z)/2 R=ABS(P1z-P2z)/2	
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	 Start position of tool at start of cycle, to the right of the measuring probe Start position of tool at start of cycle, to the left of the measuring probe Start positions of cutting miller at start of cycle and different axial positions

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	Start position of tool at start of cycle, to the right of the measuring probe Start position of tool at start of cycle, to the left of the measuring probe Start positions of cutting miller at start of cycle and different radial positions

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.
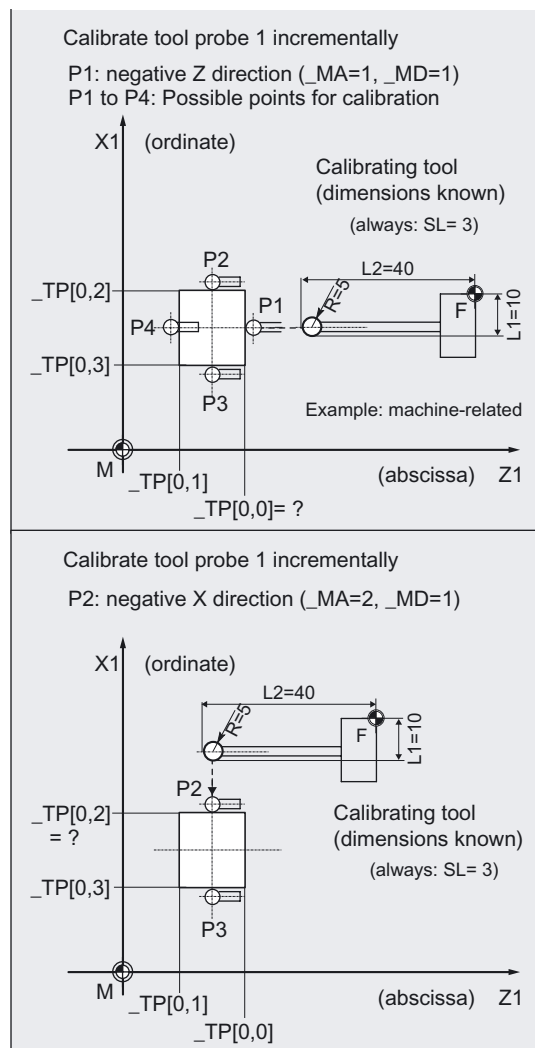
See also

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.

Calibrate tool probe 1 incrementally

P1: negative Z direction (_MA=1, _MD=1)
P1 to P4: Possible points for calibration

Calibrating tool (dimensions known)
(always: SL= 3)

Example: machine-related

Calibrate tool probe 1 incrementally

P2: negative X direction (_MA=2, _MD=1)

Calibrating tool (dimensions known)
(always: SL= 3)

Position after end of measuring cycle

When the calibration procedure is completed the calibration tool is positioned on the starting position again.
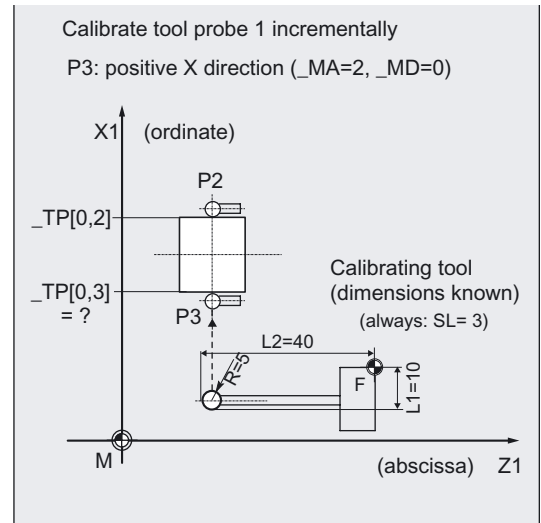

Comments

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.
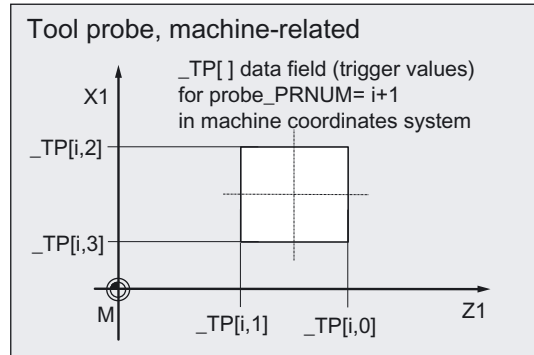
Programming example

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.
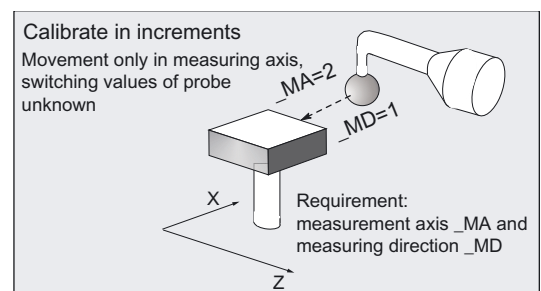
The calibration tool is inserted in the turret as tool T7.

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

Tool probe, machine-related

_TP[ ] data field (trigger values) for probe_PRNUM= i+1 in machine coordinates system

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	Measure a tool incrementally – machine-related
	1xxx11	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

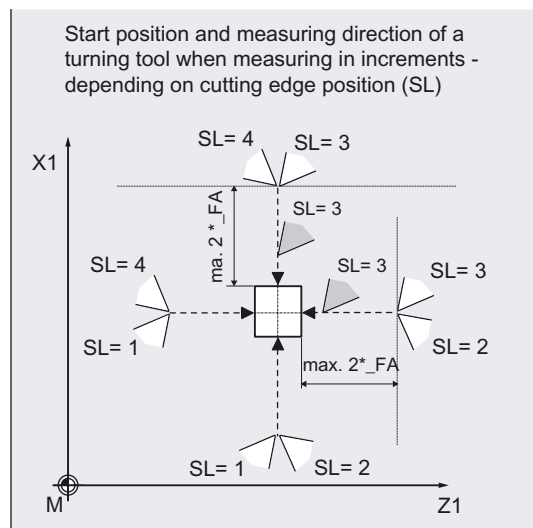Additional parameters _VMS, _FA, _PRNUM and_NMSP **also apply.**

See also

Defining parameters (Page 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Multiple measurement at the same location: _NMSP (Page 82)

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.

Start position and measuring direction of a turning tool when measuring in increments - depending on cutting edge position (SL)

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").
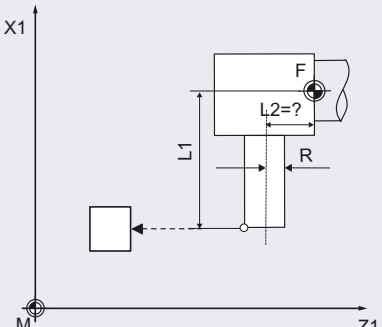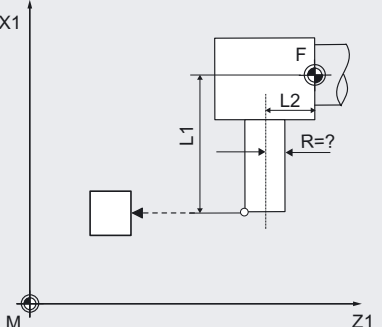
Position after end of measuring cycle

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	

Measuring variant	Specified geometry	Offset applied in	Milling tools, drills
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	
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].

Length measurement L1 in increments
Turning tool SL=3
(machine-related)
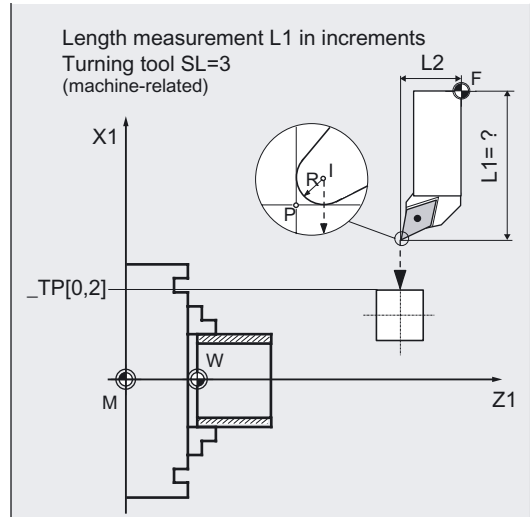
```
%_N_INCR_MEAS_MPF
N10 T3 D1 G94                                    ;Turning tool T3 is active,
                                                 ;Starting position reached
N20 _MVAR=100001 _MA=2 _FA=20 _MD=1 _PRNUM=1 _VMS=0   ;Parameters for the measuring
_NMSP=1                                          ;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=xx0xxx) 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)
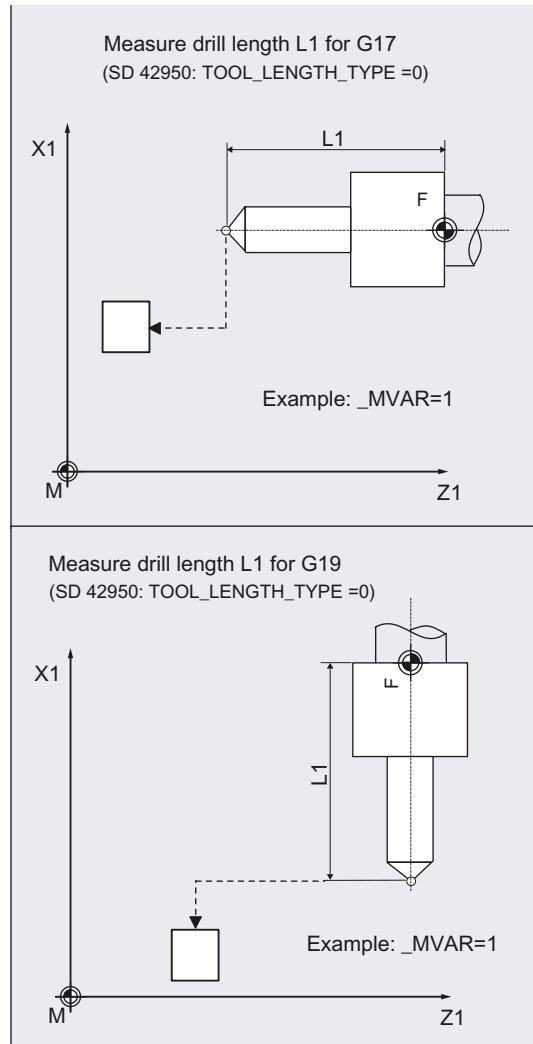
Length L1 is determined if the following conditions are satisfied:

- 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.

In measuring cycle release SW 6.3 and higher, tool measurement is workpiece-related and in measuring cycle version SW 7.3 and higher it is machine-related.

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,-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).
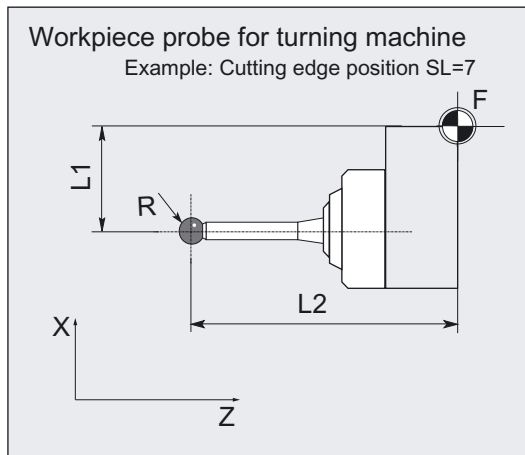
Calibration in a "reference groove" is relative to the machine. In this case, calibration is possible in one cycle call in both axis directions.

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.
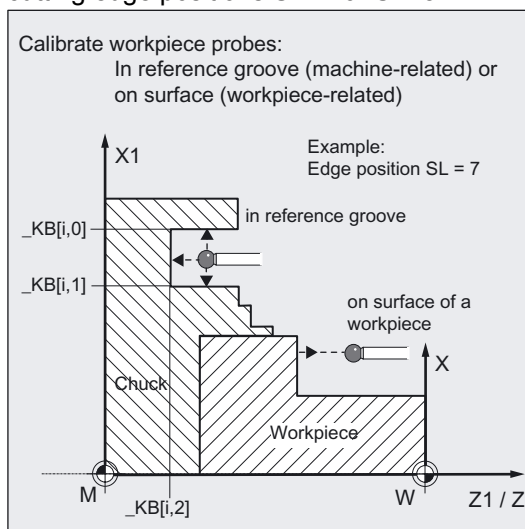
Calibration principle

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).
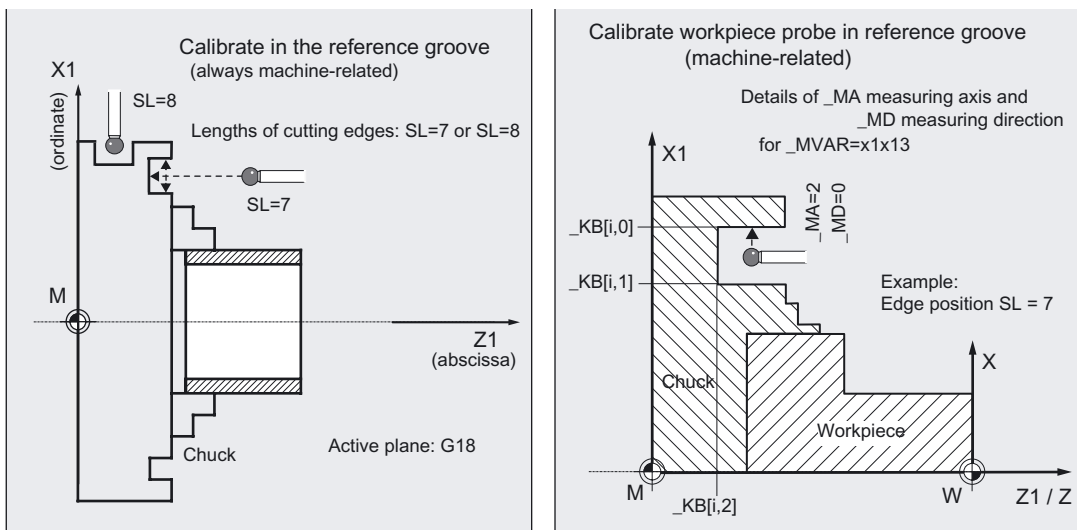
It is also possible to calibrate the position deviation of the probe and the active diameter of the probe ball in both directions.
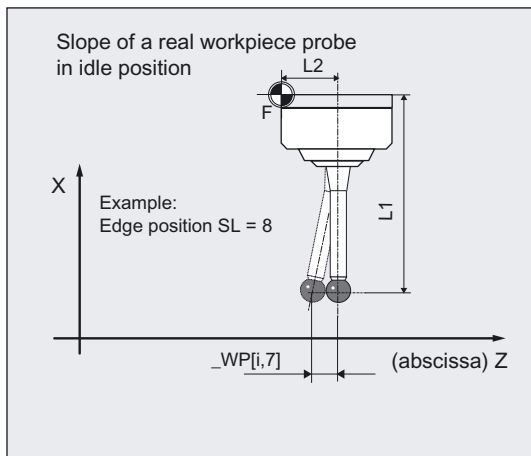
The workpiece probe calibrated is selected with **_PRNUM**. The associated array _WP[ ] in data block GUD6.DEF is _WP[_PRNUM-1,...] (for a detailed description of the array, refer to Chapter "Data description", "Central values").

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 65)
>
> Result parameters (Page 67)
>
> Variable measuring velocity: _VMS (Page 77)
>
> Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)
>
> Measurement path: _FA (Page 79)
>
> Multiple measurement at the same location: _NMSP (Page 82)

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

Calibrate workpiece probe in reference groove
Example: SL=7
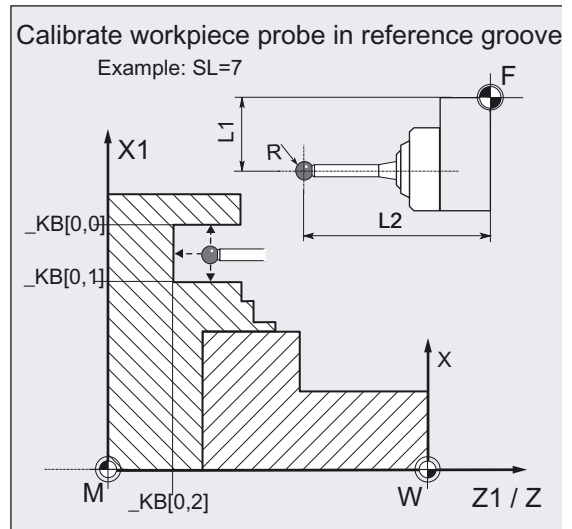
> The data for reference groove 1 have already been entered:
>
> _KB[0,0] = 60.123, _KB[0,1] = 50.054,
> _KB[0,2] = 15.021

```
%_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,...].

Calibrate workpiece probe on surface
(workpiece-related)
Details of _MA measuring axis and
_MD measuring direction
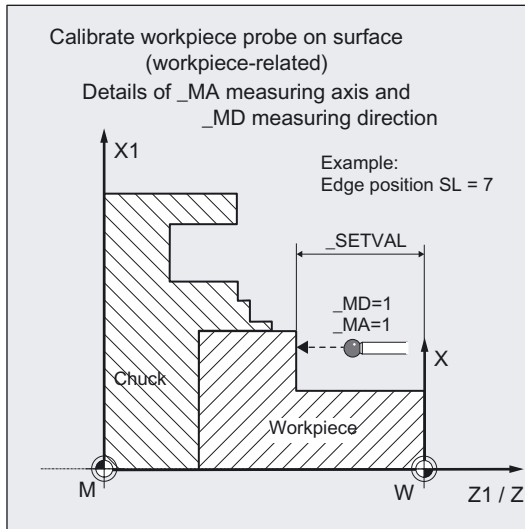
Prerequisite

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	Measuring direction
	1 negative axis 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 65)
>
> Result parameters (Page 67)
>
> Variable measuring velocity: _VMS (Page 77)
>
> Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)
>
> Measurement path: _FA (Page 79)
>
> Multiple measurement at the same location: _NMSP (Page 82)

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

Calibrate workpiece probe on surface
Example: SL=7, in minus Z direction

> 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
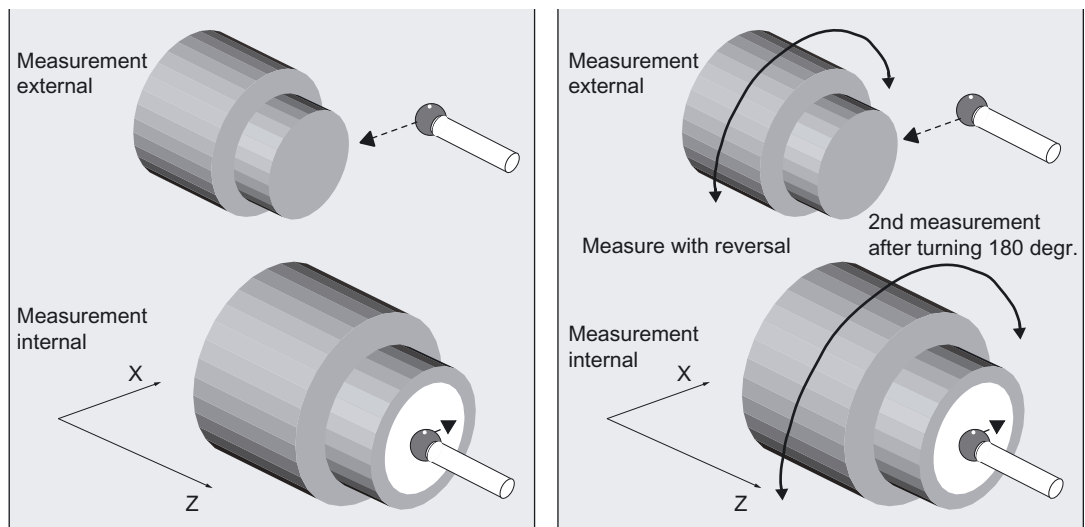
The measuring cycle determines the actual value of the workpiece with respect to the workpiece zero in the selected measuring axis _MA and calculates the difference from a defined setpoint (setpoint-actual value).

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

Parameters	Data type	Result
_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) from meas. cycles SW 6.3: For "tool offset" the offset value always appears in _OVR[20] as radius dimension.		

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.
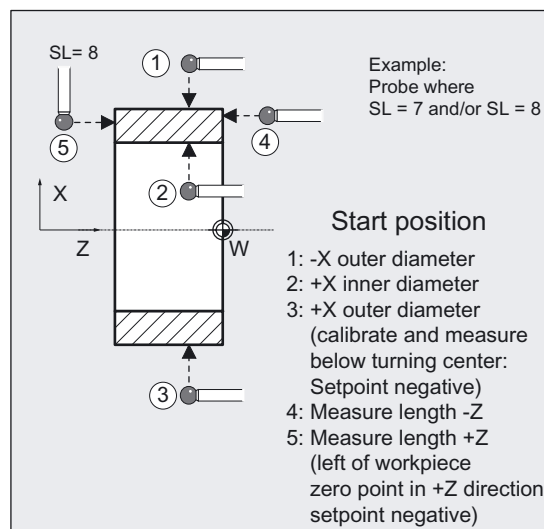
6.5.2   1-point measurement and ZO determination

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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

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
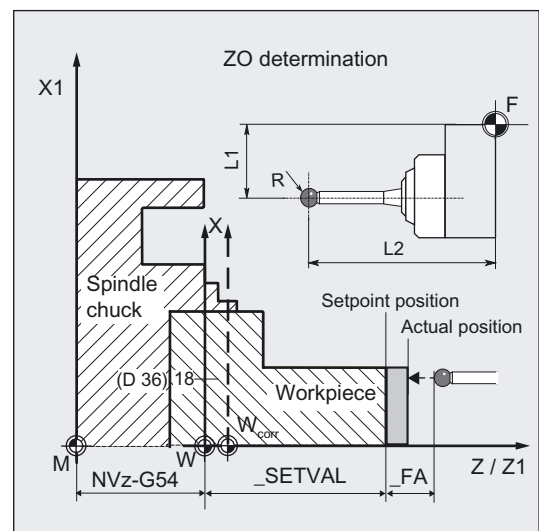
Zero offset, with settable ZO G54: NVz

```
%_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")
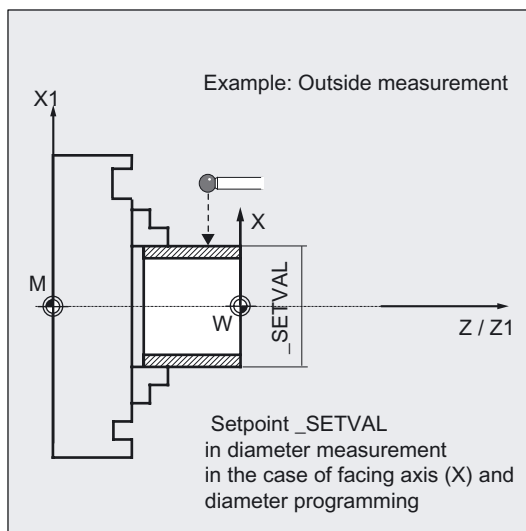

6.5.2.3 Operational sequence

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**.

From measuring cycles SW 6.3, extended tool offset is available. 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

Parameter	Data type	Meaning
_MVAR	0	1-point measurement and tool offset
_SETVAL	REAL[2]	Setpoint (according to drawing)
		(in the case of facing axis (X) and diameter programming, this is a diameter dimension)
_MA	1, 2, 3[1]	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
		(from meas. cycles SW 6.3)
_TENV	STRING[32]	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)
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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

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
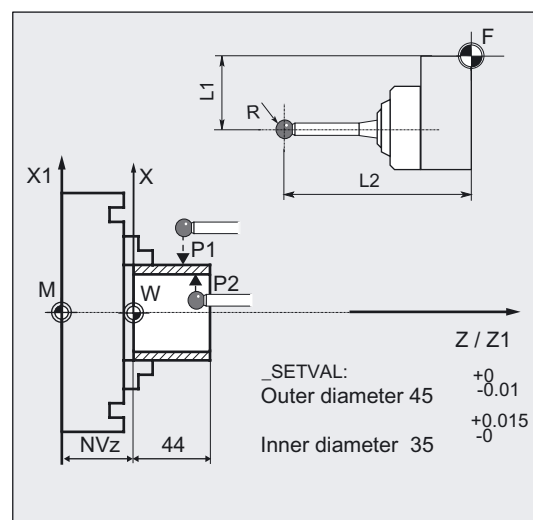
```
%_N_ONE_POINT_MEAS_MPF
N10 G54 G18 G90 T9 D1 DIAMON                    ;Call ZO, tool = probe
N20 G0 Z30 X90                                  ;Preposition probe
N25 _CHBIT[4]=1                                 ;With mean value calculation
N30 _TZL=0.002 _TMV=0.005 _TDIF=0.04 _TSA=0.5   ;Parameters 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.

Example: Outside measurement

Setpoint _SETVAL
in diameter measurement
in the case of facing axis (X) and
diameter programming

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
		(from meas. cycles SW 6.3)
_TENV	STRING[32]	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)
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 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

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
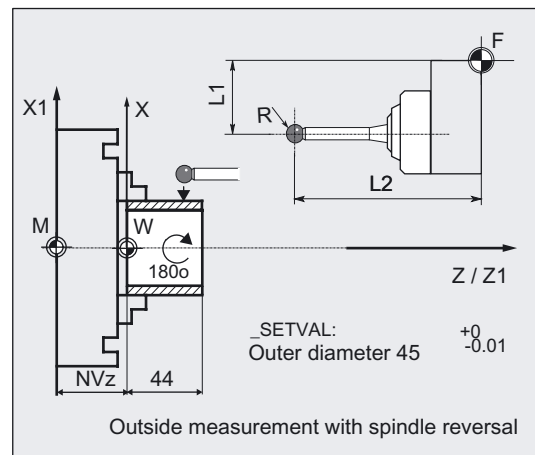
```
%_N_REVERSALMEAS_MPF
N10 G54 G90 G18 T9 D1 DIAMON                  ;Call ZO, tool = probe
N20 G0 Z30 X90                                ;Preposition probe
N30 _MVAR=1000 _SETVAL=45 _TUL=0 _TLL=-0.01   ;Parameters for cycle call
_MA=2 _STA1=0 _KNUM=1 _TNUM=7 _EVNUM=0
_TZL=0.002 _TDIF=0.4 _TSA=1 _PRNUM=1 _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.
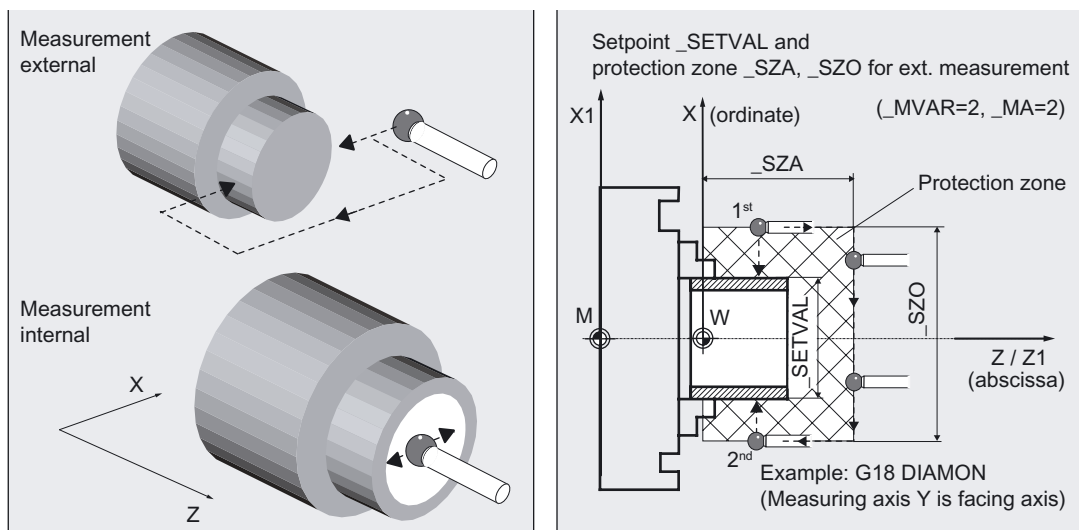
Two opposite measuring points in measuring axis _MA are approached symmetrically to the workpiece zero at the distance of the setpoint _SETVAL.

Order: 1st 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,**...**])

Example: G18 DIAMON
(Measuring axis Y is facing axis)

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**.

From measuring cycles SW 6.3, extended tool offset is available. 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

Parameter	Data type	Result
_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) from meas. cycles SW 6.3: For "tool offset" the offset value always appears in _OVR[20] as 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	REAL[2]	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, 3[1]	Measuring axis
_SZA	REAL	Protection zone at the workpiece in the abscissa[2] 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 ordinate[2] 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)

Parameter	Data type	Meaning
_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 (from measuring cycles SW 6.3)
_TENV	STRING[32]	Name of tool environment for automatic tool compensation (from measuring cycles SW 6.3)

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.
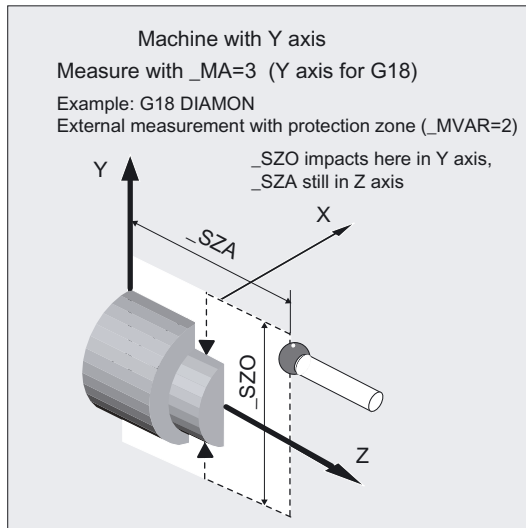
Additional parameters _VMS, _TZL, _TMV, _TUL _TLL, _TDIF, _TSA, _FA, _PRNUM, _EVNUM, _NMSP and _K also apply.

See also

Defining parameters (Page 65)

Result parameters (Page 67)

Variable measuring velocity: _VMS (Page 77)

Tolerance parameters: _TZL, _TMV, _TUL, _TLL, _TDIF and _TSA (Page 78)

Measurement path: _FA (Page 79)

Probe type, probe number: _PRNUM (Page 80)

Empirical value, mean value: _EVNUM (Page 81)

Multiple measurement at the same location: _NMSP (Page 82)

Weighting factor for mean value calculation: _K (Page 83)

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

External and internal measurement

_SETVAL:
Outer diameter 45 $\begin{smallmatrix}+0\\-0.01\end{smallmatrix}$

Inner diameter 35 $\begin{smallmatrix}+0.015\\-0.01\end{smallmatrix}$
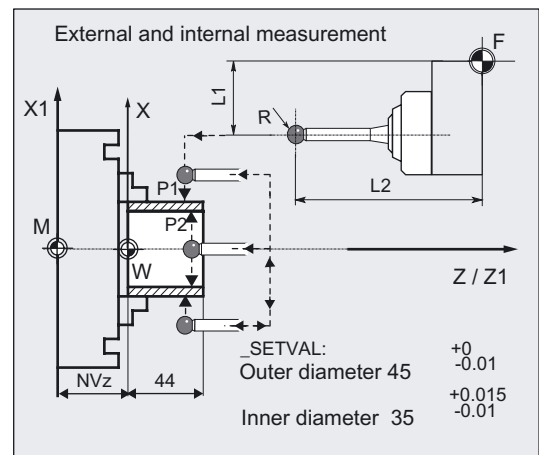
```
%_N_TWO_POINT_MEAS_MPF
N10 T1 D1 DIAMON                                 ;Call tool = probe (MT)
N20 G0 G54 Z30 X60                               ;ZO selection,
                                                 ;Position probe facing P1

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 (outside measurement)
_TDIF=0.04 _TSA=0.5 _VMS=0 _NMSP=1 _FA=1
_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.
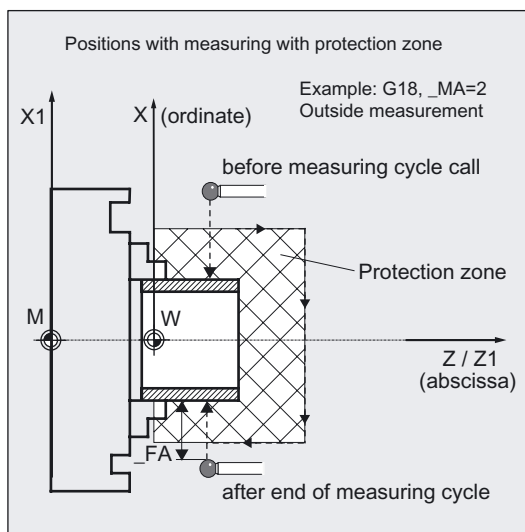
NOTICE
Precise measurement is only possible with a probe calibrated under the measurement conditions, i.e. working plane and measuring velocity are the same for both measurement and calibration.
If the probe is used in the spindle for a powered tool, the spindle orientation must also be considered. Deviations 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 inside
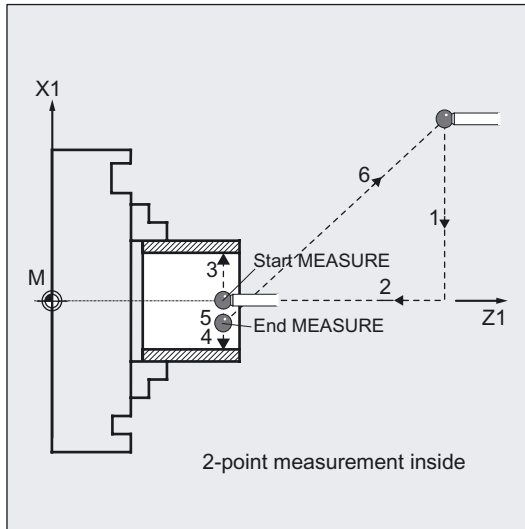
Procedure for inside measurement with _MVAR=2, _MA=2:

(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
```

Miscellaneous functions

<div style="text-align: right; font-size: 3em;">7</div>

7.1 Log measurement results

The measuring cycles support measuring cycle logging into a file on the control.

There are no special hardware requirements for logging measurement results. It is executed solely by the software.

7.1.1 Overview of the logging cycles

CYCLE100	Log ON
CYCLE101	Log OFF
CYCLE105	Generate log contents
CYCLE106	Log sequential controller
CYCLE113	Internal subroutine: Log
CYCLE118	Format real values

7.1.2 Log file

Function

The log file is stored in the directory where the calling program is located. You can specify the file name for the log file. The restrictions that apply to program names also apply here. Only letters, numbers and underscores are permitted, and the name must commence with two letters or a letter followed by an underscore. The file always has the extension "MPF".

The maximum length of the log file is limited in MD 11420: LEN_PROTOCOL_FILE. If the system detects during writing that a data record is too long, another log file is automatically created. Underscore and a digit are added to the name specified in _PROTNAME[1] and the following message is output: **"New log file has been created"**.

In this way, up to 9 subsequent logs can be stored in the control.

After the 10th log operation is halted and the following message is output: **"Please specify new log name"**.

After restart, operation is continued. If a log file with the same name already exists before logging is started, then it is deleted before writing is started.

7.1.3 Handling the log cycles

7.1.3.1 General information

Function

- The log is enabled and disabled via the program (CYCLE100/CYCLE101). This requires a cycle call without setting any parameters.

- After disabling the log function, the log files can be exported from the part program memory to diskette (HMI Advanced only) or via V.24.

Operational sequence

When used with the measuring cycles, it is sufficient to activate and deactivate the logging with CYCLE100 and CYCLE101 respectively. Logging is undertaken under the parameters described in Sections "Selection of log content", "Log format" and "Log header".

Logging is executed by CYCLE105, CYCLE106, CYCLE113, and CYCLE118. These cycles are called up in conjunction with measuring cycles.

The log cycles may be used independently of the measuring cycles. CYCLE100 and CYCLE101, and CYCLE105 and CYCLE106 are called explicitly in this context. CYCLE113 and CYCLE118 are called internally. You can also be called separately, if necessary.

See also

Selection of the log content (Page 394)

Log format (Page 396)

Log header (Page 397)

7.1.3.2 CYCLE100 Logging ON

After the log is enabled, an existing file with the specified name is automatically deleted in the control. All follow-up logs with _PROTNAME[1]_digit are only deleted when the preceding logs overflow. The log is reopened and the header is entered. The internal status variables are set.

7.1.3.3 CYCLE101 Logging OFF

Disables the logging function and resets the internal flag.

7.1.3.4 CYCLE105(PAR1) Creating log content

This cycle generates up to 4 lines of log contents (lines of values) according to the entries in the variables of the data block (GUD6). It allows you to generate only value lines or only the log header depending on the setting for PAR1.

Parameter	Data type	Value	Meaning
PAR1	INTEGER	0	Output block of values
		1	Output header

7.1.3.5 CYCLE106(PAR1) Logging sequence control

This cycle controls how logging is executed.

Parameter	Data type	Value	Meaning
PAR1	INTEGER	1	Output header
		2	Output block of values

The CYCLE106 cycle is called by CYCLE100 automatically when the log is activated. CYCLE106 deletes all old log files with the same name as required, creates follow-up log files and monitors the page layout of the log.

7.1.3.6 CYCLE113(PAR1,PAR2) Read system date and time

Parameter	Data type	Value	Meaning
PAR1	INTEGER	1	Read date and return in PAR2
		2	Read time and return in PAR2
PAR2	STRING[10]		Specify the length with the STRING type

7.1.3.7 CYCLE118(PAR1,PAR2,PAR3,PAR4,PAR5)

The CYCLE118 cycle formats real numbers (data type REAL) for a set number of decimal places.

It can be called to format just one number of to format several numbers.

Formatting one number:

- The input and output values are specified directly in the first 3 parameters passed on cycle call, i.e. the number to be formatted (PAR1), the number of digits (PAR2), and the name of a string variable for the formatted string that is returned.

- For the return value, up to 12 characters are provided, i.e. the return variable is of type STRING[12].

Formatting more than one number:

- Up to 10 numbers can be formatted; the actual number of numbers to be formatted is passed to the cycle in PAR4.
- The cycle takes the numbers from consecutive R parameters, e.g. R11 to R20.
- It is possible to start with any R parameter. It is passed to the cycle on calling (PAR5).
- The number of decimal places is specified in the same way as for formatting one number (PAR2).
- The return values are in the predefined variables **_TXT[0]** up to **_TXT[9]** (variable field data block GUD6).

Parameter

Parameter	Data type	Value	Meaning
PAR1	REAL		Number to be formatted
PAR2	INTEGER	≥0	Number of decimal places
PAR3	STRING[12]		Formatted return as STRING
PAR4	INTEGER	≥1	Number of numbers to be formatted
PAR5	INTEGER	≥0	Number of the first R parameter only relevant if PAR4>1

7.1.3.8 Programming example for formatting a single number

The value of **one** variable of type REAL is to be formatted for 2 decimal places and displayed:

```
DEF STRING[12] TEXTVAR
DEF REAL VAR1
VAR1=100/$PI                          ;$PI – circle constant
                                      ;PI = 3,1415927
CYCLE118(VAR1,2,TEXTVAR)
MSG("VAR1:"<<VAR1<<" TEXTVAR="<<TEXTVAR)
M0                                    ;Stop – view values:
                                      ;"TEXTVAR=31.83"

M30
```

7.1.3.9 Programming example for formatting three numbers

The intention is to format the values of R parameters **R11 to R13** for the decimal places in _DIGIT and display them.

_DIGIT is a variable in data block GUD6 for setting the decimal places in the measuring cycles. The value in the default setting is _DIGIT=3.

$PI circle constants PI = 3.1415927. The results in STRING format are supplied in _TXT[0] to _TXT[2]; the value for the last parameter (R13) also in TEXTVAR.

```
DEF STRING[12] TEXTVAR

R11=0.1/$PI R12=1/$PI R13=10/$PI

CYCLE118(0,_DIGIT,TEXTVAR,3,11)

MSG("_TXT[0]="<<_TXT[0]<<" _TXT[1]="_TXT[1]<<" _TXT[2]="<<TXT[2])

M0                                  ;Stop – view values:

                                    ;"_TXT[0]=0.032 _TXT[1]=0.318 _TXT[2]=3.183"

M30
```

7.1.4 Variables when logging

Function

With these parameters you can:

● select the content of the log.

● format the log.

● determine the content of the log header.

In the measuring cycle, data logging is controlled via the following data bit:

Variable	Value	Meaning
_CBIT[6]=	0	With measuring cycle name and measuring variant
	1	Without measuring cycle name and measuring variant
_CBIT[11]=	0	Standard log header
	1	User-defined log header

The following variables (data block GUD6) describe the contents of the measuring log:

Variable	Type	Default Value	Contents
_PROTNAME[2]	STRING[32]	Blank string	_PROTNAME[0] = Name of the main program from which the log is written
			_PROTNAME[1] = Name of the log file
_HEADLINE[10]	STRING[80]	Blank string	_HEADLINE[0] ... _HEADLINE[9] The user can enter customized texts in these STRINGs; they are included in the log
_PROTFORM[6]	INTEGER	60	_PROTFORM[0] = Number of lines per page
		80	_PROTFORM[1] = Number of characters per line
		1	_PROTFORM[2] = First page number
		3	_PROTFORM[3] = Number of customized header lines
		1	_PROTFORM[4] = Number of value lines in the log
		12	_PROTFORM[5] = Number of characters per column
_PROTSYM[2]	CHAR	";"	_PROTSYM[0] = Separators between the values in the log
		"#"	_PROTSYM[1] = Special characters for identification when tolerance limits are exceeded
_PROTVAL[13]	STRING[80]		_PROTVAL[0] = Contents of the header line (line 9)
			_PROTVAL[1] = Contents of the header line (line 10)
			_PROTVAL[2]...[5] = Specification of the values to be logged in successive lines
_TXT[100]	STRING[12]		Field for formatted STRINGs

7.1.5   Selection of the log content

Function

The measurement result log contains parts that are fixed and some that can be set. It always contains:

- Measuring cycle (cycle name)
- Measuring variant (value of _MVAR)

Output of the measuring cycle and measuring variant can be suppressed by setting _CBIT[6].

The following additional data can be included in a log:

- Time (specification _TIME)
- Axis name of associated measuring axes
  - Specification _AXIS:

    The axis name is entered automatically according to the measuring axis entered in _MA.
  - or specification _AXIS1... 3:

    _AXIS1: Axis name of abscissa in the selected plane

    _AXIS2: Axis name of ordinate in the selected plane

    _AXIS3: Axis name of applicate in the selected plane
- All result data provided by the measuring cycle in the _OVR[ ].
- R parameters
- Comment texts and
- STRINGs stored in _TXT[ ] (GUD6)

The logging values to be selected must correspond to the measuring cycle and the selected measuring variant. This makes for versatile adaptation of the contents of the log to meet your requirements.

Specification of the log contents is conducted via the variable _PROTVAL[ ]. The strings stored in _PROTVAL[0], _PROTVAL[1] are used as header lines for the log (see Section "Example: Creating a measurement result log", line 8-10).

_PROTVAL[2]...[5] specify the line contents of the individual log lines. If you change the measuring cycle or the measuring variant, you may have to adapt _PROTVAL[2]...[5] (see Section "Example: Creating a measurement result log").

The comma is used as the separator between variables.

Note

If only one header line is needed, _PROTVAL[1] (second header line) should be described using a string of blanks. If this requirement is not observed, the content of an earlier log may be displayed in the second header line.

Example:

_PROTVAL[2]="R27,_OVR[0],_OVR[4],_OVR[8],_OVR[12],_OVR[16],_TIME"
_PROTVAL[3]="_AXIS,_OVR[1],_OVR[5],_OVR[9],_OVR[13],_OVR[17], INCH"
_PROTVAL[4]="_AXIS,_OVR[2],_OVR[6],_OVR[10],_OVR[14],_OVR[18], Metr"

R27 is just an example of an R parameter. The texts "INCH" and "Metro" at the end of the second and third line are examples for comment texts. This makes it easy, for example, to append dimensions after the measurement results.

7.1.6 Log format

Programming

The following values can be specified for the log format:

Variable	Data type	Meaning
_PROTFORM[0]	INTEGER	Number of characters per page including log header
_PROTFORM[1]	INTEGER	Number of characters per line
_PROTFORM[2]	INTEGER	First page number
_PROTFORM[3]	INTEGER	Number of customized log header lines
_PROTFORM[4]	INTEGER	Number of value lines in the log
_PROTFORM[5]	INTEGER	Column width/variable column width
_PROTSYM[0]	CHAR	Separators between the values in the log
_PROTSYM[1]	CHAR	Special characters for identification when tolerance limits are exceeded
_DIGIT	INTEGER	Number of decimal places

Explanation

The value set in parameter _PROTFORM[0] determines when a log header with title lines is output again. If this parameter is set to zero, the log only contains a header at the beginning.

The value of parameter _PROTFORM[5] determines the column width of the log. If the parameter=0, the column width of each column is derived from the string lengths (number of characters between the commas) of the 1st header line (_PROTVAL[0]). This makes it possible to individually define the width of each column. If the value >0, each column is formatted to this value if the string length allows it. Logging of variables always has priority, i.e. when specified format limits are exceeded they are modified and an alarm without terminating execution is generated.

The _PROTSYM[1] parameter can be used to define the special characters used to identify when tolerance limits are exceeded (_TSA,_TDIF,_TUL,_TLL) in the log.

Identification takes the form of the addition of the special character to the relevant actual value and associated measurement difference if these values are logged.

The number of decimal places can be set via the variable _DIGIT in GUD6 data block (display precision).

7.1.7 Log header

Function

The log header can be customized by the operator or a log header prepared by the standard measuring cycles can be used.

The selection is made via measuring cycle data bit `_CBIT[11]`.

`_CBIT[11]=0`: Default log header

`_CBIT[11]=1`: User-defined log header

The contents of the header are stored in an array of string variables `_HEADLINE[10]`, which are automatically output when logging (CYCLE100) is enabled. The maximum number of header lines can be changed during measuring cycle start-up (`_PROTFORM[3]`).

Each field element contains a line for the log header.

User-defined log header

The content of the string array `_HEADLINE[ ]` is entered in line 1 ff. The number of header lines can be defined by the user (according to the length of the `_HEADLINE`).

Default log header

The default log header contains fixed and variable components.

All variable components are in bold formatting, that is:

Line 1 page number,

Line 3 program name,

Line 5, 6, 7 (`_HEADLINE[0-2]`) ff. and

Line 9 (`_PROTVAL[0]`)

Line 10 (`_PROTVAL[1]`)

Line 1 is fixed and predefined.

```
Line 1    Date:     98/09/15                    Time:      10:05:30                  Page: 1
Line 2
Line 3    Program: MEASPROGRAM_1
Line 4
Line 5    Part number: 123456789
Line 6    Job number: 6878
Line 7    Supervisor: Müller Phone: 1234
Line 8    ---------------------------------------------------------------------------
          ---------------
Line 9    Meas.     , Axis     , Set      ,          ,            , Time
                                           Actual   Differen
                                           value    ce
Line 10   point               value
Line 11   ---------------------------------------------------------------------------
          --------------
```

When filling in the standard log header shown above the following program lines must be inserted in the main program before the measuring cycle is called:

```
DEF INT PARTNUM, JOBNUM
_CBIT[11]=0                                    ;Log with default header
PARTNUM=123456789 JOBNUM=6878 _LOGNAME[0]="MEASPROGRAM_1"
_PROTNAME[1] ="MY_LOG1"
_HEADLINE[0]="Part number: "<<PARTNUM
_HEADLINE[1]="Job number:"<<JOBNUM
_HEADLINE[2]="Supervisor: Müller Phone: 1234"
_PROTVAL[0]="Meas. , Axis , Set , Act. value, Difference , Time"
_PROTVAL[1]="point , , value
```

7.1.8 Example: Creating a measurement result log

Log view

%N_LOG_1_MPF

```
Line 1   Date:        98/11/15                    Time:       10:05:30       Page: 1
Line 2
Line 3   Program: MEASPROGRAM_1
Line 4
Line 5   Part number: 123456789
Line 6   Job number: 6878
Line 7   Supervisor: Müller Phone: 1234
Line 8   -----------------------------------------------------------------------------
         ---------------
Line 9   Meas.         , Axis     , Set      ,          ,           , Time
                                              Actual    Differenc
                                              value     e
Line 10  point                     value
Line 11  -----------------------------------------------------------------------------
         --------------
Line 12  CYCLE978      , _MVAR    , 100
Line 13  1             , Z        ,          ,          , -0.013   ,
                                              80.000    79.987                 09:35:12
Line 14
Line 15
Line 16  CYCLE977      , _MVAR    , 102
Line 17  2             , X        ,          ,          , 0.009    ,
                                              64.000    64.009                 09:36:45
Line 18                , Y        ,          ,          , -0.002
                                              38.000    37.998
```

Programming

The log with the default log header shown above is created using the following program. The example shows the user how to handle the log.

```
%_N_MEASPROGRAM_1_MPF
;$PATH=/_N_MPF_DIR
;Measure shaft with measuring log
DEF INT PARTNUM, JOBNUM, MP_COUNTER
; ---------- Set parameters for log ----------------
_CBIT[11]=0                                  ;Log with default header
; ----------------------- Log header ----
-------------------

PARTNUM=123456789 JOBNUM=6878                ;Name of calling program
_LOGNAME[0]="MEASPROGRAM_1"
_PROTNAME[1]="LOG_1"                         ;Name of log file
_HEADLINE[0]="Part number: "<<PARTNUM
_HEADLINE[1]="Job number:"<<JOBNUM
_HEADLINE[2]="Supervisor: Müller Phone: 1234"
; --------------------- Log format -------- Formats: Default values from GUD6
-------------
_PROTSYM[0]="," _PROTSYM[1]="*"             ;Define separators and special
                                            ;characters
_PROTFORM[0]=60                             ;60 lines per page
_PROTFORM[1]=80                             ;80 characters per line
_PROTFORM[2]=1                              ;Start of page 1
_PROTFORM[3]=3                              ;Three customized
                                            ;log header lines
_PROTFORM[4]=1                              ;One value line
_PROTFORM[5]=12                             ;12 characters per line
; --------------------- Log contents ------
----------------
; Header lines
_PROTVAL[0]="Meas. , Axis , Set , Act. value, Difference , Time"
_PROTVAL[1]="point , , value"
; --------------- Other value assignments -
----------------
MP_COUNTER=1 _TXT[0]=<<MP_COUNTER           ;Assign counter for measurement log
; -------- Perform measurements with log ---
----------
N100 G0 G17 G90 T3 D1 Z100 F1000            ;Approach start position for
                                            ;measurement
N110 X70 Y90
;
```

```
_MVAR=100 _SETVAL=80 _MA=3 _TSA=2 _FA=2        ;Set measuring cycle parameters
...                                            ;Measuring variant: Measure surface
                                               ;with zero offset
; Contents of the value lines
_PROTVAL[2]="_TXT[0],_AXIS,_OVR[0],_OVR[4],_OVR[16],_TIME"
N150 CYCLE100                                  ;Activate log
N160 CYCLE978                                  ;Measure surface
N170 Z200                                      ;Retraction in Z
N180 X64 Y38                                   ;Position above shaft center
N185 Z130                                      ;Lower in Z
;
_MVAR=102 _SETVAL=70 _FA=2 _TSA=2 _ID=-20      ;Set measuring cycle parameters
...                                            ;Measuring variant: Measure shaft with
                                               ;ZO compensation
_PROTFORM[4]=2                                 ;two value lines
_PROTVAL[2]="_TXT[0],_AXIS1,_OVR[1],_OVR[5],_OVR[17],_TIME"
_PROTVAL[3]=" ,_AXIS2,_OVR[2],_OVR[6],_OVR[18]"
MP_COUNTER=MP_COUNTER+1 _TXT[0]=<<MP_COUNTER   ;Increase user-def. counter for
                                               ;measurements
N190 CYCLE977                                  ;Measure shaft
N210 CYCLE101                                  ;Deactivate log
N220 Z200                                      ;Retraction in Z
N290 M2
```

7.2 Measuring cycle support in the program editor (up to measuring cycles SW 5.4)

Function

In SW 4.3 and higher, cycle support for measuring cycles in the ASCII editor is provided as for the standard cycles.

With this support function, the parameters described as mandatory parameters are input for each measuring cycle. For the additional parameters the last values input are retained. Furthermore, it is possible to change the additional parameters.

The measuring cycles are selected in the editor by using the vertical softkeys. The softkey menu is divided up according to measuring tasks, e.g. "Calibration" and then "Calibration in hole" or "Tool probe". This results in a one-to-one assignment between softkeys and measuring cycles.

As of SW 5 of MMC100/100.2, MMC102/103 and HMI Advanced/Embedded, measuring cycle support is reached using the softkeys

| > | → | Support | → | New cycle | → | Measuring cycles |
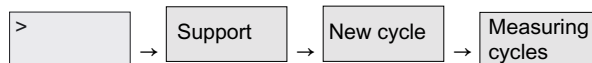
from the extended menu of the editor.

In the edited program there are calls with parameter list, e.g.

- CYCLE_PARA(...) for the provision of additional parameters
- CYCLE_976(...) for calibrating in hole,
- CYCLE_CAL_TOOLSETTER(...) for calibrating the tool probe.

7.2.1 Measuring cycle support files

Function

Measuring cycle support requires the following files:

- cov.com

    Configuring the softkeys for cycle selection

- sc.com

    Configuring the input screens for the individual parameters

- Auxiliary cycle*.spf

    Additional cycles with parameter list that transfer the input parameters to the data blocks (GUD) of the measuring cycles and call the measuring cycles.

These files are combined in the following two archives on the measuring cycle diskette:

- MCSUPP_1.COM
- MCSUPP_2.COM

7.2.2 Load the measuring cycle support

Function

The files mcsupp_1.com and mcsupp_2.com are loaded from diskette or via RS-232-C with "Data in" into the "Services" menu.

With the MMC 102/103 the auxiliary cycle programs (see list Subsection "Assigning calls and measuring cycles") must be transferred to the NCU with "Load".

The Power ON is executed.

7.2.3 Assigning calls and measuring cycles

Function

The following table provides an overview of:

- Measurement task
- Measuring cycle
- Start

Measuring task, function	Measuring cycle	Call in the program
Auxiliary parameters	-	CYCLE_PARA(...)
Calibrating tool probes	CYCLE971, CYCLE972, CYCLE982	CYCLE_CAL_TOOLSETTER(...)
Calibrate workpiece probe on surface	CYCLE973, CYCLE976	CYCLE_CAL_PROBE(...)
Calibrate workpiece probe in reference groove	CYCLE973	CYCLE_973(...)
Calibrate workpiece probe in hole	CYCLE976	CYCLE_976(...)
Measure milling tool on milling machines	CYCLE971	CYCLE_971(...)
Measure turning tool	CYCLE972	CYCLE_972(...)
Measure hole/shaft parallel to axis/at an angle	CYCLE977, CYCLE979	CYCLE_977_979A(...)
Measure groove/web parallel to axis/at an angle	CYCLE977, CYCLE979	CYCLE_977_979B(...)
Measure rectangle inside/outside parallel to axis	CYCLE977	CYCLE_977_979C(...)
Single-point measurement milling machine	CYCLE978	CYCLE_978(...)
Angle measurement	CYCLE998	CYCLE_998(...)
Measure corner, specifying angles	CYCLE961	CYCLE_961_W
Measure corner, specifying points	CYCLE961	CYCLE_961_P
Single-point measurement turning	CYCLE974	CYCLE_974(...)
Two-point measurement	CYCLE994	CYCLE_994(...)

7.2.4 Description of the parameterizing cycles

7.2.4.1 General information

The individual parameterization cycles of the measuring cycles together with their input parameters are described below.

The parameter names in the table directly refer to the defining parameters of the measuring cycle in question in the GUD variables. If no parameter is given, it is a selection field in the input screen form for particular functions.

7.2.4.2 Setting additional parameters - CYCLE_PARA

With CYCLE_PARA, you can program all generally valid parameters of the measuring cycles. These parameters do not depend on the individual measuring variant. If an entered parameter has the value 0, the target parameter is not overwritten, i.e. its previous value is retained.

Parameter

Parameter	Type	Value	Meaning
_FA	REAL	>0	Measurement path in mm
_VMS	REAL	≥0	Variable measuring speed
_NMSP	INTEGER	>0	Number of measurements at the same location
_RF	REAL	>0	CYCLE979 only: Feedrate in circular-path programming
_PRNUM	INTEGER	>0	Probe number
_CORA	REAL		Only if mono probe is used: Offset angle position
_TZL	REAL	≥0	Tolerance range for zero offset
_TMV	REAL	≥0	Select range for offset with mean value calculation, greater than _TZL
_TUL	REAL		Upper tolerance range workpiece, oversize acc. to drawing
_TLL	REAL		Lower tolerance range workpiece, undersize acc. to drawing
_TSA	REAL	>0	Safe area for measuring result
_EVNUM	INTEGER	≥0	Number of empirical value memory that is calculated
_K	INTEGER	≥1	Weighting factor for mean value calculation
_TDIF	REAL	>0	Tolerance range for dimensional difference check

7.2.4.3 Calibrate tool probe - CYCLE_CAL_TOOLSETTER

With CYCLE_CAL_TOOLSETTER

Softkeys [Measurem. milling] → [Calibrate TL probe] (CYCLE971)

or

Softkeys [Measurem. turning] → [Calibrate TL probe] (CYCLE972)

measuring cycles CYCLE971 and CYCLE972 can be parameterized to calibrate a tool measuring probe.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Cycle number
			971...for CYCLE971 (milling machine), 972...for CYCLE972 (turning machine)
_MA	INTEGER	>0	Number of measuring axis and for CYCLE972 also the offset axis
_PRNUM	INTEGER	>0	Probe number
	INTEGER		For CYCLE971 only Selection: Measuring variant 0...absolute calibration/1...incremental calibration
_FA	REAL	>0	Measurement path

7.2.4.4 Calibration on surface - CYCLE_CAL_PROBE

With CYCLE_CAL_PROBE

Softkeys [Measurem. turning] → [Probe calibrat.] → [Plane]

or

softkeys [Measurem. milling] → [Probe calibrat.] → [Plane]

measuring cycles CYCLE973 and CYCLE976 can be parameterized to calibrate a surface.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Cycle number 976...for CYCLE976 (milling machine), 973...for CYCLE973 (turning machine)
_SETVAL	REAL		Calibration setpoint with respect to workpiece zero
_MA	INTEGER	1...3	Number of the measuring axis
_MD	INTEGER	0, 1	Measuring direction
_PRNUM	INTEGER	>0	Probe number
_MVAR	INTEGER	≥0	Selection: Measuring variant (for CYCLE976 only) 0: Calibration on any surface 10000: Calibrating in the 3rd axis with calculation of probe length

7.2.4.5 Calibration in groove - CYCLE_973

With CYCLE_973

Softkeys | Measurem. turning | → | Probe calibrat. |

CYCLE973 can be parameterized to calibrate a reference groove.

Parameter

Parameter	Type	Value	Meaning
_SETVAL	REAL		Setpoint
	INTEGER		Selection: Positional deviation 0…without / 1...with specification of positional deviation
	INTEGER		Selection: Number of axes Number of axes to be calibrated, 1, 2
	INTEGER		Selection: Ball calculation 0…without / 1...with calculation of probe ball diameter
_MA	INTEGER	>0	Number of measuring axis 1, 2
_MD	INTEGER	≥0	Determines measuring direction 0…in positive direction / 1...in negative direction
_CALNUM	INTEGER	≥0	Selection of calibration groove with number
_PRNUM	INTEGER	>0	Probe number

7.2.4.6 Calibration in hole - CYCLE_976

With CYCLE_976

Softkeys | Measurem. milling | → | Probe calibrat. |

CYCLE976 can be parameterized to calibrate a hole.

Parameter

Parameter	Type	Value	Meaning
_SETVAL	REAL		Setpoint
	INTEGER		Selection: Angular position
			0...paraxial calibration/1...calibration at an angle
	INTEGER		Selection: Positional deviation
			0…without / 1...with specification of positional deviation
	INTEGER		Selection: Number of axes
			Number of axes to be calibrated, 1, 2 or 4
	INTEGER		Selection: Ball calculation
			0…without / 1...with calculation of probe ball diameter
_MA	INTEGER	>0	Number of measuring axis 1, 2
_MD	INTEGER	≥0	Determines measuring direction
			0…in positive direction / 1…in negative direction
_STA1	REAL		Angle (for calibration at an angle only)
_PRNUM	INTEGER	>0	Probe number
			Selection: Hole type
			0…hole center known / 1...unknown

7.2.4.7   Measuring milling tools - CYCLE_971

With CYCLE_971

Softkeys [Measurem. milling] → [Measurem. tool]
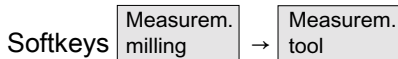
CYCLE971 can be parameterized for tool measurement.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	>0	Measuring variant
_MA	INTEGER	>0	Number of the measuring axis
_ID	REAL	>0	Offset
_PRNUM	INTEGER	>0	Probe number
_MFS[0]	REAL	>0	Feed 1st probing (only with _CBIT[12]=1)
_MFS[1]	REAL	>0	Speed 1st probing (only with _CBIT[12]=1)
_MFS[2]	REAL	≥0	Feed 2nd probing (only with _CBIT[12]=1)
_MFS[3]	REAL	≥0	Speed 2nd probing (only with _CBIT[12]=1)
_MFS[4]	REAL	≥0	Feed 3rd probing (only with _CBIT[12]=1)
_MFS[5]	REAL	≥0	Speed 3rd probing (only with _CBIT[12]=1)

7.2.4.8 Measuring turning tools - CYCLE_972

CYCLE_972 can be used to parameterize CYCLE972 to gauge tools.

Parameter

Parameter	Type	Value	Meaning
_MA	INTEGER	>0	Number of the measuring axis
_PRNUM	INTEGER	>0	Probe number

7.2.4.9 Hole, measure shaft – CYCLE_977_979A

With CYCLE_977_979A

Softkeys `Measurem. milling` → `Workpiece measure` → `Hole shaft`
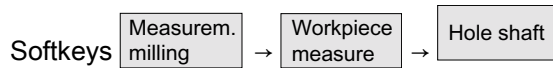
measuring variants xxx1 and xxx2 of measuring cycles CYCLE977 and CYCLE979 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Angular position 977…paraxial measurement / 979...measurement at an angle
_MVAR	INTEGER	>0	Measuring variant
_SETVAL	REAL		Setpoint
_ID	REAL		Infeed path
_SZA	REAL		Safety zone (for paraxial measurement only)
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	≥0	Offset number D number for measurement/ZO number for calculating zero offset
_CPA	REAL		Center point hole, shaft 1st axis
_CPO	REAL		Center point hole, shaft 2nd axis
_STA1	REAL		Start angle
_INCA	REAL		Incrementing angle
_PRNUM	INTEGER	>0	Probe number Only CYCLE979: the number of measuring points is provided using the thousands digit; 0...3 measuring points, 1...4 measuring points

7.2.4.10 Groove, measure web – CYCLE_977_979B

With CYCLE_977_979B

Softkeys | Measurem. milling | → | Workpiece measure | → | Slot or web |
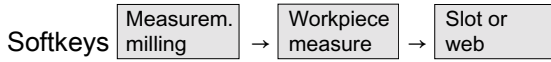
measuring variants xxx3 and xxx4 of measuring cycles CYCLE977 and CYCLE979 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Angular position
			977…paraxial measurement / 979...measurement at an angle
_MVAR	INTEGER	>0	Measuring variant
_SETVAL	REAL		Setpoint
_ID	REAL		Infeed path
_MA	INTEGER	>0	Number of measuring axis 1, 2
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	≥0	Offset number
			D number for measurement/ZO number for calculating zero offset
_CPA	REAL		Center groove, web 1st axis
_CPO	REAL		Center groove, web 2nd axis
_STA1	REAL		Start angle
_SZA	REAL		Safe area (for paraxial measurement only)
_PRNUM	INTEGER	>0	Probe number

7.2.4.11 Measure rectangle - CYCLE_977_979C

With CYCLE_977_979C

Softkeys | Measurem. milling | → | Workpiece measure | → | >> | → | Rectangle |
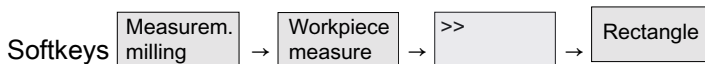
measuring variants xxx5 and xxx6 of measuring cycle CYCLE977 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	>0	Measuring variant
_SETV[0]	REAL		Setpoint length
_SETV[1]	REAL		Setpoint width
_ID	REAL		Infeed path
_SZA	REAL		Protection zone length
_SZO	REAL		Protection zone width

Parameter	Type	Value	Meaning
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	≥0	Offset number
			D number for measurement/ZO number for calculating zero offset

7.2.4.12 Single-point measurement - CYCLE_978

With CYCLE_978

Softkeys [Measurem. milling] → [Workpiece measure] → [Plane]
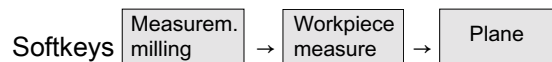
CYCLE978 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	≥0	Measuring variant
_SETVAL	REAL		Setpoint
_MA	INTEGER	>0	Measuring axis 1, 2, 3
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	≥0	Offset number
			D number for measurement/ZO number for calculating zero offset

7.2.4.13 Angle measurement - CYCLE_998

With CYCLE_998

Softkeys [Measurem. milling] → [Workpiece measure] → [Angle]
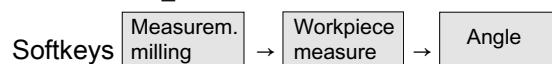
CYCLE998 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	>0	Measuring variant
_SETVAL	REAL		Setpoint
_ID	REAL		Distance
_RA	INTEGER	≥0	Number of rotary axis
_MA	INTEGER	>0	Number of measuring axis and offset axis 102...302
_KNUM	INTEGER	≥0	ZO number
_STA1	REAL		Angle
_PRNUM	INTEGER	>0	Probe number

7.2.4.14 Corner measurement with specification of angles - CYCLE_961_W

With CYCLE_961_W

Softkeys | Measurem. milling | → | Workpiece measure | → | Corner |
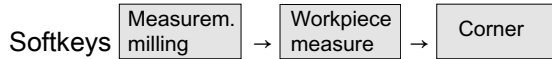
measuring variants 105 to 108 for CYCLE961 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Outside or inside corner
			0…inside corner / 1...outside corner
	INTEGER		Selection: Number of measuring points, 3 or 4
_SETV[0]	REAL	>0	Distance between starting point and measuring point 2, without sign
_SETV[1]	REAL	>0	Distance between starting point and measuring point 4, without sign
_ID	REAL	>0	Retraction path in 3rd axis (applicate), for outside corner only, without prefix
_STA1	REAL		Enter approx. angle between 1st axis (abscissa) and 1st edge, clockwise with negative prefix
_INCA	REAL	<>0	Enter angle from 1st edge to 2nd edge of the workpiece, clockwise with negative prefix
_KNUM	INTEGER	≥0	ZO number
_SETV[4]	REAL		**For 3 measuring points only:**
			Selection: Offset
			1 measured corner entered as zero point
			2 measured corner is offset in 1st axis by the value from _SETV[2] and entered as zero point
			3 measured corner is offset in both axes and entered as zero point
			4 measured corner is offset in 2nd axis by the value from _SETV[3] and entered as zero point
_SETV[2]	REAL		**For 3 measuring points only:**
			Offset of coordinate origin in 1st axis (abscissa)
_SETV[3]	REAL		**For 3 measuring points only:**
			Offset of coordinate origin in 2nd axis (ordinate)
_PRNUM	INTEGER	>0	Probe number

7.2.4.15 Corner measurement with specification of points - CYCLE_961_P

With CYCLE_961_P

Softkeys | Measurem. milling | → | Workpiece measure | → | Corner |

measuring variants 117 to 118 for CYCLE961 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
	INTEGER		Selection: Outside or inside corner 0…inside corner / 1...outside corner
_ID	REAL	>0	Infeed path of measuring probe to measuring height, without sign
_SETV[0]	REAL		Starting position for measuring the 1st point in the 1st axis (abscissa)
_SETV[1]	REAL		Starting position for measuring the 1st point in the 2nd axis (ordinate)
_SETV[2]	REAL		Starting position for measuring the 2nd point in the 1st axis (abscissa)
_SETV[3]	REAL		Starting position for measuring the 2nd point in the 2nd axis (ordinate)
_SETV[4]	REAL		Starting position for measuring the 3rd point in the 1st axis (abscissa)
_SETV[5]	REAL		Starting position for measuring the 3rd point in the 2nd axis (ordinate)
_SETV[6]	REAL		Starting position for measuring the 4th point in the 1st axis (abscissa)
_SETV[7]	REAL		Starting position for measuring the 4th point in the 2nd axis (ordinate)
_KNUM	INTEGER	≥0	ZO number
_PRNUM	INTEGER	>0	Probe number

7.2.4.16 Single-point measurement - CYCLE_974

With CYCLE_974

Softkeys | Measurem. turning | → | Workpiece measure | → | 1- point measurem. |

CYCLE974 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	≥0	Measuring variant
_SETVAL	REAL		Setpoint
_MA	INTEGER	>0	Number of measuring axis 1, 2, 3
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	>0	Offset number D number for measurement/ZO number for calculating zero offset
_PRNUM	INTEGER	>0	Probe number
_STA1	REAL		Start angle

7.2.4.17   Two-point measurement - CYCLE_994

With CYCLE_994

Softkeys [Measurem. turning] → [Workpiece measure] → [Two point measurem.]
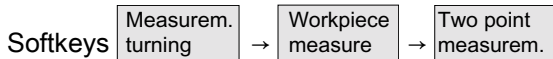
CYCLE994 can be parameterized.

Parameter

Parameter	Type	Value	Meaning
_MVAR	INTEGER	1, 2	Measuring variant
_SETVAL	REAL		Setpoint
_MA	INTEGER	>0	Number of measuring axis 1, 2, 3
_TNUM	INTEGER	≥0	Tool number for automatic offset
_TNAME	STRING		Tool name with active tool management
_KNUM	INTEGER	≥0	Offset number D number for measurement/ZO number for calculating zero offset
_SZA	REAL		Protection zone on workpiece, 1st axis (abscissa)
_SZO	REAL		Protection zone on workpiece, 2nd axis (ordinate)
_PRNUM	INTEGER	>0	Probe number

7.3 Measuring cycle support in the program editor (from measuring cycles SW 6.2)

From measuring cycles SW 6.2, the program editor provides extended measuring cycle support for inserting measuring cycle calls into the program.

Prerequisite

HMI Advanced/Embedded as from SW 6.2 required.

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.

7.3.1 Menus, explanation of the cycles

7.3.1.1 General information

Explanation

The input screens for the measuring cycles are selected depending on the technology being used via horizontal softkeys.
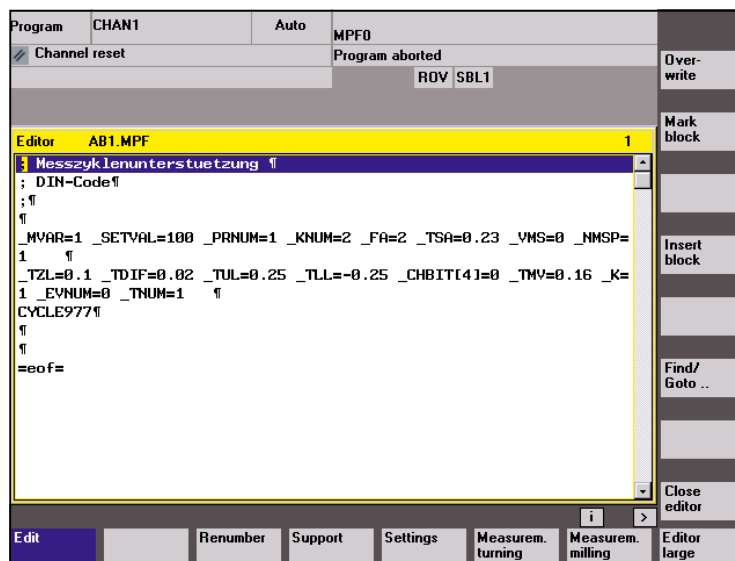
| Measurem. turning | Input screen forms for measuring cycles for turning technology. |

| Measurem. milling | Input screen forms for measuring cycles for milling technology. |

7.3.1.2   Softkey bars for turning

Vertical softkey menu for turning technology
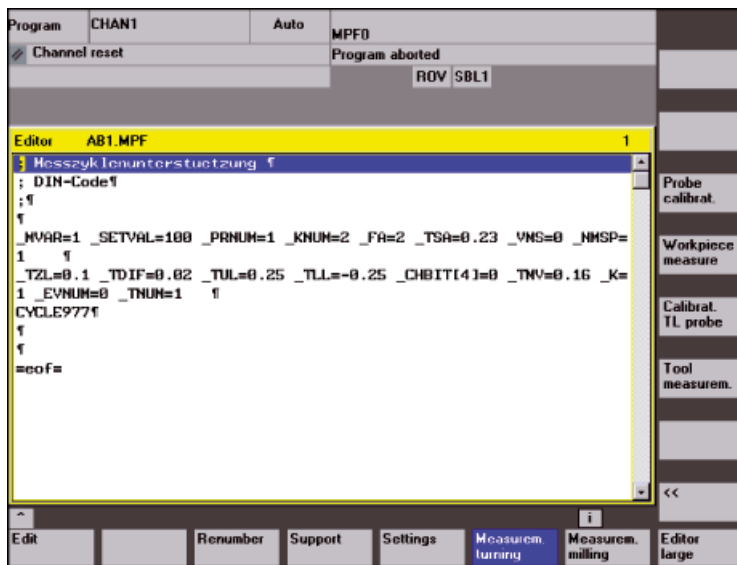
| Probe calibrat. | Call screen form for CYCLE973 Calibrate workpiece probe for turning machines. |

| Workpiece measure | Call new vertical softkey menu for "measure workpiece". |

| Calibrate TL probe | Call screen form for CYCLE982 Calibrate tool probe for turning machines. |

| Measurem. tool | Call screen form for CYCLE982 Gauge turning and milling tools for turning machines |

| << | Back |

Vertical softkey menu for measure workpiece, turning
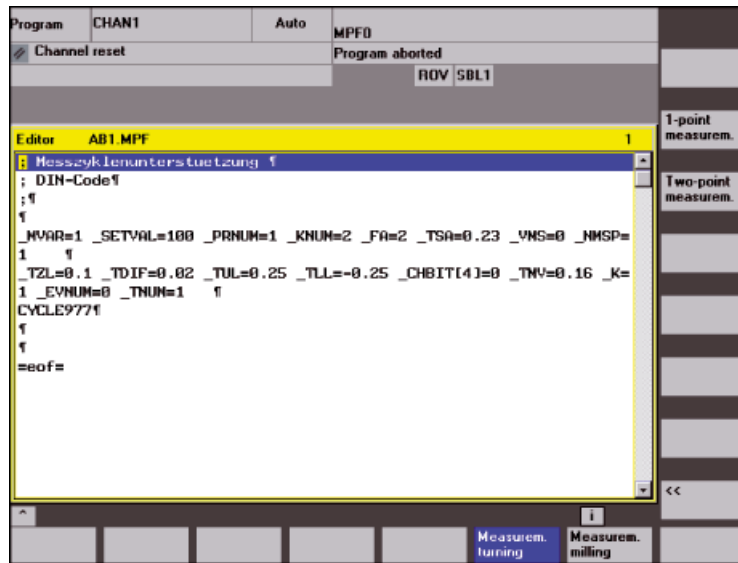
| 1- point measurem. | Call screen form Workpiece measurement for turning machines CYCLE974 1 point measurement. |

| Two point measurem. | Call screen form Workpiece measurement for turning machines CYCLE994 2-point measurement. |

| << | Back to selection menu turning. |

7.3.1.3   Softkey bars for milling

Vertical softkey menu for milling technology
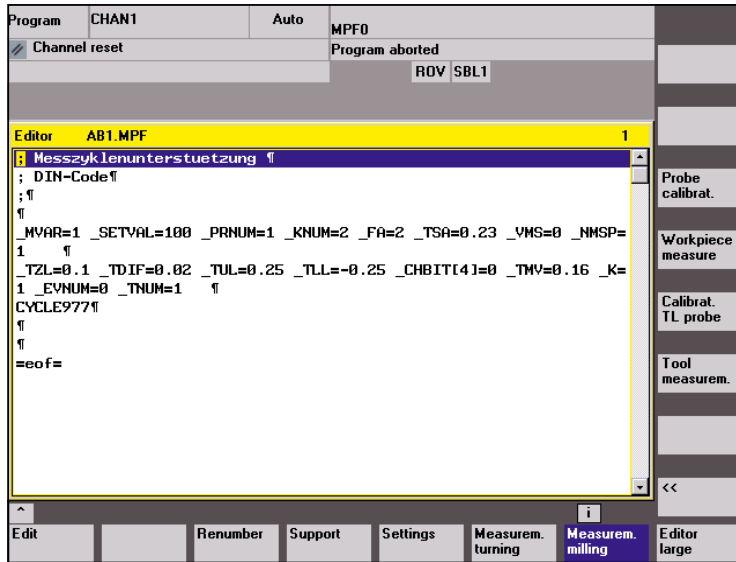
Probe calibrat.	Call screen form for CYCLE976 Calibrate workpiece probe for milling machines.
Workpiece measure	Call new vertical softkey menu for selection "measure workpiece".
Calibrate TL probe	Call screen form for CYCLE971 Calibrate tool probe for milling machines.
Measurem. tool	Call screen form for CYCLE971 Gauge milling tools on milling machines.
<<	Back

Vertical softkey menu for workpiece measuring, milling
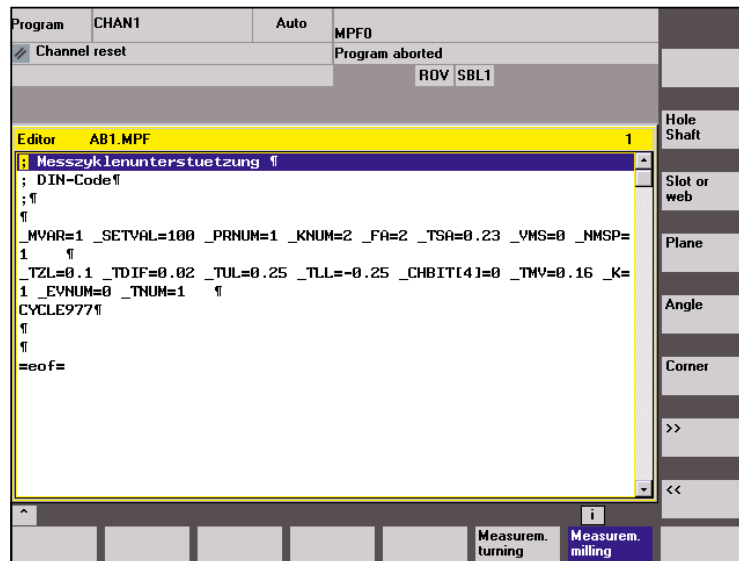
Hole shaft	Call screen form for workpiece measurement for milling machines CYCLE977/CYCLE979 hole/shaft.
	Hole/shaft and paraxial/at an angle switchover are performed in the screen form.

Slot or 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.

Plane	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

Program	CHAN1		Auto	MPF0	

```
Program    CHAN1              Auto    MPF0
// Channel reset                    Program aborted
                                          ROV SBL1

                                                              Hole
                                                              Shaft
Editor     AB1.MPF                                    1
; Messzyklenunterstuetzung ¶                          ▲       Slot or
; DIN-Code¶                                                   web
;¶
¶                                                            Plane
_MVAR=1 _SETVAL=100 _PRNUM=1 _KNUM=2 _FA=2 _TSA=0.23 _VMS=0 _NMSP=
1       ¶
_TZL=0.1 _TDIF=0.02 _TUL=0.25 _TLL=-0.25 _CHBIT[4]=0 _TMV=0.16 _K=   Angle
1 _EVNUM=0 _TNUM=1    ¶
CYCLE977¶
¶                                                            Corner
¶
=eof=
                                                             >>

                                                     ▼       <<
  ▲                                     i
                            Measurem.  Measurem.
                            turning     milling
```
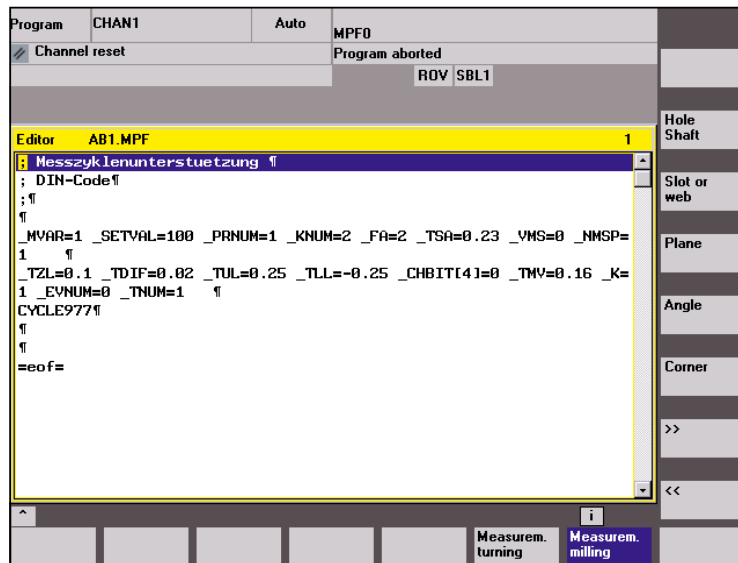
Rectangle Call screen form for workpiece measurement for milling machines CYCLE977 rectangle internal/external.

Sphere Call screen form for workpiece measurement for milling machines CYCLE997 measure ball and ZO determination (from measuring cycles SW 6.3).

<< Back to selection list measure workpiece milling.

7.3.1.4 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          ;Main block
N110 T7 M6                                 ;Insert probe
N120 G17 G0 G90 X50 Y50                    ;Position probe in X/Y
                                           ;plane on hole center
                                           ;point

N130 Z20 D1                                ;Position Z axis in hole

; from the measuring cycle support using the
; NC code _MZ_MASK[0]=1 generated using the input screen
```

```
N130 _MVAR=1001 _SETVAL=100.000 _PRNUM=101          ;Parameter transfer to
     _KNUM=2002 _FA=2 _TSA=0.23                      ;measuring cycle
     _VMS=0 _NMSP=1 _ID=-20.000 _SZA=50.000          ;call measuring cycle
     _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)

7.3.2 Pre-setting of the measuring cycle support

General information

A field _MZ_MASK is declared in the data block (GUD6) in which the screen forms can be adapted:

● technological measuring conditions

● to measuring variants

The settings in the data block for the _MZ_MASK field can be changed in a screen form in "Setup" operating area.
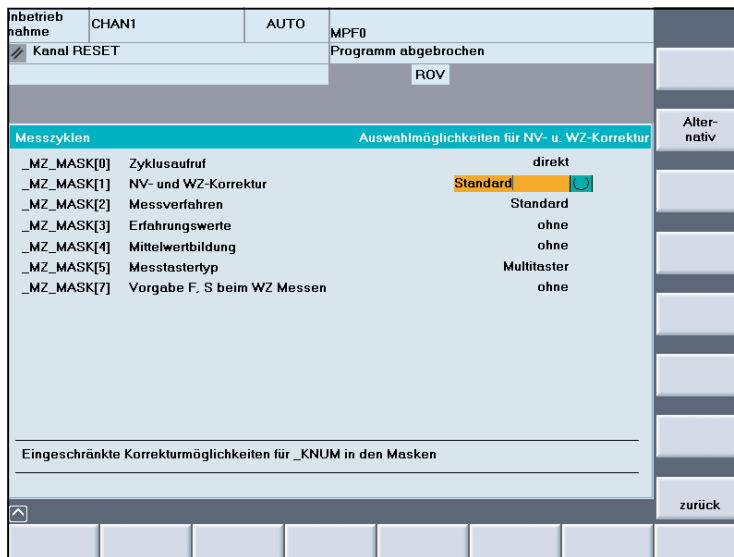
Setting

Variable	Value	Default:	Meaning
_MZ_MASK[0]	0	-	An indirect measuring cycle call is inserted in the NC code. Example: CYCLE977/drill-hole CYCLE_PARA(...............) CYCLE_977_979A(977,........)
	1	1	A direct measuring cycle call is inserted in the NC code. Example: CYCLE977/drill-hole _MVAR=1 _KNUM=1 _PRNUM=1 .... CYCLE977

_MZ_MASK[1]	0	0	The workpiece screen forms contain the following selection options for zero offset and tool offset:
			• Zero offset - default:
			    – Settable zero offsets
			    – Last channel-specific basic frame
			• Tool offset – default:
			    – Milling: Tool radius is corrected
			    – Turning: Length offset in the measuring axis

Variable	Value	Default:	Meaning

	1	-	The workpiece screen forms contain the following selection options for zero offset and tool offset:
			• Zero offset - extended:
			  – Settable zero offsets
			  – Last channel-specific basic frame
			  – Offset in system frame
			  – Offset in active frame
			  – Offset in any basic frame (global or channel-specific)
			• Tool offset – extended:
			  – Offset radius, length, or length selection (L1, L2, or L3)
			  – Calculation of measurement results normal or inverted
			  – Offset in setup/additive offset

_MZ_MASK[2]	0	0	Forms without input fields for parameters: • _VMS: Measuring velocity • _NMSP: Number of measurements at the same location. The following default values are entered in the NC code for the parameters: • _VMS=0: Corresponds to 150 mm/min or 5.9055 inch/min • _NMSP=1: Number of measurements = 1
	1	-	Forms with input fields for parameters: • _VMS: Measuring velocity • _NMSP: Number of measurements at the same location
_MZ_MASK[3]	0	0	Screen forms for workpiece measurement with automatic tool offset and tool measurement do not contain an input field for the following parameters: • _EVNUM: Number of empirical value memory The following default value is entered in the NC code: • _EVNUM=0: No empirical value memory is taken into account.
	1	-	Screen forms for workpiece measurement with automatic tool offset and tool measurement contain an input field for the following parameters: • _EVNUM: Number of empirical value memory
_MZ_MASK[4]	0	0	Screen forms without input fields for the following parameters for mean value calculation with automatic tool offset: • _TMV: Select range for offset with mean value calculation • _K: Weighting factor for mean value calculation • EVNUM: Mean value memory number The following default values are entered in the NC code: • _TMV=ABS(_TUL-_TLL)/3 • _K=1 • _EVNUM=0 • _CHBIT[4]=0

Variable	Value	Default:	Meaning
	1	-	Screen forms with input fields for the following parameters for mean value calculation with automatic tool offset: • _TMV: Select range for offset with mean value calculation • _K: Weighting factor for mean value calculation • _EVNUM: mean value memory number The following is also entered in the NC code: • _CHBIT[4]=1
_MZ_MASK[5]	0	0	Probe type for workpiece measurement is a multi probe
	1	-	Probe type for workpiece measurement is a mono probe The relevant screen forms show an input field for the offset angle _CORA.
_MZ_MASK[6]			Reserved
_MZ_MASK[7]	0	0	Screen form for CYCLE971 – tool measurement/milling does not contain input fields for feedrate and spindle speed. F and S are calculated within the cycle. The following is also entered in the NC code: • _CBIT[12]=0
	1	-	Screen form for CYCLE971 – tool measurement/milling contains input fields for feedrate and spindle speed. The following is also entered in the NC code: • _CBIT[12]=1

References:

/BEM/, HMI Embedded Operator's Guide

/IAM/, Installation & Start-Up Guide, IM2 "Commissioning HMI Embedded"

Recompiling

Recompilation of programs allows you to change existing programs using the cycle support.

When recompiling measuring cycle calls, please note that a field of defaults for programming is active (_MZ_MASK) in addition to the screen forms. If there has been a change in this settings between program creation and recompilation, the changes will also be included in the program.

Programs with measuring cycle calls cannot be recompiled after a change in the type of tool programming, i.e. change in the machine data setting

- MD 18102: MM_TYPE_OF_CUTTING_EDGE

- MD 18080: MM_TOOL_MANAGEMENT_MASK

.

7.4 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

Zyklen	CHAN1		AUTO	\WKS.DIR\MESSEN_SCA_TEST.WPD TEST_102.MPF	
Kanal unterbrochen					
Halt: M0/M1 aktiv				ROV	

NV-ERMITTLUNG AN WELLE

Messergebnis CYCLE977

NV-Ermittlung Welle				Messvariante:	102
	Sollwert	Istwert	Differenz		
X	100.000000	100.373567	0.373567	mm	
Y	55.000000	54.773794	-0.226206	mm	
Welle	50.000000	41.013243	-8.986757	mm	

NV-Speicher-Nr.　1

Messtasternr.　102　　Vertrauensbereich　10.000000　mm

Keine Zugriffsrechte

Hardware/software

<div style="text-align: right; font-size: 2em;">8</div>

8.1 Hardware requirements

8.1.1 General hardware prerequisites

Axis assignment

For correct execution of the measuring cycles the machine axes must be assigned according to DIN 66217.

Probes that can be used

Switching probes should be connected up for the measuring cycles.

For an explanation of these, refer to descriptions in Section 1.6 "Probes that can be used".

8.1.2 Measuring probe connection

8.1.2.1 General information

Only the main situation regarding the connections assigned to the probe signal are shown below in the cable distributor and on the control units.

8.1.2.2 SINUMERIK 810D, 840D powerline, 840Di

The probe for SINUMERIK 810D, 840D powerline or 840Di is generally connected up via the additional **"cable distributor"** module!

The cable distributor is universally connected to the **peripheral interface X121**.

For more detailed information on contact routing, electric characteristics, and additional material needed, see:

References:

/PHC/ SINUMERIK 810D HW Configuration Manual

/PHD/ SINUMERIK 840D NCU Configuration Manual

/HBi/ SINUMERIK 840Di Manual

Cable distributor
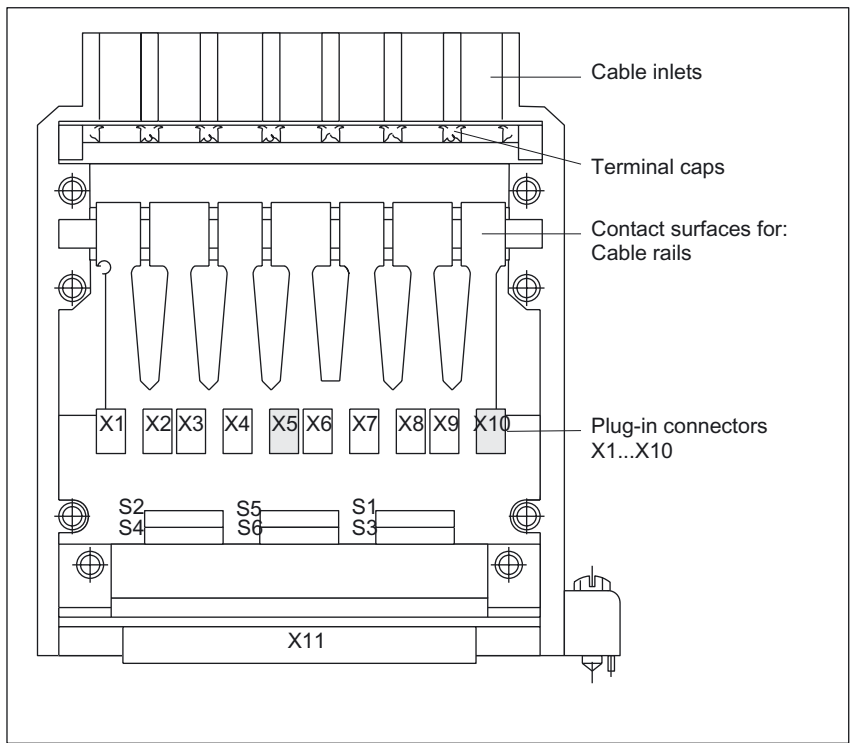
Figure 8-1   View of the opened cable distributor

- Connecting up the probe
  - Probe 1 to X10
  - Probe 2 to X5
- The X10 and X5 connector type is a DU–BOX plug connector
- The cable connector's X11 is plugged on to X121 of the corresponding control unit

SINUMERIK 810D

Probe connection to X121, 810D/CCU module
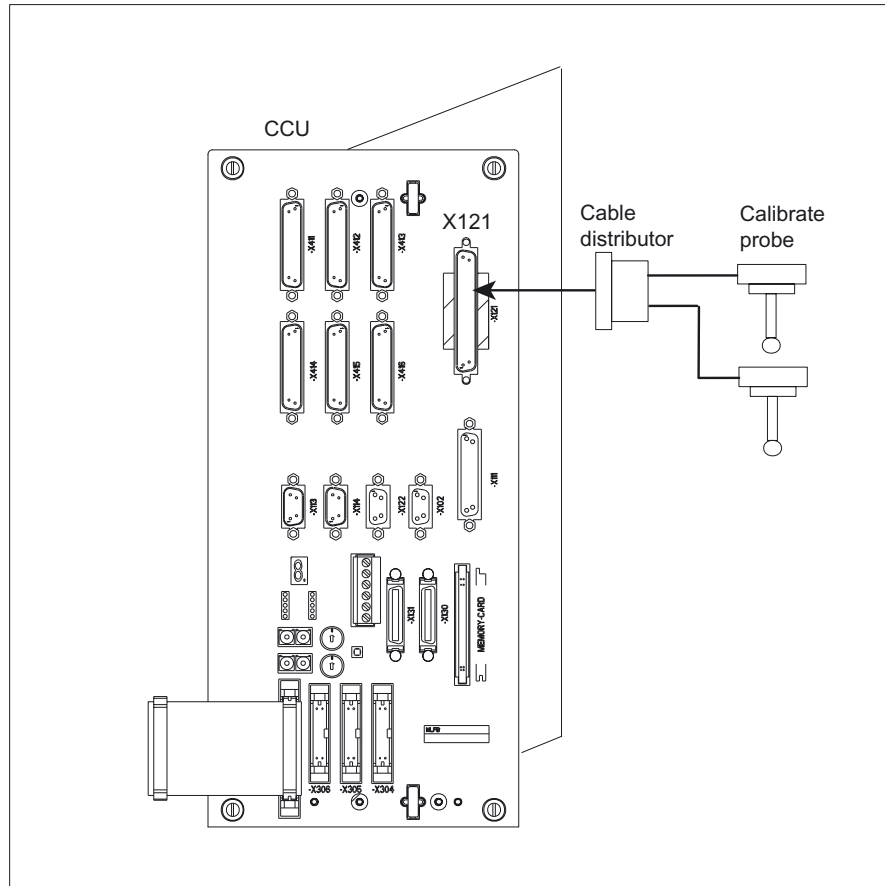
Figure 8-2   Front view of 810D/CCU module

SINUMERIK 840D

Probe connection to X121, 840D/NCU module
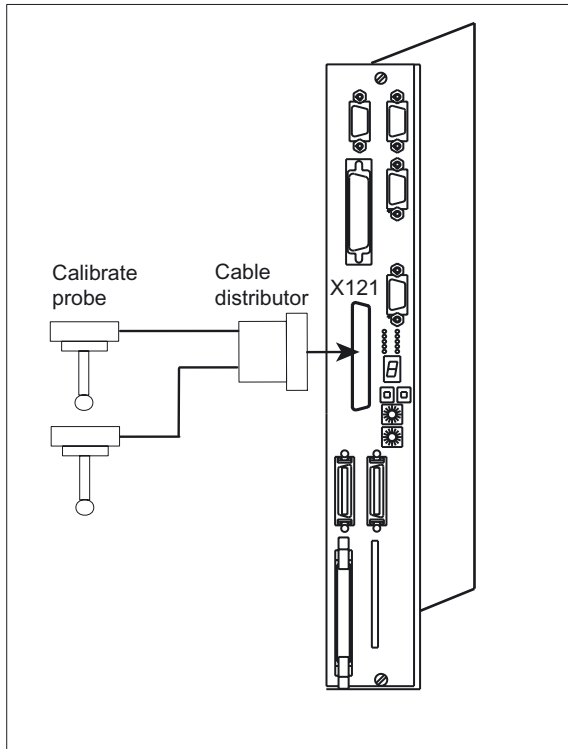
Figure 8-3   Front view of 840D/NCU module

SINUMERIK 840Di

Probe connection to X121, 840Di/PCU50

The additional **MCI board extension, slot variant** module, which is located on interface X121, is needed to connect probes up to SINUMERIK 840Di using cable distributors.
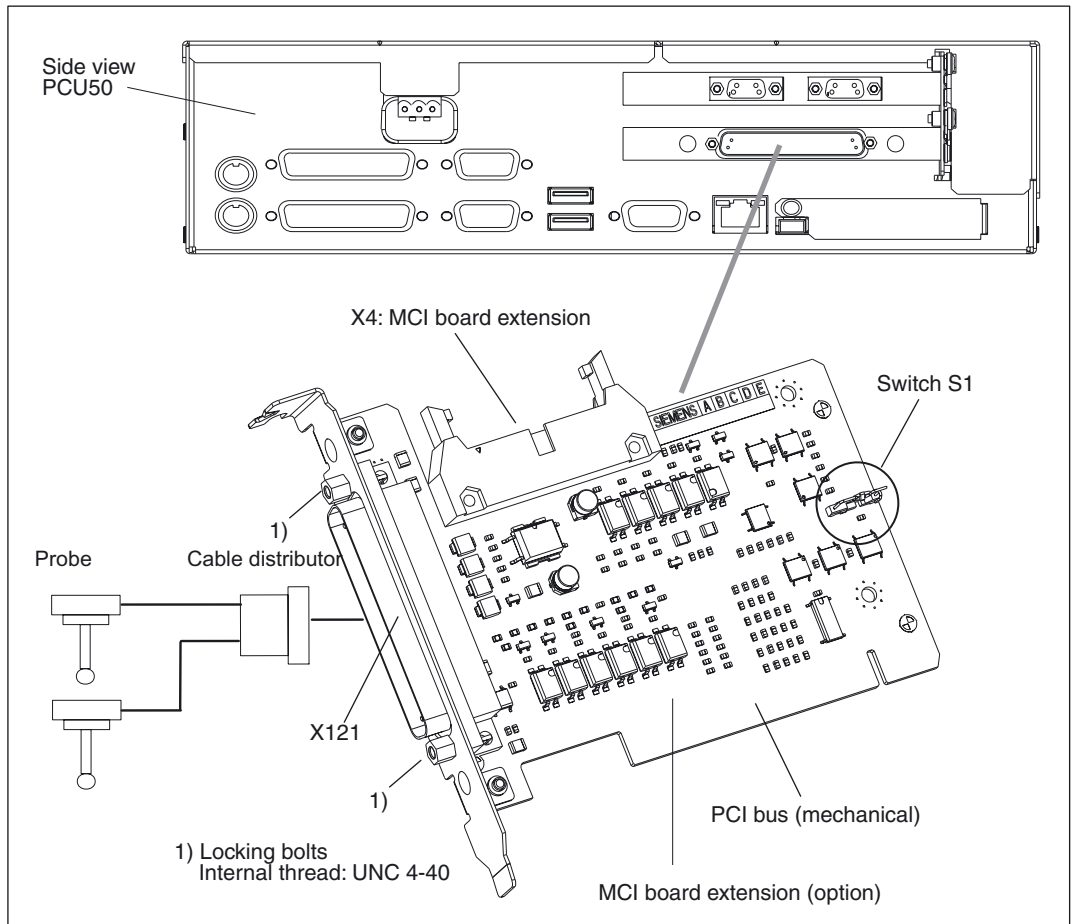
Side view of PCU50 with MCI board extension slot variation

8.1.2.3 SINUMERIK 840D sl (solution line) probe connection to X122, NCU 7x0

Probe connection to X122, NCU 7x0

The prerequisite for measuring on X122 is set machine data
MD 13210: MEAS_TYPE = 0.

For more detailed information on contact routing, electric characteristics, commissioning using configuration macros, and additional material needed, see:

References:

/GDsl/ SINUMERIK 840D sl NCU Manual

/IDsl/ SINUMERIK 840D sl/SINAMICS S120 CNC Commissioning, Part 1 (NCK, PLC, Drive)
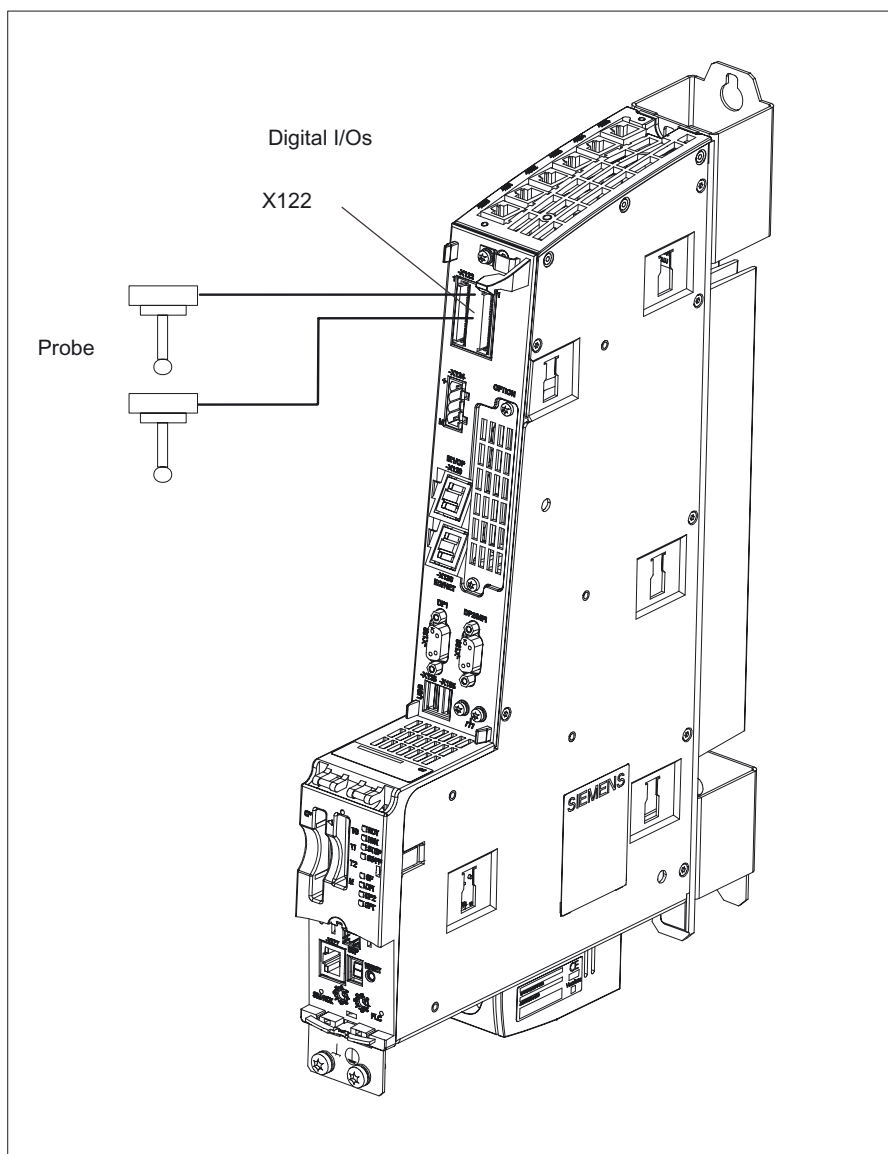
Figure 8-4   Example of probe connection to NCU 720

8.1.3 Measuring in JOG

Measuring in JOG is only possible with:

- SINUMERIK 840D sl → in conjunction with HMI Advanced (PCU 50)
- SINUMERIK 840Di → in conjunction with HMI Advanced (PCU 50)
- SINUMERIK 840D → in conjunction with HMI Advanced (PCU 50) or MMC 103
- SINUMERIK 810D → in conjunction with HMI Advanced (PCU 50) or MMC 103

8.2 Software requirements

8.2.1 How the measuring cycles are supplied

The measuring cycle software is supplied on diskette.

8.2.2 Software versions NC and MMC/HMI

NC software version

The measuring cycles can be used with NCK SW 6.3 and higher.

MMC SW

The measuring cycles require an MMC/HMI software version as from SW 4.4.

PLC program

No adaptation of the PLC user program is required to run the measuring cycles and use the probe switching signals.

8.2.3 Options

SINUMERIK 840D/840Di:

Measuring in automatic mode

→ No options are needed!

Measuring in JOG

→ The "Inter-modal actions" option (ASUP's and synchronized actions in all modes) is needed

Order No.: 6FC5800-0AM43-0YB0   Order code: M43

SINUMERIK 840D sl:

Measuring in automatic mode

→ The "Measuring cycles" option is needed!

Order No.: 6FC5800-0AP28-0YB0   Order code: P28

Measure kinematics

→ The "Measuring kinematics" option is needed!

Order No.: 6FC5800-0AP18-0YB0   Order code: P18

Measuring in JOG

→ The "Inter-modal actions" option (ASUP's and synchronized actions in all modes) is needed

Order No.: 6FC5800-0AM43-0YB0   Order code: M43

See also

General (Page 276)

8.3 Function test

Measure command

The control has the command MEAS for generating a measuring block.

The measuring input number is set in the command parameters.

Saving measurement results

The results of the measurement command are stored in the system data of the NCK and can be accessed from the program.

These steps include:

System data	Meaning
$AC_MEA[<No.>]	Software switching signal for the probe no. stands for measuring input number
$AA_MW[<axis>]	Measured value of the axis in workpiece coordinatesAxis stands for the name of the measuring axis
$AA_MM[<axis>]	Measured value of the axis in machine coordinates

References: /PG/, Programming Guide

PLC service display

The functional test for the probe is conducted via an NC program.

The measuring signal can be controlled via the diagnostics menu "PLC status".

Table 8-1   Status display for measurement signal

Probe	Display
Probe 1 deflected	DB10 DB X107.0
Probe 2 deflected	DB10 DB X107.1

Example of functional check

```
%_N_PRUEF_MESSTASTER_MPF
;$PATH=/_N_MPF_DIR
;Testing program probe connection
N05 DEF INT MTSIGNAL                    ;Flag for trigger status
N10 DEF INT ME_NR=1                     ;Measurement input number
N30 G17 T1 D1                           ;Select tool offset for probe


N40 G0 G90 X0 F150                      ;Starting position and meas. velocity
N50 MEAS=ME_NR G1 X100                  ;Measurement at measuring input 1 in
                                        ;the X axis
N60 STOPRE                              ;Preprocessing stop
N70 MTSIGNAL=$AC_MEA[ME_NR]             ;Read software switching signal at
                                        ;1st measurement input
N80 IF MTSIGNAL == 0 GOTOF _FEHL1       ;Evaluation of signal
N90 R1=$AA_MW[X]                        ;Read in measured value in workpiece
                                        ;coordinates
N95 M0                                  ;View measured value in R1
N100 M2
N110 _FEHL1: MSG ("Probe not switching!")
N120 M0
N130 M2
```

Data description   9

9.1   Machine data for machine cycle runs

9.1.1   Machine data that configure the memory

9.1.1.1   General information

The measuring cycles use separate **GUD** and **LUD variables** (**G**lobal **U**ser **D**ata and **L**ocal **U**ser **D**ata).

The memory areas needed for this are configured using NC machine data.

The amount of memory needed for GUD variables is determined when loading data modules GUD5 and GUD6!

If the "Measure in JOG" function is installed, data module GUD7 (as of measuring cycles SW 6.3: GUD7_MC) will also have to be loaded.

For more details on "Measuring in JOG": see the the following chapter.

LUD variables are only generated during program and cycle runtime. The memory needed for them (DRAM) is therefore used during program processing.

This LUD memory should be configured with a sufficient reserve because the NC may have vastly differing memory requirements in different phases of program processing.

Note

Memory of the measuring cycles

The memory needed directly for the system frames, GUDs and LUDs functions in relation to measuring cycles is ensured by the parameter settings shown in sections 9.1.1.2, 9.1.1.3, and 9.1.2.

Future versions of the measuring cycles

Future versions of the measuring cycles may possibly need different parameter settings from those described here. For current data, see files SIEMENSD.TXT or SIEMENSE.TXT in the measuring cycle software supplied.

NOTICE
The following details in the machine data only refer to the use of SIEMENS measuring cycles and are valid up to NCK software version 59.xx.yy
As of NCK software version 63.xx.yy, the standard machine data setting should be such that the memory configuration requires no further adjustments when only SIEMENS measuring cycles are installed for automatic mode and measuring in JOG.
If using applications requiring ShopMill, ShopTurn or another NC memory, the requirements of these products must also be taken into account.

NOTICE
Machine data whose name starts "_MM" are memory configuring data. Changing these data reallocates the memory. Data it contains will be lost.
If this memory is in the non-volatile memory range of the control (**SRAM**), the **user data** (loaded programs and definitions, R-parameters, tool offsets, zero offsets, etc.) it contains will be lost.

Therefore:

When first starting up the system, the following machine data should already be set at the start of commissioning.

If user data is already present in SRAM, proceed as follows:

- Alarm 4400 (reorganization of the buffered memory) is displayed after changes to the memory-configured MD.

- In order to prevent the loss of data in this situation, the start-up archive MUST be read (in the "SERVICES" menu area)!

- If this archive is then loaded into the NCU, the SRAM is configured and the archived data and programs are then installed at the same time!

9.1.1.2 Memory configuring machine data, SRAM

18118	MM_NUM_GUD_MODULES		
MD number	Number of data blocks		
Default setting: 7[1] Default setting: 7[2] **When using measuring cycles: 7**	Min. input limit: 1		Max. input limit: 9
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 2
Significance:	Number of GUD files in the active file system (SRAM)		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

18120	MM_NUM_GUD_NAMES_NCK		
MD number	Number of GUD variable names in the control		
Default setting: 10[1] Default setting: 50[2] **When using measuring cycles: 30**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 1
Significance:	Memory reservation for GUD variable names, NCK (SRAM) range **Note**: The number of GUDs may also be limited by MD 18150.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

18130	MM_NUM_GUD_NAMES_CHAN		
MD number	Number of GUD variable names per channel		
Default setting: 40[1] Default setting: 150[2] **When using measuring cycles: 100** **with measurement in JOG: 130**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 1
Significance:	Memory reservation for GUD variable names in each channel, CHAN (SRAM) range **Note**: The number of GUDs may also be limited by MD 18150.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

18150	MM_GUD_VALUES_MEM		
MD number	Memory for values of the GUD variables		
Default setting: 12/16[1] Default setting: 32[2] **When using measuring cycles: 28/32[1]** (see table below)	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: KB
Data type DWORD			Applies as of SW 1
Significance:	Memory for user variables (SRAM): Provides indication of the number of GUD variables that can be created. The FRAME data type requires almost 1 KB. It is the largest data type. The BOOLEAN data type needs just 1 byte; REAL type 8 bytes. An array of variables requires only one name (MD 18120, MD 18130) – but memory for all elements. The memory needed for all GUD variables is entered here; for the NCK area and for all channels together. **Note**: The number of GUDs may also be limited by MD 18120 or MD 18130 .		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

Memory requirement of GUD variables for meas. cycles

The machine data settings recommended above provide overall values that enable work with measuring cycles. Deviating settings may be required for particular applications. The memory requirement of each measuring cycle is therefore specified here (approximate values). It may be higher in future measuring cycle versions.

The resulting memory requirement must be added to other user memory requirements.

The number of measuring programs "loaded" in the CNC, including the internal measuring programs, are also added to the user's loaded NC programs!

If necessary, the general machine data MD 18280: MM_NUM_FILES_PER_DIR and MD 18320: MM_NUM_FILES_IN_FILESYSTEM has to be adapted!

Area	Number of names	Memory in KB MD 18150
NCK	MD 18120: **20**	7
CHAN (GUD5, GUD6 only)	MD 18130: **60**	Two channels: **8** (number of channels * 4)
CHAN (from GUD7, also for "Measuring in JOG")	MD 18130: **30**	Two channels: **1** (number of channels * 0.5)
		Example: Measuring cycles with 2 channels and "measuring in JOG": **16**

28082	MM_SYSTEM_FRAME_MASK		
MD number	Configuration screen form for channel-specific system frames		
Default setting: 21Hex[1] Default setting: 21Hex[2] **When using measuring cycles: 21 Hex** Bit 5 = 1	Min. input limit: 0		Max. input limit: 7Fhex
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type:INTEGER			Applies as of SW 6.2
Significance:	The following applies to measuring cycles: Bit 0: 1 system frames for preset mode and scratching, recommended[3] Bit 5: 1 system frames for cycles (must always be available for measuring cycles)		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy 3) 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!			

28083	MM_SYSTEM_DATAFRAME_MASK		
MD number	System frames (SRAM)		
Default setting: 21Hex[1] Default setting: 21Hex[2] **When using measuring cycles: 21 Hex** Bit 5 = 1	Min. input limit: 0		Max. input limit: 7Fhex
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type:INTEGER			Applies as of SW 6.3
Significance:	The following applies to measuring cycles: Bit 0: 1 system frames for preset mode and scratching, recommended[3] Bit 5: 1 system frames for cycles (must always be available for measuring cycles)		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy 3) 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!			

9.1.1.3 Memory configuring machine data, DRAM

18170	MM_NUM_MAX_FUNC_NAMES		
MD number	Number of names of miscellaneous functions - cycles		
Default setting: 40[1] Default setting: 100[2] **When using measuring cycles: 80**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 1
Significance:	Number of cycles with input parameters (DRAM)		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

18180	MM_NUM_MAX_FUNC_PARAM		
MD number	Number of parameters in the additional functions - cycles		
Default setting: 300[1] Default setting: 1000[2] **When using measuring cycles: 800**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 1
Significance:	Number of parameters for cycles acc. to MD 18170 (DRAM)		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

28020	MM_NUM_LUD_NAMES_TOTAL		
MD number	Number of LUD variable names (in total in all program levels)		
Default setting: 200[1] Default setting: 400[2] **When using measuring cycles: 200**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 3.2
Significance:	Number of local user variables – for each channel (DRAM) **Note**: The number of LUDs may also be limited by MD 28040.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

28040	MM_NUM_LUD_VALUES_MEM		
MD number	Memory for values of the LUD variables (DRAM)		
Default setting: 12/25[1] Default setting: 50[2] **When using measuring cycles: 16/29[1]**	Min. input limit: 0		Max. input limit: plus
Changes effective after POWER ON		Protection level: 2/7	Units: KB
Data type DWORD			Applies as of SW 3.2
Significance:	Provides indication of the number of LUD variables that can be created. The FRAME data type requires almost 1 KB. It is the largest data type. The BOOLEAN data type needs just 1 byte. An array of variables requires only one name (MD 18120, MD 18130) – but memory for all elements. **Note:** The number of LUDs may also be limited by MD 28020.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

9.1.2   Other machine data

Machine data for adapting the probe

13200 MD number	MEAS_PROBE_LOW_ACTIVE[n] Switching characteristics of probe (n=0: Measuring input 1, n=1: Measuring input 2)			
Default setting: FALSE[1] Default setting: FALSE[2] **When using measuring cycles: FALSE**	Min. input limit: FALSE		Max. input limit: TRUE	
Changes effective after POWER ON		Protection level: 2/7	Units: -	
Data type BOOLEAN			Applies as of SW 2.2	
Significance:	Value 0 (FALSE):		not deflected status deflected status	0 V (low) 24 V (high)
	Value 1 (TRUE):		not deflected status deflected status	24 V (high) 0 V (low)
	Note: When programming MEAS, the data always refers to "not deflected", "deflected" – but not to the voltage level. The voltage level is set with this MD. 1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

Machine data for adapting MMC commands in cycles

10132 MD number	MMC_CMD_TIMEOUT Monitoring time for MMC command in part program		
Default setting 1[1] Default setting 3[2] **When using measuring cycles: 3.0**	Min. input limit: 1.0	Max. input limit: 100.0	
Changes effective after POWER ON	Protection level: 2/7	Units: s	
Data type DOUBLE		Applies as of SW 3.2	
Significance:	Monitors the time until the MMC acknowledges a command from the part program.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

Machine data for logging

11420 MD number	LEN_PROTOCOL_FILE File size for log files		
Default setting: 1[1] Default setting: 1[2] **When using measuring cycles: 5**		Min. input limit: 1	Max. input limit: 1000000
Changes effective after POWER ON		Protection level: 2/7	Units: KB
Data type DWORD			Applies as of SW 4.3
Significance:	Maximum size of protocol files that are created with WRITE command.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

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

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
_CVAL[4]=(3,3,3,3)	INTEGER	3 arrays each for • tool probe, machine-related (_TP[3,10]) • workpiece probe (_WP[3,11]) • gauging block (_KB[3,7]) • tool probe, workpiece-related (_TPW[3,10])
_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

Global data	Data type	Meaning	
_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
_SI[3]=("","6","")	STRING[8]	Central strings (system information) • Internal data item • software version of the control • Internal data item	

Global data	Data type	Meaning	
_PROTNAME[2]	STRING[32]	• name of main program the log is from, • name of log file	
_HEADLINE[10]	STRING[80]	Strings for log header	
_PROTFORM[6]=(60,80, 1,3,1,12),	INTEGER	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	
_PROTSYM[2]=(";","#")	CHAR	• Separator in the log is ";" • Special character for identification of tolerance limits being exceeded is "#"	
_PROTVAL[13]	STRING[100]	Values	Title line in log; Specification of the values to be logged
		0...1:	two title lines
		2...5:	up to 4 value lines
		6...12:	internal fields
_PMI[4]	INTEGER	Field for internal flags for logging	
_SP_B[20]	INTEGER	Variable column width	
_TXT[100]	STRING[12]	Field for formatted strings	
_DIGIT=3	INTEGER	Number of decimal places is 3	
_MZ_MASK[20] =(1,0,0,0,0,0,0,0)	INTEGER	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)	

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

General information

There are two main steps for adapting the data to a specific machine:

1. **Adapting the data definitions** in the GUD blocks and loading them in the PLC.

2. **Subsequent adaptation** of certain values in part program.

1. Adapting the data definitions

The following example shows how to adapt the data blocks GUD5.DEF and GUD6.DEF to a machine with SINUMERIK 840D with the characteristics described below:

- 2 data fields (data arrays) for using tool probes

- 2 data fields (data arrays) for using workpiece probes

- without calibration groove pair,

- only 10 empirical and mean values

The following example only shows the lines to be changed!

Example:

```
%_N_GUD6_DEF
;$PATH=/_N_DEF_DIR
;(date) adaptation to a machine_1
...
N10 DEF NCK INT _CVAL[4]=(2,2,0,0)1)
N11 DEF NCK REAL _TP[2,10]=(0,0,0,0,0,0,0,133,0,2)1)
N12 DEF NCK REAL _WP[2,11]1)
;N13 DEF NCK REAL _KB[3,7]1)
N40 DEF CHAN INT _EVMVNUM[2]=(10,10)1)
...
M17
1) Characters and digits in bold (highlighted) have  been changed with respect to
the status when  first supplied
```

2. Subsequence adaptation of specific values

Value adaptation is achieved by loading a part program in the PLC and running it in AUTOMATIC mode.

The following adaptations are to be achieved:

- A tool probe with a disk in the XY plane is being used with an active disk diameter of 20 mm for tool length measurement.

- Measurement repetition when the permissible dimensional difference or the safe area are exceeded, but without M0.

- Length of workpiece probe relative to end of probe ball.

- Static measurement result display.

- No repeat of an unsuccessful attempted measurement.

- Retraction of the probe from the measuring point at 80% of rapid traverse velocity.

Example:

```
%_N_MZ_VALUE ASSIGNMENT_MPF
;$PATH=/_N_MPF_DIR
;(date) pre-assignment of meas. cycle data to machine_1
N10 _TP[0,6]=20 _TP[1,6]=20 _TP[0,8]=101     ;Specification of disk diameter and
_TP[1,8]=101                                 ;type of tool probe
N20 _CBIT[0]=1                               ;Preset measurement repeat bit
N30 _CBIT[14]=1                              ;Length of workpiece probe relative to
                                             ;end of probe ball
N40 _CHBIT[10]=1 _CHBIT[11]=0 _CHBIT[18]=1   ;Bits for static
                                             ;display of meas. result.
N50 _CHBIT[15]=1                             ;Measurement abort after unsuccessful
                                             ;attempt
N60 _CHBIT[16]=1                             ;Retraction from measuring point at
                                             ;% ;rapid traverse velocity defined in
                                             ;_SPEED[0]

N65 _SPEED[0]=80                             ;Reduction of rapid traverse to 80 %
N99 M2
```

9.2.3   Central values

Data block GUD6.DEF

	_CVAL[ ] Number of elements, arrays			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment		Protection level: -		Units: -
Data type INTEGER				Applies as of SW 3.2/6.3
Significance:				Preset default
	_CVAL[0]	Number of arrays for tool probes _TP[ ] (machine-related)		3
	_CVAL[1]	Number of arrays for workpiece probes _WP[ ]		3
	_CVAL[2]	Number of arrays for gauging blocks _KB[ ]		3
	_CVAL[3]	Number of arrays for tool probes _TPW[ ] (workpiece-related)		3

	_TP[ ] Array for tool probes (machine-related)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment		Protection level: -		Units: -
Data type:REAL				Applies as of SW 3.2
Significance:	Index "k" stands for the number of the current data field (_PRNUM-1)			Preset default
	Assignment for milling			
	_TP[k,0]	Trigger point in minus direction	**X** (1st geometry axis)	0
	_TP[k,1]	Trigger point in plus direction	**X** (1st geometry axis)	0
	_TP[k,2]	Trigger point in minus direction	**Y** (2nd geometry axis)	0
	_TP[k,3]	Trigger point in plus direction	**Y** (2nd geometry axis)	0
	_TP[k,4]	Trigger point in minus direction	**Z** (3rd geometry axis)	0
	_TP[k,5]	Trigger point in plus direction	**Z** (3rd geometry axis)	0
	_TP[k,6]	Edge length/disk diameter		0
	_TP[k,7]	Axes and directions for "automatic calibration"		133
	_TP[k,8]	Probe type	0: Cube	0
			101: disk in XY	
			201: disk in ZX	
			301: disk in YZ	
	_TP[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)			
	_TP[k,0]	Trigger point in minus direction of abscissa		0
	_TP[k,1]	Trigger point in plus direction of abscissa		0
	_TP[k,2]	Trigger point in minus direction of ordinate		0
	_TP[k,3]	Trigger point in plus direction of ordinate		0
	_TP[k,4] to _TP[k,9]	irrelevant		0

- **Tool probe on milling machine**

  Example: Probe type disk in XY (_TP[k,8]=101)

  Tool probe machine-related,
  disk version in XY (_TP[k,8]=101)
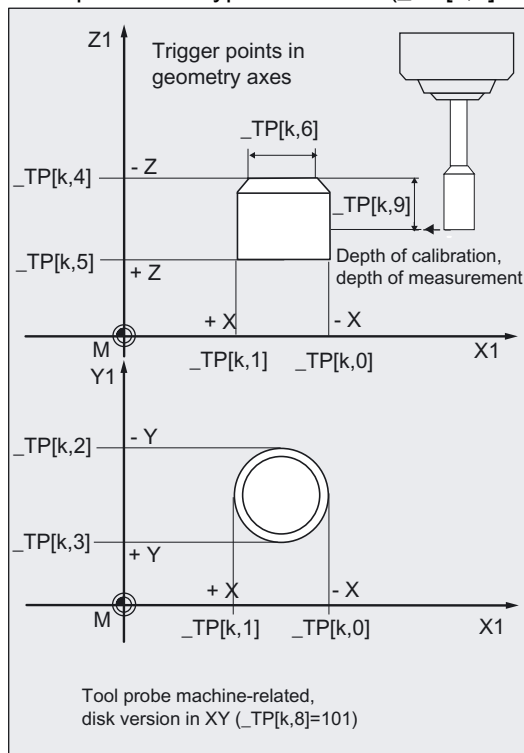
- **Tool probe on turning machine**

  Example: G18 plane, values machine-related

  Tool probe machine-related,
  cube version

	_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 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	0	
			101: Disk in XY		
			201: Disk in ZX		
			301: Disk in YZ		
	_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
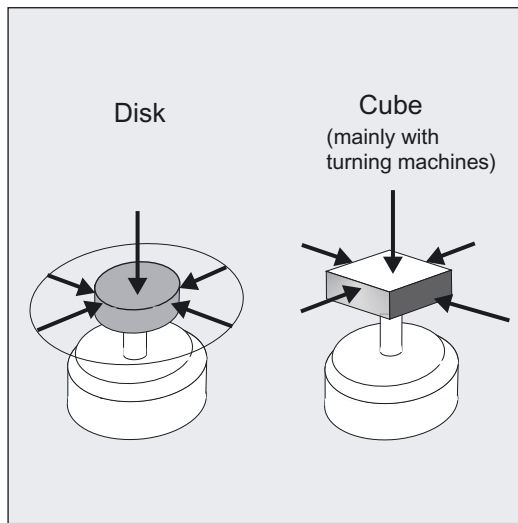
	_WP[ ] Workpiece probe			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type REAL				Applies as of SW 3.2
Significance:	Index "k" stands for the number of the current data field (_PRNUM-1)			Preset default
	_WP[k,0]	Active ball diameter 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
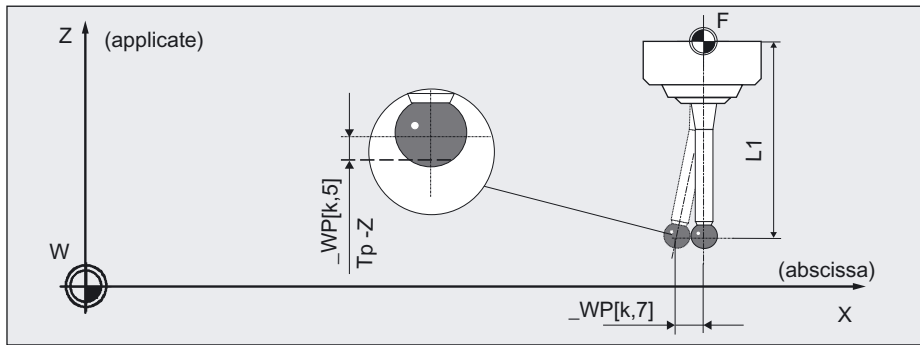
Position deviation and trigger points Tp in X and Y (magnified illustration):
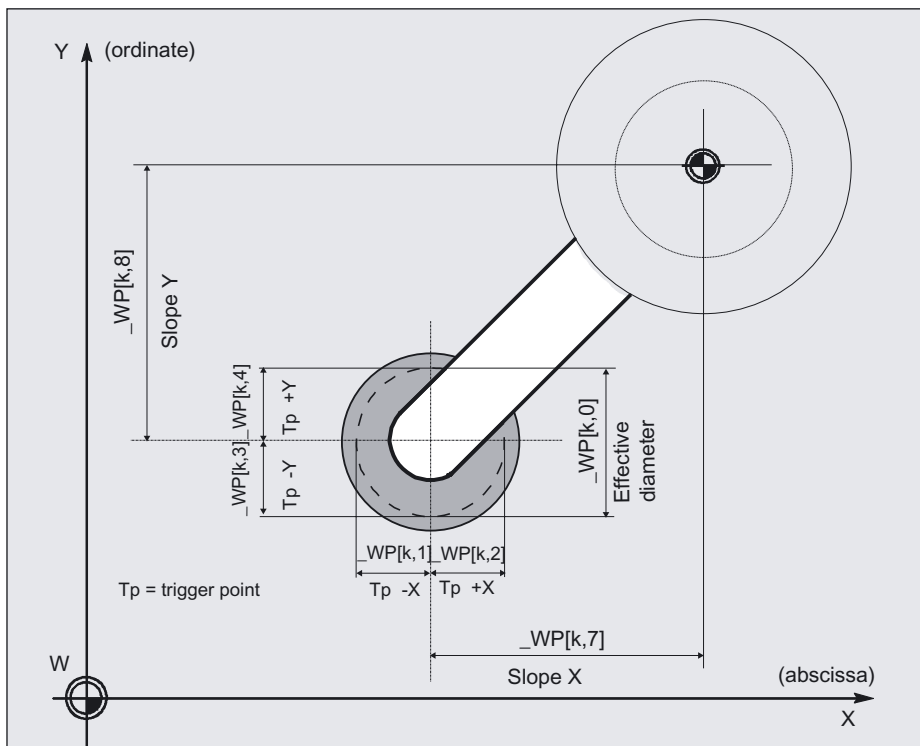
	_KB[ ]			
	Gauging block (pair of reference grooves)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Unit: -
Data type REAL				Applies as of SW 3.2
Significance:	Index "k" stands for the number of the current data field (_CALNUM-1)			Preset default
	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 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 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				Applies as of SW 3.2
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 on 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]	Central marker for basic dimension system of the control 0: Basic system setting is inches 1: Basic system setting is metric		1
	_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. From measuring cycles SW 6.3, function switchover via _MVAR is available.		0
	_CBIT[6]	Logging without output of the measuring cycle name and measuring 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[ ] Central bits		
	_CBIT[11]	Selection of log header for logging 0: standard 1: user-defined	0
	_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 the measuring cycle arrays in the 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.

Central marker for basic dimension system of the control

_CBIT[3]=0:	Basic system is based on inches
_CBIT[3]=1:	The basic system is metric

When starting up the measuring cycles, this bit has to be set according to the basic settings of the PLC MD 10240: SCALING_SYSTEM_IS_METRIC must be set.

If modifying the basic settings of the control results in _CBIT[3] no longer matching MD 10240, arrays _TP[], _WP[], _KB[] and _EV[] will be converted the first time a measuring cycle is called after the modification and a message will be output.

The data for tool measurement with rotating spindle (_CM[ ], _MFS[ ]) are also converted as are the data in the _SPEED[ ] field.

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

From measuring cycles SW 6.3, function switchover via _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 measuring 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 the measuring cycle arrays in the 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" measuring variant, the determined "effective probe sphere diameter" (_WP[k,0]) converted as radius value is entered into the radius geometry memory of the active workpiece measuring probe as 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　Central strings

Data block GUD6.DEF

	_SI[ ] Central strings (only up to measuring cycle version SW 6.2)			
		Min. input limit: -		Max. input limit: -
Changes valid after value assignment			Protection level: -	Units: -
Data type STRING				Applies as of SW
Significance:				Preset default
	_SI[0]	currently not assigned		
	_SI[1]	Software Version		"6"
	_SI[2]	currently not assigned		

Software Version

Here you have to enter the first digit of the version of the NCU software on the control, e.g. for SW 05.xx.xx, enter 5.

9.2.6 Channel-oriented values

Data block GUD5.DEF

<table>
<tr><td colspan="2">_EV[ ]
Empirical values</td><td></td><td></td></tr>
<tr><td></td><td>Min. input limit: -</td><td colspan="2">Max. input limit: -</td></tr>
<tr><td colspan="2">Changes valid after value assignment</td><td>Protection level: -</td><td>Units: -</td></tr>
<tr><td colspan="3">Data type REAL</td><td>Applies as of SW 3.2</td></tr>
<tr><td>Significance:</td><td colspan="2">Index "k" stands for the number of the current array -1</td><td>Preset default</td></tr>
<tr><td></td><td>_EV[k]</td><td>Number of empirical values</td><td>0</td></tr>
</table>

<table>
<tr><td colspan="2">_MV[ ]
Mean values</td><td></td><td></td></tr>
<tr><td></td><td>Min. input limit: -</td><td colspan="2">Max. input limit: -</td></tr>
<tr><td colspan="2">Changes valid after value assignment</td><td>Protection level: -</td><td>Units: -</td></tr>
<tr><td colspan="3">Data type REAL</td><td>Applies as of SW 3.2</td></tr>
<tr><td>Significance:</td><td colspan="2">Index "k" stands for the number of the current array</td><td>Preset default</td></tr>
<tr><td></td><td>_MV[k]</td><td>Number of empirical values</td><td>0</td></tr>
</table>

Data block GUD6.DEF

<table>
<tr><td colspan="2">_EVMVNUM[ ]
Number of empirical values and mean values</td><td></td><td></td></tr>
<tr><td></td><td>Min. input limit: 0</td><td colspan="2">Max. input limit: -</td></tr>
<tr><td colspan="2">Changes valid after value assignment</td><td>Protection level: -</td><td>Units: -</td></tr>
<tr><td colspan="3">Data type INTEGER</td><td>Applies as of SW 3.2</td></tr>
<tr><td>Significance:</td><td colspan="2"></td><td>Preset default</td></tr>
<tr><td></td><td>_EVMVNUM[0]</td><td>Number of empirical values</td><td>20</td></tr>
<tr><td></td><td>_EVMVNUM[1]</td><td>Number of mean values</td><td>20</td></tr>
</table>

	_ SPEED[ ]			
	Traversing velocities for intermediate positioning			
	Min. input limit: 0		Max. input limit: -	
Changes valid after value assignment		Protection level: -	Units: -	
Data type REAL			Applies as of SW 3.2	
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! Excessive values 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 output.

- **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			Applies as of SW 6.2
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			Applies as of SW 6.2
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			Applies as of SW 6.2
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			Applies as of SW 6.2
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		

9.2.7 Channel-oriented bits

9.2.7.1 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			Applies as of SW 3.2
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, CYCLE9997!** 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
	_CHBIT[24]	Channel-oriented flag for basic dimension system (on deviation from MD 10240, cycle parameters are converted internally and this bit is reset.) 0: the basic system is inch 1: the basic system is metric	1

9.2.7.2   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.

From measuring cycles SW 6.3, an offset in the set-up/additive offset can also be programmed. 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)

Channel-oriented marker for basic dimension system

_CHBIT[24]=0:	Basic system is based on inches
_CHBIT[24]=1:	The basic system is metric

When starting up the measuring cycles, this bit has to be set according to the basic settings of the PLC (MD 10240: SCALING_SYSTEM_IS_METRIC) must be set.

If modifying the basic settings of the control results in _CBIT[24] no longer matching MD 10240, the channel-specific dimensioned values are converted in each channel the first time a measuring cycle is called.

9.3 Data for measuring in JOG

9.3.1 Machine data for ensuring operability

11602	ASUP_START_MASK		
MD number	Ignore stop conditions for ASUB		
Default setting: 0[1] Default setting: 0[2] **For measuring in JOG: 1, 3** **(Bit 0 = 1)**	Min. input limit: 0		Max. input limit: 3
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type DWORD			Applies as of SW 4.1
Significance:	Bit 0: 1 ASUB start possible in JOG.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

11604	ASUP_START_PRIO_LEVEL		
MD number	Priorities for "ASUP_START_MASK" effective		
Default setting: 0[1] Default setting: 0[2] **For measuring in JOG: 1 - 64H**	Min. input limit: 0		Max. input limit: 64H
Changes effective after POWER ON		Protection level: 2/7	Units: HEX
Data type INTEGER			Applies as of SW 4.1
Significance:	"ASUP_START_MASK" included from ASUB priority "64H" to ASUB priority 1.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

20050	AXCONF_GEOAX_ASSIGN_TAB[i]		
MD number	Assignment of geometry axes to channel axes [i = Geometry axis index]: 0 ... 2		
Default setting: 1, 2, 3[1] Default setting: 1, 2, 3[2] **For measuring in JOG:** **all 3 geometry axes must be present**	Min. input limit: 0		Max. input limit: 15
Changes effective after POWER ON		Protection level: 2/7	Units: -
Data type BYTE			Applies as of SW 1
Significance:	The MD specifies channel axes onto which the axes of the Cartesian coordinate system (WCS) are mapped. Index i assumes values 0, 1, 2 and refers to the 1st, 2nd and 3rd geometry axis.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

20110	RESET_MODE_MASK		
MD number	Define control default setting after power-up and RESET		
Default setting: 0[1] Default setting: 1[2] **For measuring in JOG: at least 4045H** **(Bit 0 = 1, Bit 2 = 1, Bit 6 = 1, Bit 14 = 1)**	Min. input limit: 0		Max. input limit: 07FFFH
Changes effective after RESET		Protection level: 2/7	Units: HEX
Data type DWORD			Applies as of SW 2
Significance:	Bit 0: 1 tool length offset active. Bit 2: 1 The tool length correction last selected is active after POWER ON. Bit 6: 1 The tool length correction last selected is active after POWER ON. Bit 14: 1 The current setting of the basic frame is retained.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

20112	START_MODE_MASK		
MD number	Define control default setting after part program start		
Default setting: 400H[1] Default setting: 400H[2] **For measuring in JOG: 400H** **(Bit 6 = 0)**	Min. input limit: 0		Max. input limit: 07FFFH
Changes effective after RESET		Protection level: 2/7	Units: HEX
Data type DWORD			Applies as of SW 3.2
Significance:	Bit 6: 0 active tool length correction is retained.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

20310	TOOL_MANAGEMENT_MASK		
MD number	Channel-specific activation of tool management Note: MD only relevant if tool management is active (bit 0 = 1)		
Default setting: 0[1] Default setting: 0[2] **For measuring in JOG: at least 4001H** **(Bit 0 = 1, Bit 14 = 1)**	Min. input limit: 0		Max. input limit: 0FFFFH
Changes effective after POWER ON		Protection level: 2/7	Units: HEX
Data type DWORD			Applies as of SW 2
Significance:	Bit 0: 1 tool management active. Bit 14: 1 Automatic tool change on RESET and START according to MD 20110: RESET_MODE_MASK.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

24006	CHSFRAME_RESET_MASK		
MD number	Reset behavior of the channel-specific system frame, actual value setting and scratching (basis reference)		
	Note: MD only relevant if frames are configured (MD 28082 SYSTEM_FRAME_MASK)		
Default setting: 0[1] Default setting: 0[2] **For measuring in JOG: at least 1** **(Bit 0 = 1)**	Min. input limit: 0		Max. input limit: 07FFFH
Changes effective after RESET		Protection level: 2/7	Units: HEX
Data type DWORD			Applies as of SW 2
Significance:	Bit 0: 1 system frame for PRESET and scratching (basis reference) is active after RESET.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

24007	CHSFRAME_RESET_CLEAR_MASK		
MD number	Clear system frames on RESET		
	Note: MD only relevant if frames are configured (MD 28082 SYSTEM_FRAME_MASK)		
Default setting: 0[1] Default setting: 0[2] **For measuring in JOG: Bit 0 = 0**	Min. input limit: 0		Max. input limit: 07FFFH
Changes effective after RESET		Protection level: 2/7	Units: HEX
Data type DWORD			Applies as of SW 2
Significance:	Bit 0: 0 system frame for PRESET and scratching (basis reference) is not deleted at RESET.		
1) up to NCK software version 59.xx.yy 2) as of NCK software version 63.xx.yy			

9.3.2　Modifying the GUD7 data block

General information

Measurement in JOG requires data definitions in data block GUD7.DEF.

Different procedures are followed depending on the configuration of the overall system.

1. If the "ShopMill" programming interface is installed on the control, then all of the required GUD data are already active. No reloading or additional modification of definition blocks is required.

2. From SW 6.02.17 of the measuring cycle package, the definition files GUD7.DEF and SMAC.DEF are split-up. Now a differentiation is made between basis definition files and application-specific definition files. All applications, measuring cycles, technology cycles, ShopMill etc. only incorporate their own application-specific definitions. For this purpose, new cycle files GUD7_xxx.DEF and SMAC_xxx.DEF have been introduced, and are located in the HMI data management, in the definition directory DEF.DIR. This means, when measuring in JOG, from measuring cycles SW 6.02.17, the data block GUD7_MC.DEF supplied must be used. A secondary condition/limitation is that file GUD7.DEF must be used – also for measuring cycles from SW 6.02.17

Commissioning "measuring in JOG" for the first time, up to measuring cycles SW 6.2.16

1. In this case, definition block GUD7.DEF must be modified. Select definition file GUD7.DEF in menu "Services" in directory "Definitions" with the arrow keys and unload it by pressing the softkey "Unload". Before modifying data in GUD7, the "old" data should be backed-up (archived). Then open file GUD7.DEF by pressing the Enter key. In the section "**Measure**", remove the semicolons at the beginning of each definition line with the DEL key. This affects the definition lines as from the comment "Definitions for measurement in JOG and ShopMill" (starting with data item E_MESS_IS_METRIC).

```
DEF CHAN INT        E_MESS_IS_METRIC=1
DEF CHAN INT        E_MESS_IS_METRIC_SPEZ_VAR=1
DEF CHAN BOOL       E_MESS_MS_IN=0
DEF CHAN BOOL       E_MESS_MT_IN=1
DEF CHAN REAL       E_MESS_D=5
DEF CHAN REAL       E_MESS_D_M=50
DEF CHAN REAL       E_MESS_D_L=2
DEF CHAN REAL       E_MESS_D_R=1
DEF CHAN REAL       E_MESS_FM=300
DEF CHAN REAL       E_MESS_F=2000
DEF CHAN REAL       E_MESS_FZ=2000
DEF CHAN REAL       E_MESS_MAX_V=100
DEF CHAN REAL       E_MESS_MAX_S=1000
DEF CHAN REAL       E_MESS_MAX_F=20
DEF CHAN REAL       E_MESS_MIN_F=1
DEF CHAN REAL       E_MESS_F_FAK1=10
DEF CHAN REAL       E_MESS_F_FAK2
DEF CHAN REAL       E_MESS_MIN_D=0.01
DEF CHAN INT        E_MESS_MS_SOUTH=1
DEF CHAN INT        E_MESS_MS_MONO=0
DEF CHAN INT        E_MESS_MT_TYP[3]=SET(0,0,0)
DEF CHAN INT        E_MESS_MT_AX[3]=SET(133.133.133)
DEF CHAN REAL       E_MESS_MT_DL[3]
DEF CHAN REAL       E_MESS_MT_DR[3]
DEF CHAN REAL       E_MESS_MT_DZ[3]=SET(2,2,2)
DEF CHAN INT        E_MESS_MT_DIR[3]=SET(-1,-1,-1)
DEF CHAN REAL       E_MESS_MT_D=10
DEF CHAN REAL       E_MESS_MT_FM=100
DEF CHAN INT        E_MESS_MT_CF
DEF CHAN INT        E_MESS_MT_COMP
DEF CHAN REAL       E_MESS[3]
DEF CHAN REAL       E_MEAS
DEF CHAN BOOL       E_MESS_SETT[10]
```

Possibility of minimizing the memory requirements

The number of available data fields (data arrays) regarding the measuring probes that can be connected, can be adapted by the machinery manufacturer to the specific relationships and situations. When supplied, 3 data fields (data arrays) are available for tool measuring probes (MCS-WCS-related), workpiece measuring probes and calibration gauging blocks. If, for example, in the specific application case, only one data field (data array) is required for the workpiece and the tool measuring probe, and there is no gauging block available, then the appropriate parameters can be adapted in data block GUD6 and in GUD7.DEF and GUD7_MC.DEF. The details can be taken from the following example.

Example:

There is only one tool and workpiece measuring probe on a specific milling machine. The tool is to be only gauged in the interpolation plane G17.

In order to minimize the NC memory requirement in the SINUMERIK, the following changes are required:

- GUD7.DEF or GUD7_MC.DEF

```
DEF CHAN INT        E_MESS_MT_TYP[1]=SET(0)
DEF CHAN INT        E_MESS_MT_AX[1]=SET(133)
DEF CHAN REAL       E_MESS_MT_DL[1]
DEF CHAN REAL       E_MESS_MT_DR[1]
DEF CHAN REAL       E_MESS_MT_DZ[1]=SET(2)
DEF CHAN INT        E_MESS_MT_DIR[1]=SET(-1)
DEF CHAN INT        E_MESS_CALL_D[1]=SET(0)
DEF CHAN INT        E_MESS_CALL_L[1]=SET(0)
```

- GUD6.DEF

```
N10 DEF NCK INT _CVAL[4]=(1,1,0,3)      ;1x tool and 1x workpiece probe data set
N11 DEF NCK REAL _TP[1,10]=(0,0,0,0,0,0,0,133,0,2)
N12 DEF NCK REAL _WP[1,11]
;N111 DEF NCK REAL _TPW[3,10]
```

The definition blocks should be opened in the HMI area Services\Definitions using the operator panel "INPUT key" and after editing, re-closed using the vertical softkey "Close editor"; i.e. to save and to activate.

Basic settings of GUD7_MC.DEF

Note

For HMI with ShopMill

If the settings for "Measuring in JOG" or "Measuring in manual" need changing, this should preferably be done in the display machine data for ShopMill. The corresponding cross-references between the ShopMill display machine data and the GUD7_MC parameters can also be seen in the following table!

MD ShopMill	Date	Data type	Meaning	
	E_MESS_IS_METRIC=1 E_MESS_IS_METRIC_SPEZ_VAR=1	INTEGER	All dimensioned data are metric	
9750	E_MESS_MS_IN=0	BOOL	Work piece probe connected to measuring input 1	
9751	E_MESS_MT_IN=1	BOOL	Tool probe connected to measuring input 2	
9752	E_MESS_D=5	REAL	Internal data for measuring in JOG not relevant	
9753	E_MESS_D_M=50	REAL	Measuring path for manual measuring [mm] (in front of and behind meas. point)	
9754	E_MESS_D_L=2	REAL	Measuring path for length measurement [mm] for tool measurement (in front of and behind the measuring point)	
9755	E_MESS_D_R=1	REAL	Measuring path for radius measurement [mm] for tool measurement (in front of and behind the measuring point)	
9756	E_MESS_FM=300	REAL	Measuring feedrate [mm/min] for workpiece measurement and calibration	
9757	E_MESS_F=2000	REAL	Plane feedrate for collision monitoring [mm/min]	
9758	E_MESS_FZ=2000	REAL	Infeed feedrate for collision monitoring [mm/min]	
	E_MESS_CAL_D=[3]	REAL	Diameter, calibration ring [mm]	0
	E_MESS_CAL_L=[3]	REAL	Calibration height in the feed axis (referred to the WCS) [mm]	0
9759	E_MESS_MAX_V=100	REAL	Max. peripheral speed for measuring with rotating spindle [m/min]	
9760	E_MESS_MAX_S=1000	REAL	Max. spindle speed for measuring with rotating spindle [rpm]	
9771	E_MESS_MAX_F=20	REAL	Max. feedrate for measuring with rotating spindle [mm/min]	
9761	E_MESS_MIN_F=1	REAL	Min. feedrate for measuring with rotating spindle on 1st probing [mm/min]	
9769	E_MESS_F_FAK1=10	REAL	On tool measurement with rotating spindle, traversal with 10 times measuring feed is performed in the 1st probing (limitation by E_MESS_MAX_F)	
9770	E_MESS_F_FAK2=0	REAL	For tool measurement with rotating spindle, 2nd probing is performed with measuring feed. There is no 3rd probing.	
9762	E_MESS_MIN_D=0.01	REAL	Measuring accuracy for measuring with rotating spindle [mm/min]	
9763	E_MESS_MT_TYP[3]=SET(0,0,0)	INTEGER	3 arrays for tool measuring probe; tool measuring probe type; cube	
9764	E_MESS_MT_AX[3]=SET(133.133.133)	INTEGER	Permissible axis directions for tool probes in X and Y in plus and minus direction, in Z in minus direction only	
9765	E_MESS_MT_DL[3]	REAL	Active diameter of tool measuring probe for length measurement	0
9766	E_MESS_MT_DR[3]	REAL	Active diameter of tool measuring probe for radius measurement	0
9767	E_MESS_MT_DZ[3]=SET(2,2,2)	REAL	Distance between upper edge of tool probe and lower edge of tool probe [mm] when measuring the tool radius	2

9768	E_MESS_MT_DIR[3]=SET(-1,-1,-1)	INTEGER	Approach direction in plane of tool measuring probe for tool measurement (minus direction in 1st plane axis)	-1
9772	E_MESS_MT_D=10	REAL	Calibrate measurement path for tool probe and tool measurement with motionless spindle (before and after expected switching position)	
9773	E_MESS_MT_FM=100	REAL	Calibrate measuring feed for tool probe and tool measurement with motionless spindle	
9774	E_MESS_MT_CF=0	INTEGER	No tool probe make (manufacturer) specified	
9775	E_MESS_MT_COMP=0	INTEGER	No offset of the measurement result on tool measurement with rotating spindle	
	E_MESS[3]	REAL	Internal values	
	E_MEAS	REAL	Internal values	
	E_MESS_RETT	FRAME	Internal values	
9776	E_MESS_SETT[10]	BOOL	Field for settings	
	E_MESS_AM	BOOL	Internal values	
9778	E_MESS_MS_SOUTH01	INTEGER	Probe is used with reference to the probe sphere end	
9779	E_MESS_MS_MONO=0	INTEGER	Probe is treated as multi probe	

NOTICE
Arrays E_MESS_MT_DL[] and E_MESS_DR[] (active diameter, width of tool measuring probe for length/radius measurement) must be assigned.

E_MESS_SETT[ ]			
Field for settings			
	Min. input limit: 0		Max. input limit: 1
Changes valid after value assignment		Protection level: -	Units: -
Data type BOOL			Applies as of SW 6.2
Significance:			Preset default
	E_MESS_SETT[0	0: Spindle coupling with coordinate rotation 1: Spindle position on cycle call is initial position	0
	E_MESS_SETT[1...9]	Internal data item	

9.3.3 Settings in data block GUD6

The channel specific arrays _JM_I[ ], and _JM_B[ ] in data block GUD6 are used for adaptation to the requirements of the machine

N92 DEF CHAN INT _JM_I[10]=SET(0,1,1,17,100,0,0,0,0,0)

_JM_I[ ] INT value field for JOG measurement					
		Min. input limit: -		Max. input limit: -	
Changes valid after value assignment			Protection level: -	Unit: -	
Data type INTEGER				Applies as of SW 5.3	
Significance:					Preset default
	_JM_I [0]	Setting for the workpiece probe number			0
		0:	Set by _JM_I[1]		
		1:	Specified as with ShopMill G17 plane: Workpiece probe number 1 G18 plane: Workpiece probe number 2 G19 plane: Workpiece probe number 3		
	_JM_I [1]	Probe number and probe type for workpiece measurement only if JM_I[0]=0			1
	_JM_I [2]	Probe number for tool measurement			1
	_JM_I [3]	Plane			17
		17:	Measurement in G17 plane		
		18:	Measurement in G18 plane		
		19:	Measurement in G19 plane		
		Each other value: Measurement made in the plane defined by the machine data			
	_JM_I [4]	Definition of the active ZO on measurement			100
		0:	Measurement made with G500		
		1...99:	Measurement made with settable ZO defined G54...G57 or G505...G599 where 1: G54...4: G57 5...99: G505 ...G599		
		100:	Measurement made with ZO defined in machine data		
	_JM_I [5]	0:	Standard compensation (measuring only, basic reference, settable ZO)		0
		1:	Extended compensation (additional global and channel-specific basis frame)		
	_JM_I [6]	Internal copy of _JM_I[4]			
	_JM_I [7]	Reserved			
	_JM_I [8]	Reserved			
	_JM_I [9]	Reserved			

	_JM_B[ ]				
	BOOL value field for JOG measurement				
		Min. input limit: -		Max. input limit: -	
Changes valid after value assignment			Protection level: -	Unit: -	
Data type BOOLEAN				Applies as of SW 5.3	
Significance:					Preset default
	_JM_B[0]	Tool offset mode for tool measurement			0
		0	Offset in geometry on tool measurement		
		1	Offset in wear		
	_JM_B[1]	Number of measurement attempts			1
		0	5 measurement attempts		
		1	1 measurement attempt		
	_JM_B[2]	Retraction from the measuring location			0
		0	Retraction as for intermediate positioning		
		1	Retraction with rapid traverse		
	_JM_B[3]	Fast measuring feed			0
		0	Measuring with measuring feed		
		1	1st measuring with feed in _SPEED[3] 2nd measuring with measuring feed		
	_JM_B[4]	0	Selection "basic frame" in the screen means offset in last channel-specific basic frame		0
		1	Selection of "basis" in screen form means offset in "Setting zero point" system frame ($P_SETFRAME)		
	_JM_B[5]	unassigned			0
	_JM_B[6]	Internal data item			0

9.3.4 Loading files for measuring in JOG

File transfer from software supplied

The following files located in the JOG_MEAS\CYCLES\SPFFILES directory on the software supplied are transferred to the control into directory "Standard cycles" from the diskette in menu "Services" after selection of softkey "Data in", "Diskette" and selection of the file in question and then pressing the "Start" softkey. They must then be loaded into the NC memory by pressing the softkey "Load". After the next Power on, they are known to the control.

File	Description
CYC_JM.SPF	Auxiliary cycle for measuring
CYC_JMA.SPF	Aux. cycle for activation
CYC_JMC.SPF	Aux. cycle for calculation
E_MS_CAL.SPF	For calibrating a workpiece measuring probe
E_MS_CAN.SPF	To measure a corner
E_MS_HOL.SPF	To measure a hole

File	Description
E_MS_PIN.SPF	To measure a spigot/shaft
E_MS_POC.SPF	To measure a rectangular pocket
E_MS_SPI.SPF	To measure a rectangular spigot
E_MT_CAL.SPF	For calibrating a tool measuring probe
E_MT_LEN.SPF	For length measurement of a tool
E_MT_RAD.SPF	For radius measurement of a tool
E_SP_NPV.SPF	Auxiliary cycle for activating the ZO that is active during measurement

When performing a software upgrade, make sure the variable values in the existing DEF files are kept. Back them up first, if necessary!

Transfer other files

The following files must also be transferred to the control.

File	Description
JOG_MEAS.COM (up to meas. cycles SW 6.2)	Configuring file for measuring in JOG user interface
COM_FILE.COM (from meas. cycles SW 6.3)	
MA_JOG.COM (up to meas. cycles SW 6.2)	Configuring file for the softkeys for measuring in JOG in the JOG basic display
COM_FILE.COM (from meas. cycles SW 6.3)	
BMP_FILE.ARC (up to measuring cycles SW 6.2) BMP_FILE.EXE	Help displays for measuring in JOG
MC_CST0.ARC or MC_CST1.ARC (from measuring cycles SW 6.3)	All screens/displays

BMP_FILE.EXE contains:

File	Description
BMPJ640.EXE	Aux. displays, resolution 640 · 480
BMPJ800.EXE	Aux. displays, resolution 800 · 600
BMPJ1024.EXE	Aux. displays, resolution 1024 · 768

Note

Up-to-date information is provided in the file SIEMENSD.TXT or SIEMENSE.TXT of the software being supplied.

Start-up (hardware)

<div style="text-align: right; font-size: 3em;">10</div>

10.1 Commissioning measuring cycles for the first time

10.1.1 Requirements

- The hardware and software requirements of the measuring cycle version have been fulfilled (see chapter 8 "Hardware, software and installation").
- The probe is functional (Functional check probe connection → see chapter 8 "Hardware, software and installation").
- Before beginning start-up, the existing state should be archived; if necessary now export series start-up archive.

NOTICE
Heed the information on measuring cycle start-up in connection with ShopMill / ShopTurn in file SIEMENSD.TXT / SIEMENSE.TXT!

10.1.2 Overview of diskette in delivery form

Below you will find an overview of the folder structure of diskettes when delivered for measuring cycles as of SW 6.3. The content of the individual folders is not detailed. More information in the content can be found in the SIEMENSD.TXT / SIEMENSE.TXT file.

The folder structure shown is not a statement on the assignment of specific diskettes.

However, you can generally assume an ascending order, beginning with "Diskette 1".

\cycles	Measuring cycle programs (turning and milling)
\cycles\cyp_file	Files for version display in HMI
\cycles\deu	User cycles program - comments in German
\cycles\eng	User cycles program - comments in English
\cycles\spf_file	Individual cycle programs
\define	Data blocks, definitions for measuring cycles
\demo	Example programs: measuring cycles in simulation

\jog_meas	Files for measuring in JOG
\jog_meas\cycles\cyp_file	Files for version display in HMI
\jog_meas\cycles\spf_file	ndividual cycle programs
\jog_meas\define	Data blocks, definitions for measuring cycles
\jog_meas\hmi_adv	Files, images - zipped
\hmi_adv	Files for HMI Advanced
\hmi_emb	Files for HMI Embedded
\hmi_emb\mcresult	Files for measurement result display
\hmi_emb\mcsupp	Files for measuring cycle support, images
\hmi_emb\text	Current texts (alarm, reporting texts)
\hmi_emb\text\d	German
\hmi_emb\text\e	Spanish
\hmi_emb\text\f	French
\hmi_emb\text\g	English
\hmi_emb\text\i	Italian
\hmi_emb\tools	Tools for incorporating in HMI Embedded

10.2 Steps for commissioning measuring cycles for the first time

10.2.1 General information

Manufacturer password must be set! (HMI\Commissioning\Password)

10.2.2 Step 0.1 – set up memory configuring machine data

- Set memory configuring machine data for measuring cycles (for data see Section 9.1 "Machine data for executing measuring cycles" and the **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the delivered software).

- The following machine data must be observed:

  MD18118: MM_NUM_GUD_MODULES

  MD18120: MM_NUM_GUD_NAMES_NCK

  MD18130: MM_NUM_GUD_NAMES_CHAN

  MD18150: MM_GUD_VALUES_MEM

  MD18280: MM_NUM_FILES_PER_DIR

  MD18320: MM_NUM_FILES_IN_FILESYSTEM

  MD28082: MM_SYSTEM_FRAME_MASK

The following alarm is displayed after changes to the memory-configured parameters:

"4400 MD change results in reorganization of the buffered memory (loss of data!)"

The following operating sequences are needed to prevent data from being lost:

1. Read out NCK series machine start-up archive into the archive. (HMI\Services\>\Series start-up)

2. Read the read out NCK series machine back in.

10.2.3 Step 0.2 – set up other machine data

- Set other machine data for measuring cycles
  (for data see Section 9.1 "Machine data for executing measuring cycles" and the **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the delivered software).

- The following machine data must be observed:

  MD18170: MM_NUM_MAX_FUNC_NAMES

  MD18180: MM_NUM_MAX_FUNC_PARAM

  MD28020: MM_NUM_LUD_NAMES_TOTAL

  MD28040: MM_NUM_LUD_VALUES_MEM

  MD10132: MMC_CMD_TIMEOUT

  MD11420: LEN_PROTOCOL_FILE

  MD13200: MEAS_PROBE_LOW_ACTIV

- Then perform an NC reset. (HMI\Commissioning\NC reset)

10.2.4   Step 0.3 - set up machine data for measuring in JOG

- The following machine data should only be parameterized for the "Measuring in JOG" function (for details, see section 9.3 "Data for measuring in JOG")

- The following machine data must be observed:

  MD11602: ASUP_START_MASK

  MD11604: ASUP_START_PRIO_LEVEL

  MD20110: RESET_MODE_MASK

  MD20112: START_MODE_MASK

  MD20050: AXCONF_GEOAX_ASSIGN[i]

Then perform an NC reset. (HMI\Commissioning\NC reset)

HMI variants

The next steps of commissioning depend on the HMI hardware and software used.

HMI version (HMI\Diagnosis\Service displays\Version\HMI)

1. HMI-Advanced PCU50 powerline
    up to SW 06.03.18 or up to SW 06.04.08   → continue with section 10.3
    as of SW 06.03.19 or as of SW 06.04.10   → continue with section 10.4
2. HMI-Advanced PCU50 solution line   → continue with section 10.4
3. HMI-Embedded PCU20 powerline   → continue with section 10.5
4. HMI-Embedded TCU solution line SW 1.x   → continue with section 10.6

10.3 Commissioning measuring cycles for HMI-Advanced PCU50 powerline up to SW 06.03.18 and/or SW 06.04.08

10.3.1 Requirements

Successful execution of steps 0.1, 0.2 and optionally step 0.3 from chapters 10.2.2, 10.2.3 and 10.2.4.

10.3.2 Step 1 – load definition files

10.3.2.1 General

Variant 1

Modules GUD5.DEF and GUD6.DEF are not active in the NCU (HMI/Services/Manage data).

- Transfer GUD5.DEF and GUD6.DEF from the subdirectory "define" (supplied on floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using RS-232-C.
- Select the DEF modules singly (HMI/Services/Manage data) and press softkey "Activate".

Variant 2

Modules GUD5.DEF and GUD6.DEF are active in the NCU (HMI/Services/Manage data).

- Save data to the archive or floppy disk using "Services", "Data out", folder "NC-active data", "User data".
- Select definition files GUD5.DEF and GUD6.DEF individually in the menu "Services", directory "Definitions" and unload by pressing the softkey "Unload".
- Transfer GUD5.DEF and GUD6.DEF from the subdirectory "define" (supplied on floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.
- Select the DEF modules singly (HMI/Services/Manage data) and press softkey "Activate".

Note
Without measuring in JOG

Without this function, commissioning continues from step 2 in chapter 10.3.3.

10.3.2.2 Only for measuring in JOG up to measuring cycle release SW 6.02.16

Only for measuring in JOG up to measuring cycles SW 6.02.16

Variant 1

The GUD7.DEF is not active in the NCU. (HMI/Services/Manage data)

- Transfer GUD7.DEF from the subdirectory "define" (supplied on a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.
- Adjust GUD7.DEF (refer to Subsection 9 "Modifying the GUD7 data block").
- Select the DEF module (HMI/Services/Manage data) and press softkey "Activate".

Variant 2

The GUD7.DEF is already active in the NCU. (HMI/Services/Manage data)

- Save data to the archive or floppy disk using "Services", "Data out", folder "NC-active data", "User data".
- Select definition file GUD7.DEF in menu "Services" in directory "Definitions" with the arrow keys and unload it by pressing the softkey "Unload".
- Transfer GUD7.DEF from the subdirectory "define" (supplied on a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.
- The DEF module then has to be adjusted (you will find more details in Subsection 9.3.2 "Modifying the GUD7 data block").
- Once the DEF module has been adjusted, select it (HMI/Services/Manage data) and press softkey "Activate".
- Read the data saved at the beginning back in again via "Services", "Data in".

Only when measuring in JOG from measuring cycles SW 6.3 (also from patch measuring cycles SW 6.02.17) with HMI Advanced from SW 6.3

Variant 1

Modules GUD7.DEF and GUD7_MC.DEF are not active in the NCU. (HMI/Services/Manage data)

- Transfer GUD7.DEF and GUD7_MC.DEF from the subdirectory "define" (supplied as a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.
- Select the GUD7_MC.DEF module in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Load HD → NC". Then select module GUD7.DEF and press softkey "Activate".

Variant 2.1

The GUD7.DEF is already active in the NCU, the GUD7_MC.DEF is not active. (HMI/Services/Manage data)

- Save data to the archive or floppy disk using "Services", "Data out", folder "NC-active data", "User data".

- Select definition file GUD7.DEF in menu "Services" in directory "Definitions" with the arrow keys and unload it by pressing the softkey "Unload".

- Transfer GUD7.DEF and GUD7_MC.DEF from the subdirectory "define" (supplied as a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.

- Select the GUD7_MC.DEF module in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Load HD → NC". Then select module GUD7.DEF and press softkey "Activate".

- Read the data saved at the beginning back in again via "Services", "Data in".

Variant 2.2

The GGUD7.DEF and GUD7_MC.DEF are not active in the NCU. (HMI/Services/Manage data)

- Save data to the archive or floppy disk using "Services", "Data out", folder "NC-active data", "User data".

- Select definition files GUD7.DEF and GUD7_MC.DEF individually in the menu "Services", directory "Definitions" and unload by pressing the softkey "Unload".

- Transfer GUD7.DEF and GUD7_MC.DEF from the subdirectory "define" (supplied as a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.

- Select the GUD7_MC.DEF module in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Load HD → NC". Then select module GUD7.DEF and press softkey "Activate".

- Read the data saved at the beginning back in again via "Services", "Data in".

10.3.3   Step 2 – load cycle programs

- Read in the cycles from the subdirectory "cycles" (supplied as a floppy disk) from the floppy disk or using V.24.

  The cycles can be read in individually or as a package depending on the technology.

  The following packages are available in the software supplied:

  - mcycles.spf   → all measuring cycles for milling and turning
  - mcycmill.spf   → all measuring cycles for milling technology
  - mcycturn.spf   → all measuring cycles for turning technology

- If new cycles are added, load these in the NCU if necessary.

- Run NC reset to update the cycle interface (HMI/Commissioning/NC reset)

10.3.4   Step 3 – load measuring cycle text files

When using measuring cycles, the measuring cycle text files have to be loaded afterward.

- The file mc_text.com out of directory "hmi_adv" is loaded from the floppy disk or via V.24.

  It contains the measuring cycle text files in the five standard languages.

If you require languages other than the standard languages, please order the appropriate HMI language versions.

10.3.5 Step 4 – load files for measurement result display

- The following files are loaded via V.24 or from the floppy disk out of directory "hmi_adv"

  – MCRESULT.COM

  – BMP_RESU.ARC

- After loading the files for the measurement result displays, check and adjust the entry for the text format in system file HMI MMC2\MBDDE.INI if necessary. The entry for indicating the measurement result displays must be changed from

  – MEASURE_CYCLES_RESULT=DOS

    to

  – MEASURE_CYCLES_RESULT=

  (delete DOS!).

10.3.6 Step 5 – load measuring cycle support

- The following files are needed from the software supplied from subdirectory "hmi_adv":

  – hmi_adv\bmp_xxx.exe (displays for measuring cycle support, xxx stands for the screen resolution)

  – hmi_adv\mcsupp.com
    hmi_adv\aeditor.com
    hmi_adv\startup.com

- Handling the EXE file:

  – This file is not loaded into the control, but initially has to be loaded onto a PC. When this file is started, it is unpacked automatically and the following archive is produced: MZ_BMP01.ARC ... MZ_BMPxx.ARC

  – These must be copied onto floppy disk and downloaded into the HMI or via V.24 (binary format). These archives contain the bitmaps for measuring cycles support.

- Handling the COM file:

  – Load MCSUPP.COM, AEDITOR.COM, and STARTUP.COM from floppy disk or via RS-232-C, then restart HMI.

10.3.7 Step 6 – activate measuring cycle support, configure

The entry softkeys "Measure turning" and "Measure milling" for measuring cycle support are activated in the file AEDITOR.COM ("Services" are in the directory "Standard cycles") by deleting the semicolons in front of the following lines:

```
;HS14=($83530,,se1)

;PRESS(HS14)

;LS("D_mess","MZ_SKL.COM",1)

;END_PRESS

;HS15=($83531,,se1)

;PRESS(HS15)

;LS("F_mess","MZ_SKL.COM",1)

;END_PRESS
```

The entry softkey "Measuring cycles" in the "Commissioning" area is activated in the file STARTUP.COM ("Services" are in the directory "Standard cycles") by deleting the semicolons in front of the following lines:

```
;HS15=($83070,,se1)

;PRESS(HS15)

;LS("Meas. c")

;END_PRESS
```

Press the etc. key ">" in the "Commissioning" area, then press the softkeys "Measuring cycles", "Automatic measuring". A start-up screen in which the settings for the measuring cycle screens can be undertaken is then displayed . The settings for the start-up screen are saved in an integer type GUD field "_MZ_MASK". This is located in the GUD6 under NCK global data.

10.3.8 Step 7 - load and activate measuring in JOG

- Load the files for measurement in JOG (see Subsection 9.3.4 "Loading files for measurement in JOG").

- Activate softkeys for measurement in JOG in file "MA_JOG.COM" by deleting semicolons. The semicolons before the following lines must be deleted:

```
;HS4=($83358,ac7,se1)

;PRESS(HS4)

;LM("Messen1","jog_meas.com")

;END_PRESS

;HS5=($83359,ac7,se1)

;PRESS(HS5)

;LM("Messen2","jog_meas.com")

;END_PRESS
```

10.3.9 Step 8 – set measuring cycle data

- Check default values of the GUD variables and set other values, if necessary.

- That is done by selecting and changing the variables in "Parameters", "User data" … or using a program (see Section 9.3).

- Data description (see Section 9.2 "Cycle data", Section 9.3 "Data for measuring in JOG" and **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the software delivered).

10.4 Commissioning measuring cycles for HMI-Advanced PCU50 powerline as of SW 06.03.19. and/or SW 06.04.10 and HMI-Advanced PCU50 Solutionline

10.4.1 Requirements

Successful execution of steps 0.1, 0.2 and optionally step 0.3 from chapters 10.2.2, 10.2.3 and 10.2.4.

10.4.2 Step 1 – load definition files

Load the archive specified for each measuring cycle release using "Services", "Data in", "Archive", "Cycles archive", "Measuring cycles" (\ARC\CYC\MCYC.DIR):

For measuring cycles SW6.2

DEFINES.ARC	Archive with definition files (GUD5.DEF, GUD6.DEF)
JOGDEF.ARC	Archive with definition file (GUD7_MC.DEF)

NOTICE
Only load the JOGDEF.ARC archive if ShopMill is not installed!

For measuring cycles SW6.3

DEFINES.ARC	Archive with definition files (GUD5.DEF, GUD6.DEF, GUD7_MC.DEF)
JOGDEF.ARC	Empty archive which does not have to be loaded.

Select the GUD5.DEF and/or GUD6.DEF modules singly in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Activate".

Only for measuring in JOG measuring cycles SW 6.2 and SW 6.3

Select the GUD7_MC.DEF module in the area "Services", "Manage data", in the folder "Definitions".

Press softkey "Load HD → NC".

Then select module GUD7.DEF and press softkey "Activate".

Start-up (hardware)

10.4 Commissioning measuring cycles for HMI-Advanced PCU50 powerline as of SW 06.03.19. and/or SW 06.04.10 and HMI-Advanced PCU50 Solutionline

The following questions:

"Do you want to activate the definitions from file GUD7.DEF?" and if required "Should the previous values for the definitions be retained?" on HMI

should be answered with "Yes".

Note

The GUDs of the measuring cycles are therefore activated and can if necessary be viewed in the "Parameter" area, "User data".

10.4.3   Step 2 – load other archive

Load the archive files needed using the "Start" softkey using "Services", "Data in", "Archive", "Cycles archive", "Measuring cycles" (\ARC\CYC\MCYC.DIR).

Overview of the archive:

CYCCUST_GR.ARC	Archive for user cycles (CYCLE198, CYCLE199) German
CYCCUST_UK.ARC	Archive for user cycles (CYCLE198, CYCLE199) English
JOGMCYC.ARC	Archive with cycles for measuring in JOG
MCSUPP.ARC	Archive with files for measuring result display and MZU
MCYCLES.ARC	Archive with all measuring cycles (milling and turning)
MCYCMILL.ARC	Archive with all milling measuring cycles
MCYCTURN.ARC	Archive with all turning measuring cycles
MC_TEXT.ARC	Archive with reporting and alarm texts
SIEMENSD.ARC	Archive with info on commissioning and using measuring cycles in German
SIEMENSE.ARC	Archive with info on commissioning and using measuring cycles in English
VERSION.ARC	Archive with files for the version display

For meas. cycles SW 6.2:

MCRESULT.ARC	Files for measurement result display (com files)

For meas. cycles SW 6.3:

MCRESULT.ARC	Empty archive which does not have to be loaded

The following archives must be loaded:

- for milling machines (with measuring in JOG):
    - CYCCUST_GR.ARC
    - JOGMCYC.ARC
    - MC_TEXT.ARC
    - MCSUPP.ARC
    - MCYCMILL.ARC

- for turning machines:
  - CYCCUST_GR.ARC
  - MC_TEXT.ARC
  - MCSUPP.ARC
  - MCYCTURN.ARC.

Once loaded, run a NC reset to update the cycle interface.

10.4.4 Step 3 - activate entry softkeys "Measure turning" and "Measure milling" for measuring cycle support

Use the Enter key to open AEDITOR.COM in the "Services" operating area in the "Standard cycles" directory.

The semicolons before the following lines must be deleted:

```
;HS14=($83530,,se1)
;PRESS(HS14)
;LS("D_mess","MZ_SKL.COM",1)
;END_PRESS
;HS15=($83531,,se1)
;PRESS(HS15)
;LS("F_mess","MZ_SKL.COM",1)
;END_PRESS
```

10.4.5 Step 4 - activate softkey "Measuring cycles" in the "Commissioning" area

Use the Enter key to open STARTUP.COM in the "Services" operating area in the "Standard cycles" directory and delete the semicolons in front of the following lines:

```
;HS15=($83070,,se1)
;PRESS(HS15)
;If SYSTEM ==1
;LS("Messz","mz_einst.com")
;Else
;LS("Messz1","mz_einst.com")
;EndIf
;END_PRESS
```

Start-up (hardware)

10.4 Commissioning measuring cycles for HMI-Advanced PCU50 powerline as of SW 06.03.19. and/or SW 06.04.10 and HMI-Advanced PCU50 Solutionline

10.4.6 Step 5 - activate entry softkeys "Measure workpiece" and "Measure tool" for measuring in JOG in the machine's "JOG" area

Use the Enter key to open MA_JOG.COM in the "Services" operating area in the "Standard cycles" directory.

The semicolons before the following lines must be deleted:

```
;HS4=($83358,ac7,se1)
;PRESS(HS4)
;LM("Messen1","jog_meas.com")
;END_PRESS
;HS5=($83359,ac7,se1)
;PRESS(HS5)
;LM("Messen2","jog_meas.com")
;END_PRESS
```

10.4.7 Step 6 – set measuring cycle data

- Check default values of the GUD variables and set other values, if necessary.
- That is done by selecting and changing the variables in "Parameters", "User data" … or using a program (see Section 9.3).
- Data description (see Section 9.2 "Cycle data", Section 9.3 "Data for measuring in JOG" and **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the software delivered).

10.5 Commissioning measuring cycles for HMI-Embedded PCU20 powerline

10.5.1 Requirements

- Successful execution of steps 0.1 and 0.2 from chapters 10.2.2 and 10.2.3.
- As of V06.03.30 of HMI-Embedded, the measuring cycles are integrated in the software.
- Only the following steps 1 to 5 are needed for further commissioning.

10.5.2 Step 1 – load definition files

- Transfer GUD5.DEF and GUD6.DEF from the subdirectory "define" to the NCU using "Services", "Data in" (e.g. using V.24 or floppy disk).
- Select blocks singly and press softkey "Activate".

10.5.3 Step 2 – load cycle programs

- Load SPF files for the cycles into NCU from the directory "cycles" (or individual cycles from the directory \cycles\spf_file).
- Run NC reset to update the cycle interface

10.5.4 Step 3 – set measuring cycle data

- Check default values of the GUD variables and set other values, if necessary.
- That is done by selecting and changing the variables in "Parameters", "User data" … .

  Data description (see Section 9.2 "Cycle data" and **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the software delivered).

10.5.5 Step 4 – menu tree for extending measuring cycles

- Adjust file common.com and then load the following file in NCU:
  - hmi_emb\mcsupp\common.com
  - Adaptation: Remove semicolon in front of SC617, SC326, and SC327
- Then load the file in the NCU and perform an NC reset.

10.5.6 Step 5 – configure measuring cycle support

The measuring cycle screen forms can be set via GUD field _MZ_MASK. It is of type integer and is located in the GUD6 under NCK global data. In the "Start-up" operating area under softkey "Meas. cycles", "Measure automatic", a start-up screen form appears allowing you to make the settings.

Note

For additional commissioning steps:

The following steps are only needed if HMI-Embedded does not yet contain a cycle release or the existing software release is to be upgraded.

10.5.7 Step 6 – incorporate text files

When using measuring cycles with HMI up to measuring cycle version 6.2, the measuring cycle text files have to be loaded afterward.

Newer versions already contain the text files of the measuring cycles in the standard languages.

If you require languages other than the standard languages, please order the appropriate HMI language versions.

- The text files(almc.txt, alz.txt) are supplied individually in the following directories. More information can be found in SIEMENSD.TXT / SIEMENSE.TXT.

\hmi_emb\text	
\hmi_emb\text\d	Text files German
\hmi_emb\text\e	Text files Spanish
\hmi_emb\text\f	Text files French
\hmi_emb\text\g	Text files English
\hmi_emb\text\i	Text files Italian

- Out of the language-specific files ALMC.TXT and ALZ.XT, select the files of the required language path.

- Incorporate the text files in the HMI-Embedded software (see HMI-Embedded Upgrading Instructions).

10.5.8 Step 7 – incorporate files for measurement result display

- The following files must be incorporated in the HMI-Embedded software for the measurement result display.

  – HMI_EMB\MCRESULT\MZBILD01.COM

  – HMI_EMB\MCRESULT\MZBILD02.COM

  – HMI_EMB\MCRESULT\MZBILD03.COM

  – HMI_EMB\MCRESULT\MZBILD04.COM

- The MZBILDnn.COM files are incorporated packed as MZBILDnn.CO_.

  Commands for packing:

  – arj a MZBILD01.CO_ MZBILD01.COM

  – arj a MZBILD02.CO_ MZBILD02.COM

  – arj a MZBILD03.CO_ MZBILD03.COM

  – arj a MZBILD04.CO_ MZBILD04.COM

10.5.9 Step 8 – incorporate measuring cycle support

- A tool make_com.bat is supplied for packing the COM files for the measuring cycle support.

- Sequence:

  Set-up an empty directory and copy the following files there:

  – hmi_emb\mcsupp*.com

  – hmi_emb\tools\arj.exe

  – hmi_emb\tools\make_com.bat

- Start make_com.bat

- Incorporate the *.co_ files in the HMI-Embedded software (see HMI-Embedded Upgrading Instructions).

10.5.10 Step 9 – incorporate displays for measuring cycle support

- The tools make_cst.bat, mcst_800.bat and mcst1024.bat for three screen sizes (OP10, OP12, OP15) are supplied for packing the Bitmap files for the measuring cycle support.

- Sequence:

  Set-up an empty directory with two subdirectories and copy the following files there: In the 1st subdirectory which should be set up with the name "mcsupp":

  – hmi_emb\mcsupp*.exe and *.arj

  In the 2nd subdirectory which can be set up with any name:

  – hmi_emb\tools\arj.exe

  – hmi_emb\tools\arj_idx.exe

  – hmi_emb\tools\bmp2bin.exe

  – hmi_emb\tools\make_cst.bat or mcst_800.bat or mcst1024.bat

  – hmi_emb\tools\sys_conv.col

- Start the Batch file depending on screen size. Another directory called "bmp_file" is produced in the 2nd subdirectory.

- Incorporate the files "cst.arj" and "cst_idx.arj" from the directory "bmp_file" in the HMI-Embedded software (see HMI-Embedded Upgrading Instructions).

10.5.11   Step 10 - produce image file and program on a Flash card

Once the measuring cycle files from the previous steps have been incorporated in the HMI-Embedded software, a "PCU_20.ABB" image file now has to be produced.

This file should be programmed on a corresponding Flash.

For a precise description of this process, see the HMI-Embedded Upgrading Instructions.

10.6 Commissioning measuring cycles, HMI-Embedded TCU solution line SW 1.x

10.6.1 Requirements

The software release of the measuring cycles to be started up must be present on the CF card.

Up to NCK 63.xx.xx, the following machine data from steps 0.1 and 0.2 from chapters 10.2.2 and 10.2.3 should be checked:

- MD18130: MM_NUM_GUD_NAMES_CHAN
- MD18180: MM_NUM_MAX_FUNC_PARAM
- MD11420: LEN_PROTOCOL_FILE
- MD28082: MM_SYSTEM_FRAME_MASK

10.6.2 Step 1 – load archive

Load the archive files needed:

CYCCUST_GR.ARC	Archive for user cycles German
CYCCUST_UK.ARC	Archive for user cycles English
MCYCLES.ARC	Archive with all measuring cycles (milling and turning)
MCYCMILL.ARC	Archive with all milling measuring cycles
MCYCTURN.ARC	Archive with all turning measuring cycles
DEFINES.ARC	Archive with definition files (GUD5.DEF, GUD6.DEF, GUD7_MC.DEF)
JOGMCYC.ARC	Archive with all measuring cycles for measuring in JOG

In the "Services" area, softkey "Program data", use the cursor keys to change to "Cycle storage" and use the Input key to open.

In the "Cycle storage" area, use the cursor keys to change to "Measuring cycles" and use the Input key to open. Load the archive files needed using the 1st vertical softkey "Load archive". It should be noted that the archive files have to be selected and loaded individually. Once all the archive files needed have been loaded, an NC reset should be run via the operating area "Commissioning" softkey "NC reset".

10.6.3 Step 2 – activate definition files

In the "Program" operating area, use the etc. key ">" to change to the 3rd level. Press the softkey "Definition files", then individually select the definitions GUD5.DEF, GUD6.DEF, and GUD7.DEF and press the softkey "Activate".

10.6.4 Step 3 - activate entry softkeys "Measure turning" and "Measure milling" for measuring cycle support

Use the Enter key to open the file "common.com" in the "Program", "Standard cycles" operating area and delete the semicolons in the following lines:

```
;SC326 = AEDITOR.COM                    ;* SK "Measure turning"
;SC327 = AEDITOR.COM                    ;* SK "Measure milling"
```

Then close the file using the "Close editor" softkey.

An NC reset should then be run via the operating area "Commissioning" softkey "NC reset".

10.6.5 Step 4 - activate softkey "Measuring cycles" in the "Commissioning" area

Use the Enter key to open the file "common.com" in the "Program", "Standard cycles" operating area and delete the semicolons in the following line:

```
;SC617 = STARTUP.COM
```

Then close the file using the "Close editor" softkey.

Then perform an "NC reset" using the "Commissioning" operating area softkey.

10.6.6 Step 5 – set measuring cycle data

- Check default values of the GUD variables and set other values, if necessary.
- That is done by selecting and changing the variables in "Parameters", "User data" … or using a program (see Section 9.3).
- Data description (see Section 9.2 "Cycle data", Section 9.3 "Data for measuring in JOG" and **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT included with the software delivered).

10.7 Upgrading measuring cycles

10.7.1 General information

Upgrading measuring cycles is basically performed in the same order as initial installation.

Special notes:

- Only use files with the same measuring cycle software version. Do not mix files with different versions!

- Always heed the **up-to-date information** in SIEMENSD.TXT / SIEMENSE.TXT.

- Whether you need to increase the memory configuring machine data depends on the state of the machine and the previous measuring cycle version.

- When performing a software upgrade, make sure the variable values in the existing DEF files are preserved. These should first be saved if necessary.

- The measuring cycle data usually only has to be adjusted when upgrading an initial release of 5.x (or 4.x). When upgrading within measuring cycles SW 6, only the values set by previously archiving the NC-active data need be reconstructed (unless other settings are specified specifically in the SIEMENSD.TXT / SIEMENSE.TXT).

The next steps of upgrading depend on the HMI hardware and software used.

HMI version (HMI\Diagnosis\Service displays\Version\HMI)

1. HMI-Advanced PCU50 powerline
   up to SW 06.03.18 or up to SW 06.04.08 → continue with section 10.7.2
   as of SW 06.03.19 or as of SW 06.04.10 → continue with section 10.7.3
2. HMI-Advanced PCU50 solution line → continue with section 10.7.3
3. HMI-Embedded PCU20 powerline → continue with section 10.7.4

10.7.2 Upgrading measuring cycles for HMI-Advanced PCU50 powerline up to SW 06.03.18 and/or SW 06.04.08

> **Note**
> Refer to Chapter 10.3.

10.7.3 Upgrading measuring cycles for HMI-Advanced PCU50 powerline as of SW 06.03.19. and/or as of SW 06.04.10 and HMI-Advanced PCU50 solution line

10.7.3.1 Requirements

For meas. cycles SW 6.2

Transfer the following archive from the subdirectory "hmi_adv" (supplied on a floppy disk) to the HMI using "Services", "Data in" from the floppy disk or using V.24.

CYCCUST_GR.ARC	Archive for user cycles (CYCLE198, CYCLE199) German
CYCCUST_UK.ARC	Archive for user cycles (CYCLE198, CYCLE199) English
JOGMCYC.ARC	Archive with cycles for measuring in JOG
MCSUPP.ARC	Archive with files for measuring result display and MZU
MCYCLES.ARC	Archive with all measuring cycles (milling and turning)
MCYCMILL.ARC	Archive with all milling measuring cycles
MCYCTURN.ARC	Archive with all turning measuring cycles
MC_TEXT.ARC	Archive with reporting and alarm texts
SIEMENSD.ARC	Archive with info on commissioning and using measuring cycles in German
SIEMENSE.ARC	Archive with info on commissioning and using measuring cycles in English
VERSION.ARC	Archive with files for the version display
MCRESULT.ARC	Files for measurement result display (com files)
MC_CST0.ARC	Displays for measuring cycle support in the new design
MC_CST1.ARC	Displays for measuring cycle support in the old design

With meas. cycles SW 6.3

Copy the following files from the directory "hmi_adv" in "Services" to the directory "Archive" (\ARC):

- MC63ARC1.ARC
- MC63ARC2.ARC
- MC_CST0.ARC
- MC_CST1.ARC

Individually select and load the four archives using "Services", "Data in", "Archive" (softkey "Start").

When loading the files MC63ARC1.ARC and MC63ARC2.ARC, the MC archive is unpacked and the existing MC archive overwritten under \ARC\CYC\MCYC.DIR.

When the files MC_CST0.ARC and MC_CST1.ARC are loaded, the displays are unpacked in the new and old design.

10.7.3.2 Step 1 – load definition files

Save data to the archive or floppy disk using "Services", "Data out", folder "NC-active data", "User data". Select the GUD5.DEF, GUD6.DEF and if necessary GUD7_MC.DEF modules singly in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Unload NC → HD".

Load the archive specified for each measuring cycle release using "Services", "Data in", "Archive", "Cycles archive", "Measuring cycles" (\ARC\CYC\MCYC.DIR):

● With meas. cycles SW 6.2:

    DEFINES.ARC   Archive with definition files (GUD5.DEF, GUD6.DEF)

    JOGDEF.ARC   Archive with definition file (GUD7_MC.DEF)

NOTICE

Only load the JOGDEF.ARC archive if ShopMill is not installed!

● With meas. cycles SW 6.3

    DEFINES.ARC   Archive with definition files (GUD5.DEF, GUD6.DEF, GUD7_MC.DEF)

    JOGDEF.ARC   Empty archive which does not have to be loaded.

Select the GUD5.DEF and/or GUD6.DEF modules singly in the area "Services", "Manage data", in the folder "Definitions" and press softkey "Activate".

● Only for measuring in JOG

Select the GUD7_MC.DEF module in the area "Services", "Manage data", in the folder "Definitions".

Press softkey "Load HD → NC".

Then select module GUD7.DEF and press softkey "Activate".

The following questions:

"Do you want to activate the definitions from file GUD7.DEF?" and if required "Should the previous values for the definitions be retained?" on HMI should be answered with "Yes".

Load the saved user data again via "Services", "Data in".

10.7.3.3 Step 2 – load other archive

Note

Refer to Chapter 10.4.3 Step 2.

10.7.3.4   Step 3 – update Bitmaps

Selection "Commissioning", "Machine data", "Display MD"

Set display machine data MD 9021 LAYOUT_MODE = 1.

Turn HMI-Adv off and on again.

Set display machine data MD 9021 LAYOUT_MODE = 0.

Turn HMI-Adv off and on again.

Remark:

If the MD 9021 is set to 1 ("previous design"), then firstly set to 0 ("new design") and then reset to 1; ⇒ all bitmaps for measuring cycle support and for measuring JOG are updated.

10.7.4   Upgrading measuring cycles for HMI-Embedded PCU20 powerline

Note

Refer to Chapter 10.5.

10.8 Sequence for probe installation

```
                    ◇ Start ◇
                        │
                        ▼
        ┌───────────────────────────────────┐
        │        Set machine data           │
        │ MC 13200: MEAS_PROBE_LOW_ACTIV     │
        │         and POWER-ON               │
        └───────────────────────────────────┘
                        │
                        ▼
        ┌───────────────────────────────────┐
        │    Connect signal cable of probe   │
        │  to peripheral interface X 121/122 │
        │       (according to control type)  │
        └───────────────────────────────────┘
                        │
                        ▼
        ┌───────────────────────────────────┐
        │ Check measuring function with test │
        │         program TEST_PROBE         │
        │            See Section 8.3         │
        └───────────────────────────────────┘
                        │
                        ▼
   No   ⬡───────────────────────⬡
◄───────    Single block ?
        ⬡───────────────────────⬡
                        │ Yes
                        ▼
   No   ⬡───────────────────────⬡
◄───────    Override to zero ?
        ⬡───────────────────────⬡
                        │ Yes
                        ▼
        ┌───────────────────────────────────┐
        │     Load and preselect program     │
        │            TEST_PROBE              │
        └───────────────────────────────────┘
                        │
                        ▼
        ┌───────────────────────────────────┐
        │             NC START              │
        └───────────────────────────────────┘
                        │
                        ▼
   No   ⬡───────────────────────⬡
◄───────  Measuring block with
   │       MEAS present?
   │    ⬡───────────────────────⬡
   ▼                    │ Yes
┌──────────────┐        ▼
│ Let NC block │      ( 1 )
│ be machined  │
└──────────────┘

( 2 )
```

```
  ( 2 )                                                          ( 1 )
    │                                                              │
    │                                                              ▼
    │         ┌──────────────────────────────┐          ╱─────────────────────╲
    │◄────────┤ Pulses on the measuring cable!│   Yes   ╱ Indexing of measuring  ╲
    │         │ Cause:                        │◄────────  block without measuring  )
    │         │ Possibly interferences        │         ╲ probe having been       ╱
    │         │ To correct or avoid errors:   │          ╲ deflected?            ╱
    │         │ Check probe connection or     │           ╲─────────┬──────────╱
    │         │ measurement cable not shielded│                     │ No
    │         └──────────────────────────────┘                     ▼
    │                                                    ┌──────────────────────┐
    │                                                    │ Override is zero,     │
    │                                                    │ distance-to-go reached,│
    │                                                    │ activate probe manually│
    │                                                    └───────────┬──────────┘
    │                                                                ▼
    │                                                    ┌──────────────────────┐
    │                                                    │ PLC interface         │
    │                                                    │ Meas. input 1: DB10   DB B107.0│
    │                                                    │ Meas. input 2: DB10   DB B107.1│
    │                                                    └───────────┬──────────┘
    │                                                                ▼
    │         ┌──────────────────────┐    No     ╱─────────────────────╲
    │◄────────┤ Check probe connection│◄─────────╱ Does the bit change    ╲
    │         └──────────────────────┘           ( with probe deflection   )
    │                                             ╲ from "0" to "1"?       ╱
    │                                              ╲──────────┬──────────╱
    │                                                         │ Yes
    │                                                         ▼
    │                            No              ╱─────────────────────╲
    │                        ┌──────────────────╱ Has the distance-to-go ╲
    │                        │                  ( been deleted and entered )
    │                        │                   ╲ in MEASVAL_IN_X?       ╱
    │                        ▼                    ╲──────────┬──────────╱
    │              ┌──────────────────┐                      │ Yes
    │              │ Contact service   │                     ▼
    │              │ dept.             │                  ╱──────╲
    │              └──────────────────┘                 ( End    )
    │                                                     ╲──────╱
```

10.9 Example of calculating the repeat accuracy

Test program

This program allows the measuring scatter (repeat accuracy) of the entire measuring system (machine-probe-signal transmission to NC) to be calculated.

In the example, ten measurements are taken in the X axis and the measured value recorded in the workpiece coordinates.

It is therefore possible to determine the so-called random dimensional deviations which are not subject to any trend.

Example

```
%_N_CHECK_ACCURATE_MPF
;$PATH=/_N_MPF_DIR
N05 DEF INT SIGNAL, KK                 ;Variable definition
N10 DEF REAL MESSWERT_IN_X[10]
N15 G17 T1 D1                          ;Start conditions, preselect tool offset
                                       ;for probe
N20 ANF: G0 X0 F150                    ;Prepositioning in the measured axis
N25 MEAS=+1 G1 X50                     ;Measurement at 1st measurement
                                       ;input with switching signal from "not
                                       ;deflected" to "deflected" in the X axis.
                                       ;Probe switching expected between X0 and X50.
N30 STOPRE                             ;Stop decoding for subsequent
                                       ;evaluation of result (pre-processing stop)
N35 SIGNAL= $AC_MEA[1]                 ;Read software switching signal at
                                       ;1st measurement input
N37 IF SIGNAL == 0 GOTOF_FEHL1         ;Check switching signal
N40 MESSWERT_IN_X[kk]=$AA_MW[X]        ;Read measured value in workpiece
                                       ;coordinates
N50 KK=KK+1
N60 IF KK<10 GOTOB ANF                 ;Repeat 10 times
N65 M0
N66 STOPRE                             ; preprocessing stop
N70 M2
N80 _FEHL1: MSG ("Probe not switching")
N90 M0
N95 M2
```

Alarm, error, and system messages   11

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

Adaptation of the Measuring Cycles to Previous Software Versions

12

12.1 General information

Parameter _SI[1] in data block GUD6 is used to adapt measuring cycle versions up to SW 5 to previous NC software versions.

In the delivery status of the measuring cycles, the current software status of the control is entered in parameter _SI[1], i.e. 5 for SW 5. This parameter must be changed to match the measuring cycles <SW 6 to older software releases.

Example:

When using measuring cycles status 5.x.x on a control with SW 4 → _SI[1] = 4

Precondition:

To use the measuring cycles, the software status of the control must be ≥ 3.

12.2 Measuring cycle subroutines

General information

These measuring cycle subroutines are called directly by the cycles. With the exception of CYCLE100, CYCLE101, and CYCLE116, these subroutines cannot be executed by a direct call.

Programming

Cycle	Function	As of SW 4	As of SW 4.5	As of SW 6.2
CYCLE100	Activate logging	X		
CYCLE101	Deactivate logging	X		
CYCLE102	Measuring result display			
CYCLE103	Parameter setting in interactive mode			
CYCLE104	Internal subroutine: Measuring cycle interface			
CYCLE105	Internal subroutine: Log	X		
CYCLE106	Internal subroutine: Log	X		
CYCLE107	Output of measuring cycle messages	only up to measuring cycles – SW 6.2		
CYCLE108	Output of measuring cycle alarms	only up to measuring cycles – SW 6.2		
CYCLE109	Internal subroutine: Data transfer		X	
CYCLE110	Internal subroutine: Plausibility checks			
CYCLE111	Internal subroutine: Measuring functions			
CYCLE112	Internal subroutine: Measuring functions			
CYCLE113	Internal subroutine: Log	X		
CYCLE114	Internal subroutine: Load ZO memory, load WCS wear			
	Internal subroutine: Load WCS wear			
CYCLE115	Internal subroutine: Load ZO memory			X
CYCLE116	Calculation of center point and radius of a circle			X
CYCLE117	Internal subroutine: Measuring functions			
CYCLE118	Internal subroutine: Log	X		

If the operating area is switched over during the course of the input dialog, the dialog can be selected again at a later stage with "Cycles" softkey in the extended menu.

Programming is undertaken using CYCLE103.

Programming example: Workpiece probe calibration

```
CALIBRATE_IN_X_Y
N10 G54 G17 G0 X100 Y80              ;Position probe at the center of the hole
                                     ;and select ZO
N15 T9 D1 Z10                        ;Selection of length correction,
                                     ;position probe in hole
N20 CYCLE103                         ;The operator can assign the parameters for
                                     ;calibration cycle CYCLE976 in interactive mode

N25 CYCLE976                         ;Measuring cycle call for calibration in
                                     ;the X-Y plane
N50 M30                              ;End of program
CALIBRATE_IN_X_Y                     ;Position probe at the center of the hole and
                                     ;select ZO
```

Appendix A

A.1 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

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					
_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)	

CYCLE961		Workpiece measurements					
_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)	
_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)	

CYCLE961		Workpiece measurements					
_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))					

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	----	----	----	----	

CYCLE971		Tool measurement of milling tools on milling machines			
_MA	INT	Measuring axis 1...3			
		1: Calibration in +/- direction in 1 (abscissa)		1: Meas. of radius in direction 1 (abscissa)	
		2: Calibration in +/- direction in 2 (ordinate)		2: Meas. of radius in direction 2 (ordinate)	
		3: Calibration in +/- direction in 3 (applicate)		3: Meas. of length at center point of the tool probe	
		Also possible for calibration in plane:		103: Meas. of the length, offset about radius 1 (abscissa)	
		102: a) Calculation of center in 1(abscissa) b) Calibrate in 2 (ordinate)		203: Meas. of the length, offset about radius 2 (ordinate)	
		201: a) Calculation of center in 2 (ordinate) b) Calibrate in 1 (abscissa) **not for incremental calibration!**			
_MD	INT	----	----	----	----
_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	----	----	----	----

CYCLE971		Tool measurement of milling tools on milling machines			
_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	

CYCLE972		Tool measurement of turning tools with cutting edge position 1 – 8 on turning machines (machine-related)	
Parameter GUD5	Type	**Possible 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 probes	Measuring tool
_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	
_ID	REAL	----	----
_INCA	REAL	----	----
_K	INT	----	----
_KNUM	INT	----	----
_MA	INT	Measuring axis 1...2	
_MD	INT	----	----
_MVAR	INT >0	Measuring variant	
		0	1
_NMSP	INT >=1	Number of measurements at the same location	
_PRNUM	INT >=1	Tool probe number (number of the data field assigned to the tool probe **GUD6:_TP[_PRNUM-1]**)	
_RA	INT	----	----

CYCLE972		Tool measurement of turning tools with cutting edge position 1 – 8 on turning machines (machine-related)	
_RF	REAL	----	----
_SETVAL	REAL	----	----
_SETV[8]	REAL	----	----
_STA1	REAL	----	----
_SZA	REAL	----	----
_SZO	REAL	----	----
_TDIF	REAL	----	Dimension difference check
_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))	

CYCLE973		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 tool probes	
		Machine-related	Workpiece-related
		Reference groove	Area
_CALNUM	INT	Number of the gauging block (number of the data field assigned **GUD6: _KB[_CALNUM-1]**)	----
_CORA	REAL	----	----
_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 1...2	Measuring axis 1...3
_MD	INT	Measuring direction (0 = positive / 1 = negative)	

CYCLE973		Workpiece measurements			
_MVAR	INT >0	Measuring variant			
		xxx13			0
		5 4 3 2 1 1 3 Reference groove 0 Not incl. probe ball in calculation 1 Including probe ball in calculation (for calibration in groove only) 1 1 axis direction (specify measuring axis and axis direction) 2 2 axis directions (specify measuring axis) 0 Without position calculation 1 With position calibration (for calibration in groove only)			Area
_NMSP	INT >0	Number of measurements at the same location			
_PRNUM	INT >0	Tool probe number (number of the data field assigned to the tool probe **GUD6:_TP[_PRNUM-1])**			
		_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	----		Calibration setpoint	
_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			
		Meas. 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)		

CYCLE976		Workpiece measurements		
_MVAR	INT >0	Measuring variant		
		xxxx01	xxxx08	x0000
		Calibrate in the plane 6 5 4 3 2 1 T T T T T T___ 1 Calibrate in hole with unknown center | | | | | 8 Calibrate in hole with unknown center | | | | L____ 0 | | | | | | | | _____ 0 Not including probe ball in calculation | | | 1 Including probe ball in calculation | | | | | L____ 0 4 axis directions | | 1 1 axis direction (specify measuring axis | | and axis direction) | | 2 2 axis directions (specify measuring axis) | | | L_____ 0 Without position calculation | 1 With position calculation | L_____ 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 T L L____ 2-digit number | | L_____ 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	Groove	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	----	----	----	----	----	----	----	----
_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					

CYCLE977		Workpiece measurements							
		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		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		**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-digit number 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)							
_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)				----	----	----	----

CYCLE977		Workpiece measurements				
_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	----

CYCLE978		Workpiece measurements		
_KNUM	INT	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	**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
		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	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	
_MA	INT	Measuring axis 1...3		
_MD	INT	----		----
_MVAR	INT >=0	Measuring variant		
		0		100
		1000 (Difference measurement not with mono probe)		1100 (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 1 Mono probe 0 Multi probe (number of the data field assigned to the tool probe **GUD6:_WP[_PRNUM(2-digit)-1])**		
_RA	INT	----		----
_RF	REAL	----		----
_SETVAL	REAL	Setpoint (acc. to drawing)		Setpoint
_STA1	REAL	----		----
_SZA	REAL	----		----
_SZO	REAL	----		----

CYCLE978		Workpiece measurements	
_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))	

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	Groove	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 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		9 8 7 6 5 4 3 2 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 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		**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-digit number 1 Mono probe 0 Multi probe 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 ⊤ ⊤ ⊤ ⊤ ⊤ ⊤ ⊤ ⊤__ 0 Calibrate I I I I I I I 1 Measurement of turning (SL 1-8), milling and drilling I I I I I I I tools Measuring axis in _MA I I I I I I 2 Automatic measurement in abscissa and ordinate I I I I I I 0 Machine-related I I I I I I 0 Workpiece-related I I I I I I For milling tools only (also automatically), setting data SD42960 = 2! I I I I I 0 Measure without reversal I I I I I 1 Measure with reversal I I I I 0 Measure: Only correct length if 1st digit = 1 I I I I 1 Measure: Only correct length if 1st digit = 1 I I I I 2 Measure: Correct length and radius if 1st digit = 1 I I I I 3 Automatic measurement: Only correct length and radius if 1st digit = 2 I I I I Travel around toolsetter to starting position I I I I 4 Automatic measurement: Correct length and radius if 1st digit = 2 I I I I Measuring in opposite direction to approach I I I 0 Axial position of milling tool/drill (radius in I I I ordinate, at G18: X axis I I I 1 Radial position of milling tool/drill (radius in I I I abscissa, at G18: Z axis I I 0 Measure or calibrate I I 1 Measure or calibrate incrementally I Reserved 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**	

MVAR (1st, 2nd, 3rd measurements):

```
9 8 7 6 5 4 3 2 1
                  _MVAR
              1   1st measurement
              2   2nd measurement
              3   3rd 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
```

MVAR (Calculate kinematics):

```
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
`_MVAR`	INT >0	Measuring variant	
		x0xxxx	x1xxxx
		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	

CYCLE997		Workpiece measurements	
_NMSP	INT >0	Number of measurements at the same location	
_PRNUM	INT >0	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]**	
_RF	REAL	Velocity for intermediate paths on circular path (G2 or G3) (or _MVAR=xx1109 only, measuring at an angle)	
_SETV[8]	REAL	Setpoints, center point of the spheres (balls)	
_STA1	REAL	Starting angle (for _MVAR=xx1109 only, measuring at an angle)	
_TNVL	REAL	----	Limit for triangle distortion (for _MVAR=x1x109 only, measure 3 spheres and ZO correction)
_TSA	REAL	Safe area	
_VMS	REAL >=0	Variable measuring velocity (for _VMS=0: 150 mm/min (if _FA=1); 300 mm/min (if _FA>1))	

CYCLE998		Workpiece measurements	
Parameter GUD5	Type	**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**	
		Measuring with automatic ZO correction	
		1 angle	1 angle
_CALNUM	INT	----	
_CORA	REAL 0...359.5	Offset angular position (only active if mono probe)	
_CPA	REAL	----	
_CPO	REAL	----	
_EVNUM	INT	----	
_FA	REAL >0	Measurement path in mm	
_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

CYCLE998		Workpiece measurements	
		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 │ │ │———— 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	----	
_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	972 982	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						----	----	----	----
_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	Measuring variant							----	----

Result parameters calibration										
						CYCLE:	971	972 982	973	976
GUD5	Data type	Meaning								
_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	CYCLE972 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		----	----	----
_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			

Result parameters measurement (turning machines)					
GUD5	Data type	Meaning	CYCLE974	CYCLE994	CYCLE972 CYCLE982
_OVR [21]	REAL		----	----	----
_OVR [22]	REAL		----	----	----
_OVR [23]	REAL		----	----	----
_OVR [24]	REAL		----	----	----
_OVR [25]	REAL		----	----	----
_OVR [26]	REAL		----	----	----
_OVR [27]	REAL	Zero offset range[1]			
_OVR [28]	REAL	Safe area			
_OVR [29]	REAL	Permissible dimension difference[1]			
_OVR [30]	REAL	Empirical value			
_OVR [31]	REAL	Mean value[1]			----
_OVI [0]	INT	D number / ZO number			----
_OVI [1]	INT		----	----	----
_OVI [2]	INT	Measuring cycle number			
_OVI [3]	INT	Measuring variant	----	----	----
_OVI [4]	INT	Weighting factor[1]			----
_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 request[2]	----	----	----
_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 angles
_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
_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

Result parameters measurement (milling and machining centers)						
					CYCLE998	
_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
_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

Result parameters measurement (milling and machining centers)					CYCLE998	
_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	----	----

Result parameters measurement (milling and machining centers)						
			CYCLE977		CYCLE978	CYCLE979
_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		----	----	----	----
_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		----	----	----	----

Result parameters measurement (milling and machining centers)							
			CYCLE977		CYCLE978	CYCLE979	
_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)	
_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		----	----	----	----	

Result parameters measurement (milling and machining centers)				CYCLE977		CYCLE978	CYCLE979
_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	----
_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**
	_CVAL[ ]	**Number of elements**	
GUD6	_CVAL[0]	Number of data fields for tool probe, machine-related	3
GUD6	_CVAL[1]	Number of data fields for workpiece probe	3
GUD6	_CVAL[2]	Number of data fields for gauging block	3
GUD6	_CVAL[3]	Number of data fields for tool probe, tool-related (from measuring cycles SW 6.3)	
	_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)	
	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

Cycle data			
The measuring cycle data are stored in blocks GUD5 and GUD6.			
Central values			
Block	**Identifier**	**Description**	**As-delivered value**
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

Central values			
Block	Identifier	Description	As-delivered value
	_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 value for logging			
GUD6	**_PROTFORM**	Int field for formatting for log	
GUD6	_PROTFORM[0]	Number of line per page	60
GUD6	_PROTFORM[1]	Number of characters per line	80
GUD6	_PROTFORM[2]	First page number	1
GUD6	_PROTFORM[3]	Number of header lines	5
GUD6	_PROTFORM[4]	Number of value lines in the log	1
GUD6	_PROTFORM[5]	Number of characters per column	12
GUD6	**_PROTSYM**	Separator in the log	
GUD6	_PROTSYM[0]	Separators between the values in the log	";"
GUD6	_PROTSYM[1]	Special characters for identification when tolerance limits are exceeded	";#"
GUD6	**_PMI**	Int field for internal flags for logging	
GUD6	_PMI[0]	Current line number	0
GUD6	_PMI[1]	Flag for interim output of log header 1: Log header output	0
GUD6	_PMI[2]	Current page number	0
GUD6	_PMI[3]	Number of log files	0
GUD6	**_SP_B**	Int field for variable column widths	
GUD6	_SP_B[0...19]	Internal flag	0
GUD6	_DIGIT	Integer number of decimal places	3

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
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]	Central marker for basic dimension system of the control 0: basic system setting is inches 1: basic system setting is metric Note. If _CBIT[3] and MD 10240 are not equal, the value in fields TP[ ], _TPWW[ ], _KB[ ], _MV[ ], _CM, and _MFS are converted.	1
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

Central bits

Block	Identifier	Description	As-delivered value
GUD6	_CBIT[13]	Deletion of the measuring cycle arrays in the GUD6 0: No deletion 1: delete _TP[ ], _TPW[ ], _WP[ ], _KB[ ], _EV[ ], _MV[ ], _CBIT[13]	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

Central strings

Block	Identifier	Description	As-delivered value
	_SI	**Central strings**	
GUD6	_SI[0]	currently not assigned	0
GUD6	_SI[1]	Software Version	6
Central strings for logging			
	_PROTNAME (32 chars)		
GUD6	_PROTNAME [0]	Name of the main program to log from (for log header)	
GUD6	_PROTNAME [1]	Name of the log file to be created	
GUD6	**_HEADLINE (80 chars)**	Strings for log header (80 chars)	
GUD6	_HEADLINE[0...9]	The user can enter customized texts in these strings; they are included in the log	
GUD6	**_PROTVAL (80 chars)**	Strings for log content	
GUD6	_PROTVAL[0]	Content of the header line (line 9)	
GUD6	_PROTVAL[0]	Content of the header line (line 10)	
GUD6	_PROTVAL[2...5]	Specification of the values to be logged in successive lines	
GUD6	_TXT[100]	String field for formatted strings (12 characters)	

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)			
Block	Identifier	Description	As-delivered value
	_JM_I		
GUD6	_JM_I [0]	Setting for the workpiece probe number 0: Specification by *JM*[1] 1: Set by tool parameters (ShopMill)	0
GUD6	_JM_I [1]	Probe number for workpiece measurement (_PRNUM) only if *JM*[0]=0	1
GUD6	_JM_I [2]	Probe number for tool measurement (_PRNUM)	1
GUD6	_JM_I [3]	Plane 17: G17 18: G18 19: G19 Every other value for working plane is defined in the machine data.	17
GUD6	_JM_I [4]	Definition of the active ZO on measurement 0: G500 1: G54 ... 4: G57 5...: G505... 100: active ZO is defined in machine data	0
GUD6	_JM_I [5] (as from meas. cycle SW 6.3)	Compensation 0: Standard compensation (measuring only, basic reference, settable ZO) 1: Extended compensation (additional global and channel-specific basis frame)	0

Channel-specific values (for measuring in JOG)			
Block	Identifier	Description	As-delivered value
GUD6	**_JM_I** [6] (as from meas. cycle SW 6.3)	Internal copy of _JM_I[4]	0
GUD6	**_JM_I** [7] to **_JM_I** [9] (as from meas. cycle SW 6.3)	Reserved	-

Channel-specific values (for measuring in JOG, from measuring cycles SW6.3, 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 (from measuring cycles SW 6.3)	Diameter, calibration ring	0
GUD7	E_MESS_CAL_L (from measuring cycles SW 6.3)	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
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

Channel-specific values (for measuring in JOG, from measuring cycles SW6.3, GUD7_MC)			
Block	Identifier	Description	As-delivered value
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

Channel-oriented bits			
Block	**Identifier**	**Description**	**As-delivered value**
	_CHBIT	**Channel bits**	
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
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

Channel-oriented bits			
Block	Identifier	Description	As-delivered value
	_CHBIT	Channel bits	
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
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

Channel-oriented bits			
Block	Identifier	Description	As-delivered value
	_CHBIT	Channel bits	
GUD6	_CHBIT[24]	Channel-oriented marker for basic dimension system (On deviation from MD 10240, cycle parameters are converted internally and this bit is reset.) 0: The basic system is inch 1: The basic system is metric	1

Channel-specific bits (for measuring in JOG)			
Block	Identifier	Description	Value for meas. cycles
	_JM_B		
GUD6	_JM_B[0]	Tool offset mode for tool measurement 0: offset in geometry, wear is deleted	0
GUD6	_JM_B[1]	Number of measurement attempts	0
GUD6	_JM_B[2]	Retraction from measuring point in rapid traverse	0
GUD6	_JM_B[3]	Fast measuring feed	0
GUD6	_JM_B[4]	Selection offset frame	0
GUD6	_JM_B[5]	currently not assigned	0
GUD6	_JM_B[6]	Internal data item	0

List of abbreviations

B

ASUB	Asynchronous subroutine
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
FM-NC	Function module - numerical control
GUD	Global User Data Global user data
I/O	Input/Output
IBN	Start up
JOG	JOGging: Setup mode
LUD	Local User Data
MCS	Machine coordinate system
MD	Machine data
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
PCIN	Name of the SW for data exchange with the control
PG	Programming device
PLC	Programmable Logic Control Controller
SR	Subprogram
SW	Software
TO	Tool Offset Tool offset
TO	Tool offset
TOA	Tool Offset Active: Identifier (file type) for tool offsets
UI	User interface
V.24	Serial interface (definition of the exchange lines between DTE and DCE)
WCS	Workpiece coordinate system
ZO	Zero point offset

Parameter

C

List of input/output variables for cycles

Name	Meaning in English	
_CALNUM	**Cal**ibration groove **num**ber	Number of the gauging block
_CBIT[30]	**C**entral **Bits**	Field for NCK global bits
_CHBIT[16]	**Ch**annel **Bits**	Field for channel-specific bits
_CM[8]		Field: Monitoring functions for tool measurement with rotating spindle each with eight elements
_CORA	**Cor**rection **a**ngle position	Offset angle position
_CPA	**C**enter **p**oint **a**bscissa	Center point of abscissa
_CPO	**C**enter **p**oint **o**rdinate	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	**Ind**exing **a**ngle	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 **m**easuring **ax**is	Measuring axis
_MD	**M**easuring **d**irection	Measuring direction
_MFS[ ]		Field: Feeds and speeds with measuring tools with rotating spindles each with 6 elements
_MV[20]		20 mean value memories
_MVAR	**M**easuring **var**iant	Measuring variant
_NMSP	**N**umber of **m**easurements at same **sp**ot	Number of measurements at the same location
_OVI [20]		Field: Output values INT
_OVR [32]		Field: Output values REAL
_PRNUM	**Pr**obe type and probe **num**ber	Probe number
_PROTFORM[6]		Log formatting
_PROTNAME[2]		Name of log file
_PROTSYM[2]		Separator in the log
_PROTVAL[13]		Log header line

Name	Meaning in English	
_RA	Number of rotary axis	Number
_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

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.

Index