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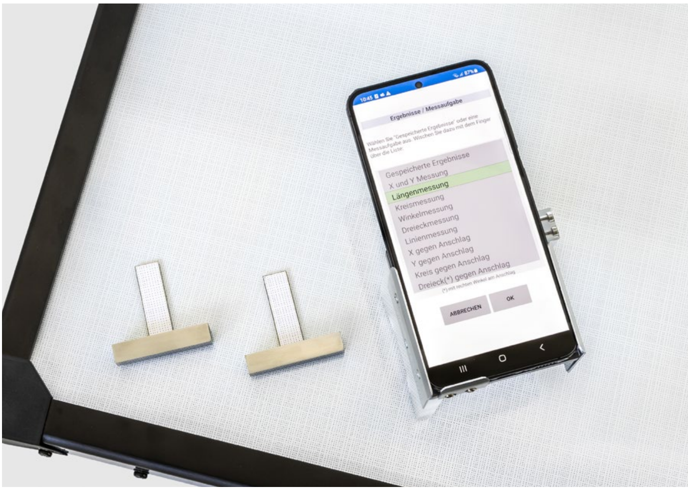
Operation Manual
MICRO CONTROL

2D Measuring System for Precisely Measuring the Dimensions and Shapes of Thin and Flat Objects



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Made in Germany

EN

Subject to technical modifications.

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1 General Information

These operating instructions support you during the initial start-up, operation and maintenance of the 2D Measuring System MICRO CONTROL.

It contains important information, the observance of which ensures safe use. Familiarize yourself with this documentation carefully before using the measuring system to avoid personal injury and material damage. Always keep the documentation close to the measuring system so that it can be referred to for its entire service life.

Any application that deviates from or uses the measuring system beyond that specified in the operating instructions shall be deemed improper. Modifications, bypassing or decommissioning of individual components of the measuring system are prohibited.

If the measuring system is not used as intended, the manufacturer accepts no liability. General safety and accident prevention regulations remain valid in addition to these operating instructions.

1.1 Symbols

Warning	**Warning!** Severe to life-threatening personal injuries can occur.
Attention	**Attention!** Slight to moderate personal injury can occur.
IMPORTANT	Property damage can occur.
	Important information for operating the measuring system.
	NOTE! Note or tip on using the measuring system.
	Cross Reference See also!
Save	Label for views, fields and buttons

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2 Intended Use and Restrictions on Use

The 2D Measuring System MICRO CONTROL was developed for the precise measurement of primarily thin, flat objects. Even extremely thin objects, such as paper or card-board, can be measured with the system.

	The coordinate system can have a maximum dimension of 1 x 1 m.
	The ambient temperature is taken into account and compensated for.

3 Safety Instructions

The safety instructions will be supplemented with additional safety information throughout the text.

Attention	Deviating usage from the intended application can cause property damage and personal injury.
Attention	Failure to follow these operating instructions can result in property damage and personal injury.
Attention	Improperly opening individual system components can lead to property damage and personal injury.
Attention	If safe operation of the device is not possible, the measuring system must be taken out of operation or not started up. If necessary, secure the device against unintentional start-up.
Attention	A lithium-ion battery is built into the device. The guidelines for handling lithium-ion batteries apply.
IMPORTANT	The device belongs to protection class III. The device has the degree of protection IP 20.

4 Technical Data

Determinable dimensions	Parallelism Straightness Angle Diameter Length Width
Measurement area	Up to 1 m x 1 m
Response time/ measurement duration	< 1 s
Accuracy up to	± 15 µm for linear measurements ± 0.1° for angle measurements ± 50 µm for length measurements
Operating temperature	15 ... 30° C (59 ... 86° F)
Measuring device weight	< 800 g
Scope of delivery	Mobile measuring device (Smartphone) incl. power supply unit Software/App Holder PointArea End stop (optional) Two measurement tools Operation manual

5 Measuring Principle

The measuring system is based on the PointArea – a surface designed as a coded coordinate system. Two measuring tools equipped with a separate coordinate system are used to mechanically contact the object to be measured.

A smartphone captures an image of the measuring tool and PointArea. The position of the measuring tool and therefore the edge of the measurement object can be precisely determined using internal calculations in the smartphone.

The operator is guided intuitively through a clearly organised app, typical of smart-phones. Measured results are directly displayed and visually depicted.

6.1 Scope of Delivery

- Smartphone as the mobile measuring device including power supply unit
- Pre-installed smartphone software/app
- Holder for supporting the smartphone
- PointArea as a coordinate system in customer-specific dimensions
- A precise, right-angled end stop mounted on the PointArea (optional)
- Two measurement tools for contacting the objects to be measured
- This operation manual

> The measuring system was controlled before delivery. However, please check the delivery for completeness and transport damage after unpacking. In the event of damage or missing system components, please contact the supplier or manufacturer.

6.2 Operation and Control Elements, Connections

The measuring system is operated using the supplied smartphone.
Operating and control elements are essential components of the software.

> The necessary functionality on the smartphone (Fig. 1) was supple-mented by information elements:

6.3 Sensor

The sensor used for the measurements is the high-resolution digital camera integrated into the smartphone. The measurement tools and PointArea must also be used for measurements with the MICRO CONTROL.

7 Operation

7.1 Software Installation

The software/app required to use the 2D Measuring System has already been pre-installed on the smartphone supplied.

You can also install the software on the smartphone by following the steps below:

1. Copy the PointArea.apk installation file to the internal memory of the mobile device.
2. By running the installation file, the app is installed. To do this, you must allow the installation of apps from unknown sources.
3. Allow the app to access photos, media and files as well as the camera when launching the app.
4. Start the app. A message about missing files appears. Exit the app.

After opening the app for the first time, the PointArea folder is created in the internal memory under the directory .../Documents/. This folder will later contain all measurement and calibration data. The supplied calibration data PA0000XXXX.bmp and PA0000XXXX.csv must now be copied into this folder.

After opening the app for the second time, a message appears stating that the basic settings have not yet been verified. The app has now been successfully installed and the system can now be calibrated.

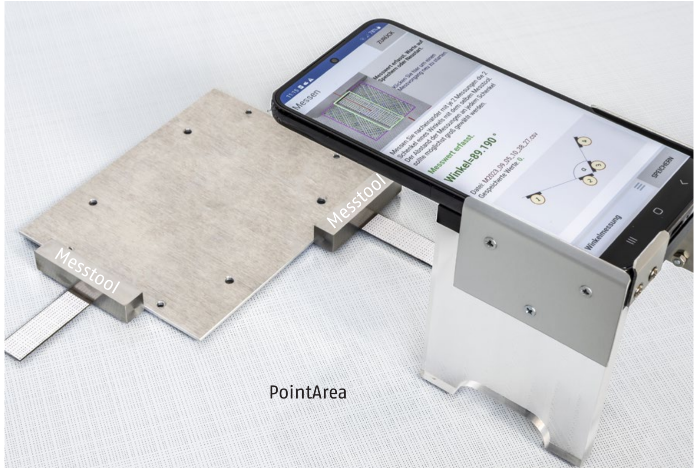

Fig. 1. The 2D Measuring System MICRO CONTROL consisting of a Smartphone, Measurement tools and the PointArea

7.2 Calibration Procedure

In order for the measuring system to be ready for operation, it requires basic settings, a correction of the distortion of the camera's optical system, a correction of the geometric distortions of the PointArea used and all calibration data of the used measurement tools. Most of this data must be generated with the device itself, as it is dependent on the properties of the device.

The basic image sharpness settings and a suitable zoom can be determined automatically by the device itself within two minutes.

The same applies to distortion correction, in which the data from 16 images that capture the PointArea at different positions and angles are used to calculate the necessary correction values utilizing a statistical procedure.

The geometric distortions and other details of the PointArea used are determined by the manufacturer and must be transferred once to the measuring system (smart-phone) in the form of two supplied files.

All measurement tools must first be integrated into the system and their parallax errors must be calibrated against the measuring system. The utilities required for this can be found under Calibrations/Measurement tools. This menu starts with "Tests and information" and shows the status of a measurement tool and branches to any further required calibrations.

If you have already configured the basic settings and calibrated the distortion, please refer to Calibrations/Measurement tools (➦ 7.2.4 Measurement tools) to calibrate your measurement tools.

7.2.1 Basic Settings

The first step is to configure the basic settings, which you can access from the main menu via Calibrations/Basic settings.

- Place the measurement system onto the PointArea. Click on the "Automatic" button.
- Wait one to two minutes without moving the measuring system while the system determines the desired parameters automatically. The process is complete when "Settings successfully determined" is displayed. You should now only see coloured measuring points in the image. You can now perform the distortion correction (➦ 7.2.2) via the "Go back" button.
- If the message "PointArea not found" appears, this means that the automatic system was unable to find any basic settings. In this case, you must search for and find the basic settings manually.
- To do this, click on the "Manual" button. Place the measuring system onto the PointArea. Move the µm/Pixel slider to the centre. Now adjust the sharpness of the image using the Sharpness slider. Make sure that the image is also sharp at the edges.
- Then move the µm/Pixel slider to different positions until the measuring points in the image become coloured or a message beginning with "WAIT" appears. When this happens, wait a few seconds while the measuring system automatically corrects the positions of the µm/Pixel and Zoom sliders.
- If you cannot find a position using the µm/Pixel slider in which the measuring points in the image become coloured, then move the Zoom slider to another position and again try to vary the µm/Pixel slider so that the measuring points in the image become coloured. Repeat this process until you obtain coloured measuring points and the automatic system changes the µm/Pixel and Zoom sliders.
- Now correct the sharpness of the image using the Sharpness slider until coloured measuring points are visible everywhere, i.e. in the centre of the image as well as at the edges. If you now only see coloured measuring points, the basic settings are complete and you can perform the distortion correction (➦ 7.2.2).

7.2.2 Distortion Correction

You can access the distortion correction from the main menu via Calibrations/ Distortion Correction. Distortion correction is a statistical procedure used to correct the optics and image sensor of the measuring system and must be carried out before the first measurement.

- To do this, place the measuring system onto the PointArea. In the display you will now see either green and blue measuring points – if the system has already been calibrated – or numerous red vectors. The red vectors represent the current distortion errors.
- Wait two to three seconds. Click on "Capture PointArea". Wait one second. Move the measuring system at least 5 cm further in the X and Y directions to another position on the PointArea, turning the measuring system as desired. Wait another two to three seconds. Repeat this process 15 more times so that the data from a total of 16 images is available for calculating the necessary correction values.
- Only coloured, predominantly green measuring points should then be visible. The sensor is then calibrated. The display shows "S Px=xx µm". This is the standard deviation of all calculated measuring points from a defined grid. Regardless of how you have rotated the measuring system and where you have placed it on the PointArea, this value should be ≤ 5 µm.
- If S Px > 5 µm, this calibration must be carried out again. If this fails a second time, the basic settings must be checked again.

IMPORTANT	Distortion correction is a statistical correction method. If you do not move the measuring system by at least 5 cm between each of the 16 image recordings, the distortion correction will not work over the entire PointArea!
	You can switch to this menu at any time to check the current sensor calibration using the display. Clicking on the display shows all distortion errors visually in the wrong colour.

7.2.3 PointArea

Here is some information summarised for defining the axis zero points of the PointArea.

Calibrate End Stops

To set the coordinate system of the PointArea in such a way that its zero axes are aligned with the existing end stops. To set the coordinate system, define Y=0 by taking measurements at two separate positions at the X-axis end stops (XStart and XEnd). Finally, define X=0 at any Y position to determine where the Y axis intersects the X axis. After these three measurements, press "Start" to calibrate the end stops.

Discard End Stops

Resets the coordinate system of the PointArea to its original settings. To do this, press "Start". The end stops can then be redefined with Calibrate End Stops.

Configure Offset X

Shifts the Y-axis of the PointArea by the amount entered. This makes it possible to calibrate an external end stop that is far away from the PointArea.

Measure Offset X

Shifts the Y-axis of the PointArea by the directly measured amount. This makes it possible to calibrate an external end stop that is far away from the PointArea.

Configure Offset Y

Shifts the X-axis of the PointArea by the amount entered. This makes it possible to calibrate an external end stop that is far away from the PointArea.

Measure Offset Y

Shifts the X-axis of the PointArea by the directly measured amount. This makes it possible to calibrate an external end stop that is far away from the PointArea.

Show Calibrated Image

Displays a visual representation of the distortion calibration of the current PointArea. The determined linear expansion coefficients are displayed by pressing the "Start" button.

7.2.4 Measurement Tools

The measuring system is supplied with two measurement tools, as you need two measurement tools to be able to calibrate them.

The calibration procedure is as follows:

1. Integrate measurement tool 1.
2. Integrate measurement tool 2.
3. Calibrate measurement tool 1 parallax.
4. Calibrate measurement tool 2 parallax.
5. Capture/Improve measurement tool 1 vector angle. (3x)
6. Capture/Improve measurement tool 2 vector angle. (3x)
7. Capture/Improve measurement tool 1 to measurement tool 2. (3x)

Capture/Improve Measurement tool 1 to measurement tool 2 is understood to mean that both measurement tools are placed against each other in such a way that a measured value = 0 should be determined.

If your PointArea does not have an end stop or is not calibrated, please carry out the "Calibrate A to B" calibration.

Tests and Information

This menu item is used to analyse a measurement tool, to display information about this tool and, if necessary, to provide various calibration options.

If, for example, a measurement tool is entered but is shown on the screen as "Measurement tool unknown", this measurement system does not yet recognise the targeted measurement tool. In this case, if you press "Start", the system opens the "Integrate" menu item and the measurement tool can be registered on the system immediately.

If necessary, other calibration options are also offered in the same way. If the "Start" button remains grey, the targeted measurement tool is considered fully calibrated.

Integrate

You use this function to register a measurement tool with the measuring system. A measurement tool cannot be calibrated any further without registering it. If it is already known, "Tests and Information" provides further information on what still needs to be calibrated.

Calibrate Parallax

This calibration must be repeated until an error < 0.01 mm is shown. To do this, a measurement tool must be measured at least three times at different points in the PointArea, each time from four directions.

Capture/Improve

Various options for calibrating and improving calibrations are offered here. "General Help" within this menu provides you with further information.

- This menu also opens automatically if "Tests and Information" recognises a necessary and pending calibration. In such cases, the appropriate help for the pending calibration is automatically displayed. In order to capture or improve something, you should then proceed as described in the relevant help instructions.
- If an improvement is recognised automatically, it will be displayed and the "Start" button will take on a new meaning: If you press it, you will be asked whether the improvement should be applied.
- If you confirm this, the new value is then included in the internal counter for this calibration, whereby the internal counter is increased to a maximum of ten.
- If you reject the application of the improvement, you will be asked whether the current value should be replaced. If you confirm this, the new value is set and the internal counter is set to one. As a result, further improvements to this value will be required to increase the internal counter to its minimum value.

The following improvement options are available to you:

1 Tool Improve Vector Angle.

Two measurements. Requires a calibrated Y-axis end stop.

Measure a measurement tool twice at least 3 cm apart at the Y-axis end stop. If an angle improvement is displayed, press **"Start"** to improve this value.

1 Tool Improve Vector to End Stop.

Two measurements. Requires a calibrated Y-axis end stop.

Measure a measurement tool twice at a distance of 1 mm from the Y-axis end stop. If a vector improvement to 0 is detected, press "Start" to improve this value.

2 Tools Improve Vectors to End Stop.

Two measurements. Requires a Y-axis end stop.

Measure two different measurement tools in succession at the same point on the Y-axis end stop. If a vector improvement is recognised, press **"Start"** to improve this value for both measurement tools.

2 Tools Improve Vectors to Each Other.

Two measurements.

Measure two measurement tools against one another at any position and at any angle on the PointArea. If a vector improvement is recognised, press **"Start"** to improve this value for both measurement tools.

1 Cylinder Tool Calibrate Diameter to End Stop.

One measurement. Requires a calibrated Y-axis end stop and a calibrated cylinder tool.

Measure the cylinder tool at the Y-axis end stop. If a diameter improvement is detected, press **"Start"** to improve this value.

☞	Regardless of what the current help prompt shows you, you can carry out all improvement options one after the other as desired, even with different measurement tools.

Calibrate A to B (Without End Stop)

This function allows you to calibrate two measurement tools alternatively, e.g. if you do not yet have any calibrated measurement tools available or you do not have a calibrated Y-axis end stop.

- To do this, switch to Measure. Create a new measurement file. Rename this to **"AB"**. Then switch to X and Y measurement.
- Mount a reference standard at least 10 cm long with a polished edge as parallel as possible to the Y-axis of the PointArea. Mark two points named 0 and 1 on this standard at a distance of about 10 cm.

IMPORTANT	Point 0 must be closer to the x-axis than point 1!
IMPORTANT	For each of the following measurements, the detection frame in the video image must be in an upright position and the measuring system must be facing the measuring edge.

- Use two measurement tools. These are referred to below as Tool A and Tool B.
- Touch Tool A to point 0, measure and save. [Saved values=1] Touch Tool A to point 1, measure and save. [2] Move Tool A out of range of the measurement to the right and rotate it by 180°.
- Touch Tool B to point 0, measure and save. [3] Touch Tool B to point 1, measure and save. [4] Touch Tool B to Tool A without changing its alignment.
- Align Tools A and B exactly parallel to the X-axis and check their contact.
- Measure Tool A and save. [5] Measure Tool B and save. [6] Move Tools A and B by at least 5 cm.
- Check the contact and alignment of both tools. Measure Tool A and save. [7] Measure Tool B and save. [8] Move Tools A and B by at least another 5 cm.
- Check the contact and alignment of both tools for the last time. Measure Tool A and save. [9] Measure Tool B and save. [Saved values=10]
- From the main menu, switch to the Calibrations/Utilities/Calibrate A to B menu and press "Start" to calibrate A to B.
- Check your calibration by contacting both tools at different points on the PointArea at different angles and measuring them using the length measurement. The length determined must not exceed 50 µm in each case.

Calibrate Cylinder

- Construct an auxiliary tool with which you can rotate your cylinder measurement tool by at least 90° exactly around its cylinder centre. For example, a holder with an exact and grooved bore, glued to a weighted holding device, is suitable for this purpose.
- Switch to Measure. Create a new measurement file. Rename this to "Cylinder". Enter the exact diameter of the measurement cylinder in µm as the leading entry. Then switch to X and Y measurement.
- Place your holder with the mounted cylinder on the PointArea and weigh it down. Rotate the cylinder to the maximum angle, measure and save.
- Rotate the cylinder to a medium angle, measure and save.
- Rotate the cylinder to the smallest angle, measure and save.

- Position your holding device at a different position on the PointArea and weigh it down.
- Repeat the repositioning process and the three measurements at least five more times.
- Switch to the Calibrations/Utilities/Calibrate Cylinder menu via the main menu and press "Start" to calibrate the cylinder.

7.2.5 Level Gauge

You can use this function after a calibration to ensure that your PointArea is aligned exactly horizontally.

- You can find it from the main menu via Calibrations/Level Gauge.
- The level gauge is calibrated if you can turn the measuring system in any direction on a plane and the red bubble always points in the same direction after a short time. If this is not the case, the level gauge must be calibrated. This menu shows you how to calibrate the level gauge.

7.2.6 Backup

You can use the "Backup" button to create a backup of all relevant settings and calibration files. You should always use this option if you are calibrating the measuring system for the first time or have added new measurement tools to the system and calibrated them successfully, for example.

Technically speaking, a backup creates a file called BackUp.dat in the PointArea directory, which contains all individual files and relevant settings. If you back up this file manually after each backup and, if necessary, to a different medium, you can also archive different backups.

7.2.7 Restore

You can use this button to completely restore the measuring system to the state at the time of the last backup. All changes made to the data during this time since the last backup are cancelled. PointAreas or measurement tools that were added and calibrated after the last backup are not affected by the restoration: This information is retained in full.

7.3 Measure

The Measure menu combines all the tasks of the software for recording measured values, visualising results and simple data management.

- You can switch between the "Measuring modes" and "Saved results" at any time using the central selection box at the bottom left, which also displays the current operating mode.
- A distinction is made between two operating modes when measuring. The first operating mode comprises measurements that only require one measurement, such as the X and Y measurement. The second operating mode comprises guided measurements, which are only possible once several measured values have been captured according to a specific sequence.
- Each measuring mode uses a small graphic to visualise the respective measuring task and where the measurement is currently being taken. In the first operating mode, measured values can only be saved while they are being recorded. This is indicated by the visual measurement tool and the "Save" button.
- In the second guided operating mode, measured values can only be saved once all the necessary measurements have been carried out. The visual measurement tools indicate the position at which the next measurement is to be taken. If it is possible to save, this is indicated by the "Save" button.
- If you do not wish to save recorded measurements, you can reset a guided measurement at any time by clicking to the right of the video image.

7.3.1 Saved Results

This display is used to present the results saved in a file. If you save results from a measurement type, they are always written at the end of the currently selected file.

- You can use the "Select" button to choose between different files that have already been saved.
- The "..." button is used to choose another function for "Saved results". This allows you to create new measurement files, change the file name, print or delete the currently selected file.
- You can use the "+" button to append a comment or a command to the current data.
- You can use the "-" button to delete the last comment or the last measurement after confirmation.

7.3.2 X and Y Measurement

The XY measurement provides the X and Y values of a measurement tool. If end stops have been calibrated, you can very quickly determine the width of an object to be measured, for example, with just one measurement.

7.3.3 Length Measurement

You can determine the length of an object to be measured with two opposite and aligned contact points.

7.3.4 Circle Measurement

You can determine the diameter of a circular object by contacting it three times. The contact points should be made at a large angular distance (ideally 120°) from each other. To ensure high accuracy, the measurement tool should contact exactly at its center.

7.3.5 Angle Measurement

You can determine the angle of an object to be measured with four contact points (two contact points per angle segment). The contact points should preferably be at the ends of the angle segments.

7.3.6 Line Measurement

You can use this measurement to check whether an edge is actually straight. To do this, you can measure several contact points on the edge. The measured results are rotated so that they are displayed from the point of view of the contact points, regardless of how the edge was placed on the PointArea.

- You can select measured values using the "< " und ">" buttons.
- Use the "Delete" button to delete the selected measured value.
- You can use the "Save" button to save all measured values after confirmation.

☞	The colour of "X=..Y=.." changes with each captured measured value.

7.3.7 Triangle Measurement

You can determine the dimensions of a triangle with six contact points (two points on each side). The contact points must be made counter-clockwise at the ends of the triangle sides, starting at A (see Triangle on Wikipedia). The angles α, β and γ in [°], the sides a, b and c in [mm], the perimeter U and the area are determined.

7.3.8 X Against End Stop

With the X measurement, you obtain the X value of a measurement tool against a calibrated end stop.

7.3.9 Y Against End Stop

With the Y measurement, you obtain the Y value of a measurement tool against a calibrated end stop.

7.3.10 Circle Against End Stop

The circle measurement provides you with the diameter of a circle that is in contact with a calibrated end stop.

7.3.11 Right Triangle Against End Stop

This measurement provides you with all the parameters of a right-angled triangle with two contact points, with its right angle in contact with a calibrated end stop.

7.3.12 Rectangle Against End Stop

The rectangle measurement provides you with the width, height, perimeter and area of a rectangle with two contact points, which is positioned against a calibrated end stop at a right angle.

7.3.13 Video Magnifier

The video magnifier is a tool that displays the captured video image in four magnification levels.

7.4 Software

7.4.1 File Format

The content of the CSV files for saving measurement data was organised with the aim of machine readability as follows:

- Defined parameters:

  Version;;3;;// Version
  CultureInfo;;de-DE;;// CultureInfo
  Comment;;Sequence test measurement;;// Comment
  Values;;2;;// Values
  Val0;;TYPE;VALUES...
  Val1;;TYPE;VALUES...
  ... additional ValXX
- The semicolon (;) is used as a separator.
- The version information allows future changes to be made.
- "CultureInfo" defines the number formatting.
- "Comment" can describe the content of the file and can be output as a heading or label, for example.
- "Values XX" describes how many value lists Val0 ... Val(XX-1) will follow in the CSV file.
- A value list is always saved per line of the CSV file and begins with its name Val(0..XX-1). Two separators are followed by a type specification as an integer, followed by further values, which are precisely specified by the type specification.
- Type=1, Commect

  Value: Comment as text
- Type=2, X and Y measurement

  Values: X in µm; Y in µm; other, undocumented values
- Type=3, length measurement

  Values: Length in µm; other, undocumented values

- Type=4, circle measurement
  Values: diameter in µm; area A in mm*mm; circumference in µm; other, undocumented values
- Type=5, angle measurement
  Values: Angle in °; other, undocumented values
- Type=6, line measurement heading
  Values: Heading in text form; other, undocumented values
- Type=7, line measurement values
  Values: X measured in µm; Y measured in µm; X rotated calculated in µm; Y rotated calculated in µm
- Type=8, triangle measurement
  Values: Angle alpha in °; Angle beta in °; Angle gamma in °; a in µm; b in µm; c in µm; U in µm, Area A in mm*mm
- Type=9, X against end stop
  Values: X in µm; Y in µm; other, undocumented values
- Type=10, Y against end stop
  Values: X in µm; Y in µm; other, undocumented values
- Type=11, rectangle against end stop
  Values: X in µm; Y in µm; U in µm; area A in mm*mm
- Type=12, circle against end stop
  Values: Diameter in µm; area A in mm*mm; circumference in µm; other, undocumented values
- Type=13, right triangle against end stop
  Values: Angle alpha in °; angle beta in °; angle gamma in °; a in µm; b in µm; c in µm; U in µm, area A in mm*mm
- Type=14, temperature and elongation information
  Values: Temperature in °C; elongation coefficient at 20 °C in 0.000001/K

7.4.2 Commands

In the "Saved results" view, comments can be added to the currently selected measured data using the + button.

Certain comments are interpreted as commands and results for example in more complex displays of previously measured data.

The following commands are available:

.l	Displays all previously saved length measurement values in a diagram (requires length measurements).
.xy	Displays all previously saved XY values in an XY diagram (requires XY measurements).
.x	Displays all previously saved X values in an X diagram (requires XY measurements).
.y	Displays all previously saved Y values in a Y diagram (requires XY measurements).
.roundness	Calculates and displays roundness errors (requires >3 XY measurements on a circle).
.radius	Calculates and displays the radius (requires >2 XY measurements on a circle).
.alv2 .. .alv7	This command summarises several line measurements in a diagram, calculates a polynomial X (X=2 [.alv2] to X=7 [.alv7] degree) using regression calculation over all data points, calculates the standard deviation of all data points, the standard deviation of all data points to the trend of the polynomial, as well as the straightness of all data points. This procedure makes it possible to more accurately capture this edge statistically through multiple line measurements on an edge at different points in the PointArea..

8. Measurement Uncertainty

The measurement uncertainty of the PointArea measuring system cannot be described in general terms, as it depends on the specific measuring task.

Other factors that influence the measurement uncertainty are various calibrations, the manufacturing quality of the measurement tools, the PointArea and the end stops used. The ability of the person carrying out the measurement to properly contact the measurement tools on edges, the edge quality, the material and size of the object to be measured and the temperature also have an influence.

No definitive statements can yet be made regarding the calibration and manufacturing quality of individual components in series production. However, it will be possible to control and optimise these processes in the future, which is why more concrete statements on measurement uncertainty can be expected going forward.

However, experience to date shows that measurement uncertainties, e.g.

1. for length measurements are smaller than ± 50 µm
2. for angle measurements are smaller than ± 0.1°
3. and for line measurements are smaller than ± 15 µm

are realistic and have consistently been lowered so far.

This measuring system therefore enables you to determine the mean values and standard deviations of measurement series. Calibrations can be repeated and improved. To make further statements on absolute measured values and measurement errors, you can use calibrated gauge blocks in accordance with DIN ISO 3650.

By taking multiple measurements and using these tools, you can make more precise statements about specific measurement tasks. If, for example, a right angle with a side length of 200 mm is measured from three directions at three different positions on the PointArea with a standard deviation of 0.01°, a real measurement uncertainty of ± 0.03° can be assumed.

To measure larger objects as accurately as possible, it is necessary to condition the temperature of the object and the PointArea, including an exact temperature specification. Take into account that, for example, a 50 cm long aluminium object expands or contracts by more than 11 µm per Kelvin temperature change.

The following is a list of various measurement uncertainty tests carried out to date:

Measuring a measurement tool from one direction:

- Average of four measurement tools, each measured ten times from one direction in the X direction.
- S X: 0.69 µm,
- Measurement uncertainty = ± 2 µm
- Comment 1: A pure reproducible measurement without calibration error of the PointArea.
- Comment 2: Allows a conclusion to be made about the functionality of the distortion and parallax correction.

Measuring a measurement tool from three directions:

- Average of four measurement tools, each measured twice from three directions in the X and Y directions.
- S X/Y: 2.08 µm,
- Measurement uncertainty = ± 6 µm
- Comment 1: A pure reproducible measurement without calibration error of the PointArea.
- Comment 2: Allows a conclusion to be made about the functionality of the distortion and parallax correction.

Maximum angle measurement error in degrees as a function of the segment length:

- Measurement uncertainty for segment length > 100 mm: < ± 0.1°
- Measurement uncertainty for segment length > 200 mm: < ± 0.05°
- Measurement uncertainty for segment length > 500 mm: < ± 0.02°

- Comment 1: An XY measurement uncertainty of ± 20 µm was assumed.
- Comment 2: These specifications are only valid if it is possible to measure a 90° angle < ± 0.01° at the end stop.

Length measurement of a ceramic gauge block at any position on the PointArea and in any measurement direction:

- 30 length measurements of a 100 mm long ceramic gauge block in random positions and orientations and freely varying measurement directions.
- S Length: 9 µm
- Measurement uncertainty = ± 27 µm
- Comment 1: The specified values include all calibration errors of the PointArea and measurement tools, as well as contact errors.
- Comment 2: Two measurements = 2 times the measurement error.
- Comment 3: Only measurements > 100 mm were taken into account here.

Complex measurement of a precision flat straight edge made of grade 1 steel in accordance with DIN 874/1:

- Comparative line measurement over 700 mm with five different PointAreas from two measurement directions on four material edges of the precision flat straight edge. Ten line measurements – specifically five PointAreas multiplied by two measurement directions – were carried out and combined for each material edge of the precision flat straight edge. A seventh-degree polynomial was formed as a fictitious material edge using a regression calculation. Finally, the standard deviation of the difference between all assignable individual measured values and the polynomial was calculated (S for the trend of the edge). The calculated standard deviations were just under 4 µm for all four material edges, i.e. the measuring system functioned with a statistical measurement uncertainty of around ± 12 µm in its main measuring direction. The calculated polynomials correlated with each other on each side of the flat straight edge.
- Measurement uncertainty = ± 12 µm
- Comment 1: The specified value includes all calibration errors of five PointAreas and measurement tools, as well as approximately 800 contact errors.
- Comment 2: Approximately 200 assignable measured values were compared with each other four times.
- Comment 3: Two opposing measurement directions were compared.

9 Maintenance

9.1 Lithium-Ion Polymer Rechargeable Battery

The measuring system is equipped with a lithium-ion polymer rechargeable battery. These batteries are low-maintenance and have a long service life with appropriate use.

Please note:

- The battery is charged using the power adapter supplied with the smartphone.
- It is recommended to charge batteries with a remaining charge of 75 % to 30 % of the battery capacity.
- The battery should never be fully discharged.

IMPORTANT	Excessive discharge can destroy the battery.

- The temperature of the battery during the charging process should not exceed the range of 5 … 40° C.

IMPORTANT	Extreme temperatures can cause damage. The charging capacity and service life of the battery will be reduced.

- Never use a damaged or defective power supply unit for charging.

Warning	Damaged or defective chargers can cause an electric shock!
IMPORTANT	Damaged or defective chargers can cause damage to the device..

- Removal of the battery is not intended for the user

IMPORTANT	Improperly opening the device can lead to damage.
	If necessary, have the battery replaced by the smartphone manu-facturer!
	Please also refer to the operating instructions for the smartphone.

9.2 Cleaning

The PointArea should be cleaned when dirty using a soft cloth and standard, non-aggressive cleaning agents.

The smartphone and its sensors in particular should also be cleaned when dirty.

When doing so, please note:

Warning	The smartphone is not waterproof and dustproof (protection class IP20). There is a risk of short circuit.
IMPORTANT	Penetrating liquids can cause damage to the smartphone.
IMPORTANT	The use of unsuitable chemicals or solvents can cause damage to the exterior and interior of the smartphone. Observe the chemical resistance of the materials.
	Avoid excessive contamination of the measuring system.
	Please also refer to the operating instructions for the smartphone.

If necessary, clean the sensors (PET/stainless steel) and the housing (TPU/PC) of the smartphone with a soft, lint-free cloth and standard, non-aggressive cleaning agents.

10 Storage, Transportation

When storing and transporting the PointArea, care must be taken to avoid contami-nation and damage (scratches, creases, holes, cracks).

When storing and transporting the smartphone, observe the operating manual.

Always store the measuring system in a dry place. Avoid strong impacts and shocks to the device.

The generally applicable safety instructions for the transport and storage of rechargeable batteries apply.

	Repairs and service work on the measuring system may only be carried out by the manufacturer.
	To avoid unnecessary questions, please return the device with a brief description of the fault after contacting us:

PITSID Polygraphische innovative Technik Leipzig GmbH

Mommsenstrasse 2

04329 Leipzig

Germany

Tel: +49 341 25942-0

Fax: +49 341 25942-99

E-Mail: info@pitsidleipzig.com

Web: www.pitsidleipzig.com

If it becomes necessary to replace parts (e.g. sensors) after a long period of use, please contact the above address.

12 Disposal

PITSID Polygraphische innovative Technik Leipzig GmbH will assume responsibility for the disposal of old MICRO CONTROL measuring system devices sent in.

If you dispose of the device yourself, you must also comply with the applicable safety regulations for the disposal of lithium-ion polymer batteries.

	The Measuring System MICRO CONTROL must be disposed of as electronic waste in accordance with the applicable laws. PITSID Polygraphische innovative Technik Leipzig GmbH is registered in the WEEE directive (Waste Electrical and Electronic Equipment) register under WEEE reg. No. DE73410149.

Attachment

Warranty

There is a guarantee for the product within the framework of the contractual agreements. There is no warranty claim in the following cases:

- Accidental or willful damage
- Damage due to failure to observe the documentation
- Unauthorised changes to hardware or software

The warranty claim expires if changes to the product by the customer or by third parties are not agreed upon with PITSID – Polygraphische Innovative Technik Leipzig GmbH and go beyond the activities described in this product. This also applies to repair measures carried out independently or carried out by third parties.

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