Anton Paar

Instruction Manual and Safety Information

MKT 50

Millikelvin Thermometer

Instrument software version: from 2.04

Published and printed by Anton Paar

Find out more

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1 Safety instructions

Read the documentation

- Read the documentation before using the product.
- Follow all hints and instructions in the documentation to ensure the correct use and safe functioning of the product.

1.1 General safety instructions

General

- The documentation is a part of the product. Keep it for the complete working life of the product and make it easily accessible to all persons involved with the product. If you receive any additions or revisions from Anton Paar, these must be treated as part of the documentation.

Liability

- This document does not claim to address all safety issues associated with the use of the product and samples. It is your responsibility to establish health and safety practices and to determine the applicability of regulatory limitations.
- Anton Paar only warrants the safe and proper functioning of the product if no modifications are made to mechanics, electronics, or software.
- Use the product only for the purpose described in the documentation. Anton Paar is not liable for damages caused by incorrect use of the product.
- The results delivered by the product depend on the correct function of the product and various other factors. We recommend that you have experts check the results (i.e., perform plausibility testing) before taking consequential actions based on the results.

General precautions

- Check the wetted parts of the product for chemical resistance to all samples and cleaning liquids.

Installation

- The installation procedure shall only be carried out by authorized personnel who are familiar with the installation instructions.
- Use only accessories, consumables, or spare parts supplied or approved by Anton Paar.

Using the product

- Ensure that all operators have been trained beforehand to use the product safely and correctly.
- The product is suited for indoor use only.
- In case of damage or malfunction, stop operating the product. Do not operate the product under conditions that could result in damage to goods or injuries or loss of life.

Battery handling

- If the product is not to be used for a longer period, remove the batteries from the battery compartment.
- Leaking or damaged batteries can cause burns if they come into contact with your skin. Use gloves for their handling.
- Never short-circuit or open batteries.
- Do not expose batteries to heat or throw them into fire.
- Do not charge non-rechargeable batteries. There is a risk of explosion.
- Do not insert damaged batteries in the battery compartment. They can cause short circuits and fire.
- Use only 1.5 V AA batteries or 1.2 V AA rechargeable batteries of the same type and charge condition.
- Observe the correct polarity when placing the batteries.

Operation in areas with risk of explosion

- The product is **not** explosion-proof and therefore must not be operated in areas with risk of explosion.

Service and repairs

- Service and repair procedures may be carried out only by authorized persons or by Anton Paar.

Disposal

- Concerning the disposal of the product, observe the legal requirements in your country. Contact your Anton Paar representative for further questions.

1.2 Conventions of safety messages

The following conventions for safety messages are used in this document:

WARNING

Description of risk

Warning indicates a hazardous situation which, if not avoided, **could** result in death or serious injury.

CAUTION

Description of risk

Caution indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

> **NOTICE**
> **Description of risk**
> Notice indicates a situation which, if not avoided, could result in damage to property.

TIP: *Tip gives extra information about the situation at hand.*

1.3 Safety signs on the instrument

Fig. 1: *Warning sign next to the battery compartment (rear of the instrument)*

2 Overview

The Millikelvin Thermometer MKT 50 measures temperatures in °C, K, or °F with exceptional accuracy. Combined with calibrated high-precision platinum resistance thermometers, MKT 50 achieves a reduction of system measurement uncertainties to an absolute minimum of as little as 1 mK (0.001 °C).

Connect the instrument to one or two Pt 100 industrial platinum resistance thermometers. Their temperature is calculated according to EN 60751 (formerly DIN IEC 751).

Pt 25.5 or Pt 100 standard platinum resistance thermometers are also suitable for the use as temperature sensors. The temperature of standard thermometers is calculated according to ITS-90 (International Temperature Scale 1990). Individual calibration parameters for up to 30 different sensors can be stored in the MKT 50. This provides easy recalibration and good traceability of the temperature measurement.

The instrument is operated via a menu-driven user interface. The current value, the mean value, and the standard deviation of 5 up to 50 values can be continuously displayed.

The self-heating effect of the sensor can be determined via the integrated self-heating test.

The instrument features an RS-232 serial interface and an Ethernet terminal. The integrated web server delivers all important data to any given web browser via internet or intranet.

2.1 Functional components

Front

Fig. 2: *Front view of the instrument*

1 *Display*
2 *Power on/off key*
3 *CH1 (channel 1) connector for sensor*
4 *CH2 (channel 2) connector for sensor*
5 *Function keys*
6 *Carrying handle*

Rear

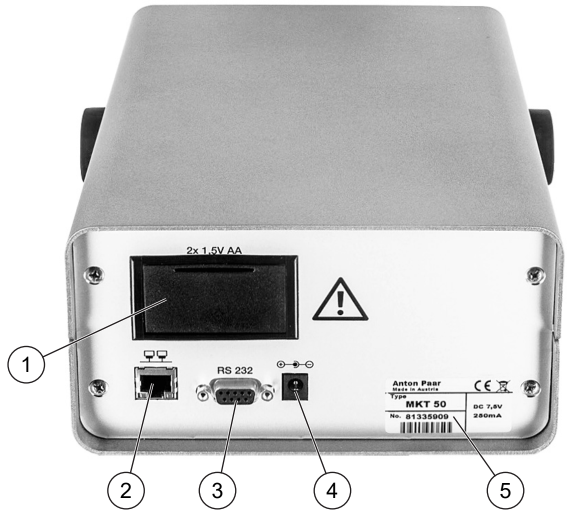


Fig. 3: *Rear view of the instrument*

1 *Battery compartment for two batteries of type AA*
2 *Ethernet (LAN) terminal (RJ45 connector)*
3 *RS-232 serial port (DE-9F connector)*
4 *Inlet for power adapter*
5 *Type plate with serial number*

3 Supplied parts

The product was tested and packed carefully before shipment. However, damage may occur during transport.

– Keep the packaging material (box, foam piece, transport protection) for possible returns and further questions from the transport and insurance company.

– Check the delivery for completeness by comparing the supplied parts to those noted in the table(s) below.

– If a part is missing, contact your Anton Paar representative.

– If a part is damaged, contact the transport company and your Anton Paar representative.

Table 1: Supplied parts

	Qty.	Description	Mat. No.
	1	MKT 50 Millikelvin Thermometer	26878
	1	Factory calibration certificate	
	1	Instruction manual and Safety Information English	43535
	1	Power adapter 7.5 V DC, 5.34 A	223140
	1	Cable for power adapter	
	2	Alkaline battery 1.5 V, LR06 Mignon AA *(already inserted in the battery compartment)*	82610
	1	Ethernet cable for PC connection, CAT 5e, RJ45G–RJ45G, SFTP, 2 m, crossed	18597

Table 2: Optional accessories and consumables

Article description	Mat. no.
For suitable MPMI and SPRT sensors, sensor cables, and calibrations available directly from Anton Paar, refer to the catalog **“Sensors for MKT 50”**. The catalog can be downloaded from the Anton Paar web site (http://www.anton-paar.com): Under *Services & Support* > *Document Finder* select the Product group “Thermometers”, then select the catalog from the list of free downloads.	
Adapter cable USB–RS232 180 cm	15446
Interface cable D-sub male 9 / female 9	11062
Carrying case for MKT 50	82556

4 Installation

1. Check that the calibration numbers on these parts are identical:
   – the calibration certificate,
   – the sensor,
   – the parameter printout (*Configuration Parameters*) if existent.
2. Check that the serial number on the MKT 50 (refer to 5, Fig. 3 [▶ 6]) matches the number on the optional parameter printout (*Configuration Parameters*).

Contact the manufacturer or supplier of the instrument in the case of any discrepancy.

4.1 AC-powered operation

NOTICE
Use only the supplied power adapter, mat. no. 223140.

1. Connect the supplied power adapter to the instrument's power inlet (4, Fig. 3 [▶ 6]).
2. Connect the power adapter to the mains supply with the power cable.

   The power adapter provides 7.5 V DC at a maximum of 5.34 A.

   While the instrument is AC-powered, the batteries will not be used.

   When the instrument is AC-powered, the main screen will show *line* in the bottom line.

4.2 Battery-powered operation

NOTICE
- Use only 1.5 V AA batteries or 1.2 V AA rechargeable batteries of the same type and charge condition.
- To charge rechargeable batteries, you have to remove them from the instrument.

The instrument comes with two 1.5 V AA batteries already inserted.

Exchanging the batteries

1. Gently pry the lid of the battery compartment (1, Fig. 3 [▶ 6]) with a screwdriver.
2. Remove the worn-out batteries from the compartment.
3. Insert two new batteries.

NOTICE
Observe the correct polarity when you insert the batteries (see label in the battery compartment).

4. Close the lid of the battery compartment.

Battery charge status

When the instrument is battery-powered, the main screen will show the current battery voltage in the bottom line (e.g. *U: 2.5 V*).

If the voltage sinks below 2.2 V, the main screen shows *batt.*. In this case replace the batteries as soon as possible or operate the instrument AC-powered. Otherwise, the instrument will switch itself off within a few minutes.

TIP: *Under typical operating conditions, the supplied alkaline batteries will last approx. 10 hours.*

TIP: *If you use batteries frequently, we recommend the use of rechargeable batteries due to environmental protection considerations.*

TIP: *The use of backlight, an RS-232 connection or an Ethernet connection cut the battery runtime short. When you employ these features, use batteries with a large capacity (> 2000 mAh).*

4.3 Assembling the measuring system

1. Connect the instrument to the mains supply (refer to Section 4.1 [▶ 8]) or ensure that two batteries are loaded (refer to Section 4.2 [▶ 8]).
2. If necessary, connect the sensor to the measuring cable (some sensors come with a non-detachable cable).
3. Plug the sensor cable into the *CH1* connector (3, Fig. 2 [▶ 6]).

Fig. 4: *MKT 50 with connected sensor*

4.4 Switching the instrument on/off

- To switch the instrument on, press the *Power on/off* key (2, Fig. 2 [▶ 6]).

  The instrument performs a self-test. If the self-test is completed successfully, you will briefly see a display as in Fig. 5 [▶ 8].

  After start-up the instrument is in measuring mode, indicated by a blinking asterisk in the lower left corner of the main screen.

```
MKT 50
S/N:  12345678
Date:        17.05.2010
V1.97  Build:  05/10
...................ok
```

Fig. 5: *Example of a display after self-test*

- To switch the instrument off, press the *Power on/off* key (2, Fig. 2 [▶ 6]) for 1–2 seconds.

  The instrument displays the message *Power down* and turns itself off.

  - If you switch off the instrument with the *Power on/off* key, the current operating status (e.g. averaging over 20 values) will be stored.
  - If you interrupt the power supply in any other way (e.g. by pulling the plug), the instrument will turn itself off without storing the current operating status.

IMPORTANT: *The instrument can only be switched off in measuring mode (when the main screen is shown).*

4.5 Getting started with pre-stored sensor parameters

If sensor parameters have already been entered and assigned to the sensor channels 1 and 2 ex-factory, the instrument will display the current temperature of the sensors.

```
CH1 No:00123456  IEC751
   24.369°C
CH2 No:00987654  IEC751
   24.373°C
             line
```

Fig. 6: *Example of a measuring display*

Before you start measuring with the instrument:

1. Check that the displayed sensor numbers *No* match the respective numbers on the sensor labels.
2. Check that the sensor parameters on the calibration certificate match the settings in the instrument, refer to Section 6.4.1 [▸ 11].

4.6 Getting started without stored sensor parameters

If no sensor parameters have been entered yet, the instrument will not display temperatures:

```
CH1               Warning
NO SENSOR CALIBRATION


CH2               Warning
NO SENSOR CALIBRATION

               line
```

Fig. 7: *Display before input and/or selection of sensor parameters*

You may either switch to the resistance display mode (refer to Section 6.5 [▸ 13]), or enter sensor parameters and assign these to sensor channels 1 or 2:

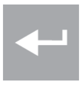
1. Enter the sensor parameters according to the calibration certificate (refer to Section 6.4.1 [▸ 11]).
2. Assign the sensor parameters to the sensor channel 1 (*CH1*) or 2 (*CH2*) (refer to Section 6.4.2 [▸ 13]).

   The instrument will then display the current temperature of the sensor as in Fig. 6 [▸ 9].

5 Operation

5.1 Keys on the front

0,1,2,3,4,5,6,7,8,9 (numerical keys)	– In menu mode: Selects a menu item directly by number. – In an input field: To enter a number.
. -	*Decimal point* / *Minus sign* To enter a number.
CE	*Clear* key – In menu mode: Deletes the last character entered. – In measuring mode (if **statistics display** has been selected): Toggles between two displays: – Display current temperature/resistance, mean, and standard deviation. – Display mean in big digits.
ESC	*Escape* key – In menu mode: Returns to the next higher menu level / to **measuring mode** (from the main menu). – In an active input field: Aborts the input and restores the previous content of the field.
▲ ▼	Arrow keys: *Up* / *Down* – In menu mode: Selects the previous/next menu item or input field within one menu. – In measuring mode (if **statistics display** has been selected):

	Increments/decrements the number N of measurements for the calculation of the average.
M	*Menu* key Switches from measuring mode to **menu mode**.
	*Lamp* key Backlight on/off
EXP	*Exponent* key To enter the exponent of a number.
	*Enter* key – In menu mode: Confirms the input. – In measuring mode (if statistics display has been selected): Temporarily shows the sensor name.
	*Power on/off* key Switches the instrument on or off (in measuring mode only).

5.2 Main screen (measuring mode)

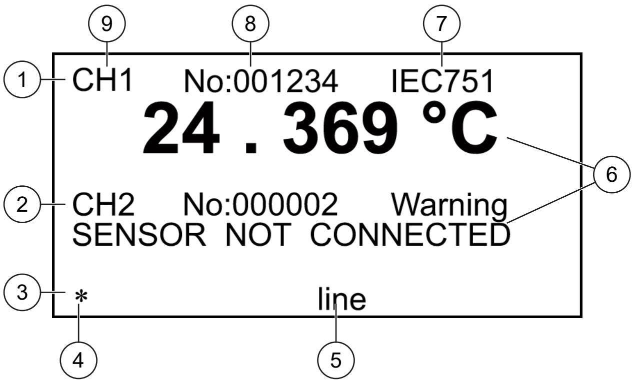


***Fig. 8:** Example main screen: one sensor connected, AC-powered operation*

1 *Sensor input 1 (channel 1)*
2 *Sensor input 2 (channel 2)*
3 *Instrument status*
4 *Blinking asterisk indicates "measuring mode"*
5 *Power supply / battery charge status*
6 *Temperature display (or error message)*
7 *Temperature calculation method (or "Warning")*
8 *Calibration number of sensor*
9 *Channel number*

5.3 Menu navigation / making a selection

MKT 50 always starts in measuring mode (main screen).

- Press *M* to switch to menu mode.

  You will see the main menu.

```
MAIN  MENU

➡ 1 Temperature Mode
  2 Resistance Mode
  3 Edit Configuration
  4 Security Options
  5 Self Heat Test:OFF
```

***Fig. 9:** Main menu*

- To switch menus or make a selection:
  - Either enter the digit heading the menu item,
  - or use the arrow keys to navigate within menus and to select an item, then press *Enter*.

With longer screen content, the symbols for the arrow keys will show beside the menu title. Use the arrow keys to scroll through the content.

- Press *ESC* to return to the next higher menu level.
- Press *ESC* in the main menu to leave menu mode and return to measuring mode.

5.4 Entering numbers

After you have selected an input field and pressed *Enter*:

- Use the numerical keys, *Decimal point*, *Minus sign*, and *EXP* to enter numbers.
- Use *CE* to correct errors.
- Press *Enter* to finish character entry and to confirm the entered number.

6 Configurating the instrument

6.1 Date / time

Set date and time so that you may check the validity of a calibration.

1. Press *M* and select *3 Edit Configuration* > *1 Clock*.
2. Use the arrow keys to change between date and time setting.
3. Select the date or time setting by pressing *Enter*.
4. Set the current date in the format *dd.mm.yyyy* (dd=day, mm=month, yyyy=year).
5. Set the current time in the format *hh:mm:ss* (hh=hours, mm=minutes, ss=seconds).
6. To change from day to month to year, or to change from hours to minutes to seconds, press *Enter*.
7. Press *ESC* and confirm with *1 YES* to store your settings.

6.2 Display backlight and contrast

Set the backlight to be automatically activated (*ON*) or deactivated (*OFF*) when the instrument is switched on.

During operation, you can use the *Lamp* key to activate or deactivate the backlight as needed.

```
UNITS & BACKLIGHT

  1 Units     :  °C
➡ 2 Backlight :  ON
  3 Contrast  :  27
```

Fig. 10: *Setting backlight and contrast of the display*

1. Press *M* and select *3 Edit Configuration* > *6 Units & Backlight*.
2. Set *2 Backlight* to *ON* or *OFF* by pressing *Enter*.
3. To set the display contrast, select *3 Contrast*.

   Pressing *Enter* once, increments the contrast level by 1 step until you have reached maximum contrast (41), then it will switch the contrast level back to minimum contrast (20).
4. Press *ESC* and confirm with *1 YES* to store your settings.

6.3 Temperature units for display

1. Press *M* and select *3 Edit Configuration* > *6 Units & Backlight*.
2. Set *1 Units* to one of three temperature units by pressing *Enter*:
   – Celsius (°C)
   – Kelvin (K)
   – Fahrenheit (°F)

6.4 Sensor parameters and channels

The instrument measures the electrical resistance of the connected platinum sensors and calculates from it the temperature via internal formulas (in the most simple case, a quadratic equation).

The coefficients for these formulas are different for each sensor, they are called sensor parameters (or calibration parameters). Find these parameters in your calibration certificate.

The instrument can hold calibration parameters for up to 30 sensors.

IMPORTANT: *When you perform a precise temperature measurement, use calibrated sensors only.*

6.4.1 Entering or changing calibration parameters for a sensor

For each sensor that you connect to the instrument, you have to enter the calibration parameters according to the calibration certificate in order to be able to measure temperatures.

```
SENSORS

➡ 1 New/Edit Calibr.
  2 Delete Calibr.
  3 Select Sensor #1
  4 Select Sensor #2
```

Fig. 11: *Entering, deleting, and assigning calibration parameters*

IMPORTANT: *Make sure that you are using the correct calibration parameters for your sensors since incorrect calibration parameters lead to erroneous results.*

1. Before you enter the calibration parameters, make sure that the date stored in the instrument is correct (refer to Section 6.1 [▶ 10]).
   The date will be stored with the calibration parameters.
2. Press *M* and select *3 Edit Configuration* > *3 Sensors*.
   When prompted for your user password, enter it.
3. Select *1 New/Edit Calibr*.
   A list of stored sensor parameters for up to 30 sensors is shown. Initially all 30 sensor positions show "-------- *Free*".
   In the example in Fig. 12 [▶ 11] sensor parameters for several sensors have already been stored. The sensor numbered *00000001* has been assigned to channel 1, and the sensor numbered *00125607* to channel 2. Sensor position 3 is free.

```
SELECT SENSOR   No:03 ▼

  00000001 IEC751   #1
  00125607 IEC751   #2
➡ -------- Free
  00001298 ITS-90
  00991111 ITS-90
  00778808 ITS-90
```

Fig. 12: *Example list of stored sensor parameters*

4. Select the first free sensor position (showing "-------- *Free*"), then press *Enter*.
   If all sensor positions are occupied, you will have to overwrite an existing sensor position.
5. Select the appropriate temperature calculation method and/or the temperature range (refer to Appendix D [▶ 26]).

If the norm is not specified on the calibration certificate, you can use the calibration parameters on the calibration certificate for differentiation. With EN 60751 the parameter R0 will always be used, whereas with ITS-90 the parameter R.01 [0.01 °C] will be specified.

- For industry sensors, e.g. the MPMI sensors in Anton Paar's MKT 50 sensor catalog, select *DIN IEC 751*.
- For standard thermometers, select one of the 11 ranges of *ITS-90* or one of the two *auto-switch ranges* (refer to Appendix D [▶ 26]).
- For measurements between –40 °C and 600 °C (with medium to high requirements on uncertainty), standard polynomials are well suited (according to DAkkS guideline DAkkS-DKD-R 5-6[1], chapter 3). MKT 50 provides a polynomial of 4^{th} order that can be used to approximate temperature sensors.

Polynomial of 4^{th} order:
$Rt = R0 \cdot (1 + A \cdot t + B \cdot t^2 + C \cdot t^3 + D \cdot t^4)$

6. Enter the calibration number *Cal.No.* written on the sensor and in the calibration certificate.
If you have purchased the sensor with a calibration certificate, e.g. a DAkkS certificate (DAkkS: Deutsche Akkreditierungsstelle / German accreditation body) together with the MKT 50, you will find a calibration label on the LEMO socket of the sensor.

1234	current calibration number
D-K-15219-01-00	registration number of the accredited body / calibration office
2017-07	date of calibration (YYYY-MM)

All specifications on the calibration label are also included in the corresponding calibration certificate.
Each calibration service provides differently designed calibration labels, but all of them should at least include a calibration number and a date.

7. Enter a calibration time *Cal.Time* according to your experience and accuracy requirements.
The calibration time *Cal.Time* counts the days until a re-calibration is due.
A negative value for *Cal.Time* indicates for how many days a re-calibration has been overdue.
When you use a sensor with expired calibration, the message *SENSOR CAL TIME* will be shown on the main screen next to the channel in question, and no temperature will be displayed anymore.
   - In this case check the sensor either at a fixed point or by comparison calibration with a reference thermometer.

IMPORTANT: *The calibration time depends mainly on the thermal stress on the platinum thermometer. It can only be estimated, and ultimately you will have to decide on it. Therefore, check your sensors and the instrument at the triple point or freezing point of water on a regular basis (independent of the calibration time) and also after major thermal stress. We recommend to perform a re-calibration at least once a year.*

8. If you have selected *DIN IEC 751*:
Set the calibration temperature range (e.g. –50 °C to 200 °C, 0 °C to 420 °C, etc.) with the fields *Cal.Low* and *Cal.High*.
9. Set the maximum sensor temperature in the field *Max.Temp.*.
If the sensor producer has not specified the maximum temperature, set it to a value approx. 5 °C above the upper limit of the calibration temperature range (*Cal.High*).
Do not choose a value below the upper limit of the calibration temperature range (*Cal.High*), or else the maximum temperature limit will not be monitored.

NOTICE
Exceeding the permissible operating temperature range can cause an irreversible change in sensor behavior and may require a new calibration.

10. Enter the calibration parameters (R0 / R.01 [0.01 °C], A, B, C, C1, ... C5) according to the calibration certificate by overwriting the default values.
Any ITS-90 parameter that does not have a corresponding coefficient on the calibration certificate must be set to 0.
The number of parameters depends on the temperature range and the selected temperature calculation method.
If you have selected *DIN IEC 751*, the constant C is only used for temperatures below 0 °C. You can either set *C* to 0 or use the default value.
11. After you are done with your input, press *ESC* and save the new values.

Example of a Pt 100 sensor

Calibration number: 00000001
Temperature calculation method: EN 60751
Validity of the calibration: 180 days
Calibration temperature range: 0–200 °C
Maximum sensor temperature: 250 °C
R0= 100.017
A= 0.0039126
B= –5.9153E–7

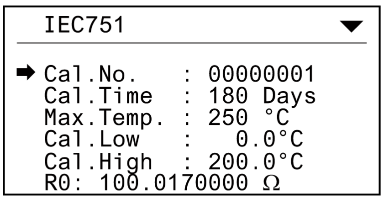


Fig. 13: *Display after the example sensor parameters have been entered*

[1] Bestimmung von Thermometerkennlinien [Determination of Thermometer Characteristics], Richtlinie DAkkS-DKD-R 5-6, 2010

After the maximum sensor temperature has been exceeded

1. Press *M* and select *3 Edit Configuration > 3 Sensors > 1 New/Edit Calibr*.

   The calibration of an *overheated* sensor is marked by *Max.Temp* in the field *Cal.Time*.

   No temperature will be displayed when this calibration is assigned to a sensor channel, instead the message *Max Temp. exceeded* will be shown.

   – In order to use this calibration again, enter a positive number for calibration time.

2. Before continuing your work, check the sensor at least at the triple point or freezing point of water.

   You may only continue to use the calibration parameters if the deviation from the reference is within the permissible range.

   In most cases a new sensor calibration will be necessary, which means that you are provided new calibration parameters.

6.4.2 Assigning sensor parameters to a sensor channel

1. Press *M* and select *3 Edit Configuration > 3 Sensors*.
2. Select
   – *3 Select Sensor #1* or
   – *4 Select Sensor #2*.

TIP: *If you select the item "NO SENSOR Calibr." (first line of the list, sensor position 00) instead of a valid sensor calibration, only resistance values can be displayed for the sensor channel; you will not get temperatures displayed.*

6.5 Display type

Table 3: Display types

Display mode	Display type	Description
Temperature Mode	**Temperature**	Displays the temperature (with 3 digits after the decimal point).
	Temperature Stat. (statistics display)	Displays the current temperature (with 4 digits after the decimal point) as well as mean temperature and standard deviation of the moving average over N previous values (each with 5 digits after the decimal point). Recommended for high-precision temperature measurements
	T1–T2	Displays the temperature difference between sensor channels 1 and 2.
Resistance Mode	**Resistance**	Displays the ohmic resistance (with 4 digits after the decimal point).
	Resistance Stat. (statistics display)	Displays the current resistance as well as mean resistance and standard deviation of the moving average over N previous values (each with 5 digits after the decimal point). Recommended for high-precision resistance measurements
	R1/RR, R2/RR	Displays the ratios of the sensor resistances to the internal reference resistance (in large digits).
	R1/R2, R2/R1	Displays the ratios of the two sensor resistances (in large digits).

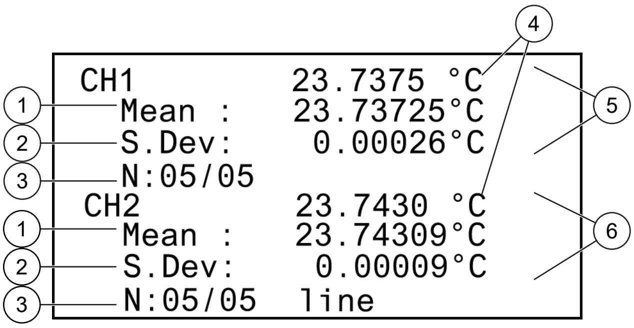


Fig. 14: *Example display of temperature statistics (resistance statistics analogical)*

1 *Mean of the moving average over N previous values*
2 *Standard deviation of the moving average over N previous values*
3 *Number of measurements performed/set for the calculation of the average*
4 *Current measuring value*
5 *Sensor input 1 (channel 1)*
6 *Sensor input 2 (channel 2)*

1. Press *M* and select the display mode (refer to Table 3 [▶ 13]):
   – *1 Temperature Mode* or
   – *2 Resistance Mode*
2. Select the display type (refer to Table 3 [▶ 13]).

   After the selection of a display type, the instrument automatically returns to measuring mode.
3. If you have selected a statistics display type:

   On the main screen press the *Up* and *Down* arrow keys at any time to set the number N of measurements used for the calculation of the average.

   N can be set between 5 and 50 in steps of 5.

   The currently set number N is shown below the statistical parameters, see example in Fig. 14 [▶ 14].

   After each change of N, it takes N×1.44 seconds until new statistical parameters are displayed.

Calculation of the statistical parameters

Mean:

$$Mean = Y_{mean} = \frac{1}{N} \times \sum_{i=1}^{N} Y_i$$

Empirical standard deviation:

$$S.Dev = \sqrt{\frac{1}{(N-1)} \times \sum_{i=1}^{N} (Y_i - Y_{mean})^2}$$

In both formulas, variable Y designates the measured quantity “temperature” or “resistance”.

TIP: *The standard deviation is a measure of the short-term stability of the measuring values and should be lower than the expected measurement uncertainty.*

6.6 Securing your settings

6.6.1 User password

The user password restricts the access to the menus *Edit Configuration* and *Lock/Unlock Device*. You will also have to specify the user password before you can change it.

TIP: *The instrument comes without a password set. We recommend setting a user password as soon as possible.*

TIP: *Use the lock password (refer to Section 6.6.2 [▶ 14]) to restrict the access to the instrument via the RS-232 interface.*

IMPORTANT: *If you have forgotten your user password, contact your Anton Paar representative.*

– To prevent unauthorized access to the menus, change into measuring mode before you leave the instrument, or switch the instrument off.

Setting a user password

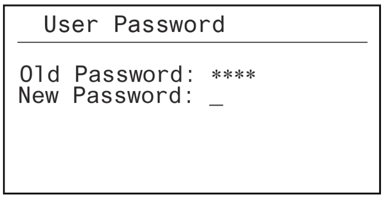


Fig. 15: *Setting or changing the user password*

1. Press *M* and select *4 Security Options > 1 Edit User Password*.
2. Enter the old user password (*Old Password*), then press *Enter* to confirm.

   When you are setting a user password for the first time, enter the factory default *0000*.
3. Enter a new user password (*New Password*), then press *Enter* to confirm.
4. To save the new user password, answer the question *Save changes?* with *1 YES*.

6.6.2 Lock password

With the lock password, a second password besides the user password, you can lock parts of the menu so that the settings relevant for temperature measurement can no longer be manipulated. In this way, for example, standards bureau officers can lock the instrument for temperature measurements requiring official calibration.

After a lock password has been set, the menu items 1 to 3 in the submenu *3 Edit Configuration* are locked. Date and time, reference resistor parameters, and sensor parameters can no longer be altered, although they can still be viewed.

The lock password also prevents manipulation of these parameters via the RS-232 interface, notably you cannot assign new calibration parameters to a sensor channel.

IMPORTANT: *If you have forgotten the lock password, contact your Anton Paar representative. They are able to unlock the instrument. Afterwards you need to define a new lock password.*

Setting a lock password

1. Press *M* and select *4 Security Options* > *2 Lock Device*.
2. Enter a lock password.

   The instrument is locked now. Menu item 2 in submenu *4 Security Options* changes to *2 Unlock Device*.

To unlock the instrument

1. Press *M* and select *4 Security Options* > *2 Lock Device*.
2. Enter the lock password.

   The instrument is unlocked now. Menu item 2 in submenu *4 Security Options* changes back to *2 Lock Device*.

7 Data transfer

7.1 Collecting data via Ethernet

The instrument features an integrated web (HTTP) server, which can deliver measurement results and relevant data as HTML pages and as an XML data set.

7.1.1 Cable connection

– Connect the instrument to a LAN (local area network) with a standard Ethernet cable.

– Or connect the instrument directly to the Ethernet connector of a PC with the supplied Ethernet crossover cable, mat. no. 18597.

On the instrument connect the Ethernet cable to the Ethernet terminal (2, Fig. 3 [▸ 6]).

7.1.2 Ethernet interface settings

In order to be able to access the web server of the instrument, you need to configure the Ethernet interface properly.

1. Press *M* and select *3 Edit Configuration* > *5 Ethernet*.

```
  ETHERNET
 ───────────────────────────
➡ WEBSERVER : ON
  IP: 172.020.002.055
  NM: 255.255.000.000
  GW: 172.020.002.001

  MAC: 000DD9010761
```

Fig. 16: *Example Ethernet interface settings*

2. Set *WEBSERVER* to *ON* to enable network access.
3. Set the required IP address (*IP*), netmask (*NM*), and gateway address (*GW*) to values that fit your network.

   In case of doubt ask your network administrator.

TIP: *The MAC (media access control) address shown is unique to your instrument and cannot be changed.*

TIP: *Only if you connect the instrument directly to a PC (no LAN in between), you may use any reasonable values for the network settings. You might just as well use the values in the example above (Fig. 16 [▸ 15]).*

In this case assign the PC an IP address in the same subnet as that of the instrument. (For example, you may set on the PC IP: 172.20.2.56 / NM: 255.255.0.0 / GW: 172.20.2.1 when you use the network settings as shown in Fig. 16 [▸ 15] for the instrument.)

IMPORTANT: *Ensure that there are no firewall settings blocking the instrument access on the PC.*

7.1.3 Reading data

After you have connected the cable and configured the network, you can access the instrument with any HTTP client (e.g. a web browser) in the same network.

IMPORTANT: *The web server of MKT 50 delivers data only in measuring mode, not in menu mode.*

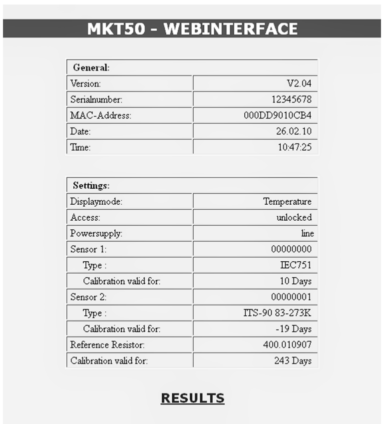
IMPORTANT: *Mind that statistical parameters (mean and standard deviation) are only delivered if the corresponding display type ("Stat.") has been selected on the instrument.*

Network addresses for data access

– [IP address of MKT 50]
  (e.g. 172.20.2.55)

  Delivers an **HTML** page (main page) with general information.

  You can access the current measurement results via the link *RESULTS* or directly via the network address.



MKT50 - WEBINTERFACE

General:	
Version:	V2.04
Serialnumber:	12345678
MAC-Address:	000DD9010CB4
Date:	26.02.10
Time:	10:47:25

Settings:	
Displaymode:	Temperature
Access:	unlocked
Powersupply:	line
Sensor 1:	00000000
Type :	IEC751
Calibration valid for:	10 Days
Sensor 2:	00000001
Type :	ITS-90 83-273K
Calibration valid for:	-19 Days
Reference Resistor:	400.010907
Calibration valid for:	243 Days

RESULTS

Fig. 17: *Example main page with general information*

– [IP address of MKT 50]/cgi/results
  (e.g. 172.20.2.55/cgi/results)

  Delivers an **HTML** page with the current measurement results.

You can access the general information via the link *GENERAL* or directly via the network address.

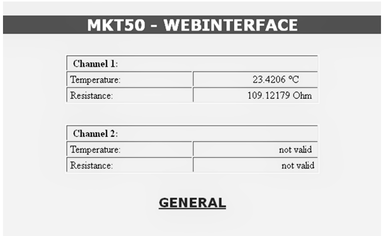


Fig. 18: *Example HTML page with the current measurement results*

– [IP address of MKT 50]/cgi/xml (e.g. 172.20.2.55/cgi/xml)

  Delivers an XML data set with the current measurement results like the example inFig. 19 [▸ 16].

```
<devicedata dataversion="1.1">
  <device name="MKT-50" version="V2.04" serialnumber="12345678" MAC="000DD9010CB4"/>
  <device date="26.02.10" time="10:48:43"/>
  <settings>
    <setting name="Displaymode">Temperature</setting>
    <setting name="Access">unlocked</setting>
    <setting name="Powersupply">line</setting>
    <setting name="Sensor1" type="IEC751" caltime="10 Days">00000000</setting>
    <setting name="Sensor2" type="ITS-90 83-273K" caltime="-19 Days">00000001</setting>
    <setting name="Reference Resistor" caltime="243 Days">400.010907</setting>
  </settings>
  <results>
    <channel number="1">
      <result name="Temperature" status="valid" unit="degC">+23.4403</result>
      <result name="Resistance" status="valid" unit="ohm">109.12946</result>
    </channel>
    <channel number="2">
      <result name="Temperature" status="invalid"></result>
      <result name="Resistance" status="invalid" unit="ohm"></result>
    </channel>
  </results>
</devicedata>
```

Fig. 19: *Example XML data set*

7.2 Controlling the instrument via RS-232 interface

The instrument is able to answer service requests by client software like a LIMS (Laboratory Information Management System) or a simple terminal program. The client software may retrieve information from or execute operations on the instrument. Communication is handled via RS-232 serial interface.

7.2.1 Cable connection

You need a straight, 3-wire, shielded RS-232 serial cable for the hardware connection:

Table 4: Pinout and wiring of the serial cable

PC: serial port (9-pin) RS-232		MKT 50: RS-232
1 Shield		
2 (RxD)	↔	2 (TxD)
3 (TxD)	↔	3 (RxD)
5 (GND)	↔	5 (GND)

– Use the optional interface cable D-sub male 9 / female 9, mat. no. 11062.

– If your PC does not feature an RS-232 connector, you can connect to a USB socket using the optional adapter cable USB–RS232, mat. no. 15446.

With only a crossed RS-232 serial cable at hand, you need an adapter that crosses RxD and TxD. We recommend using the appropriate cable wired as specified in Table 4 [▸ 16].

On the instrument connect the RS-232 serial cable to the RS-232 serial port (3, Fig. 3 [▸ 6]).

7.2.2 RS-232 serial interface settings

In order to be able to access the instrument over a serial connection, you need to configure the RS-232 interface properly.

```
RS232
➡ 1 RS232     : ON
  2 BaudRate  : 9600
  3 DataBits  : 8
  4 Parity    : NONE
  5 Stopbits  : 1
```

Fig. 20: *Recommended RS-232 serial interface settings*

1. Press *M* and select *3 Edit Configuration > 4 RS232*.
2. Set *RS232* to *ON* to enable serial access.
3. We recommend to set the RS-232 interface settings as shown in Fig. 20 [▸ 16].

MKT 50 needs no handshaking (neither hardware nor software).

IMPORTANT: *The interface settings on MKT 50 must match those in the client program / on the PC.*

7.2.3 Communication protocol

After you have connected the cable and configured the interfaces on both sides, you can access the instrument with a client program over the serial connection.

- Send commands as listed in the command reference, Section 7.2.4 [▶ 17], and the instrument will respond as described there.
- If you send an incorrect command, the instrument responds with a list of available commands.
- Command error responses are explained in Section 7.2.5 [▶ 20].
- Server and client communicate text based.
- Parts of a command are separated by a space character (ASCII 32).
- Commands are terminated by [CR] (ASCII 13).
- Responses of the instrument consist of lines terminated by [CR] (ASCII 13) and [LF] (ASCII 10).

MKT 50 delivers data only in measuring mode, not in menu mode.

7.2.4 Command reference

Command	Example response by instrument	Remarks
DEL SENSOR xx	SENSOR xx deleted	Deletes the calibration at position xx.
GET CAL1	CAL TIME (DAYS): 364	Reads calibration time of sensor at channel 1 or 2 (refer also to Section 6.4.1 [▶ 11]).
GET CAL2	CAL TIME (DAYS): 270	
GET CONFIG	Configuration: Software V1.000 18.12.07 17:43:03 RREF Calibration: INT. RREF = 380.009068 CAL TIME (DAYS): 364 Sensor 1 = N:007833 IEC751 CAL TIME (DAYS): 100 MAX TEMP[*C]: 800 CAL LOW[*C]: -50 CAL HIGH[*C]: 200 R0: 100.0000000 A: 0.00390830 B: -5.77500E-07 C: -4.183000E-12 Sensor 2 = N:007845 IEC751 CAL TIME (DAYS): 100 MAX TEMP[*C]: 800 CAL LOW[*C]: -50 CAL HIGH[*C]: 200 R0: 100.0000000 A: 0.00390830 B: -5.77500E-07 C: -4.183000E-12 Sensor 3 = N:000001 IEC751 CAL TIME (DAYS): 29 MAX TEMP[*C]: 250 CAL LOW[*C]: 0 CAL HIGH[*C]: 200 R0: 100.0000000 A: 0.00390802 B: -5.802000E-07 C: -4.273500E-12 Sensor 5 = N:000419 ITS-90 0-419*C CAL TIME (DAYS): 30 MAX TEMP[*C]: 990	Reads the whole instrument configuration.

Command	Example response by instrument	Remarks
	CAL LOW[*C]: 0 CAL HIGH[*C]: 420 R.01: 100.0000000 A: 0.00030000 B: -9.000000E-04	
GET DATA	18.12.07 17:38:30 R1= +125.02085 Ohm R2= +109.00070 Ohm T1= +64.6448 C T2= +23.1107 C SENSOR1= No:000002 SENSOR2= No:000001	Reads the measurement data for both sensor channels. For specific command error responses refer to Table 6 [▸ 20].
GET RREF	RREF Calibration: INT. RREF = 380.009068 CAL TIME (DAYS): 364	Reads calibration data of the instrument (refer also to Appendix E.1 [▸ 28]).
GET RSTAT	R1= 108.98370 Ohm Mean= 108.98418 Ohm S.Dev= 0.00026 Ohm R2= 125.02094 Ohm Mean= 125.02093 Ohm S.Dev= 0.00003 Ohm	Reads the resistance statistics data for both sensor channels. Resistance statistics will only be transferred if the corresponding display type has been selected (SET MODE 3), refer also to Section 6.5 [▸ 13]. For specific command error responses refer to Table 7 [▸ 20].
GET SENSOR	Sensor Calibrations: Sensor 1 = N:000002 IEC751 CAL TIME (DAYS): 29 MAX TEMP[*C]: 990 CAL LOW[*C]: -300 CAL HIGH[*C]: 990 R0: 100.0000000 A: 0.00390802 B: -5.802000E-07 C: -4.273500E-12 Sensor 2 = N:000001 IEC751 CAL TIME (DAYS): 29 MAX TEMP[*C]: 250 CAL LOW[*C]: 0 CAL HIGH[*C]: 200 R0: 100.0000000 A: 0.00390802 B: -5.802000E-07 C: -4.273500E-12	Reads the sensor parameters for both sensor channels.
GET SHT	SHT: OFF	Reads the state of the self-heating test, refer also to Appendix F [▸ 29].
GET STATUS	MKT50 Status MAC: 000DD9010764 S/N: 12345678 Access: unlocked Mains supply	Reads instrument data and the general state of the instrument.
GET TSTAT	SENSOR1= No:000002 T1= +23.0535 C Mean= 23.05659 C S.Dev= 0.00183 C SENSOR2= No:000001	Reads the temperature statistics data for both sensor channels. Temperature statistics will only be transferred if the corresponding display type has been selected (SET MODE 4), refer also to Section 6.5 [▸ 13].

Command	Example response by instrument	Remarks
	T2= +64.6449 C Mean= 64.64503 C S.Dev= 0.00013 C	For specific command error responses refer to Table 7 [▸ 20].
INIT IEC xxxxxxxx	Volatile IEC SENSOR No:xxxxxxxx initialized	Creates a “volatile sensor” according to EN 60751 with sensor no. xxxxxxxx. The “volatile sensor” serves as a placeholder, which receives sensor calibration parameters and holds them until they are stored at a proper storage position (see STORE IEC). For specific command error responses refer to Table 8 [▸ 21].
SET IECA yyy.yyy	A: yyy.yyy	Defines the respective calibration parameter A, B, C, or R0 of the “volatile sensor” (see INIT IEC). For specific command error responses refer to Table 8 [▸ 21].
SET IECB yyy.yyy	B: yyy.yyy	
SET IECC yyy.yyy	C: yyy.yyy	
SET IECR0 yyy.yyy	R0: yyy.yyy	
SET MODE 1	MODE: 1 Resistance	Sets the respective display type, refer also to Section 6.5 [▸ 13].
SET MODE 2	MODE: 2 Temperature	
SET MODE 3	MODE: 3 Resistance Statistics	
SET MODE 4	MODE: 4 Temperature Statistics	
SET MODE 5	MODE: 5 R1/RR, R2/RR	
SET MODE 6	MODE: 6 Temperature Difference	
SET MODE 7	MODE: 7 R1/R2, R2/R1	
SET SEN1 xx	SET SENSOR #1: xx	Assigns the calibration parameters at position xx to sensor channel 1 or 2. The instrument will only accept this command if no lock password has been set. For specific command error responses refer to Table 8 [▸ 21].
SET SEN2 xx	SET SENSOR #2: xx	
SHOW IEC	Volatile Sensor = No:xxxxxxxx IEC751 CAL TIME (DAYS): 30 MAX TEMP[*C]: 800 CAL LOW[*C]: -70.0 CAL HIGH[*C]: 220 R0: yyy.yyy A: yyy.yyy B: yyy.yyy C: yyy.yyy	Reads the sensor parameters for the “volatile sensor” (see INIT IEC).
SHT OFF	SET SHT OFF	Switches the self-heating test off or on (refer also to Appendix F [▸ 29]).
SHT ON	SET SHT ON	
STORE IEC xx	SENSOR xx = No:xxxxxxxx stored	Stores the calibration parameters of the “volatile sensor” (see INIT IEC) at storage position xx. This voids the current “volatile sensor”. For specific command error responses refer to Table 8 [▸ 21].

7.2.5 Command error responses

Table 5: Without specific context

Command error response	Cause	Solution

`??? UNKNOWN COMMAND`
`COMMANDS:`
`GET DATA`
`GET RREF`
`GET SENSOR`
`GET CONFIG`
`GET RSTAT`
`GET TSTAT`
`GET STATUS`
`SET SEN1`
`SET SEN2`
`GET CAL1`
`GET CAL2`
`GET SHT`
`SHT ON`
`SHT OFF`
`SET MODE`
	The previous command has not been recognized.	Make sure that you use the correct syntax.

Table 6: After “GET DATA” has been sent

Command error response	Cause	Solution
`R1= not valid` `R2= not valid`	– No sensor is connected to the corresponding sensor channel. – The calibration time of the internal reference resistor has expired.	– Connect a sensor. – Calibrate the reference resistor (or have it calibrated).
`T1= not valid` `T2= not valid`	– No sensor is connected to the corresponding sensor channel. – The calibration time of the corresponding sensor has expired or its maximum temperature has been exceeded. – The calibration time of the internal reference resistor has expired.	– Connect a sensor. – Re-calibrate the sensor and enter the new calibration parameters. – Calibrate the reference resistor (or have it calibrated).

Table 7: After “GET RSTAT” or “GET TSTAT” have been sent

Command error response	Cause	Solution
`??? too few samples`	Mean and standard deviation have been requested directly after starting up the instrument or after changing the number “N” (i.e., before N measuring values have been collected).	Wait N x 1.44 seconds before reading out the result.
`??? wrong display mode selected`	The instrument is not in the correct statistics display mode.	Set the correct display mode.

Table 8: When you edit or assign sensor calibration parameters

Command error response	Cause	Solution
`??? access denied – instrument locked`	You have tried to assign or delete a sensor calibration although a lock password is set.	Unlock the instrument.
`??? invalid memory number`	You have specified storage position xx outside of the val-id range 01–30.	Use the correct syntax – *SET SEN1 xx* or – *SET SEN2 xx* or – *DEL SENSOR xx* with xx in the range 01–30.
`??? invalid sensor name`	*INIT IEC xxxxxxxx* with an invalid sensor name.	A valid sensor name is any number with 8 digits.
`??? memory already free`	You have tried to free up a storage position that has already been free.	No need for further action.
`??? memory not free`	You have tried to store a calibration set at an already occupied memory position.	Use a free memory position to store the calibration set. Maybe you have to delete a calibration to free up a memory position.
`??? no calibration data`	Data for the selected sensor calibration are missing.	Choose a different sensor calibration or complete the calibration data of the chosen sensor calibration.
`??? no sensor data to store`	No “volatile sensor” has been created before you have tried to store the calibration set.	Create a “volatile sensor” by *INIT IEC* before you define and store the calibration set (refer to Section 7.2.7 [▶ 21]).
`??? parameter to short`	You have used too few char-acters to specify a calibration parameter with *SET IECR0*, *SET IECA*, *SET IECB*, or *SET IECC*.	Use at least two characters for R0 or three characters for A, B, or C.
`??? too few parameters for SET SEN`	The value xx for storage position is missing.	Use the correct syntax

7.2.6 Example: Assigning calibration parameters to a sensor channel via RS-232 serial interface

If you use an external multiplexer or several calibrations for a sensor, you can assign a stored calibration to a sensor channel by a command, provided no lock password has been set on the instrument. The remote assignment will be lost when the instrument is switched off.

To assign a calibration xx to a sensor channel, send the command *SET SEN1 xx* or *SET SEN2 xx* (xx = 01, ..., 30).

Refer to example 1 in Table 9 [▶ 22].

7.2.7 Example: Specifying calibration parameters according to EN 60751 via RS-232 serial interface

You can specify calibration parameters according to EN 60751 and store them as a calibration set by commands, provided one of the 30 storage positions of the instrument is free.

1. Create a “volatile sensor” in the memory of the instrument and define the sensor number.
2. Define the calibration parameters.
3. Store the sensor parameters as a calibration set.

   Storing the calibration voids the “volatile sensor”.

   If all storage positions are occupied, you have to free a storage position by deleting a stored calibration. Use the command *DEL SENSOR xx* for this operation.

Proceed as shown in example 2 in Table 9 [▶ 22]: an existing calibration at storage position 6 is replaced by the new calibration set.

Table 9: Examples for instrument control via RS 232 serial interface

Commands sent	Response by instrument	Remarks
Example 1: Assigning calibration parameters to a sensor channel		
`SET SEN1 01`	`SET SENSOR #1: 1`	calibration 01 is assigned to sensor channel 1
`SET SEN2 03`	`SET SENSOR #2: 3`	calibration 03 is assigned to sensor channel 2
Example 2: Specifying calibration parameters according to EN 60751		
`DEL SENSOR 06`		delete stored calibration at position 6
	`SENSOR 6 deleted`	if storage position 6 is occupied
	`??? memory already free`	if storage position 6 is already free
`INIT IEC 12345678`	`Volatile IEC SENSOR No:12345678 initialized`	create a “volatile sensor” with sensor no. 12345678
`SET IECR0 100.01111`	`R0: 100.0111100`	define the calibration parameters for the “volatile sensor”
`SET IECA 3.9083e-3`	`A: 0.00390830`	
`SET IECB -5.775e-7`	`B: -5.775000E-07`	
`SET IECC -4.183e-12`	`C: -4.183000E-12`	

`SHOW IEC`	`Volatile Sensor = No:12345678`
	`IEC751`
	`CAL TIME (DAYS): 30`
	`MAX TEMP[*C]: 800`
	`CAL LOW[*C]: -70.0`
	`CAL HIGH[*C]: 220`
	`R0: 100.0111100`
	`A: 0.00390830`
	`B: -5.775000E-07`
	`C: -4.183000E-12`
		verify the sensor data of the “volatile sensor”

`STORE IEC 06`	`SENSOR 6 = No:12345678 stored`	store the “volatile sensor” at position 6

8 Upkeep and cleaning

Handling instrument and sensors

> **NOTICE**
> Connect only separated extra low voltage circuits (SELV according to EN 60950) to the instrument.

– Avoid exposing the instrument to direct sunlight and large temperature changes.
– After a large change of the ambient temperature the instrument requires some time to adjust to the ambient conditions.
– The instrument is designed for operation under typical laboratory conditions. Air humidity must not be condensing.
– Treat the sensor according to specifications of the manufacturer and the instructions coming with the sensor.
– Treat the sensor and its cable with utmost care.

> **NOTICE**
> Damage to temperature sensors and cables may affect the accuracy of the temperature measurement. Mechanical stress or humidity alter the properties of the sensor.
> – Protect the sensor against thermal and mechanical shocks or stress as well as quick temperature changes. Otherwise, the calibration may shift, or the sensor may be destroyed.
> – Do not bend the sensor as this will break it.
> – Do not bend, pinch, or stretch the cable. Do not pull at the cable.

– Use only shielded cables for connecting the sensors.
– Keep an appropriate term for repeating the calibration of the reference resistor and sensors used. Re-calibrate the MKT 50 and sensors at least once a year.
– In the following cases perform an instrument self-test (turn off the instrument for at least 3–4 seconds) and check the set parameters (RR, sensor calibration, user password):

– before large measuring cycles,
– after extraordinary operating conditions,
– after service work on the instrument.

Calibration and adjustment on a regular basis

The instrument uses an internal reference resistor for measuring the electrical resistance of the sensor. For the calculation of an accurate temperature from the measured electrical resistance, it is necessary to regularly calibrate/adjust the instrument and the sensors used.

– Send the instrument to Anton Paar or to an official calibration service once a year for calibration/adjustment. For further information contact your local Anton Paar representative.
– In case you have the capacities to perform a calibration yourself, find details in Appendix E [▸ 28].

Cleaning housing and display

1. Clean the instrument housing and the display with a soft tissue and (warm) water.
2. Dry with a soft and dry tissue.

9 Maintenance and repair

9.1 Maintenance performed by an authorized Anton Paar representative

The product does not require a periodic maintenance by an authorized Anton Paar representative to retain warranty coverage.

To fulfill requirements of regulatory authorities e.g. FDA 21 CFR 211.67, PIC/S 023-2 (5.5), Anton Paar offers services for compliant preventive maintenance and requalification for qualified Anton Paar products in case of software update, repair, and location change.[2]

Following parts are generally excluded from the warranty (wear and tear parts)

– Cables
– Fuses
– Batteries

All parts damaged in consequence of a fall of the instrument are generally excluded from the warranty as well.

9.2 Repair performed by an authorized Anton Paar representative

In case your product needs repair, contact your local Anton Paar representative, who will take care of the necessary steps. If your product needs to be returned, request an RMA (Return Material Authorization Number). It must not be sent without the RMA and the filled "Safety Declaration for Instrument Repairs". Please make sure it is cleaned before return.
Do not return products that are contaminated by radioactive materials, infectious agents or other substances that cause health hazards.

TIP: *Find the contact data of your local Anton Paar representative on the Anton Paar website (https://www.anton-paar.com) under "Contact".*

Appendix A Technical data

The following specifications apply to an ambient temperature of +23 °C.

Find all terms explained in "Grundlagen der Messtechnik" ("Fundamentals of metrology"), DIN 1319.

[2] For detailed information, please refer to general terms of delivery (GTD) on the Anton Paar website (https://www.anton-paar.com).

Appendix A.1 Specifications: MKT 50 as a high-precision resistance meter

Internal reference resistance	approx. 400 Ω
Measuring range	approx. 0 Ω to 440 Ω
Resolution	40 µΩ (0.1 ppm full scale)
Linearity error	< 0.4 mΩ (< 1 ppm full scale)
Measuring uncertainty[a] (confidence level: 95 %, number of measuring values: 50)	< 0.4 mΩ

[a] *This value does not include the calibration uncertainty of the reference resistor used.*

Appendix A.2 Specifications: MKT 50 as a high-precision thermometer (specifications without sensor)

Measuring range (depending on sensor)	–200 °C to 850 °C (as specified in EN 60751)
Resolution	0.1 mK (Pt 100)
Linearity error	< 1 mK (Pt 100) (< 1 ppm full scale)
Measuring uncertainty[a] (confidence level: 95 %, number of measuring values: 50)	< 1 mK (Pt 100)
Sensor	Platinum sensor up to a resistance of 440 Ω

[a] *This value does not include the calibration uncertainty of the reference resistor used.*

Appendix A.3 Instrument data and operating conditions

Internal reference resistor		
Producer, type	VISHAY, VHP 101 (400 Ω)	
Temperature coefficient	< 0.3 ppm/°C (+15 °C to +25 °C)	
Stability without strain (producer information)	±2 ppm max. dR after at least 10 years	
Measuring current I_{DC}	0.5 mA	
Measuring current I_{eff}	Normal operation:	0.41 mA
	During self-heating test:	0.29 mA (0.41/√2 = 0.29)
Self-heating test on	Measuring current/√2	
Measuring time (complete, for both channels)	1.44 seconds	
Warm-up time	60 minutes	
Sensor connections	2 LEMO sockets, type 1S.304, 4-pin	
Sensor input (channels)	2	
Data output	– LAN/Ethernet (RJ45 connector) – RS-232 (DE-9F 9-pin D-sub socket) – optionally via USB (with a USB–RS-232 converter)	
Display	Liquid crystal display, graphic, with LED backlight, 128×64 dots (approx. 65 mm × 35 mm)	
Keyboard	20 keys	
Dimensions (L × W ×H) (without handle)	240 mm × 190 mm × 110 mm (9.4 in × 7.5 in × 4.3 in)	

Weight	approx. 2 kg (4.4 lbs)		
Power supply	2 × AA batteries / rechargeable batteries 1.2–1.5 V *or*		
	Power adapter:	input	100–240 VAC 50/60 Hz 1.0–0.5 A voltage fluctuation ±10 %
		output	7.5 VDC 5.34 A 40 W max.
Environmental conditions (EN 61010)	indoor use only no direct exposure to sunlight		
Ambient operating temperature	0 °C to 35 °C (32 °F to 95 °F)		
Air humidity	< 90 % relative humidity, non-condensing		
Altitude	max. 3000 m (9800 ft)		
Pollution degree	2		
Overvoltage category	II		

Appendix B Data connectors on the instrument

Appendix B.1 Sensor connectors on the front

MKT 50 features two 4-pin sockets of type LEMO 1S.304 enabling you to connect up to two sensors (*CH1* and *CH2* in Fig. 2 [▶ 6]).

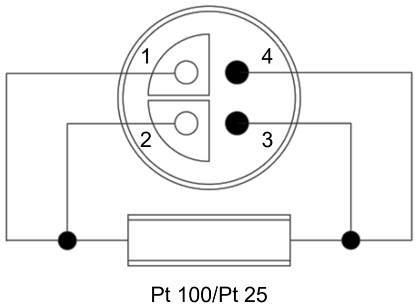


Fig. 21: *Pin assignment of the LEMO 1S.304 socket*

Appendix B.2 Ethernet terminal on the rear

The Ethernet terminal complies with the standard IEEE 802.3 (10 Mbit/s).

Appendix B.3 RS-232 serial port on the rear

Table 10: RS 232 signals and pin assignment

Pin	Signal
1	not assigned
2	TxD (transmit data)
3	RxD (receive data)
4	not assigned
5	GND (ground)
6	not assigned
7	not assigned
8	not assigned
9	not assigned

The instrument does also work with a standard USB–RS-232 converter (optionally available from Anton Paar, mat. no. 15446).

Appendix C Sensors

TIP: *For suitable MPMI and SPRT sensors, sensor cables, and calibrations available directly from Anton Paar, refer to the catalog “Sensors for MKT 50”. The catalog can be downloaded from the Anton Paar web site (http://www.anton-paar.com): Under Services & Support > Document Finder select the Product group “Thermometers”, then select the catalog from the list of free downloads.*

You can connect to MKT 50 any platinum resistance thermometer that meets the requirements of EN 60751 and has a nominal value of 100 Ω (R0).

EN 60751 specifies tolerances for the temperature range from –200 °C to +850 °C. These tolerances range from several tenths to several °C dependent on the temperature value. MKT 50 allows to determine the resistance of a sensor with a measurement uncertainty of 1 ppm. To make full use of the instrument’s accuracy, you should definitely use a sensor that is delivered with a calibration certificate. This enables you to measure temperatures across a wide range with very low measurement uncertainty. System measurement uncertainties below 10 mK are possible. The contribution of MKT 50 to this measurement uncertainty is usually negligible.

It is also possible to use ITS-90 for Pt 100 thermometers. However, the spectral purity of the platinum and sufficient stability are essential requirements for this.

Find more information in the specifications of the sensor manufacturer and/or the sensor manual.

TIP: *The instrument and sensor have been carefully calibrated and adjusted before shipment. Since thermal stress on the sensor and/or the minor drift of the instrument's reference resistor cause changes to your measuring system, be absolutely sure to check the temperature measuring system before each major measurement. In most cases a test using freezing point calibrators or water triple point cells is sufficient.*

Appendix D Temperature calculation methods

The instrument employs two methods for calculating the temperature from the primarily measured property "ohmic resistance": the EN 60751, which describes the relation between resistance and temperature for industrial sensors, and the ITS-90 (International Temperature Scale 1990), the temperature scale valid for standard thermometers since 1990.

Appendix D.1 EN 60751: Industrial platinum resistance thermometers and platinum measuring resistors

EN 60751 defines requirements for industrial platinum resistance thermometers whose electrical resistance is a defined function of the temperature. It applies to platinum thermometers in the temperature range from –200 °C to +850 °C.

Basic values

EN 60751 defines the relation between resistance and temperature by the equations below.

Temperature range –200 … 0 °C (equ. 1):

$$R_t = R_0 \cdot [1 + A \cdot t + B \cdot t^2 + C \cdot (t - 100) \cdot t^3]$$

Temperature range 0 … 850 °C (equ. 2):

$$R_t = R_0 \cdot (1 + A \cdot t + B \cdot t^2)$$

t temperature in °C
R_t resistance at temperature t
R_0 resistance at 0 °C

Constants

$A = 3.9083 \times 10^{-3}$ °C^{-1}
$B = -5.775 \times 10^{-7}$ °C^{-2}
$C = -4.183 \times 10^{-12}$ °C^{-4}

The basic values for platinum resistance thermometers are calculated from equ. 1 or equ. 2.

Nominal values

The nominal value for platinum resistance thermometers is usually 100 Ω (at 0 °C).

Limiting deviations

Two classes of resistance thermometers are discerned based on their limiting deviations:

Class	Limiting deviations [°C]
A	0.15 + 0.002·|t|
B	0.3 + 0.005·|t|

\|*t*\| *absolute numerical value of the temperature* [°C]

Thermometers with a nominal value of 100 Ω have to be classified based on the limiting deviations.

Class A cannot be used for Pt 100 above 650 °C and for thermometers with 2-wire connection of the sensor.

Calibration of industrial platinum resistance thermometers

The equations and constants defined in EN 60751 are used to classify sensors with regard to their highest permissible deviations. This allows according sensors to be replaced without any on-site calibration.

Uncalibrated sensors are not suitable for high-precision temperature measurements because already at 0 °C their allowed deviation amounts to several tenths of degrees Celsius.

Therefore, new solutions were called for. Based on many years of experience, it has been found out that industrial sensors with a considerably higher accuracy (10 mK) over a wide temperature range can be produced and calibrated.

To achieve this accuracy, the sensors have to be compared to reference thermometers at three or four certain temperatures. The equation used in EN 60751 for determining the basic values is then used to fit a curve to these measuring points. This gives individual parameters R_0, A, B, and C for each sensor.

Example:

Let us assume that you need a platinum resistance thermometer for the range 0 °C to 200 °C. The thermometer is compared to a high-precision reference thermometer at 0 °C, 100 °C, and 160 °C. With the three measuring points and equ. 2 above the parameters R_0, A, and B can be determined.

As a plausibility check the calibrated platinum resistance thermometer is also compared to the reference thermometer at 60 °C. From the congruence of the temperatures at this point you can deduce the measurement uncertainty between the calibration points for the thermometer.

Combined with an MKT 50 a sensor calibrated in such a way will achieve measurement uncertainties of < 10 mK in the calibrated range.

The total measurement uncertainty depends largely on the calibration of the sensor, the measurement uncertainty of the high-precision thermometer MKT 50 is negligible.

Appendix D.2 International Temperature Scale 1990 (ITS-90)

The instrument features 11 temperature ranges of ITS-90[3] as well as two “auto-switch ranges”. For further details on this temperature scale, refer to the technical literature.

Table 11: ITS 90: Calibration points and parameters for the temperature ranges 1 through 4 (in K)
[T...triple point]

Temperature range [K]		Calibration points	Parameters		
			MKT 50	US	Europe[a]
1	13.8033 … 273.16	TH_2, TNe, TO, THg, TH_2O [b]	A, B, C1, C2, C3, C4, C5		
2	24.5561 … 273.16	TH_2, TNe, TO, TAr, THg, TH_2O	A, B, C1, C2, C3		
3	54.3584 … 273.16	TO, TAr, THg, TH_2O	A, B, C1		
4	83.8058 … 273.16	TAr, THg, TH_2O	A, B	a4, b4	a, b (negative)

[a] *The parameters for the positive and negative ranges are often written as ap, bp, cp and an, bn, respectively.*

[b] *and 2 additional temperatures close to 17 K and 20.3 K*

Table 12: ITS-90: Calibration points and parameters for the temperature ranges 5 through 11 (in °C)
[T...triple point | E...freezing point | S...melting point]

Temperature range [K]		Calibration points	Parameters		
			MKT 50	US	Europe[a]
5	0 … 961.78	TH_2O, ESn, EZn, EAl, EAg	A, B, C, D[b], W (660 °C)	a6, b6, c6, d	a, b, c, d (positive)
6	0 … 660.32	TH_2O, ESn, EZn, EAl	A, B, C	a7, b7, c7	a, b, c (positive)
7	0 … 419.527	TH_2O, ESn, EZn	A, B	a8, b8	a, b (positive)
8	0 … 231.928	TH_2O, EIn, ESn	A, B	a9, b9	a, b (positive)
9	0 … 156.5985	TH_2O, EIn	A	a10	a (positive)
10	0 … 29.7646	TH_2O, SGa	A	a11	a (positive)
11	–38.8344 … 29.7646	THg, TH_2O, SGa	A, B	a5, b5	a, b (positive / negative)

[a] *The parameters for the positive and negative ranges are often written as ap, bp, cp and an, bn, respectively.*

[b] *D=0 for t90 < 660.323 °C*

“Auto-switch ranges” of MKT 50

- **ITS90A –38 … 961 °C**

  This auto-switch range covers the temperature range from –38 °C to +961 °C, which is usually covered by two temperature ranges of the ITS-90, namely ranges no. 11 (–38 … +29 °C) and no. 5 (0 … 961 °C).

  To configure the auto-switch range, specify the appropriate values A and B for the range of negative temperatures (“negative range”) and the appropriate values A, B, C, D, and W for the range of positive temperatures (“positive range”). With this auto-switch range the scales are automatically switched at the triple point of water.

- **ITS90A –189 … 961 °C**

  This auto-switch range covers the temperature range from –189 °C to +961 °C, which is usually covered by two temperature ranges of the ITS-90, namely ranges no. 4 (–189 … 0 °C) and no. 5 (0 … 961 °C).

  To configure the auto-switch range, specify the appropriate values A and B for the range of negative temperatures (“negative range”) and the appropriate values A, B, C, D, and W for the range of positive temperatures (“positive range”). With this auto-switch range the scales are automatically switched at the triple point of water.

[3] The International Temperature Scale of 1990 (ITS-90). [Original title: L’Échelle internationale de température de 1990 (EIT-90), Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92312 Sèvres.]

Appendix E Calibration and adjustment

Appendix E.1 Calibrating and adjusting MKT 50

- **Calibration**

  The displayed temperature value or resistance value is compared to the reading of an accurate reference thermometer or reference resistor. The deviation from the reference is determined.

- **Adjustment**

  The instrument parameters are set in a way that the deviation from the reference is as small as possible.

The absolute accuracy of the resistance and temperature measurement depends on the calibration and subsequent adjustment of the MKT 50.

- Let only well-trained staff or an authorized institute perform the calibration and adjustment.
- Record each calibration and adjustment in writing and keep these records safe.

MKT 50 uses the highly stable high-precision resistor VHP 101 by Vishay as an internal reference resistor. Its specifications can be found in Appendix A.3 [▸ 24].

The internal reference resistor is barely strained during laboratory use, neither thermally nor electrically (dissipation loss 100 µW). These conditions can be practically considered as storage conditions.

Before the instrument is shipped, the resistance of the internal reference resistor is determined to an accuracy of four decimal places and stored in the instrument. To ensure the absolute accuracy of the resistance and temperature measurement, do not change the numerical value of the reference resistance without prior re-calibration.

Performing an automatic adjustment

To adjust the internal reference resistor, simply connect an exactly known, certified standard resistor and determine the new internal reference resistance.

Equipment:

- MKT 50
- standard resistor (100 Ω or rather 400 Ω)
- calibration certificate for the standard resistor certified by a bureau of standards (measurement uncertainty < 1 ppm)
- thermostat with oil bath

1. Bring the standard resistor in the oil bath to the reference temperature specified in the calibration certificate.
2. Connect the standard resistor to sensor channel 1 (*CH1*).
3. Press *M* and select *3 Edit Configuration > 2 Reference Resistor > 2 Adj. internal RR*.
4. For *Std. Res* enter the standard resistor value according to the calibration certificate.
5. Press *Enter*.
6. Wait approx. 1.5 minutes (50 measuring values). The newly determined resistance of the internal reference resistor (*New RR*) and the old resistance value (*Old RR*) will be displayed.
7. Note down the old and the new resistance values of the reference resistor together with the current date.
   Keep this record safe.
8. Press *Enter* to continue.
9. Press *Enter* again to store the new internal reference resistance.
   The calibration time *Cal.Time* will be automatically set to 100 days. You can customize the calibration time at your own discretion.

The calibration time can only be estimated. It is your own responsibility to perform periodic checks of the measuring instrument at the triple point or freezing point of water.

10. After the adjustment perform another calibration to check the instrument:
    - Press *M* and select *2 Resistance Mode > 2 Resistance Stat.*.
    - Set the number N of measurements used for the calculation of the average to 50 (refer to Section 6.5 [▸ 13]).
    - Wait approx. 1.5 minutes.
    - Check that the mean value displayed for the resistance of the externally connected standard resistor accords with the value specified in the calibration certificate.
      The two values must not differ by more than the measurement uncertainty of the MKT 50.

Performing a manual adjustment

For a manual adjustment, as opposed to the automatic adjustment, you will have to calculate the new internal reference resistance yourself and enter it into the instrument.

Use the following formula for the calculation (equ. 3):

$$RR_{[new]} = RR_{[old]} \cdot \frac{R_{ext}}{R_{an}}$$

$RR_{[new]}$	*calculated resistance of the internal reference resistor [Ω]*
$RR_{[old]}$	*resistance of the internal reference resistor stored in MKT 50 [Ω]*
R_{ext}	*resistance of the externally connected standard resistor according to the calibration certificate [Ω]*
R_{an}	*mean displayed for the resistance values of the externally connected standard resistor (number N of measurements used for the calculation of the average: 50) [Ω]*

Equipment:

- MKT 50
- standard resistor (100 Ω or 400 Ω)
- calibration certificate for the standard resistor certified by a bureau of standards (measurement uncertainty < 1 ppm)
- thermostat

1. Find the value for $RR_{[old]}$:

   Press *M* and select *3 Edit Configuration* > *2 Reference Resistor* > *1 Edit internal RR*.
2. Find the value for R_{ext} in the calibration certificate of the standard resistor.
3. For the determination of the value R_{an} use the thermostat to bring the standard resistor to the reference temperature specified in the calibration certificate.
4. Connect the standard resistor to sensor channel 1 (*CH1*).
5. Press *M* and select *2 Resistance Mode* > *2 Resistance Stat.*.
6. Set the number N of measurements used for the calculation of the average to 50 (refer to Section 6.5 [▸ 13]).
7. After approx. 1.5 minutes read the mean value R_{an} from the display.
8. Use *equ. 3* together with the found values to calculate the new resistance value of the internal reference resistor $RR_{[new]}$.
9. Store the new reference resistance in the instrument:

   Press *M* and select *3 Edit Configuration* > *2 Reference Resistor* > *1 Edit internal RR*.
10. Check that the mean value displayed for the resistance of the externally connected standard resistor accords with the value specified in the calibration certificate.

    The two values must not differ by more than the measurement uncertainty of the MKT 50.
11. Note down the date, the measuring medium, and $RR_{[new]}$ in a measurement report.
12. Keep this record safe.

Example:

$RR_{[old]}$ (stored in MKT 50)	= 400.003 Ω
R_{ext} (resistance value of the externally connected standard resistor according to calibration certificate)	= 100.014 Ω
R_{an} (mean value displayed on MKT 50)	= 100.0185 Ω

In this example the displayed value deviates from the actual value specified in the calibration certificate. Equ. 3 with the found values gives:

$$RR_{[new]} = 400.003 \cdot \frac{100.014}{100.0185} = 399.9850\ \Omega$$

After you have stored the new value for RR (399.9850 Ω) in the instrument, the mean value displayed on the MKT 50 must match the actual resistance value of the standard resistor.

- If it does not, repeat the procedure.

Appendix E.2 Calibrating and adjusting a sensor

To calibrate and adjust a sensor, connect a known, certified reference sensor and your unadjusted sensor to the MKT 50. Then determine the resistance values of the sensor at various temperatures by use of a highly precise thermostat. With the appropriate equations of EN 60751 or ITS-90 you can calculate the sensor parameters.

Equipment:

- MKT 50 (adjusted)
- reference sensor with calibration certificate
- unadjusted sensor
- thermostat

1. Connect the reference sensor to sensor channel 1 (*CH1*).
2. Connect the unadjusted sensor to sensor channel 2 (*CH2*).
3. Press *M* and select *2 Resistance Mode* > *2 Resistance Stat.*.
4. Read the resistance values.
5. Calculate the coefficients in the appropriate equation.
6. Record the calibration and adjustment data in writing and keep these records safe.
7. Enter the newly calculated coefficients for your sensor into the MKT 50, and assign these calibration parameters to a sensor channel.

Appendix F Performing a self-heating test

The self-heating test is a function for users with an expertise in temperature measurement. As an expert, you are familiar with all aspects regarding the calibration of thermometers to an accuracy of down to 1 mK.

If you use the MKT 50 for the calibration of DMA or SVM instruments, you may ignore this function.

The term self-heating refers to the sensor being heated by the measuring current. On account of this, the measured temperature is a little higher than the temperature of the sample medium. Self-heating errors of approx. 2 mK and higher can be determined with the self-heating test.

During this test, the self-heating effect is determined by reducing the measuring current and observing the resulting temperature change. Temperature changes of less than 0.5 mK, when operated with the lower measuring current, are within the measurement uncertainty of MKT 50 and cannot be interpreted as a self-heating effect.

Usually the self-heating of the sensor is considered in the calibration parameters. However, if the measuring current during calibration deviates strongly from the measuring current in the MKT 50, or if the thermal transfer resistance differs strongly between media at calibration time and later (air, water, still or moving), this function can be useful to avoid major errors. The self-heating of sensors used to measure the temperature of still air, for example, is usually already too significant to be ignored.

1. Select temperature statistics for display (refer to Section 6.5 [▶ 13]):
   - Press *M* and select *1 Temperature Mode > 2 Temperature Stat.*
   - Set the number N of measurements used for the calculation of the average to 25 (with the arrow keys).
2. Note down the average temperature $Temp_I$.
3. Press *M* and select *5 Self Heat Test* to switch the self-heating test on.

   Now the measuring current is reduced by a factor of $1/\sqrt{2}$.

   The measuring display shows *SHT* for “Self Heating Test ON” in the lower right corner.
4. Again select temperature statistics for display, with N=25.
5. Note down the average temperature $Temp_{I/\sqrt{2}}$.
6. Calculate the temperature difference

   $\Delta Temp = (Temp_I - Temp_{I/\sqrt{2}})$.
7. Two times the determined temperature difference ($2 \cdot \Delta Temp$) gives you the current self-heating of the sensor.
8. Press *M* and select *5 Self Heat Test* to switch the self-heating test off and return to normal measurement.

Appendix G Troubleshooting

Appendix G.1 Error messages on the instrument

Error message	Cause	Solution
ADC ERROR OUT OF RANGE	The sensor is damaged or the ADC of the instrument is defective.	– Contact your local Anton Paar representative. – Connect a different sensor.
CALIBRATION RANGE	– You have entered incorrect sensor parameters or parameters with a wrong sign. – The temperature range entered (EN 60751) or selected (ITS-90) with the sensor parameters has been underrun or overrun.	– Verify that the entered sensor parameters are correct. – Assign another calibration with an appropriate temperature range to the sensor channel.
MAX TEMP EXCEEDED	The sensor has been heated to a temperature higher than the maximum specified in the calibration data. (Field *Cal.Time* in the sensor calibration parameters shows *Max.Temp*.)	Re-calibrate the sensor and enter the new calibration parameters.
NO SENSOR CALIBRATION	No sensor calibration parameters have been assigned to the channel.	Assign sensor calibration parameters to the sensor channel.
RR CAL TIME	The calibration time of the reference resistor has expired. (Field *Cal.Time* in the reference resistor configuration shows a negative number.)	Calibrate the reference resistor (or have it calibrated) and update the calibration time in the reference resistor configuration.
SENSOR CAL TIME	The calibration time of the selected sensor has expired.	Calibrate the sensor and enter the new calibration parameters (also update the calibration time).

Error message	Cause	Solution
	(Field *Cal.Time* in the sensor calibration parameters shows a negative number.)	
SENSOR NOT CONNECTED	No sensor is connected to the sensor channel.	Connect a sensor.
WRONG RREF SELECTION	The actual resistance of the reference resistor differs too much from the entered value.	Calibrate MKT 50 again and enter a precise value.

Appendix G.2 Problems with instrument activation

If the instrument cannot be switched on or switches itself off again immediately after activation, perform the following checks:

- If you operate MKT 50 battery-powered, check the charge condition of the batteries or rechargeable batteries.
- If you operate MKT 50 AC-powered, check that the power adapter is properly plugged in.
- If the instrument switches itself off right away despite functional power supply, check the sensors:

1. Disconnect the sensors from the instrument.
2. Switch the instrument on.
   - If the instrument can now be switched on without any problems, the error is caused by a defective sensor or sensor cable.
   - In this case repair the sensor or sensor cable or exchange them.

NOTICE

The inputs of MKT 50 are not free-of-ground. Therefore, all wires of the sensor have to be insulated against ground (e.g. against the cable shield).

Appendix H Converting temperature units

Use the following equations for the conversion between different measurement units of temperature.

Conversion of degrees Fahrenheit

$$T_{[K]} = \frac{5}{9} \cdot (t_F[°F] - 32) + 273.15$$

$$t_C[°C] = \frac{5}{9} \cdot (t_F[°F] - 32)$$

Conversion of Kelvin

$$t_C[°C] = T[K] - 273.15$$

$$t_F[°F] = \frac{9}{5} \cdot (T[K] - 273.15) + 32$$

Conversion of degrees Celsius

$$T[K] = t_C[°C] + 273.15$$

$$t_F[°F] = \frac{9}{5} \cdot T_C[°C] + 32$$

T [K] *temperature in K*
t_C [°C] *temperature in °C*
t_F [°F] *temperature in °F*

Appendix I Software versions

Software version	Date of release	Document number	Remarks
1.000	17.12.2007	A91IB04A	first software version released
1.030	18.06.2008	A91IB04B	minor changes
		A91IB04C	minor changes for DMA M
1.15	21.10.2009	A91IB04D	– improved approximation methods for DIN IEC 751 calculations – improved data transfer via RS-232
1.97	10.06.2010	A91IB001EN-A	– improved web interface (LAN) – XML page available (LAN)

Software version	Date of release	Document number	Remarks
			– 8 digits serial numbers for sensors – 8 digits device serial numbers introduced – new PC commands for DIN IEC 751 sensor definitions – more decimal places for the resistance and temperature means – new features in statistics display: switch to big digits for mean and temporary display of sensor number
		A91IB001EN-B	– direct connection to a PC – new sensors
2.04	09.07.2013	A91IB001EN-C A91IB001EN-D A91IB001EN-E A91IB001EN-F A91IB001EN-G A91IB001EN-H	– ITS-90: 2 auto-switch ranges available – new PC commands – modified menu structure – polynomial of 4^{th} order (new sensor type: approximation by a standard polynomial)

Appendix J Declarations of conformity

EU Declaration of Conformity

(original)

Anton Paar

The Manufacturer **Anton Paar GmbH,** Anton-Paar-Str. 20, 8054 Graz, Austria – Europe hereby declares that the product listed below

Product designation:	**MKT 50 MILLIKELVIN-THERMOMETER**
Model:	**MKT 50**
Material number:	26878

is in conformity with the relevant European Union harmonisation legislation. This declaration of conformity is issued under the sole responsibility of the manufacturer.

Low Voltage Directive (2014/35/EU, OJ L 96/357 of 29.3.2014)

Applied harmonised standard:

- EN 61010-1:2010 + A1:2019 + A1:2019/AC:2019

Electromagnetic Compatibility (2014/30/EU, OJ L 96/79 of 29.3.2014)

Applied harmonised standard:

- EN 61326-1:2013

RoHS Directive (2011/65/EU, OJ L 174/88 of 1.7.2011)

Place and date of issue: Graz, 11.06.2024

DocuSigned by:
17130DDD5260426...
DI Steffen Riemer, MBA
Executive Director
Business Unit Measurement

DocuSigned by:
66833374CFAF464...
DI Dr. Wolfgang Baumgartner
Head of Lab Density & Concentration
Business Unit Measurement

A91IB001EN-H