



Operating Instructions
FSC1/7, FSC1000

PRELIMINARY

Layer thickness measuring device for insulators on metal and carbon fiber-reinforced plastics (CFRP)

MICRO-EPSILON
MESSTECHNIK
GmbH & Co. KG
Königbacher Strasse 15

94496 Ortenburg/Germany

Phone +49 (0) 8542/168-0
Fax +49 (0) 8542/168-90
email info@micro-epsilon.com
www.micro-epsilon.com

Contents

1.	Safety	5
1.1	Symbols Used	5
1.2	Warnings	5
1.3	Notes on CE Marking	6
1.4	Notes regarding FCC Approval	6
1.5	Intended Use	7
1.6	Proper Environment.....	7
2.	Overview	8
2.1	Structure, Functional Principle	8
2.2	FSC1/7 and FSC1000 Technical Data.....	9
3.	Delivery	10
3.1	Unpacking, Included in Delivery.....	10
3.2	Storage	10
4.	Initial Operation.....	11
4.1	Dimensional Drawings.....	11
4.2	Battery Pack.....	13
5.	FSC1/7 and FSC1000 Operation.....	14
5.1	Switch-on Phase, Warm-up	14
5.2	General Controller Operation	14
5.3	Measuring Program Start	15
5.4	Setup, Parameters	16
5.5	Adjustment of the Measuring System	18
5.5.1	General	18
5.5.2	Load Adjustment Table	19
5.5.3	Managing Adjustment Tables.....	20
5.5.4	Performing an Adjustment.....	21
5.6	Performing a Measurement.....	26
5.7	Statistics.....	28

5.8	Measurement Data	29
5.8.1	General info	29
5.8.2	Displaying Measurement Data	30
5.8.3	Managing Measurement Data	31
5.8.4	Saving/ Exporting Measurement Data	31
5.9	Ending the Measuring Program, Switching off the Controller	33
6.	Liability for Material Defects.....	33
7.	Cleaning, Service, Repair	34
8.	Decommissioning, Disposal	34
9.	License agreement, software	35

1. Safety

System operation assumes knowledge of the operating instructions.

1.1 Symbols Used

The following symbols are used in these operating instructions.

NOTICE

Indicates a situation that may result in property damage if not avoided.



Indicates a user action.



Indicates a tip for users.

Measurement

Indicates hardware or a software button/menu.

1.2 Warnings

NOTICE

Avoid shocks and impacts to the sensor.

> Damage to or destruction of the sensor

Avoid exposure of sensor and controller to splashes of water.

> Damage to or destruction of the sensor/controller

Avoid exposure of sensor to aggressive media (detergents, cooling emulsions).

> Damage to or destruction of the sensor

Avoid bending, clamping and tensile stress of the sensor cable.

> Damage or destruction of the sensor cable

1.3 Notes on CE Marking

The following apply to the FSC1/7 and FSC1000:

- EU Directive 2014/35/EU
- EU Directive 2014/30/EU
- EU Directive 2011/65/EU, "RoHS" Category 9

Products which carry the CE mark satisfy the requirements of the EU directives cited and the European harmonized standards (EN) listed therein. The EU Declaration of Conformity is available to the responsible authorities according to EU Directive, article 10, at:

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Königbacher Straße 15
94496 Ortenburg/Germany

The measuring system is designed for use in industrial environments and meets the requirements.

1.4 Notes regarding FCC Approval

The FSC1/7 and FSC1000 are registered under the FCC identifier: 2AMBGMEMW02, equipment class

- Part 15 Class B Computing Device Peripherals and
- Part 15 Class C Low Power Communication Device Transmitter

with the US Federal Communications Commission (FCC).

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

If sensor and/or controller are modified, the FCC approval becomes void.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help

1.5 Intended Use

- The FSC1/7 and FSC1000 are designed for use in industrial and laboratory applications. They are used to measure the thickness of paint and other electrically insulating layers on substrates such as carbon fiber-reinforced plastics (CFRP), CFRP with metallic lightning protection and metals.
- The system must only be operated within the limits specified in the technical data, see Chap. [2.2](#).
- The system must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the measuring system.
- Take additional precautions for safety and damage prevention in case of safety-related applications.
- The system is designed for battery operation; operating with a charger connected is not permitted.

1.6 Proper Environment

- Protection class: IP 40
- Temperature range
 - Operation: +10 ... +40°C (+50 ... +104 °F)
 - Storage: -0 ... +45°C (+32 ... +113 °F)
- Humidity: 20 ... 80% (non-condensing)
- Ambient pressure: Atmospheric pressure

2. Overview

2.1 Structure, Functional Principle

The FSC1/7 and the FSC1000 are suitable for thickness measurements of dielectric layers on

- CFRP,
- CFRP with lightning protection,
- metals
- and conductive or weakly conducting materials.

The device includes a sensor (handheld module) and a controller (control and display module). The system operates based on microwaves. No coupling medium is required. One measurement takes less than 2 seconds.



Fig. 1 Sensor



Fig. 2 Controller

2.2 FSC1/7 and FSC1000 Technical Data

Model	FSC1/7	FSC1000
Measuring range	0 to 500 μm	0 to 1000 μm
Linearity ¹	$\leq \pm 3 \mu\text{m}$	$\leq \pm 5 \mu\text{m}$ ²
Repeatability	$\leq 2 \mu\text{m}$	$\leq 4 \mu\text{m}$
Duration single measurement	< 2 sec.	
Contact time	∞ for surface temperatures < 40 °C	
	< 3 sec for surface temperatures 41 ... 65 °C	
Resolution of the display	1 μm or 0.01 mils	
Active measuring area	approx. 20 mm diameter	
Coupling medium	no coupling medium required	
Substrates (selection)	CFRP ³ , CFRP ³ with lightning protection, metals	
Power supply	NiMh battery	
Temperature	Operation	+10 ... +40 °C (+50 ... +104 °F)
	Storage	-0 ... +45 °C (+32 ... +113 °F)
Dynamic tilt prevention	ON/OFF, Parameters	
Statistical functions (with recording and data export)	Min., Max., counter, median and standard deviation	
Measuring principle	non-destructive due to microwaves	
Operating frequency	approx. 24 GHz	

- 1) Adjustment based on support points, distance from support points max. 150 μm , regardless of the film tolerance.
- 2) from 500 μm : also depends on the dielectric constant, typically $< \pm 3\%$.
- 3) With woven materials at least one layer; with laid materials at least two layers with different angles of the respective fiber orientation.

3. Delivery

3.1 Unpacking, Included in Delivery

- 1 Sensor including hand strap
- 1 Controller including shoulder strap
- 1 Exchangeable battery
- 1 Charger
- 1 Sensor cable with push-pill latching mechanism
- 1 Box with calibration foils
- 1 Operating instructions and test certificate
- 1 Carry case

- ➡ Carefully remove the components of the measuring system from the packaging and ensure that the goods are forwarded in such a way that no damage can occur.
- ➡ Check the delivery for completeness and shipping damage immediately after unpacking.
- ➡ If there is damage or parts are missing, immediately contact the manufacturer or supplier.

3.2 Storage

Temperature range storage: 0 ... 45 °C (+32 ... +113 °F)

4. Initial Operation

4.1 Dimensional Drawings

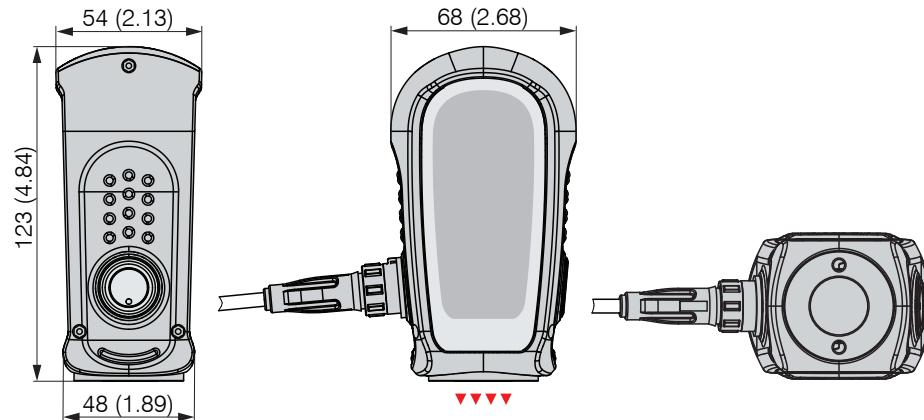


Fig. 3 Sensor dimensions, in mm (inches)

▼▼▼▼ Active measuring surface sensor

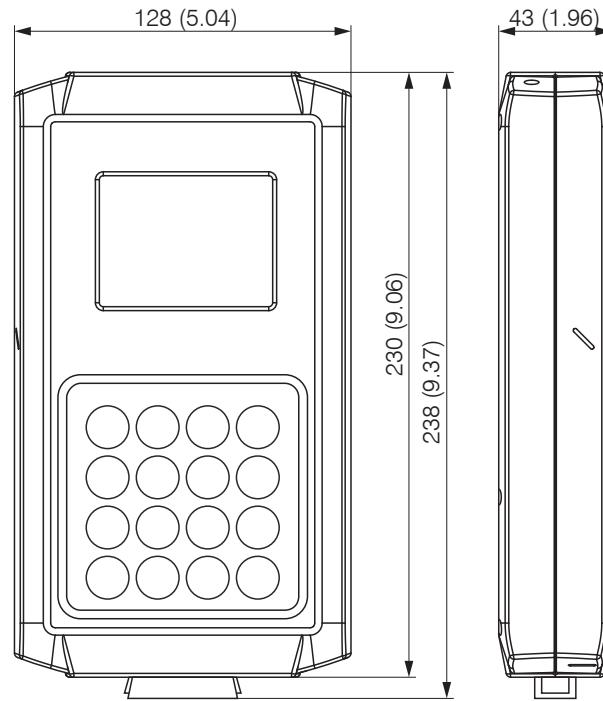


Fig. 4 Controller dimensions, in mm (inches)

4.2 Battery Pack

- ➡ Connect the battery to the controller with the contacts on the upper side, see [Fig. 5](#).
- **i** Charge the battery before initial operation. The battery must not be charged during measurements. Switch the controller off as defined before replacing the battery.

Replacing the battery: Press the latching mechanism on the battery together and pull it out.

Charging the battery: Connect the battery to the charger. The LED of the charger signalizes the charging process.



Fig. 5 Controller with battery

The state of charge of the battery is displayed on the controller screen, see [Fig. 6](#). The display will light up green with a state of charge from 20% to 100% and red for less than 20%. The controller will display a warning message when the remaining capacity is 10%. The controller will switch off automatically when the status display reaches 0%.

The status display for the battery becomes visible approximately one minute after the controller is switched on.

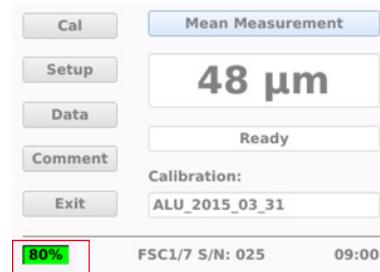


Fig. 6 Battery state of charge

5. FSC1/7 and FSC1000 Operation

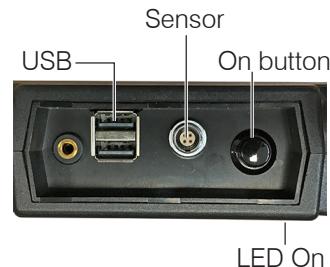
5.1 Switch-on Phase, Warm-up

To prevent temperature and/or drift effects, which can lead to incorrect measurement results, proceed as follows:

- ▶ Switch on the controller.

The ON LED in the upper right corner will light up.

- ▶ Connect the sensor with sensor cable to the Sensor connection on the upper side of the controller.
- Before operation, the measuring system requires sufficient time to adapt to the ambient temperature.



5.2 General Controller Operation

The controller can be operated using the touchscreen or the keyboard. The touchscreen is “resistive,” which means that it can also be operated when wearing gloves or with a round stylus.

- Do not use any sharp objects on the touch screen and the keyboard in order to avoid damage.

Keyboard: Use the arrow keys to navigate the menu.

ENTER key: Activates the next menu

ESC key: Return to the previous menu.

The numeric field is used to enter, for example, a comment for a measurement or the name for an adjustment.



Fig. 7 Controller Keyboard

5.3 Measuring Program Start

After switching-on, the controller displays the start page, see [Fig. 8](#).

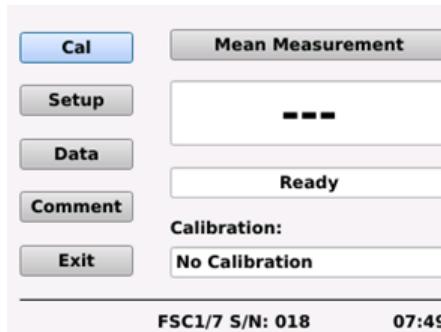


Fig. 8 Controller start screen

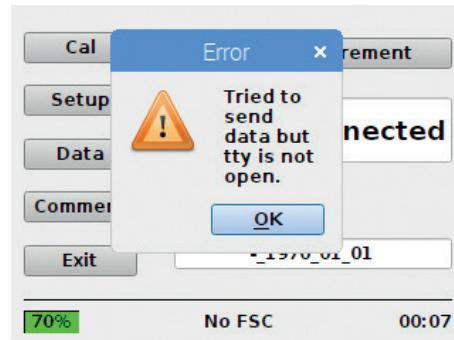


Fig. 9 No sensor connection

The connection to the sensor is established when the sensor's serial number is displayed at the bottom of the screen, see [Fig. 8](#). The device is ready for operation.

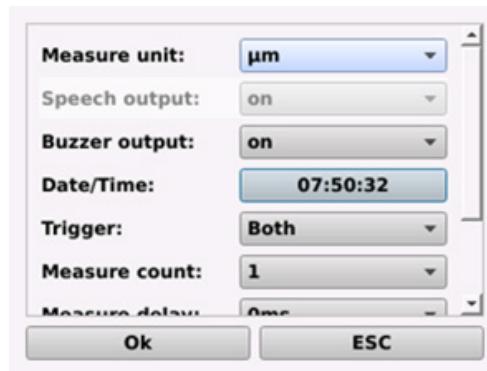
If a connection to the sensor cannot be established, this is reported, see [Fig. 9](#).

If the connection to the sensor is interrupted, e.g. because the sensor cable is removed, this will be displayed, see [Fig. 9](#). Press **OK** and connect the sensor cable with the controller to continue the measurements.

5.4 Setup, Parameters

In the **Setup** menu, see [Fig. 10](#), settings can be configured via the pull-down menus.

Measurement unit	$\mu\text{m} / \text{mils}$	
Buzzer output	<i>On / Off</i>	<i>An audible signal indicates successful/unsuccessful measurement.</i>
Date/Time	Time in the format hh:mm:ss Date in the format YYYY-MM-DD	
Trigger	<i>Button / Key 1 / Both</i>	<i>Settings for triggering the measurement. Button: Start measurement by pressing the button on the sensor. Key: Start measurement by pressing keys 1, 2 or 3 on the controller. Both: Start measurement by pressing the button on the sensor or keys 1 to 3.</i>
Measure count	<i>1 / 2 / 3 / 4 / 5</i>	<i>All three parameters ensure repeatable measurement results. Measure count sets the number of sequential individual measurements; the mean value from this automatic series of measurements is displayed.</i>
Measure delay	<i>0 / 100 / 200 / 300 / 400 / 500 ms</i>	<i>In the Measure delay menu, a break can be added between the sequential measurements.</i>
Max delta	<i>5 / 7.5 / 10 / 12.5 μm</i>	<i>Max Delta defines the maximum permissible difference between the smallest and the largest measured value in the sequential measurements.</i>
Style	<i>Dark contrast / Bright contrast</i>	<i>Display</i>



Gray highlighted fields
allow for a selection.

Fig. 10 Setup menu

5.5 Adjustment of the Measuring System

5.5.1 General

The Cal (calibration) menu makes it possible to load, manage and create adjustments.

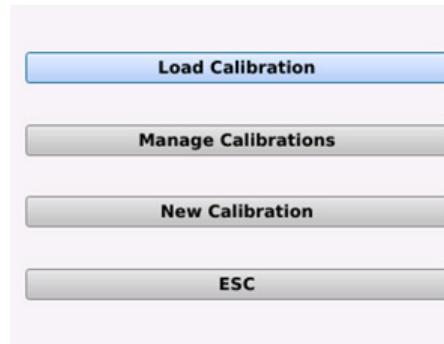


Fig. 11 Cal (calibration) menu

Load Calibration	Select and start existing adjustment table.
Manage Calibrations	Manage, delete existing adjustment tables.
New Calibration	Create new adjustment table. The measuring system can be calibrated on various substrate materials. Potential substrate materials are, for example, metals, CFRP or CFRP with lightning protection.
ESC	Back to measuring mode

- Create a separate adjustment table for each potential material, because the measurement on CFRP with settings for metal may, for example, lead to incorrect results.

5.5.2 Load Adjustment Table

► Switch to the Load Calibration menu.

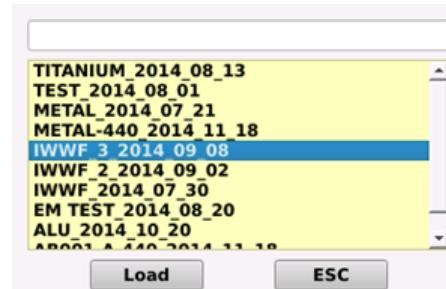


Fig. 12 Data set selection

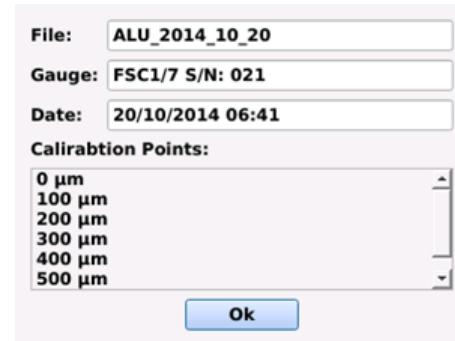


Fig. 13 Data set details

► Select the desired file and confirm with the Load button.

Once an adjustment is loaded, a window will appear with the basic information regarding the adjustment, see Fig. 13. After the Ok button is pressed, the window will close and the measuring mode will be activated.

5.5.3 Managing Adjustment Tables

You can manage existing data sets in the Manage Calibration submenu.

Possible options:

- Del Deletes the selected data set
- Load Loads the selected data set
- ESC Back to measuring mode

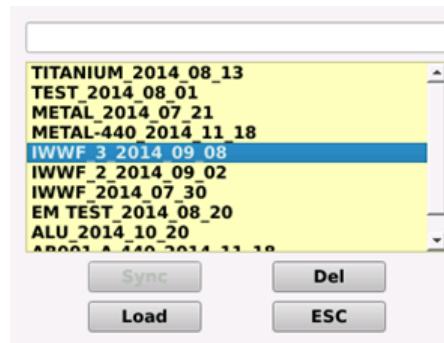


Fig. 14 "Manage Calibration" for loading or deleting

5.5.4 Performing an Adjustment

- **i** Only use undamaged calibration foils. Contamination, bends or damage within the black circle will lead to incorrect results.
Only use the foil within the black circle for the adjustment.¹
Foil are also available with a certificate.
It is not possible to certify, or recertify, the foils after the fact.

► Switch to the New Calibration menu.

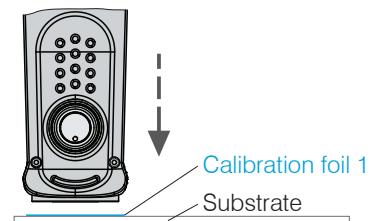
The adjustment can be started when **Ready** is displayed in the status window.



Fig. 15 Adjustment ready

You must select at least two support points for an adjustment, e.g. 0 μm (= without calibration foil, measurement directly on the substrate) and 100 μm .

► Place the first calibration foil on the substrate, place the sensor on top, avoid vibrations/tilting and trigger the measurement.



1) Influences due to film tolerances are not considered with the adjustment.

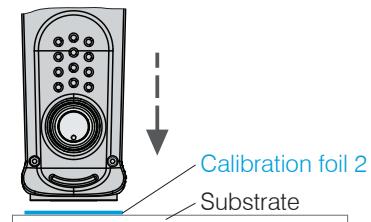
Depending on the setup configuration, press the button on the sensor or keys 1 to 3 on the controller. The measurement will start appr. 300 ms after you release the button.

► Then enter the thickness of the calibration foil in the Thickness field in micrometers as an integer.



Fig. 16 Indicate the thickness of calibration foil 1

- **i** Select the distance between the support points in a range of max. 100 to 150 μm over the entire measuring range. Make sure that the measuring area of the sensor, the calibration foil and the measuring point are clean.
- Place the second calibration foil on the substrate, place the sensor on top, avoid vibrations/tilting and trigger the measurement.



Depending on the setup configuration, press the button on the sensor or keys 1 to 3 on the controller. The measurement will start 300 ms after you release the button.

► Then enter the thickness of the calibration foil in the Thickness field in micrometers as an integer.



Fig. 17 Indicate the thickness of calibration foil

Carry out this sequence with as many calibration foils as necessary and use the same position on the substrate to the extent possible. Stack the calibration foils if necessary.

If information was entered for the parameters Measure count, Measure delay and Max delta in the setup, these settings will also be used for the adjustment.

- To carry out the adjustment, set the Max delta parameter to the smallest possible value and set the Measure count parameter to the largest possible number.

If a measuring point fails within the adjustment due to vibrations/tilting, the adjacent message will appear.

Trigger the measurement for this support point again.

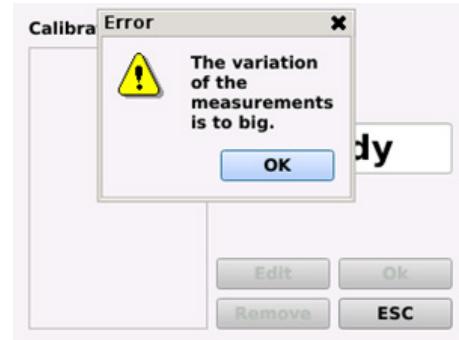


Fig. 18 Note regarding an interrupted adjustment point

- ▶ Press the **OK** button to save and end the adjustment.
- Use the **Remove** button to remove a support point during an adjustment.

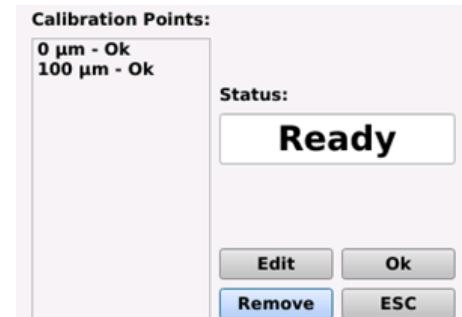


Fig. 19 List of support points during an adjustment

You can change a selected support point using the **Edit** button.

Use the **ESC** button to cancel an adjustment series; the system will return to measuring mode.

Use the **OK** button to end an adjustment series.

- ▶ To test the support points created, trigger the measurement by pushing the **Test Value** button.



Fig. 20 Testing the support points created

Then compare the result with the thickness value entered of the adjustment foil used. If the comparison result reveals an impermissible deviation, delete the support point and recreate it, see [Fig. 19](#).



Fig. 21 Test result

- ▶ Use the Save Calibration Data field to assign a name to the adjustment data set. Then press Save.

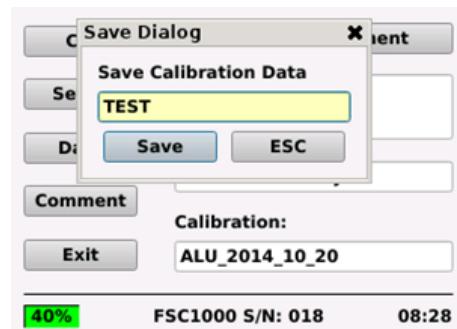


Fig. 22 Name assignment for an adjustment

Once the submenu “Manage calibration” has been exited, the system will return to measuring mode. If the adjustment was saved, it will be used for a subsequent measurement.

5.6 Performing a Measurement

► Load the adjustment data set suitable for the measurement/measurement object, see Chap. [5.5.2](#).

The system will start the measuring mode.

► To measure the thickness, place the sensor on the component, avoid vibrations/tilting and trigger the measurement. Depending on the setup configuration, press the button on the sensor or keys 1 to 3 on the controller.

The measurement will start 300 ms after you release the measuring button.



Fig. 23 Measurement preparation

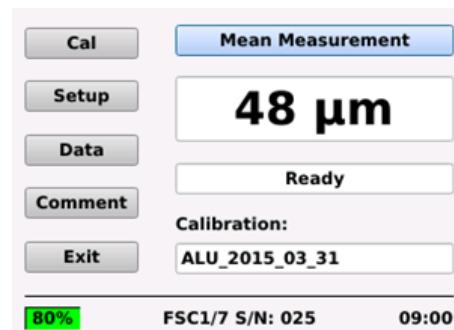


Fig. 24 Display of measurement results

If the measurement was successful, the measured thickness value and/or the calculated mean value of the individual results will be shown to the user, see [Fig. 24](#). Each measured value is saved in a log file. The results of the individual measurements are not visible to the user.

As an option, you can activate an acoustic signal (Buzzer output) for a successful measurement.



Fig. 25 Measuring range limits

If the measured thickness values are outside the adjusted measuring range, the system will generate the message **Out of range**.



Fig. 26 Message, if the measured thickness values are outside the adjusted measuring range

If the individual measurements have a deviation that is greater than the default (Setup > Max Delta menu), the measurement was not successful. The system will generate the message **Diff Error**.



Fig. 27 Measurement was not successful

Use the **Comment** menu item to add comments to the current measurement results. Comments will be stored in the current `measure_data_xy` file; see **Data > View Data** menu.

- The “Out of range” message might also indicate that an adjustment file is used which is not suitable for the substrate.

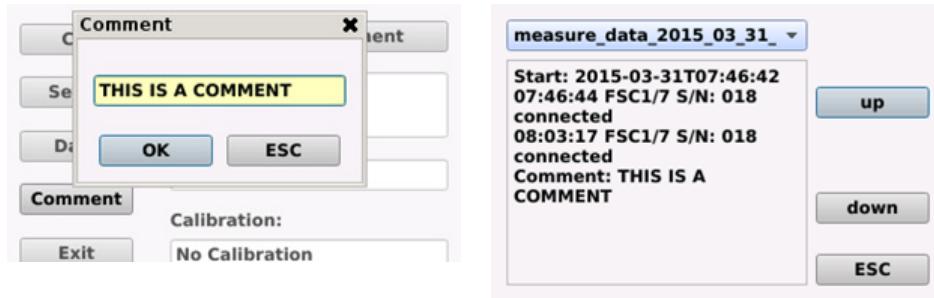


Fig. 28 Creating a comment (left), excerpt from the measurement data file (right)

5.7 Statistics

In order to analyze the measurement data, the mean value and the standard deviation are determined for the measured values within the values listed.

► Switch to the Mean Measurement menu on the start screen.



Fig. 29 Mean value and standard deviation menu

Also in the statistics menu, each measured value is saved in the log file.

When the menu is exited using the **ESC** button, a data set with the statistical information is stored in the log file, see [Fig. 32](#).

The **Clear** button is used to write the current statistics into the log file and delete the display; the most recent measured value (**Last**) remains in the display in this case.

The **Remove** button keeps the measured values selected and removed from the list in the log file but they are not used, however, for the statistical data set.

The measured values displayed in the statistic and overview are used for the statistics function. If the value of the last measurement is deleted from the overview, this value remains in the **Last** field.

5.8 Measurement Data

5.8.1 General info

When the controller is started, a new measuring file (log file) is created with the current date. All activities and measurement results are recorded in this file. The file is closed when the controller is switched off.

The measurement results are saved as a text file.



Fig. 30 Data menu

➡ Switch to the **Data** menu on the start screen.

5.8.2 Displaying Measurement Data

The View Data menu shows the log of the current measurement series directly after opening.

The pull-down menu in the upper part of the display enables the selection of a measurement series and shows this in the detail window.

► Switch to the Data menu on the screen.

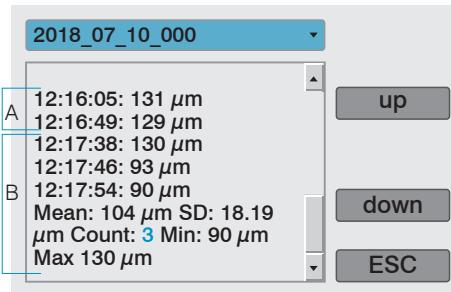


Fig. 32 Structure of measured value and log file

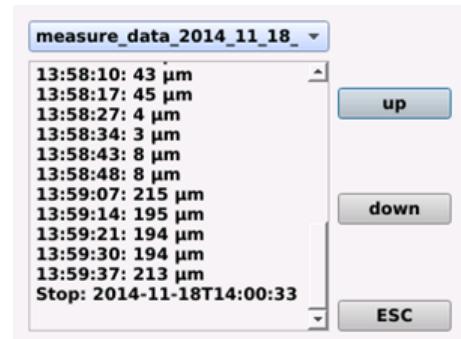


Fig. 31 Measurement file selection

- A Measured value determined in the Start menu: No statistical values are calculated for these measured values.
- B Measured value determined in the Statistics menu: For these measured values, statistical values are calculated and adopted into the measured value and log file.

5.8.3 Managing Measurement Data

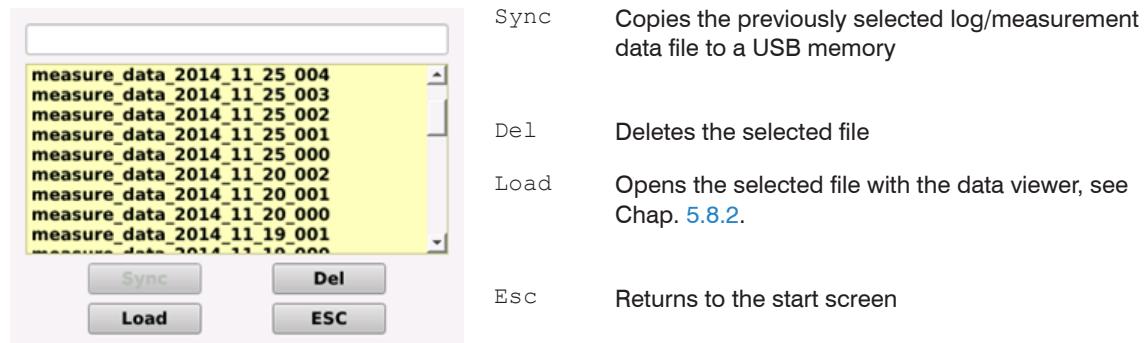


Fig. 33 Managing the measuring files

5.8.4 Saving/Exporting Measurement Data

You can use the **Save Data** menu to export the measured data from the device using a USB storage medium. Select the desired timeframe for this. The data will be copied. It will continue to be on the device.



After the data has been successfully saved, this is displayed.



Fig. 34 Saving the measurement data

If no data carrier is connected or it is not recognized, you will see a message.

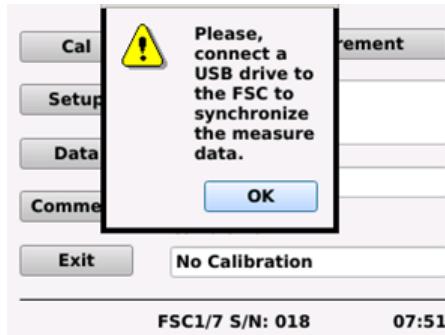


Fig. 35 Note: No USB storage medium found

5.9 Ending the Measuring Program, Switching off the Controller

Press the **Exit** button to end the measuring program and switch off the controller. If the prompt is answered with **Yes**, the controller will shut down and then automatically switch off.

- To replace the battery, the controller must be switched off.
1

6. Liability for Material Defects

All components of the device have been checked and tested for functionality at the factory. However, if defects occur despite our careful quality control, MICRO-EPSILON or your dealer must be notified immediately.

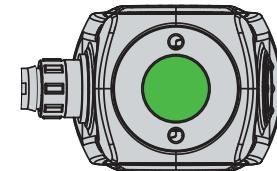
The liability for material defects is 12 months from delivery. Within this period, defective parts, except for wearing parts, will be repaired or replaced free of charge, if the device is returned to MICRO-EPSILON with shipping costs prepaid. Any damage that is caused by improper handling, the use of force or by repairs or modifications by third parties is not covered by the liability for material defects. Repairs are carried out exclusively by MICRO-EPSILON.

Further claims can not be made. Claims arising from the purchase contract remain unaffected. In particular, MICRO-EPSILON shall not be liable for any consequential, special, indirect or incidental damage. In the interest of further development, MICRO-EPSILON reserves the right to make design changes without notification. For translations into other languages, the German version shall prevail.

7. Cleaning, Service, Repair

Make sure that the measuring area (green cover foil) on the sensor is clean. If necessary, clean with a moist, soft cloth.

You can clean the touchscreen on the controller with a screen cleaner.



In the event of a defect on the measuring device or if the cause of a fault cannot be clearly determined, always send the complete measuring system to:

MICRO-EPSILON MESSTECHNIK
GmbH & Co. KG
Königbacher Strasse 15
94496 Ortenburg/Germany
Tel. +49 (0) 8542/168-0
Fax +49 (0) 8542/168-90
email info@micro-epsilon.com
www.micro-epsilon.com

8. Decommissioning, Disposal

Incorrect disposal may cause harm to the environment.

Dispose of the device, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.

9. License agreement, software

The software contained in this product includes a number of software components to which Micro-Epsilon or third-parties hold copyrights. This includes general components such as the operating system on the microcomputer used as well as specific components that were specially developed for the operation of the product.

The software developed by Micro-Epsilon, including its source code and documentation, is property of Micro-Epsilon and protected by copyright.

In addition, this product uses third-party software or software components that are freely distributed by their authors under so-called free open source licenses (open source software).

The open source software used in this product is subject to the following terms of license:

- GNU Library General Public License
- Modified BSD License
- Apache License
- Expat/MIT-style Licenses
- zlib-style Licenses
- W3C Software Notice and License
- OpenSSL License
- Sleepycat License
- vhf Public License
- „No problem Bugroff“ License
- Unmodifizierte BSD-Lizenz
- IBM Public License Version 1.0
- FreeType License
- Qt / Qpl
- LGPL license Ver. 2, Ver. 2.1, Ver. 3
- Digia Qt LGPL Exception version 1.1
- Raspbian, Jessie
- Raspbian, Kernel 4.4.34-v7+
- GNU General Public License GPL 2
- GNU GPL plus the GCC Runtime Library Exception

- ICU License - ICU 1.8.1 and later
- libpng license
- MIT License / MIT/X Consortium license
- SGI Free Software License B
- zlib license

Any terms and conditions of use/licensing or copyright notices contained in the documentation for this product or other material such as product information provided shall have no applicability to any open source components.

For all open source components, it is the open source licenses under which the respective program components were licensed that shall apply exclusively and have priority. Some of these terms of license require the user to provide the source code. You can request the source codes and associated terms of license at Micro-Epsilon.

In accordance with the terms of the open source licenses, Micro-Epsilon hereby points out that the authors have excluded any liability or warranty for the software and its features. Details can be found in the respective terms and conditions of license.

Through this notice on exclusion of liability, Micro-Epsilon is complying solely with the terms of license of the authors. Statutory and contractual claims against Micro-Epsilon shall not be affected by this exclusion of liability.



MICRO-EPSILON MESSTECHNIK GmbH & Co. KG
Königbacher Str. 15 · 94496 Ortenburg/Germany
Tel. +49 (0) 8542/168-0 · Fax +49 (0) 8542/168-90
info@micro-epsilon.com · www.micro-epsilon.com

X9751382-A051109SWE
© MICRO-EPSILON MESSTECHNIK

