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Machine-integrated workpiece measurement for 3-axis milling

Principle and application with SINUMERIK Operate

Restricted

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Machine-integrated workpiece measurement for 3-axis milling

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1 SINUMERIK measurement functions – Overview
Introduction to workpiece measurement with SINUMERIK

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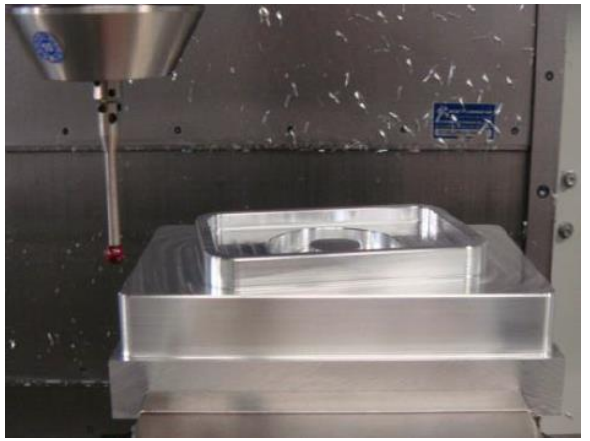
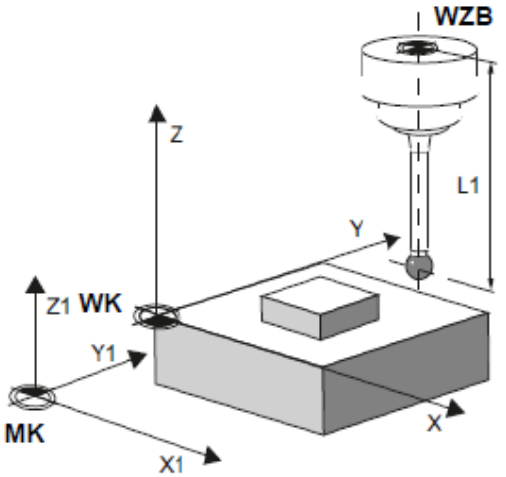
Measuring the workpiece is used to define the **position and alignment of the workpiece in the machine coordinate system**.



Workpiece measurement can take place in two **modes**:

- **JOG**
  Setup mode
- **AUTOMATIC**
  Process measuring

Measuring cycles are used in various measuring tasks.
The measuring cycle for the measuring task is configured by setting various parameters in the input screen.



1.1 SINUMERIK measurement functions – Overview
Coordinate systems and reference points

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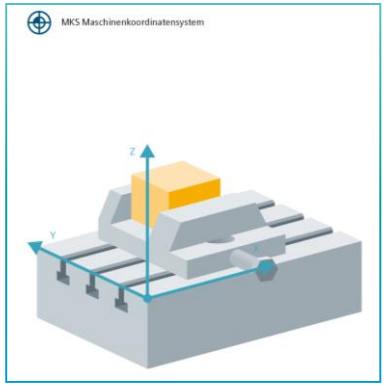
Automated and repeated execution of workpiece programs requires the definition of **reference points**:

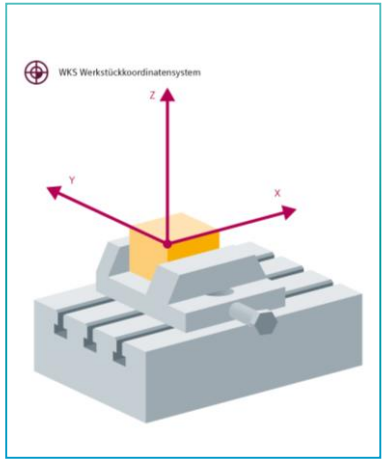
Machine zero point

- Located in the MCS machine coordinate system and defined by the machine manufacturer
- Cannot be changed from end-user
- Reference point for internal measuring systems in the machine
- Limits the machine's working area

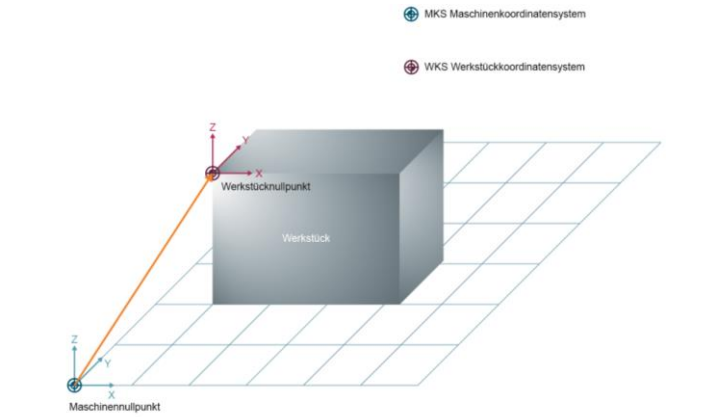
Workpiece zero point

- The basis of the WCS workpiece coordinate system - Zero point of the workpiece
- Can be freely selected by the end-user
- Is often positioned on a corner or in the center of the workpiece, a hole, a pin (to suit workpiece machining)





Work offset



Adaptation of MCS to WCS i.e. transformation of the machine zero point to the workpiece zero.

1.1 Measuring instruments for measuring workpieces

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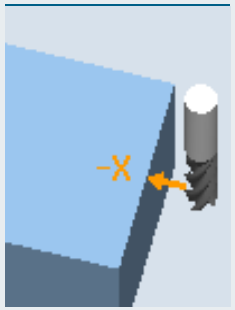
Manual contacting / scratching



- The operator manually moves an edge finder or a rotating tool to the workpiece
- The operator determines the current position on the basis of visual signals
- The operator confirms the touching via a softkey
- The workpiece zero point is automatically saved by the CNC

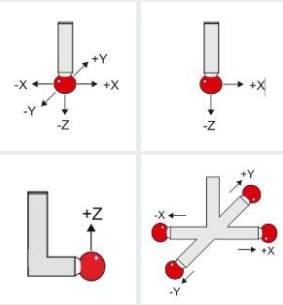
Manual probe

JOG

- The measuring instrument is located in the spindle, which has its probe length and diameter stored in the tool offset
- The operator determines the current position of the spindle center above an edge using a scale
- The operator confirms the touching via a softkey

Switching probes

JOG AUTO



- The operator positions a previously **calibrated probe** in the vicinity of the desired measuring object
- The cycle is selected and the measurement is started via NC-Start
- The desired position is automatically determined and saved by the CNC

1.1 Measuring instruments for measuring workpieces

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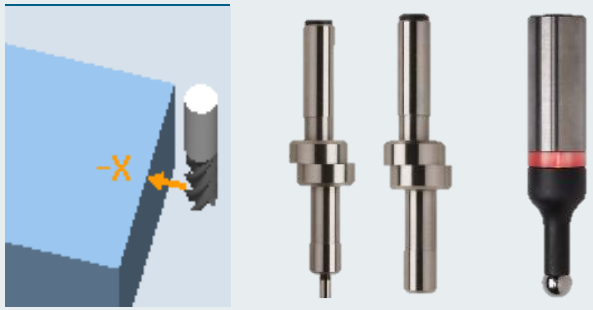
Manual contacting / scratching



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Switching probes

JOG AUTO

The machine must be prepared on both the HW and SW side for the use of switching probes!

Receiver

Transmitter

1.2 Measuring accuracy
Calibration, the key factor in accurate measurements

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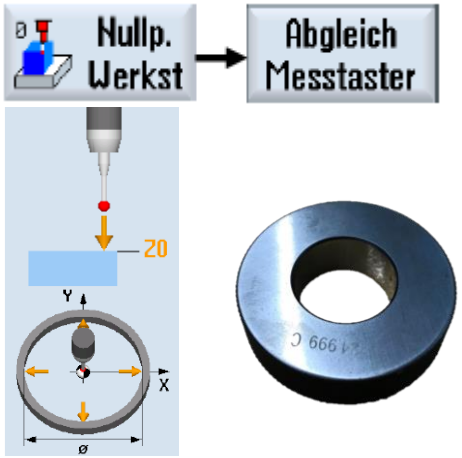
Calibration = calibration of the probe before use

- Set the radial eccentricity of the probe, see manufacturer's specifications
- Radius alignment with calibration
- Length alignment with internal or external length measuring device

→ Determination of individual switching points (trigger points) in reference to the spindle center of each direction of the axis (e.g. +X, -X, +Y, -Y, -Z)



Measurements must be made under the same conditions as for the calibration

- Calibrations and measurements should be done in the same planes (G17, G18, G19).
- The measuring feed must correspond to the calibration feed
- At the start of the measurement, the probe should be located approximately in the center of the calibration ring (by eye)
- In the best case, the probe will always be calibrated in the spindle (clamping tolerance)

1.2 Measuring precision
Influencing factors and measuring inaccuracies

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- The following lead to **measuring inaccuracies**:
  - Geometric errors in the machine axes
  - Radial eccentricity of the spindle
  - A faulty calibration process (e.g. feedrate must be 100%!)
  - A faulty or dirty probe sphere
  - A dirty surface of the measuring object (e.g. due to chips)
  - Temperature fluctuations during the measurement

The **obtainable measuring precision** that can be obtained is dependent on the following factors:

- Accuracy of the machine
- Measuring precision of the **calibrated** probe

2 Workpiece measurement In the JOG and AUTOMATIC modes

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When measuring workpieces, a measuring instrument similar to a tool is moved to the clamped workpiece.

These measuring tasks can take place in two **modes**:

JOG (set-up mode)	AUTOMATIC (in-process measurement)
	
• To prepare the machine for processing • The determination of the position and alignment of a workpiece • Definition of the zero point position of the workpiece in the machine space	• Quality assurance in the machining process • For the correction of work offsets • Correction of thermally influenced changes to the machine • The creation and provision of measurement reports
Partially automatic measurement, as interactive operation in the set-up mode of the machine	Fully automatic measurement by calling measuring cycles in the CNC machining program

2.1 Workpiece measurement / Setup in the JOG mode
Overview of the measurement functions

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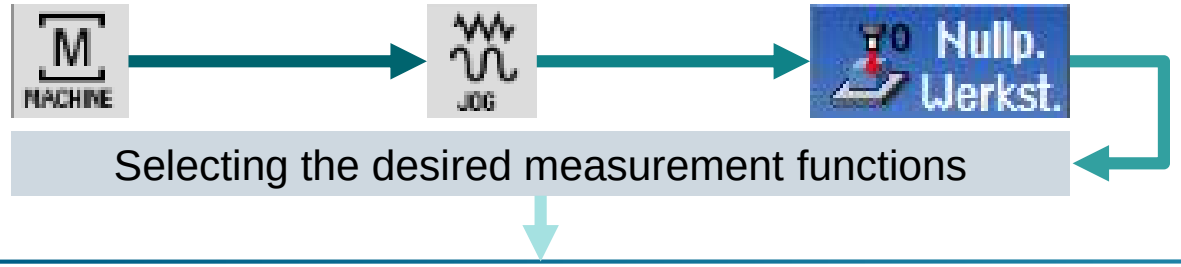
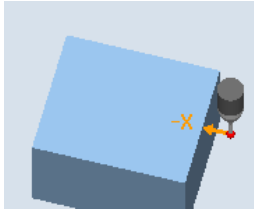
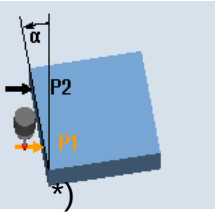
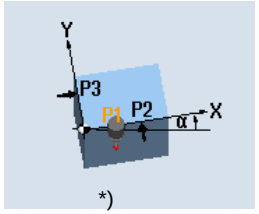
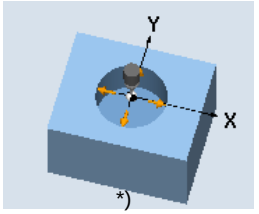
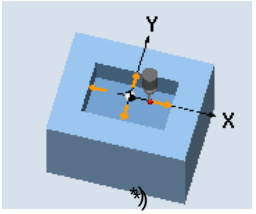
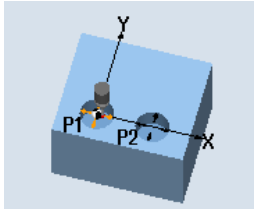
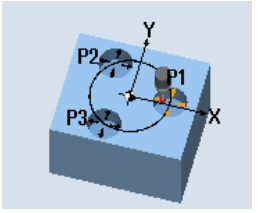
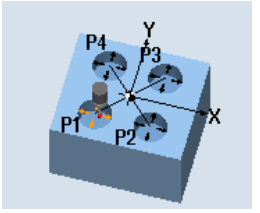
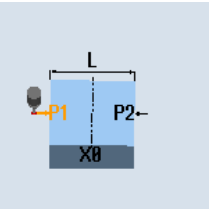
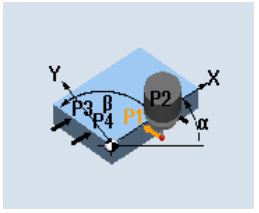
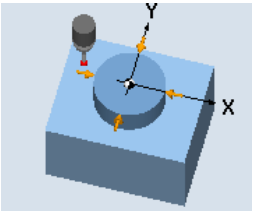
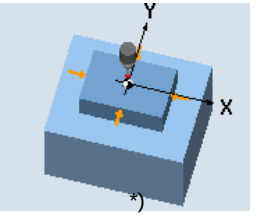
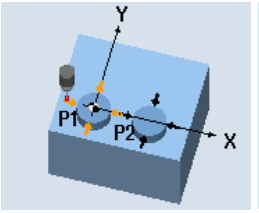
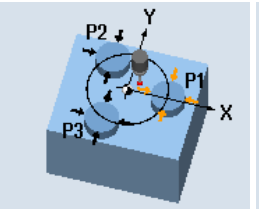
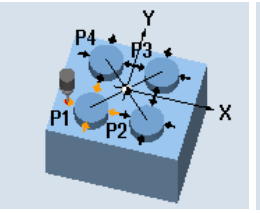
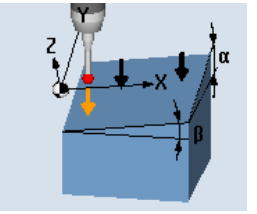


Edge	Align edge	Rectangular corner	1 hole	Rectangular pocket	2 holes	3 holes	4 holes
							

Distance 2 edges	Any corner	1 circular spigot	Rectangular spigot	2 circular spigots	3 circular spigots	4 circular spigots	Plane
							

Abgleich Messtaster

Measuring variants for **manual measuring instruments**

Measuring variants for **switching probes**

2.1 Workpiece measurement / Setup in JOG mode
Aligning the workpiece on the workpiece edge

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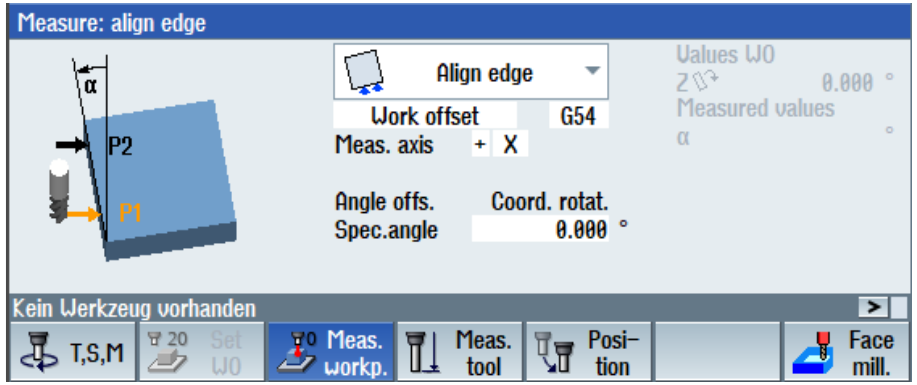
Alignment on the workpiece edge



- Saving the axis position in the rotary part of the zero point FRAME.
- The **twisting of the workpiece** is compensated by rotating the coordinates of the workpiece coordinate system

2.2 Workpiece measurement in AUTOMATIC mode Control-internal correction of measured values

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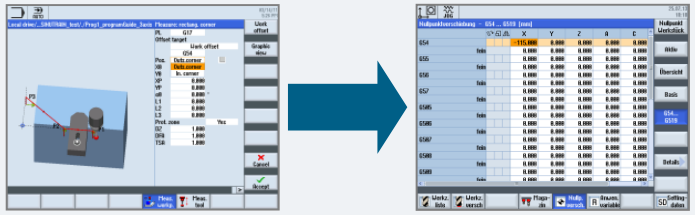
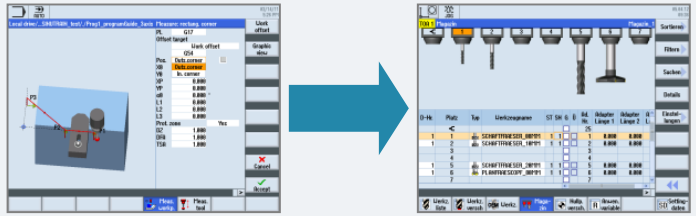
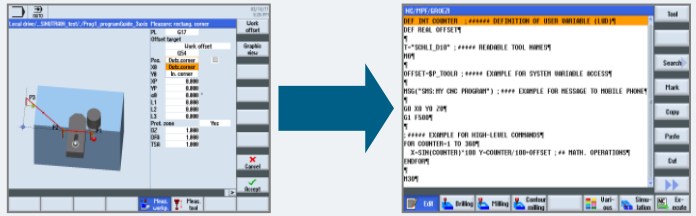
Workpiece measurement		
… with correction of the work offset	… with correction of the tool geometry	… measuring only
• Checking the current clamping situation • Correction of the workpiece zero point offset resulting from the manual or automatic feeding of workpieces	• Ensuring the adherence to workpiece tolerances • Continuous correction of the tool wear or thermal expansions that occur during machining	• Measurement of workpiece geometries for individual reuse • Display of the workpiece geometry
		

2.2 Workpiece measurement in AUTOMATIC mode
Overview of the measurement functions

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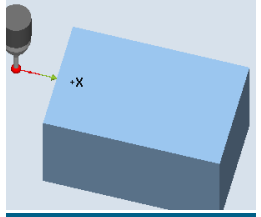
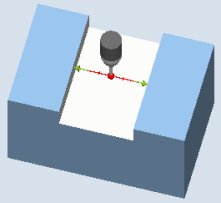
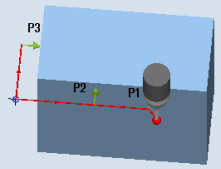
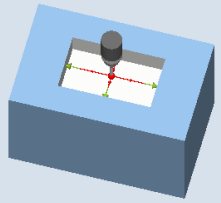
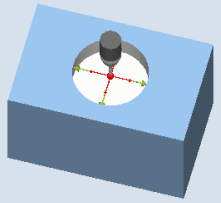
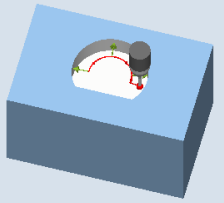
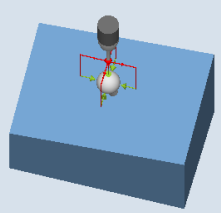
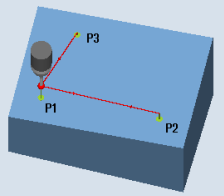
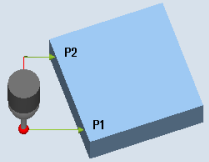
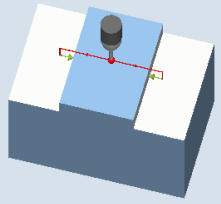
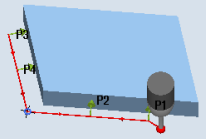
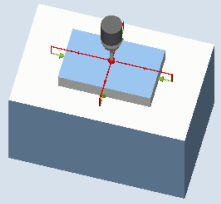
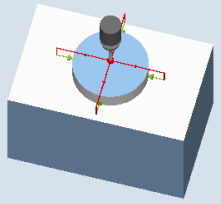
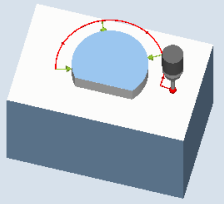
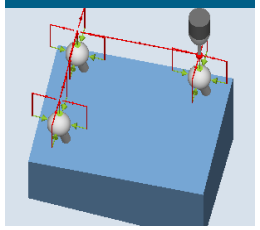
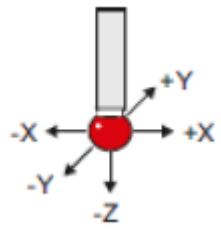
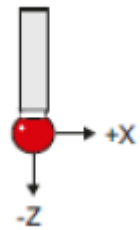
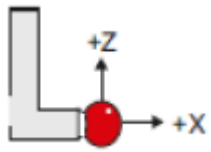
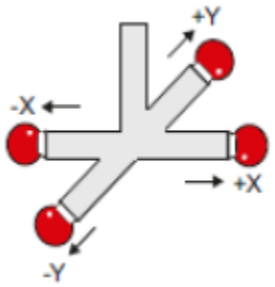
Edge	Groove	Rectangular corner	Rectangular pocket	Hole	Inner circle segment	Ball	Align plane
							

Align edge	Web	Any corner	Rectangular spigot	Circular spigot	Outer circle segment	3 balls
						

Measuring variants only for **switching probes**

3D probe	Mono probe	L probe	Star probe
			

Special tools	
710 - 3D-Messtaster	
711 - Kantentaster	
712 - Monotaster	
713 - L-Taster	
714 - Sterntaster	
725 - Kalibrierwerkzeug	

2.3 Creating measuring reports
Quality transparency can be achieved using standard reports

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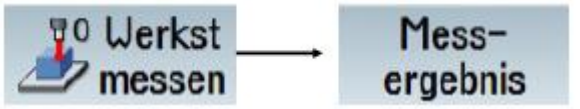
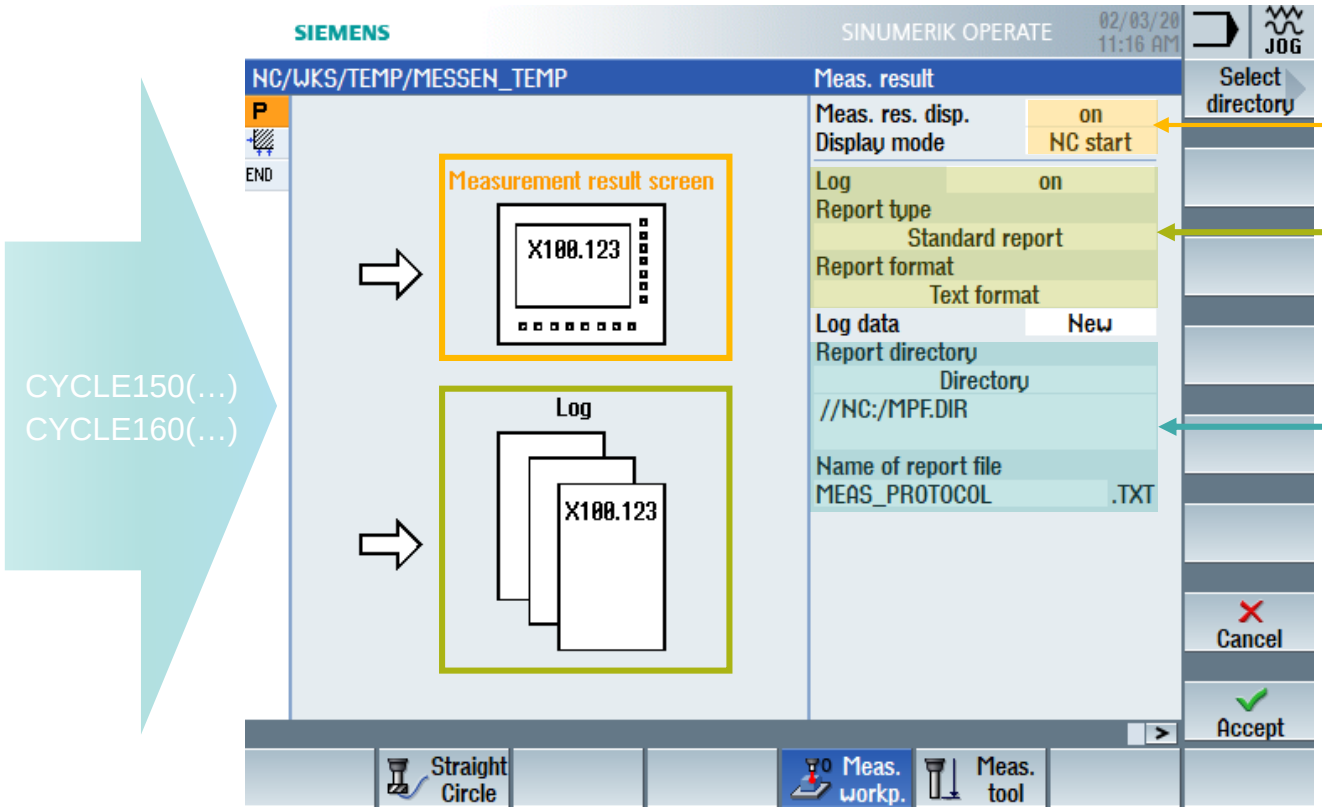
SINUMERIK makes a distinction between two kinds of measuring reports:

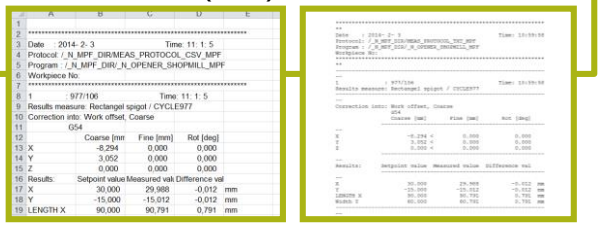
- User measuring report (user-defined formatting of the contents)
- **Standard measuring report** (pre-formatted form for each automatic measuring cycle)





Meas. res. disp.: on/off
Display mode: NC start, On alarm, autom. 8 s

Log: on/off
Report type: Standard report / User report
Report format: Text format (*.txt) / Table format (*.csv)



Path: storage of the measuring report where the part program is located
Name of report file: name of the file

3 Practical part: SINUMERIK measuring cycles in the application

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4 Summary

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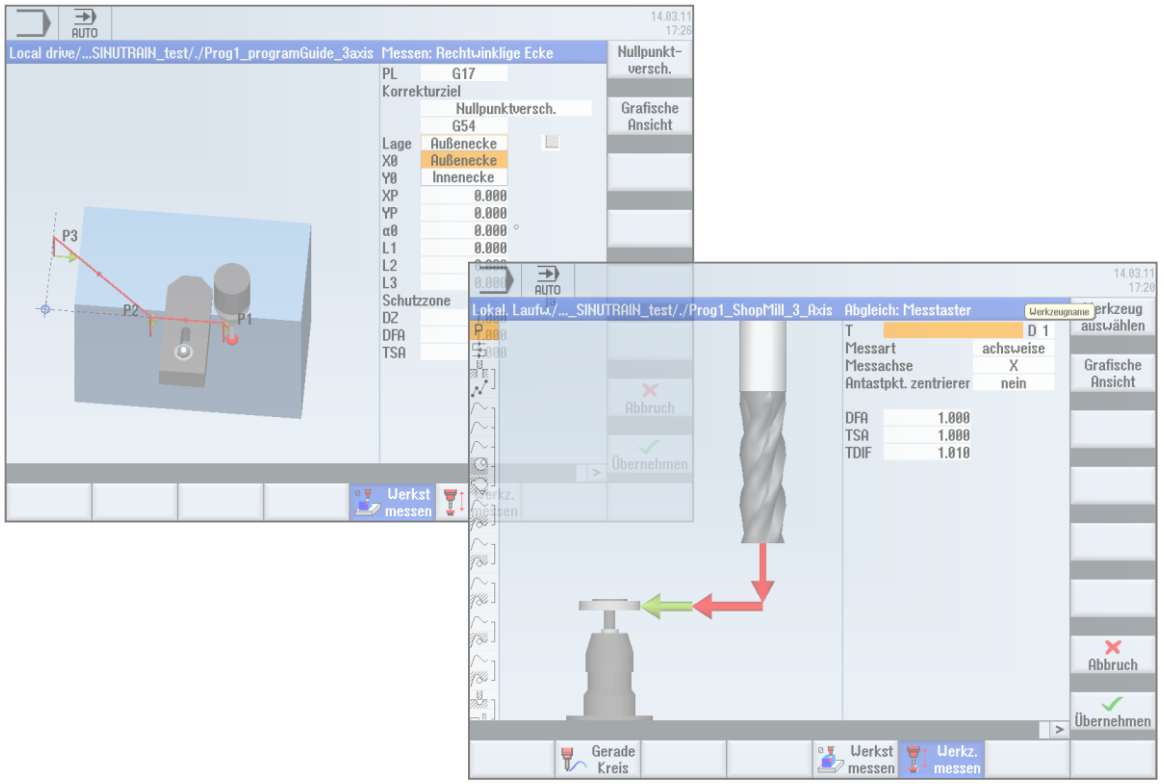

User benefits

- Time savings thanks to reduction in setup times
- Increased process reliability due to cycle-driven applications
- Integrated input support in ShopMill and programGUIDE workstep programming
- Realistic display of the measuring process in the SINUMERIK simulation
- Easy creation and output of measuring reports

The multi-faceted application area of the SINUMERIK measuring cycles and measurement functions make it possible to cover nearly all measuring tasks involving milling technology.

Thank you for your attention

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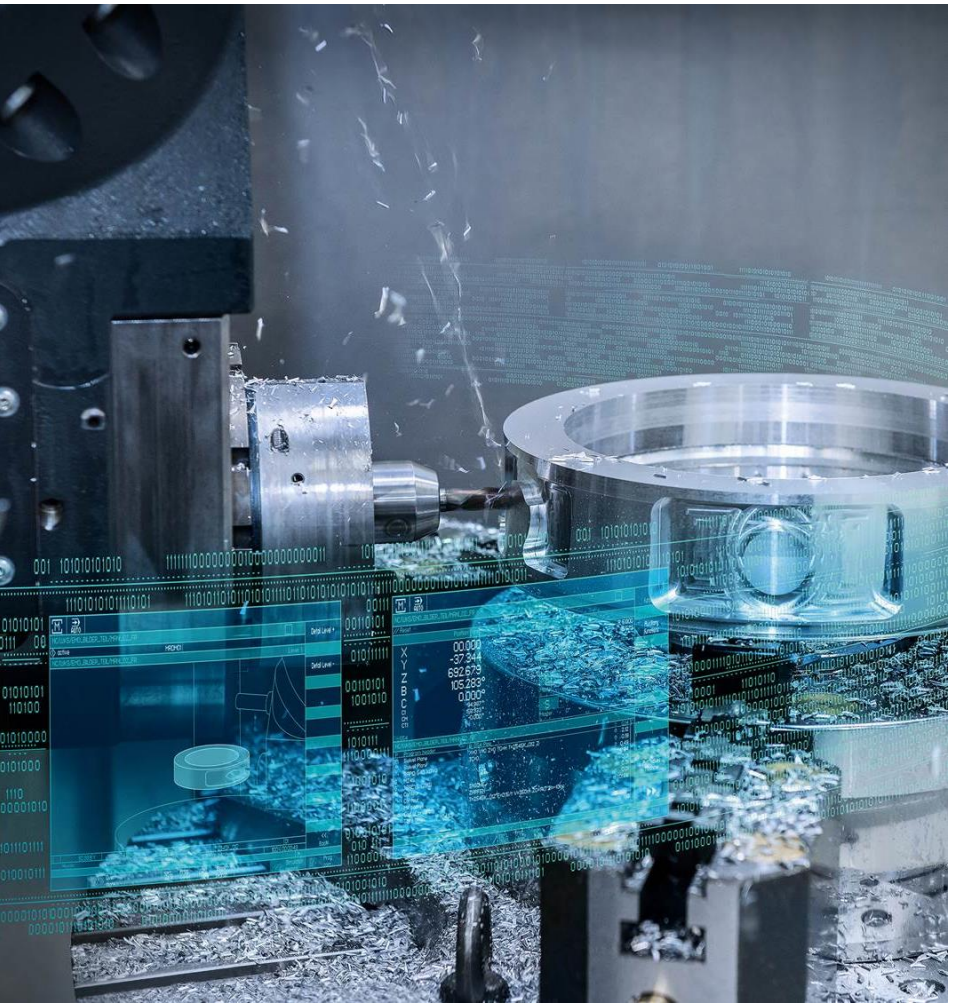

Digital Experience and Application Center Erlangen

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