MiniTest 3100 - 4100

Technical Manual and Operating Instructions

Advancing with Technology ElektroPhysik

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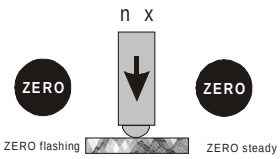
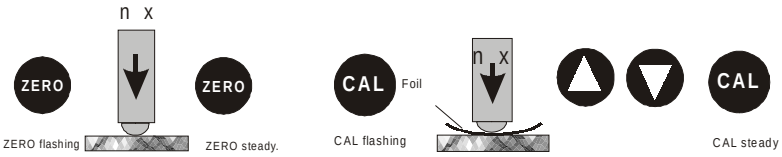
Short instructions with key symbols

Activate
standard calibration

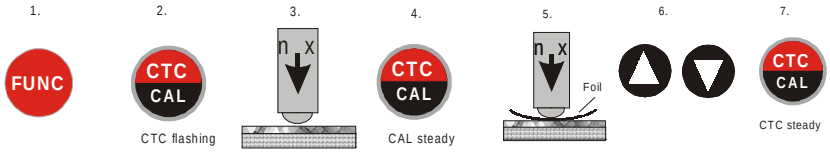
One-point calibration
without foil



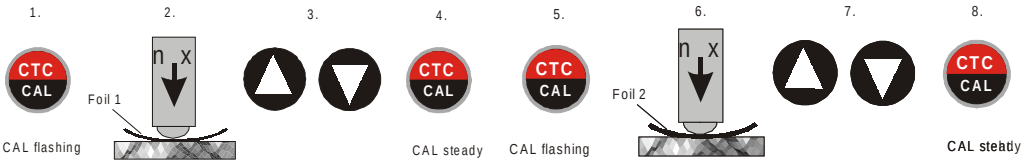
Two-point calibration using
zero set and one foil



Calibration on the
coated surface



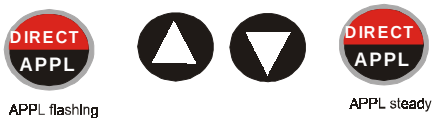
Two-point calibration
using two foils



OFFSET

Set Limits

Select APPL-BATCH mode and memory



Select BATCH memory

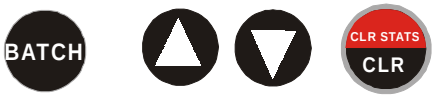
Delete Functions

Delete last reading

Delete statistics

Delete a measuring series incl. statistics in one APPL-BATCH group

Delete a measuring series incl. limits and statistics in one APPL-BATCH group



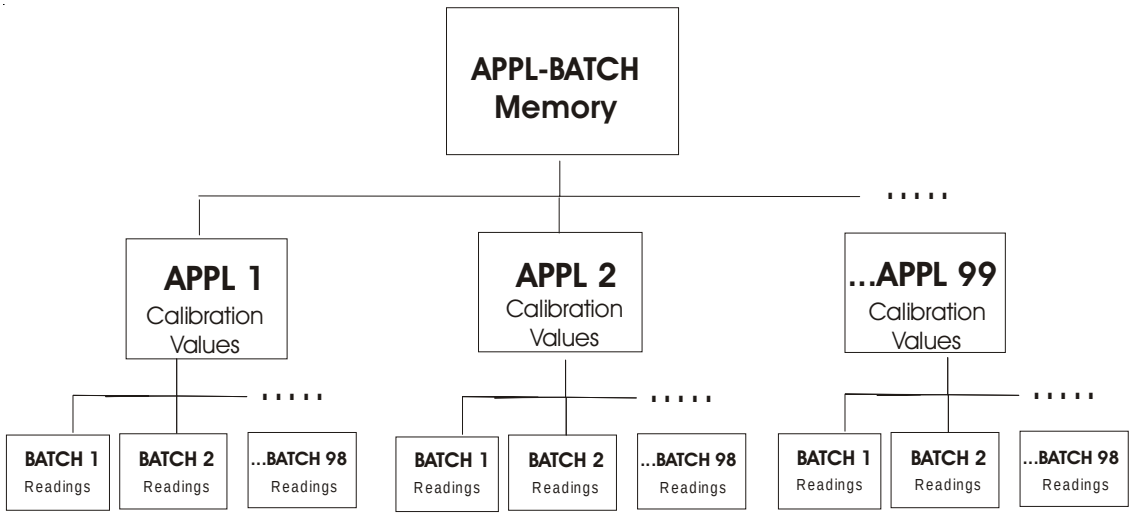
Delete limits in one APPL-BATCH group

Delete Functions

Delete all measuring series incl. statistics, limits and calibration values of a certain APPL #

Delete all measuring series incl. statistics, limits and calibration values of all APPL-BATCH memories = TOTAL RESET

Press keys subsequently and keep pressed down.


APPL-BATCH Memory
APPL 1 Calibration Values
APPL 2 Calibration Values
...APPL 99 Calibration Values
BATCH 1 Readings
BATCH 2 Readings
...BATCH 98 Readings
BATCH 1 Readings
BATCH 2 Readings
...BATCH 98 Readings
BATCH 1 Readings
BATCH 2 Readings
...BATCH 98 Readings

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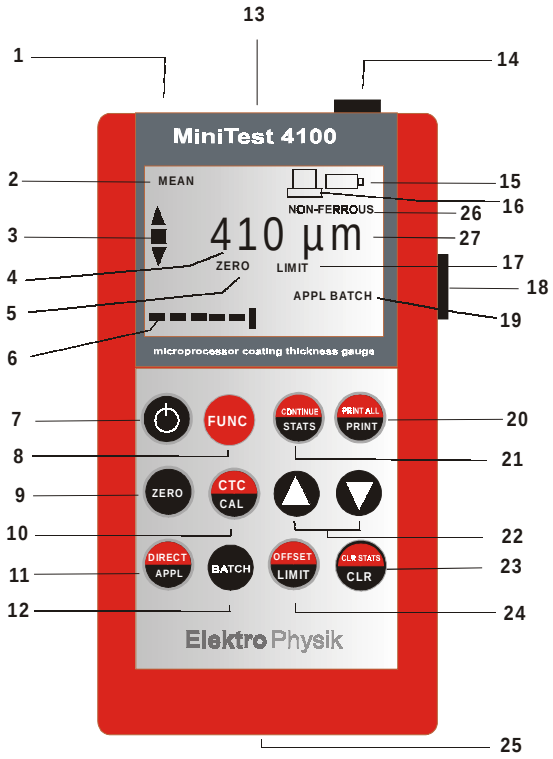
MiniTest 4100 Front view



1	Probe socket
2	Indicates a statistical value (mean value in this case)
3	Indicates whether the reading is within or beyond limits
4	4-digit LCD with floating point and measuring unit
5	Zero setting indicator
6	Analogue bar (if limits are set)
7	ON/OFF key
8	Key for activating upper (red) key function
9	Key for zeroing with calibration standards
10	Key for calibrating with standards
11	Key for activating DIRECT- or APPL-BATCH mode
12	Key for selecting a BATCH group within a certain Application number
13	Socket (option) : 1. external trigger feature (e.g. for foot switch) 2. Signal to confirm reading (e.g. lamp or horn)
14	Probe socket
15	BAT: Low battery / storage battery indicator
16	Indicates that the gauge is currently controlled via PC. MiniTest key-lock activated.
17	Indicates that tolerance limits are set.
18	Combi interface (for MiniPrint data printer, Mitutoyo miniprocessor or PC)

19 APPL BATCH mode indicator.

20 Key for print-out of readings, statistics and histogram

21 CONTINUE: Switching to continuous mode/ STATS: calling statistics

22 Arrow key for selecting all parameters such as calibration values or tolerance limits.

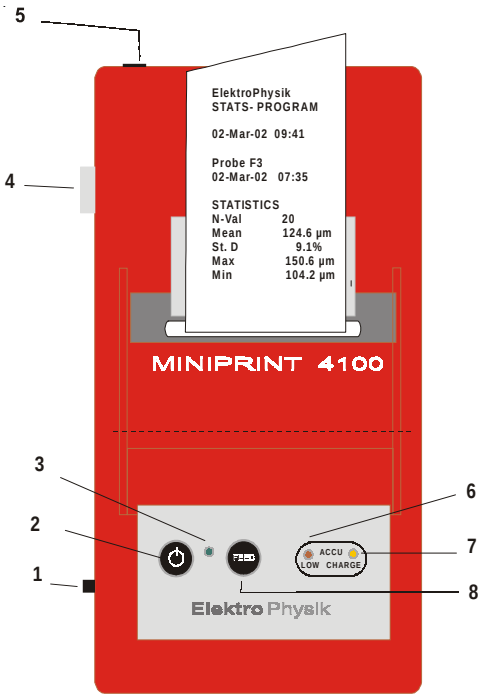
23 Delete key.

24 OFFSET/LIMIT: Key for entering OFFSET or limit values

25 Battery compartment at bottom side.

26 NON-FERROUS (indicates readings on non ferrous metals) FERROUS (indicates readings on ferrous metals)

27 Measuring unit: Switches automatically according to probe connected, setting and/or measuring value: µm, mm or mils, inch



1 Connector pin for MiniTest

2 ON/OFF-key

3 Green LED, switch on control lamp

4 Interface

5 Socket for charger unit

6 Low battery indicator

7 Battery charge control lamp

8 Paper feed

Foreword

The present operating instructions refers to MiniTest 3100 and MiniTest 4100. Please select your applicable sections from the table of contents or index.

The last section includes short instructions along with an example measurement.

1. General Information

The MiniTest 3100 and 4100 coating thickness gauges work either on the magnetic induction principle or on the eddy current principle, depending on the type of probe used. If dual probes are connected, MiniTest works on both principles.

The gauges conform to the following industrial standards:

DIN EN ISO 2178

DIN EN ISO 2360

DIN EN ISO 2808

DIN 50982

ASTM B244

ASTM B499

1.1 Application

This compact and handy gauge is designed for non-destructive, fast and precise coating thickness measurement. The principal applications lie in the field of corrosion protection. It is ideal for manufacturers and their customers, for offices and specialist advisers, for paintshops and electroplaters, for the chemical, automobile, shipbuilding and aircraft industries and for light and heavy engineering.

MiniTest gauges are suitable for laboratory, workshop and outdoor use.

When connected to the MiniPrint 4100 portable data printer, the gauge can document all readings and statistical values, either immediately or for later analysis.

A large selection of probes is available to cover a wide range of applications.

F probes work on the magnetic induction principle and should be used for non-magnetic coatings such as aluminium, chrome, copper, zinc, paint and varnish, enamel, rubber etc., on an iron or steel substrate; they are also suitable for alloyed and hardened magnetic steel (however, they are not suitable for austenic steel).

N probes work on the eddy current principle and should be used for insulating coatings e.g. paint, anodizing, ceramics, etc., on all non-ferrous metals such as Aluminium, copper, zinc die casting, brass etc. and on austenitic stainless steels.

FN probes are dual probes and work on both principles, magnetic induction and on the eddy current principle. One probe only is required for coating measurement both on ferrous and non-ferrous metal substrates.

All MiniTest 'smart' probes are adaptable to specific tasks; i.e. they can be used on special geometries or on materials with special properties. Special probe data are stored within the probe to be recalled for the required conditions.

1.2 Description of the gauge

For measurement on steel substrates, the MiniTest gauges work on the magnetic induction principle, for measurement on non-ferrous metal substrates, they work on the eddy currents principle.

MiniTest can be controlled via a personal computer thus making it a network capable tool in automated work places.

Measured values and user information are shown on large, easy-to-read LC display. A display back light ensures easy reading of screen data in dark conditions.

Two different operating modes are available:DIRECT mode and APPL-BATCH mode.

DIRECT mode is recommended for simple, quick, occasional measurements. It provides statistical analysis and on-the-spot print-out of readings. Single values are not saved.

The statistical analysis program can evaluate up to 9,999 readings.

'APPL-BATCH mode' permits measurement and storage of readings in a free programmable memory. A maximum of 10,000 readings and over 500 series of measurements (100 with MiniTest 3100) can be analysed according to various statistical criteria. If limits are set before measurement, cp and cpk (process capability) values can be determined and a histogram (distribution graph) printed out.

When connected to the MiniPrint data printer, the gauge can print out all single readings and six statistical values (eight with input of tolerance limits) with the appropriate histogram.

1.3 Supply schedule

Gauge with alkaline battery, plastics carrying case, screw driver, operating instructions (German/English).

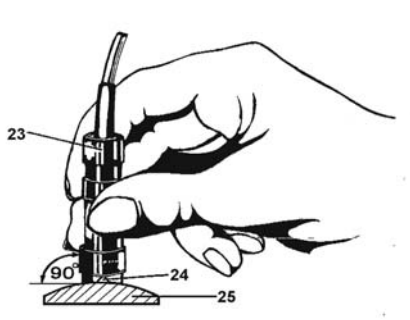
Optional accessories:

- various probes
- MiniPrint 4100, portable data printer. Can be connected laterally to the MiniTest gauge without using a cable
- Belt-case set - two cases of different sizes for gauge and accessories
- Transparent dust protection case
- Twin case for gauge and printer
- 'MSave' program disc for data transfer of single readings to a PC (DOS program)
- MSoft41' program disc for WINDOWS 3.1x® or WINDOWS 9x® to process MiniTest measuring and statistical values
- connecting cable (serial), 9 or 25 pole connection for PC
- connecting cable for Mitutoyo mini processor
- high precision measuring stand for measuring on small parts
- mains adaptor 230V AC/12V DC
- mains adaptor 110V AC/12V DC
- accumulator battery and charger, 230V AC or 110V AC

1.4 Probes

All the probe systems (apart from CN02-probe and special models) are spring-mounted in the probe sleeve. This ensures safe and stable positioning of the probe and constant contact pressure. A V-groove in the sleeve of the probes facilitates reliable readings on small cylindrical parts.

The hemispherical tip of the probe (24) is made of hard and durable material.



Hold the probe by the spring mounted sleeve (23) and put on measuring object (25).

Probes for measuring on steel substrates

Type Nr.	Measuring range metric	Measuring range imperial
F05	0...500 µm	0...20 mils
F1.6	0...1600 µm	0...60 mils
F1.6/90 tube probe	0...1600 µm	0...60 mils
F1.6P powder probe	0...1600 µm	0...60 mils
F2/90 tube probe	0...2000 µm	0...80 mils
F3	0...3000 µm	0...120 mils
F10	0...10 mm	0...400 mils
F20	0...20 mm	0...800 mils
F50	0...50 mm	0...2 inches

Probes for non ferrous metal substrates

Type Nr.	Measuring range metric	Measuring range imperial
N.08Cr	0...80 µm	0...3 mils
N02	0...200 µm	0...8 mils
N1.6	0...1600 µm	0...60 mils
N1.6/90 tube probe	0...1600 µm	0...60 mils
N2/90 tube probe	0...2000 µm	0...80 mils
N10	0...10 mm	0...400 mils
N20	0...20 mm	0...800 mils
N100	0...100 mm	0...4 inches
CN 02 Cu-coatings on insulating substrates	10...200 µm	0.4...8 mils

Dual probes for steel and non ferrous metal substrates

Type Nr.	Measuring range metric	Measuring range imperial
FN 1.6	0...1600 µm	0...60 mils
FN 1.6 P powder probe	0...1600 µm	0...60 mils
FN 1.6/90 tube probe	0...1600 µm	0...60 mils
FN2/90 tube probe	0...2000 µm	0...80 mils

2. Preapring MiniTest

2.1 Power supply

- 1 x 9 Volt alkaline battery or
- 1 x 9 Volt accumulator battery or
- mains adapter

For checking the battery's state of charge please press ON-key:

No LC display: Battery or accumulator missing or battery charge too low to illuminate display.

Flashing BAT display, gauge switches off after about one second: Replace battery immediately.

BAT flashes during measurement: The battery is running low and should be replaced before the gauge is switched on next time. If not, the LC display will show the permanent BAT warning and the gauge will switch itself off after about a second.

Note that the gauge will not make faulty measurements even if the voltage is very low.

2.2 Replacing the battery

1. Place the gauge upside down on a suitable surface.
2. Remove the screws from the battery compartment with a crosstip screwdriver.
3. Raise the lid of the compartment.
4. Remove battery.
5. Insert new battery.
6. Close the lid and fasten with screws.

Caution:

Make sure the positive and negative poles are correctly positioned. If not, all data saved to memory will be lost.

An interval of more than 10 seconds between removing the old battery and inserting the new one will also result in the loss of data (readings, calibration values, time and date.

Battery disposal: Do not discard used batteries in your regular trash. Please observe your local instructions for battery disposal.

2.3 Probe selection

Select a probe according to your application, connect it to the MiniTest gauge and screw in place.

2.4 Start-up functions and Basic Settings

The MiniTest 3100 and 4100 gauges include a number of functions that can only be called up or activated during start-up.

Table of start-up functions

Function	Key action
Total-Reset	FUNC + CLEAR + ON
LCD-Test	⇧ -key+ ON
APPL-BATCH Directory	APPL + ON
Setting Time	CAL + ON
Basic Settings	FUNC + ON

2.4.1 Total-Reset

A total reset erases data from all memories. This includes all sets of readings of all APPL-BATCH memories plus their associated statistics, calibration values and tolerance limits. Total reset erases temporary settings and the gauge will resume the basic mode setting (FUNC : / **0**, see section 2.5)

1. Connect probe.
2. Switch off gauge.
3. Press CLEAR + FUNC + ON simultaneously.
4. Total reset is confirmed by a long bleep.

2.4.2 LCD Test

The LCD segment test enables all sections of the LC display to be inspected and checked

1. Switch off the gauge if necessary.
2. Hold down the ⇧ -key and press ON-key. As long you keep both keys pressed down, all sections of the LC display will be shown.

2.4.3 APPL-BATCH Directory

1. Switch off gauge. Connect printer and switch on.
2. Press APPL-key and hold down.

3. Press ON and keep both keys pressed down until a signal bleeps.

4. Das APPL-BATCH Directory (Inhaltsverzeichnis) wird auf dem Drucker ausgedruckt.

2.4.4 Viewing / Adjusting Date and Time

The gauge has a quartz-controlled timer which relays information to the MiniPrint 4100. The current date and time appear automatically on each print out of statistics.

To view and if necessary adjust the time and date:

1. Switch off the MiniTest gauge.

2. Hold down the CAL key and press ON. Keep both keys depressed until you hear the bleep. If an FN1.6 or FN2 probe is attached, press one of the arrow keys.

3. 'TIME' flashes with a preset year, e.g. <2Y>.

4. Use arrow keys to set the required year. Press CAL to confirm.

5. A month appears, e.g. <3M>. Use Arrow-keys to adjust to the required month. Press CAL to confirm.

6. A day of the month appears, e.g. <3d>. Use Arrow-keys to ajust to the required day. Press CAL to confirm.

7. The hour now appears, e.g. <3h>. Use Arrow-keys to adjust to the requird hour. Press CAL to confirm.

8. The minute now appears, e.g. <3m>. Use Arrow-keys to adjust to the required minute.

9. To save the new date and time , press CAL again. The gauge will return automatically to measuring mode.

Note:

When you view the time and date, please remember that the clock stops for as long as it is on display. If the timer does not need adjusting, keep pressing CLEAR until the gauge returns to measuring mode.

2.5 Basic Settings

Please refer to the opposite table for basic setting options. For setting options please proceed as follows:

1. Switch off the gauge , hold down the FUNC key and press ON.
2. Keep both keys pressed until you hear the signal. The gauge will now display a pair of numbers: 1:0 or 1:1.
3. Press FUNC to move through each of the table's functions from 1 to 10. Use the arrow keys to set the option 0 or 1.
4. Press FUNC again to return to measuring mode.

Note:

If using a FN dual probe, press FUNC and ON and use the arrow keys to activate the F section (⇧) or the N section (⇩) respectively.

Table of Basic Settings

Func	Setting	Mode	Option
1	0	Measuring unit	metric / mm
	1		imperial / inch
2	0	Automatic switch off	ON
	1		OFF
3	0	Data format	Floating point
	1		Fixed point
4	0	Statistics	Single value statistics
	1		Block value statistics
5	0	Data transfer to statistics memory (in contin. mode)	on key action
	1		automatic
6	0	Stabilization of reading (in contin. mode)	ON
	1		OFF
7	0	Keylock for ZERO, CAL, CTC, OFFSET	OFF
	1		ON
8	0	Display backlight	OFF
	1		ON
9	0	Storage of Min. value (in contin. mode)	OFF
	1		ON
10	0	Acoustic alarm in if readings are off limits	OFF
	1		ON

2.5.1 Measuring Unit: 'Metric' - 'Imperial'

To switch from metric units (µm, mm, cm) to Imperials (mils, inch) or vice versa, proceed as follows:

1. Switch off gauge.
2. Hold down the FUNC key and press ON.
3. Keep both keys depressed until you hear the bleep. The gauge will now display a pair of numbers: 1: 0/1.
4. Use the arrow keys to adjust to the required measuring unit. 0 = metric, 1 = Imperial.
5. Press FUNC 10 times. The gauge will now return to the measuring mode. The series of measurements can be continued with the new measuring unit. Previous readings in the series will be converted to the new unit automatically.

2.5.2 Automatic Switch-off Mode

The gauge is programmed to switch itself off after about 90 seconds of inactivity. This can hinder operations in certain circumstances. In this case the operator should disable the automatic switch-off to operate in the continuous mode.

Please refer to the table of basic setting in section 2.5 and use FUNC and Arrow-keys to make your setting.

2.5.3 Data format: Floating Point / Fixed Point

The standard data format of readings transferred via the combination interface uses the floating point data format. For data loggers etc. this default setting can be changed to fixed point format.

In the fixed point format, all metric readings in microns will be displayed with one digit after the decimal point. In Imperial units, readings in mils will be displayed with two digits after the decimal point.

To switch between fixed and floating point options, please refer to the table of gauge settings in section 2.5. Adjust to the required mode using FUNC and Arrow keys.

2.5.4 Single Value / Block Value Statistics

The statistical values can be calculated on the basis of either individual values or blocks of values before being transferred to a printer or PC.

Block value statistics are calculated from a block of mean values. The number of readings assigned to each block can be altered via a PC. Default = 5 readings.

To select the single-value or block-value option, please refer to the table of gauge settings on section 2.5. Select an option with the FUNC and arrow keys as described.

2.5.5 Manual / Automatic Data Transfer

The continuous mode allows automatic transfer of readings to statistics memory or to a printer or PC (setting <1>). If only selected readings are to be logged to memory, choose manual measurement mode (setting <0>) and enter the readings either via the keyboard (UP Arrow-key) or by a foot-operated switch (optional extra). (See also section 2.5.9)

In automatic mode readings can be entered at a rate of approx. 5 per second.

To switch between automatic and manual mode, please refer to the table of gauge settings in section 2.5. Select option with the FUNC and arrow keys as described.

2.5.6 Stabilising of Readings

In factory setting, readings are not displayed, stored into the statistics memory or transferred to a printer or PC until the signal stabilises within a given range (data filter).

In continuous measuring mode, however, this stabilising procedure can be disabled, e.g. for easier acquisition of minimum and maximum readings. (See also sections 4.2.8 and 4.2.14).

To disable the stabilising procedure, please refer to the table of gauge settings in section 2.5. Select option with the FUNC and Arrow keys as described.

2.5.7 KEYLOCK of ZERO, CAL, CTC and Offset

An accidental action of above keys can be prevented by using the KEYLOCK function.

Please refer to the table of gauge settings in section 2.5. Select option with the FUNC and arrow keys as described.

2.5.8 LCD Backlight

If you enable the backlight function, the display lights up for about 2 secs after a reading has been taken. Please remember that using the lamp requires extra current.

To activate the display light please refer to the table of gauge settings in section 2.5. Select option with the FUNC and Arrow keys as described.

2.5.9 Storage of Min Reading in Continuous Mode

This function allows to determine the Min reading within a continuous measuring procedure. When measuring, the readings are currently updated. After lifting the probe from the surface, the Min reading (minimum value of a measuring series) is displayed for about 5 seconds.

If within these 5 seconds you will not take another reading or after the Min reading has been stored to the statistics memory, it will disappear from display. If further measurements are taken within these 5 seconds, the Min reading remains and shortly appears on display.

The Min reading mode is set by FUNC- and Arrow-key as described in 2.5 and in the table of basic settings.

2.5.10 Off-limits Alarm in Continuous Mode

The alarm signal which sounds when deviating the set tolerance limits can be enabled or disabled.

To activate the alarm setting, please refer to the table of gauge settings in section 2.5. Select option with the FUNC and Arrow keys as described.

2.5.11 Single Measurement / Continuous Measurement Mode

It can sometimes be of advantage (measurement inside tubes) if the probe does not need to be raised between each measurement so that there is a running display of readings.Please adjust to the continuous mode as follows:

1. Switch on gauge.
2. Press FUNC, then CONTINUE. A short bleep sounds.
3. A flashing measuring unit (µm, mm, cm) indicates the continuous mode being enabled. Readings beyond the measuring range will be indicated by 4 strokes (**- - - -**). In continuous mode, readings are not accompanied by a bleep and the display lamp is disabled.
4. To log readings to the statistics memory or to print-out readings on a printer, or to transfer readings to a PC via the interface, press the ⇧-arrow key or push the foot-operated switch (optional extra).

5. For continuous input of all readings, follow the procedure described in section 2.5.5. Readings taken in this mode will automatically be entered into the statistics program as long as sufficient memory is available.

6. Return to default mode (i.e. single measurement mode) either by repeating steps 1 and 2 or by switching the MiniTest off and on again. (Switching OFF and ON again does not apply to probes F20, F50 and N100.)

3. Measuring, Storage and Data Processing in DIRECT or APPL-BATCH Mode

The following section describes

- the DIRECT mode
- the APPL-BATCH mode
- the structure of APPL-BATCH memory system
- How to change from DIRECT to APPL-BATCH mode
- How to select a certain memory in APPL-BATCH mode
- How to enter calibration values and toerance limits
- Special features of the APPL-BATCH memory system.

APPL = Application memory

BATCH = Group memory

MiniTest 3100 und 4100 offer two operating modes: DIRECT and APPL-BATCH mode.

DIRECT mode is intended for quick occasional readings. In this mode, individual readings are not logged to memory. The readings and the 6 statistical values (8 after input of tolerance limits) can be shown on the LC display and printed out by pressing STATS. The statistical analysis program can evaluate up to 9,999 readings.

In APPL-BATCH mode , ‘a maximum of 10,000 single readings and approx. 500 separate series of measurements (MiniTest 3100: approx. 100 measuring series) can be stored in memory. Single values, statistical values and their accompanying histogram can all be printed out directly or at a later time.

In APPL-BATCH mode , ‘a maximum of 10,000 single readings and approx. 500 separate series of measurements (MiniTest 3100: approx. 100 measuring series) can be stored in memory. Single values, statistical values and their accompanying histogram can all be printed out directly or at a later time.

Important Note:

In order to work in APPL-BATCH mode, e.g. to calibrate, take readings, set limits, etc., the words „APPL“ „BATCH“ must appear on the LC display. If not, an APPL-BATCH number must be specified with the APPL and BATCH keys. (See sections 3.4 and 3.5.)

Status after Switch-on

Press ON-key while holding the probe in the air. The gauge resumes the previously selected mode, either DIRECT or APPL-BATCH mode.

If start-up proceeds in APPL-BATCH mode, the gauge will select the previously selected APPL-BATCH memory and the last reading will be shown (if available).

Calibration values and statistics are stored in memory.

Measurement can follow immediately in DIRECT or APPL-BATCH mode, providing the gauge has been calibrated.

If all data have been deleted, only the measuring unit, e.g. µm along with the measuring mode FERROUS or NON-FERROUS will be shown. FERROUS or NON-FERROUS indicate whether the attached probe type is for measurement on ferrous or on non-ferrous metals.

Note:

If you switch from DIRECT to APPL-BATCH mode, the statistical data will be kept in memory.

The statistical data will not be stored if you change the probe or, if using the dual probes, if you change the measuring principle (from magnetic induction to eddy currents).

When pressing APPL-BATCH key, the pair of numbers of the previously used APPL-BATCH memory will be shown on display.

The gauge switches itself off automatically about 90 sec’s after the last measurement.

If you disconnect the probe, the gauge will also switch off.

3.1 The Structure of APPL-BATCH System

The application memory (APPL) with its accompanying batch memories (BATCH) is designed to store calibration settings for different applications in an APPL (application) memory. The BATCH memory contains single readings of a series with their statistical analysis (see diagram.) With MiniTest 4100, BATCH no. 99 blocks readings from being written to the statistics memory.

It also contains a print command which assembles the statistical data of BATCH numbers 1 - 98 within one APPL memory for transfer to a printer or PC (not with MiniTest 3100).

With **MiniTest 3100**, 10 application (APPL) memories are available subdivided into 10 group (BATCH) memories, i.e. MiniTest offers a maximum of 100 memories.

The **MiniTest 4100** comprises 99 application memories (APPL memory lines) - subdivided into 98 BATCH memories; in all, there are 9702 batches, of which up to 500 can be assigned to particular sets of measurements. The maximum storage capacity is 10,000 readings. The greater the number of initialised APPL-BATCH fields, the fewer the number of measured values which can be logged to memory.

	BATCH-(Group-)Memories							
		1	**2**	**3**	**...**	**97**	**98**	**99**
APPLIC-ATION Memory Lines	**1**	1 1	1 2	1 3		1 97	1 98	1 99
	2	2 1	2 2	2 3		2 97	2 98	
	3	3 1	3 2	3 3		3 97	3 98	
	. . .							
	97	97 1	97 1	97 1		97 97	97 98	
	98	98 1	98 1	98 1		98 97	98 98	
	99	99 1	99 1	99 1		99 97	99 98	99 99

APPL-Memory Line

(for saving calibration values only)

Each of the 99 application memory lines can be allotted a calibration and an OFFSET setting for one probe. A selection of calibrations are thus instantly available for different tasks, e.g. for measuring coating thickness on flat or curved surfaces or for taking measurements using a range of probe types. Once a calibration has been entered into an APPL memory line it remains there and can be activated at any time simply by entering the corresponding APPL number. After this, readings can start immediately within a selected group (BATCH) of particular application memory.

BATCH-(Group-) Memory

(for storing limits and readings)

Each of the application memories (APPL memory lines) is subdivided into BATCH memories. Each BATCH memory can store a series of readings using one calibration and also evaluate them in statistical form. In addition, a set of two tolerance limits (LO and HI) can be stored in each BATCH memory. The BATCH subdivisions provide for individual assessment of the coatings of a number of product samples measured with one probe and based on a common calibration.

3.2 Switching APPL-BATCH mode on/off

When the gauge is switched on it will resume the previously selected mode, i.e. either APPL-BATCH or DIRECT mode.

In order to switch from DIRECT to APPL-BATCH mode, press APPL. The last APPL-BATCH number will appear, e.g. < 2 : 1 >.

Either continue taking readings in this APPL-BATCH memory or select a different memory (see section 3.4). Confirm your choice by pressing APPL again. Readings can be taken as soon as APPL-BATCH appears on display.

To switch from APPL-BATCH mode to DIRECT mode press FUNC while the gauge is switched on. Then press DIRECT-key to enable the DIRECT mode. Now the gauge is ready for measurement.

3.3 Displaying the APPL-BATCH number in current use

If the gauge is switched on and is already functioning in APPL-BATCH mode, a reading will normally be displayed.

Press either APPL or BATCH to display the two-number memory in current use, e.g.<2 : 1>. Press the same key again to confirm your choice. Readings can be taken as soon as APPL-BATCH appears on the display.

3.4 Selecting an APPL memory

1. Press APPL. This displays the two number combination of the last APPL-BATCH in use e.g. < 2 : 1 >.If required, use the arrow keys to select a new APPL-BATCH.

2. If you hold down the key you can quickly scroll through the memory showing a running display of numbers already occupied until a free APPL address is found. The number of this memory will then appear on screen, e.g. < **5** : 1>. Free memories can be distinguished by a flashing APPL number.

Please note:

When selecting an APPL-memory, you must use exactly the same probe as used when creating this APPL-memory. If you try to use another probe (even it is of the same type) the error message E:16 will appear and the gauge switches into DIRECT mode.

This also happens if the probe which has been used for APPL-memory creation has been repaired.

When using the dual probes, make sure to activate the same probe part (FERROUS or NON-FERROUS) as used for creation of the APPL-memory.

To delete or select APPL-memories please refer to section 9.6.

3. The calibration valid for your selected APPL-memory is shown on display, e.g. one-point or two-point calibration. If the standard calibration is valid, there will be no indication on display.

   Either retain the currently valid calibration or recalibrate according to one of the methods described in section 4.2.1-4.2.16.

4. All the following readings will be stored in the selected APPL-BATCH memory.

3.5 Selecting a BATCH memory

1. Select an APPL memory line if this has not been done.

2. Press BATCH. The number of the previously selected number will now appear, e.g. <3 : 2>. If, for example, APPL memory line number 3 has not yet been used, the gauge automatically selects the first BATCH memory, e.g. <3 : **1**>. A free BATCH is indicated by flashing numbers on the display.

3. If required, use the arrow keys to select a new BATCH no. Keep the key pressed down for quickly scrolling through the memory until a free BATCH number is found. The number will then be displayed, e.g. <3 : **8**>. Press BATCH to confirm.

4. If required, use the LIMIT and arrow keys to set upper and lower limits. (See section 6).

5. The gauge is now ready for use and all readings will be stored in the selected APPL-BATCH memory.

Please note:

Limits can also be entered after readings have been taken.

4. Calibration and Measurement

4.1 General Hints for Calibration

4.1.1 Calibration methods

There are five different methods available for calibration:

1. **Standard calibration**: recommended for measurement on even surfaces and if the measuring object has the same material, size and curvature as the ElektroPhysik zero plate.

2. **One-point calibration** (zeroing without using a calibration foil): recommended if measuring errors up to ± (3% of reading* plus the constant error of probe) are permitted. (Example for constant probe error: F.1.6: 1 µm).

3. **Two-point calibration** (zeroing and calibrating using a calibration foil): recommended if readings to be expected will be close to the calibration value and if the permitted error of probe will be max.±(1%...3% of reading* (according to probe) plus constant probe error)

   * referring to the supplied calibration standards under laboratory conditions.

4. **Two-point calibration** (using a set of two calibration foils):

   a) Recommended for measurements on rough surfaces.

   b) recommended for precise measurements on smooth surfaces if the thickness to be expected lies between that of the two calibration foils.

5. **Calibration through the coating (CTC):** Calibration using a calibration foil. Recommended if the test sample is coated and no uncoated sample is available for comparison. This method is suitable for the following probes: F05, F1.6, F3 and FN1.6 (ferrous part only), F1.6/90, F2/90, F10, F20 and F50.

Please note:

In this manual, the term calibration foil applies to all calibration standards, including those usually not described as 'foil': e.g. those of 2mm, 5mm and 10mm thickness.

4.1.2 Storing Calibration Values

If the gauge is calibrated for a particular purpose, the calibration values will be stored in memory until changed.(See also section 4.1.8 Stability of calibration values).

If a calibration is to be altered for a certain probe, simply carry out a recalibration. This automatically deletes the previous calibration values and saves the new ones for immediate use.

Note:

The calibration procedure should be restarted from the beginning if

- an incorrect reading has been taken
- an incorrect command has been entered
- the gauge has switched off

4.1.3 Calibration Example

Calibration is the most important requirement for accurate measurement. The more closely the calibration sample matches the product sample, the more accurate the calibration, and therefore the reading, will be.

If, for instance, a product is to be measured on a steel cylinder, quality ST37 (mild steel), ø 6 mm, the calibration of the uncoated sample must take place on a steel cylinder of **similar quality with the same diameter.**

The calibration sample must correspond to the product sample in the following ways:

- curvature radius
- substrate material properties
- substrate thickness
- size of measuring area
- The point at which the calibration is made on the calibration sample must always be identical with the point of measurement on the product itself, especially in the case of corners and edges of small parts. The precision stand will prove invaluable here.

For more details please refer to the technical data.

4.1.4 Influence of Substrate Thickness

In case of steel substrates, as long as the substrate is thicker than the range of probe, it is sufficient to use the standard calibration. The minium measuring areas as specified in the technical data should also be taken into account.

In the case of non-magnetic metals, it is sufficient if substrate thickness is 50 microns and strong enough not to give way under the pressure of the probe tip. Thin, coated aluminium foils should be stuck on a hard base for measurement.

The enclosed steel and aluminium zero plates are intended for checking accuracy only and not for calibration purposes.

Exceptions:

The zero plates may be used for calibration if the product sample has a smooth, even surface (not shot-blasted) and if it has the same thickness as the zero plate.

4.1.5 High-Accuracy Calibration

To achieve high-accuracy readings, it is advisable to log calibration values (both zero values and calibration foil values) several times in succession. In this way, the gauge will automatically establish a mean calibration value. For more details see 4.2 Special Hints for Calibration. The high-accuracy calibration is an obvious advantage when calibrating on uneven, e.g. shot-blasted, surfaces.

4.1.6 Cleaning the Measuring Point

Before calibration the measuring point the probe tip must be free from grease, oil, scraps of metal, etc. The slightest impurity will affect measurement and distort readings.

4.1.7 Acoustic Signals

Whether the probe is being used for calibration or for measurement, it must be held in place and not lifted until the bleep sounds.

4.1.8 Stability of Calibration

The gauge is temperature and drift compensated. For that reason it is not necessary to recalibrate in changeable external conditions (see Technical Data).

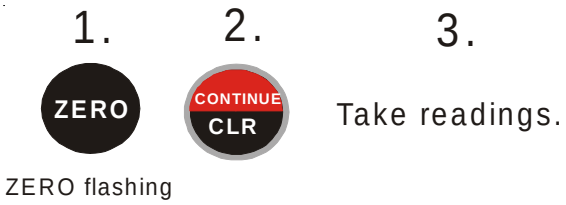
4.2 Special Hints for Calibration

For calibration according to sections 4.2.2 to 4.2.13 please proceed as follows:

1. Switch the gauge on.
2. Press appropriate key according to required calibration method: ZERO, CAL or FUNC + CTC. The activated function flashes on display.
3. Position the probe on the calibration standard.
4. To complete calibration press calibration key again: ZERO, CAL or CTC

4.2.1 Enable Standard Calibration

Applies to all probes except CN02.

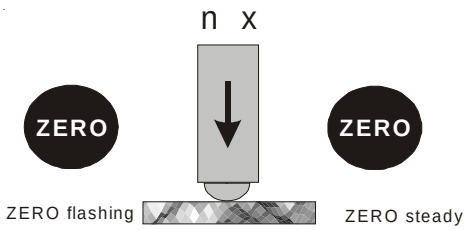


The standard calibration stored in the gauge should only be used for measurements on even surfaces, i.e.on steel components made of conventional steel (mild steel) or on aluminium components.

Note:

It is important to record a sufficient number of exact zero readings on an uncoated sample. If not, one-point or two-point calibration should be used.

4.2.2 One-Point Calibration without Foil (Zeroing)



Applicable for all probes except CN02.

1. Press ZERO to initialise ZERO calibration. The display will show ZERO (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings is shown on the display.

2. Place the probe on uncoated sample (zero coating thickness) and raise it after the bleep. Repeat this procedure several times. The display always shows the mean value of the previous readings.

3. Press ZERO to complete Zero calibration. 'ZERO' appears on display.

4. Now take readings by placing the probe on the object to be measured and raise the probe after the bleep. The reading is shown on display.

Deleting ZERO Calibration:

It may be necessary to delete the ZERO calibration if, for example, an incorrect zero value has been entered. In this case:

a) press ZERO then CLEAR to delete the zero calibration and any existing CAL calibration.

Note:

This will reactivate the default standard calibration for use on even surfaces.

b) or restart ZERO calibration by repeating steps 1 to 3 above. This automatically deletes the old calibration and saves the new one.

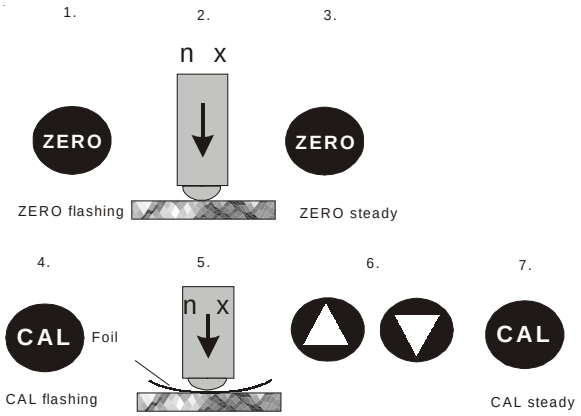
Note:

ZERO calibration deletes any existing CAL calibration.

4.2.3 Two-point Calibration (with Zeroing and one Calibration Foil)

Applicable for all probes except CN02.

This method is recommended for high precision measurements, measurements on small parts and on hardened and low-alloy steel.



1. Press ZERO to initialise ZERO calibration. The display will show ZERO (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings will be shown on the display.
2. Place the probe on uncoated sample (zero coating thickness) and raise it after the bleep. Repeat this procedure several times. The display always shows the mean value of the previous readings.
3. Press ZERO to complete Zero calibration. ‘ZERO’ appears on display.
4. Press CAL to initialise foil calibration. CAL flashes and MEAN appears (steady). MEAN indicates that the mean value of the readings is shown on display.
5. Lay the calibration foil on an uncoated sample, apply the probe and raise it after the bleep.The thickness of the foil should be roughly equivalent to the estimated coating thickness. Apply the probe to the test sample several times. The display always shows the mean value of the previous readings.To discontinue calibration, press CLEAR.
6. Use Arrow key to adjust the required foil thickness.
7. Press CAL. CAL will appear on the display (steady).

8. Now take readings by placing the probe on the coating and raise it after the bleep.

It may be necessary to delete CAL calibration, e.g. after entry of a faulty calibration value:

a) Press CAL key followed by CLEAR key. CAL calibration and any existing ZERO calibration will be deleted.

Note:

This will reactivate the default standard calibration for use on even surfaces.

b) Restart CAL calibration by repeating steps 4 to 7 above. This automatically overwrites the old calibration and saves the new values.

Note:

Even while a series of measurements is being taken, foil calibration can be carried out as often as necessary. The old calibration will be overwritten; the ZERO calibration remains in memory.

Special remark:

When using F10, F20 or F50 probes for measuring on metal coatings, it is essential to carry out two-point calibration. The calibration standards must be of the same metal as the actual coating. Under certain circumstances, this may also apply to F probes with a low measuring range.

4.2.4 Two-point Calibration with two Foils

Applicable to all probes (except CN02)

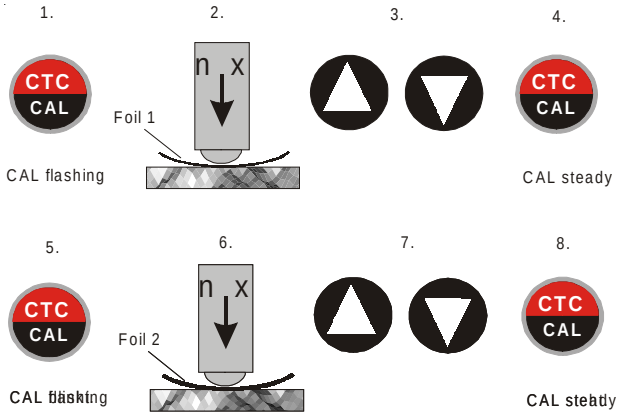
Calibration is only possible in single measurement mode. If necessary switch to the mode as in section 2.5.11.

This method requires the use of two different foils. The thicker one should be at least twice as thick as the thin one. For best results, the thickness to be expected should be somewhere between the two calibration values.

This method is especially suitable for taking measurements on rough shot-blasted surfaces or for high-precision readings. It is advisable to take a mean of CAL values. This considerably reduces the effect of scattering which occurs during calibration of upper and lower values.

Note:

Before carrying out the two-foil calibration, the factory set standard calibration should be enabled (please also refer to 4.2.1).



Press ZERO key followed by CLEAR-key. Proceed with step 1.

The calibration foils may be used in any order.

1. Press CAL-key. The display will show CAL (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings will be shown on display.

2. Place the thinner of the two foils (e.g. approx. 20...30µm) on the uncoated test sample, apply the probe and raise it after the bleep. Repeat this

procedure several times. The display always shows the mean value of the previous readings.

To discontinue calibration, press CLEAR.

3. Use Arrow key to adjust to the required foil thickness.

4. Press CAL key. 'CAL' appears on display (steady).

5. Press CAL to initialise calibration with the second foil. This step must follow straight on from step 5. The gauge will not accept readings until CAL has been pressed.

   The LC display will show the CAL (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings will be shown on display.

6. Place the thicker of the two foils (this should be at least twice as thick as the other foil) on the uncoated sample, apply the probe and raise it after the bleep.

   To discontinue calibration, press CLEAR.

7. Use Arrow key to adjust to the required foil thickness.

8. Press CAL key. 'CAL' appears on display (steady).

9. Now take readings by placing the probe on the coating to be measured and raise it after the bleep. The reading is shown on display.

It may be necessary to delete CAL calibration, e.g. after entry of a faulty calibration value:

a) Press CAL key followed by CLEAR key. Both CAL calibrations will be deleted.

Note:

This will reactivate the default standard calibration for use on even surfaces.

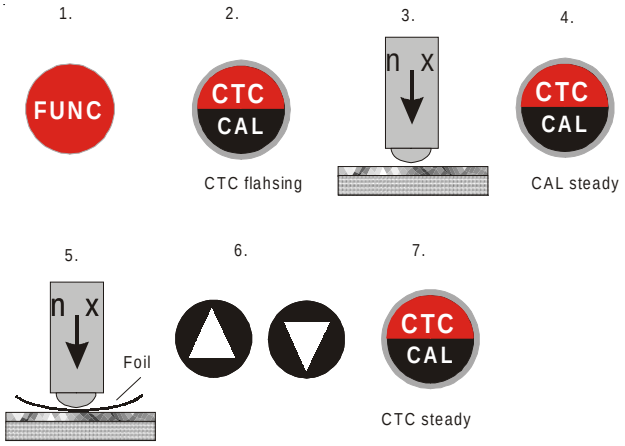
b) Restart CAL calibration by repeating the steps 2-9 as above. This automatically overwrites the old calibration and saves the new values.

4.2.5 CTC: Calibration Through the Coating

(**CTC**: Procedure according licence patent DE3404720C2)

This method is recommended when an uncoated test sample is not available. It can be employed with the probe types F06, F1.6, F3, FN1.6 and FN2 (F-part), F1.6/90, F2/90, F10, F20 and F50.

The CTC method may, however, only be used when the coating is smooth at the calibration point and measured values are reproducible. Do **not** use for textured coatings.



1. Press FUNC key.
2. Then CAL / CTC to initialise CTC calibration. Display will show CTC (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings will be shown on the display.
3. Place the probe on the calibration point of the test sample and raise it after the bleep. Repeat this procedure several times. The display always shows the mean value of the previous readings
4. Press CAL key.
5. Lay the calibration foil on the same point, apply the probe and raise it after the bleep. The thickness of the foil should be roughly equivalent to the estimated coating thickness. Apply the probe to the test sample several times. The display always shows the mean value of the previous readings. To discontinue calibration, press CLEAR.
6. Use Arrow keys to adjust to the required foil thickness.
7. Press CAL to confirm calibration. CTC will appear on the display (steady).

8. Now take readings by placing the probe on the unknown coating and raise it after the bleep. The reading is shown on display.

It may be necessary to delete CTC calibration, e.g. after entry of a faulty calibration value:

a) Press FUNC key followed by CLEAR key. CTC calibration will be deleted.

Note:

This will reactivate the default standard calibration for use on even surfaces.

b) Restart CTC calibration by repeating the steps 1-7 as above. This automatically overwrites the old calibration and saves the new values.

4.2.6 FN Dual Probes

The FN dual probes can work on both, the magnetic induction and the eddy current principle.To select the measuring procedure, press ON. FERROUS will flash on screen. Press the ⇧-arrow key to select FERROUS, i.e. the magnetic induction method. Press the ⇩-arrow key to select NON-FERROUS, i.e. the eddy current method. If you make no selection at all, the gauge will automatically display FERROUS after about 5 secs. and select the magnetic induction method.

For calibration and measurement, proceed as usual according to either 4.2.2 or 4.2.3 or 4.2.4 or (for the magnetic induction principle) 4.2.5.

4.2.7 N10 and N20 Probes

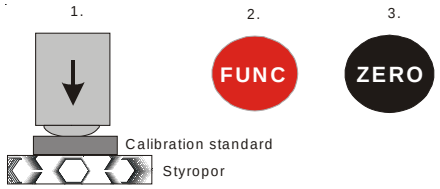
During calibration with N10 and N20 probes the dielectric properties of the calibration standard and of the coating material must be taken into consideration.

Switch the gauge on. The gauge automatically switches to „Continuous Mode“. This mode will be of advantage when measuring with the N10 and N20 probes. The „Continuous Mode“ will be indicated by a flashing measuring unit (µm, mm, cm). Readings beyond the measuring range will be indicated by 4 strokes flashing (**- - - -**). To switch to „Single measurement mode“ press FUNC followed by CONTINUE.

Standardization (Acquisition of Infinite Value)

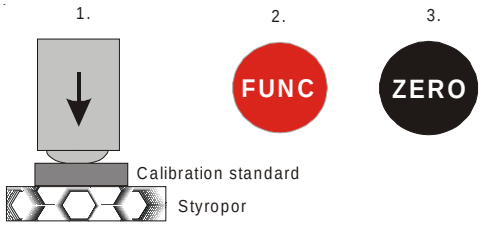
Place the probe on the thicker of the two supplied standards, without any metal underneath. To avoid any external dielectric influences, an effective base for the standard is a polystyrene block of at least 3cm thickness.

Press FUNC followed by ZERO key.



Press FUNC- and ZERO-key subsequently.

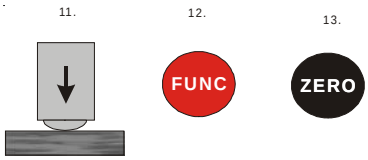
For calibrating or zeroing please proceed as described in section 4.2.2., 4.2.3. or 4.2.4, respectively.



(Calibration according to 4.2.3.)

Eliminating the effects of of the coating material.

Place the probe on the coating material without a metal base. Press FUNC and followed by ZERO.



Note:

This deactivates the automatic temperature compensation feature. Recalibrate in case of changes in temperature.

4.2.8 N100 Probe

For coating or wall thickness measurement with the N100 probe, the base material can be of ferrous or non-ferrous metal.

The base must be a minimum 30x30 cm. With smaller areas, the measuring tolerance will be greater. For minimum error the following is recommended:

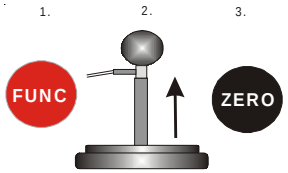
a) For calibration choose a spacer whose thickness is similar to the expected coating or wall thickness, respectively (see following calibration principle).

b) Make a two point calibration (4.2.4) with two spacers. Here the expected thickness should lie between that of the two spacers.

1. Switch the gauge on. The gauge automatically switches to „Continuous Mode“. This mode will be of advantage when measuring with this probe. The „Continuous Mode“ will be indicated by a flashing measuring unit (µm, mm, cm). Readings beyond the measuring range will be indicated by 4 strokes flashing (**- - - -**).

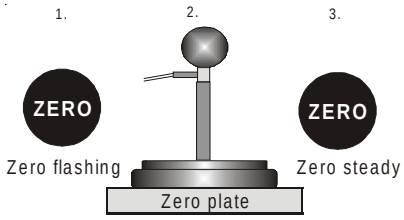
   To switch to „Single measurement mode“ press FUNC followed by CONTINUE.

2. **Standardization (Acquisition of Infinite Value)**



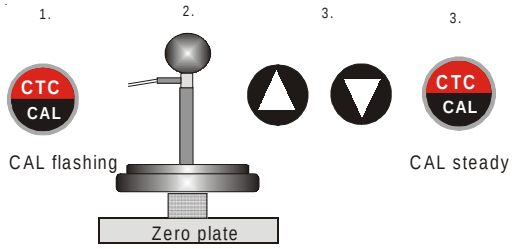
   Hold probe in the air and press FUNC followed by ZERO.

3. **Zeroing**



   Press ZERO and place the probe on the zero plate. ZERO flashes and a bleep sounds repeatedly. Press ZERO again. ZERO stops flashing and the bleep stops. Display shows 0.0 mm.

4. **Calibrating**



   Press CAL.CAL flashes and there is a repeated bleep.

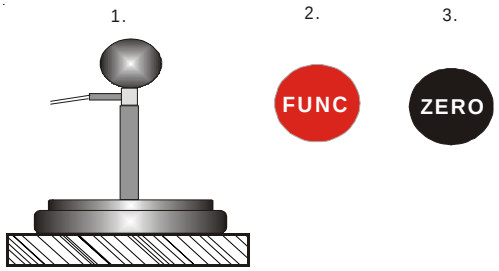
Place the spacer supplied - e.g. 50 mm - in the recess in the base of the probe. The thickness of the spacer should be similar to that of the expected thickness to be measured. Adjust to the spacer thickness with arrow keys.

Place both together on the measuring reflector. The probe base must be held parallel to the measuring reflector.

Use Arrow keys to adjust to the value specified on the spacer, e.g. 50 mm.

Press CAL to confirm. CAL appears on display (steady).

5. Eliminating the effects of dielectric interference of the coating material



After entering calibration values, the probe must be placed on the material - minimum thickness 30mm, but without a metal base.

Now press FUNC and ZERO one after the other.

This procedure must be carried out for both calibration methods 4.2.8.a) and b). Now the gauge is ready for operation.

Note:

It is recommended that you check and repeat the calibration occasionally, e.g. after using the gauge for more than two hours or in case of variations of temperature of more than 10°C.

If the gauge is to be used on other types of material, point 5 „Eliminating...“ must be repeated

4.2.9 F20 Probe

Switch the gauge on. The gauge automatically switches to „Continuous Mode“. This mode will be of advantage when measuring with this probe. The „Continuous Mode“ will be indicated by a flashing measuring unit (µm, mm, cm). Readings beyond the measuring range will be indicated by 4 strokes flashing (**- - - -**).

Hold the probe in the air and pres FUNC followed by ZERO. The probe will be drift and temperature compensated.

Please follow the instructions as described under 4.1 ‘General Remarks on Calibration’ and 4.2 ‘Special Hints for Calibration’.

Place the probe on the sample to be measured. If necessary, store reading into the statistics memory by pressing UP Arrow key (see section 2.5.5 and 2.5.6).

Note: If the display backlight function is enabled in continuous mode, battery consumption is higher.

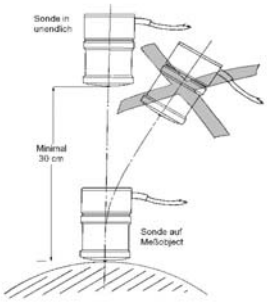
4.2.10 F50 Probe

Switch the gauge on. The gauge automatically switches to „Continuous Mode“. This mode will be of advantage when measuring with this probe. The „Continuous Mode“ will be indicated by a flashing measuring unit (µm, mm, cm). Readings beyond the measuring range will be indicated by 4 strokes flashing (**- - - -**).

Notes on calibration and measurement using F50 probe: Use the calibration and measurement routines of this instruction manual. In addition, the following remarks should be observed:

The position of the probe influences the measuring result. The infinite value automatically taken by the instrument or probe must be taken from the same angle to the measuring object as the reading which is to be taken later on. Further, the probe must be moved at a constant speed towards the measuring object.

In order to avoid hysteresis errors, after each measurement, the probe must be held away from the measuring object ensuring a minimum distance of 0.3m away from any metal parts.



Note:

The magnetic field created by the measuring probe might interfere with or even destroy electronic or medical equipment or gauges in the vicinity. To avoid such interference, it is recommended to keep a distance of at least 1m away from such instruments or any magnetic data carrier.

4.2.11 Tube probes F1.6/90, F2/90, N1.6/90 and N2/90

In single measurement mode, proceed as normal for calibration and measurement. In continuous measurement mode, the use of tube probes requires a slightly different procedure:

Calibration should be carried out in single measurement mode according to sections 4.4.2.2-4.2.4. For F1.6/90 and F2/90 probes, you can also proceed according to 4.2.5.

In the continous measuring mode, you can enter the current reading into the statistics memory by pressing ⇧-key or by operating the foot-switch (optional).

You can switch from single measurement mode to continuous mode by pressing „FUNC“ and „CONTINUE“.

4.2.12 Chrome Coatings on Copper

Applicable to probe N08C. Requires to use a special calibration foil.

1. The two-point calibration method described in 4.2.3 must be used.

2. Use the special calibration foil marked ‘Chrome on Cu‘.

4.2.13 CN02 Probe

The CN02 is a flat probe for use on even surfaces.Only one-point calibration using one calibration foil is required.

To measure the thickness of copper laminates or copper foil:

1. Press CAL to initialise calibration. The LC display will show CAL (flashing) and MEAN (steady). MEAN indicates that the mean value of the readings will be shown on the display.

2. Place the metalic calibration foil on an insulating piece of minimum 10mm thickness, apply the probe and raise it after the bleep.The thickness of the foil should be roughly equivalent to the estimated sample thickness. Apply the probe to

the metallic calibration foil several times. The display always shows the mean value calculated from the previous readings.

3. Use Arrow keys to adjust to the foil thickness.

4. Press CAL. 'CAL' appears (steady).

5. Place the probe to the layer to be measured. Wait for the bleep and raise the probe.

Important:

Measurements on double-sided laminated PC boards will require calibration using a double sided laminated copper standard.

4.2.14 Recalibration in an APPL-memory Line

(See also APPL-BATCH diagram in section 3.1.)

If recalibration is carried out for an APPL memory line, all stored values and statistical data are retained. The new values will simply be added to the old ones. It is up to the operator to decide if two different calibrations are permissible for one series of measurements. This method can be used to store a series of measurements in various BATCH groups of any one APPL memory line in succession, even if these have different calibrations.

Important note:

Only the last recalibration will become valid. Any previous calibration within the same APPL-memory line will become invalid.

4.2.15 Shot-blasted Surfaces

The physical nature of shot-blasted surfaces results in coating thickness readings that are too high. The mean thickness over the peaks can be determined as follows (note that the statistics program is of great benefit in this procedure):

Method A (Rz > 20µm)

1. The gauge should be calibrated according to 4.2.2 or 4.2.3. Use a smooth calibration sample with the same curvature radius and the same substrate as the later measuring sample.

2. Now take approx. 10 readings on the uncoated, shot-blasted sample to produce the mean value $\overline{x}_o$.

3. After this take approx. 10 further readings on the coated, shot blasted test sample to produce the mean value $\overline{x}_m$.

4. The difference between the two mean values is the mean coating thickness $\bar{x}_{eff}$ over the peaks. The greater standard deviation s of the two values $\bar{x}_m$ and $\bar{x}_o$ should also be taken into consideration:

$$\bar{x}_{eff} = (\bar{x}_m - \bar{x}_o) \pm s$$

Method B (Rz < 20µm)

1. Carry out a zero calibration of 10 readings on a shot-blasted, uncoated sample. Then carry out a foil calibration on the uncoated substrate. The foil set should consist of a number of individual foils of max. 50 microns thickness each and should roughly correspond to the estimated coating thickness.

2. The coating thickness can be read directly from display and should be averaged from 5...10 single measurements. The statistics function is useful here.

Method C: Calibration with two different calibration foils.

This method also gives reliable results. Simply follow the two-point calibration method using two foils as described in section 4.2.4.

For a maximum approach to the respective nature of surface, the foil value can be reached by using several foils - 50µm each.The mean coating thickness should be calculated from 5...10 readings. The statistics programme is very useful here.

Note:

For coatings thicker than 300 µm, the influence of roughness generally is of no importance and it will not be necessary to apply above calibration methods.

4.2.16 Adjusting to Basic Calibration

In certain cases it can be of assistance or even imperative to reset the basic probe calibration e.g.

- if the probe tip is worn
- for special applications

The basic calibration can be adjusted to your specific requirements. Please contact ElektroPhysik for more detailed information

4.3 General Remarks on Measurement

After careful calibration has been made, all subsequent measurements will lie within the guaranteed measuring tolerance (see technical data).

Strong magnetic fields near generators or live rails with strong currents can affect the reading.

When using the statistics programme for obtaining a mean value it is advisable to place the probe several times at a typical measuring spot. Any false readings or outliers can be removed immediately by pressing CLEAR.

The final reading derives from the statistical calculation and from the guaranteed tolerance levels of the gauge.

Coating Thickness **D =** $\bar{X} \pm s \pm u$

Example:

Readings: 150 µm, 156µm, 153 µm

Mean value: $\bar{X}$ = 153 µm

Standard deviation: s = ± 3 µm

Measuring uncertainty: u = ± (1% of readingt + 1µm)*

* referred to the supplied standards under laboratory conditions

D = 153µm ± 3µm ± (1,53 µm + 1µm)

= 153 µm ± 5,5µm

4.4 Using the Foot-Operated Switch

In continuous mode, readings are logged to statistics memory by pressing (⇧)-arrow key or by operating the foot-switch. Data can also be printed-out on an optional printer or transferred to a PC via an interface. The foot-switch is especially helpful if the operator needs both hands for measurement, as when using the probes for internal tube measurement.

5. Offset Function

The OFFSET function enables a constant value to be added to or subtracted from a measured value.

Offset can be used in both DIRECT and APPL-BATCH mode. In APPL-BATCH mode OFFSET is stored in an APPL memory.

1. Press FUNC followed by OFFSET-key. The word OFFSET will flash on the LC display with either 0.0 or 0.00 or the last OFFSET value.
2. Adjust to the new OFFSET value with one of the arrow keys. Hold down the arrow key for fast setting.
3. Press OFFSET again. OFFSET (not flashing) will appear on the display. This fixed value will now be added to or subtracted from the measured value.

6. Limit Function

Limits can be entered in DIRECT mode and in a selected APPL-BATCH memory at any time, i.e. before, during and after a series of measurements. There are three practical uses for limits.

1. Any reading which falls outside the set tolerance limits will be registered by a warning bleep and sub-sequently marked in the print-out:

   <: reading below LO limit

   >: reading above HI limit

2. The gauge will produce an analog bar graph of readings, based on the mean value derived from the set limits. Set limit symbols:

   σ reading above upper limit (HI)

   ν reading within tolerance limits

   τ reading below lower limit (LO)

3. The histogram will be calculated and printed out within the upper (HI) and lower (LO) tolerance limits.

For metrological reasons, there is a restriction on how close the upper and lower set limits can be to each other. Over the full measuring range the minimum permissible distance between upper and lower limits depends on the probe type in use. (e.g. 5µm for the F3 probe). Any attempt to set too small a range will result in the gauge shifting automatically to the minimum permissible range.

1. Press LIMIT; either 0.0 or 0.00 or the previous lower limit and the flashing LIMIT LO will be displayed. Now select the new lower limit with one of the arrow keys. Hold down the key for fast setting.

2. Press LIMIT again, the display will show either the previous upper limit or the lower limit plus the smallest permissible range. Select the upper limit with one of the arrow keys. Hold down the key for fast setting.

3. Press LIMIT again. The word LIMIT (not flashing) appears on display.

7. Measurement Using Statistics

For both gauges, MiniTest 3100 and MiniTest 4100, two different statistical programs are available: single value statistics and block value statistics (DIN 50982).

Within the APPL-BATCH memory system, MiniTest 3100 calculates statistics from a maximum of 100 series of readings while MiniTest 4100 is able to calculate statistics from as much as 500 measuring series. In total, a maximum of 10,000 single values can be stored.

Single value statistics

All readings of a measuring series are automatically stored for statistical evaluation. From each measuring series, the following statistical values are calculated or printed out:

n-values	:	number of single readings
mean ($\bar{x}$)	:	mean value
st.d. (s)	:	standard deviation
kvar	:	variation coefficient
max	:	maximum reading

min : minimum reading

cp : process capability index

cpk : process capability index

Block value statistics (also refer to 2.5.4)

Block value statistics are only available in APPL-BATCH mode. In DIRECT mode, only the single value statistics can be calculated. In this mode, the readings of a series are logged in blocks. The size of a block is alterable via PC and optional software. Default: 5 readings = 1 block. The statistics are calculated from the mean value ($\bar{x}$) of a block. The analysis of any one series appears on the display and on the print-out as follows:

N-Groups : number of blocks or groups

MEAN ($\bar{\bar{x}}$) : mean of mean values

ST.D (s) : standard deviation (mean value)

KVAR : variation coefficient (mean value)

MAX : max. mean value of all blocks

MIN : min. mean value of all blocks

Please note:

During measurement, a double bleep sounds after five readings have been taken. This also applies to the DIRECT mode, even though the block value statistics does not function in this mode.

At least 2 single readings or 2 block values are required to produce a statistical analysis, which will consist of the 6 (8) values listed above; the last two (cp) and (cpk), require the input of tolerance limits.

7.1 Statistical Terms

Mean value : ($\bar{x}$)

The sum of single readings divided by the number of readings.

$$\bar{x} = \frac{\Sigma x}{n}$$

Standard Deviation s (STD. DEV.):

The sample standard deviation is a statistic that measures how „spread out“ the sample is around the sample mean. The sample standard deviation increases

.

with increasing spread out. The standard deviation of a set of numbers is the root mean square of the variance s^2.

The variance of a list is the square of the standard deviation of the list, that is, the average of the squares of the deviations of the numbers in the list from their mean divided by the (number of readings - 1).

Variance $s^2 = \frac{\Sigma(x - \bar{x})^2}{n - 1}$

Standard deviation $s = \sqrt{s^2}$

Variation coefficient *Kvar*

The variation coefficient „Kvar“ is the Standard Deviation of a set of samples divided by its Mean. The result is expressed as a percentage.

$$K\,var = \frac{s}{\bar{x}} \times 100\%$$

Process capability index *cp*

The *cp* index is a measure of the spread of the readings as related to the specification limits. Only the spread is of importance here. The *cp* index is calculated as follows:

$$Cp = \frac{USL - LSL}{6s}$$

USL = uppper specification limit

LSL = lower specification limit

Process capability index *cpk*

In addition to the spread, the **cpk** index also takes into account the location of midpoint as related to the specification limits.

$$Cpkl = \frac{\bar{x} - LSL}{3s}$$

$$Cpku = \frac{USL - \bar{x}}{3s}$$

$$Cpk = Min\ \{\ Cpkl, Cpku\ \}$$

7.2 Storing a Measuring Series with Statistics Calculation

In DIRECT mode (Press FUNC, then DIRECT-key):

1. Switch on and take readings. All readings will be automatically logged to the statistics program.
2. Remember to check whether calibration is required and/or if any redundant statistical values need to be erased. To recalibrate, simply overwrite the old calibration
3. To delete „old“ statistics, press FUNC followed by CLEAR/STATS-key.
4. To continue a series of measurements in DIRECT mode after the gauge has been switched off, simply switch the gauge on again and continue your series of measurements.

In APPL-BATCH Mode:

If necessary, press APPL-key to activate APPL-BATCH mode.The number of the previously activated APPL-BATCH memory appears. If necessary, select new APPL-BATCH memory (section 3.4).

1. To delete a measuring series including statistics press FUNC followed by CLEAR/STATS-key.
2. If necessary, enter new calibration values and tolerance limits (sections 4.2.1-13, 5 and 6). All further readings will be automatically stored into the statistics program.
3. To continue a series of measurements in APPL-BATCH mode after the gauge has been switched off, simply switch the gauge on again and continue your series of measurements.

7.3 Deleting Outliers or Erratic Readings

Deletion must take place immediately after an outlier or erratic reading has been taken (see also section 9). Press CLEAR once. A bleep confirms that the value has been deleted.

7.4 Storage Capacity Overflow

If the storage capacity is exceeded, statistics will not be updated, although measurement can continue. If the memory is full, subsequent readings will be omitted from the statistics. They will be marked with the error message E11 (shortly appears).

7.5 Display and Print-out of the Statistics of one measuring series

7.5.1 Single value statistics

In Single Value Statistics mode (see section 2.5.4) you can print-out or display statistics as follows:

1. Showing statistics on display (without printer)

   Each time STATS is pressed the statistical values will appear in the order: N (number of values), MEAN, ST.D., Kvar, MAX, MIN, Cp, Cpk.

2. Printing individual statistical values

   If a MiniPrint printer is connected the statistical values can be printed out or transferred via a serial interface to a PC. Each time STATS is pressed the statistical values will be printed/transferred in the order: N (number of values), MEAN, ST.D., Kvar, MAX, MIN, Cp, Cpk.

3. Complete print-out of statistical values with histogram option

   Press PRINT once. If a printer is connected, the single value statistics will be printed out together with date, time and probe type used.

   If tolerance limtis have been entered a histogram will also be printed out.

Please note:

The MiniTest print-out of single-value statistics is headed STATISTICS. To cancel printing, switch off the MiniPrint printer. The statistical values can be viewed at any time, even while a series of measurements is being taken

7.5.2 Block-value statistics

In block-value statistics mode (see also section 2.5.4) statistics can be displayed or printed out as below. (It is also possible to display and print out single-value statistics in this mode.)

1. Showing single-value statistics on display

   Each time STATS is pressed the statistical values will appear in the order: N (number of values), MEAN, ST.D., Kvar, MAX, MIN, Cp, Cpk.

2. Printing single-value statistics

   If a MiniPrint printer is connected the statistical values can be printed out or transferred via a serial interface to a PC. Each time STATS is pressed the statistical values will be printed or transferred.

3. Showing block-value statistics on display (without printer)

   Press PRINT-key once. Block value statistics are displayed for about 1 sec each in the following order: N (Groups), MEAN, ST.D., Kvar, MAX, MIN, Cp, Cpk.

4. Showing block-value statistics with complete print-out of statistics with histogram option

   Press PRINT-key once. If a printer is connected, the block-value statistics will be displayed for about 1 second each. At the same time, the block-value statistics will be printed out together with date, time and the probe used.

   If tolerance limtis have been entered a histogram will also be printed out.

Please note:

The MiniTest print-out of block-value statistics is headed BLOCK-STATISTICS. To cancel printing, switch off the MiniPrint printer. The statistical values can be viewed at any time, even while a series of measurements is being taken.

7.6 Printing Statistics and Readings of a Measuring Series

7.6.1 Single value statistics

In single-value statistics mode (see also section 2.5.4) all individual readings of a series and the accompanying statistics can be displayed and printed out as follows:

Press FUNC and PRINT ALL.

If a printer is connected the following will be printed out:

- all readings of a series
- the 6 (8) single-statistics values and
- a histogram

Please note:

1. Pressing FUNC followed by PRINT-ALL-key prints all readings, statistics and histogram.
2. Pressing PRINT-key only prints statistics and histogram.

3. The histogram will only be printed out if tolerance limits have been set (see section 6).

4. To cancel printing switch off MiniPrint.

5. Readings are shown on display as rounded values. The class intervals, however are not calculated on the basis of rounded values.

7.6.2 Block-value statistics

In block-value statistics mode (see also section 2.5.4) the corresponding statistical values and all individual readings of a series can be displayed and printed out as follows:

1. Showing block-value statistics (without printer)

   Press FUNC and PRINT-ALL. The 6 (8) block-statistics values will appear for just over a second at a time in the order N (groups), MEAN, ST.D., Kvar, MAX, MIN, Cp, Cpk.

2. Print-out of all readings of a series, the statistics of each block and all block-value statistics.

   Press FUNC and PRINT-ALL. If a printer is connected the following will be printed out:

   - all readings of a series of measurements
   - MEAN and St.D
   - 6 (8) block statistics values
   - histogram (in APPL-BATCH mode if limits have been set)

Please note:

1. Pressing FUNC followed by PRINT-ALL-key prints all readings, statistics and histogram.

2. Pressing PRINT-key only prints statistics and histogram.

3. The histogram will only be printed out if tolerance limits have been set (see section 6).

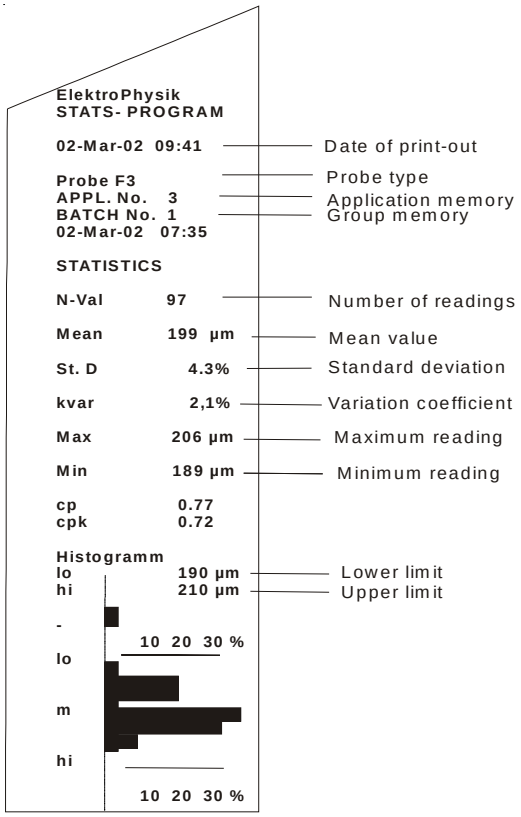
4. To cancel printing switch off MiniPrint.

5. Readings are shown on display as rounded values. The class intervals, however are not calculated on the basis of rounded values.

Table of Single-value and Block-value Statistics

Key	Single Value Statistics		Block Value Statistics	
	Display	Print-out	Display	Print-out
STATS *DIRECT and APPL-BATCH mode*	Single value statistics each time you press STATS.	Single value statistics each time you press STATS.	Single value statistics each time you press STATS.	Single value statistics each time you press STATS.
PRINT *APPL-BATCH mode*	--	Single value statistics including date, time and histogram (if limits have been set)	Block value statistics are continuously displayed for 1 sec. at a time.	Block value statistics incl. date, time and histogram (if limits have been set)
PRINT ALL *APPL-BATCH mode*	--	All readings of a measuring series, single value statistics incl. date, time and histogram (if limits have been set)	Block value statistics are continuously displayed for 1 sec. at a time.	All readings of a measuring series, block value statistics incl. date, time and histogram (if limits have been set)

Print-out of Single-value Statistics



7.7 BATCH 99 Function: Complete Statistics without Single Readings

This function (only available with MiniTest 4100) calculates a complete statistics from all BATCH memories of a certain APPL-line. The statistics includes no single values.

Press PRINT-key. If a printer is connected, the following data will be printed out:

- 6 (8) statistical values
- histogram (if limits have been set in BATCH 9)

If no printer is connected, above data will only be shown on display (at a higher display rate).

7.8 BATCH 99 Function: Complete Statistics including Single Readings

Press PRINT-key. If a printer is connected, the following data will be printed out:

- all readings of all BATCH memories (= group memories) of a certain APPL-memory (application memory)
- 6 (8) statistical values calculated from all BATCH memories of one APPL-memory.
- histogram (if limits have been set in BATCH 99)

If no printer is connected, above data will only be shown on display (at a higher display rate).

Please note:

1. Pressing FUNC followed by PRINT-ALL-key prints all readings, statistics and histogram.
2. Pressing PRINT-key only prints statistics and histogram.
3. The histogram will only be printed out if tolerance limits have been set (see section 6).
4. To cancel printing switch off MiniPrint.
5. Readings are shown on display as rounded values. The class intervals, however are not calculated on the basis of rounded values.

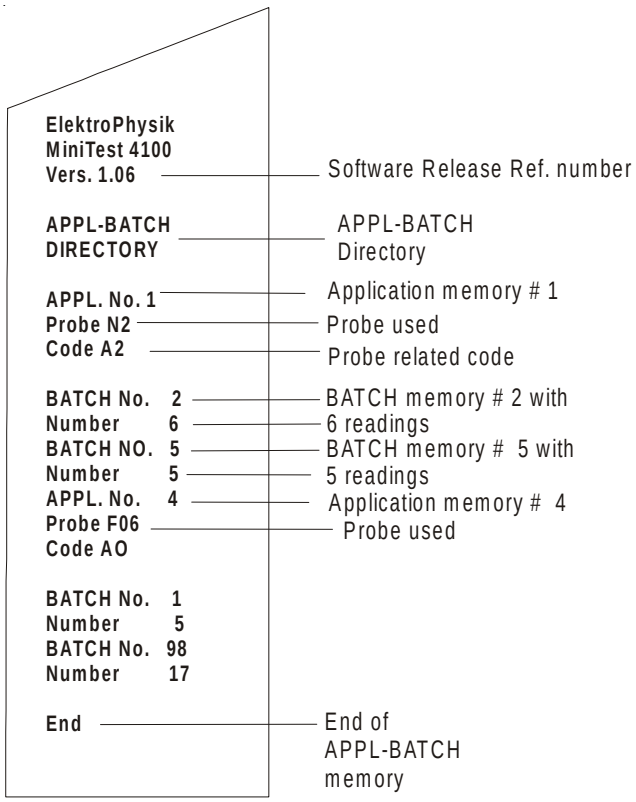
8. Printing out APPL-BATCH Directory and Number of Readings

1. Switch off MiniTest and switch on MiniPrint.
2. Press APPL-key and hold down while pressing ON-key. Keep both keys pressed down until a bleep sounds.

   MiniPrint prints out a directory with the following details:

- APPL-BATCH memory occupancy
- Probe type used for creating the individual APPL memories
- Number of readings stored in the individual BATCH memories

Directory Print-out

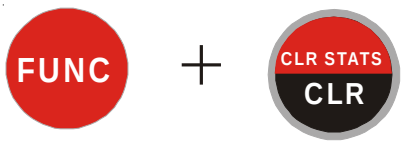


9. Delete Functions

9.1 Delete the Last Reading

Press CLEAR once immediately after the reading to be deleted has been taken. A bleep confirms the reading has been deleted.

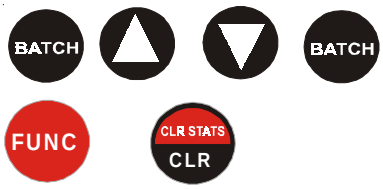
9.2 Delete Statistics in DIRECT Mode



Press FUNC and CLEAR STATS simultaneously. A short bleep confims deletion.

9.3 Delete a Series of Measurements incl. Statistics within an APPL-BATCH Memory

Example: APPL-BATCH memory <3:2>.

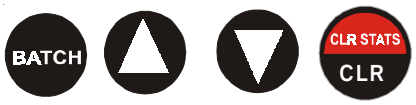


(This action does not delete calibration values)

1. Press BATCH and use arrow keys to select a BATCH number (see section 3.5).
2. Press BATCH to confirm.
3. Press FUNC and CLR STATS. A short bleep confirms deletion.

9.4 Delete a Series of Measurements incl. Statistics within one APPL-BATCH Memory

Example: APPL-BATCH memory <3:2>.



(This action does not delete calibration values)

1. Press BATCH and use arrow keys to select a BATCH number (see section 3.5).
2. Press CLEAR-key. A short bleep confirms deletion.

9.5 Delete Limits of an APPL-BATCH Memory

Example: APPL-BATCH memory <2:3>.

1. Press BATCH and use arrow keys to select a BATCH number (see section 3.5). LIMIT appears.
2. Press LIMIT-key. LIMIT flashes.
3. Press CLR-key. The display will be cleared. A short bleep confirms deletion.

9.6 Delete all Series of Measurements incl. Statistics, Limits and Calibration Values of an APPL memory

Example: In memory 2:1; 2:2; 2:3, ...2:98 (10)

1. Press APPL-key. Use arrow keys to select an APPL memory (see section 3.4). <2:5> appears, for instance.
2. Press CLR-key. 3 short bleeps sound. To cancel deletion press APPL-key.
3. To complete deletion, press CLR. A long bleep confirms deletion. An APPL number flashing indicates a free application memory.

9.7 Total Reset

A Total Reset deletes all measuring series including readings, calibration, limits and statistical values in all APPL-BATCH memories.

1. Switch the gauge off.
2. Press CLEAR, FUNC and ON subsequently and keep pressed down. A long bleep confirms deletion of all values.

10. Using the Gauge without Probe

Certain gauge functions can be activated without a probe being connected. These are as follows:

1. Defining the initialising function and standard gauge settings.
2. Print-out of statistics and readings.
3. Selecting APPL-BATCH memories.
4.. Gauge control via a PC (see section 13.)

11. MiniPrint 4100 Data Printer

The MiniPrint 4100 provides immediate or later print-out of single readings, statistics, histogram and directory.

1. Simply connect the printer laterally to the MiniTest gauge without using a cable.
2. Switch on the MiniTest gague.
3. Switch on the MiniPrint 4100 data printer.

For further details please refer to separate operating instructions supplied with the MiniPrint 4100 data printer.

12. Connecting a PC

MINITEST 3100 and 4100 are equipped with a combination interface which can accommodate a MiniPrint 4100 data printer or a Mitutoyo miniprocessor. In addition, they have a two-way RS232C interface. The connecting cable and the data transfer program can be used to transfer all readings and statistics to a PC for further processing. The data transfer procedure is the same as that for data print-out.

Note on the Mitutoyo miniprocessor DP1-HS:

As the Mitutoyo miniprocessor DP1-HS works on his own statistics function, the MiniTest statistics cannot be printed out with this miniprocessor. For that reason, the statistics provided by the Mitutoyo DP1-HS is different from the MiniTest statistics program.

13. Gauge Control via PC

The two-way interface can be used to control the MiniTest gauge functions via a PC keyboard and a PC program. The option of program control enables the gauge to be used both for semi-automatic and fully automatic operation.For further details consult our special leaflet (interface description).

14. Combination Interface for foot-operated Switch, Bleeper or Lamp

This optional interface makes available an external trigger mechanism which enters readings in continuous mode into the statistics program by a foot-operated switch as well as a reading confirmed signal for a bleeper or a lamp. Length of reading confirmed signal - 0.2 sec.

15. Interface Descriptions for MiniTest and MiniPrint

Available on request.

16. Useful Accessories

- Various probes
- Belt-case
- Transparent case protection case
- Twin case for gauge and printer
- MiniPrint 4100 portable data printer
- PC connecting cable
- Program disk: processes MiniTest readings and statistics. For IBM PC or compatible.
- High-precision stand for measurement on small parts.
- Mains adapter 230V AC / 12V DC or 110V AC/ 12V DC
- Accu battery including charger 230V AC or 110V AC

17. Maintenance and Maintenance Contracts

The MiniTest needs an occasional battery change but is otherwise maintenance-free. It is extremely robust, but, as with any measuring apparatus, it should be handled with care.

Used batteries must be removed from the gauge without delay. The accumulator batteries in the MiniPrint printer need regular recharging.

If the customer takes out a **maintenance contract** the gauge and all supplementary hardware will be serviced annually. We will gladly supply an estimate for maintenance agreement with further details of the service guarantee.

18. After-Sales Service

Please send a damaged or defective gauge to us directly or forward it via your dealer. Please enclose a brief error description.

19. Trouble Shooting

The following list of error messages explains how to identify and eliminate faults. „E“ (E = error).

Faults that cause the gauge to switch off:

E 1 : Probe type incompatible

E 2 : Probe not connected. This message only appears when no probe is connected after a Total Reset.

E 3 : Probe defective. This message only appears immediately after the gauge is switched on or if the probe becomes detached from the socket while in use.

E 4 : Probe is giving unreliable readings (e.g. as a result of strong fluctuations in the magnetic field or readings taken on soft coatings).

E 5 : Probe was held too near to metal when switched on.

E 6 : Low battery.

Error messages displayed for about 1.5.secs:

E 11 : Memory full.

E 12 : Zero calibration not possible.

E 13 : CTC calibration not possible.

E 14 : 2-point calibration (using 2 calibration foils) not possible.

E 15 : 1-point calibration after CTC calibration not possible.

The following errors can be remedied by a Total Reset:

- The gauge does not switch off automatically

- Readings are no longer registered.

- None or several of the keys work

- Illogical readings

Total Reset:

1. Switch the gauge off.

2. Press FUNC and CLEAR and keep pressed down while pressing ON.

A long bleep confirms that all readings and calibration values have been deleted

If you cannot switch the gauge off via key operation, remove batteries to perform Total Reset.

20. EC Declaration of Conformity

We declare that the gauges MiniTest 3100 and MiniTest 4100 as well as the data printer MiniPrint 4100 are in correspondence with the safety requirements of the EMC directive 89/336/EWG, which is applied through the German law for electromagnetic conformity (EMVG) dated 9.11.1992

21. Measuring Example

Chose probe according to your application, e.g. F3. For calibration please use an uncoated sample of the same material and geometry as the later measuring object. To check whether gauge and probe work within the specified tolerances, please use the ferrous zero plate supplied with the probe.

1. Insert and screw in probe.
2. Press ON. 'FERROUS' flashes.
3. Carry out one-point calibration (zeroing): Press ZERO. 'ZERO' flashes.
4. Apply the probe serveral times to the zero plate.
5. Press ZERO. 'ZERO' appears on display.
6. Now start measurement: Take a calibration foil, lay it on the zero plate and place the probe on it several times.The gauge will now display the calibration foil thickness, taking into account gauge tolerances.
7. For two-point calibration press CAL. 'CAL' appears on display.
8. Place one of the enclosed calibration foils on the zero plate and apply the probe several times.
9. Adjust to the thickness of the foil with the arrow keys.
10. Press CAL. 'ZERO' and 'CAL' appear on display along with 'µm' or 'mm'.
11. Now take readings on your measuring sample.

Calibration and Measurement in APPL-BATCH mode:

12. Press APPL-key. APPL flashes and a one- or two-digit number is displayed.
13. If a one-digit number flashes press APPL-key. Note the flashing number. APPL stops flashing.
14. If neither of the numbers flashes, Press ⇧-key until one of the numbers starts flahsing, then press APPL. Note the flahsing number. APPL stops flahsing.
15. Perform calibration according to section 4.
16. You have now reached the first free memory of the APPL memory line which can be identified by the number you have noted (see also section 3.1 The Structure of APPL-BATCH System).

17. Take readings (see also section 7. Measurement Using Statistics).

18. Press STATS-key. „N“ appears specifiying the number of reading.

19. Press STATS-key repeatedly to scroll through the statistical values.

End of Example.

22. Technical Data

F Probes (Magnetic Induction) - Metric Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions in mm
F05	0...500 µm	0,1 µm	± (1% of reading + 0,7 µm)	0,75 mm / 5 mm	Ø 3 mm (using stand)	0,1 mm	Ø 12 x 49
F1.6	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	1,5 mm / 10 mm	Ø 5 mm	0,5 mm	Ø 15 x 62
F3	0...3000 µm	0,2 µm	± (1% of reading + 1 µm)	1,5 mm / 10 mm	Ø 5 mm	0,5 mm	Ø 15 x 62
F1.6/90 Internal tube probe	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	flat / 6 mm	Ø 5 mm	0,5 mm	8 x 11 x 180
F1.6P Powder probe	0...1600 µm	0,1 µm	± (3% of reading + 1 µm)	flat surfaces only	Ø 30 mm	F 0,5 mm N 0,5 mm	Ø 21 x 89
F2/90 Internal tube probe	0...2000 µm	0,2 µm	± (1% of reading + 1 µm)	flat / 6 mm	Ø 5 mm	0,5 mm	8 x 11 x 180
F10	0...10mm	5 µm	± (1% of reading + 10 µm)	5 mm / 16 mm	Ø 20 mm	1 mm	Ø 25 x 46
F20	0...20 mm	10 µm	± (1% of reading + 10 µm)	10 mm / 30 mm	Ø 40 mm	2 mm	Ø 40 x 65
F50	0...50 mm	10 µm	± (3% of reading + 50 µm)	50 mm / 200 mm	Ø 300 mm	2 mm	Ø 45 x 70

F Probes (Magnetic Induction) - Imperial Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions
F05	0...20 mils	0.01 mils	± (1% of reading + 0.028 mils)	0.03" / 0.20"	Ø 0.12" (using stand)	0.004"	Ø 0.47" x 1.93"
F1.6	0...60 mils	0.01 mils	± (1% of reading + 0.04 mils)	0.06" / 0.40"	Ø 0.20"	0.020"	Ø 0.60" x 2.44"
F1.6P	0...60 mils	0.01 mils	± (3% of reading + 0.4 mils)	flat surfaces only	Ø 1.20"	F 0.02" N 0.02"	Ø 0.83 x 3.50"
F3	0...120 mils	0.01 mils	± (1% of reading + 0.04 mils)	0.06"/ 0.4"	Ø 0.20"	20 mils	Ø 0.60" x 2.44"
F1.6/90 Internal tube probe	0...60 mils	0.01 mils	± (1% of reading + 0.04 mils)	flat / 0.24"	Ø 0.02"	0.020"	0.32" x 0.43" x 7.09"
F2/90 Internal tube probe	0...80 mils	0.01 mils	± (1% of reading + 0.04 mils)	flat / 0.24"	Ø 0.02"	0.020"	0.32" x 0.43" x 7.09"
F10	0...400 mils	0.5 mils	± (1% of reading + 1 mils)	0.20" / 0.63"	Ø 0.80"	0.04"	Ø 0.98" x 1.81"
F20	0...800 mils	1 mils	± (1% of reading + 1 mils)	0.40" / 1.2"	Ø 1.60"	0.08"	Ø 1.57" x 2.55"
F50	0...2 inches	1 mils	± (3% of reading + 2 mils)	2" / 7.9"	12" x 12"	0.08"	Ø 1.77" x 2.75"

N Probes (Eddy Currents Probe) - Metric Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions in mm
N.08Cr	0...80 µm	0,1 µm	± (1% of reading+ 1 µm)	2,5 mm / 10 mm	Ø 5 mm	≥100 µm (Cu on steel)	Ø 16 x 70
N02	0...200 µm	0,1 µm	± (1% of reading+ 0,5 µm)	1 mm / 5 mm	Ø 0,2 mm	50 µm	Ø 16 x 70
N1.6	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	1,5 mm / 10 mm	Ø 5 mm	50 µm	Ø 15 x 62
N1.6/90 Internal tube probe	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	flat / 6 mm	Ø 5 mm	50 µm	8 x 11 x 180
N2/90 Internal tube probe	0...2000 µm	0,2 µm	±(1% of reading+ 1 µm)	flat / 6 mm	Ø 5 mm	50 µm	8 x 11 x 180
N10	0...10mm	10 µm	± (1% of reading+ 25 µm)	25 mm / 100 mm	Ø 50 mm	50 µm	Ø 60 x 50
N20	0...20 mm	10 µm	± (1% of reading + 50 µm)	25 mm / 100 mm	Ø 70 mm	50 µm	Ø 65 x 75
N100	0...100 mm	100 µm	± (3% of reading + 0,3 mm)	100 mm / eben	Ø 200 mm	50 µm	Ø 126 x 155
CN02 Cu coatings on insulating substrates	10...200 µm	0,2 µm	± (3% of reading + 1 µm)	flat surfaces only	Ø 7 mm	any substrate thickness	Ø 17 x 80

N Probes (Eddy Currents Probe) - Imperial Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions
N.08 Cr	0...3 mils	0.01 mils	± (1% of reading + 0.04 mils)	0.1" / 0.40"	Ø 0.20"	≥ 0.004" (Cu on steel)	Ø 0.63" x 2.75"
N02	0...8 mils	0.01 mils	± (1% of reading + 0.20 mils)	0.04" / 0.20"	Ø 0.008"	0.002"	Ø 0.63" x 2.75"
N1.6	0...60 mils	0.01 mils	± (1% of reading + 0.04 mils)	0.06" / 0.40"	Ø 0.20"	0.002"	Ø 0.59" x 2.44"
N 1.6/90 Internal tube probe	0...60 mils	0.01 mils	± (1% of reading + 0.04 mils)	flat / 0.25"	Ø 0.20"	0.002"	0.32" x 0.43" x 7.09"
N2/90 Internal tube probe	0...80 mils	0.01 mils	± (1% of reading + 0.04 mils)	flat / 0.25"	Ø 0.20"	0.002"	0.32" x 0.43" x 7.09"
N10	0...400 mils	0.40 mils	± (1% of reading + 1 mils)	1.0" / 3.94"	Ø 1.96"	0.002"	Ø 2.36" x 1.96"
N20	0...800 mils	0.40 mils	± (1% of reading + 2 mils)	1.0" / 3.94"	Ø 2.75"	0.002"	Ø 2.56" x 2.95"
N100	0...4 inches	4.0 mils	± (3% of reading + 12 mils)	3.94" / flat	Ø 7.87"	0.002"	Ø 4.96" x 6.10"
CN 02 Cu coatings on insulating substrates	0.4...8 mils	0.01 mils	± (3% of reading + 0.04 mils)	flat surfaces only	Ø 0.28"	any substrate thickness	Ø 0.67" x 3.14"

Dual Probes (Magnetic Induction & Eddy Currents) - Metric Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions in mm
FN1.6	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	1,5 mm / 10 mm	Ø 5 mm	F 0,5 mm N 50 µm	Ø 15 x 62
FN1.6P	0...1600 µm	0,1 µm	± (3% of reading + 1 µm)	flat surfaces only	Ø 30 mm	F 0,5 mm N 0,5mm	Ø 21 x 89
FN 1.6 / 90 Internal tube probe	0...1600 µm	0,1 µm	± (1% of reading + 1 µm)	flat / 6 mm	Ø 5 mm	F 0,5 mm N 50 µm	8 x 11 x 180
FN2/90 Internal tube probe	0...2000 µm	0,2 µm	± (1% of reading + 1 µm)	flat / 6 mm	Ø 5 mm	0,5 mm	8 x 11 x 180

Dual Probes (Magnetic Induction & Eddy Currents) - Imperial Table

Probe	Measuring range	Low range sensitivity	Measuring accuracy related to the supplied standards and under laboratory conditions	Min. curvature radius (convex/ concave)	Min. measuring area	Min. substrate thickness	Probe dimensions
FN1.6	0...60 mils	0.01 mils	± (1% of reading + 0.4 mils)	0.06" / 0.40"	Ø 0.20"	F 0.02" N 0.002"	Ø 0.6" x 2.44"
FN1.6P	0...60 mils	0.01 mils	± (3% of reading + 0.4 mils)	flat surfaces only	Ø 1.20"	F 0.02" N 0.02"	Ø 0.83" x 3.50"
FN 1.6/90 Internal tube probe	0...60 mils	0.01 mils	± (1% of reading + 0.4 mils)	flat / 0.24"	Ø 0.20"	F 0.02" N 0.002"	32" x 0.43" x 7.09"
FN2/90 Internal tube probe	0...80 mils	0.01 mils	± (1% of reading + 0.4 mils)	flat / 0.24"	Ø 0.20"	0.02 "	32" x 0.43" x 7.09"

Further Technical Data

Power supply:	1 x 9 V Alkaline battery (mor than 10,000 measurements), Akku, mains adapter
Ambient temperature gauge:	0°...50°C 32°...122° F
Ambient temperature probe:	-10°C...70°C, briefly to 120°C (High temperature probes up to 350°C) 14°...158°F, briefly to 248°F (High temperature probe F2 HT up to 662°F)
Norms and standards:	DIN EN ISO 2178, DIN EN ISO 2360, DIN EN ISO 2808, DIN 50982 ASTM B244, ASTM B499
Dimensions / weight of gauge without probe:	150 mm x 82 mm x 35 mm / 270 g 5.9" x 3.2" x 1.4" / 9.5 ozs

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