OPERATION MANUAL

RESISTOMAT®
Type 2304

Valid from: 25.11.2013

Manufacturer:
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Präzisionsmessgeräte, Sensoren und Messsysteme
für elektrische, thermische und mechanische Größen

burster

QM-System zertifiziert ISO 9001

E G - K o n f o r m i t ä t s e r k l ä r u n g

EC- Declaration of Conformity according to EN ISO/IEC 17050-1:2004

Name des Herstellers: burster präzisionsmesstechnik gmbh & co kg
Manufacturer's Name:

Adresse des Herstellers: Talstr. 1-5
Manufacturer's Address: 76593 Gernsbach, Germany

erklärt unter alleiniger Verantwortung, dass das gelieferte Produkt
declares under sole responsibility that the product as originally delivered

Produktname: Hochpräziser Meß- und Prüfautomat für die elektrische Widerstandsmeßtechnik
Product Name: *High-Precision Automatic Inspection and Test Unit for Electrical Resistance Testing*

Modellnummer(n) (Typ): 2304 / 2305
Models Number / Type:

Produktoptionen: Diese Erklärung beinhaltet obengenannte Produkte mit allen Optionen
Options *This declaration covers all options of the above product(s)*

mit den folgenden europäischen Richtlinien übereinstimmt und entsprechend das CE-Zeichen trägt:
complies with the requirements of the following applicable European Directives, and carries the CE marking accordingly:

2006/95/EC Elektrische Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen
Low Voltage *Electrical Equipment designed for use within certain voltage limits*

2004/108/EC Elektromagnetische Verträglichkeit
EMC *Electromagnetic Compatibility*

Obengenannte Produkte entsprechen folgenden harmonisierten Normen:
Above named products conform with the following product standards:

Sicherheit: *Safety requirements:*	IEC 61010-1:2001 / EN 61010-1:2001	Messkategorie 1 CAT 1	Schutzklasse 1; (110)/ 230 V~ Kat. II
EMV Störaussendung: *EMC Generic emission:*	IEC/CISPR 11:2003 + A1:2004 + A2:2006 / EN 55011:2007 + A2:2007		
EMV Störfestigkeit: *EMC Generic immunity:*	IEC 61326-1:2005 / EN 61326-1:2006		Industrie Bereich *Industrial environment*

Ergänzende Informationen:
Additional Information:

Das Produkt wurde in einer typischen Konfiguration getestet.
The product was tested in a typical configuration.

Diese Konformitätserklärung betrifft alle nach Ausstellungsdatum ausgelieferten Produkte:

This DoC applies to above-listed products placed on the EU market after:

Gernsbach 09.07.2008 i.V. Alfred Großmann
Datum / *date* *Quality Manager*

Dieses Dokument ist entsprechend EN ISO/IEC 17050-1:2004 Abs. 6.1g **ohne Unterschrift** gültig / *According EN ISO/IEC 17050 this document* ***is valid without a signature***.

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Installation and maintenance of the RESISTOMAT®2304

General information

Position the RESISTOMAT® resistance measuring device so that enough space is left behind the back panel to ensure proper ventilation of the black heat sink. The output of the ventilation channel shown in Fig. 1.2 must not be obstructed. Enough space should also be allowed for the connection of interface cables.

Input control

The device weighs 28 kg and is contained in appropriately shock-resistant packaging. Unpack it carefully and check whether any contents are missing. The standard scope of delivery includes:

- a type 2304 resistance measuring device,
- a mains cable,
- a copy of this handbook.

Check the device carefully for damage. Should there be signs of damage which has occurred during transport, inform the shipping company within 72 hours. The packaging should be kept so that it can be examined by the manufacturer´s representative or the shipping company.

The RESISTOMAT may only be transported in its original packaging or a comparable packaging.

Optional features and accessories

The following optional features and accessories are available for the 2304 RESISTOMAT®:

- Version for 115VAC + 6% - 10% power line voltage.

- Type 2304-Z004 calibration resistance package:
  5 type 1240 calibration resistances with values of 100μΩ, 1 mΩ, 10 mΩ, 100 mΩ and 1 Ω. Every resistance has a DKD (german calibration service) label.In addition, every package contains a type 2394 adapter for direct connection of the calibration resistances to the measurement sockets of the RESISTOMAT® (see Chap. 2.4.5).

- Temperature measuring sensor (Pt100) including LEMO 1B type 2304-V001 plug connector:
  For measuring the temperature of the test unit in the case of automatic temperature compensation (see Chap. 3.2.2), cable length: 2.5 m.

- 37-pin type 2304-Z001 mating connector for the digital inputs/outputs (see Chap. 1.4.4.3 and 7.2.3.)

- 25-pin type 2304-Z002 mating connector for the RS232/485 output (see Chapters 1.4.4.2 and 7.2.2.)

- 5-pin type 2304-Z003 mating connector for rear-panel connection of the test unit (see Chap. 7.2.4)

- Kelvin measuring tongs and Kelvin test prods see specification sheet KM 2.3.

- Clamping device, see specification sheets EV 2.3 und PE 2.3.

- 19" type 2304-Z004 assembly kit.

Installation

The measuring amplifier (analog section) of the device is connected internally with the equipment grounding conductor as shown in Fig. 1.1.

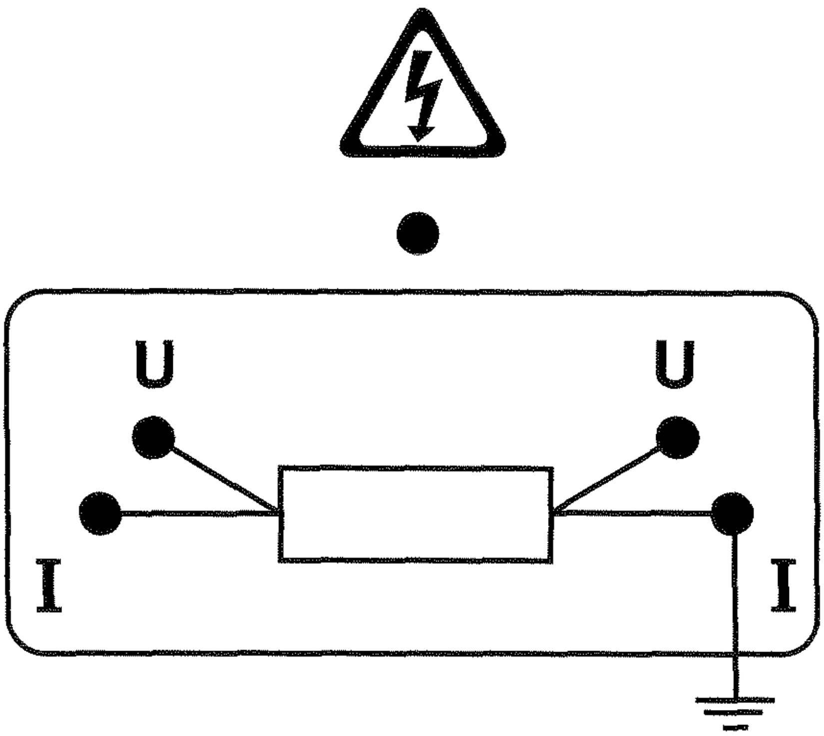


Fig. 1.1.: Ground conductor connection

Normally, this INTERNAL ground is used. It is advisable to use a seperate, EXTERNAL ground only for networks which are particularly prone to interference. This also applies to measurements on objects with single-end grounding, like motors. In order to avoid ground loops here, the reference potential of the measuring circuit should be connected directly with the neutral point of the test unit.(see Chap. 4.7 for changeover from INTERNAL to EXTERNAL grounding).

Installation

Power supply

The standard RESISTOMAT® is designed to operate at a mains voltage of 230_{VAC} + 6% - 10% and a mains frequency of 45 - 65 Hz. 115_{VAC} is available as an option (conversion is only carried out by the manufacturer; it is not sufficient to simply switch the voltage selector shown in Fig. 1.2).

For this reason, it must be checked whether the voltages specified on the type and voltage plates correspond with the local mains voltage, before the mains voltage is connected (Fig. 1.2) and turned on (Chap. 2.2).

The adaption of the device´s internal time base (for synchronizing the A/D converter and other functional units) to mains frequencies other than 50 Hz is described in Chap. 4.3).

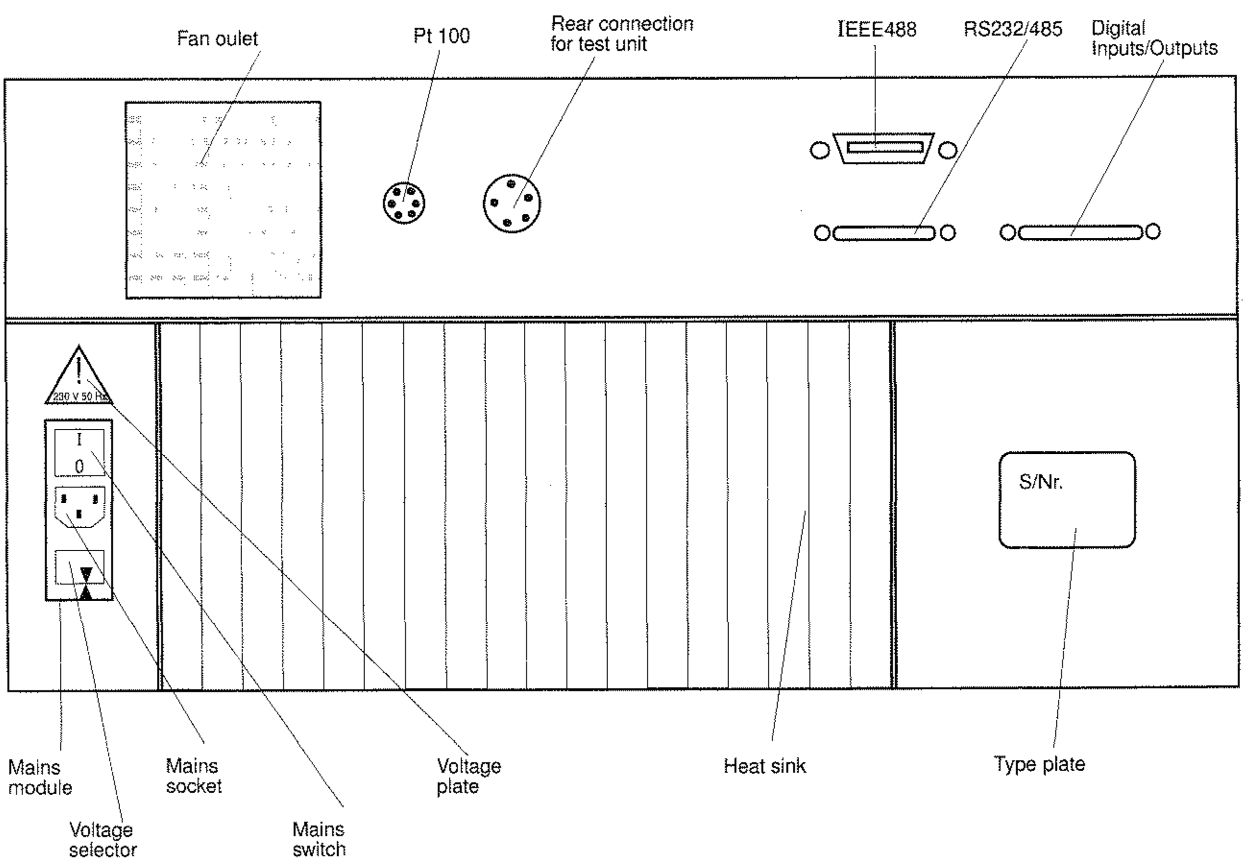


Fig 1.2: Rear panel

Installation

Line Power fuse

The two line power fuses each rated at 2 A (both with medium time-lag) are located behind the panel with the voltage information, inside the mains connection module (see Fig. 1.2). The fuses are changed by inserting a screwdriver into the notch underneath the upper edge of the mains socket, lifting the plate with the voltage information slightly, and pulling out the fuse-insert.

ATTENTION:

After a fuse has been changed, the fuse-insert must be pushed into the mains module in the correct manner (mark on housing facing arrow with the desired mains voltage).

Connection of the inputs and outputs

IEEE488

The GPIB cable is connected to the 24-pin socket (IEEE-488 standard) on the rear panel of the device (see Fig. 1.2 and Chap. 7.2.1).

RS232/485

The RS232/485 interface cable is connected to the 25-pin subminiature D-socket on the rear panel of the device (see Fig. 1.2 and Chap. 7.2.2).

Digital inputs/ outputs

The following inputs/outputs are accessible via the 37-pin subminiature D-socket on the rear panel of the device (see Fig. 1.2 and Chap. 7.2.2):

- 9 relays each with a changeover switch for the comparator or classify functions (see Chapters 3.2.4 and 3.2.5)
- 1 START/STOP1 input for connecting a foot switch (Pin 1 to DGND/Pin 20),
- 1 START/STOP2 input via optocoupler (Pin 23 to GNDEXT/Pin 5),
- 1 status output„Measurement error“ (optocoupler, „open collector“, „active low“),
- 1 status output „Measurement in progress“ (optocoupler, „open collector“, „active low“),
- 1 printer enable input (optocoupler, „open collector“, „active low“).

Device address for computer control

The device address can be selected via a keyboard or an external interface. The following chapters contain the relevant information:

- IEC bus control:	Chap. 6.1.2.1),
- RS232/485:	Chap. 6.1.3),
- Interfaces:	Chap. 3.3.4).

The address selected last is stored after the mains voltage is turned off; the factory presettings (see Chap. 7.4) are "9" (IEC bus) and "0" (group and device address in the case of RS 232/485).

19"type 2304-Z004 assembly set

Removing the upper and lower casings:

- Loosen the fastening screws (4 each at the top and bottom),
- take off the casings,
- remove the 8 clamping nuts which have been released.

Removing the front panel:

- Loosen the shaft screws (one each on the vertical side),
- lift the front panel out of the notch by bending the horizontal sides.

Removing the lateral grips:

- Loosen the fastening screws (3 on each side),
- take off the grips and lateral rails,
- remove the clamping nuts which have been released.

Attaching the cover plates at the top and the bottom:

- Prepare the cover plates for assembly by sliding on the clamping nuts contained in the accompanying bag (smooth side of the clamping nuts facing outwards).
- stick on the HF contact strips (1 each at the top and the bottom)
- insert the tabs of the plates into the corresponding slots in the chassis tie-bar,
- tilt the cover plate toward the front panel and secure the plate and the panel by means of 3 M4 recessed screws in each case (accompanying bag).

Attaching the 19" front angle:

- secure the front angle with 2 M5 recessed screws (accompanying bag) on the left and right hand sides of the front panel.

In this manner, the device is converted to a 19" insert-module.

Maintenance

General information

In principle, the RESISTOMAT does not require any maintenance by the user. If any repairwork becomes necessary, it must only be carried out by the manufacturer. The device complies with the relevant VDE (Associaton of German Engineers) specifications and postal interference suppression regulations.

Customer service

Enquiries

The manufacturer strongly recommends accompanying technical enquires with the relevant serial numbers. Only then is it possible to determine the technical model (including the software version) and thus ensure a prompt solution. The serial number is shown on the the type plate at the bottom, right-hand corner of the rear panel of the device.

Shipping instructions

If the RESISTOMAT® has to be sent in for repairwork, the following must be observed as regards packaging and shipping:

- If complaints arise, we recommend describing the fault in keywords and attaching the list to the housing of the device. Stating your name, department and complete telephone number (in case further enquiries arise) will also accelerate service.

- For shipping via rail, forwarding agencies or other transport companies, it is advisable to use the carefully stored original packaging or an equivalent. Damage occuring during transport as a result of inadequate packaging is not covered by the guarantee.

Factory guarantee

Burster precision measurement technology guarantees reliable operation and correct calibration data for a period of 12 months after delivery.
Repairwork required within this period will be carried out free of charge.

Damage caused through improper handling of the device or transgression of the specified limiting values are not covered by the guarantee.

In addition, the manufacturer will on no account accept any responsibility for consequential damage.

Our delivery and payment terms are applicable.

Operation

The measuring unit of the high-precision RESISTOMAT® 2304 automatic measuring and testing device operates on the principle of an advanced 4-wire design shown in Fig. 1.3. The voltage drops when current is applied are measured not only across the test unit, but also across an internal reference resistor. Both voltage drops are used to calculate the quotient, which is multiplied by the characteristic value of the reference resistor in order to determine the ohmic value of the test unit. This procedure eliminates contact and transition resistances and is advantageous in that measurement errors are only dependent on the quality of the internal, highly stable reference resistors. Accordingly, the measuring device allows an extremely accurate determination of the test unit´s resistance, irrespective of the parasitic resistances in the electrical circuit.

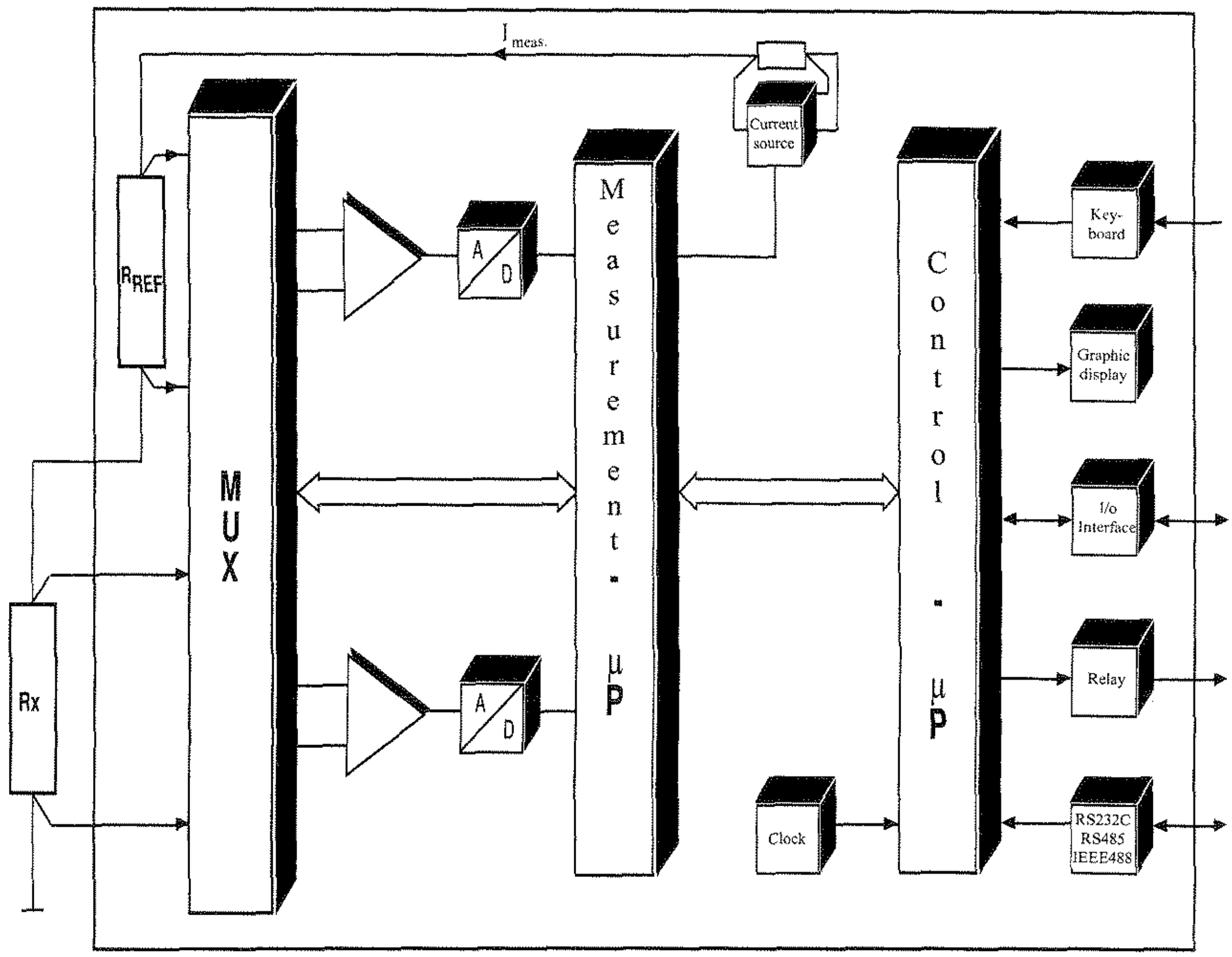
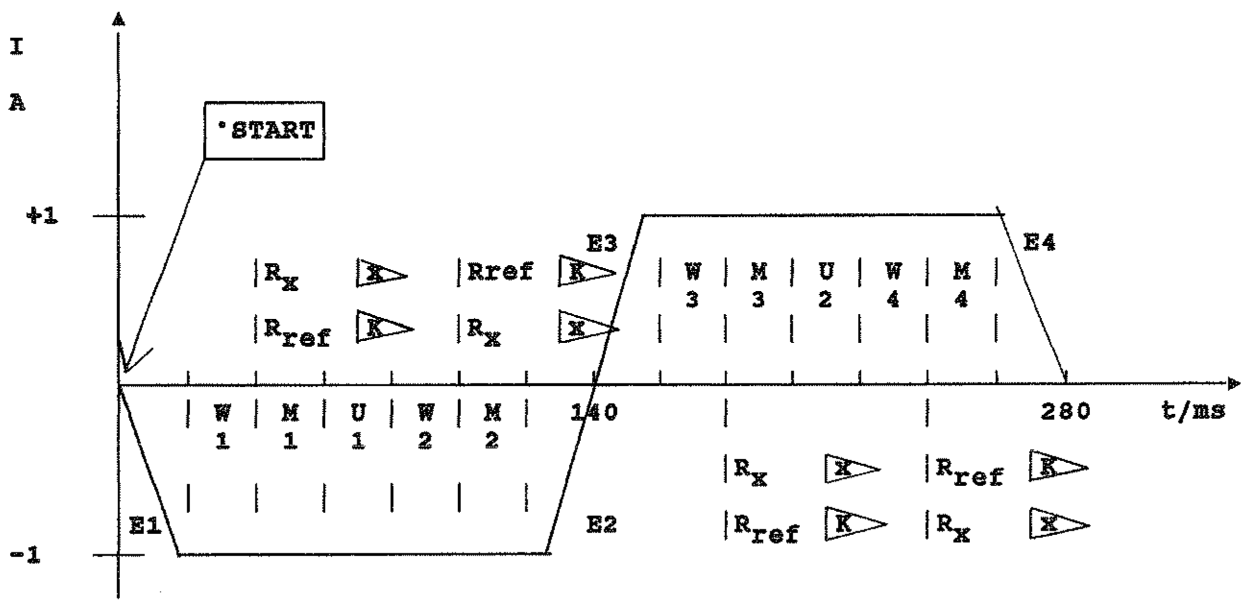


Fig. 1.3: Block diagram of the 2304

A measured value results from the computational combination of 2 * 4 single measurements from a measurement cycle and comparison with the internally stored reference value. In this context, a distinction is always made between BIPOLAR and UNIPOLAR measurements of ohmic or inductive resistances (see Chap. 4.5, V.1). The resulting measurement cycles are illustrated in the following Figures 1.4, 1.6 and 1.7:

A1) BIPOLAR measurement of ohmic resistances R (see Chap. 3.1.2, V.6)



A meaW = Wait M = Measurements U = Switch over E = Settling

Fig. 1.4: BIPOLAR measurement of ohmic resistances

The transient period E1 leading to the negative measurement current value and a subsequent waiting period (see Chap 3.1.2, V.5 variable, standard value=1), are followed by two parallel, single measurements of R_X via amplifier channel V_X and of R_{ref} via amplifier channel V_K. After that, the amplifier channels V_X and V_K are switched over and the two measurements are repeated after a renewed waiting period with the amplifiers interchanged. Now the polarity of the measurement current is switched to the positive value, and the above-mentioned half-cycle is repeated accordingly. The allocation of the switching operations to the resistors and amplifier is clarified once again in Fig. 1.5.

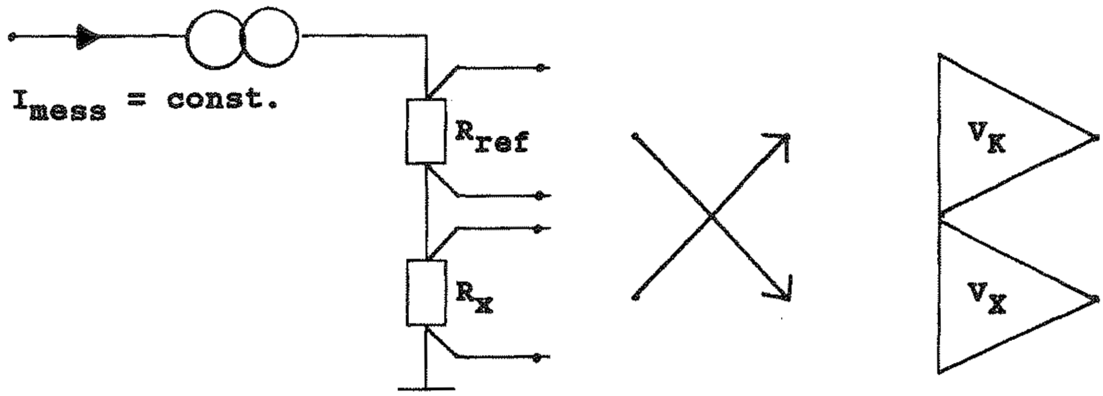


Fig. 1.5 : Measuring resistors and amplifier channels

A.2) BIPOLAR measurements of inductive resistors Z
(see Chap.3.1.2, V.6)

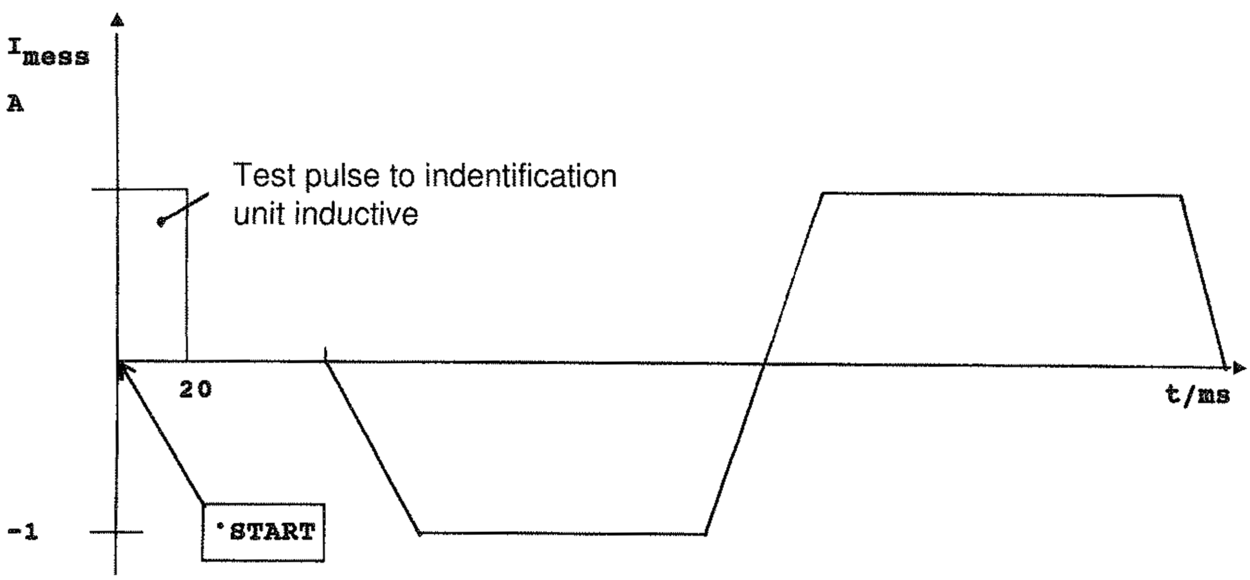
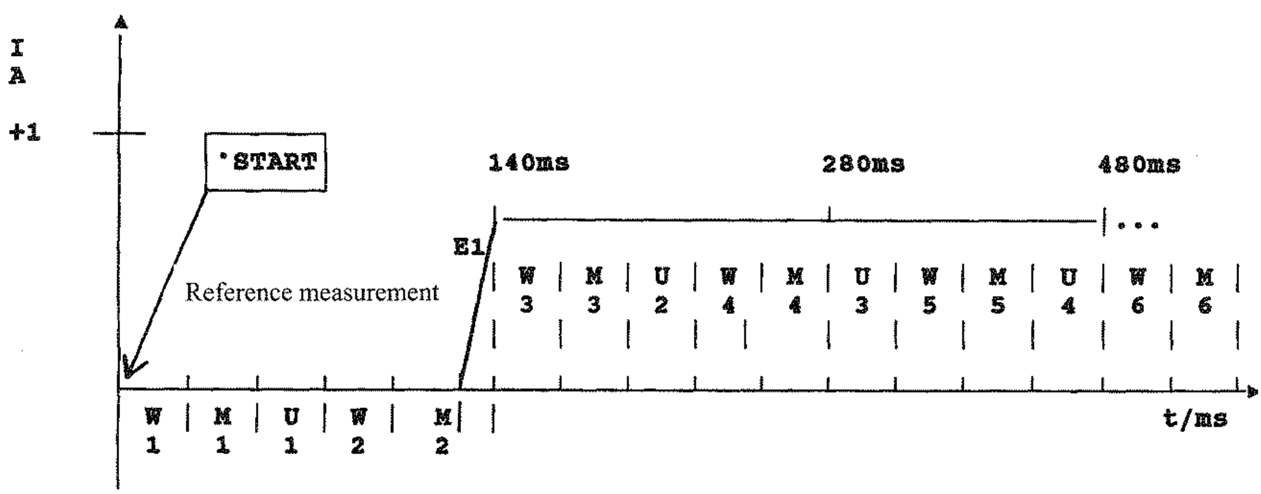


Fig. 1.6: BIPOLAR measurement of inductive resistances

After the start key is operated, a test pulse about 30 ms long is sent to the test unit. If the test unit actually has a significant inductive content, the maximum transient and waiting periods (see Chap. 3.1.2, V.5) are prolonged and the measurement is started as shown in Fig. 1.4.
In the MEASMODE = SINGLE (see Chap. 3.1.2., V1), this sequence is repeated after renewed operation of the start key (including the test pulse).
In contrast, in the MEASMODE = REPETITION, the test pulse only occurs once.
If MEASSEQ = BIPOLAR is selected, the connection of large inductances can lead to excessively long measurement cycles, due to the counter-voltage arising during switchover and polarity reversal; in certain cases, stable measurement values cannot be obtained at all. Then it is advisable to select MEASSEQ = UNIPOLAR.

B.1) UNIPOLAR measurement of ohmic resistances R.



W = Wait M = Measurement U = Switch over E = Settling

Fig. 1.7: UNIPOLAR measurement of ohmic resistances

After the start key is operated, a reference measurement (half-cycle) is carried out (see Fig. 1.7), the transient period E1 leading to the positive measurement current value is allowed to elapse, and the measurement sequence (from Fig. 1.4) for positive currents is started. In MEASMODE = SINGLE, the sequence is repeated after renewed operation of the start key (including reference measurement).
In contrast, in the MEASMODE = REPETITION, the reference measurement is only carried out once.

B2) BIPOLAR measurement of inductive resistances Z

The measurement sequence corresponds to B.1 and Figure 1.7. In order to save time, an inductive test unit is presupposed, i.e. no inductance test is carried out as in Fig. 1.6. However, the prolonged values in A2 apply for the transient and waiting periods.

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Operating the RESISTOMAT®2304

Operation of the RESISTOMAT®2304

Introduction

The RESISTOMAT® 2304 is a precision electronic device for measuring resistances; it has been developed specially for applications involving industrial measurement and testing techniques. It is capable of high resolution up to 1 nΩ, offers measuring currents of between 100 µA and 10 A, and can be controlled completely with a standardized programming language (SCPI) via a computer.

Due to the complexity of its functions, it is advisable to install the device in steps (Chap. 1), start it up (Chap. 2) and parameterize it (Chap. 3). Chapters 4 (configuration), 5 (calibration) and 6 (programming) should not be dealt with at the beginning, as useful preselections have been provided for these features in Chap. 7.4.

In order to facilitate the treatment of Chapters 3 - 5 , it should be mentioned here that all menu descriptions have been arranged in the following, standard format:

I) Access,
i.e. key designation for access to the menu,

II) Function
of the menu,

III) Restrictions,
to be observed when using the menu,

IV) Function keys,
within the menu and its sub-menus

V) Parameters,
which can be displayed or changed within the menu,

VI) Special points,
to be observed as regards the menu,

VII) Exit,
i.e. key designations for leaving the menu.

In the case of certain menus, this sequence does not always correspond with the "normal" control sequence. However, this disadvantage has been accepted in the interests of a standard representation.

Switching on the device

The device is switched on by switching the mains switch up.
The mains switch is located at the bottom, left-hand corner of the rear panel of the device, as shown in Fig. 1.2.

Display

General information

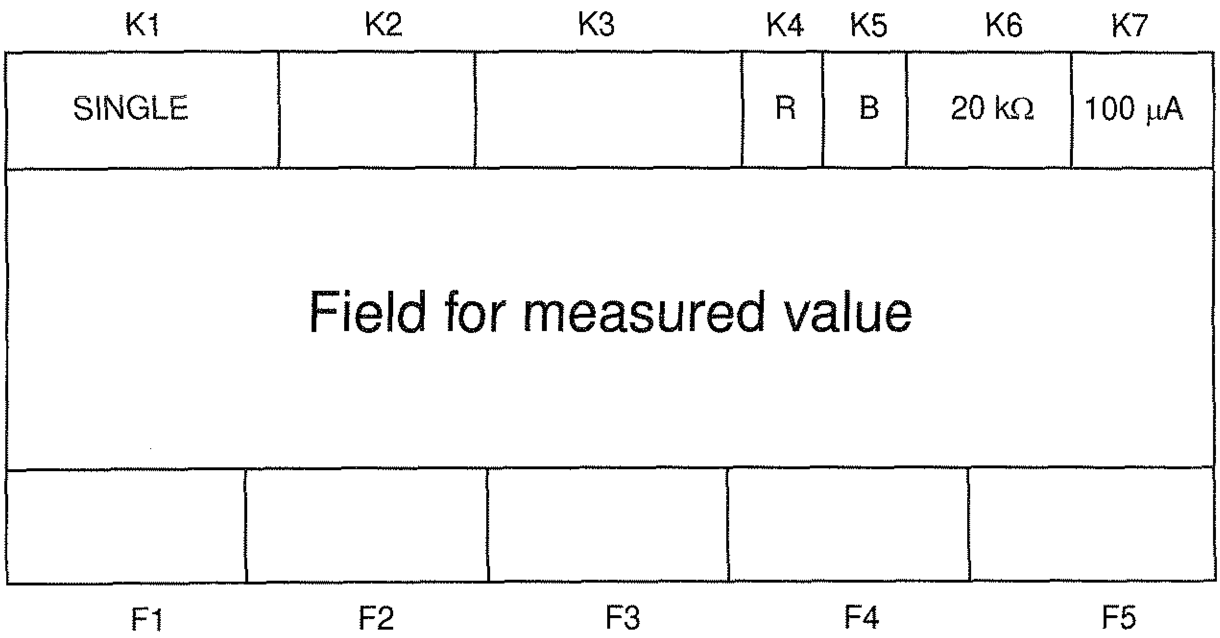


Fig. 2.1: Display

The display consists of an illuminated graphic liquid crystal display.
It displays measured values, status information, and operating instructions.
Fig. 2.1, for example, shows the allocation for three main menus: „Parameterize", „Evaluate" and „Special Function".

Header fields

K1 (≤ 6 characters + 1 number):

SINGLE or REP. measurement (see Chap. 3.1.2, V.1) and measurement cycle information (continuous numbers from 1 to 9, every number represents a measurement cycle as described in Chap, 1.6).

K2 (≤ 5 characters):

Error messages, e.g. I selected measurement current cannot be adjusted (the complete list can be found in the appendix ≙ following Chap. 7.3). An error message remains until a new error occurs or the original error has disappeared.

K3 (≤ 9 characters):

Temperature display if temperature compensation has been activated (see Chap. 3.2.2, V.1). An *A* before the temperature value represents automatic temperature measurement, and an *M* before the temperature value represents manual temperature measurement,

e.g.A 20.5°C or M 120.5°C.

K4 (1 character):

Type of test unit (see Chap. 3.1.2, V.6),
R means: purely ohmic test unit,
Z means: inductive test unit with ohmic component.

K5 (1 character):

Measurement mode (see Chap. 4.5),

B means: BIPOLAR measurement,
U means: UNIPOLAR measurement

Only the bipolar measurement mode ensures that parasitic thermoelectric voltages in the measurement circuit are compensated during every measurement.

K6 (≤ 6 characters):

Currently selected measurement range (see Chap. 2.4.2.1), for example, the largest measurable value for the 20 kΩ measurement range is 19.999 KΩ.

K7 (≤ 6 characters):

Currently selected measuring current (see Chap. 3.1.2, IV.3) + V.2), e.g.100 μA.

Function keys

F1 - F4:

Depending on the selected menu, these keys have different meanings which are redefined via the software in accordance with the selected menu.

F5:

This key is reserved for jumps to other menus. At the highest level of the main menu („Parameterize", „Evaluate" and „Special functions"), for example, it allows a changeover to the next menu at the same level (in the sequence mentioned). At the lowest menu level, a return to the intermediate level is always effected with F5.

Field for the measured value

The measured value can be indicated in this field as follows:

A) as an ohmic resistance in Ω,

B) as a resistance per unit length in Ω/unit length,

C) as the specific resistance of a conductor in Ω * unit of length, whereby the following applies:

$$\rho = R \cdot S/l \quad = R \cdot m / (\rho_m \cdot l^2),$$

S is the cross-sectional are of the conductor,

l the measured length of the test unit,

m the mass of the measured length of the test unit,

ρ_m the specific conductor material density in g/cm³.

D) as a specific conductance in 1/(Ω * unit length), whereby the following applies:

$$\gamma = 1/r.$$

E) as a perentage deviation from an entered specified value R.

If the comparator or classify function has been activated (see Chap. 3.2.3) the following displays are possible:

F) Use of the 3-class comparator:

=: Measured value in specified window,

<: Measured value smaller than the lower limit LL,

>: Measured value larger than the upper limit value UL.

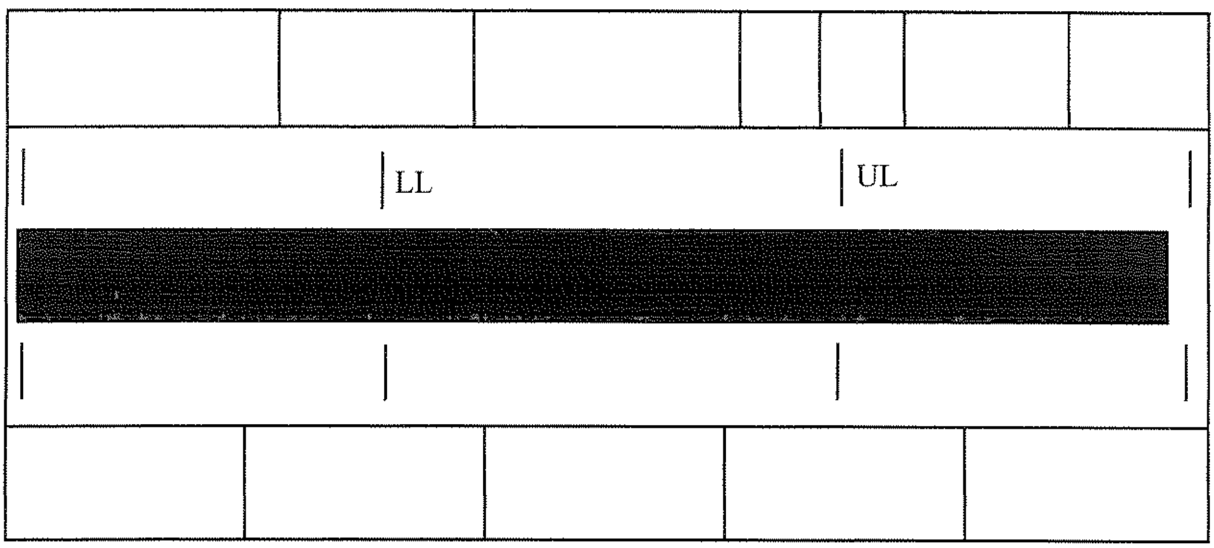
G) Use of the 9-class classify function:

<: Measured value smaller than the lowest limit LV1 (RanGE 0),

>: Measured value larger than the highest limit LV8 (RanGE 8),

LV1 ≤ Measured value ≤ LV8:
Measured value within a range RGE1 to RGE7.

If the bar display is also activated, the following additional information appears (also see Fig. 3.23):



The bandwith containing measured values between the lower and upper limiting values is indicated graphically.

The temperature compensation (see Chap. 3.2.2) can be combined with all the display modes mentioned.

Controls

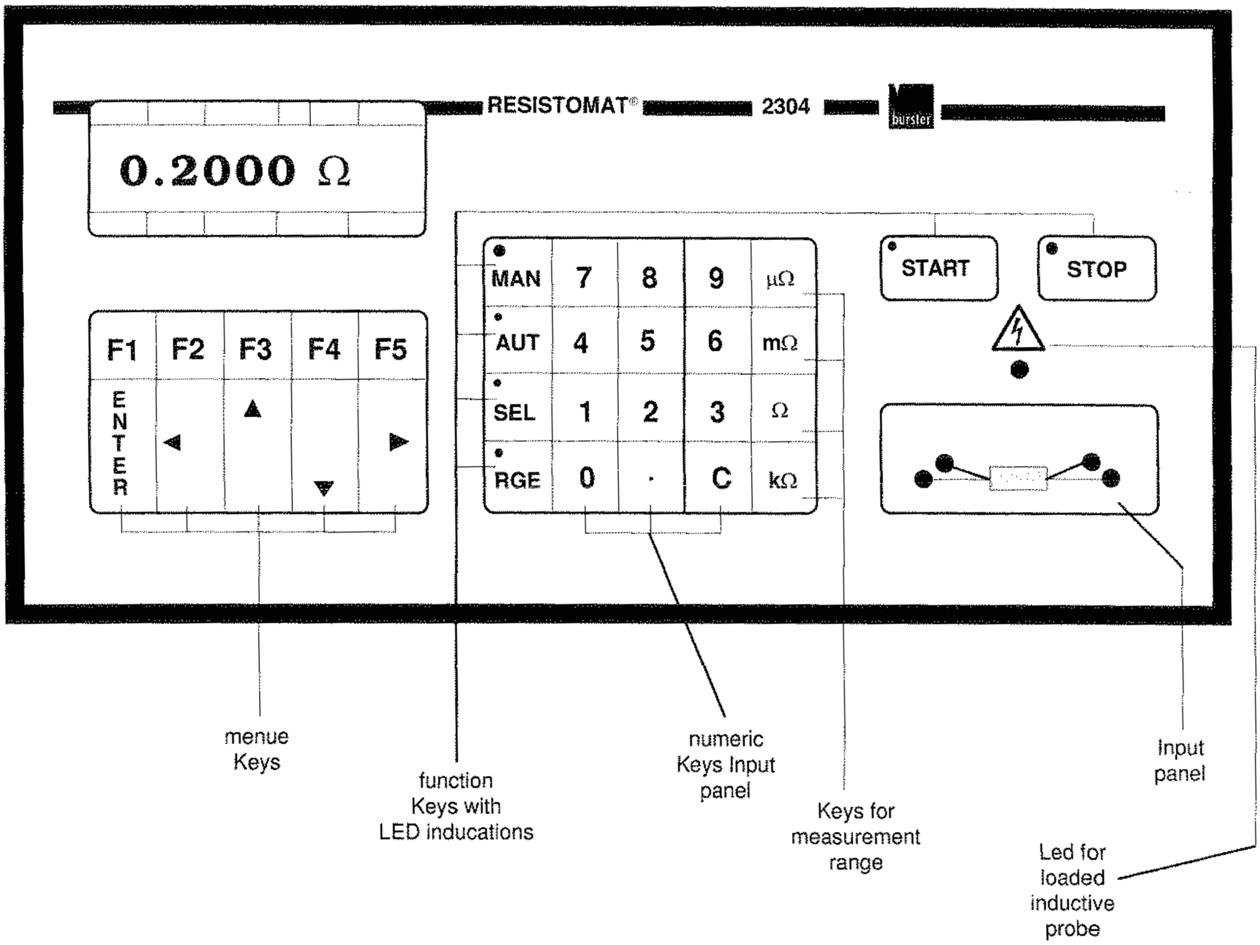


Figure 2.2: Controls

When is the warning LED ⚠ lit?

1) The measurement mode Z for inductive test objects (see page 3-1-10) must be selected and start of measurement should be triggered (inductive test objects are not identified by the device itself).
2) After the STOP button has been pressed the LED will glow on for a while (depending on the inductance).

For safety reasons it is not allowed to remove the test objects as long as the LED is illuminated (setup of inductive reverse voltage). This also applies, if the STOP-LED is illuminated simultaneously.

The controls in Fig. 2.2 are arranged in the following function blocks:

Display-oriented keypad

This block has five function keys

F1 - F5,

whose meanings are defined according to the selected menu, as well as the

Cursor controls ◀ , ▲ , t
and ▶ .

Using the

Cursor controls, ▲ , t , ◀ , ▶

parameters (lines) are selected and value lists are scrolled through.

In the case of external computer control (see Chap. 6),

the F5 key

has a special function:

It allows a return to keyboard operation, which causes the F5 definition = LOCAL displayed during computer control to vanish.

The

***ENTER* key**

is meant for acknowledging entries. After this key is operated, the program returns to one of the three main menus (exceptions: scaling factor calibration described in Chap. 5.3 and the menu for individual, range-dependent selection of the measuring current described in Chap. 3.1.2, IV.3).

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Permanently assigned function keys

Measurement range selection:

| · AUT | : | AUTomatic range selection, i.e. the device automatically selects the smallest possible measurement range (automatically to 20 kΩ after power-up).When the automatic range selection is active (only possible when ohmic load R is selected, see Chap. 3.1.2, V.6), the LED (light emitting diode) integrated in the key lights up. |

| · MAN | : | MANual measurement range selection, i.e. the desired measurement range must be entered with the · RGE key. If this operating mode is active, the LED integrated in the key lights up. |

| · RGE | : | Start of the manual measurement range entry („RanGE"). This is only possible under the following conditions: |

- The STOP LED is lit (no measurements are in progress), and the MAN LED is lit (manual measurement range selection), and the ⚠ LED does not light up, and
- one of the three main menus is shown on the display.

(e.g.):
Sequence:

· RGE 1 5 0 Ω

The RGE LED stays lit until the entry with the unit key Ω is complete. In this example, the expected measured value of 150 Ω is entered; this is acknowledged by the system in that the appropriate measurement range of 200 Ω is selected.

1st Alternative:
Use of the units key (see Chap. 2.4.4)

· RGE Ω ,

i.e. entry of the expected order of magnitude of the measured value [μΩ, mΩ, Ω, kΩ]; this is acknowledged by the system in that the largest possible corresponding measurement range is selected (200 Ω in this example again):

[μΩ]	Key:	200	μΩ	Range,
[mΩ]	Key:	200	mΩ	Range,
[Ω]	Key:	200	Ω	Range,
[kΩ]	Key:	20	kΩ	Range.

2nd Alternative:
Incrementing or decrementing the measurement range with the cursor keys

· RGE ▲ (or ▶) ENTER

or

· RGE ▼ (or ◀) ENTER

i.e. selection of the measurement range indicated in the field for measured values with the help of the cursor keys.

The RGE LED remains lit until the entry is completed with the ENTER key. The entry has then been accepted.

In principle, the following range limits are valid:

Range	Measured value
200 µΩ	< 200 µΩ
2 mΩ	< 2 mΩ
20 mΩ	< 20 mΩ
200 mΩ	< 200 mΩ
2 Ω	< 2 Ω
20 Ω	< 20 Ω
200 Ω	< 200 Ω
2 Ω	< 2 kΩ
20 kΩ	< 20 kΩ

Measurement range selection

Starting a measurement:

A measurement can be started via the keyboad or an externally connected switch. During the measurement, no entries are possible apart from STOP and F5 LOCAL!

I) Sequence when a keyboard is used::

· START	and acknowledgement of a succesful measurement start is indicated by the flashing of the LED integrated in the key. The START LED remains lit until the measurement is stopped.

II) Sequence with external switch:

Connection of a control cable (see Chap. 7.2.3.) and closing of the external switching contact (directly or via optocoupler).
In the REPETITION measurement mode, this control contact is equipped internally with a bi-stable circuit function; as a result, the measurement is stopped when the contact is closed a second time, and started again the third time the contact is actuated.
The time interval between two contact operations must be ≥ 1 second.

Stopping a measurement:

Similar to 2.4.2.2.1, a measurement can be stopped via the keyboard or via an externally connected switch:

I) Sequence when the keyboard is used:

· STOP	and acknowledgement of a successful measurement stop is indicated the flashing of the LED integrated in the key. The STOP LED remains lit until the measurement is started.

In the SINGLE measurement mode, the device stops automatically after a measurement sequence is completed (the START LED goes off, and the STOP LED comes on).

II) Sequence with an external switch:

The sequence described in 2.4.2.2.1,II) applies here, if the REPETITION measurement mode is selected. Otherwise the device stops automatically after a measurement sequence is completed.

Access to configuration and calibration menus

· SEL	Start of the entry of a 4-digit security code („SELect"), with the help of which various configuration and calibration menus are accessible as described in Chapters 4 and 5 (not possible while a measurement is in progress, i.e. the STOP LED must be lit).

Sequence:

· SEL   N1   N2   N3   N4

The SEL LED remains lit until the entry of the last *Number N4* is complete.

The selected configuration or calibration menu only appears after the correct code has been entered.

Any attempt to enter a security code (successful or unsuccessful) effects an entry (with date and time) in the access monitor (see Chap. 3.3.2).
A current entry up to N3 can be aborted with the clear key C.

Numerical keyboard:

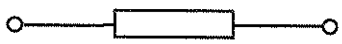
This section contains the nine numerical keys 0 ... 9, the decimal point and the clear key *C*, with the help of which entries which have been started can be cleared.
This clear function also resets the
· SEL und · RGE
functions.

Units key:

The μΩ ... kΩ keys are meant for completing range entries which have been started with the · RGE key, and for completing all other entries with the Ω unit (e.g. comparator limiting values, reference variables etc.) without use of the · RGE -key.

Test unit connections:

Test units are connected in 4-wire resp. Kelvin configuration; the two outer terminals on the front panel shown in Fig. 2.2



comprise the current path, while the inner terminals next to the resistance symbol comprise the voltage circuit.

The warning LED marked with ⚠ indicates whether an inductive test unit has been recognized if load type Z has been selected (see Chap. 2.3.1, K4 and Chap. 3.1.2 .
As long as this LED stays lit, the test unit may not be removed, for reasons of safety (build-up of inductive counter e.m.f's). This also applies when the STOP LED lights up at the same time.

As shown in Fig. 1.2, it is also possible to connect the test unit to a connector on the rear panel of the device.
The pin assignment can be found in Chap. 7.2.4.

As long as the ⚠ -LED stays on, no entries are possible, except for STOP and F5-LOCAL.

Measurement of inductive test-units

(e.g. motors, transformers, cable drums)

Important!

Particular caution must be exercised with inductive test units!

If
- the plugs are pulled out of their sockets,
- the measurement current is switched over,
- the cables tear,
- the terminals on the test unit are loose,
- the unit is turned off during a measurement,
- the power fails during a measurement,
- the measurement current changes due to other

Then this could give rise to extremely hazardous induced voltages which might also destroy the unit.

Notes

When inductive test units are measured, energy accumulates inside them. In case of any interruption, no matter how brief, this energy is discharged in an uncontrolled manner. This could result in severe injuries to operators and damage to the measuring device. Consequently, only controlled discharges via the internal circuit are permissible. For this, press the STOP key and wait for the red warning lamp above the measurement terminals on the front panel to go off.

Recommended device setting:

- UNIPOLAR measuring sequence	see page	4-5-1
- LOW or MEDIUM resolution	"	3-1-12
- LARGE measurement current	"	3-1-6
- Average value 1	"	3-1-6
- Time base 9	"	3-1-6
- Measurement pause 1	"	3-1-6
- Load Z	"	3-1-6

Note that the device does not recognize inductive test units itself, but that the "Z" operating mode must be selected by the user.

Bipolar as well as single measurements are possible for test units with a small inductive component (known to include transformers and motors rated up to approx. 2 kVA).

The moment the measurement values are no longer reproducible, i.e. exhibit distinct steps, a switchover must be made to unipolar and continuous measurement.

The measurement current must be as large as possible, due to the constant presence of ambient interferences and thermal e.m.f's in the measuring circuit.

To obtain stable measurement values nevertheless, the time base of the A/D converter must be set to 9, and the average-value formation must be increased to the required value (1- approx. 10).

The measurement pause should always remain set to 1.
Increases in the case of small inductive test units and bipolar measurement are only feasible in extreme ranges and the presence of severely fluctuating thermal e.m.f's. The set value combined with the transient time has a multiplicative effect on the total measurement time. For this reason, particular caution must be exerceised here.

In the case of extremely long discharge times, the measurement is interrupted. If this occurs, a careful increase in the measurement pause can still allow the measurrement to be continued.

For test units with an inductive response, the „Load" must always be set to „Z".

The measuring circuit must be checked before a measurement is started; in particular, it must be ensured that the contacts are mechanically and electrically secure.

By selecting the appropriate measurement leads and connecting them properly to the test unit, ensure that the current flow cannot be interrupted under any circumstances until the test unit is completely discharged.
To discharge the test unit:

Press the STOP key and wait for the red warning lamp above the measurement terminals on the front panel to go off. It is only afterwards that the measurement circuit can be interrupted without any danger to the operator or the device.

To check the extent to which a measurement can be reproduced, wait sufficiently long after the warning lamp has extinguished before repeating the measurement. This is because the test unit still carries low residual induced voltages which are not yet discharged entirely when the warning lamp goes off, and which would thus affect results if a new measurement were commenced immediately.

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Operation of the RESISTOMAT®2304

Operation of the RESISTOMAT®2304

Parameterizing (main menu 1)

General information

The main menu shown in Fig. 3.1 allows access to setting menus with the help of which measurement parameters, boundary conditions, measurement units and their reference variables can be specified. Figure 3.2 shows the underlying, three-level menu hierarchy as well as the function keys and paths via which transitions between the individual menus can be made.

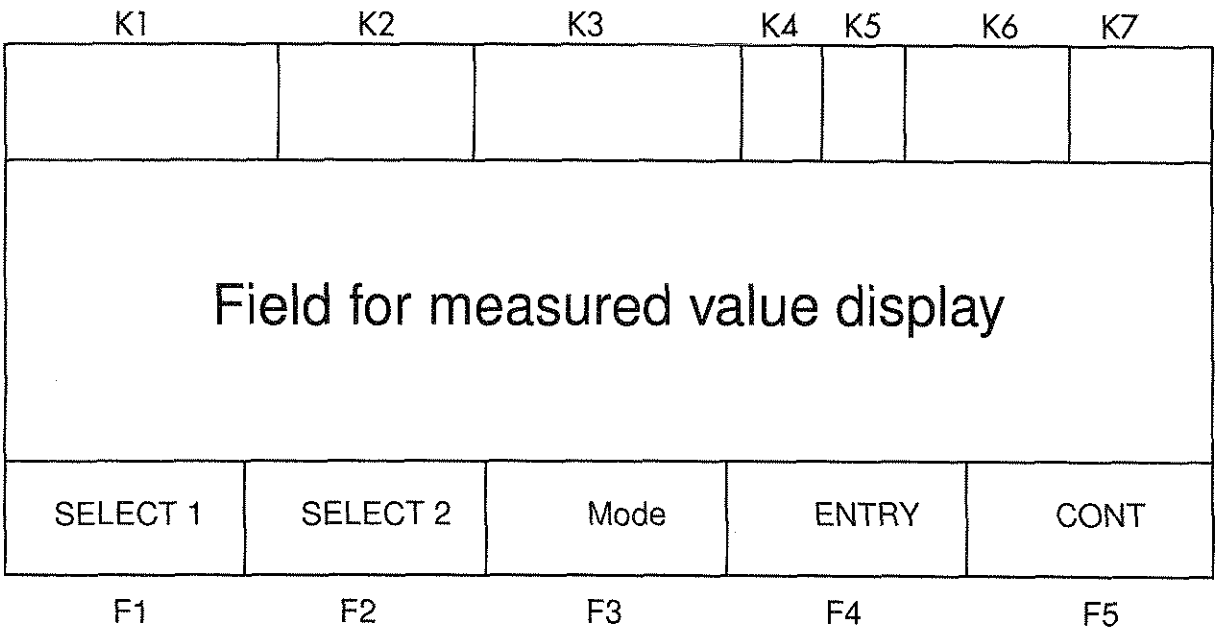

Fig. 3.1: Parameterizing (main menu 1)

I) Access,
Via cold start (mains switch on) or via
F5 = CONTINUE into special functions (main menu 3).

II) Function
Measured value or comparator display and selection
of various parameterizing menus.

III) Restrictions,
F4 in IV.4 is dispensed with if the measurement unit Ω
has been selected.

IV) Function keys:

IV.1)	SELECT 1 / F 1 :	Setting the measurement parameterizing menu (**SELECT** menu **1**)
IV.2)	SELECT 2 / F 2 :	Setting the boundary conditions (**SELECT** menu **2**)
IV.3)	MODE / F 3 :	Selecting the measurement units (DISPlay **MODE**)
IV.4)	ENTRY / F 4 :	Selecting the **ENTRY** of the reference variables for the measurement unit selected via F 3 (Ω/m, Ω/km, Δ %) or the indicated variable r = specific resistance, the indicated variable g = specific conductance.

V) Parameters

Header fields as described in Chap. 2.3.2

VI) Special comments

None.

VII) Exit

Via F 5 / = **CONT**inue into Evaluation (main menu)

or

via / SEL / N1 / N2 / N3 / N4 / into the configuration menus.

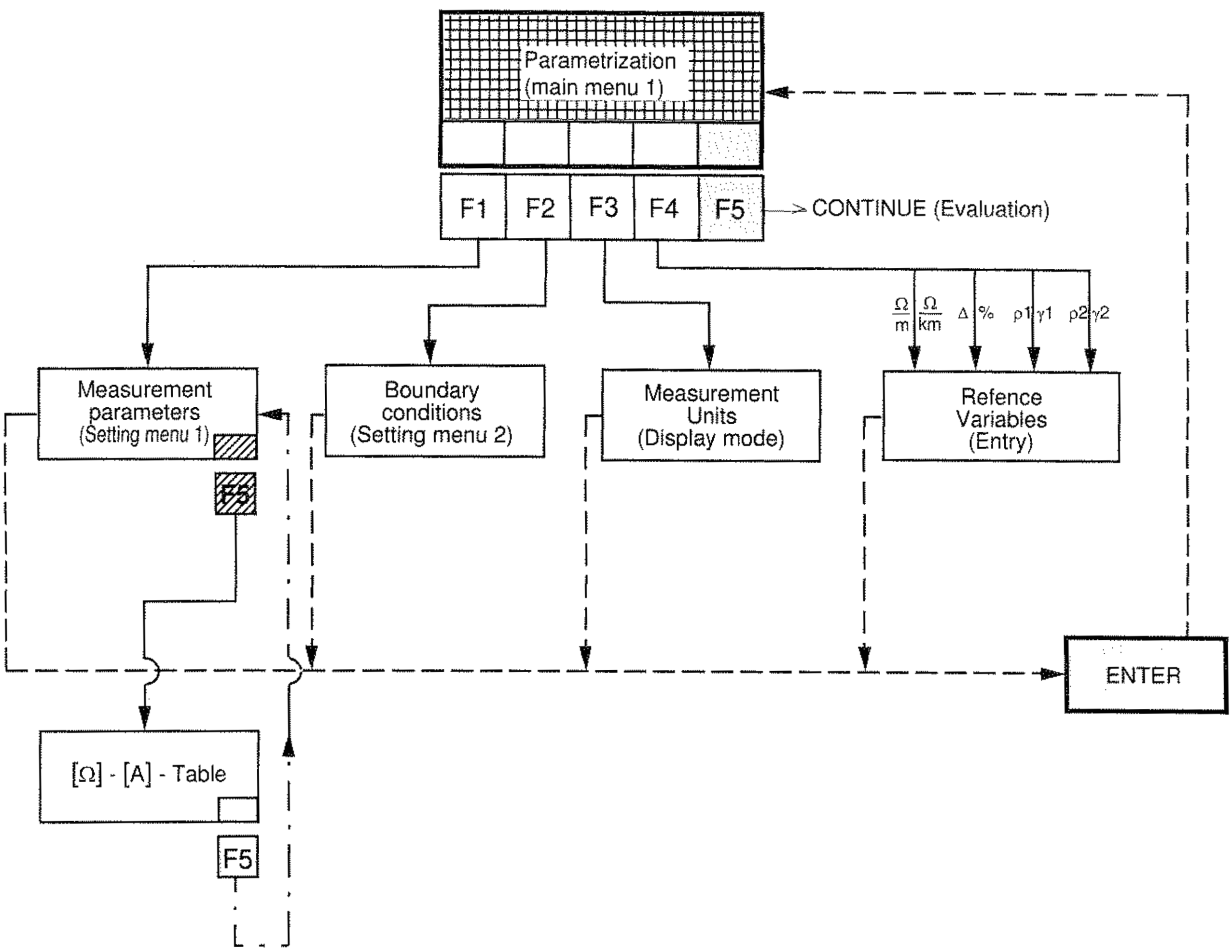

Fig. 3.2: Hierarchy of the parameterizing menu

Measurement parameters (SELECT 1)

MEASUREMENT MODE:	REPETITION
MEASURING CURRENT:	LARGE
AVERAGE VALUE:	1
TIME BASE(50 HZ):	5
MEAS. PAUSE:	1
LOAD:	R
	INDIV.

Fig. 3.3: Measurement parameters

I) Access:
Via F1 = SELECT 1 within "parameterize" (main menu 1)

II) Function:
Setting.

III) Restrictions:
The setting of individual measuring currents via F5 = INDIV is only possible if the INDIV option in line 2 in the measuring current value list has also been selected.

IV) Function keys:

IV.1) ▲ ▼ : (Cursor) keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is indicated in the display field in inverse form.

IV.2) ◀ ▶ : Cursor keys for scrolling through the value list provided for the selected parameter. The next parameter appears when the ▶ key is pressed, and the previous parameter appears when the ◀ key is presssed.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.3) INDIV. / F 5 : Selection of the menu for INDIVidual, range-dependent setting of the measurement current (100µA...10A), provided the INDIV option in line 2 of the measurement current value list has also been selected.

After this function key is operated, the table shown in Fig. 3.4 appears. (Variations in the current are possible depending on the previous setting).

200 µΩ	10 A	200 Ω	1 mA
2 mΩ	10 A	2 kΩ	1 mA
20 mΩ	1 A	20 kΩ	100 µA
200 mΩ	100 mA		
2 Ω	10 mA		
20 Ω	1 mA		RETURN

Fig. 3.4: Table of measurement currents which can be set individually

Every line represents one of the measurement ranges between 200 μΩ and 20 kΩ, and is selected by means of the ▲ - ▼ keys.
A maximum of four measuring currents are assigned to each measurement range, as shown in Fig. 3.5.

Measurement range	Selectable measuring currents					
200 μΩ	10 A					
2 mΩ	10 A,	1 A				
20 mΩ	10 A,	1 A,	100 mA			
200 mΩ		1 A,	100 mA,	10 mA		
2 Ω		1 A,	100 mA,	10 mA,	1 mA	
20 Ω			100 mA,	10 mA,	1 mA,	100 μA
200 Ω				10 mA,	1 mA,	100 μA
2 kΩ					1 mA,	100 μA
20 kΩ						100 μA

Fig. 3.5: Value list of the measuring currents which can be selected for each measurement range

The value lists are scrolled through with the ◀ - ▶ - keys.
The acknowledgement of the displayed value and, thus, the return to the "parameterize" menu is effected via the F5 RETURN key.

V) Parameters

V.1) MEASUREMENT MODE:

The following value lists are provided:

SINGLE: When the START key is pressed, only one measured value is computed and displayed (= 1 measurement cycle); after that, the device automatically returns to the · STOP state.

REP.: When the START key is pressed, measured values are computed and displayed until the measurement is aborted by pressing the STOP key, or a measurement or contact error occurs during operation with a preselected load type Z (resistance with inductive component).

REF0.: You can only choice it, if you have adjust measurement "CONSTANT" (see page 4-5-2). On mesure start the device make first a zero-reference measurement.

V.1) MEASURING CURRENT:

The following value lists are provided; they can be scrolled through with the ◀ - ▶ - keys:

SMALL,

MEDIUM,

LARGE,

INDIV.

Depending on the range selected, the first three settings correspond to the current values shown in Fig. 3.6:

Range	SMALL	MEDIUM	LARGE
200 μΩ	10 A	10 A	10 A
2 mΩ	1 A	10 A	10 A
20 mΩ	100 mA	1 A	10 A
200 mΩ	10 mA	100 A	1 A
2 Ω	1 mA	100 A	1 A
20 Ω	100 μA	10 mA	100 mA
200 Ω	100 μA	1 mA	10 mA
2 kΩ	100 μA	1 mA	1 mA
20 kΩ	100 μA	100 μA	100 μA

Fig. 3.6: Measurement currents for the SMALL, MEDIUM and LARGE categories.

Only the last option, INDIV, allows the individual, range-dependent selection of the measurement current (see Chap. 3.1.2, IV.3).

V.3) AVERAGE VALUE:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$1 \leq \text{input value} \leq 255$$

is available, whereby the input value specifies the number of selected measurement cycles by means of which an average value is formed and indicated.

V.4) TIME BASE:
Inputs for this menu line are made with the numerical keyboard (see Chap. 2.4.3). For this, the value range:

$$1 \leq \text{input value} \leq 9$$

is available, whereby the input value specifies the multiple of the mains frequency period (50 Hz: 20 ms, 60 Hz: 16.7 ms) over which the single measured values are integrated within a cycle.
The adaption to the line frequency can be altered within the scope of the configuration menu 4.3.

V.5) MEASUREMENT PAUSE:

Entries for this menu line, which is significant for inductive test units, are made with the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$1 \leq \text{input value} \leq 255$$

is available, whereby the input value specifies the waiting periods between two different measuring currents or amplifier channels within a measurement cycle. This waiting period constitutes a multiple of the mains frequency period (50 Hz: 20 ms, 60 Hz: 16.7 ms) and is sometimes needed for inductive test units in order to adapt transient periods and charging periods for the test unit. Details concerning this can be found in Chap. 1.6.

V.6) LOAD:

The following list values

R and Z

are available; they can be scrolled through with the ◄ - ► keys.
R implies a purely ohmic test load, while Z represents an inductive or ohmic load.

When Z is selected, an inductance test is carried out before each measurement. For this reason, the measurement time is always longer than on the R selection, where this test is omitted.
Before measurements on transformers and motors are carried out, all windings must be fully discharged and open. Otherwise the error message ERR 0 could occur. (see Chap. 7.3).

VI) Special comments:

Assuming that sufficiently stable measured results are to be obtained within the shortest possible measuring time, the table in Fig. 3.7 contains guidelines on how to select the correct measuring parameters (MEASUREMENT PAUSE as described in Chap. 3.1.2, V.5 is normally = 1):

Operating mode / Criterion	MEASUREMENT SEQUENCE Chap. 4.5 V.1)	MEASURING CURRENT Chap. 3.1.2 V.2)	TIME BASE Chap. 3.1.2 V.4)	AVERAGE VALUE Chap. 3.1.2 V.3)	MEASURING RANGE Chap. 2.4.2.1)
Stable measurement of ohmic resistances (R)	BIPOLAR	MEDIUM or LARGE	Basic settings as in Chap. 7.4		Arbitrary
Preventing ohmic test units (R) from heating up	BIPOLAR or UNIPOLAR	MEDIUM or SMALL; if LARGE is required, observe measurement-range instructions!	Arbitrary		Examine load capacity of test unit.
Interference in measurement set-up expected (R or Z)	BIPOLAR or UNIPOLAR	As LARGE as possible	1st. Prior.: as large as possible, ≤ 9	2nd. Prior.: as large as necessary, ≤ 255	In case of unstable display and/or amp. overload, select next highest range.
Large or strongly varying thermal e.m.f's (R or Z)	Preferably BIPOLAR	As LARGE as possible	1st. Prior.: as small as possible ≥ 1	2nd. Prior.: as large as necessary ≤ 255	Arbitrary
	If BIPOLAR not possible, UNIPOLAR	As LARGE as possible	1st. Prior.: as large as necassary for stable display	2nd. Prior.: in case TIME BASE = max. increase AVERAGE VALUE	Arbitrary
Stable measurement of resistances with arge inductive component (Z)	Large Z: UNIPOLAR; Small Z: BIPOLAR; Medium Z: Possibly BIPOLAR with MEAS. PAUSE > 1	As Large as possible	TIME BASE = 5 - 9 MEAS. PAUSE = 1	As large as necessary	Beginning at 20 kΩ, "approach" from above! RESOLUTION (Chap. 3.1.3 V.5) = LOW
		In case of oscillations or undesived transient phases, adapt release limits as described in Chap. 4.6 !			

Fig. 3.7: Correct selection of parameters

VII) E x i t:
Via the function key ENTER into "parameterize" (main menu1)).

B o u n d a r y c o n d i t i o n s (select menu 2)

DATE:	dd. mm. yy
TIME:	hh. mm. ss
CONTRAST:	54
BUZZER:	OFF
RESOLUTION:	MEDIUM

Fig. 3.8: Boundary conditions

I) A c c e s s:
Via F2 = SELECT 2 within "parameterize" (main menu 1).

II) F u n c t i o n :
Display and setting of various boundary conditions relating mainly to the operating interface.

III) R e s t r i c t i o n s:
None.

IV) F u n c t i o n k e y s:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is indicated in inverse form.

◀ ▶	:	Cursor keys for scrolling through the value list provided for the selected parameter. When the ▶ key is pressed, the next value appears; when the ◀ key is pressed, the last value appears.
IV.2) ENTER	:	Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) DATE:

This line acommodates the current date to be indicated ("READ ONLY" mode), which can also be changed in the configuration menu (see Chap. 4.4.).

V.2) TIME:

This line accommodates the current time to be indicated („READ ONLY"-mode), which can also be reset in the configuration menu (see Chap. 4.4).

V.3) CONTRAST:

Entries for this menu line are made by means of the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$1 \leq \text{input value} \leq 100$$

is available, whereby the input value 1 constitutes the smallest, and the value 100 the largest contrast setting for the liquid crystal display. The value 54 is ideal at room temperature (20°C).

V.4) BUZZER:

The list values

ON and OFF

are avaliable; they can be scrolled through with the ◀ - ▶ - keys.

ON means that the BUZZER is active. This indicates the discharge of an inductive test unit (together with the warning LED described in Chap. 2.4.5)

OFF means that the BUZZER is inactive.

V.5) RESOLUTION:

The following list values are avaliable; they can be scrolled through with the ◀ - ▶ -keys:

HIGH	=	display of 5 1/2 digit positions,
MEDIUM	=	display of 4 1/2 digit positions,
LOW	=	display of 3 1/2 digit positions,

The larger the selected resolution, the longer the measurement period. On the LARGE setting, which is normally only meant for basic investigations, the AVERAGE VALUE (V.3 from Chap. 3.1.2) and MEASUREMENT TIME (V.4 from Chap. 3.1.2) parameters are automatically set to ≥ 5. Lower settings are not possible then.

VI) Special comments:

With this device, even a resolution of 1 nΩ can be achieved if the following settings are chosen:

MEASUREMENT RANGE	=	200 $\mu\Omega$,	
RESOLUTION	=	HIGH,	
AVERAGE VALUE	$\geq$	40	} Measurement time $\geq$ 35 s with load "R"
MEASUREMENT TIME	=	9	

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VII) Exit:

Via the function key ENTER into the "parameterize" menu (main menu 1)

Measurement units (display mode)

Ω	ρ_1	=	$R \cdot S / l$
Ω / m	ρ_2	=	$R \cdot m / (\rho_m \cdot l^2)$
Ω / km	γ_1	=	$l / (R \cdot S)$
Ω / 10 ft	γ_2	=	$\rho_m \cdot l^2 / (R \cdot m)$
Ω / kft	Δ %		

Fig. 3.9: Measurement units ("S" implies cross-sectional area in accordance with DIN 1304)

I) Access:

via F3 = MODE within "parameterize" (main menu 1).

II) Function:

Setting of the measurement unit to be indicated for the resistance measurement.

III) Restrictions:

The measurement of cooling curves (see Chap. 3.3.3) is only possible with the Ω unit!

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is indicated on the display field in inverse form.

◀ ▶ : Cursor keys for column selection. Pressing the ▶ key effects a shift to the right, while pressing the ◀ key effects a shift to the left.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) Ω:
If this line is selected by means of the cursor keys, all measured values are indicated in Ω. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

V.2) Ω / m:
If this line is selected by means of the cursor keys, all measured values are indicated in Ω/m. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

V.3) Ω / km:
If this line is selected with the cursor keys, all measured values are indicated in Ω/km. All evaluating and special functions described in Chap.3.2 and 3.3 also relate to this measurement unit.

V.4) Ω / 10 ft:
If this line is selected by means of the cursor keys, all measured values are indicated in Ω/10 ft. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

V.5) Ω / kft:
If this line is selected by means of the cursor keys, all measured values are indicated in Ω/kft. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

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V.6) $\rho_1 = R \cdot S / l$:

If this line is selected with the cursor keys, the device indicates the specific resistance r in $\Omega *$ unit of length, based on the conductorcross-section S and the conductor length l. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

V.7) $\rho_2 = R \cdot m / (\rho_m \cdot l^2)$:

If this line is selected with the cursor keys, the device indicates the specific resistance ρ in $\Omega *$ unit of length, based on the mass m, density ρ_m and conductor length l. All evaluating and special functions described in Chap. 3.2 and 3.3. also relate to this measurement unit.

V.8) $\gamma_1 = l / (R \cdot S)$:

If this line is selected with the cursor keys, the device indicates the specific conductance g in $l/(\Omega *$ unit of length), based on the conductor cross-section S and the conductor length l. All evaluating and special functions described in Chap. 3.2 and 3.3. also relate to this measurement unit.

V.9) $\gamma_2 = \rho_m \cdot l^2 / (R \cdot m)$:

If this line is selected with the cursor keys, the device indicates the specific conductance g in $l / (\Omega *$ unit of length), based on the mass m, density ρ_m and conductor length l. All evaluating and special functions described in Chap. 3.2 and 3.3 also relate to this measurement unit.

V.10) Δ %:

If this line is selected by means of the cursor keys, the device shows Δ R as a precentage deviation from the entered specified value R. Evaluating and special functions relate to Ω.

VI) Special comments:

The reference variables required for the measurement units V.2) to V.10) are entered in the reference variable menu shown in Chap. 3.1.5. This menu is only inaccessible when the measurement unit Ω has been selected. The mass m in the case of ρ_2 and γ_2 must be based on the measured length!

VII) Exit:

Via the function key ENTER into "parameterize" (main menu 1).

Reference variables (ENTRY)

Reference variable for Ω/m and Ω/km

LENGTH: 1 m

m	km			

Fig. 3.10: Reference variable for Ω/unit of length

I) Access:

via F4 = ENTRY within „parameterize“ (main menu 1), provided Ω/m or Ω/km has been selected in the measurement unit menu (see Chap. 3.1.4)

II) Function:

Input of the reference variable m oder km.

III) Restrictions:

None.

IV) Function keys:

IV.1) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.2) | m / F 1 | : Unit key for completing a numerical entry of length in **m** as the reference variable.

IV.3) | km / F 2 | : Unit key for completing a numerical entry of length in **km** as the reference variable.

V) Parameters:

V.1) LENGTH:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$$0.001 \text{ m} \leq \text{input value} \leq 999.999 \text{ km}$$

is available.

VI) Special comments:

None.

VII) Exit:

Via the function keys F1 or F2 into „parameterize" (main menu 1).

Reference variables (ENTRY)

Reference variable for Ω/10 ft and Ω/kft

LENGTH: 100 ft

ft	k ft			

Fig. 3.10: Reference variable for Ω/unit of length

I) Access:
via F4 = ENTRY within „parameterize“ (main menu 1), provided Ω/10 ft or Ω/kft has been selected in the measurement unit menu (see Chap. 3.1.4)

II) Function:
Input of the reference variable ft oder kft.

III) Restrictions:
None.

IV) Function keys:

IV.1) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.2) | ft / F 1 | : Unit key for completing a numerical entry of length in **m** as the reference variable.

IV.3) | kft / F 2 | : Unit key for completing a numerical entry of length in **km** as the reference variable.

V) Parameters:

V.1) LENGTH:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

0.001 ft ≤ input value ≤ 999.999 kft

is available.

VI) Special comments:

None.

VII) Exit:

Via the function keys F1 or F2 into „parameterize“ (main menu 1).

Reference variable for Δ %

SPEC. VALUE 100.00 Ω

Fig. 3.11: Reference variable for Δ %

I) Access:

Via F4 = ENTRY within „parameterize" (main menu 1), provided that D % has been selected in the measurement unit menu (see Chap. 3.1.4)

II) Function:

Input of the reference resistance resp. specified resistance R.

III) Restrictions:

Only Ω is permissible as a measurement unit for the D % reference variable!

IV) Function keys:

IV.1) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.2) μΩ kΩ : Unit key for completing a numerical entry of resistance in μΩ ... kΩ.

V) Parameters:

V.1) SPECIFIED VALUE:

Entries for this menu line are made with the help of the numerical keyboard (see Chap.2.4.3) including the decimal point.

VI) Special comments:

None.

VII) Exit:

Via the function key ENTER into „parameterize" (main menu 1).

Reference variable for ρ_1 and γ_1

LENGTH: 1 m

CROSS-SECTION: 1 mm²

m		mm²		

Fig.3.12: Reference variable for ρ_1 and γ_1

I) **Access:**
Via F4 = ENTRY within „parameterize" (main menu 1), provided ρ_1 or γ_1 has been selected in the measurement unit menu (see Chap. 3.1.4).

II) **Function:**
Input of the reference length and the reference cross-section.

III) **Restrictions:**
None.

IV) **Function keys:**

IV.1) ▼ ▲ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is displayed in inverse form.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.3) [m / F 1] : Unit key for completing a numerical entry of length in **m** as the reference variable.

IV.4) [mm^2 / F 3] : Unit key for completing a numerical entry of cross-sectional area in **mm^2** as the reference variable.

V) Parameters:

V.1) LENGTH:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$$0.01 \text{ m} \leq \text{input value} \leq 99.999 \text{ m}$$

is available.

V.2) CROSS-SECTION:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$$0.00001 \text{ mm}^2 \leq \text{input value} \leq 9999 \text{ mm}^2$$

is available.

VI.) Special comments:

None.

VII) Exit:

Via the function key ENTER into „parameterize“ (main menu 1).

Reference variable for ρ_2 and γ_2

MASS:		1 g		
LENGTH:		1 mm		
DENSITY:		8.9 g/cm³		
MEAS.-LENGTH:		0.8 m		
m		g	kg	g/cm³

Fig.3.12: Reference variables for ρ_2 and γ_2

I) Access:
via F4 = ENTRY within „parameterize“ (main menu 1), provided that ρ_2 or γ_2 has been selected in the measurement unit menu (see Chap. 3.1.4).

II) Function:
Input of the reference mass, length and density.

III) Restrictions:
None.

IV) Function keys:

IV.1) ▼ ▲ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is displayed in inverse form.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.3) m / F1 : Unit key for completing a numerical entry of length in **m** as the reference variable.

IV.4) | g / F 3 | : Unit key for completing a numerical entry of mass in **g** as the reference variable.

IV.5) | mm^2 / F 1 | : Unit key for completing a numerical entry of cross-sectional area in **mm²** as the reference variable.

IV.6) | g/cm^3 / F 5 | : Unit key for completing a numerical entry of density in **g/cm³** as the reference variable.

V) Parameters:

V.1) MASS:
Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$0.00001 \text{ g} \leq \text{input value} \leq 99.9999 \text{ kg}$

is available.

V.2) LENGTH:
Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$0.01 \text{ m} \leq \text{input value} \leq 99.999 \text{ m}$

is available.

V.3) DENSITY:
Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3) including the decimal point key. For this, the value range

$0.01 \text{ g/cm}^3 \leq \text{input value} \leq 99 \text{ g/cm}^3$

is available.

VI.) Special comments:
Entries of mass must be related to the measured length!

VII.) Exit:
Via the function key ENTER into „parameterize“ (main menu 1).

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Evaluation (main menu 2)

General information

Main menu 2 shown in Fig. 3.14 allows access to parameterizing and evaluating menus related to temperature compensation and the comparator functions. Fig. 3.15 shows the underlying, three-level menu hierarchy and the function keys resp. paths via which transitions between the individual menus can be made.

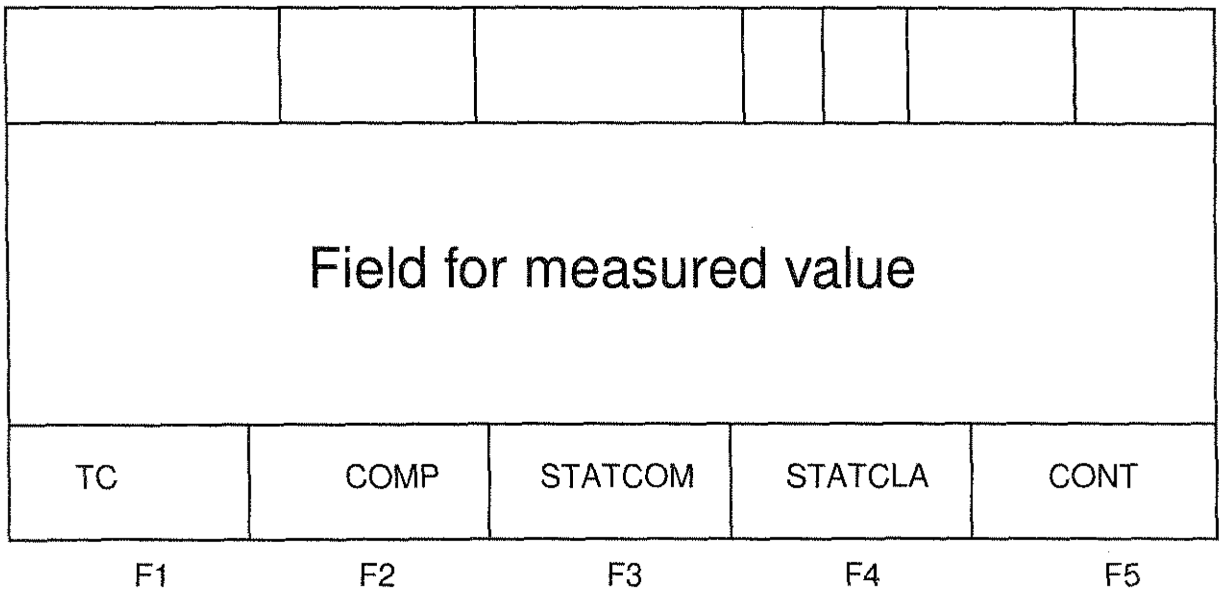

Fig. 3.14: Evaluation (main menu 2)

I) Access:

via F5 = CONTinue within parameterize (main menu 1).

II) Function:

Measured-value or comparator display, selection of the menu for temperature compensation, comparator parameterizing, and two comparator evaluation functions.

III) Restrictions:

None.

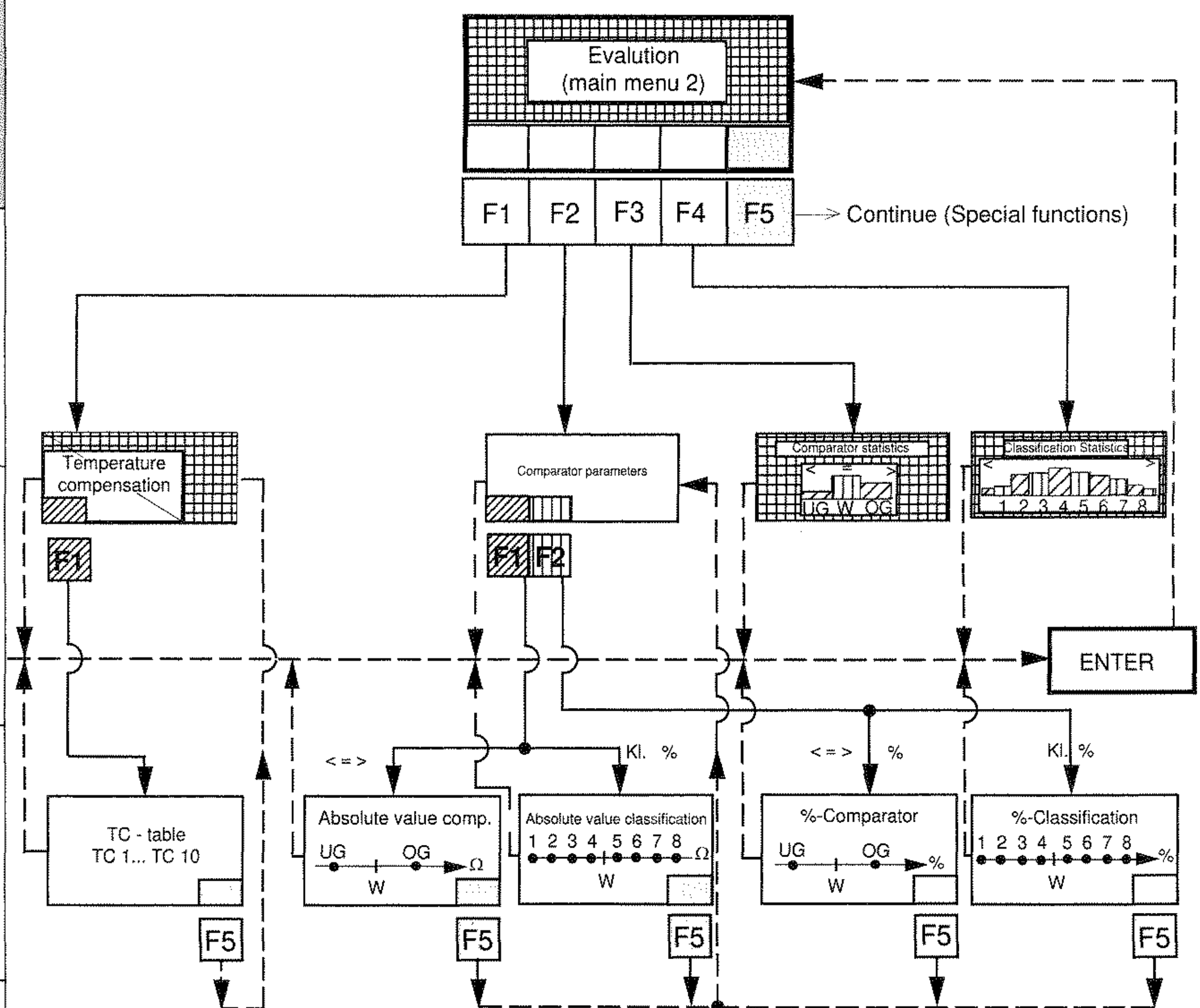

Fig. 3.15: Hierarchy of the evaluation menu

IV) Function keys:

IV.1) TC / F 1 : Selection of the menu for parameterizing the **T**emperature **C**ompensation resp. for indicating the temperature of the test unit.

IV.2) COMP / F 2 : Selection of the menu for parameterizing the **COMP**arator functions (including the bar display).

IV.3) STATCOM / F 3 : Selection of the **COM**parator evaluation **STAT**istics (< = > and summation).

IV.4) STATCLA / F 4 : Selection of the **CLA**ssification evaluation **STAT**istics (9 classes and summation).

V) Parameters:

Header fields (see Chap. 2.3.2)

VI) Special comments:

None.

VII) Exit:

via F 5 / = CONTinue within special functions (main menu 3)
or
via / SEL / N1 / N2 / N3 / N4 / into the configuration menus.

Temperatur compensation (TC)

TEMP.COMP:	OFF
MEASUREMENT:	MAN
TEMPERATURE:	+ 20 °C
TEMP.COEFF.:	3980 ppm/k

COEFF	+ / -			

Fig.3.16: Temperature compensation

I) Access:
via F1 = TC within "evaluation" (main menu 2)

II) Function:
Setting of various parameters which specifiy the type of temperature compensation.

III) Restrictions:
None.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is shown in the display field in inverse form.

◀ ▶	:	Cursor keys for scrolling through the value list provided for the selected parameter. When the ▶ key is pressed, the next value appears; when the ◀ key is pressed, the last value appears.
IV.2) ENTER	:	Acknowledgement of the current parameter setting and return to the next higher menu level.
IV.3) Coeff. / F 1	:	Selection of the table with 10 temperature COEFFicients which can be preset. When the function key is operated, the table shown in Fig. 3.4 appears.

TC 1	:	1600	TC 6	:	4030
TC 2	:	1700	TC 7	:	4500
TC 3	:	2400	TC 8	:	4800
TC 4	:	3100	TC 9	:	6000
TC 5	:	3980	TC 10	:	6500
					RETURN

Fig. 3.17: Table with 10 temperature coefficients which can be preset.

Every line represents one of the 10 temperature coefficient presettings, is selected with the ▲ - ▼ - keys. This line is then indicated in inverse form. Renewed entry of a selected temperature coefficient can be made via the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$0 \leq \text{input value} \leq +9999$$

is available.
The acknowledgement of the display value and the consequent return to the "temperature compensation" menu is effected via the F5 RETURN key.

IV.4)	+/- F 2	:	Sign entry for the temperature of the test unit in the case of manual temperature compensation. (line 3, parameter V.3).

V) Parameters:

V.1) TEMP.COMP (= On/off switch for temperature compensation)

The list values

OFF and ON

are available. They can be scrolled through with the ◀ - ▶ - keys.
OFF means that the **TEMP**erature **COMP**ensation is inactive;
ON means that it is active.

When the **TEMP**erature **COMP**ensation is active,
the test unit's resistance R20 at 20 °C is displayed. This value is calculated from the test unit's resistance RT at measurement temperature V 3, taking into account the linear temperature coefficient V 4.

V.2) MEASUREMENT (= manual or automatic temperature measurement)
The list values

MAN and AUT

are available; they can be scrolled through with the ◀ - ▶ - keys.

MAN means manual temperature measurement, in which case the test unit's temperature is entered in line 3, parameter V 3.

AUT means automatic temperature measurement, in which case the test unit's temperature is measured via an externally connected Pt100 unit.

V.3) TEMPERATURE (= temperature display or input)

Entries for this menu line are only possible in case of MANual temperature MEASUREMENT; they are made with the numerical keyboard (see Chap. 2.4.3) The sign is entered with the function key
+/- = F2 in accordance with IV.4.
The line is used as a display when AUTomatic MEASUREMENT has been selected.

The test unit´s temperature also appears in header field K3 of the main menu (see Chap. 2.3.2). An A preceding the temperature value signifies automatic temperature measurement, while an M signifies manual temperature measurement.

V.4) TEMP.COEFF. (= display of the selected temperature coefficient)

This menu line only involves one display („Read Only"-mode), which shows the temperature coefficient selected in the COEF = F1 submenu (see IV.3)

VI) Special comments:

Before the temperature compensation TEMPCOMP: ON is activated (line 1, IV.1) the following procedure is recommended:

- Manual selection of a fixed reference temperature:

  MEASUREMENT = MAN and entry of the desired temperature value in line 3, IV.3 +
  COEFF = F1 and selection of a suitable temperature coefficient from the table shown in Fig. 3.16 (or preceded by entry of a new coefficient in the table)+
  RETURN = F5.

- Automatic measurement of the reference temperature for temperature compensation:

  MEASUREMENT = AUT and COEFF = F1 and selection of a suitable temperature coefficient from the table shown in Fig. 3.16 (or preceded by the entry of a new coefficient in the table) +
  RETURN = F5.

VII) Exit:

Via the function key ENTER into „evaluation" (main menu 2).

Comparator parameters

COMPARATOR:		OFF		
COMPARATOR TYPE:		COMPARATOR		
BAR DISPLAY:		OFF		
LIM. VALUE UNIT:		Ω		
DISPLAY UNIT:		Ω		
LV. ABS	LV. PER			

Fig. 3.18: Comparator parameters

I) Access:

via F2 = COMP within "evaluation" (main menu 2).

II) Function:

Setting of various parameters which specify the type of comparator resp. classification function.

III) Restrictions:

- The display and comparator resp. classification units must correspond; only under this condition can the menu be exited again.
- During comparator or classification operation, the upper limiting value must lie in the **MAN**ually adjusted measurement range. If this is not possible, the **AUT**omatic measurement range selection mode should be selected.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is shown in the display field in inverse form.

IV.3)

LV.ABS.
F 1

: Selection of the menu for setting the specified value and the comparator **L**imiting **V**alues as **ABS**olute values in the selected measurement unit.

After this function key is operated, two different setting menus can appear, depending on the COMPARATOR TYPE selected in line 2:

A as shown in Fig. 3.19 or B as shown in Fig. 3.20.

Comparator **L**imiting **V**alues entered as **ABS**olute values are automatically converted into **PER**centages and transfered into the menus IV.4, A or IV.4, B. That is, limiting values can be entered as **ABS**olute values or as **PER**centages of the specified value, according to requirement.

IV.3.A) COMPARATOR TYPE = COMPARATOR, i.e. dual comparator operation with specified value and lower and upper limiting values:

SPE. VAL.:	100.00 Ω
LOWER LIMIT:	90.00 Ω
UPPER LIMIT:	110.00 Ω

				RETURN

Fig.3.19: Entry of comparator, specified and limiting values as absolute values.

Line 1 states the SPECIFIED VALUE, line 2 the LOWER LIMIT and line 3 the UPPER LIMIT of the comparator. One of these lines is selected with the ▲ --▼ keys; it is then displayed in inverse form. A numeric value entered in this manner can be re-entered via the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$0\ \Omega < \text{input value} \leq 20\ \text{K}\Omega$$

is available, whereby the upper limit must be larger than the lower limit.

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The following restriction also applies to the SPECIFIED VALUE:

UPPER LIMIT/100 < input value ≤ 20 kΩ and ≤ UPPER LIMIT.

If the Ω unit has been selected (see Chap. 3.1.4), entries are completed simply by means of one of the measurement range keys (see Chap. 2.4). Units different to Ω, e.g. Ω/m etc. are shown in the field above the function key F1. In this case, entries of numbers are completed by operating F1. A return to the menu „comparator parameters" is effected via the F5-RETURN key.

IV.3.B) COMPARATOR TYPE = CLASSIFY, i.e. operation with 9-class classification function:

LV 1 :	96 Ω	LV 5 :	101 Ω
LV 2 :	97 Ω	LV 6 :	102 Ω
LV 3 :	98 Ω	LV 7 :	103 Ω
LV 4 :	99 Ω	LV 8 :	104 Ω
		SPE:	100 Ω

				RETURN

FIG. 3.20: Classify function, entry of the specified value and limiting value as absoltue values.

Lines 1 to 8 contain the limiting values available for classification, and line 9 states the corresponding specified value. One of these lines is selected wit the ▲- ▼ keys and then indicated in inverse form. A numerical value selected in this manner can be re- entered via the numerical keyboard (see Chap.2.4.3).
For this, the value range

0 Ω < input value ≤ 20 KΩ

is available, whereby

LV1 < LV2 < LV3 < LV4 < LV5 < LV6 < LV7 < LV8

applies as a boundary condition.

The following restriction also applies to the SPECIFIED value:

LV8/100 < input value ≤ 20 kΩ and ≤ LV8.

If the unit Ω has been selected (see Chap. 3.1.4), entries are completed simply via one of the measurement range keys (see 2.4).
Units different to Ω , e.g.Ω/m etc. are shown in the field above the function key F1. In this case, entries of numbers are completed by operating F1.
A return to the menu „comparator parameters" is effected via the F5 RETURN key.

IV.4)

LV.PER
F 2

: Selection of the menu for setting the specified value and the comparator **L**imiting **V**alues as **PER**centages of the specified value.

After this function key is operated, either of two setting menus A (see Fig. 3.21) or B (see Fig. 3.22) can be selected, depending on the COMPARATOR TYPE selected in line 2:

Comparator Limiting Values which have been entered as PERcentages, are converted automatically into ABSolute values and transferred to the menus IV.3, A or IV.3, B.
Consequently, limiting values can be entered as PERcentages or ABSolute values , according to requirement.

IV.4.A) COMPARATOR TYPE = COMPARATOR, i.e. simple comparator operation with specified value and lower and upper limiting values:

SPECIFIED VALUE:	100.00 Ω
LOWER LIMIT:	- 10.000 %
UPPER LIMIT:	+ 10.000 %

				RETURN

Fig.3.21: Comparator, entry of specified value as absolute value, entry of limiting values as percentages

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Line 1 states the SPECIFIED VALUE, line 2 the LOWER LIMIT and line 3 the upper limit of the comparator. One of these lines is selected with the ▲ - ▼ keys and then indicated in inverse form. A numerical value selected in this manner can be reentered via the numerical keyboard (see Chap. 2.4.3). The value range

$$0\,\Omega < \text{input value} \leq 20\,\mathrm{K}\Omega$$

is available for the specified value. For the limiting values expressed as a percentage of the specified value,

$$-99.9\% \leq \text{input value} < 10000\%,$$

applies, whereby the upper limit must be larger then the lower limit. Negative limiting values can be entered with the F3 key which reverses the sign of the number just selected.
If the unit Ω has been selected for the specified value (see 3.1.4), entries are completed simply via one of the measurement range keys (see 2.4). Units different to Ω, e.g. Ω/m, are shown in the field above the function key F1. In this case, numerical entries are completed by pressing F1.

In contrast, the entries of limiting values as percentages are completed with the F2 key.

A return to the menu „comparator parameters" is effected via F5-RETURN.

IV.4.B) COMPARATOR TYPE = CLASSIFY, i.e. operation with 9-class classification function:

LV 1 :	- 4 %	LV 5 :	1 %
LV 2 :	- 3 %	LV 6 :	2 %
LV 3 :	- 2 %	LV 7 :	3 %
LV 4 :	- 2 %	LV 8 :	4 %
		SPE :	100 Ω

	%	+ / -		RETURN

Fig.3.22: Classification function, entry of the specified value (absolute), entry of the limiting value (percentage)

Lines 1 to 8 contain the limiting values available for classification, and line 9 states the corresponding specified value. One of these lines is selected with the ▲ - ▼ - keys and then indicated in inverse form.
A numerical value selected in this manner can be re-entered via the numerical keyboard (see Chap. 2.4.3). The value range

$$0\,\Omega < \text{input value} \leq 20\,\mathrm{K}\Omega$$

for the specified value. For the limiting values expressed as percentages of the specified value,

$$-99.9\% \leq \text{input value} < 10000\,\%$$

applies, whereby

$$LV1 < LV2 < LV3 < LV4 < LV5 < LV6 < LV7 < LV8$$

must be considered as a boundary condition. Negative limiting values can be entered with the F3 key which reverses the sign of the number just selected.

In case the Ω unit has been selected for the specified value (see 3.1.4), entries can be completed simply via one of the measurement range keys (see 2.4). Units different to Ω, e.g. Ω/m, are shown in the field above the function key F1. In this case, numerical entries are completed by pressing F1.

In contrast, the entries of limiting values as percentages are completed with the F2 key.

A return to the menu „comparator parameters" is effected via F5-RETURN.

V) Parameters:

V.1) COMPARATOR = on/off switch for the comparator (as dual comparator or classification comparator):
The list values

OFF and ON

are available. They can be scrolled through with the ◀ - ▶ keys.
OFF means that the COMPARATOR function is inactive,
ON means that it is active.

In this case, the fields for indicating the measured values in all three main menus show the following comparator symbols instead of the measured value:

- Dual comparator mode:
  < : measured value < lower limiting value,
  = : lower limiting value ≤ measured value ≤ upper limiting value,
  > : measured value> upper limiting value.

- Classify operation

Display	Classification window	Range
<	Measured value < LV1	RGE0
1	LV1 ≤ Measured value < LV2	RGE1
2	LV2 ≤ Measured value < LV3	RGE2
3	LV3 ≤ Measured value < LV4	RGE3
4	LV4 ≤ Measured value ≤ LV5	RGE4
5	LV5 < Measured value ≤ LV6	RGE5
6	LV6 < Measured value ≤ LV7	RGE6
7	LV7 < Measured value ≤ LV8	RGE7
>	LV8 < Measured value	RGE8

V.2) COMPARATOR TYPE = Select whether the comparator is to operate with two limits (dual comparator) or eight limits (classification comparator):

The list values

COMPARATOR and CLASSIFY

are available. They can be scrolled through with the ◀ - ▶ - keys.

COMPARATOR means dual comparator mode with three ranges, >, = , <. CLASSIFY means that the classification comparator with nine classes is active.

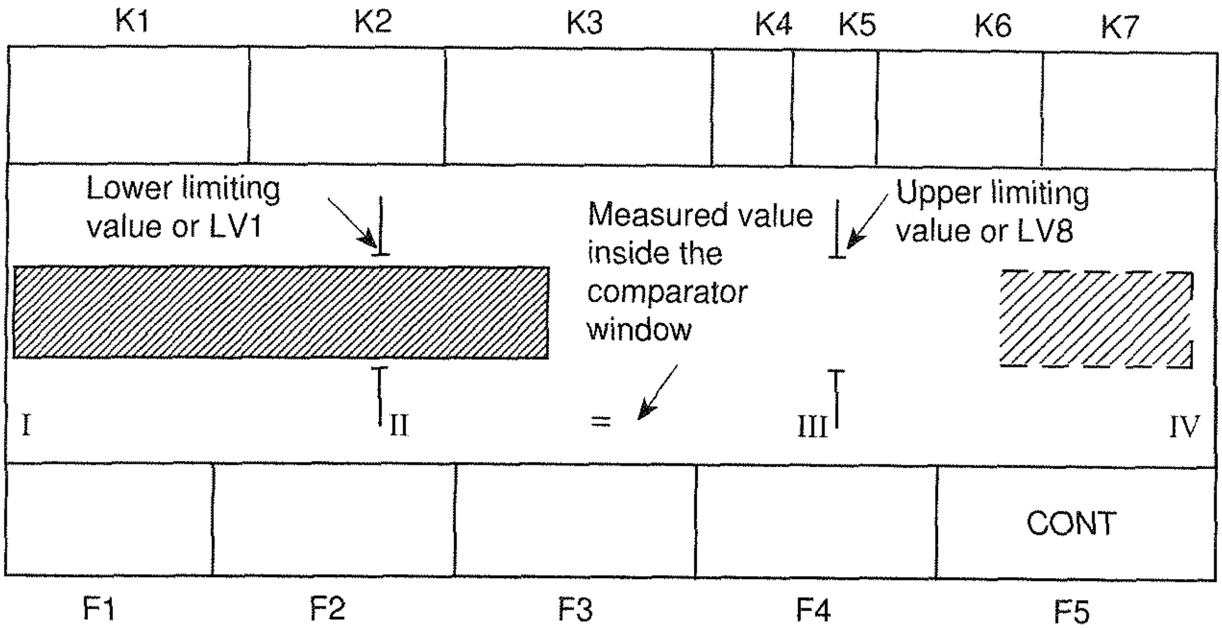
V.3) BAR DISPLAY = on/off switch for the bar display:

The list values

OFF and ON

are available. They can be scrolled through with the ◀ - ▶ - keys.

OFF means that the bar display is inactive. ON means that it appears - instead of the measured value - on the fields for displaying the measured values in all three main menus. However, this only applies if the COMPARATOR was also activated beforehand. Fig. 3.23 shows the appearance of a typical bar display.



I: Starting scale value, e.g.0 ohm

IV: MAN -> Range end value,
AUT -> 20 kOhm.

Linear sensitivity between the "limits" I - IV in each case!

Fig.3.23: Bar display

When the bar is to the left of the lower limiting value, i.e. smaller than it, the < - sign appears as a symbol. When the upper limiting value is exceeded, the > symbol is displayed instead. If the bar display is used in the 9-class classification mode, the display shown in Fig. 3.22 is obtained; in this case, however, the equality symbol = is replaced by the respective class index 1...7.

V4) LIMITING VALUE UNIT = Display of the unit selected for the limiting values:

This only involves one display („read only“ mode), which states the previous unit active for the specified value and comparator limiting values in the setting menus.

Attention:

A change of the measurement unit in the unit menu (see Chap. 3.1.4) does not have any effect on the unit of the selected limiting values. For this reason, they must be changed in accordance with the specification in the field of the F1 function key after a change of measurement unit in the setting menus 3.19, 3.20, 3.21 or 3.22.

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V.5) DISPLAY UNIT = Indication of the selected measurement unit:

This only involves one display („read only" mode) which states the selected measurement unit (see Chap.3.1.4).

VI) Special comments:

- The comparator can only be activated in accordance with V.1) if the DISPLAY UNIT (V.5) and LIMITING VALUE UNIT (V.4) are identical.

- The comparator ranges are assigned to relay outputs whose pin assignment is shown in Chap. 6.2.3. The relays are inactive in the idle state. In this case, O is connected to W.
  The relay function becomes **active** (S is connected to W) **only when** the **SINGLE** measurement mode and comparator function are selected.
  In addition, a valid measurement must be available.
  The relay remains active until another one is switched, or an invalid measurement (with error message) occurs, or the REPETITION measurement mode is selected, or the device is switched off.
  Duringcomparator operation, the following applies:

  Relay 0 $\triangleq$ <,
  Relay 4 $\triangleq$ = and
  Relay 8 $\triangleq$ >.

  For the classification function, relay number $\triangleq$ range number applies.
  (see page 3-2-14).

VII) Exit:

Via the function key ENTER into „evaluation" (main menu 2).

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Comparator statistics

Range 1 (<) :	0			
Range 2 (=) :	0			
Range 3 (>) :	0			
Total:	0			
RESET				

Fig. 3.24: Comparator statistics (value range 9999999)

I) Access:
Via F2 = STATCOM within "evaluation" (main menu 2).

II) Function:
Display of the subtotals allotted to the three evaluation ranges of the comparator after a certain number of single measurements, as well as the total.

III) Restrictions:
The comparator statistics function only when the comparator is active (see Chap. 2.3.2, V 1) and when the SINGLE mesaurement mode is selected (see Chap. 3.1.2, V.1).

IV) Function keys:

IV.1) ENTER — Acknowledgement of the current measurement parameter setting and return to the next higher menu level.

IV.4)

RESET
F 1

: **RESET** of the subtotals and the total.

V) Parameters:

V.1) RANGE 1 (<) :
Number of measured values allotted to range 1 after a certain number of single measurements:
measured values < lower limiting value.

V.2) RANGE 2 (=):
Number of measured values allotted to range 2 after a certain number of single measurements:
lower limiting value ≤ measured values ≤ upper limiting value.

V.3) RANGE 3 (>) :
Number of measured values allotted to range 3 after a certain number of single measurements:
upper limiting value < measured values.

V.4) TOTAL: sum of V.1 + V.2 + V.3.

VI) Special comments:

The following procedure is recommended for using the comparator statistics:

- MEASUREMENT MODE = SINGLE (Kap. 3.1.2, V.1),
- COMPARATOR TYPE = COMPARATOR (Chap. 3.2.3, V.2),
- select the LIMITING VALUE UNIT equal to the DISPLAY UNIT!

(Check for equality; if necessary, match the measured value units - see Chap.3.1.4 - and the limiting value units - see Chap. 3.2.3, IV.3),

- COMPARATOR = ON (Chap. 3.2.3, V.1),
- Performing of the desired number of measurements (see Chap. 2.4.2.2).

The totals remain stored even after the mains voltage is turned off.

VII) Exit:

Via the function key ENTER into „evaluation" (main menu 2).

Classification statistics

RGE 0 (<)	:	0	RGE 5	:	0
RGE 1	:	0	RGE 6	:	0
RGE 2	:	0	RGE 7	:	0
RGE 3	:	0	RGE 8 (>)	:	0
RGE 4	:	0	TOTAL	:	0

RESET				

Fig. 3.25: Comparator statistics (value range 9999999)

I) Access:

Via F4 = STATCOM within "evaluation" (main menu 2).

II) Function:

Display of the subtotals allotted to the nine evaluation classes after a certain number of single measurements, as well as the total.

III) Restrictions:

The classification statistics can be used only when the classification function is active (see Chap.2.3.2, V.1) and the SINGLE measurement mode is selected (see Chap. 3.1.2, V.1).

IV) Function keys:

IV.1) ENTER : Acknowledgement of the current measurement parameter setting and return to the next higher menu level.

IV.2) RESET / F 1 : **RESET** of the subtotals and the total.

V) Parameters:

V.1) RANGE 0 (<):
Number of measured values allotted to the range 0 after a certain number of single measurements:

measured values < lowest limiting value LLV1

V.2) - V.8) RANGES 1 - 7:
Number of measured values allotted to one of the classification windows 1 to 7 (see Chap. 3.2.3, V.1) after a certain number of single measurements.

V.9) RANGE 8 (>):
Number of measured values allotted to range 8 after a certain number of single measurements:

highest limiting value HLV8 < measured values.

V.10) TOTAL:

Sum of V.1 + V.2 + V.3 + V.4 + V.5 + V.6 + V.7 + V.8 + V.9.

VI) Special comments:

The following procedure is recommended for using the classification statistics:

- MEASUREMENT MODE = SINGLE (Chap. 3.1.2, V.1)
- COMPARATOR TYPE = CLASSIFY (Chap. 3.2.3, V.2),
- select the LIMITING VALUE UNIT equal to the DISPLAY UNIT!

(Check for equality; if necessary, match the measured value units -see Chap. 3.1.4 - and the limiting value units - see Chap.3.2.3 IV.3),

- COMPARATOR = ON (Chap. 3.2.3, V.1),
- Performing the desired number of measurements (see Chap. 2.4.2.2).

The totals remain stored even after the mains voltage has been turned off.

VII) Exit:

Via the function key ENTER into „evaluation“ (main menu 2).

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Special functions (main menu 3)

General information

Main menu 3 (see Fig. 3.26) allows access to various special functions, in particular, to the interface menus. Fig. 3.27 shows the underlying three-level menu hierarchy and the function keys resp. paths via which transitions between the individual menus can be made.

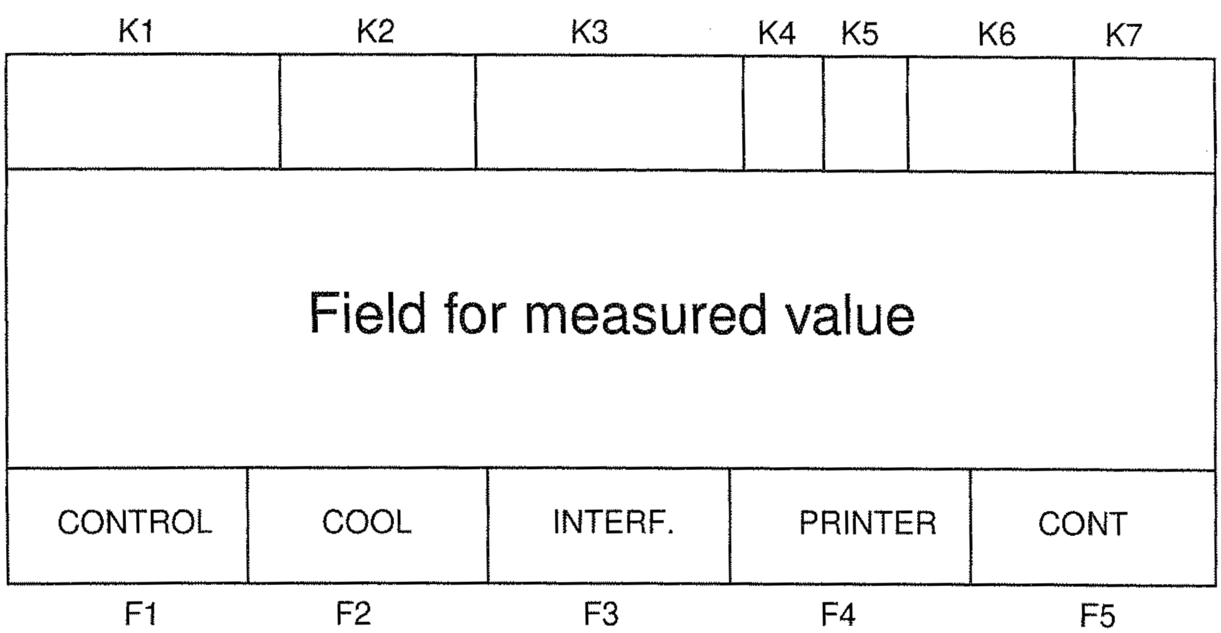

Fig. 3.26: Special functions (main menu 3)

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I) Access:
Via F5 = CONTINUE within parameterize (main menu 2).

II) Function:
Measured value or comparator display, selection of the table for access monitoring, and of the parameterization menu for the interfaces and cooling curve.

III) Restrictions:
The function key F4 only appears if the interface type IEEE488 was previously selected via F3 (see Chap. 3.3.4).

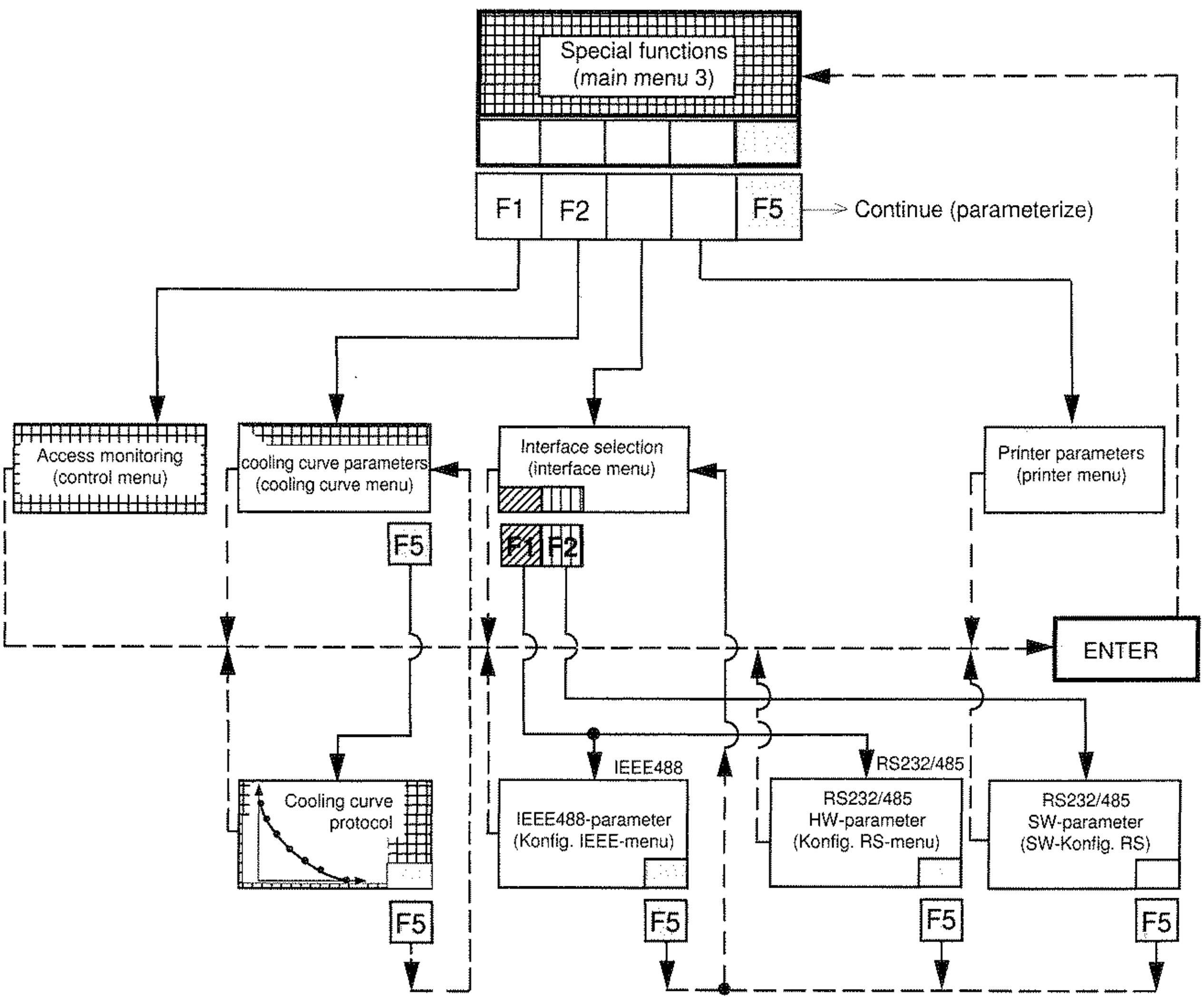

Fig. 3.27: Hierarchy of the special functions menu

IV) Function keys:

IV.1) CONTROL / F 1 : Selection of the table for access monitoring, i.e. **CONTROL** of any access to the configuration menus which has been carried out via the SEL key.

IV.2) COOL / F 2 : Selection of the parameterization menu for recording a **COOL**ing curve.

IV.3) INTERF. / F 3 : Selection of the menu for **INTERFace** parameterization.

IV.4) PRINTER / F 4 : Selection of the menu for **PRINTER** parameterization.

V) Parameters:

Header fields (see Chap. 2.3.2)

VI) Special comments:

None.

VII) Exit:

Via F 5 / = CONTINUE into parameterize (main menu 1)

or

via / SEL / N1 / N2 / N3 / N4 / into the configuring menus.

Access monitoring (CONTROL)

21.02.91	11:01:23	SEL
22.02.91	12:02:10	SEL
22.02.91	13:03:11	SEL
23.02.91	14:04:12	SEL
24.02.91	16:06:34	SEL

Fig.3.28: Access monitoring

I) Access:

Via F1 = CONTROL within "special functions" (main menu 3)

II) Function:

Time-based registration of all attempts by the user to access the configuration and calibration menus (see Chap. 4).

III) Restrictions:

A maximum of 256 positions (lines) can be registered. Should this number be exceeded, the oldest line is deleted every time a new line is to be registered

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting further lines which are not currently displayed.
The six preceding lines are displayed with the ▲- key, while the six succeeding lines (provided they exist) are displayed with the ▼- key.

IV.2) ENTER : Return to the next higher main menu 3.

V) Parameters:

V.1) - V.6) Lines 1 - 6 with time-based registration of the attempts (successful and unsuccessful) to access the configuration and calibration menus (see Chap. 4and 5).
The following format is used:

< day month year> < hr:min:sec> SEL key.

VI) Special comments:

The access monitor is used to check whether unauthorized persons have carried out "systematic trials" to determine the security codes for access to the configuration and calibration menus.

VII) Exit:

via the function key ENTER into „evaluation“ (main menu 2).

Cooling curve (COOL)

Rc:	100.00	Ω
T1:	+ 20.0	°C
D t:	1	s
R(t):		Ω
T2:	+ 20.0	°C

R-RESET	+ / -	L-REM	MEAS-t	EVAL

Fig. 3.29: Cooling curve parameters and display

I) Access:
Via F2 = COOLing into special functions (main menu 3)

II) Function:

II.1) Parameter setting and recording of a cooling curve as part of a heating measurement, e.g. on isolating transformers in accordance with VDE0551, §13.
Fig. 3.30 illustrates this measurement procedure:

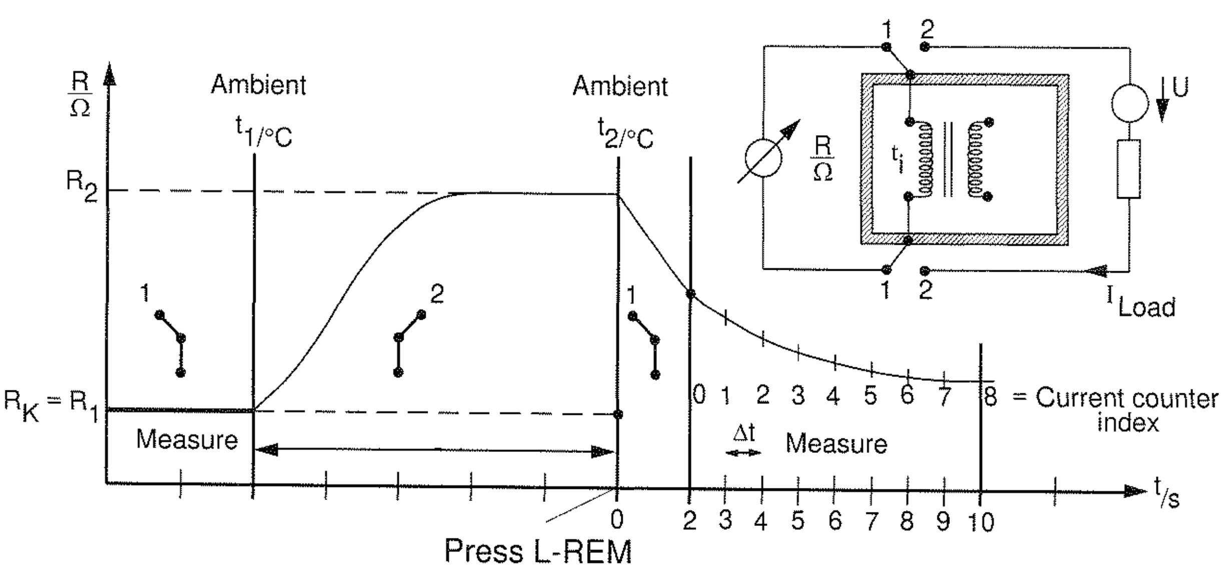

Fig. 3.30: Change in the resistance of a transformer winding as a function of time.

As R cannot be measured until the load current has been turned off, i.e. after a certain delay time, R2 can only be determined by extrapolating the cooling curve.

II.2) Parameter settings and recording of the dynamic characteristic of any electrical resistance ≤ 20 kΩ (data logging).

III) Restrictions:

For resistance measurement R(t), the values set in the parameterization and evaluation menus are always taken over, and can no longer be changed in the cooling-curve menu.
Consequently, the parameters should be optimized (see Chap. 3.1.2, VI) before the cooling curve is recorded. However, the following exceptions apply:

A) Measurement of the cold resistance Rc of the test unit:

LOAD (see Chap. 3.1.2, V.6)	= Z,
Measurement unit (see Chap. 3.1.4. V.1)	= Ω,
TEMP.COMP: (see Chap. 3.2.2, V.1)	= OFF,
COMPARATOR (see Chap. 3.2.3, V.1)	= OFF.

B) Measurement of the test unit´s resistance R(t) as a function of the cooling time:

as in A), and additionally,

MEAS. MODE (see Chap. 3.1.2, V.1) = REPETITION.

After the cooling curve menu is selected, these parameters are set automatically, and are reset to their initial state after this menu has been exited.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set or measured, i.e. the line containing the parameter. The selected parameter appears in inverse form on the display field.

IV.2)	ENTER	:	Acknowledgement of the current measurement parameter setting and return to the next higher menu level main menu 3).
IV.3)	μΩ : kΩ	:	Completion of the entry of a resistance value for R_c
IV.4)	+ / - / F 2	:	Entry of the sign for the ambient temperature t_1 at the beginning of the load phase and t_2 at the end of the load phase.
IV.5)	L-Rem / F 3	:	Entry of the load **REM**oval (= start of the internal stopclock for the cooling curve); after this key is operated, the cooling curve menu may not be exited until the recording of the cooling curve is complete. Every access to the menu causes the stopclock to be reset.
IV.6)	Meas-t / F 4	:	Changeover of the lines 2 (T1) or 5 (T2) to **MEAS** mode; in each case, only one temperature measurement is performed (the measurement phase is indicated by the inverse display of the MEAS-t field).
IV.7)	EVAL / F 5	:	Selection of the cooling curve protocol (**EVAL**uation). After this function key is operated, the table in Fig. 3.31 appears, provided that a cooling curve was recorded previously.
IV.8)	R-RESET / F 1	:	The key is only indicated if measured values are present in the memory. If it is operated, the memory for measured values is cleared, and the (R-RESET) key is no longer indicated.

1	1.46 s	100.20 Ω		
2	2.46 s	100.19 Ω		
3	3.46 s	100.17 Ω		
4	4.46 s	100.15 Ω		
5	5.46 s	100.12 Ω		
POS 0			PRINTER	RETURN

Fig 3.31: Cooling curve protocol

Each of the lines 1 - 5 states a pair of cooling-curve values (measured-value index/time reference in sec. with respect to the load removal/test unit´s resistance in Ω); needless to say, this method of registration can also be used as a normal data-logging function.

The cursor key can be used for selecting further lines which are not currently displayed. The five preceding lines are displayed with the ▲ key, while the five succeeding lines (provided that they exist) are displayed with the ▼ key. With the help of the F1 = POS. key, every pair of measured values whose current index is known can be positioned in line 1. The desired index is simply entered via the numerical keyboard (control display in the F1 field) and the entry completed with F1. The maximum memory depth is 256 pairs of values.

The F4 = PRINTER key allows the stored values to be printed via the RS232 type serial interface, which must be set previously in the interface menu (see Chap. 3.3.4). In addition, IEEE488 must be chosen as part of the interface selection. The return to the „cooling curve„ menu is effected via F5 - RETURN.

V) Parameters:

V.1) Cold resistance R_c:

V.1.1) Enter cold resistance R_c manually:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3), including the decimal-point key. For this, the value range 0 µΩ ≤ input value ≤ XXXXXX kΩ is available. (X = any number or a decimal point. The entry is complete via the unit key (see IV.3). R_C can only be entered manually when the measurement is in the STOP mode.

V.1.2) Measurement of the cold resistance R_C:

For the cold resistance R_C to be measured, the START key must be operated. The resulting measured values are then written over the value entered in accordance with V.1.1). The SINGLE or REPETITION MEASUREMENT MODE can be selected for this purpose. The restrictions stated in Chap. 3.3.3, III should be observed.

V.2) Ambient temperature (T1 before the load phase, T2 at the end of the load phase):

V.2.1) Entries for the menu lines 2 (T1) or 5 (T2) are made with the help of the numerical keyboard (see Chap. 2.4.3) including the decimal-point key. For this, the value range

$$-99.9\ °C \leq \text{input value} \leq +999.9\ °C$$

is available. (Sign change via F2 in accordance with IV.4).

V.2.2) Measurement of the ambient temperature:

Select menu line 2 (T1) or 5 (T2), operate the MEAS-t key as described in IV.6).

V.3) Enter the time reference for the cooling curve Δ t:

Entries for this menu line are made with the numerical keyboard (see Chap. 2.4.3.). For this, the value range

$$0\ s \leq \text{input value} \leq 3600\ s$$

is available. D t specifies the time interval during which no values are stored. The next pair of values determined after Δ t has elapsed are stored.

V.4) Measurement of the resistance R (t)with respect to time:

After the restrictions stated in III have been observed, the procedure below is to be followed:

- Selection of line 4 (inverse display),
- Operation of the START key,
- Display of the measured values together with the current measured value index,
- Operation of the STOP key or attainment of the maximum number of measured-value pairs (256).

VI) Special comments:

- The cold resistance R_C (V.1) and ambient temperatures T_1 and T_2 (V.2) are only entered for the purpose of documentation. Further computationa evaluations with R_C, T_1 and T_2 are not carried out.
- To increase the measurement rate in the case of small inductances, it might be advisable to switch the measurement cycle from BIPOLAR to UNIPOLAR mode (see Chap. 4.5). In this operating mode, the compensation measurement at I = 0 A is only carried out once after operation of the START key, which saves the time otherwise required for charge reversal.
  However, this could result in a considerable deterioration of the measuring accuracy (particularly with small and medium measuring currents) because, as is generally known, the thermal e.m.f's in the measuring circuit change over long cooling periods, thus increasing the measurement errors. As only the BIPOLAR mode compensates the thermal e.m.f's during every measuring cycle, this setting is preferable for small inductances (if possible, in combination with a LARGE measuring current and TIME BASE > 1). In the case of large inductances, correct measured values are only obtained in the UNIPOLAR mode.

VII) Exit:

Via the function key ENTER into „special functions" (main menu 3).

Interfaces
(INTERFACE)

HW - CONFIGURATION

RS485

RS232

IEEE488

HW-CONF	SW-CONF			

Fig.3.32: Interface selection

I) <u>Access:</u>

Via F3 = INTERFace within „special functions“ (main menu 3).

II) <u>Function:</u>

Selection of the desired interface type.

III) <u>Restrictions:</u>

The function key SW-CONF is only accessible if RS485 or RS232 has been selected.

IV) <u>Function keys:</u>

IV.1) ▲ ▼ : Cursor keys for selecting the type of interface to be set, i.e. the line containing the desired type of interface. The selected line is indicated in the display field in inverse form.

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IV.2) | E N T E R | : Acknowledgement of the current interface setting and return to the next higher menu level (main menu 3)

IV.3) | HW-KONF / F 5 | : Selection of the setting menu for the IEEE488 interface (**H**ard**W**are-**CONF**iguration) or the operating-mode/ format menu for serial interfaces.
After this function key has been operated, two different setting menus could appear depending on the selected interface type: A as shown in Fig. 3.33 or B as shown in Fig.3.34.

A) Interface type = IEEE488

INTERFACE :	IEEE488
ADDRESS:	9
TRIGGER:	PASSIVE

				RETURN

Fig. 3.33: IEEE488 parameters

Line 1 only serves as a header, while line 2 states the address and line 3 states the trigger mode. The individual lines are selected with the ▲ - ▼ keys, and indicated subsequently in inverse form. A parameter selected in this manner can be changed as follows:

Line 2: ADDRESS; for this, the value range

$$0 \leq \text{input value} \leq 30$$

is available. The desired value can be selected with the numerical keyboard (see Chap. 2.4.3).

Line 3: TRIGGER; for this the list values ACTIVE and PASSIVE are available.

The list values can be scrolled through with the ◀ ▶ keys. A return to the „interface“ menu is effected via the F5 RETURN key.

B) Interface type = RS485 or RS232 (Line 1 or 2):

RS485 (232):	FULL DUPLEX (only with RS485)
BAUD RATE:	9600
DATA BITS:	8
STOP BITS:	1
PARITY:	NONE

				RETURN

Fig 3.34: Operating modes and data format for the RS232/485

Line 1 states the operating mode and line 2 states the corresponding transfer rate. The desired data format (number of data bits, number of stop bits and parity check) is shown in lines 3 to 5. The individual lines are selected with the ▲ - ▼ keys, and subesquently indicated in inverse form. A parameter selected in this manner can be changed as follows:

Line 1: Serial interface type; for this the list values
FULL DUPLEX and HALF DUPLEX
are available, provided that type RS485 has been selected. Otherwise line 1 is disabled.

Line 2: BAUD RATE = rate of data transfer; for this, the list values
19,200, 9,600, 4,800, 2,400, 1,200, 600 bauds
are avaialble.

Line 3: DATA BITS = number of data bits; for this, the list values
7 and 8
are available.

Line 4: STOP BITS = number of stop bits; for this, the list values
1 and 2
are available.

Line 5: PARITY= parity check desired?
For this, the list values EVEN, ODD and NONE
are available.

The list values can be scrolled through with the ◀ ▶ keys.

A return to the „interface“ menu is effected via the F5 RETURN key.

IV.4) SW-CONF / F 2 : Selection of the setting menu for the software parameters of the serial interfaces (**S**oft**W**are **CONF**iguration). After this function key is operated, the setting menu shown in Fig. 3.3.5 appears.

SW CONFIGURATION	
GROUP ADDRESS:	0
USER ADDRESS:	0
CHARACTER DELAY:	OFF
BLOCK CHECK:	OFF
	RETURN

Fig 3.35: Software parameters for the RS232/485

Line 1 is the header, and lines 2 and 3 state the group and user addresses respectively. Lines 4 and 5 serve as switches for the character delay and the block check character. The individual lines are selected with the ▲ - ▼ keys, and subsequently indicated in inverse form. A parameter selected in this manner can be changed as follows:

Line 2: GROUP ADDRESS and

Line 3: USER ADDRESS

For both lines, the value range
$0 \leq$ input value ≤ 15
is available.

Line 4: CHARACTER DELAY= fixed time delay between the transfer of individual characters (approx. 2 ms) and

Line 5: BLOCK CHECK = check sum of the transferred data block. For both lines, the list values
OFF and ON
are available.

The list values can be scrolled through with the ◀ ▶ keys. A return to the „interface" menu is effected via the F5 RETURN key.

V) Parameters:

V.1) RS485:
Selection of the bus-compatible serial interfaces type RS 485 ($\leq$ 32 connected measuring devices).

V.2) RS232:
Selection of the bus-incompatible serial interface type RS 232 (1 control station with only one connected measuring device).

V.3) IEEE488:
Selection of the bus-compatible parallel interface type IEEE488 (1 control station with $\leq$ 30 connected measuring devices).

VI) Special comments:

Selection of the parameter V.3) IEEE 488 also allows printer operation via the RS232 interface jack. The underlying parameters for this are shown in Fig. 3.34. The format of the printed data is shown in Fig. 3.37.

VII) Exit:

Via the function key ENTER into „special functions" (main menu 3).

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Printer parameters (PRINTER)

PRINT:	OFF	TC:	OFF
TYPE:	T 0	TEST NO.:	OFF
NUMERATOR:	ON	TEST NO.:	
DATE:	ON	MV/HEAD.:	1000
TIME:	ON		
TIME REF.:	hh : mm : ss		RESNUM

Fig. 3.36: Printer parameters

I) Access:

Via F4 = PRINTER within „special functions" (main menu 3).

II) Function:

Setting of the printer parameters and stipulation of the desired printer listing (see Fig. 3.37).

III) Restrictions:

The format settings only apply for the IBM character set 2 (see Appendix 7.5). They were tested, for example, on an „NEC Pinwriter P6 plus" printer. TYPE 0 requires 8 data bits. The TYPE 1 and TYPE 2 settings replace the „Ω" symbol with „O", the „µ" symbol with „u" and the „°" symbol with a space.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the printer parameter to be set, i.e. the line containing the desired parameter. The selected line is indicated in the display field in inverse form.

| ◀ | ▶ | : Cursor keys for scrolling through the value list available for the selected parameter. The next list value appears when the ▶ key is pressed, and the previous list value appears when the ◀ key is pressed.

The ◀ ▶ keys also serve as a means of selecting the entry fields for hours, minutes and seconds, but only in line V.10) = TIME REFERENCE.

IV.2) | ENTER | : Acknowledgement of the current interface setting and return to the next higher menu level (main menu 3).

IV.3) | RESNUM. / F 5 | : **RES**et of the **NUM**erator as described in V.3).

V) Parameters:

V.1) PRINT = on/off switch for the printer:

The following list values are available:

OFF = the printer is off,
ON = the printer is on.

Note:

In addition to this function, the printer can also be activated via an external signal (see Chap. 7.2.3).

V.2) TYPE = printer type:

The following list values are available:

T 0 : DIN A4 printer (80 characters/line),
T 1 : 40 character protocol printer,
T 2 : 20 character protocol printer.

V.3) NUMERATOR = current counter index for the measured-value lines to be printed out:
The following list values are available:

OFF = the numerator is not printed,
ON = the numerator is also printed in the 1st column of every measured-value line.

V.4) DATE = on/off switch for the date:
The following list values are available:

OFF = the time is not printed,
ON = the time is also printed in every measured-value line.

V.6) TIME REF. = time reference for the printout of the measured-value lines:

After the entry field (hr., min., sec.) is selected with the ◀ ▶ keys, the value of the time reference (= minimum waiting time between two measured-value lines) is entered via the numerical keyboard (see Chap. 2.4.3). For this, the value ranges 0-24 hrs., 0-59 min. and 0-59 sec. are available.
On the 00:00:00 setting, every measured value is printed out.

V.7) TC = on/off switch for the temperature of the test unit in the case of temperature compensation:

The following list values are available:

OFF = the temperature of the test unit is not printed out,
ON = the temperature of the test unit is printed out, provided that the temperature compensation has been activated (see Chap. 3.2.2, V.1).

V.8) TEST NO. (2nd column, 2nd line) = on/off switch for a test number or experimental number sepcified by the customer:

The following list values are available:

OFF = the test number (see V.8) is not printed out,
ON = the test number is printed out in the 1st line of the protocol header (see V.9)

V.9) TEST NO. (2nd column, 3rd line) = input line for the test number:

The test number is input via the numerical keyboard (see Chap. 2.4.3). For this, the value range

$$0 \leq \text{input value} \leq 999999$$

is available.

V.10) MV/HEAD. = measured-value line reference up until a new protocol header is printed:

It is possible to print a protocol header before a certain number of measured-value lines; it contains the following information (also see Fig. 3.37):

Line 1: Test number (see V.7, 8)

Line 2: Temperature coefficient, provided that the temperature compensation (see Chap. 3.2.2, V.1) and the TC switch (see V.6) have been activated.

Line 3: Specified value on which the comparator limiting values are based as percentages (see Chap. 3.2.3, IV.4), provided that the comparator function (see Chap. 3.2.3, V.1) has been activated.

Lines 4-11: Comparator or classification limiting values (lower and upper limiting value for COMPARATOR TYPE = simple comparator or limiting values 1-7 for COMPARATOR TYPE = classification comparator with nine classes), provided that the comparator function (see Chap. 3.2.3, V.1) has been activated.

Last line: Headers for the protocol columns 1 to 6. Columns which are not selected are omitted and indented.

The entry of the number of measured-value lines until the next protocol header is carried out via the numerical keyboard (see Chap. 2.4.3).
For this, the value range

$$1 \leq \text{input value} \leq 9999$$

is available.

VI) Special comments:

The menu for the printer parameters is only accessible from main menu 3, if the interface type IEEE488 was previoulsy selected. It is only in this operating mode that the RS232 interface connector is not assigned to a control station for communication tasks and thus available for printer control.

VII) Exit:

Via the function key ENTER into „special functions" (main menu 3).

PROTOCOL HEADER

TEST NUMBER :	1245	
TEMP. COEFFICIENT:	0.003980	
SPEC VAL.:	100	Ω*mm2/m
LIM VALUE 0 :	101.000	Ω*mm2/m
LIM VALUE 1 :	102.000	Ω*mm2/m
LIM VALUE 2 :	103.000	Ω*mm2/m
LIM VALUE 3 :	104.000	Ω*mm2/m
LIM VALUE 4 :	105.000	Ω*mm2/m
LIM VALUE 5 :	106.000	Ω*mm2/m
LIM VALUE 6 :	106.999	Ω*mm2/m
LIM VALUE 7 :	108.000	Ω*mm2/m

MEASURED-VALUE LINES

POS	MEAURED VALUE	EVAL.	TIME	DATE	TEMPERATURE
1	101.39 Ωmm2/m	2	10:42:03	17.12.90	21.6 °C
2	101.40 Ωmm2/m	2	10:42:04	17.12.90	21.6 °C
3	101.41 Ωmm2/m	2	10:42:05	17.12.90	21.5 °C
4	101.33 Ωmm2/m	2	10:42:06	17.12.90	21.5 °C
5	101.35 Ωmm2/m	2	10:42:07	17.12.90	21.5 °C
6	101.32 Ωmm2/m	2	10:42:08	17.12.90	21.6 °C
7	101.40 Ωmm2/m	2	10:42:09	17.12.90	21.6 °C
8	101.32 Ωmm2/m	2	10:42:10	17.12.90	21.6 °C

Numerator

Comparator or classivication evalutation (<=> or <1 ... 7>), is only pronted out when COMPARATOR = ON (Chap. 3.2.3, V.1).

TEST NUMBER :	1245	
TEMP. COEFFICIENT:	0.003980	
SPEC VAL.:	100	Ω*mm2/m
LIM VALUE 0 :	101.000	Ω*mm2/m
LIM VALUE 1 :	102.000	Ω*mm2/m
LIM VALUE 2 :	103.000	Ω*mm2/m
LIM VALUE 3 :	104.000	Ω*mm2/m
LIM VALUE 4 :	105.000	Ω*mm2/m
LIM VALUE 5 :	106.000	Ω*mm2/m
LIM VALUE 6 :	106.999	Ω*mm2/m
LIM VALUE 7 :	108.000	Ω*mm2/m

POS	MEAURED VALUE	EVAL.	TIME	DATE	TEMPERATURE
9	101.94 Ωmm2/m	2	10:42:11	17.12.90	21.5 °C
10	101.33 Ωmm2/m	2	10:42:12	17.12.90	21.5 °C
11	101.35 Ωmm2/m	2	10:42:13	17.12.90	21.5 °C
12	101.34 Ωmm2/m	2	10:42:14	17.12.90	21.7 °C
13	101.28 Ωmm2/m	2	10:42:15	17.12.90	21.7 °C
14	101.27 Ωmm2/m	2	10:42:16	17.12.90	21.7 °C
15	101.26 Ωmm2/m	2	10:42:17	17.12.90	21.8 °C

Fig. 3.37: Format of the measurement protocol for TYPE 0, 1 and 2

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Configuring the RESISTOMAT®2304

Operation of the RESISTOMAT®2304

Configuration

General information

Configuration and calibration functions influence the fundamental characteristics of the device; for this reason, they are only accessible through special security codes (see Fig. 4.1).

The access procedure from any of the three main menus is as follows:

RGE	N1	N2	N3	N4

The SEL light-emitting diode remains on until the entry of the last number N4 has been completed.

The return from the configuration menu into the calling main menu is effected with the ENTER key.

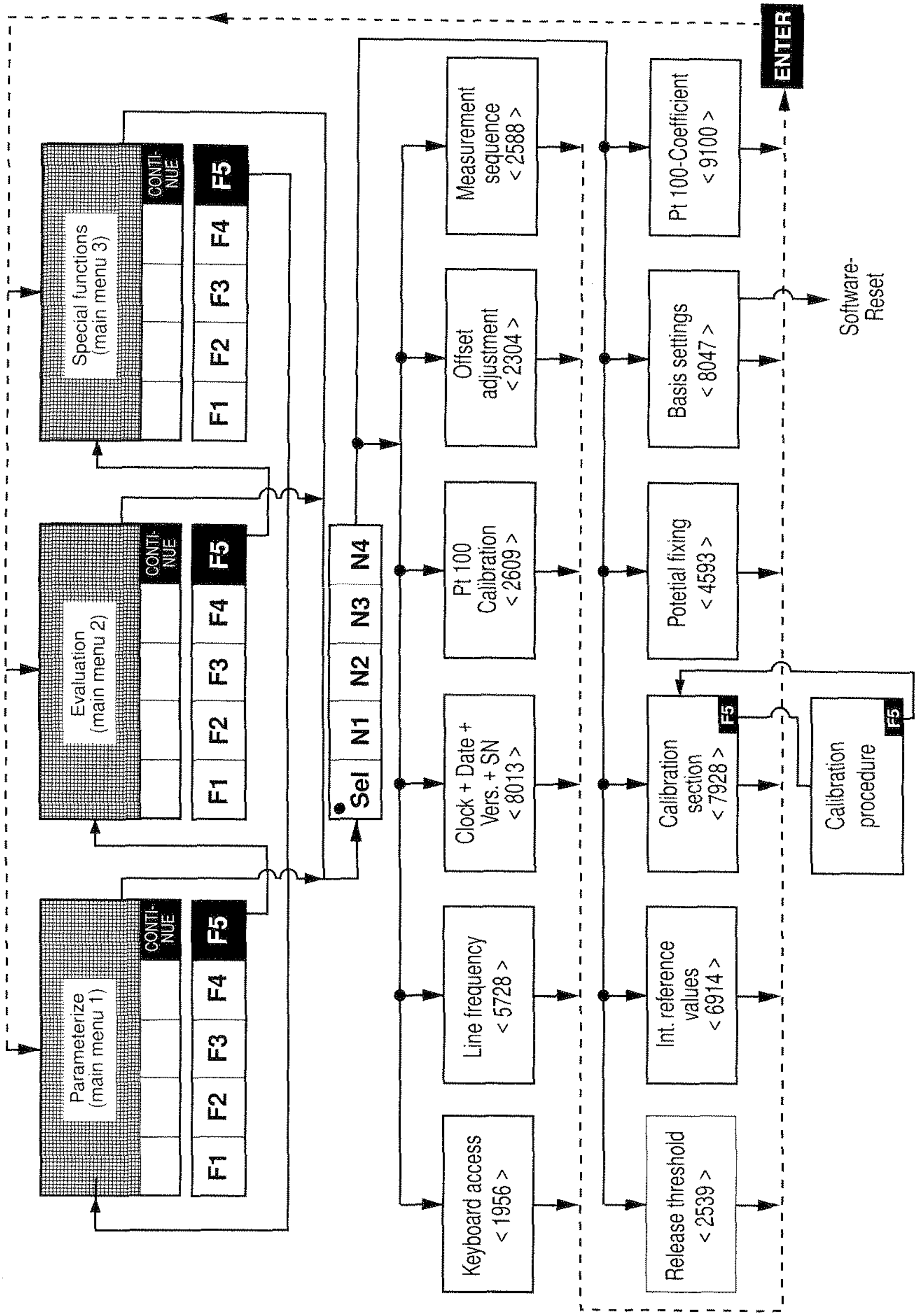


Fig. 4.1: Configuration and calibration menu

Keyboard access

KEYBO ARD ACCESS
MEASUREMENT
MEASUREMENT + RANGE SELECT.
FULL ACCESS

Fig. 4.1: Keyboard access

IMPORTANTE NOTE:

Fig. 4.2 shows all the security for selecting the configuration and calibration menus.

An unqualified operaator familiar with these codes would posses the capability of altering the fundamental functions of the measuring device, thus rendering the displayed values useless. Consequently, this sheet should be separated before the device is put into operation, an kept in the custody of a responsible person.

The guarantee does cover malfunctions resulting from improper configuration or calibration.

I) Access:

Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

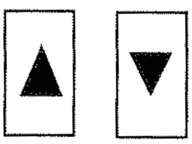
II) Function:

Specification of the method of keyboard access by the user in three different stages.

III) Restrictions:

In the case of extended keyboard access (see V.2), the entry of the reference variable is only possible if the keyboard limitation has been selected via main menu 1.

IV) Function keys:

IV.1)  : Cursor keys for selecting the parameter to be set. The selected parameter is indicated on the field in inverse form.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) MEASUREMENT:

The hatched keys shown in Fig. 4.3 are accessible. The measured values are shown on the main menu via which the keyboard limitation was selected.

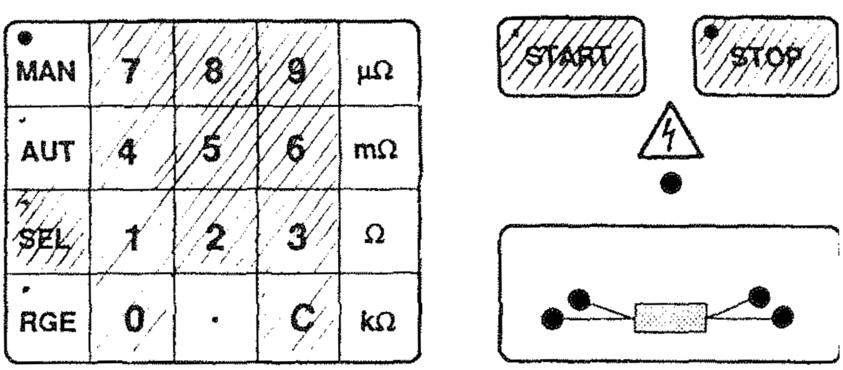


Fig. 4.3: Minimal keyboard access

V.2) MEASUREMENT + RANGE SELECTION:

The hatched keys shown in Fig. 4.3 are accessible. The measured values are indicated on the main menu via which the keyboard access limitation was selected.

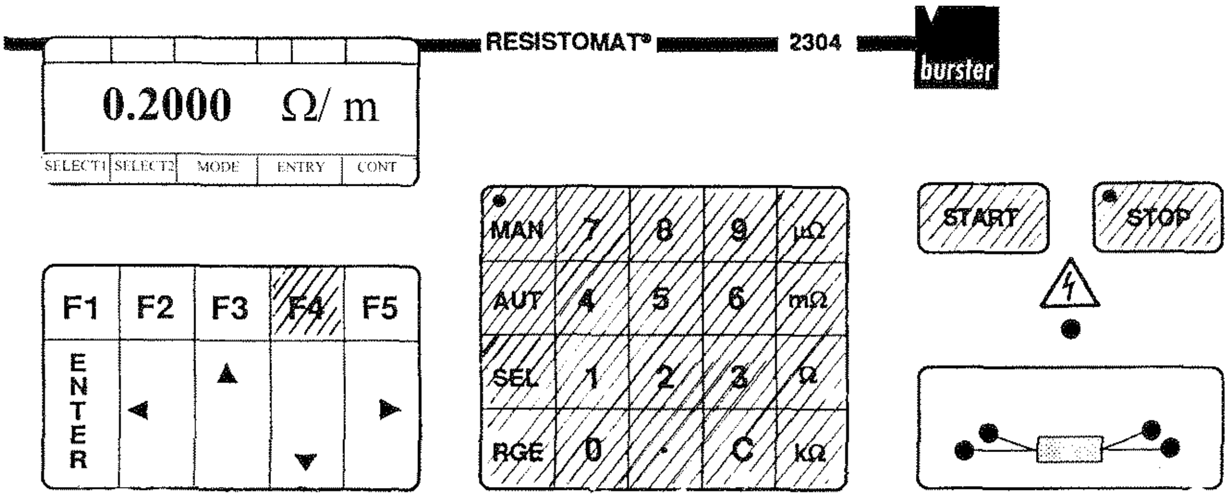


Fig 4.4: Extended keyboard access

In addition to measurement start and stop, code entry and measurement range selection, the reference variables can also be input. However, this only applies if the keyboard limitation has been selected via main menu 1.

V.3) FULL ACCESS:

All keys and functions are accessible.

V.I) <u>Special comments:</u>

After the keyboard access has been configured, the measured values are ndicated on the main menu via which the keyboard limitation was selected.

V.II) <u>Exit:</u>

Via the function key ENTER into the main menu which was exited previously.

Line frequency

LINE FREQUENCY-BASE
50 Hz
60 Hz
16 2/3 Hz

Fig. 4.5: Keyboard access

I) Access:

Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

II) Function:

Matching of the internal INTEGRATION TIME of the device with the existing line frequency.

III) Restrictions:

None.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set. The selected parameter is indicated on the display field in inverse form.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) 50 Hz:

Matching of the internal integrating time with the interference frequency of 50 Hz.
All statements of the measurement time (TIME BASE) are based on multiples of 20 ms (1/50 Hz).

V.2) 60 Hz:

Matching of the internal integrating time with the interference frequency of 60 Hz.
All statements of the measurement time (TIME BASE) are based on multiples of 16.67 ms (1/60 Hz).

V.3) 16 2/3 Hz:

Matching of the internal integrating time with the interference frequency of 16 2/3 Hz.
All statements of the measurement time (TIME BASE) are based on multiples of 60 ms (1/16 2/3 Hz).

VI) Special comments:

There are no value lists for the individual lines V.1) - V.3); the parameters are selected simply by positioning the inversely inticated cursor on the desired line and acknowledging with ENTER.

VII) Exit:

Via the function key ENTER into the main menu which was exited previously.

Clock

DATE: 25 . 02 . 91
TIME: 08 : 29 : 10

VERSION: V0193

Fig. 4.6: Setting menu for the date and time, and display of the software version used.

I) Access:

Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

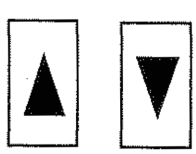
II) Function:

Input of the date and time, and display of the software version used.

III) Restrictions:

None.

IV) Function keys:

IV.1)  : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is shown on the display field in inverse form.

IV.1) ◀ ▶ : Cursor keys for positioning the cursor field on the entry fields Day Month Year and Hr.:Min.:Sec.

IV.2) ENTER : Acknowledgement of the current parameter settings and return to the next higher menu level.

V) Parameters:

V.1) DATE:

After the entry field (day,month,year) has been selected with the ◀ - ▶ - keys, the desired value is entered via the numerical keyboard (see Chap. 2.4.3). For this, the value ranges

00-31 . 00-12 . 00-99

are available.

V.2) TIME:

After the entry field (hr., min., sec.) has been selected with the ◀ - ▶ - keys, the desired value is entered with the numerical keyboard (see Chap. 2.4.3). For this, the value ranges

00-23 : 00-59 : 00-59

are available.

VI) Special comments:

The clock and date „remain stationary" during the time of the display, i.e. the counter stops running.

VII) Exit:

Via the function key ENTER into the main menu which was previously exited.

Measurement sequence

MEAS. SEQUENCE: BIPOLAR

Fig.4.7: Measurement sequence

I) **Access:**

Via SEL < security code as in Fig.4.1 > within one of the three main menus.

II) **Function:**

Determination of whether the measurement should be unipolar or bipolar.

III) **Restrictions:**

None.

IV) **Function keys:**

IV.1) ◀ ▶ : Cursor keys for scrolling through the value list available for the selected parameter. When the ▶ key is pressed, the next list value appears; when the ◀ key is pressed, the previous list value appears.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) MEASUREMENT SEQUENCE:
For this, the list values
UNIPOLAR, BIPOLAR and CONSTANT are available.
In the UNIPOLAR mode, the measuring current through the test unit is switched once between I = 0A and I = +I_{Meas}, i.e. no change in polarity occurs.

In the BIPOLAR mode, however, the sign of the measuring current changes cyclically, i.e. it is switched between I = -I_{Meas} and I = +I_{Meas}.

In the CONSTANT mode it´ll measure immediately with switched on measure current. This measure mode is only possible at manual range selection. Before it is necessary to make a reference zero-measurement.

VI) Special comments:
In the UNIPOLAR mode, the compensation measurement is carried out at I = 0A (see chap. 1.6) only once after the operation of the START key.
This has the following advantages:
- the measurement time is shortened and the time required for charge reversal on inductive test units is saved.

However, this is accompanied by the following disadvantages:
- a decrease in the measuring accuracy, (particularly with low and medium measuring currents), as thermal e.m.f´s are not compensated.

Only the BIPOLAR mode compensates thermal e.m.f´s during every measurement cycle; for this reason, it is advisable to use this mode in case of doubt (if possible, in combination with a LARGE measuring current and TIME BASE > 1).

The measure mode CONSTANT is for big inductivities with stability effects -to stabilise the measure values- > 5 minutes. In this case the discharge time is approx. the same. Sometimes a discharged test object has nevertheless a little residual charge, which in a new measurement in the UNIPOLAR mode results in a wrong value because the residual charge is stored as the zero point.
For all measurements in this mode the test object must be total discharged and the REFØ-value must be measured new (see page 3 - 1 - 8).
The difference to the mode UNIPOLAR is, that the measurement happens immediately after having switched on the measure current without zero point measurement.
Please choose the biggest measure current in the used range (only manual range selection possible).

VII) Exit:
Via the function key ENTER into the main menu exited previously.

Release thres hold for inductive test units

REL. THRESHOLD: 20.00 %

Fig. 4.8: Release threshold for inductive test units

I) Access:

Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

II) Function:

Setting of the ripple limiting value, which must not be exceeded during the transient phase of inductive test units, so that valid measured values can be obtained.

III) Restrictions:

None.

IV) Function keys:

IV.1) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) RELEASE THRESHOLD:

As shown in Fig. 4.9, this parameter specifies the maximum acceptable change in transient amplitudes between two consecutive measured values after the transition from I= 0A to I= $+I_{Meas}$ in UNIPOLAR operating mode involving inductive test units.

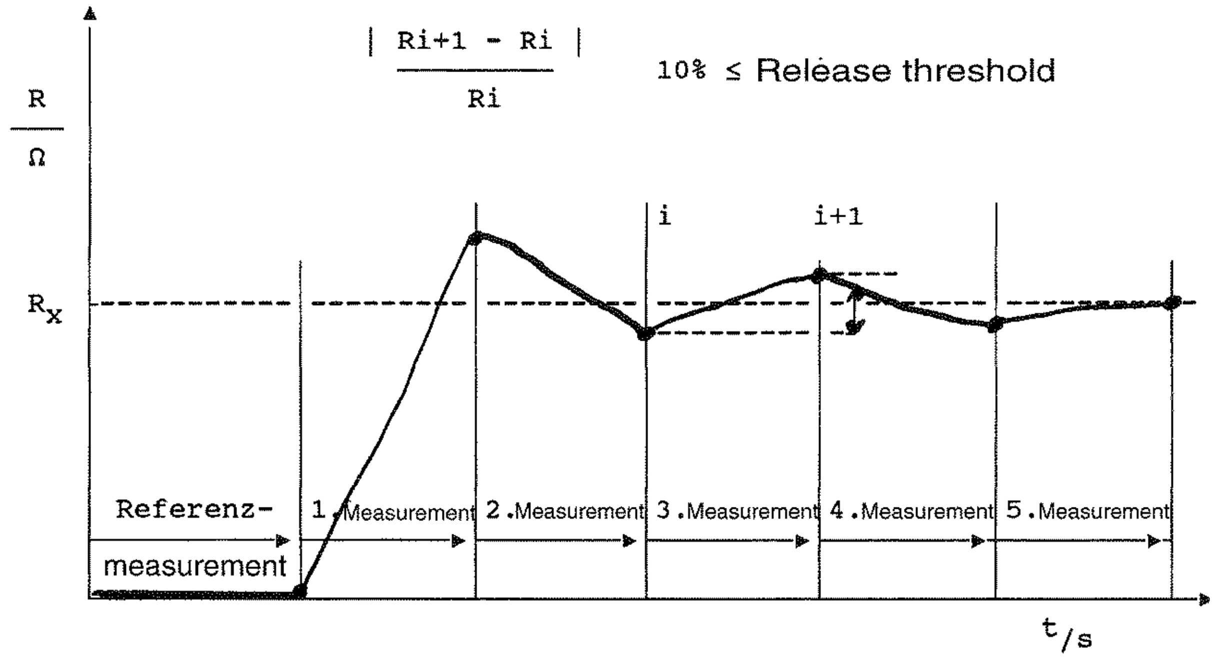


Fig. 4.9: Transient response with inductive test units

The entry of the release threshold as a percentage of the measuring current I+ is made via the numerical keyboard (see Chap. 2.4.3). For this, the value range

0.05% ≤ input value ≤ 20.00% is available.

VI) Special comments:

It is only when the amplitude difference between two consecutive measurements is determined to be smaller or equal to the release threshold after the START of a UNIPOLAR measurement that the subsequent measured values are released for display. The measurement itself is not influenced (or made quicker) by this!

VII) Exit:

Via the function key ENTER into the main menu which was previously exited.

Potential fixing

POTENTIAL FIXING	
MEAS. UNIT:	INTERN.
	GROUNDED

Fig. 4.7: Potential fixing

I) **Access:**
Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

II) **Function:**
Determination of whether the test unit is externally grounded or should be grounded internally.

III) **Restrictions:**
None.

IV) **Function keys:**

IV.1) [◄] [►] : Cursor keys for scrolling through the value list available for the selected parameter. When the ► key is pressed, the next list value appears; when the ◄ key is pressed, the previous list value appears.

IV.2) [ENTER] : Acknowledgement of the current parameter setting and return to the next higher menu level.

V) Parameters:

V.1) MEASURING UNIT:

The list values

INTERNALLY GROUNDED and EXTERNAL

are available.

In the case of INTERNAL grounding, the analog reference potential (analog ground) is connected to protective ground. In the case of EXTERNAL grounding, there is no electrical connection between the two potentials. The control (= digital) section of the device is grounded internally as a rule!

VI) Special comments:

Normally, the INTERNAL grounding is used. It is only advisable to select a separate, EXTERNAL ground for networks which are particularly susceptible to interference. This also applies to measurements on objects with single-ended grounding, e.g. motors. Here, the reference potential of the measuring circuit should be connected directly to the specified neutral point of the test unit (EXTERNAL grounding), in order to avoid ground loops. In the case of EXTERNAL grounding, the potential at the RESISTOMAT must not exceed the permissible, extra-low-voltage value specified by the VDE (Association of German Engineers).

VII) Exit:

Via the function key ENTER into the main menu exited previously.

Basic settings

RESISTOMAT®

burster präzisionsmeßtechnik

Fig. 4.11: Activate basic settings

I) Access:
Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

II) Function:
Selection of the basic parameter settings (see Chap. 7.4).

III) Restrictions:
This function can only be used after operation of the STOP key (the STOP LED is lit).

IV) Function keys: None.

V) Parameters:
After the entry of the 4th numbr N4 of the security code for activating the basic settings, the required procedure is commenced automatically, and the message shown in Fig. 4.11 appears on the display, with the 3rd line flashing. The procedure itself lasts only a few seconds. After it is completed, the calling main menu is displayed again.

VI) Special comments:
The calibration values (see Chap. 5) and the access monitoring (see Chap. 3.3.2) are not overwritten!

VII) Exit:
Automatically into main menu 1 after completion of the procedure.

Table of contents, Chapter 5-1 to 5.5

Calibration of the

RESISTOMAT® 2304

Operation of the RESISTOMAT®2304

Calibration

General information

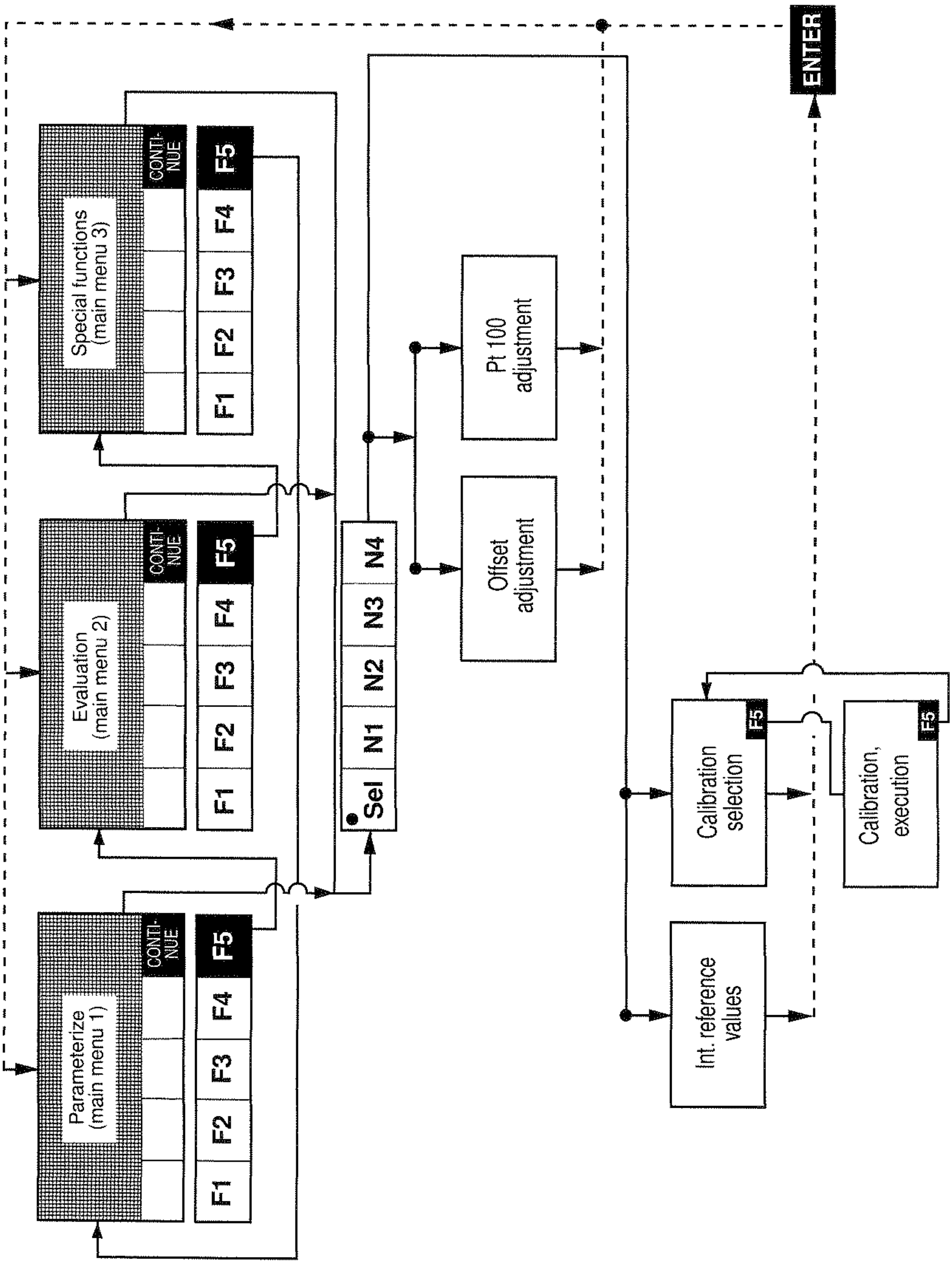
Calibration functions (see Fig. 5.1) influence the basic characteristics of the device; for this reason, they are only accesible via special security (see Fig. 4.2). The access procedure from any one of the three main menus is as follows:

SEL	N1	N2	N3	N4

The SEL light-emitting diode remains lit until the entry of the last number 4 has been completed.

The return from the calibration menu into the calling main menu is effected via the ENTER key. Only the submenu (execution) for calibration (selection) can be exited solely via the F5 RETURN key.

Fig. 5.1: Calibration menus



Offset adjustment

OFFSET ADJUSTMENT ACTIVE

Fig 5.2: Offset adjustment

I) Access:

Via SEL < security code as in Fig. 4.2 > within one of the three main menus.

II) Function:

Start and execution of the offset adjustment of the measuring amplifier.

III) Restrictions:

The adjustment is only possible after operation of the STOP key (the STOP LED is lit).

IV) Function keys:

None.

V) Parameters:

V.1) OFFSET ADJUSTMENT ACTIVE:

Before entering the security code, any resistor with less than 1 Ω has to be connected.
After the 4th number of the security code for offset adjustment has been entered, the adjustment is started automatically through a relay-switching procedure, and the message shown in Fig. 5.2 appears on the display.

The adjustment procedure itself can last between 5 s and 60 s depending on its starting values. It is completed through a second relay-switching procedure, after which the calling main menu appears again on the display.

VI) Special comments:

The zero point adjustment must be performed after every repair; during normal operation, however, a maximum of one adjustment per month is recommended.

If high gain, i.e. low measuring currents and/or small measurement ranges are used preferentially during operation, more frequent adjustment could be required.
Finally, the occurence of the error message ACOV (see chap. 7.3) could indicate that a zero point adjustment is necessary.

VII) Exit:

Automatically into the previously exited main menu after completion of the adjustment.

Calibration:

CALIBR.

200	μΩ	25.02.91	20	Ω	25.02.91
2	mΩ	25.02.91	200	Ω	25.02.91
20	mΩ	25.02.91	2	kΩ	25.02.91
2	Ω	25.02.91	20	kΩ	25.02.91

CAL

Fig. 4.5: Keyboard access

I) Access:

Via SEL <security code as in Fig. 4.1 >within one of the three main menus.

II) Function:

Selection of the resistance measurement range to be adjusted.

III) Restrictions:

None.

IV) Function keys:

IV.1) ▲ ▼ : Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is shown on the field in inverse form.

IV.2) ENTER : Acknowledgement of the current parameter setting and return to the next higher menu level.

IV.3)	RETURN / F 5 :	Return to the calibration selection (see Fig. 5.4).
		Fig. 5.3:
IV.4)	CAL / F 5 :	Selection of the menu for calibration of the scaling factor (**CAL**obration). After this function key is operated, the display in Fig. 5.4 appears.
		Fig. 5.4: Start of the scaling factor calibration for a measurement range.

CALIBR. 200 Ω 25.02.91 R_{ext} = 101.23 Ω				
CAL				RETURN

Fig. 5.4 : Calibration procedure

Line 1 states the selected measuring range, line 2 states the date of the last calibration for this measuring range. Line 3 contains the value of the calibration resistance R_{ext} which is to be externally connected; before every calibration procedure, this value must be entered via the numerical keyboard (see Chap. 2.4.3) and the entry completed with one of the measurement range keys (see Chap. 2.4). The calibration procedure for the previously selected measurement range is as follows:

a) Connection of the external calibration resistance R_{ext} (see VI).

b) Entry of the resistance value of R_{ext} . The entry must be completed with the unit key corresponding to the selected range. If the stated value of R_{ext} lies outside the permissible range, the error message R_{ext}? appears. A new entry must then be made.

c) CAL-F1: Start of the calibration procedure.

d) Check message: „CALIBR:: ACTIVE“.

e) Return to the next highest measurement range as shown in Fig. 5.4 (exception: 20 kΩ). If R_{ext} is not suitable for calibration of the selected range, i.e. if it lies far beyond the order of magnitude of the reference resistances (see Fig. 5.5), the error message R_{int}? occurs.
The calibration is then aborted.

V) Parameters:

V.1) - V.9) < measuring range> : < Day.Month.Year>

Every line contains one of the nine measuring ranges and the date of its last calibration. The measuring-range lines can also be used for selecting the corresponding calibration procedure (see Fig. 5.4). If all the measurement ranges need to be recalibrated, it is advisable to start in line 1 (200 μΩ range).

VI) Special comments:
The device only adheres to its specified fault-tolerance limits if the externally connected calibration resistances remain within the following limits (taking into account the influences of self-heating and the ambient temperature):

Measuring range	R_{Cal} Rated value of R_{Cal}	Uncertainty of the actual value	at measuring current
20 kΩ	10 kΩ	$1 \cdot 10^{-5}$	100 μA
2 kΩ	1 kΩ	$1 \cdot 10^{-5}$	1 mA
200 Ω	100 Ω	$1 \cdot 10^{-5}$	10 mA
20 Ω	10 Ω	$2 \cdot 10^{-5}$	100 mA
2 Ω	1 Ω	$2 \cdot 10^{-5}$	100 mA
200 mΩ	100 mΩ	$3 \cdot 10^{-5}$	1 A
20 mΩ	10 mΩ	$3 \cdot 10^{-5}$	1 A
2 mΩ	1 mΩ	$4 \cdot 10^{-5}$	10 A
200 μΩ	100 μΩ	$1.5 \cdot 10^{-4}$	10 A

After a calibration has been carried out, it is advisable to measure the external calibration resistance once again in the normal measuring mode, and check whether the display of its (previously entered) resistance value is correct. If a discrepancy is established, the calibration should be repeated.

VII) Exit:
Via the function key ENTER into the previously exited main menu.

Reference values

200 µΩ:100.00000	µΩ	20 Ω:10.00000	Ω
2 mΩ: 1.00000	mΩ	200 Ω:100.00000	Ω
20 mΩ:10.00000	mΩ	2 kΩ:1.00000	kΩ
200 mΩ:100.00000	mΩ	20 kΩ:10.00000	kΩ
2 Ω: 1.00000	Ω	Pt100:180.00000	Ω

Fig. 5.5: Reference values

I) Access:

Via SEL < security code as in Fig. 4.1 >within one of the three main menus.

II) Function:

Display of the internally determined reference resistance values.

III) Restrictions:

None.

IV) Function keys:

None.

V) Parameters:

V.1) - V.10) < measuring range> : < internal reference resistance>

Lines 1 to 9 contain the 9 measuring ranges, and line 10 displays the temperature-measurement channel for temperature compensation of the test unit. Every measurement range has a reference resistance assigned to it whose value lies approximately in the middle of its scale (± 10%). This resistance value is re-determined after every scaling factor calibration (see Chap. 5.3) and entered in the table shown in Fig. 5.5.

VI) Special comments:

The display of the reference resistance values serves as a plausibility check for the calibration (see Chap. 5.3). For example, if a sequence of several consecutive calibrations of a measurement range is analysed, only small deviations between the reference values should emerge, whereby the absolute values are of minor significance. Otherwise the following errors could exist:

- incorrect entry of the value of the calibration resistance R_{ext} to be connected externally,
- R_{ext} is unstable,
- the internal calibration resistance R_{ref} is unstable.

Upon return to the factory presettings (see Chap 4.8), the calibration values are not overwritten!

VII) Exit:

Via the function key ENTER into the previously exited main menu.

Pt100 - Calibration

CALIBR. Pt100 25.02.91 R_{ext} = 100 Ω				
CAL				

Fig. 5.6: Pt100 calibration

I) **Access:**

Via SEL < security code as in Fig. 4.1 > within one of the three main menus.

II) **Function:**

Calibration of the measurement channel for temperature compensation.

III) **Restrictions:**

The calibration is only possible after operation of the STOP key (the STOP LED is lit).

IV) **Function keys:**

IV.1) ENTER : Acknowledgement of the current parameter settings and return to the next higher menu level.

IV.2)

CAL
F 1

: Start of the calibration procedure (**CAL**ibration).

V) Parameters:

V.1) CALIBRATION Pt100:

Only display of the Pt 100 channel to be calibrated.

V.2) Day . Month . Year:

Date of the last calibration of the temperature measurement channel.

V.3) $R_{ext} = 100\Omega$:

Entry of the value of the calibration resistance to be connected externally; this value must be entered via the numerical keyboard (see Chap. 2.4) before every calibration, and the entry completed with the measurement-range keys (see Chap. 2.4).

VI) Special comments:

uncertainty $\leq 5 \cdot 10^{-5}$ at 1 mA.

R_{ext}

VII) Exit:

Via the function ENTER into the previously exites main menu.

Pt100 - coefficients

R_0 = 100
A = 3.9083 e^3
B = -5.775 e^{-7}
C = -4.183 e^{-12}
t_{100} = 100

Fig. 5.7: Pt100-coeffizients

I) Access:

Via SEL < security code as in Fig. 4.1 > (page 4-1-3)
within one of the three main menus.

II) Function:

Display of the actual Pt100-coefficients. The default values ex work are the above mentioned cofficients.
The calculation of the temperature ensue the following formula:

- 200 °C to 0 °C $R_t = R_0 \cdot [1 + A \cdot t + B \cdot t^2 + C \cdot (t - t_{100}) \cdot t^3]$
0 °C to 850 °C $R_t = R_0 \cdot (1 + A \cdot t + B \cdot t^2)$

III) Restrictions:

Variations of the coefficients are only possible via interface.
s. page 6-3-31
Commande: SCALe:Pt100

IV) Exit:

Via the function ENTER into the previously exites main menu.

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External interfaces of the RESISTOMAT®2304

External interfaces of the RESISTOMAT®2304

Introduction

The **RESISTOMAT ®2304** (called Res2304 in the following) has two external interfaces via which it can be controlled; one IEC bus interface and one serial interface, which can be configured as an RS232 or RS485 interface. All functions selectable via the front panel keyboard can also be configured via these interfaces. The only exception here is the function for selecting the interface via which the device is to be controlled. The command language for controlling the device is version 1990.0 of **SCPI** (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) agreed upon by leading manufacturers of measuring devices.

Remote/local change

The Res2304 must be in the remote state if it is to be controlled via an external interface. The remote state is indicated on the display by the fact that the function key F5 is shown as a local key. Except for the F5 key (change to front panel operation), all other keys on the front panel are inhibited until the device is switched back to the local state (F5 is pressed).

Control via GPIB

If the device is to be controlled via the GPIB bus interface, the IEEE488 setting must be selected in the interface menu.

Selecting the device address

The device address of the Res2304 for control via the GPIB is selected in the IEEE488 interface menu. The address can be selected from a range between 0 and 30. Address 9 is preset and used in all the examples. Every device connected to the IEEE488 must have its own address. After an address has been changed on the front panel or via the interface, the new address immediately beomes active, and from then on, the device must be activated under this new address.

Input/output commands

If the Res2304 is to be controlled by an GPIB controller, its input/output commands must be known. The syntax of the commands is stated in the operating manuals of the individual IEEE488 interface controllers. For example, the input/output commands of the HP series 200/300 in Basic language are:

OUTPUT and *ENTER*.

If a National PC GPIB board is used, these commands are:

IBWRT und *IBRD*.

The examples in this manual are written in HP Basic.

Sending a command

If a command is to be sent to the Res2304, the output command of the GPIB interface must be combined with the SCPI of the Res2304.

To set the display contrast, for example, the following is sent

1. in HP Basic:

OUTPUT 709;":DISPLAY:CONTRAST 0.5"

Output command — OUTPUT
HP-IB Select Code + device address — 709
SCPI command — :DISPLAY:CONTRAST 0.5

2. with National:

IBWRT ":DISPLAY:CONTRAST 0.5\n"

Output command — IBWRT
SCPI command — :DISPLAY:CONTRAST 0.5
Line Feed as command terminator — \n

Receiving the data of the Res2304

The Res2304 returns data requested by an SCPI query. For example, in response to the question

OUTPUT 709;":DISP:CONT?"

the Res2304 writes the current setting of the display contrast into its output buffer. This response can then be fetched using the input command of the GPIB interface.

For example, the following program in HP Basic fetches the response from the device and writes it on the screen:

```
10 ENTER 709;cont$
20 PRINT cont$
30 END
```

With national, the input command is:

IBRD <*number of bytes*> .

Remote/local

On receiving a command addressed to it, the Res2304 switches over into the remote state. The remote state is indicated by the LOCAL designation for function key F5. In this state, all keys except for the local key (F5) are inhibited.

The change to local operation is made by pressing the Local key or sending the IEEE488.1 Go-to-local command.

If the IEEE488.1 Local Lockout command is sent, the Res2304 can only be switched back to local operation by the Go-to-local command, as the local key is also inhibited then.

Contr ol via serial interface

Introduction

Control via the serial interface can be performed using the RS232 or the RS485. The type of interface can be set in the interface menu. The ANSI standard serves as the communication protocol between the system controller and the Res2304:

ANSI X3.28-1976 Subcategory 2.5, A3/A4

Settings in the serial interface menu

Hardware settings

The hardware settings of the Res2304 and the system controller must correspond in order to allow proper communication.

Baud rate

The baud rate is adjustable in steps from 600...19200 bits/sec

Data bits

7 oder 8

Stop bits

1 or 2

Parity

even, odd or none

Type of connection (only for RS485)

full duplex or half duplex

Software settings

Group address
The group address at which the Res2304 can be addressed:
0..15 (0...f)

User address
The user address at which the Res2304 can be addressed:
0..15 (0..f)

Character delay
Turn on delay time (approx. 1-1.5ms) between two transmitted bytes.

Block check
With the block check = ON, transfer is effected in accordance with the ANSI standard X3.28 Subcat.2.5,A4. The BCC is sent after <ETX>. It is formed from all bytes which follow <STX>, including <ETX>. The BCC is an "Exclusive-Or" combination of these bytes.

Description of the communications protocol for connection set-up

General description

The ANSI standard X3.28 Subc. 2.5 is used for systems in which several subordinate stations are present in a non-connected multi-point connection, and all commands are sent from a control station. On the bus, only a transmitter (master) and receiver (slave) are active at any time.

One of the stations is a control station. It receives master status and sends commands to a selected slave station or transfers its master status to a subordinate station, assuming the slave status itself in order to receive data. A link between two subordinate stations is not permissible. The control station monitors the connection constantly.

Connection set-up

Before a connection is set-up, the control station posseses master status, and none of the subordinate stations possesses slave status. The control station can either
(1) poll, in order to deliver the master status to a subordinate station
or
(2) specify a slave station in order to establish a connection

Resistomat as master

Polling

The control station sends a "Polling Supervisory Sequence". This sequence is meant to fetch requested data from the Res2304. The prefix selects a single station. <ENQ> defines the end of the "Polling Supervisory Sequence". The polling supervisory sequence of the Res2304 has the following format:

<groupadr><groupadr><useradr><useradr>po<ENQ>

group address (in hex) selected in the interface menu	user address (in hex) set in the interface menu	ASCII-characters "p"und "o"	ASCII-characters ENQ

Prefix

Example:

selected group address 10
selected user address 11

Polling Supervisory Sequence: aabbpo<ENQ>

A subordinate station which recognizes its polling supervisory sequence responds in one of two ways:

(1) When the station has to send data, it starts transmission. The control station assumes the slave status.

(2) When the station does not have to send anything, it transmits <EOT>, which ends its master status. The master status returns to the control station.

If the control station receives no reponse, or an invalid one, it terminates the connection by sending <EOT>.

Resistomat as slave

Selection with Response

The control station sends a "Selection Supervisory Sequence". This sequence initializes the Res2304 as a slave so that the control station can subsequently transmit SCPI commands to it. The prefix selects a singlestation. <ENQ> defines the end of the selection supervisory sequence.

The selection supervisory sequence of the Res2304 has the following format:

<groupadr><groupadr><useradr><useradr>sr<ENQ>

group address (in hex) set in the interface menu	user address (in hex) set in the interface menu	ASCII-characters "s" und "r"	ASCII-characters ENQ

Example:

selected group address: 5
selected user address: 6

Selection Supervisory Sequence: 5566sr<ENQ>

A subordinate station which recognizes its selection supervisory sequence asumes the slave status and sends one of two responses:

(1) When the station is ready ro receive data, it sends <ACK>. On this response, the master station begins data transfer.

(2) When the station is not ready to receive data, it sends <NAK>. The master station can then try to address the station again.

When the master station receives no response, or an invalid one, it can try to address the same station again, or it can end transmission.

Fast Selection

As an alternative to "Selection with Response", the master station can send a selection supervisory sequence without <ENQ>. This selects a subordinate station as a slave. The master station commences data transfer immediately without waiting for the acknowledgement from the subordinate station.

Example:

selected group address: 5
selected user address: 6

Fast Selection Sequence: 5566sr<STX>SCPI command <ETX>

Connection termination

Termination

The master station sends <EOT> in order to indicate that it does not have any further data to transfer. <EOT> gives the master status back to the control station.

Description of the data transfer protocol according to ANSI X3.28 Subcat A3/A4

After the connection is set-up in accordance with the specifications of the ANSI X3.28 Subcat. 2.5 Protocol, the data is transfered in accordance with the specifications of Subcat. A3 or Subcat A4 (corresponds to A3 with an additional Block Check character.

Subcat. A3/A4 are used when a master station sends data to a single slave station. The master station sends every message to the slave station and waits for a response. When the response indicates that the data has been accepted (ACK), the master station can send another message or terminate the connection. A negative response (NAK) from the slave station tells the master station that the data was not understood.

Data transfer

The data transfer is begun by the master station after the connection is set up (see Subcat 2.5). The master station commences transfer with <STX>. After that, the required data is sent. The data block is terminated with <ETX>. During transfer in accordance with Subcat. A4, the block-check - character (BCC) must follow <ETX>.

Response

After recognizing <ETX> resp. <BCC>, the slave station sends one of two possible responses:

(1) If the data has been accepted and the station is ready to receive new data, it sends <ACK>. After that, the master station can either send the next batch of data, or terminate transfer.

(2) If the data has not been accepted and the slave station is ready to receive new data, it sends <NAK>. After that, the master station can send other data or terminate the connection.

If the master station receives an invalid response, or no response at all, it can send a "Reply-Request Supervisory Sequence" consisting of <ENQ>, or terminate the connection.

Timer functions in accordance with ANSI X3.28

The timers defined by the ANSI standard are used to indicate that a certain control character was not received within a specified time period.

Timer A (Response Timer)

Timer A is used by the transmitting station for protection against an invalid response or no response.

Start: Timer A is started following the transmission of an end character after which a response is awaited (e.g. after ENQ or ETX).

Stop: Timer A is stopped if a valid response has been received.

Time Out: When a Time Out occurs, the Res2304 sends EOT, thus terminating the connection.

In the Res2304, timer A is set to 5 seconds.

Timer B (Receive Timer)

Timer B is used by the receiving station for protection against non-recognition of an end-of-text character (e.g. ETX).

Start: Timer B is started when a start-of-text character (STX) is received.

Restart: Timer B is restarted as long as data are received, to allow data blocks of variable length to be received.

Stop: Timer B is stopped when a valid end character is received.

Time Out: When a Time Out occurs, the received data are discarded, and the Res2304 waits for another transmission.

In the Res2304, timer B is set to 5 seconds.

Flow diagram for connection set-up in accordance with ANSI X3.28 Sub2.5,A3/A4

The following diagram shows the connection set-up of a system controller with the Res2304. The Res2304 has the group address 0 and the user address 0.

		Master	Slave
1.	Controller sends "Selection Supervisory Sequence"		
	0000sr<ENQ>	Controller	X
2.	Res2304 assumes slave status and sends		
	<ACK>	Controller	Res2304
3.	The controller then sends a command beginning with <STX> and ending with <ETX> resp. <BCC>		
	<STX>:DISP:CONT?0.5<LF><ETX> (<BCC>)		
4.	On recognizing the command, the Res2304 sends		
	<ACK>		
	and writes the instantaneous setting of the display contrast into the output buffer.		
5.	The controller terminates the connection with		
	<EOT>	Controller	X
6.	To fetch the response of the Res2304, the controller sends the "Polling Supervisory Sequence", thus making the Res2304 the master.		
	0000po<ENQ>	Res2304	Controller

	Master	Slave
7. The Res2304 transfers the data to its output buffer **<STX>0.5<CR><LF><ETX>(<BCC>)** 8. The controller responds with **<ACK>** 9. The Res2304 sends **<EOT>** and thus terminates the connection	Controller	X

A PC with an RS232 interface can serve as a system controller. A sample program in GW basic for controlling the Res2304 via the serial interface of a PC is shown later in the Appendix.

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The RESISTOMAT®2304 Command Language

The RESISTOMAT®2304 Command Language

Introduction

The command language of the Res2304 is called **SCPI** (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation). SCPI is a common language with standard commands, agreed upon by leading manufacturers of measuring devices. SCPI not only provides a standardized set of commands but also allows manufacturers of devices to define their own commands in accordance with specific rules.

SCPI knows four HLL commands sufficient for controlling a device: **MEASURE?, READ?, FETCH?** and **CONFIGURE** .
The commands should be understood by every SCPI device.

In addition to these commands, the following **IEEE488.2 Common Commands** should be implemented in all SCPI devices:

*CLS	Clear Status Command
*ESE	Standard Event Status Enable Command
*ESE?	Standard Event Status Enable Query
*ESR?	Standard Event Status Register Query
*IDN?	Identification Query
*OPC	Operation Complete Command
*OPC?	Operation Complete Query
*RST	Reset Command
*SRE	Service Request Enable Command
*SRE?	Service Request Enable Query?
*STB?	Read Status Byte Query
*TST?	Self-Test Query (not implemented in the Res2304)
*WAI	Wait to Continue Command

Command heading

e.g.: DISPlay

Every SCPI command heading has a long and a short form. Every SCPI device should only accept the correct long and short forms. The IEEE488.2 limits the length of a command heading to 12 characters.

The long form comprises either a single word or several abbreviated words. The short form is an abbreviation of the long form.

If the command consists of a single word, the word is the long form of the command (e.g. DISPLAY). If the command consists of several words, it is formed from the first letter of each word and the entire last word. For example, the words "Line Frequency" result in the command "LFREQUENCY".

The short form of the command heading normally consists of the first four letters of the long form (e.g. DISP). An exception is when the long form comprises more than four letters, the fourth one being a vowel. In this case, the vowel is omitted. Then the short form only consists of the first three letters of the long form. For example, the short form of the calibration command is CAL.

In the command list, the command is displayed in the long form, with the corresponding short form in capital letters and the rest of the command in small letters.

The commands can be sent in upper or lower case.

Command tree

The SCPI command tree has a hierarchial structure. Consequently, the same command heading can be used repeatedly for different tasks at different levels of the command tree.

```
e.g.:     TIME     :STATE
          PRINTER  :TIME     :STATE
             |         |         |
          Level 1   Level 2   Level 3
```

The various command levels are separated by a ":" Some commands have optional headings. In the case of the DISPlay:CONTrast command, for example, the "CONTrast" heading from level 2 is optional. None of the optional command headings need be transfered with the command.

In the command list, the optional parts of a command are enclosed in square parentheses (e.g. DISPlay[:CONTrast]). The parentheses are not part of the command, and must not be transmitted with it.

Query form

If not labelled otherwise, all commands have an appropriate query form. As defined in the IEEE488.2, the query form of a command is created by suffixing a question mark to the command heading (e.g. DISPlay:CONTrast?), A query form can, but need not be transmitted with a parameter. When the Res2304 receives the query form of a command, the current setting corresponding to the command is written into the output buffer. The response to a query command does not contain the command heading. If the response to a query command consists of one word, the short form is always used.

When measured values are requested, they are always in the same form as that shown on the display of the 2304.

For example:
Display: 100.34kOhm -> Response 100.34KOHM

Moving through the command tree

Within a command message, several commands can be sent to the Res2304. The first one always refers to the root directory. Subsequent commands always refer to the same tree level as the preceding command of the command message. The individual commands within a command message are separated by a semicolon. If a command is transmitted with a prefixed colon, it again refers to the root directory. The command message is terminated with "Line Feed" (<nl>).

Example:
If a device has the following command tree

```
INITiate
        :CONTinuous          <parameter>
        [:IMMediate]

SYSTem
        :BEEPer
        [:STATe]             <parameter>

ABORt
```

the following command messages act as described:

INIT:CONT ON;IMM<nl>
switches the device to continuous measurement and begins the measurement.

INIT:CONT ON;:INIT:IMM<nl>
switches the device to continuous measurement and begins the measurement.

INIT:IMM;ABOR<nl>
starts the measurement and generates an error, because ABOR is not a command from the current interpreter level.

INIT:CONT ON;:INIT:IMM;:ABOR<nl>
switches to continuous measurement, starts the measurement, and stops it again.

SYST:BEEP:STAT ON;:INIT;:ABOR;:SYST:BEEP:STAT OFF<nl>
switches on the beeper, begins measurement, stops it, and switches the beeper off.

Parameters

The parameters valid for a command are listed in the following command list under the syntax description. The parameters are separated from the command heading by space character.

Format of a resistance parameter:

A parameter which stets a resistance value or resistance measurement range can be entered in several formats and with several units.
The resistance value can be entered in the form of integers, floating-point numbers or exponential numbers.
Valid units for a resistance parameter are:

UOHM	->	Microohm
MOHM	->	Milliohm
OHM	->	Ohm
KOHM	->	Kiloohm
MAOHM	->	Megaohm

If the unit is omitted, the parameter is assumed to be in Ohms.
Examples of valid resistance parameters for a resistance of 123.45 Ohms:

123.45,123.45OHM,0.12345KOHM,123450MOHM,123.45E-6MAOHM.

Format of the ON/OFF parameters:

The ON/OFF parameters can be replaced by numerical parameters. When responding to query forms, the Res2304 always uses numerical values.

OFF -> 0
ON -> 1

The parameters for the quera forms of the individual commands can be omitted if only the current setting is being requested.

Command terminator

Line Feed (nl), Semicolon (;) or EOI (IEEE488.1 End or Identify), together with the last transmitted character (EOI only for GPIB control) indicate the end of the command.

For example, if the HP200/300 basic command 'OUTPUT 709;"INIT"" is sent, the controller automatically appends a <cr><nl> to the command. In the case of the other IEEE488 interfaces, e.g. a National PC insert-card, the <nl> character may need to be stated explicitly.
(e.g..:ibwrt ":init\n")

Special features of the Resistomat

If a measurement has been started, no setting can be changed or requested. This means that the Res2304 ignores all commands until the measurement is stopped. Exceptions here are the "ABORt" command for stopping the measurement, the commands for status register control ("STATus") and the IEEE488.2 commands.

If the device has been switched to the cooling curve measurement mode, all "non-cooling" curve commands are disabled until the cooling curve measurement mode is turned off.

Effects of the "MEASure?", READ?", FETCh?"commands during continuous measurement

When one of these commands is sent, the next (!) available measured value is written to the output buffer. This measured value can then be fetched. For this, the Resistomat 2304 is made a talker (GPIB) or a master (ANSI X3.28). After the measured value is fetched, a new one is not written into the output buffer until a new "FETCh?" command is sent.

Difference between GPIB and serial interface

When several "MEASure?", "READ?" or "FETCh?" commands are sent in a row without the measured values being fetched, there is a difference between serial control and control via the GPI B.

In the case of the GPIB, each requested measured value is written into the output buffer (256 bytes) until it is full. After that, no new measured values are written into the buffer until it has been emptied. This can occur through the reading out of one or more requested measured values (first in, first out) or through the transmission of a "device clear" command.

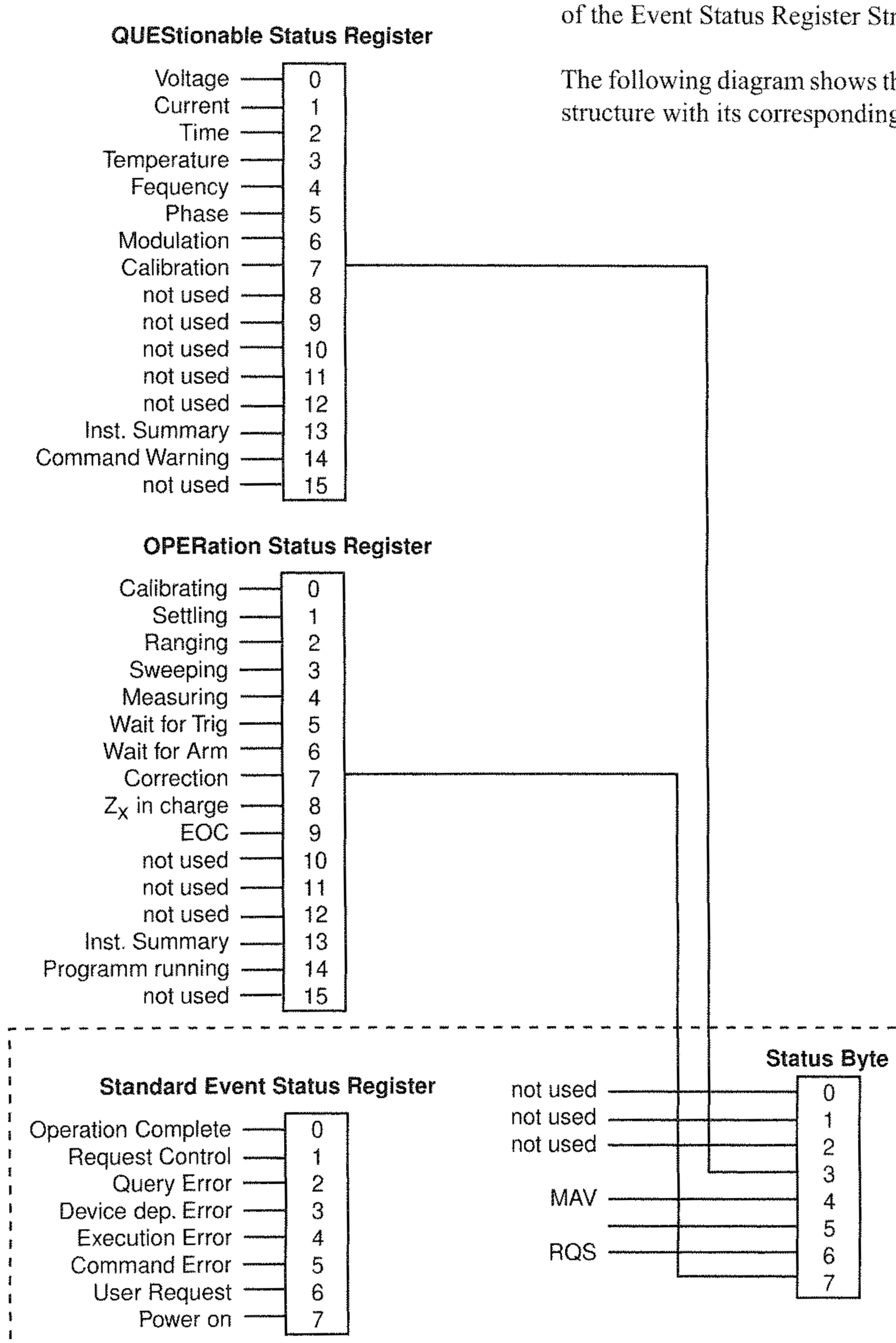
During control via the serial interface, only the newest requested value is written into the output buffer.

Status Messages

Indroduction

Every SCPI device requires the status mechanism described in Chater 11 of the IEEE488.2, including full implementation of the Event Status Register Structure.

The following diagram shows the SCPI data structure with its corresponding registers.



IEEE488.2 Data register structure

Operation status register

The operation status register contains states which are part of the normal functions of the Res 2304.

If a bit in the operation status register is set, and the corresponding bit in the operation status enable register is released, the operation status summary bit (bit 7) in the status register is set. When bit 7 in the service request enable register is released, a service request is sent to the system controller during control of the Res2304 via the IEC bus.

The bits used in the Res2304 are:

0 - Calibrating	-	The Res2304 is performing a calibration.
2 - Ranging	-	The Res2304 is changing its measurement range.
4 - Measuring	-	The Res2304 is performing a measurement.
5 - Waiting for Trigger	-	The Res2304 is waiting for a trigger signal.
8 - Z_x in charge	-	The unit under test on the Res2304 has been recognized as mainly inductive and has been loaded. The bit corresponds to the warning LED on the front panel.
9 - EOC	-	End of Conversion: The bit indicates that a valid measured value is available to the Res2304. It is reset when the measured value is read out.

The commands for controlling the operation status structure are:

STATus:OPERation:EVENt?
STATus:OPERation:ENABle

Questionable status register

The questionable status register indicates that the data which has just been registered is invalid for some reason.

If a bit in the questionable status register is set and the corresponding bit in the questionable status enable register is released, the questionable status summary bit (bit 3) in the status register is set. If bit 3 in the service request enable register is released, a service request is sent to the system controller during control of the Res2304 via the IEC bus.

Bit 14 is the command warning bit and indicates that a parameter was ignored during the execution of a MEASure command.

The commands for controlling the questionable status structure are:

STATus:QUEStionable:EVENt?
STATus:QUEStionable:ENABle

Standard event register

The standard event register indicates different states of the Res2304. If a bit in the standard event register is set and the corresponding bit in the standard event enable register is released, bit 5 in the status register is set. If this bit 5 is released in the service request enable register, a service request is sent to the system controller during control of the device via the GPIB.

The bits used in the Res2304 have the following meanings:

Bit 0 Operation Complete — This bit is set in response to the *OPC command. It indicates that the device has executed the selected functions.

Bit 2 Query Error — A query error has been detected. The bit indicates that either :

(1) non-existent data was requested or

(2) data in the output buffer was lost.

Bit 3 Device Dep.Error — The device dependent error bit indicates that an error has occurred during a measurement.

Bit 4 Execution Error — The execution error bit is set when a false parameter was sent.

Bit 5 Command Error — The command error bit is set when a command from the SCPI interpreter was not recognized.

The IEEE488.2 commands for controlling the standard event data structure are:

*ESR?
*ESE
*ESE?

Standard data register

The status byte is used to combine serval event registers in one status register. The status byte of every event register has a corresponding event register summary bit which indicates whether an event in the related event register has occurred. The corresponding summary bit is only set when the related bit in the event enable register is set. If the summary bit is set and the bit in the service request enable register is released, a service request is sent to the system controller during control of the Res2304 via the GPIB.

The bits in the status byte are:

Bit 0 - 2	not used
Bit 3	Questionable status summary bit. The bit is set when a bit released in the questionable event enable register has been set in the questionable event register.
Bit 4	MAV-Message available.. The MAV bit is set when data are present in the output buffer of the Res2304.
Bit 5	ESB-Event status summary bit. The bit indicates whether an event released in the event status register of the Res2304 has occurred.
Bit 7	Operation status summary bit. The bit is set when an event released in the operation status register has occured.

The IEEE488.2 commands for setting the status data structure are:

*STB?
*SRE
*SRE?

Comment on the "MEASure" command

The "MEASure?" command stops a current measurement, selects a desired measurement range, starts a new measurement, and writes a measured value into the output buffer the moment it is available.

The command should only be used for simple test programs, as the Resistomat 2304 writes a measured value into its output buffer as soon as it is available. When the status registers are sampled after the "MEASure?" command has been sent, it is not possible to distinctly associate the data in the output buffer with the requested data. A measured value could be obtained instead of the requested contents of the status register.

When the status registers are to be used ("STATus" commands), it is better to work with the "INITiate" and "FETCh?" commands. "INITiate" starts a measurement, but no measured value is written into the output buffer. In this manner, one can request the state of the Resistomat 2304 by means of the "STATus" commands, without obtaining a measured value on a "STATus" command - this would be possible when using the "MEASure?" command. The measured value can then be requested with the "FETCh?" command.

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The RESISTOMAT®2304 command list

The RESISTOMAT®2304 Command List

Introduction

This chapter contains all commands for controlling the Res2304. The commands are arranged in alphabetical order.

The commands are described in the following format:

Command header

DISPlay[:CONTrast]

Command descrip-tion

Description: This command is meant for setting the display contrast.

Command syntax

Syntax: :DISPlay[:CONTrast] < *parameter* >

Parameter description when a parameter is present.

parameter 0...1

The display contrast can be adjusted between:

0 -> no contrast
1 -> full contrast

Comments on the commands. Contains additional information, e.g. query form of the commands, reset values of the parameters.

Comments:

Query form: on receiving the query form of the "DISPLay: CONTrast" command, the device sends the current contrast setting betweeen 0 and 1.

Reset value: 0.54

Examples show typical applications of the commands. The examples are written in HP Series 200/300 Computers Basic.

Example:

```
10 OUTPUT 709;":DISPLAY:CONTRAST? 0.5" !normal contrast
20 ENTER 709;A$ !fetch requested contrast setting
30 PRINT A$
40 END
```

Response of the device: 0.5

ABORt

Description:

Aborts a single or repetition measurement which has been started.

Syntax:

:ABORt

Comments

The command is equivalent to pressing the "STOP" button.

Query form: none

Example:

```
10 OUTPUT 709;":INITIATE" !start measurement
20 OUTPUT 709;":FETCH?" !request measured values
30 ENTER 709;A$ !fetch measured value
40 PRINT A$
50 OUTPUT 709;":ABORT" !stop measurement
60 END
```

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CALCulate:MATH[:EXPRession]

Description:

This command selects the desired display mode of the device.

Syntax:

:CALCulate:MATH[:EXPRession] <*parameter* >

parameter: The *parameter* corresponds to the mathematical expression used for the display.

parameter	Display mode
R/LENGTH0[M]	Ohm / Meter
R/LENGTH0[KM]	Ohm / Kilometer
R/LENGTH0[10FT]	Ohm / 10 feet
R/LENGTH0[KFT]	Ohm / 1000 feet
DELTA%	Delta%
RHO1	Rho1
RHO2	Rho2
GAMMA1	Gamma1
GAMMA2	Gamma2

ATTENTION: The corresponding display mode is only set when the "CALCULATE:STATE ON" command is sent.

Otherwise the display remains on "OHM".

Comments:

Query form: The query form of the command gives the mode selected with "CALC:MATH:EXPR" (see parameter table), when "CALC:STAT ON" was sent.

Otherwise the response "R" is obtained.

CALC:STAT	Response
ON	selected mode
OFF	R

The individual parameters of the various display modes are entered with the help of the "TRACe:DATA" command.
(see "TRACe:DATA" command)

CALCulate:MATH[:EXPRession]

Example: Setting the display to "Ohm / Meter"

- 05 OUTPUT 709;":CALCULATE:STATE OFF"! turn on Ohm display
- 10 OUTPUT 709;":CALCULATE:MATH:EXPRESSION? R/LENGTH0[M]"
- 20 ENTER 709;A$!fetch current display mode
- 30 OUTPUT 709;":CALCULATE:STATE ON" !switch to "Ohm/ Meter"
- 40 OUTPUT 709;":CALCULATE:MATH:EXPRESSION?"
- 50 ENTER 709;B$!fetch new display mode
- 60 PRINT A$, B$!response on screen
- 70 END

Response of the device: R R/LENGTH0[M]

CALCulate:STATe

Description:

The command activates or deactivates the display mode set with "CALC:MATH:EXPR".

Syntax:

:CALCulate:STATe <*parameter*>

parameter

parameter	Setting
ON	mode selected with the "EXPR" command
OFF	Ohm display mode

Comments:

Query form: The query form of the command results in the following response from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: OFF

Example:

see "CALCulate:MATH:EXPRession" command.

CALibration:DATA

Description:

This command is meant for calibrating the individual resistance measurement ranges.

Syntax:

:CALibration:DATA < *parameter* >

parameter: The *parameter* consists of two parts: the resistance measurement range to be calibrated, and the corresponding calibration value.
The two parts are separated by a comma.

parameter	Description
PT100,90..110OHM	PT100 - measurement range
200UOHM,89..111UOHM	200UOHM - measurement range
2MOHM,0.89..1.11MOHM	2MOHM - measurement range
20MOHM,8.9..11.1MOHM	20MOHM - measurement range
200MOHM,89..111MOHM	200MOHM - measurement range
2OHM,0.89..1.11OHM	2OHM - measurement range
20OHM,8.9..11.1OHM	20OHM - measurement range
200OHM,89..111OHM	200OHM - measurement range
2KOHM,0.89..1.11KOHM	2KOHM - measurement range
20KOHM,8.9..11.1KOHM	20KOHM - measurement range

Example: CAL:DATA 200OHM,100.35OHM

Comments:

The calibration value may consist of no more than 7 digits.

Example: "CAL:DATA 2OHM,1.034567OHM"

Query form: The query form "CAL:DATA?" gives the calibration data of all measurement ranges, separated by commas..

The response has the following format:

<pt100>,<200UOHM>,...,<20KOHM>

Example::
104.2345OHM,98.12345UOHM,...,10.23456KOHM
| | |
PT100 200UOHM ... 20KOHM

CALibration:DATA

Example:

Calibration of all measurement ranges

Pt100
OUTPUT 709;"CALIBRATION:DATA PT100,100.4567 OHM"
200uOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 200UOHM,100.4567UOHM"
2mOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 2MOHM,1.004567MOHM"
20mOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 20MOHM,10.04567MOHM"
200mOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 200MOHM,100.4567MOHM"
2Ohm measurement range
OUTPUT 709;"CALIBRATION:DATA 2OHM,1.004567OHM"
20Ohm measurement range
OUTPUT 709;"CALIBRATION:DATA 20OHM,10.04567OHM"
200Ohm measurement range
OUTPUT 709;"CALIBRATION:DATA 200OHM,100.4567OHM"
2kOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 2KOHM,1.004567KOHM"
20kOhm measurement range
OUTPUT 709;"CALIBRATION:DATA 20KOHM,10.04567KOHM"

Request calibration data:

```
10 OUTPUT 709;"CALIBRATION:DATA?"
20 ENTER 709;A$ !fetch calibration data
30 PRINT A$ !display calibration data
40 END
```

Response of the device (e. g.):

180.0359OHM,101.4213UOHM,1.001234MOHM,...,99.99914KOHM

CALibration:ZERO

Description: This command triggers an offset adjustment of the device.

Syntax: :CALibration:ZERO

Comments: no parameters

no query form

Example:

```
10 OUTPUT 709;"CALIBRATION:ZERO" !offset adjustment
20 END
```

CONFigure[...FRESistance:DC]

Description:

Configures the device, i.e. a desired resistance measurement range can be set.

Syntax:

:CONFigure[:FRESistance:DC] <*parameter*>

parameter With the help of the parameter, the device is switched to a desired measurement range.

The paramters are:

parameter	Description
0..20KOHM	The device switches to manual range selection and selectes the measurement range containing the parameter.
DEFault	The device remains in the measurement range currently selected.

If the parameter is omitted, the device switches to automatic measurement range selection and searches for the appropriate measurement range independently.

Comments:

Query form: The query form of the "CONFigure" command provides the following response from the device:

FRES: <selected range>

Example: FRES: 20KOHM

Example:

```
10 OUTPUT 709;":CONFIGURE? 100OHM" !200OHMM-range
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device:: FRES: 200OHM

DISPlay[:CONTrast]

Description:

This command is meant for adjusting the display contrast.

Syntax:

:DISPlay[:CONTrast] < *parameter* >

parameter 0...1

The display contrast is adjustable between:

0 -> no contrast
1 -> full contrast

Comments:

Query form: On the entry of the query form of the "DISPLay:CONTrast" command, the device sends the current contrast setting between 0 and 1.

Reset value: 0.54

Example:

```
10 OUTPUT 709;":DISPLAY:CONTRAST? 0.5" !normal contrast
20 ENTER 709;A$ !fetch requested contrast setting
30 PRINT A$
40 END
```

Response of the device: 0.5

DISPlay:ENABle

Description: Activate or deactivate LCD display (during remote operation)

Syntax: :DISPlay:ENABle <*parameter*>

parameter The display is turned on or off with the help of the parameter.

The parameters are:

ON	or 1	->	LCD Display is on
OFF	or 0	->	LCD Display is off

Comments: The LCD display can only be turned on or off via one of the external interfaces.
The function is only active during remote operation.

Query form: DISPlay:ENABle?

Response of the device: 0 -> when LCD off.
1 -> when LCD on.

Reset value: OFF or 0

Example:

```
10 OUTPUT 709;":DISP:ENAB? ON"   ! DISPLAY       ON
20 ENTER 709;A$                  ! RESPONSE    FETCH
30 PRINT A$                      ! RESPONSE    DISPLAY
40 END
```

Response of the device: 1

DISPlay:MENU[:STATe]

Description:

This command activates or deactivates the bar display.

Syntax:

:DISPlay:MENU[:STATe] < *parameter* >

parameter The bar display is activated or deactivated with the help of the parameter.

parameter	setting	corresponding num. value
ON	bar display on	1
OFF	bar display off	0

When the parameter is polled, the device always sends the corresponding numerical value.

Comments:

The bar display is only visible when the comparator or classify function is active.

Query form: On the entry of the query form ":DISP:MENU:STAT?", the device responds with the corresponding numerical value.

0 -> when bar display off
1 -> when bar display on

Reset value: OFF

Example:

```
10 OUTPUT 709;":DISPLAY:MENU:STATE? ON" !bar display on
20 ENTER 709;A$  !fetch response
30 PRINT A$
40 END
```

Response of the device: 1

FETCh[:FRESistance:DC]?

Description: Revieves measured values while a measurement is in progress and places them into the device´s output buffer.

Syntax: :FETCh[:FRESistance:DC]?

Comments: The command is used to fetch a measured value via the interface while a measurement is in progress.

During single measurements, the measured value is sent via the interface on every "FETCh" inquiry.

During repetition measurements, the most recent measured value is always sent via the interface. The measurement must be stopped with "ABORt".

Example:

```
10 OUTPUT 709;":INITIATE" !start measurement
20 OUTPUT 709;":FETCH?" !request measured value
30 ENTER 709;A$ !fetch measured value
40 PRINT A$ !display measured value
50 END
```

INITiate:CONTinuous

Description: The command is meant for changing over between single and repetition measurements.

Syntax: :INITiate:CONTinuous < *parameter*>

parameter Repetition measurement is activated or deactivated with the help of the parameter.

parameter	setting	corresponding num. value
ON	repetition meas.	1
OFF	single meas.	0

When the parameter is polled, the device always sends the corresponding numerical value.

Comments: Single measurements are always stopped automatically after a measured value has been registered.

Repetition measurements must be stopped with the "ABORt" command or via the keyboard.

Query form: On the entry of the query form ":INITiate:CONTinuous?", one obtains:

0 -> during single measurement
1 -> during repetition measurement

Reset value : ON

Example:

```
10 OUTPUT 709;":INITIATE:CONTINUOUS? ON" !repetition measurement
20 ENTER 709;A$ !fetch requested measurement type
30 PRINT A$  !display value
40 END
```

Response of the device: 1

INITiate[:IMMediate]

Description: The "INITiate:IMMediate" command starts a resistance measurement when the trigger is set to passive.

When the trigger is set to active, a "group-execute-trigger" is awaited, and the measurement is not started until its occurrence.

Syntax: :INITiate[:IMMediate]

Comments:

Query form: none

Example:

```
10 OUTPUT 709;":INITIATE:IMMEDIATE"  !start measurement
20 OUTPUT 709;":FETCH?"  !request measured value
30 ENTER 709;A$  !fetch measured value
40 OUTPUT 709;":ABORT"  ! stop measurement
50 END
```

INITiate:REF Ø

Description: The measurement REFØ will adjust. Zero - reference measurement in measure kind "CONSTANT".

Syntax: :INITiate:REFØ

Comments: This instruction is only possible if measure mode "CONSTANT" is adjust.

Query form: none
Parameter: none.

INPut:LOW

Description:

Thepotential fixing of the measurement part is selected with this command.

Syntax:

:INPut:LOW < *parameter* >

parameter The potential fixing is selected with the help of this *parameter*.

parameter	Description
FLOat	the measurement part floats
GROund	the measurement part is grounded internally

Comments:

Query form: On the entry of the query form of the command, the device sends the present grounding configuration of the measurement part.

Response:

Measurement part floats	->	FLO
Measurement part grounded	->	GRO

Reset value: GRO

Example:

```
10 OUTPUT 709;":INPUT:LOW? GROUND" !ground internally and inquire
20 ENTER 709;A$ !fetch requested response
30 PRINT A$ !display grounding configuration
40 END
```

Response of the device: GRO

MEASure[:FRESistance:DC]?

Description:

configures, starts and stops (in the case of single measurements) the measurement and supplies measured values.

Syntax:

MEASure[:FRESistance:DC]? <*parameter*>

parameter: With the help of the parameter, the device is switched to the desired resistance range.
The parameters are:

parameter	Description
0..20KOHM	The device switches to manual range selection and selects the measurement range in which the parameter lies.
DEFault	The device remains in the current measurement range.

If the parameter is omitted, the device switches to automatic measurement range selection and searches for the appropriate range independently.

Comments:

Single measurements are stopped automatically after a measured value has been registered.

Continuous measurements must be stopped with the "ABORt" command.

The measured value supplied by the device has the following format:

1. Normal resistance measurement: measured value with unit
2. Comparator function: measured value with unit, valuation symbol
3. Classify function:measured value with unit, valuation class

Example:

```
10 OUTPUT 709;":MEAS?" !measurement with automatic range selection
20 ENTER 709; A$
30 PRINT A$
40 END
```

possible response: 100.00OHM

OUTPut:TTLTrgO:LEVel

Description:

With this command, the bit at pin 21 of the I/O jack can be set or reset.

Syntax:

OUTPUT:TTLTrg0:LEVel < *parameter* >

Comments:

parameter	1 or ON	->	The bit is set
	0 or OFF	->	The bit is reset

Query form: OUTPut:TTLTrg0:LEVel?

If the bit is set, a 1 is returned.

If the bit is not set, a 0 is returned.

Reset value: 1

Example:

OUTPUT 709; "OUTP:TTLT0:LEV 0"

OUTPut:TTLTrg1:LEVel

Description:

With this command, the bit at pin 3 of the I/O jack can be set or reset.

Syntax:

OUTPUT:TTLTrg1:LEVel < *parameter* >

Comments:

parameter

1 or ON -> The bit is set
0 or OFF -> The bit is reset

Query form: OUTPut:TTLTrg1:LEVel?

If the bit is set, a 1 is returned.

If the bit is not set, a 0 is returned.

Reset value: 1

Example:

OUTPUT 709; "OUTP:TTLTRG1:LEVEL 1"

PRINter:CNUMber

Description: This command is meant for entering a test number on the printer listing.

Syntax: :PRINter:CNUMber < *parameter* >

parameter The parameter consists of 6 arbitrary ASCII characters.

Comments:

Query form: On the entry of the query form of the ":PRINter:CNUMber?" command, the currently selected test number is obtained.

Any ASCII character can be entered as a test number via the interface of the device. Only numeric characters can be entered as test numbers manually via the keyboard of the device.

Reset value: <6 spaces>

PRINter:CNUMber:STATe

Description: This command is used to specifiy whether the test number is also to be printed on the measurement protocol.

Syntax: :PRINter:CNUMber:STATe < *parameter* >

parameter

parameter	Setting
ON	Test number is printed
OFF	Test number is not printed

Comments:

Query form: On the query form of the command, the following responses are obtained from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: OFF

PRINter:DATE[:STATe]

Description:

This command is used to specify whether the date is also to be printed on the printer listing.

Syntax:

:PRINter:DATE[:STATe] < *parameter* >

parameter

parameter	Setting
ON	Date is printed
OFF	Date is not printed

Comments:

Query form: On the query form of the command, the following responses are obtained from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: ON

PRINter:DELay

Description:

This command selects the delay time between two printouts.

Syntax:

:PRINter:DELay < *parameter* >

parameter Hours, minutes, seconds

With the help of the parameter, the delay time between two printouts is entered in hours, minutes and seconds.

Example: one measured value to the printer every three hours:

OUTPUT 709;"PRINTER:DELAY 03,00,00"

Comments:

Query form: On the entry of the query form ":PRINTER:DELAY?" one obtains the currently selected delay time between two measured values in the following form:

Hours, minutes, seconds

To print out every measured value, the delay time can be set to 0,0,0.

Reset value: 0,0,0

PRINter:HEADer

Description:

This command speficies the number of measured values which are to be printed out before the measurement protocol heading is repeated.

Syntax:

:PRINter:HEADer < *parameter* >

parameter The parameter states the number of measured values to be printed per measurement protocol heading.

valid values -> 1...9999

Comments:

Queryform: On the entry of the query form ":PRINter:HEADer?", the device sends the current number of measured values per measurement protocol heading.

The maximum number of measured values between two measurement protocol headings is 9999.

Reset value: 1000

PRINter:NUMerator[:STATe]

Description:

This command specifies whether a numerator of the measured values should also be printed on the measurement protocol.

Syntax:

:PRINter:NUMerator[:STATe] < *parameter* >

parameter

parameter	Setting
ON	Numerator is printed out
OFF	Numerator is not printed out

Comments:

The numerator is printed out before the measured value.

Query form: On the entry of the query form of the command, one obtains the following responses from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: ON

PRINter:NUMerator:RESet

Description:

With this command, the measured value numerator is reset to one.

Syntax:

:PRINter:NUMerator:RESet

Comments:

no parameters

no query form

PRINter[:STATe]

Description:

This command activates or deactivates the connection between the serial interface and a printer.

Syntax:

:PRINter[:STATe] < *parameter* >

parameter

parameter	Setting
ON	Printer function on
OFF	Printer function off

Comments:

Query form: On the entry of the query form "PRINter:STATe?", the device sends the current status of the printer function.

Printer function off -> 0
Printer function on -> 1

Attention: The printer function can only be selected if IEEE488 has been selected in the interface menu!

During operation via the serial interface, the printer function is not available.

The printer functions can also be configured via the serial interface. However, in order for the printer to operate afterwards, the device must be switched manually to IEEE488 interface operation, and the printer must be connected to the serial interface.

When the printer function is selected, measured values requested via the IEC bus are also printed out.

Reset value: OFF

PRINter:TCOefficient[:STATe]

Description:

This command specifies whether the selected temperature coefficient is also to be printed out in the measurement protocol heading.

Syntax:

:PRINter:TCOefficient[:STATe] < *parameter* >

parameter

parameter	Setting
ON	selected TC is printed
OFF	selected TC is not printed

Comments:

Query form: On the entry of the query form of the command, one obtains the following responses from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: OFF

The temperature coefficient is only printed out if the temperature compensation is activated.

PRINter:TIME[:STATe]

Description:

This command specifies whether the measurement time is also to be printed in the measurement protocol.

Syntax:

PRINter:TIME[:STATe] < *parameter* >

parameter

parameter	Setting
ON	Time is printed
OFF	Time is not printed

Comments:

Query form: On the entry of the query form of the command, one obtains the following responses from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: ON

PRINter:TYPE

Description:

This command selects the type of the connected serial printer.

Syntax:

:PRINter:TYPE < *parameter* >

parameter With the parameter, any one of three printer types can be selected.

parameter	Printer type
0	80 character - printer
1	40 character - printer
2	20 character - printer

Comments:

Query form: On the entry of the query form "PRINter:TYPE?", one obtains the current setting of the printer type from the device..

Response:			
	20 character - printer	->	2
	40 character - printer	->	1
	80 character - printer	->	0

Reset value: 0

PRINter:TYPE

Example:

Example for setting the printer listing menu.

```
10 OUTPUT 709;":PRINTER:TYPE 0" !80-character printer
20 ! printout every 30 minutes
30 OUTPUT 709;":PRINTER:DELAY 0,30,0"
40 ! print date and time
50 OUTPUT 709;":PRINTER:DATE:STATE ON"
60 OUTPUT 709;":PRINTER:TIME:STATE ON"
70 ! set measurement protocol number to Test 1 and print
80 OUTPUT 709;":PRINTER:CNUMBER TEST1"
90 OUTPUT 709;":PRINTER:CNUMBER:STATE ON"
100 ! print temperature coefficient
110 OUTPUT 709;":PRINTER:TCOEFFICIENT:STATE ON"
120 ! reset numerator and print
130 OUTPUT 709;":PRINTER:NUMERATOR:RESET"
140 OUTPUT 709;":PRINTER:NUMERATOR:STATE ON"
150 ! measurement protocol heading every 50 printed values.
160 OUTPUT 709;":PRINTER:HEADER 50"
170 ! activate printer function
180 OUTPUT 709;":PRINTER:STATE ON"
```

READ [:FRESistance:DC]?

Description: starts, stops (in case of single measurements), and supplies measurement result.

Syntax: READ[:FRESistance:DC]?

Comments: The command is used instead of the "MEASure" command if the desired measurement range has already been selected.

Single measurements are stopped automatically after a measured value has been registered.
Repetition measurements must be stopped by means of the "ABORt" command.

The measured value supplied by the device has the following format:
1. Normal resistance measurement: measured value with unit
2. Comparator function: measured value with unit, valuation sign
3. Classify function: measured value with unit, valuation class

Example:

```
10 OUTPUT 709; ":READ?" !measure without range selection
20 ENTER 709;A$
30 PRINT A$
40 END
```

SKALe:PT100

Description: With this command the Pt100 coefficients are transmitted.
The individual values are transmitted without unit.

Syntax: :SCALe:Pt100 < *parameter* >

Parameters in the sequence
R_0, A, B, C, t_{100} (without unit)
DIN EN 60751 values (default values)
$R_0 = 100$, $A = 3.9083\ e^{-3}$, $B = -5.775\ e^{-7}$, $C = -4.183\ e^{-12}$, $t_{100} = 100$

Comments: Only the entry of the query form SCALe:Pt100? obtains the following coefficients (R_0, A, B, C, t_{100}).
The entry of the query form SCALe:Pt100:DIN? obtains the DIN EN values.

SENSe:CORRection[:STATe]

Description:

This command specifies whether a temperature compensation is to be carried out during the resistance measurement.

Syntax:

:SENSe:CORRection[:STATe] < *parameter* >

parameter

parameter	Setting
ON	Temperature compensation is performed
OFF	Temperature compensation is not performed

Comments:

Query form: On the entry of the query form of the command, one obtains the following responses from the device :

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: OFF

If the temperature compensation is activated, the measurement result obtained is the resistance value at 20 degrees C, based on the measured value, temperature and linear temperature coefficient.

SENSe:CORRection:TCOMpensate:AUTO

Description:

This command specifies whether a temperature value in the case of temperature compensation should be registered automatically or entered manually.

Syntax:

:SENSe:CORRection:TCOMpensate:AUTO < *parameter* >

parameter

parameter	Setting
ON	Temperature is registered automatically
OFF	Temperature can be entered manually

Comments:

Query form: On the entry of the query form of the command, one obtains the following responses from the device :

when STATE = ON -> 1
when STATE = OFF -> 0

On thew setting "AUTO=ON", an exteranal Pt100 sensor must be connected.

On the setting "AUTO=OFF", the temperature can be entred with the command "SENSe:CORRection:TCOMpensate:TCOM:MAN" command.

During changeover frommautomatic to manual temperature measurement, the most recent temperature value entred manually is selected again.

The current temperatue can be polled with the "SENSe:CORRection:TCOMpensate:MANual?: command.

Reset value: OFF

SENSe:CORRection:TCOMpensate[:MANual]

Description:

This command is used for manually entering the temperature in the case of temperature compensation.

Syntax:

:SENSe:CORRection:TCOMpensate[:MANual] < *parameter* >

parameter -70...999.99

The largest possible temperature range lies between -70 und 999.99 degrees Celsius.

Comments:

Query form: On the query form ":SENS:CORR:TCOM:MAN?" one obtains the currently selected temperature from the device.

The query form of the command also supplies the current temperature during automatic temperature measurement.

The response to the query form of the command is sent with the unit "CEL". (Example: "23.4CEL").

The temperature must be selected without stating the unit.
(Example: ":SENS:CORR:TCOM:MAN 23.4")

When the temperature is selected via the "MANual" - command, the automatic temperature measurement is deactivated. (AUTO = OFF).

SENSe:CORRection:TCOMpensate:TCO1..TCO10

Description:

This command selects one of ten possible temperature coefficients.

Syntax:

:SENSe:CORRection:TCOMpensate:TCO*x* < *parameter* >

x TC - number:
1..10, depending on the desired temperature coefficient.

parameter 0..9999 , depending on the desired temperature coefficient.

The parameter has the unit "ppm/K". The unit may not be transferred as well.

Comments:

Query form: On the entry of the query form, one obtains the value of the currently selected temperature coefficient, if the TC number is not transferred as well.

If the TC number is also transferred, the value of the corresponding TC is obtained as a response.

For selecting a specific TC, the corresponding TC number and the desired TC value must be transferred.

Example:

Setting the temperature compensation menu:

```
10 ! manual entry of the ambient temperature
20 OUTPUT 709;":SENS:CORR:TCOM:MAN 23.4"
30 ! setting the desired TC (number 1) to 3980 ppm/K
40 OUTPUT 709;":SENS:CORR:TCOM:TCO1 3980"
50 ! activate temperature compensation
50 OUTPUT 709;":SENS:CORR:STAT ON"
```

SENSe:LFRequency

Description:

This commands synchronizes the integration time of the A/D converter with the nominal line frequency at which the device is operated.

Syntax:

:SENSe:LFRequency < *parameter* >

parameter

parameter	Remark
16.7	Device operated at 16 $^{2}/_{3}$ HZ
50	Device operated at 50 HZ
60	Device operated at 60 HZ

The parameter is sent without a unit.

Comments:

Query form: On the entry of the query form "SENSe:LFRequency", one obtains the current setting of the mains frequency from the device.

The response of the device has the form:

<value>HZ
(Example: 50HZ)

Reset value: 50

Example:

```
10 OUTPUT 709;":SENSE:LFREQUENCY? 50" ! 50HZ mains frequency
20 ENTER 709;A$ ! fetch response
30 PRINT A$
40 END
```

Response of the device: 50HZ

SENSe:RESistance:APERture

Description:

This command selects the measurement time base, i.e. the number of line periods over which the measurement is to be carried out.

Syntax:

:SENSe:RESistance:APERture < *parameter* >

parameter 1..9

Depending on the desired number of line periods.

Comments:

Query form: On the entry of the query form ":SENSe: RESistance:APERture?", one obtains the current setting of the time base.

Attention: At high resolution, the minimum value of the time base = 5.

Reset value:

at low resolution	->	1
at medium resolution	->	5
at high resolution	->	9

Example:

```
10 OUTPUT 709;":SENSE:RESISTANCE:APERTURE? 7"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device: 7

SENSe:RESistance:AVERage

Description:

This command selects the number of measured values whose average is to be determined.

Syntax:

:SENSe:RESistance:AVERage < *parameter* >

parameter 1..255

depending on the number of measured values required for forming a mean value.

Comments:

Queryform: On the entry of the query form "SENSe:RESistance:AVERage?", one obtains the current number of measured values meant for forming a mean value.

Attention: At high resolution, the minimum number of measured values for forming the mean value = 5.

Reset value:

at low resolution	->	1
at medium resolution	->	1
at high resolution	->	5

Example:

```
10 OUTPUT 709;":SENSE:RESISTANCE:AVERAGE? 9"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device: 9

SENSe:RESistance:COMPlex:LIMit

Description:

This command selects the release limit of the measured value during unipolar measurements involving mainly inductive test units.

Syntax:

:SENSe:RESistance:COMPlex:LIMit < *parameter* >

parameter 0.05PCT...20PCT

With the help of the parameter, the release limit is stated as a percentage.

For example, a setting of "1PCT" means that a measured value can only be displayed if it differs from the previous one by less than 1PCT.

Comments:

Query form: On the entry of the query form ":SENSe:RESistance:COMPlex:LIMit?", one obtains the selected release limt as a percentage from the device.

Selection of the release limit is only of significance for unipolar measurements on inductive resistances. It serves to suppress the measured values during the transient phase, which occurs particularly in the case of large inductances.

Reset value: 20PCT

Example:

```
05 ! Setting the release limit to 2.34 %
10 OUTPUT 709;":SENS:RES:COMP:LIM? 2.34PCT"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device:2.34PCT

SENSe:RESistance:LOAD

Description:

This command selects the load to be measured (mainly ohmic or mainly inductive resistance).

Syntax:

:SENSe:RESistance:LOAD < *parameter* >

parameter The parameter specifies whether the test unit consists of a real resistance or an inductance.

parameter	Remark
REAL	Test unit is mainly ohmic
COMPlex	Test unit is mainly inductive

Comments:

Query form: On the entry of the query form ":SENSe:RESistance:LOAD?", one obtains the currently selected type of load.

When mainly inductive test units are selected for resistance measurements (LOAD=COMPlex), automatic range selection is not possible. If automatic range selection was previously selected, the device switches to manual range selection when "COMplex" is activated.

Reset value: REAL

Example:

```
05 ! measurement of an ohmic resistance
10 OUTPUT 709;":SENSE:RESISTANCE:LOAD? REAL"
15 ENTER 709;A$
20 PRINT A$
30 END
```

Response of the device: REAL

SENSe:RESistance:PAUSe

Description:

This command selects the measurement pause.

Syntax:

:SENSe:RESistance:PAUSe < *parameter* >

parameter 1...255

depending on the required measurement pause.

Comments:

The measurement pause is a waiting period which allows the circuit to settle after switchover processes. It depends on the type of test unit and the selected operating mode. By means of the "measurement pause" factor, the internal presetting can be adapted to "problematic" test units.

As the measurement pause is entered in the charging time as a multiplicative factor, this parameter should be handled carefully.

Query form: On the entry of the query form ":SENSe:RESistance: PAUSe?", one obtains the current number of line periods over which measurement is not carried out.

Reset value:

at low resolution	->	1
at medium resolution	->	1
at high resolution	->	1

Example:

Setting the measurement pause to 9:

```
10 OUTPUT 709;":SENSE:RESISTANCE:PAUSE? 9"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device: 9

SENSe:RESistance:RANGe:AUTO

Description:

This command activates or deactivates automatic measurement range selection.

Syntax:

:SENSe:RESistance:RANGe:AUTO < *parameter* >

parameter

parameter	Setting
ON	automatic measurement range selection
OFF	manual measurement range selection

Comments:

Query form: On the entry of the query form of the command, one obtains the following responses from the device:

when STATE = ON -> 1
when STATE = OFF -> 0

Reset value: OFF

Automatic range selection is not possible when inductive test units have been selected as the load.

Example:

Setting the automatic measurement range selection:

OUTPUT 709;":SENSE:RESISTANCE:RANGE:AUTO ON"

SENSe:RESistance:RANGe[:UPPer]

Description:

This command selects the desired measurement range.

Syntax:

:SENSe:RESistance:RANGE[:UPPer] < *parameter* >

parameter 0UOHM...20KOHM

With the help of the parameter, the desired measurement range is selected.

Comments:

Queryform: On the entry of the query form ":SENSe:RANGE[UPPer]?", one obtains the currently selected measurement range from the device.

On recognizing the command, the device switches to manual range selection.

The parameter can be entered with the following units:

UOHM	Microohms
MOHM	Milliohms
OHM	Ohms
KOHM	Kiloohms
MAOHM	Megaohms

If the unit is omitted, the parameter is considered to be in ohms.

The measurement range in witch the resistance, input as a parameter, can be measured is selected.

-> The command "SENS:RES:RANG: 200OHM" switches over to the 2 kohm range.

Reset value: 20KOHM

Example:

Selecting the 200 ohm measurement range:

10 OUTPUT 709;":SENSE:RESISTANCE:RANGE:UPPER 100OHM"

SENSe:RESistance:RESolution

Description:

This command selects the resolution of the measured value display.

Syntax:

:SENSe:RESistance:RESolution < *parameter* >

parameter The desired resolution is entered with the help of the parameter.

parameter	Setting
MINimum	low resolution
DEFault	medium resolution
MAXimum	high resolution

Comments:

Queryform: On the entry of the query form ":SENSe:RESistance: RESolution?", one obtains the currently selected resolution from the device.

Response: MIN or DEF or MAX

At the highest resolution setting, the "time base" and "average value" have a minimum value of 5.

Reset value: DEFault

Example:

Selecting the highest resolution:

```
10 OUTPUT 709;":SENSE:RESISTANCE:RESOLUTION? MAXIMUM"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device: MAX

SORT:BINNing?

Description:

The comparator setting can be requested with this command.

Syntax:

:SORT:BINNing?

Comments:

- only query form
- no parameters

Response of the device:

0	->	when comparator type = comparator
1	->	when comparator type = classify function

Reset value: 0

Example:

```
10 OUTPUT 709;":SORT:BINNING?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

SORT:BINNing:ACKNowledge

Description: With this command, all classification limits set via the interface are accepted, provided that they were valid.

Syntax: :SORT:BINNing:ACKNowledge

Comments:

- no query form
- no parameters

If the classification limits entered previously with the command "SORT:BINNing:LIMit1..8" were invalid, the error message:

-220,"PARAMETER ERROR"

is filed in the error buffer and the corresponding bits in the status register are set. (Bit 4 in the Standard Event Status Register : Execution Error Bit)

If the display mode was changed, all limiting values and the specified value must be entered in the new display unit, otherwise an error is indicated again.

The discrepancy between the limiting values and the specified value should be less than 10000 %.

Example: see "SORT:BINNing:LIMit1..8" command

SORT:BINNing:DATA?

Description: The classification statistics are requested with this command.

Syntax: :SORT:BINNing:DATA?

Comments:

- only query form
- no parameters

Response of the device:

<class 0>,<class1>,<class2>,<class3>,.....,<class8>,<total>

<class0>...<class8>	->	number of measured values within the individual classification limits.
<total>	->	total number of recorded measurements.

The classification statistics are not active when the device is set to repetition measurement.

If errors occur during the measurement, so that no measured values are available, the classification statistics are not changed.

Example: see ":SORT:BINNing:LIMit1...LIMit8" command

SORT:BINNing:DATA:RESet

Description: The classification statistics are deleted with this command.

Syntax: :SORT:BINNing:DATA:RESet

Comments:

- no query form
- no paramteres

Example: see ":SORT:BINNing:LIMit1...LIMit8" command

SORT:BINNing:LIMit1...LIMit8

Description: This command selects the eight limiting values of the individual classes of the classify function.

Syntax: :SORT:BINNing:LIMit*x* <*parameter* >

x 1..8, depending on the desired limit.

parameter The magnitude of the limit is entered with the parameter.

The paramter can be sent with or without a unit.

The limiting value can also be entered as a percentage deviation (unit: PCT) from the specified value.

e. g. "SORT:BINN:LIM1 -5PCT"

Comments:

Query form: On the entry of the query form "SORT:BINNing:LIMit*x* ?", one obtains the current value of the limit x.

The percentage values cannot be requested directly.

Valid units for the parameters are:

UOHM, MOHM, OHM, KOHM, MAOHM, OHM/M, OHM/KM, OHM/10FT, OHM/KFT, M/(OHM*MM2), OHM*MM2/M or PCT.

The limiting values must be entered in **increasing** order, i.e.

limit 1< limit 2< limit 3< ... < limit 8

After the "SORT:BINNing:ACKNowledge" command is sent, the limiting values are checked for validity and then accepted.

If a limiting value was invalid, bit 4 (Execution Error Bit) in the standard event status register is set, and the error message:

-220,"PARAMETER ERROR"

is written into the error buffer.

SORT:BINNing:LIMit1...LIMit8

If the display unit was changed, all limiting values and the specified value in the new display mode must be entered.

Reset value: 96OHM, 97OHM, 98OHM, 99 OHM, 101OHM, 102OHM, 103OHM, 104OHM

Example:

Measurement of resistances with a specified value of 100 ohms.
The limits are:

Limit 1	->	-4% of specified value
Limit 2	->	-3%
Limit 3	->	-2%
Limit 4	->	-1%
Limit 5	->	+1%
Limit 6	->	+2%
Limit 7	->	+3%
Limit 8	->	+4%

```
5 n=0 ! auxiliary counter
10 OUTPUT 709;":SORT:STATE ON" ! activates sort function
20 OUTPUT 709;":SORT:BINNING:NOMINAL 100OHM" ! specified value
30 OUTPUT 709;":SORT:BINNING:LIMIT1 -4PCT"
40 OUTPUT 709;":SORT:BINNING:LIMIT2 -3PCT"
50 OUTPUT 709;":SORT:BINNING:LIMIT3 -2PCT"
60 OUTPUT 709;":SORT:BINNING:LIMIT4 -1PCT"
70 OUTPUT 709;":SORT:BINNING:LIMIT5 +1PCT"
80 OUTPUT 709;":SORT:BINNING:LIMIT6 +2PCT"
90 OUTPUT 709;":SORT:BINNING:LIMIT7 +3PCT"
100 OUTPUT 709;":SORT:BINNING:LIMIT8 +4PCT"
105 ! accept values
110 OUTPUT 709;":SORT:BINNING:ACKNOWLEDGE"
120 END
```

SORT:BINNing:NOMinal

Description:

The specified value of the classify function is entered with this command.

Syntax:

:SORT:BINNing:NOMinal <*parameter* >

parameter desired specified value with or without unit:

<specified value><unit>

Comments:

Query form: On the entry of the query form ":SORT:BINNing:NOMinal?", the device sends the currently selected specified value with the corresponding unit.

The parameter can be sent with or without a unit.

The folowing units are valid:

in display mode	"Ohm"and "Delta%":	UOHM, MOHM, OHM, KOHM, MAOHM
with	"Ohm/Meter":	OHM/M
with	"Ohm/Km":	OHM/KM
with	"Ohm/10ft":	OHM/10FT
with	"Ohm/kft":	OHM/KFT
with	"Gamma":	M/(OHM*MM2)
with	"Rho":	OHM*MM2/M

If the unit is not sent, the transmitted specified value is processed in the basic unit of each display mode.

The specified value is accepted after the ":SORT:BINNing:ACKNowledge" command is sent, when all limiting values are valid.

The units of the specified value and the limiting values must be appropriate for the display. If the display mode was changed, all limiting values must be entered with the new unit.

Reset value: 100OHM

Example:

see ":SORT:BINNing:LIMit1..LIMit8" command

SORT:COMParator?

Description: The setting of the comparator type can be requested with this command.

Syntax: :SORT:COMParator?

Comments:

- only query form
- no parameters

Response of the device:

0 -> when comparator = classify function
1 -> when comparator = comparator

Reset value: 1

Example:

```
10 OUTPUT 709;":SORT:COMPARATOR?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

SORT:COMParator:ACKNowledge

Description:

With this command, all comparator limiting values set via the interface are accepted, if they were valid.

Syntax:

:SORT:COMParator:ACKNowledge

Comments:

- no query form
- no parameters

If the comparator limits entered previously with the "SORT:COMParator: HLIMit" and "SORT:COMParator:LLIMit" commands were invalid, the error message:

-220,"PARAMETER ERROR"

is filed in the error buffer, and the corresponding bits in the status register are set. (Bit 4 in the standard event status register : execution error bit)

If the display mode was changed, both limiting values and the specified value must be entered in the new display unit, otherwise an error is indicated again.

The discrepancy between the limiting values and the specified value must be smaller than 100 %.

Example:

see "SORT:COMParator:LLIMit" command

SORT:COMParator:DATA?

Description:

The comparator statistics are polled with this command.

Syntax:

:SORT:COMParator:DATA?

Comments:

- only query form
- no parameters

Response of the device:

> , = , < ,sum

<	->	number of measured values smaller than the lower limit.
=	->	number of measured values larger or equal than the lower limit and smaller or equal than the upper limit.
>	->	number of measured values larger than the upper limit.
sum	->	total number of recorded measurements

The comparator statistics are inactive when the device is switched to continuous measurement.

If errors occur during the measurements, so that no measured values are recorded, the statistics are not changed.

Example:

see ":SORT:COMParator:LLIMit" command

SORT:COMParator:DATA:RESet

Description:

The comparator statistics are deleted with this command.

Syntax:

:SORT:COMParator:DATA:RESet

Comments:

- no query form
- no parameters

Example:

see ":SORT:COMParator:LLIMit" command

SORT:COMParator:HLIMit

Description:

This command selects the upper limiting value for the comparator function.

Syntax:

:SORT:COMParator:HLIMit < *parameter* >

parameter Desired upper limiting value with or without unit:

<upper limit><unit>

Comments:

Query form: On the entry of the query form ":SORT:COMParator:HLIMit?", the device supplies the currently selected upper limit with the corresponding unit.

Example: 110OHM

Reset value: 110OHM

The parameter can be sent with or without a unit.

The following units are valid:

UOHM, MOHM, OHM, KOHM, MAOHM, OHM/M, OHM/KM, OHM/10FT, OHM/KFT, M/(OHM*MM2), OHM*MM2/OHM.

If no unit is sent, the transmitted upper limit is processed with the basic unit.

After the ":SORT:COMParator:ACKNowledge" command is sent, the upper limit is checked for validity and accepted, if the specified value and the limiting values are valid.

The upper limit must be larger than the lower limit.

If the display unit was changed, the specified value and the limiting values must be entered again.

Example:

see ":SORT:COMParator:LLIMit" command

SORT:COMParator:LLIMit

Description:

This command selects the lower limiting value for the comparator function.

Syntax:

:SORT:COMParator:LLIMit < *parameter* >

parameter Desired lower limiting value with or without unit.

<lower limit><unit>

Comments:

Query form: On the entry of the query form ":SORT:COMParator:LLIMit?", the device supplies the currently selected lower limit with the corresponding unit.

Example: 90OHM

Reset value: 90OHM

The parameter can be sent with or without a unit.

The following units are valid:

UOHM, MOHM, OHM, KOHM, MAOHM, OHM/M, OHM/KM, OHM/10FT, OHM/KFT, M/(OHM*MM2), OHM*MM2/M

If no unit is sent, the transmitted lower limit is processed with the basic unit.

The lower limit is accepted after the ":SORT:COMParator:ACKNowledge" command has been sent.

If the display unit was changed, the specified value and the limiting values must be entered with the new unit.

SORT:COMParator:HLIMit

Example: Setting the specified value, the lower limit and the upper limit of the comparator function (device switched to single measurement).

```
10 OUTPUT 709;":SORT:STATE"! sort function activated
20 OUTPUT 709;":SORT:COMP:LLIM 90OHM"
30 OUTPUT 709;":SORT:COMP:HLIM 110OHM"
40 OUTPUT 709;":SORT:COMP:NOM 100OHM"
50 OUTPUT 709;":SORT:COMP:ACKN"
55 ! 5 single meaurements
60 OUTPUT 709;":INIT
65 ! ... switch the resistor connections when the meaurements is over
70 OUTPUT 709;":INIT
75 ! ... switch the resistor connections
80 OUTPUT 709;":INIT
55 ! ... switch the resistor connections
90 OUTPUT 709;":INIT
55 ! ... switch the resistor connections
100 OUTPUT 709;":INIT
105 wait until the measurement is over
110 OUTPUT 709;":SORT:COMP:DATA?" ! request statistics
120 ENTER 709;A$
130 PRINT A$
135 OUTPUT 709;":SORT:COMP:DATA:RES" ! delete statistics
140 END
```

possible response oof teh device:

1,3,1,5

SORT:COMParator:NOMinal

Description:

The specified value of the comparator function is entered with this command.

Syntax:

:SORT:COMParator:NOMinal <*parameter* >

parameter desired specified value with or without unit:

<specified value><unit>

Comments:

Query form: On the entry of the query form ":SORT:COMParator:NOMinal?", the device supplies the currently selected specified value with the corresponding unit.

The parameter can be sent with or without a unit.

The following units are valid:

UOHM, MOHM, OHM, KOHM, MAOHM, OHM/M, OHM/KM, OHM/10FT, OHM/KFT, M/(OHM*MM2), OHM*MM2/M

If the unit is not sent, the transmitted specified value is processed with the basic unit.

The specified value is accepted after the ":SORT:COMParator: ACKNowledge" command is sent, if all limiting values and the specified value are valid.

If the display unit was changed, the limiting values and the specified value must be entered in the new display unit.

Example:

see ":SORT:COMParator:LLIMit" command

SORT:STATe

Description:

The sort function is activated or deactivated with this command.

Syntax:

:SORT:STATe < *parameter* >

parameter

parameter	Setting
ON	Sort function on
OFF	Sort function off

Comments:

Query form: On the entry of the query form ":SORT:STATe?", the device supplies:

0 -> when STATE = OFF
1 -> when STATE = ON

Reset value: 0

Example:

OUTPUT 709;":SORT:STATE ON"

SOURce:CURRent[:LEVel:IMMediate:AMPLitude]

Description:

This command sets the measuring current.

Syntax:

:SOURce:CURRent[:LEVel:IMMediate:AMPLitude] < *parameter* >

parameter

parameter	Setting
MINimum	small measuring current
DEFault	medium measuring current
MAXimum	large measuring current

Comments:

Query form: On the entry of the query form "SOURce:CURRent?", one obtains the current setting of the measuring current.

Response:

MIN	->	small measuring current
DEF	->	medium measuring current
MAX	->	large measuring current
IND	->	individual measuring current

Reset value: MAX

Individual measuring currents are set with the "SOURce:CURRent:REFerence" command.

The individual measuring current is selected with the "SOURce:CURRent:REFerence:STATe ON" command.

Example:

Selecting a large measuring current:

OUTPUT 709;":SOURCE:CURRENT MAX"

SOURce:CURRent:REFerence

Description:

The individual measuring currents of each measurement range are selected with this command.

Syntax:

:SOURce:CURRent:REFerence < *parameter* >

parameter <range>,<current>

<range> -> desired measurement range
<current> -> desired individual measuring current

Comments:

Queryform: On the entry of the query form "SOURce:CURRent:REFerence?", one obtains as a response the individual measuring currents of all ranges.

The measuring currents are separated by commas.

Response:

10A,<2mohm range>,...,<2kohm range>,100UA

The individual measuring current is selected with the "SOURce: CURRent:REFerence:STATe ON" command.

Reset valuee: 10A, 10A, 1A, 100MA, 10MA, 1MA, 1MA, 1MA, 100UA

Example:

Selecting a measuring curent of 1mA in the 20 ohm range

```
10 OUTPUT 709;":SOUR:CURR:REF 10OHM,1MA"
20 OUTPUT 709;":SOUR:CURR:REF:STAT ON"
```

SOURce:CURRent:REFerence:STATe

Description:

The individual measuring current is selected with this command.

Syntax:

:SOURce:CURRent:REFerence:STATe < *parameter* >

parameter

parameter	Setting
ON	individual measuring current
OFF	medium measuring current

Comments:

Query form: On the entry of the query form ":SOUR:CURR:REF:STAT?", one obtains the status of the individual measuring current.

Response of the device:

0 -> small, medium or large measuring current
1 -> individual measuring current

When the "SOURce:CURRent:REFerence:STATe OFF" command is sent, the device switches to the medium measuring current range.

Reset value: 0

Example:

Selecting the individual measuring current:

OUTPUT 709;":SOUR:CURR:REF:STAT ON"

SOURce:FUNCtion[:SHAPe]

Description:

This command switches over between unipolar,bipolar and constant measurements.

Syntax:

:SOURce:FUNCtion[:SHAPe] < *parameter* >

parameter

parameter	Setting
PULS	unipolar measurement
SQUare	bipolar measurement
CONSTant	constant measurement

Comments:

Query form: On the entry of the query form ":SOURce:FUNCtion[:SHAPe]?", one obtains the current setting of the measurement procedure.

Response:

PULS -> unipolar
SQU -> bipolar
CONS -> constant

Reset value: SQU

Example:

bipolar measurement

OUTPUT 709;":SOURCE:FUNCTION:SHAPE SQUARE"

SYSTem:BUZZer[:STATe]

Description:

This command controls the buzzer. When the buzzer is active, a warning tone occurs in the case of measurements on inductive loads; this tone persists from measurement interruption until the test unit has discharged.

Syntax:

:SYSTem:BUZZer[:STATe] < *parameter* >

parameter

parameter	Setting	corresponding num. value
ON	Buzzer on	1
OFF	Buzzer off	0

Comments:

Query form: On the entry of the query form ":SYSTem:BUZZer[:STATe]?", one obtains the current status of the buzzer from the device.

Response:

0 -> Buzzer off
1 -> Buzzer on

Reset value: 0

Example:

Activate buzzer:

OUTPUT 709;":SYSTEM:BUZZER ON"

SYSTem:COMMunicate:SERial:ADDRess:GROup

Description:

This command selects the group address of the serial interface of the device.

Syntax:

:SYSTem:COMMunicate:SERial:ADDRess:GROup < *parameter* >

parameter 0...15

The group address can be set within the range between 0 and 15.

Comments:

Query form: On the entry of the query form "SYST:COMM:SER:ADDR:GRO?", one obtains the current group address from the device.

Response of the device:

0..15

Reset value: 0

The group address must be entered in decimal form.

Example:

Setting the group address to 12:

OUTPUT 709;":SYST:COMM:SER:ADDR:GRO 12"

SYSTem:COMMunicate:SERial:ADDRess:USER

Description:

This command selects the user address of the serial interface of the device.

Syntax:

:SYSTem:COMMunicate:SERial:ADDRess:USER < *parameter* >

parameter 0...15

The user address can be set within the range between 0 and 15.

Comments:

Query form: On the entry of the query form "SYST:COMM:SER:ADDR:USER?", one obtains the current user address from the device.

Response of the device:

0..15

Reset value: 0

The user address must be entered in decimal form.

Example:

Setting the user address to 12:

OUTPUT 709;":SYST:COMM:SER:ADDR:USER 12"

SYSTem:COMMunicate:SERial:BCCharacter

Description:

This command activates or deactivates the block check during serial transmission.

Syntax:

:SYSTem:COMMunicate:SERial:BCCharacter < *parameter* >

parameter

parameter	Setting	corresponding num. value
ON	BCC on	1
OFF	BCC off	0

Comments:

Query form: On the entry of the query form ":SYST:COMM:SER:BCC?", one obtains the current status of the block check character from the device.

Response:

0 -> BCC off
1 -> BCC on

Attention: In the case of the block check character, the MSB is always set to avoid mistaking it for ASCII control characters. The BCC is in the range between 128 and 255.

Device has SLAVE status:
When the block check character is active, the device awaits it after the "ETX" character during serial transmission.

Device has MASTER status:
The BCC is sent by the device after the "ETX" character.

The BCC is formed through Exclusive-OR operation on all transmitted bytes after "STX" including "ETX".
(see ANSI X3.28 1976 chapter 4.3 page 28: "Block Checking")

Reset value: 0

Example:

Activate block check character:

OUTPUT 709;":SYST:COMM:SER:BCC ON"

SYSTem:COMMunicate:SERial:CDELay

Description:

This command activates a character transmission delay of approx. 1ms - 1.5 ms.

Syntax:

:SYSTem:COMMunicate:SERial:CDELay < *parameter* >

parameter

parameter	Setting
ON	Delay on
OFF	Delay off

Comments:

Query form: On the entry of the query form ":SYST:COMM:SER:CDEL?", one obtains the current status of the character transmission delay from the device.

Response:

0 -> Delay off
1 -> Delay on

Reset value: 0

Example:

Activate character transmission delay:

OUTPUT 709;":SYST:COMM:SER:CDEL ON"

SYSTem:COMMunicate:SERial:TRANsmit:BAUD

Description: This command selects the baud rate of the serial interface.

Syntax:

:SYSTem:COMMunicate:SERial:TRANsmit:BAUD < *parameter* >

parameter 600 , 1200 , 4800 , 9600, 19200

depending on the desired baud rate

Comments:

Query form: On the entry of the query form ":SYST:COMM:SER:TRAN:BAUD?", one obtains the current setting of the baud rate from the device.

Response: 600...19200

Reset value: 9600

Example: Setting the baud rate to 9600 bits/sec:

OUTPUT 709;":SYST:COMM:SER:TRAN:BAUD 9600"

SYSTem:COMMunicate:SERial:TRANsmit:BITS

Description:

This command selects the number of data bits per character during serial transmission.

Syntax:

:SYSTem:COMMunicate:SERial:TRANsmit:BITS < *parameter* >

parameter 7 or 8

depending on the desired number of data bits

Comments:

Query form: On the entry of the query form ":SYST:COMM:SER:TRAN:BITS?", one obtains the current number of data bits per character from the device.

Response:

7 -> 7 data bits/character
8 -> 8 data bits/character

Reset value: 8

During printer operation, the number of data bits should be set to 8, so that the ASCII special characters larger than the ASCII value of 127 are understood by the printer.

Example:

8 data bits/character:

OUTPUT 709;":SYST:COMM:SER:TRAN:BITS 8"

SYSTem:COMMunicate:SERial:TRANsmit:PARity[:TYPE]

Description:

This command selects the type of parity bit in the case of serial transmission.

Syntax:

SYSTem:COMMunicate:SERial:TRANsmit:PARity[:TYPE] <*parameter*>

parameter

parameter	Setting
EVEN	even parity
ODD	odd parity
NONE	no parity

Comments:

Query form: On the entry of the query form "SYST:COMM:SER:TRAN:PAR?", one obtains the current setting of the parity type from the device (see parameter table)

Reset value: NONE

Example:

Selecting an even parity:

OUTPUT 709;":SYST:COMM:SER:TRAN:PAR:TYPE EVEN"

SYSTem:COMMunicate:SERial:TRANsmit:SBITs

Description:

This command selects the number of stop bits per character in the case of serial transmission.

Syntax:

:SYSTem:COMMunicate:SERial:TRANsmit:SBITs < *parameter* >

parameter 1 or 2

depending on the desired number of stop bits

Comments:

Query form: On the entry of the query form ":SYST:COMM:SER:TRAN:SBITs?", one obtains the current number of stop bits per character from the device.

Response:

1 -> 1 stop bit/character
2 -> 2 stop bits/character

Reset value: 1

Example:

1 stop bit/character:

OUTPUT 709;":SYST:COMM:SER:TRAN:SBIT 1"

SYSTem:COMMunicate:SERial:TYPE

Description:

This command selects the type of connection for the RS485 interface (full or half duplex).

Syntax:

:SYSTem:COMMunicate:SERial:TYPE < *parameter* >

parameter	FULL	->	full duplex
	HALF	->	half duplex

Comments:

Query form: On the entry of the query form "SYST:COMM:SER:TYPE?", the device sends the current setting of the type of connection for the RS485 interface.

Response: HALF or FULL

Reset value: FULL

Example:

Selecting the full duplex connection for the RS485 :

OUTPUT 709;":SYST:COMM:SER:TYPE FULL"

SYSTem:COMMunicate:GPIB:ADDRess

Description:

This command selects the address of the GPIB bus interface.

Syntax:

:SYSTem:COMMunicate:GPIB:ADDRess < *parameter* >

parameter 0..30

depending on the desired address of the GPIB interface

Comments:

Query form: On the entry of the query form "SYST:COMM:GPIB:ADDR?", one obtains the current setting of the GPIB address from the device.

Response: 0..30

Reset value: 9

Example:

Setting the address to 10:

```
10 OUTPUT 709;":SYST:COMM:GPIB:ADDR? 10"
20 ENTER 710;A$ ! new GPIB address
30 PRINT A$
40 END
```

SYSTem:DATE

Description:

This command selects the date on the device.

Syntax:

:SYSTem:DATE < *parameter* >

parameter <year>,<month>,<day>

<year>	->	year entry with century	(e.g. 1991)
<month>	->	month entry	(e.g. 9)
<day>	->	day entry	(e.g.23)

Comments:

Query form: On the entry of the query form":SYSTem:DATE?", the response obtained is the date currently set in the device.

Response of the device:

<year>,<month>,<day> (e.g. 91,09,23)

When the date is set, the year must be entered with the appropriate century.

In the response of the device, the year is stated without century.

Example:

Setting and requesting the date:

```
10 OUTPUT 709;":SYSTEM:DATE? 1991,09,23"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device: 91,09,23

SYSTem:ERRor?

Description: With this command, an error message is read out from the error buffer.

Syntax: :SYSTem:ERRor?

Comments: only query form

no parameters

The error buffer has a size of 2:
One buffer for the first error message and one buffer for the "QUEUE OVERFLOW" message.

The error buffer is a "first in first out" buffer.

When an error is read out of the error buffer, it is deleted. When all error messages have been read out of the error buffer, or when no error has occurred, the device responds with "NO ERROR".

The error message consists of:

<error number>,"<error description>"

Negative error messages are defined by the SCPI standard.
Positive error messages indicate device-dependent errors.

Error messages of the Resistomat 2304:

0,"NO ERROR"
No error occurred

-400,"QUERY ERROR"
Device was polled but no data was present

-410,"QUERY INTERRUPTED"
Device was interrupted without having sent a complete response

-420,"QUERY UNTERMINATED"
Device was polled without having received a complete command

-200,"EXECUTION ERROR"
Due to a certain state of the device, a command could not be executed (e.g. the device was performing a measurement).

SYSTem:ERRor?

-220,"PARAMETER ERROR"
A command with an incorrect parameter was sent

-100,"COMMAND ERROR"
An invalid command was sent

-105,"GET NOT ALLOWED"
A GET command was sent within a command

-110,"COMMAND HEADER ERROR"
Command with invalid command heading

10,"VCABLE"
Cable rupture on measuring resistor

20,"VKOVER"
Amplifier overdriven

30,"OVERRANGE"
Range transgression

40,"TEMP OVER"
Temperature of device too high (possible fan breakdown!)

50,"MEASURE ERROR"
Error occurred during measurement

60,"CURRENT ERROR"
Current cannot be controled (possible cable rupture)

Example:

Polling the error buffer:

```
10 OUTPUT 709;":SYSTEM:ERROR?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

possible response of the device: 0,"NO ERROR"

SYSTem:KEYBoard:ACCess

Description:

This command selects the access authorization for the keyboard on the front panel.

Syntax:

:SYSTem:KEYBoard:ACCess < *parameter* >

parameter

FULL	->	full keyboard access
RANGe	->	measurement + range selection
MEASure	->	only measure

Comments:

Query form: On the entry of the query form "SYSTem:KEYBoard:ACCess?", the device supplies the currently selected access authorization for the keyboard on the front panel.

Response:

FULL	->	full access
RANG	->	measurement + range selection
MEAS	->	only measure

Reset value: FULL

Example:

Keyboard access only for starting and stopping measurements:

OUTPUT 709;":SYSTEM:KEYBOARD:ACCESS MEASURE"

SYSTem:KLOCk

Description:

This command locks the keyboard on the front panel of the device.

Syntax:

:SYSTem:KLOCk <*parameter*>

parameter

parameter	Einstellung
ON	Keyboard locked
OFF	Keyboard released

Comments:

Query form: On the entry of the query form ":SYSTem:KLOCk?", the Res2304 responds with the current setting of the keyboard lock.

Response: Keyboard locked -> 1
Keyboard released -> 0

Reset value: OFF

When the device is controlled via the IEC bus interface, the keyboard can also be locked with the IEEE488.1 LOCAL LOCKOUT command.

Example:

Lock keyboard:

OUTPUT 709;":SYSTEM:KLOCK ON"

SYSTem:PRESet

Description: This command carries out a device reset with preset values.

Syntax: :SYSTem:PRESet

Comments: no query form

no parameters

After this reset, the device is set to front panel operation. PIf the device is to be controlled via serial interface, it must be set to the desired interface manually. If it is to be controlled by the GPIB, no conversion is necessary, as the device selects the IEEE488 interface control as a reset value.

The values of the individual parameters after a SYSTEM:PRESET are stated as *reset values* under the respective commands in the command list.

The values of the calibration data and the entries in the control are not lost.

SYSTem:TIME

Description:

This command sets the time on the device.

Syntax:

:SYSTem:TIME <*parameter*>

parameter <hours>,<minutes>,<seconds>

<hours>	->	0..23
<minutes>	->	0..59
<seconds>	->	0..59

Comments:

Query form On the entry of the query form "SYSTem:TIME?", the device supplies the time at which the command was received.

Response:

<hours>,<minutes>,<seconds> (e.g. 12,30,45)

Example:

Requesting the time

```
10 OUTPUT 709;":SYSTEM:TIME?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Setting the time

```
OUTPUT 709;":SYSTEM:TIME 12,30,45"
```

TRACe:DATA

Description:

By means of this command, the parameter values for each display mode are entered.

Syntax:

TRACe:DATA <*parameter* >

parameter

Display mode	*parameter*	Setting
Ohm/m and Ohm/km	LENGTH0,0.001...999999	Entry of the length in meters
Ohm/10 ft and Ohm/kft	LENGTH0,0.001...999999	Entry of the length in feet
Delta%	NOMINAL,1e^{-7}...999999e^{3}	Entry of the specified value in ohms
Rho1 and Gamma1	LENGTH1,0.01...99.999 AREA,1e^{-5}...9999999	Length in meters Cross-section in mm^2
Rho2 and Gamma2	MASS,1e^{-5}...99999.9 LENGTH2,0.01...99.999 DENSITY,0.01...99.0 LENGTH3,0.01...99.999	Mass in g Length in meters Density in g/cm^3 Measure length in meters

TRACe:DATA

Comments:

Query form: On the entry of the query form "TRACe:DATA?", the device supplies the parameter values of the current display mode accompanied with the corresponding unit.

Display mode	Response of the device
Delta%	<specified value>
Ohm/m und Ohm/km	<length>
Ohm/10ft und Ohm/kft	<length>
Rho1 und Gamma1	<length>,<cross-section>
Rho2 und Gamma2	<mass>,<length>,<density>,<measure-length>

In the "Ohm" display mode, no parameter is returned on the "TRACe:DATA?" command.

Example:

Setting the display mode to "Ohm/m" and entering the "Length" parameter (100m).

```
10 OUTPUT 709;":CALC:MATH:EXPR R/LENGTH0[M]"
20 OUTPUT 709;":CALC:STAT ON"
30 OUTPUT 709;":TRAC:DATA LENGTH0,100"
40 END
```

TRIGger:SOURce

Description:

This command selects the trigger source which is to be responded to.

Syntax:

:TRIGger:SOURce <*parameter*>

parameter The desired trigger source is selected with the parameter.

parameter	Description
IMMediate	A measurement-start command is executed at once
BUS	A measurement-start command is only executed after a group-execute-trigger is received

Comments:

Query form: On receiving the query form, the device sends the current trigger setting.

Response of the device:

Trigger passive -> IMM
Trigger active -> BUS

Reset value: IMM

Example:

```
10 OUTPUT 709;":TRIGGER:SOURCE BUS" !react to GET
20 OUTPUT 709;":INITIATE" !measurement-start command
30
 :
 :    ! set other devices
 :
80
90 SEND 7;CMD 8  !send GET  -> start measurement
100 END
```

Cooling-curve measurement commands

CCURve:ABORt

Description:

This command stops measurement of the cooling curve.

Syntax:

:CCURve:ABORt

Comments:

no query form

no parameters

If the command is not sent after the cooling-curve measurement has begun, the measurement ends after 256 measured values.

On this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example:

see "CCURve:STATe" command

CCURve:BTEMperatur

Description:

With this command, the ambient temperature of the test unit before the measurement is entered manually.

Syntax:

CCURve:BTEMperatur < *parameter* >

parameter -99.9...999.9 (in degrees Celsius)

depending on the ambient temperature

Comments:

Query form: On the entry of the query form "CCURve:BTEMperature?", the device supplies the current setting of the ambient temperature before the measurement.

Response: e.g. 23.4CEL

For setting the temperature manually, the parameter is sent without a unit. The device responds with a "CEL" unit.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example:

see "CCURve:STATe" command

CCURve:CLEAr

Description: The cooling memory is cleared with this command.

Syntax: CCURve:CLEAr

Comments: ***no parameters***

no query form

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example: OUTPUT 709;"CCURVE:CLEAR"

CCURve:BTEMperatur:INITiate

Description:

With this command, the ambient temperature of the test unit before measurement is recorded automatically.

Syntax:

CCURve:BTEMperatur:INITiate

Comments:

no parameters

no query form

An external Pt 100 sensor must be connected to the device.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example:

see "CCURve:STATe" command

CCURve:CHARge

Description:

With this command, the removal of the load on the test unit is signalled to the device.

Syntax:

:CCURve:CHARge <*parameter*>

parameter OFF

Comments:

no query form

Instead of "OFF", "0" can also be sent as a parameter.

The command starts an internal stopwatch for the cooling-curve measurement.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of the previous state.

Example:

OUTPUT 709;":CCURVE:CHARGE OFF"

CCURve:CRESistance

Description:

With this command, the cold resistance of the test unit is entered manually.

Syntax:

CCURve:CRESistance <*parameter*>

parameter 0...999999 KOHM

depending on the cold resistance value

Comments:

Query form: On the entry of the query form "CCURve:CRESistance?", the device supplies the current setting of the cold resistance with the corresponding unit.

Response: e.g. 100OHM

If the parameter is sent without a unit, it is assumed to have a unit of "Ohms".

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example:

OUTPUT 709;":CCURVE:CRESISTANCE 100OHM"

CCURve:CRESistance:ABORt

Description: With this command, the measurement of the test unit's cold resistance is stopped.

Syntax: :CCURve:CRESistance:ABORt

Comments:

no parameters

no query form

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example: see "CCURve:STATe" command

CCURve:CRESistance:INITiate

Description: With this command, the cold resistance of the test unit is measured.

Syntax: :CCURve:CRESistance:INITiate

Comments:

no parameters

no query form

If the device is set to repetition measurement, the cold resistance measurement must be stopped with the "CCURve:CRESistance:ABORt" command.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous

Example: see "CCURve:STATe" command

CCURve:DATA?

Description: With this command, the results of the cooling-curve measurement are requested.

Syntax: :CCURve:DATA?

Comments:

no parameters

only query form

Response of the device:

<meas. time> <meas. value>,<meas. time> <meas. value>,........

If a printer was activated with the "CCURve:PRINter ON" command, the cooling-curve measurement results are sent to the printer via the serial interface.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example: see "CCURve:STATe" command

CCURve:DELay

Description: With this command, the time interval between the cooling-curve measurements is set.

Syntax: :CCURve:DELay <*parameter*>

parameter 0...99999.99S

depending on the desired delay time.

Comments: ***Query form:*** On the entry of the query form "CCURve:DELay?", the device supplies the current setting of the delay time.

Response: 0...99999.99s

The parameter can be sent with a unit of seconds ("S"), milliseconds ("MS") or without a unit. If the unit is omitted, "S" is assumed.

If 0S is sent as a parameter, as many measured values as possible are recorded.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example: see "CCURve:STATe" command

CCURve:ETEMperatur

Description:

With this command, the ambient temperature of the test unit after the measurement is entered manually.

Syntax:

CCURve:ETEMperatur < *parameter* >

parameter -99.9...999.9 (in degrees Celsius)

depending on the ambient temperature

Comments:

Query form: On the entry of the query form "CCURve:ETEMperature?", the device supplies the current setting of the ambient temperature after the measurement.

Response: e.g. 23.4CEL

For setting the temperature manually, the parameter is sent without a unit. The device responds with a "CEL"unit.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Example:

see "CCURve:STATe" command

CCURve:ETEMperatur:INITiate

Description: With this command, the ambient temperature of the test unit after the measurement is registered automatically.

Syntax: CCURve:ETEMperatur:INITiate

Comments: no parameters

no query form

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

An external Pt100 sensor must be connected to the device.

Example: see "CCURve:STATe" command

CCURve:PRINter

Description:

With this command, a printer is activated in order to output the cooling-curve measurement results.

Syntax:

:CCURve:PRINter < *parameter* >

parameter:

parameter	Setting
ON	measurement results are sent via serial interface.
OFF	measurement results are sent via GPIB.

Comments:

Query form: On the entry of the query form "CCURve:PRINter?", the device supplies the current state of the serial printer.

Response: 0 or 1

The command is ineffective when the device is controlled via the serial interface.

The measurement results are sent on the "CCURve:DATA?" command.

With this command, the "cooling-curve menu" is shown on the display. At the same time, CCURve:STATe ON is switched, irrespective of its previous state.

Reset value: OFF

Example:

see "CCURve:STATe" command

CCURve[:STATe]

Description:

This command activates the "cooling-curve menu".

Syntax:

:CCURve:STATe <*parameter*>

parameter:

parameter	Setting
ON	Cooling-curve menu on
OFF	Cooling-curve menu off

Comments:

Query form: On the entry of the query form "CCURve[:STATe]?", the device supplies the current setting of the measurement mode.

0 -> normal measurement
1 -> cooling-curve measurement

If the device is not in the cooling-curve mode when a cooling-curve command is sent, the device activates the cooling-curve mode.

When the device is in the cooling-curve mode, all "non-cooling-curve" commands are disabled. In order for such commands to be executed, the cooling-curve mode must first be deactivated with the "CCURve:STATe OFF" command.

Reset value: OFF

CCURve:INITiate

Description: With this command, the cooling-curve measurement will be activated.

Syntax: CCURve:INITiate

Comments: no parameters

no query form

With this command, the "cooling-curve menu" will be displayed. Simultaneous the CCURve:STATe will be switched ON indepedence of the previous state.

Example: see "CCURve:STATe" command

CCURve[:STATe]

Example:

Example of setting the cooling-curve menu, with output of the measurement results to a serial printer.

```
10 ! cooling-curve menu - on
20 OUTPUT 709;":CCUR:STAT ON"
30 ! enter cold resistance
40 OUTPUT 709;":CCUR:CRES 100OHM"
50 ! set delay time (one measured value every minute)
60 OUTPUT 709;":CCUR:DEL 60S"
70 ! activate printer
80 OUTPUT 709;":CCUR:PRIN ON"
90 ! measure initial temperature and request it
100 OUTPUT 709;":CCUR:BTEM:INIT"
110 OUTPUT 709;":CCUR:BTEM?"
120 ENTER 709;btemp$
130 ! removal of load
140 OUTPUT 709;":CCUR:CHAR OFF"
150 ! measure final temperature and request
160 0 OUTPUT 709;":CCUR:ETEM:INIT"
170 OUTPUT 709;":CCUR:ETEM?"
180 ENTER 709;etem$
190 ! start cooling-curve measurement
200 OUTPUT 709;":CCUR:INIT"
210 ! wait until 256 measured values have been recorded
        .
        .
240 ! measured results to serial printer
250 OUTPUT 709;":CCUR:DATA?"
260 OUTPUT 709;":CCUR:STAT OFF"
```

Status - Message Commands

STATus:OPERation:ENABle

Description:

This command sets the enable mask for the "operation - event" register.

Syntax:

:STATus:OPERation:ENABle < *parameter* >

parameter 0...65535

Comments:

Query form: On the entry of the query form "STATus: OPERation:ENABle?", the device supplies the decimal value of the contents of the operation status register.

Response: 0...65535

The parameter is the decimal value of the mask for the operation status enable register.

A bit set in the enable register enables the corresponding bit in the event register.

Reset value: 0

Example:

Desired enable mask: 0000 0000 0001 0000

OUTPUT 709;":STAT:OPER:ENAB 16"

STATus:OPERation:EVENt?

Description: This command polls the contents of the operation status event register.

Syntax: :STATus:OPERation:EVENt?

Comments: only query form; the event register is cleared after read-out.

Example:

```
10 OUTPUT 709;":STATUS:OPERATION:EVENT?"
20 ENTER 709;A$
30 PRINT A$
```

Response of the device: 0...65535

STATus:PRESet

Description:

This command clears the masks of the enable register.

Syntax:

:STATus:PRESet

Comments:

no parameters

no query form

Example:

OUTPUT 709;":STATUS:PRESET"

STATus:QUEStionable:ENABle

Description:

This command sets the enable mask for the "questionable event" register.

Syntax:

:STATus:QUEStionable:ENABle <*parameter*>

parameter: 0...65535

Comments:

Query form: On the entry of the query form "STATus:QUEStionable:ENABle?", the device supplies the decimal value of the contents of the questionable status register.
Response: 0...65535

The parameter is the decimal value of the mask for the questionable status enable register.

A bit set in the enable register releases the corresponding bit in the event register.

Reset value: 0

Example:

desired enable mask: 0000 0000 0001 0000

OUTPUT 709;":STATUS:QUESTIONABLE:ENABLE 16"

STATus:QUEStionable:EVENt?

Description: This command polls the contents of the questionable status event register.

Syntax: :STATus:QUEStionable:EVENt?

Comments: only query form; the event register is cleared after read-out.

Example:

```
10 OUTPUT 709;":STATUS:QUESTIONABLE:EVENT?"
20 ENTER 709;A$
30 PRINT A$
```

Response of the device: 0...65535

IEEE488.2 Commands

*CLS

Description: Clear Status command

This command resets the IEEE488.2 status registers.

Syntax: *CLS

no parameters
no query form

Example: OUTPUT 709;"*CLS"

*ESE

Description: This command sets or polls the "STANDARD - EVENT - STATUS - ENABLE - REGISTER".

Syntax: *ESE < *parameter* >

parameter 0...255
depending on the desired setting mask.

Example: setting mask 0001 0000

OUTPUT 709;"*ESE 16"

Query form: *ESE?

Response of the device: 0...255
depending on the current setting mask.

*ESR?

Description: With this command, the "STANDARD - EVENT - STATUS - REGISTER" is read out and reset.

Syntax: *ESR?

Example:
```
10 OUTPUT 709;"*ESR?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Query form: *ESR?

only query form

Response of the device: 0...255
depending on the current register contents.

*IDN?

Description: Identification Query

This command interrogates the ID of the device.
- Company name
- Device name
- Serial number
- Device version

Syntax: *IDN?

no parameters
only query form

Example:
```
10 OUTPUT 709;"*IDN?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Response of the device:
BURSTER,RESISTOMAT2304,SN123456,V1192

*OPC

Description:

This command switches the device to the "operation complete active state" (OCAS).

In the OCAS, the "operation complete bit" (bit 0) in the standard event status register is set when an operation has been completed.

Syntax:

*OPC

no parameters

Example: OUTPUT 709;"*OPC"

*OPC?

Description:

This commands switches the device to the "operation complete query active state" (OCQAS).

In the OCQAS, the device writes "1<CR><LF" into the output buffer when a command has been executed.

Syntax:

*OPC?

only query form
no parameters

Example:

```
10 OUTPUT 709;"*OPC?"
20 OUTPUT 709;":CAL:ZERO"
30 ENTER 709;A$
40 IF A$ = "1<CR><LF>" THEN GOTO CONTINUE ELSE
                                         GOTO 30
50 CONTINUE:!
60   .
70   .
80   .
```

*RST

Description: This command switches the device to a defined initial state.

The interface setting is not changed, i.e. the device remains in the remote state, set to the interface via which it was reset.

Syntax: *RST

no parameters
no query form

Example: OUTPUT 709;"*RST"

*SRE

Description: This command sets or polls the "SERVICE - REQUEST - ENABLE - REGISTER".

Syntax: *SRE <*parameter*>

parameter 0...255
depending on the desired setting mask.

Example: setting mask 0001 0000

OUTPUT 709;"*SRE 16"

Query form: *SRE?

Response of the device: 0...255
depending on the current setting mask.

*STB?

Description: This command reads out the "STATUS - BYTE - REGISTER" with the master summary bit.

Syntax: *STB?

Example:
```
10 OUTPUT 709;"*STB?"
20 ENTER 709;A$
30 PRINT A$
40 END
```

Query form: *STB?

only query form

Response of the device: 0...255
depending on the current register content.

*TRG

Description: Trigger command

This command is equivalent to the IEEE488.1 GET command for a particular device.

Syntax: *TRG

no parameters
no query form

Example: OUTPUT 709;"*TRG"

*WAI

Description:

This command sets a device so that all commands are executed sequentially.

The command does not have any effect in the Res2304, as this device always executes commands sequentially.

Syntax:

*WAI

no parameters
no query form

Example: OUTPUT 709;"*WAI"

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HP - IB commands

HP-IB commands

Introduction

The HP-IB BASIC COMMANDS in this chapter are meant especially for the HP series 200/300 computer. Every other IEEE488 controller can also send these commands. In terms of syntax, however, their commands could differ from the ones listed here.The IEEE488 command abbreviations are stated in parentheses after every HP-IB command.

All examples presuppose that the Interface Select Code of the HP-IB interface is set to 7 and the device address set to 9.

ANSI/IEEE488.1 - 1987 capabilities

IEEE488.1 function	Code	Description
Source Handshake	SH1	Enables the Res2304 to transfer multi-wire information.
Acceptor Handshake	AH1	Enables the Res2304 to receive multi-wire information.
Talker	T6	Enables the Res2304 to transmit data via the GPIB. Enables the Res2304 to respond to the serial poll.
Listener	L4	Enables the Res2304 to receive data via the GPIB.
Service Request	SR1	Enables the Res2304 to send a service request to the controller.
Remote/Local	RL1	Enables control of the Res2304 via the front panel keyboard (local) or the GPIB(remote).
Parallel Poll	PP0	No capability.
Device Clear	DC1	Enables the Res2304 to be brought into a defined state by means of the Device Clear command.
Device Trigger	DT1	Enables the Res2304 to be triggered via the GPIB.
Controller Function	C0	No capability.
Driver Electronics	E1	Open - Collector GPIB driver.

ABORT (IFC)

Description: Interface clear command:
Resets the GPIB interface of the Res2304.

Syntax: **ABORT 7**

Example: ABORT 7 ! resets the interface.

CLEAR (DCL oder SDC)

Description: Device clear or Selected device clear command:

- clears the input buffer
- clears the output buffer
- resets the command interpreter.
- brings the device into the operation-complete-COMMAND-idle state.
- brings the device into the operation-complete-query-idle-state.

Syntax:
CLEAR 7
CLEAR 709

Example:

CLEAR 7 ! Device clear; resets all devices on the bus.

CLEAR 709 ! Selected device clear; resets the device with address 9.

LOCAL (GTL)

Description:

Go to local command:

resets the Res2304 to front panel operation.

Syntax:

LOCAL 7
LOCAL 709

Comments:

If the LOCAL key of the Res2304 has been disabled through a LOCAL LOCKOUT, the Res2304 can be switched to front panel operation through command LOCAL 709. However, a subsequent remote command disables front panel operation again. In contrast, the LOCAL 7 command also enables front panel operation after a subsequent remote command.

Example:

LOCAL 7	! Sets the FALSE IEEE488 bus line (all devices are switched to LOCAL operation). The command is cancelled with the REMOTE 7 command.
LOCAL 709	! Sets the device with address 9 to LOCAL operation by sending the GTL interface message.

LOCAL LOCKOUT (LLO)

Description: Disables the local key of the Res2304.

Syntax: **LOCAL LOCKOUT 7**

Comments: If the Res2304 is in the LOCAL operation mode when sending the LLO command, it remains in LOCAL. If the Res2304 is in the remote opertion mode, the local key is disabled at once.

If the keyboard has been disabled through a LOCAL LOCKOUT, it can be enabled a again though the LOCAL 7 command. The LOCALL 709 command also enables the keyboard; however, it is disabled again after a REMOTE command.

Example:

LOCAL LOCKOUT 7 ! sends an LLO to all devices

REMOTE

Description: Sets the REN IEEE488 bus line.

Syntax:

REMOTE 7
REMOTE 709

Comments: The REMOTE 709 command switches the Res2304 into the REMOTE state. The REMOTE 7 command alone does not switch the Res2304 into the REMOTE state. After the REMOTE 7 command, the Res2304 only assumes the REMOTE state upon receiving its listener address.

Example:

REMOTE 7	! Sets the REN IEEE488 bus line This instruction does not switch the Res2304 into the REMOTE state.
REMOTE 709	! Sets the REN line and addresses device 9 This instruction switches the Res2304 into the REMOTE state.

SPOLL (Serial Poll)

Description:

The SPOLL command corresponds to the IEEE488.2 command *STB?. The number sent back is the weighted sum of the bits in the status byte register.

Syntax:

P = SPOLL(709)

Comments:

The serial poll command differs from the *STB? command in that it does not load the microcontroller of the device. The status byte is returned by the GPIB chip of the Res2304.

The meanings of the individual bits of the status byte are described in the chapter titled "STATUS MESSAGES."

Example:

```
10 P=SPOLL(709)     !Serial poll
20 DISP P           Display of the response
30 END
```

The meanings of the individual bits of the status byte are described in the chapter titled "STATUS MESSAGES."

TRIGGER (GET)

Description:

Group execute trigger:

When the trigger setting of the Res2304 is on "active", the TRIGGER command starts a resistance measurement.

Syntax:

TRIGGER 7
TRIGGER 709

Comments:

The TRIGGER command only triggers the Res2304 when the trigger setting of the Res2304 is on "active". When the trigger setting is on "passive", the trigger command does not have any effect.

Example:

TRIGGER 7	! GET to all devices
TRIGGER 709	! GET to the device with address 9

Table of contents, chapter 6-5

Sample program for controlling the RESISTOMAT 2304 via the RS232 interface with a PC-AT as system controller.

Introduction

Examples

The following examples illustrate the control of the Resistomat 2304 via the serial interface. The ANSI standard ANSI X3.28 Subcat.2.5, A3 serves as the communication protocol. The sample program is written in GW - Basic on a PC-AT with MS-DOS Version 3.3.

The display contrast is set to 70%, and this setting is then polled.

The Resistomat must be set to RS232 in the interface menu. Its hardware settings should be as follows:
9600 bauds, no parity, 8 data bits, 1 stop bit.

Sample program 1

```
10  REM Sample program for controlling the Resistomat2304 via
20  REM theRS232 interface in accordance with ANSI X3.28 Subcat.2.5, A3
30  STX$ = CHR$(2)
40  ETX$ = CHR$(3)
50  EOT$ = CHR$(4)
60  ENQ$ = CHR$(5)
70  ACK$ = CHR$(6)
80  LF$  = CHR$(10)
90  NAK$ = CHR$(21)
100 OPEN "COM1:9600,N,8,1" AS #3
110 PRINT #3,EOT$
115 CLS
120 INPUT "Enter the group address of the Resistomat2304 :(0..f) ";GRADR$
130 INPUT "Enter the user address of the Resistomat2304 :(0..f) ";USADR$
135 REM Formation of the selection supervisory sequence
140 SELSEQ$ = EOT$+GRADR$+GRADR$+USADR$+USADR$+"sr"+ENQ$
150 REM Formation of the polling supervisory sequence
160 POLSEQ$ = EOT$+GRADR$+GRADR$+USADR$+USADR$+"po"+ENQ$
170 REM
180 REM Set the Resistomat2304 as a slave
190 REM     -> Selection supervisory sequence
200 REM
210 PRINT #3,SELSEQ$
```

```
220 REM
230 REM Fetch the response of the device (ACK or NAK)
240 REM
250 RES$ = INPUT$(1,#3)
260 IF RES$<>ACK$ THEN PRINT "Selection sequence not recognized":END
270 REM
280 REM 2304 is set as a slave
290 REM SCPI Send command
300 REM
310 SCPI$ = STX$+":display:contrast? 0.7"+LF$+ETX$
320 PRINT #3,SCPI$
330 REM
340 REM Fetch the response of the device (ACK or NAK)
350 REM
360 RES$ = INPUT$(1,#3)
370 IF RES$<>ACK$ THEN PRINT "SCPI command not recognized":END
380 REM
390 REM Fetch the response of the Resistomat 2304 to the SCPI query command
400 REM    -> Set the 2304 as master
410 REM        -> Send polling supervisory sequence
420 REM
430 PRINT #3,POLSEQ$
440 REM
450 REM Response (display contrast"0.7" )
460 REM
470 CONT$=INPUT$(5,#3)
480 REM
490 Terminate connection
500 REMM
510 PRINT #3, EOT$
515 PRINT
520 PRINT CONT$:REM Indicate contrast
530 END
```

Explanantion of sample program1

Lines 30 - 90	The ASCII characters required for communication are defined here (e.g. line feed = ASCII 10)
Line 100	The serial interface of the PC is initialized here. The serial interface of the PC must be initialized in accordance with the setting on the Resistomat. The interface is assigned the input/output channel 3.
Line 110	As system controller, the PC sends an EOT in order to deactivate any slaves present on the bus.
Lines 120-130	Input of the group and user addresses. The addresses must be entered in 'hex' (0...f), and correspond with those set on the Resistomat.
Line 140	The selection supervisory sequence is formed.
Line 160	The polling supervisory sequence is formed.
Line 210	The Resistomat2304 is initialized as a slave, in that the selection supervisory sequence is sent via the serial interface.
Line 250	The response of the Resistomat2304 is read in via the serial interface. If ACK is received, the Resistomat is initialized as a slave and can receive SCPIs.
Line 320	The SCPI "DISPLAY:CONTRAST? 0.7" is sent via the serial interface.
Line 360	The response of the Resistomat2304 is read in via the serial interface. If ACK is received, the Resistomat has understood the command.
Line 430	In order to fetch the requested setting of the display contrast, the Resistomat2304 is initialized as master. This is effected by sending the polling supervisory sequence.
Line 470	The response of the Resistomat is fetched by the serial interface.
Line 510	The connection is terminated. The master status is returned to the system controller (PC-AT).

Sample program 2

```
REM Sample program for controlling the Resistomat2304 via
REM the RS232 interface in accordance with ANSI X3.28 Subcat.2.5, A3
REM (Start measurement and fetch measured value)
REM
REM language: QBASIC operating system: MS-DOS 5.0
REM baud rate: 9600 data bits: 8 stop bits: 1 parity : none


meas$ = ""
RES$ = ""
OPERSTAT$ = ""
a$ = ""

REM Definition of the ASCII characters required for communication
STX$ = CHR$(2)
ETX$ = CHR$(3)
EOT$ = CHR$(4)
ENQ$ = CHR$(5)
ACK$ = CHR$(6)
LF$ = CHR$(10)
CRE$ = CHR$(13)
NAK$ = CHR$(21)

REM Initializing the serial interface COM1 of the PC
OPEN "COM1:9600,N,8,1" FOR RANDOM AS #3

REM As system controller, the PC sends an EOT in order to
REM deactivate any slaves present on the bus
PRINT #3, EOT$

CLS

PRINT "Sample program for controlling the 2304 via the serial
      interface"
PRINT "9600 BAUD, 8 data bits, 1 stop bit, no parity"
PRINT "(Starting a measurement, polling the end-of-conversion bit",
PRINT "Fetching the measured value and stopping the measurement")

PRINT
```

```
REM Input of the group and user addresses. The addresses must be input in HEX format
REM (0..f) and correspond with the addresses set on the 2304.
INPUT "Input group address of the Resistomat2304 :(0..f) ";GRADR$
INPUT "Input user address of the Resistomat2304:(0..f) "; USADR$

REM Formation of the selection supervisory sequence
SELSEQ$ = EOT$ + GRADR$ + GRADR$ + USADR$ +USADR$ + "sr" + ENQ$

REM Formation of the polling supervisory sequence
POLSEQ$ = EOT$ + GRADR$ + GRADR$ + USADR$ + USADR$ + "po" + ENQ$


REM Set the Resistomat2304 as a slave
REM    -> Send the selection supervisory sequence
PRINT #3, SELSEQ$

REM Fetch the response 2304  (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "Selection sequence not recognized!": END

REM A measurement currently in progress is stopped by sending the 2304 the SCPI
REM "ABORT".
PRINT #3, STX$ + ":abort" + LF$ + ETX$

REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "ABORT Sequence not recognized!": END

REM The status registers of the 2304 are cleared by sending the IEEE488.2
REM command "*CLS".
PRINT #3, STX$ + "*CLS" + LF$ + ETX$

REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "*CLS sequence not recognized!": END

REM A measurement is started by sending the SCPI
REM "INITIATE"
SCPI$ = STX$ + ":initiate" + LF$ + ETX$
PRINT #3, SCPI$
```

```
REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "INITIATE Command not recognized!": END

PRINT
PRINT "Measurement started!"

REM The measurement is started. Now the end-of-conversion bit
REM (bit 9 of the operation status registers) is polled until a
REM measured value is registered by the 2304.

Bit polling:

PRINT ".";

REM address the 2304 as a slave.
PRINT #3, SELSEQ$

REM Fetch the response of the device (ACK or NAK).
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "Selection sequence not recognized!": END

REM Poll the operation status register of the 2304.
SCPI$ = STX$ + ":status:operation:event?" + LF$ + ETX$
PRINT #3, SCPI$

REM Fetch the response of the device (ACK or NAK).
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "STATUS Command not recognized!": END

REM Fetch the contents of the operation status register of the 2304.
REM Initialize the 2304 as master.
REM    -> Send polling supervisory sequence.
PRINT #3, POLSEQ$

OPERSTAT$ = ""
a$ = ""

REM Read in the response of the 2304.
WHILE a$ <> ETX$
   a$ = ""
   a$ = INPUT$(1, #3)
   IF (a$ <> STX$) AND (a$ <> ETX$) AND (a$ <> EOT$) AND (a$ <> LF$) AND (a$ <>
CRE$) THEN OPERSTAT$ = OPERSTAT$ + a$ ELSE IF a$ = EOT$ THEN END
WEND
```

```
REM Check end-of-conversion bit:
REM When the EOC bit is set, a measured value is available, otherwise
REM poll the bit again.

IF ((VAL(OPERSTAT$) AND 512) = 512) THEN GOTO Continue ELSE GOTO bit polling

Continue:       REM Fetch measured value

REM Initialize 2304 as slave
PRINT
PRINT #3, SELSEQ$

REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "Selection sequence not recognized": END

REM Request measured value by sending the SCPI "FETCH?".
SCPI$ = STX$ + ":fetch?" + LF$ + ETX$
PRINT #3, SCPI$

REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT "Fetch command not recognized": END


REM Fetch the response of the Resistomat 2304 to the "FETCH?" command
REM   -> Set the 2304 as master
REM   -> Send the polling supervisory sequence
REM

PRINT #3, POLSEQ$
REM
REM Response (measured value)
REM

 meas$ = ""
 a$ = ""

 WHILE a$ <> ETX$
   a$ = ""
   a$ = INPUT$(1, #3)
   IF (a$ <> STX$) AND (a$ <> ETX$) AND (a$ <> EOT$) AND (a$ <> LF$) AND (a$ <>
CRE$) THEN meas$ = meas$ + a$ ELSE IF a$ = EOT$ THEN END
 WEND
```

```
REM The measurement is stopped in that the SCPI "ABORT" is sent.
REM (Fast selection sequence)
PRINT #3, EOT$ + GRADR$ + GRADR$ + USADR$ + USADR$ + "sr" + STX$ +
":abort" + LF$ + ETX$

REM Fetch the response of the device (ACK or NAK)
RES$ = ""
RES$ = INPUT$(1, #3)
IF RES$ <> ACK$ THEN PRINT RES$, "ABORT sequence not recognized": END

PRINT "Measurement stopped!"

REM Terminate connection
PRINT #3, EOT$

REM Display the measured value which has been read in
PRINT
PRINT "Measured value: ";
PRINT meas$

CLOSE #3
END
```

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Technical specifications and appendix

Technical specifications

Resolution and measuring current:

Resistance range		Resolution*		Measuring current (bipolar)
200.00	μΩ	10	nΩ	10 A
2.0000	mΩ	100	nΩ	10 A, 1 A
20.000	mΩ	1	μΩ	10 A, 1 A, 100 mA
200.00	mΩ	10	μΩ	1 A, 100 mA, 10 mA
2.0000	Ω	100	μΩ	1 A, 100 mA, 10 mA, 1 mA
20.0000	Ω	1	mΩ	100 mA, 10 mA, 1 mA, 100 μA
200.00	Ω	10	mΩ	10 mA, 1 mA, 100 μA
2.0000	kΩ	100	mΩ	1 mA, 100 μA
20.000	kΩ	1	Ω	100 μA

* on center setting

Measurement method:

Quotient process in 4-conductor Kelvin circuit

Maximum measurement error $f_{Lin,\ BIPOL}$ for BIPOLAR MEASUREMENT SEQUENCE:

I	1/2 year	1 year	2 years
200 µΩ range			
10 A	0.023% ± 2 Digits	0.025% ± 2 Digit	0.03% ± 2 Digits
2 mΩ range			
10 A	0.015% ± 2 Digits	0.016% ± 2 Digits	0.018% ± 2 Digits
1 A	0.016% ± 2 Digits	0.018% ± 2 Digits	0.02% ± 2 Digits
20 mΩ-Bereich			
10 A	0.012% ± 2 Digits	0.013% ± 2 Digits	0.015% ± 2 Digits
1 A	0.013% ± 2 Digits	0.014% ± 2 Digits	0.016% ± 2 Digits
100 mA	0.015% ± 2 Digits	0.016% ± 2 Digits	0.018% ± 2 Digits
200 mΩ range			
1 A	0.011% ± 2 Digits	0.012% ± 2 Digits	0.014% ± 2 Digits
100 mA	0.012% ± 2 Digits	0.013% ± 2 Digits	0.015% ± 2 Digits
10 mA	0.014% ± 2 Digits	0.015% ± 2 Digits	0.017% ± 2 Digits
2 Ω range			
1 A	0.01% ± 2 Digits	0.011% ± 2 Digits	0.012% ± 2 Digits
100 mA	0.01% ± 2 Digits	0.011% ± 2 Digits	0.012% ± 2 Digits
10 mA	0.011% ± 2 Digits	0.012% ± 2 Digits	0.013% ± 2 Digits
1 mA	0.013% ± 2 Digits	0.014% ± 2 Digits	0.015% ± 2 Digits
20 Ω range			
100 mA	0.01% ± 2 Digits	0.011% ± 2 Digits	0.012% ± 2 Digits
10 mA	0.01% ± 2 Digits	0.011% ± 2 Digits	0.012% ± 2 Digits
1 mA	0.011% ± 2 Digits	0.012% ± 2 Digits	0.013% ± 2 Digits
100 µA	0.013% ± 2 Digits	0.014% ± 2 Digits	0.015% ± 2 Digits
200 Ω range			
10 mA	0.009% ± 2 Digits	0.01% ± 2 Digits	0.011% ± 2 Digits
1 mA	0.009% ± 2 Digits	0.01% ± 2 Digits	0.011% ± 2 Digits
100 µA	0.012% ± 2 Digits	0.013% ± 2 Digits	0.014% ± 2 Digits
2 kΩ range			
1 mA	0.009% ± 2 Digits	0.01% ± 2 Digits	0.011% ± 2 Digits
100 µA	0.012% ± 2 Digits	0.013% ± 2 Digits	0.014% ± 2 Digits
20 kΩ range			
100 µA	0.012% ± 2 Digits	0.013% ± 2 Digits	0.014% 2 Digits

A value of ≤ 10 ppm/year can be entered as a typical value for the long-term stability.

Boundary conditions for the measurement error table:

Warm-up time for the resolution high - 30 minutes, medium - 15 minutes, low - 5 minutes.

Tu = 23°C (laboratory conditions), careful calibration in accordance with chap. 5.3, VI,

MEAS. TIME = 9, MEAS. CURRENT = LARGE/MEDIUM, MEAS. SEQUENCE = BIPOLAR,

Display value ≤ 70 % (1.400/14.000/140.000 Digits)

Measurement errors under boundary conditions deviating from these parameters:

Display value	>	70 %:	Error from table above	+	0.005 %,
RESOLUTION	=	LOW:	Error from table above	±	1 digit (instead of 2 digits).

The following applies to MEASUREMENT SEQUENCE = UNIPOLAR

$f_{LIN,\,UNI} = f_{LIN,\,BIPOL} + 0.04\,\% + U_{th} / I_{meas}$

whereby U_{th} implies the thermoelectric e.m.f´s in the measurement circuit and I_{meas} implies the measuring current through the test unit.
In practice 50 µV ≤ U_{th} ≤ mV are to be reckoned with, depending on the set-up and the change in temperature.

Temperature coefficient:

10 ppm/K (only 200 µΩ measurement range: 50 ppm/K).
A value of ≤ 10 ppm/year can be entered as a typical value for the long-term stability.

Error of the temperature measurement channel (Pt100) without a measurement pick-up:

≤	0.1	K	for	-30°C	≤	T	≤	50°C,
≤	0.3	K	for	-50°C	≤	T	≤	100°C,
≤	3	K	for	-200°C	≤	T	≤	850°C,

based on ITS 90 and DIN EN 60751.

Measurement connections:

4-wire technology in Kelvin circuit, floating circuit assembly, potential fixed with respect to the measurement object or the RESISTOMAT, according to requirement.

Max. compliance voltage:	at	100 µA ≤ I_{meas} ≤ 1 A	:10 V,
	I_{meas} =	10 A	: 8 V,

Max. voltage at the open terminals : < ± 16 V.

Max. permissible overvoltage at measurement input : 100 V DC.
(voltage circuit)

Measurement time:

Adjustable, Average value possible over ≤ 255 values:

Display	Meaurement period for purely ohmic test unit with standard setting
3 1/2-digit	≤ 300 ms
4 1/2-digit	≤ 600 ms
5 1/2-digit	≤ 5 s

Measurement type:

Repetition or single measurement, bipolar or unipolar.

Range selection:

Manual, automatic

Offset compensation:

per µP control upon request.

Display,:

240 x 64-dots, transflective graphic LCD with adjustable contrast and backglighting.

Overrange indication: >>>.

Indication of the measured value:

3 1/2, 4 1/2 and 5 1/2-digit, according to requirement; LCD 15 mm high; reading displayed: absolute, in %, or in other measurement units.

Voltage supply:

230 V + 6% - 10%; 115 V available as an option.

Line frequency: 45 - 65 Hz.

Power consumption: max. 260 VA.

Environ mental conditions:

Operation+5...23...40°C,	max. 90% relative humidity, non-condensing
Storage 0...23...60°C.	
Potential fixing:	measurement section internally grounded, switchable to external grounding. Digital section internally grounded.
Parameter entry:	Via keyboard or interface.
Weight:	28 kg.
Housing dimensions (HxLxB):	255 x 520 x 480 (mm).
Device protection:	In accordance with VDE 0411.

Connections:

Test unit connection:

- At front, via 4 recessed safety laboratory sockets, 4 mm.
- At rear. via 5-pin LEMO socket EGG.2B.305.

Control signals:

The following signals are accessible via a 37-pin subminiature D socket on the rear panel:

- Optocoupler output: ("Low-active", ≤ 27 V, ≤ 2 mA) — "Measurement in progress", "Measurement interrupted".
- Optocoupler input: ("Low active", ≤ 40 V) — For printer "ON".
- Foot switch input: — For Start/Stop (NO contact).
- 9 relay changeover contacts for classify operations RGE0 ... RGE8:
  - max. voltage: 42 V
  - max. current: 0.5 A

Temperature compensation:

Measurement of the test unit´s temperature via a Pt100 sensor which is connected via a 6-pin LEMO- socket EGG.1B.306.

Interfaces:

- IEEE-488:

  - 24-pin, standard plug connection with open collector outputs:
    SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0

  - command language: SCPI, Version 1990.0.

- RS232C:

  - full duplex with RTS, CTS,
  - 25-pin subminiature D-socket,
  - baud rate 600 - 19 200,
  - protocol ANSI X 3.28 subcategory 2.5, A3/A4,
  - command language: SCPI, Version 1990.0.

- RS485:

  - full duplex/half duplex without internal terminating resistances,
  - 25-pin subminiature D-socket,
  - baud rate 600-19200,
  - protocol ANSI X 3.28 subcategory 2.5, A3/A4,
  - command language: SCPI, Version 1990.0

Printer connection:

Use of the RS232C output and the IBM character set in accordance with Appendix 7.5).

Pin assignment

ATTENTION:

- Avoid the discharge of static electricity via the devices´terminals. (particularly via the IEEE 488 connector!) It could destroy your measuring device.

- Observe the safety precautions: Before touching the devices´ terminals and the leads connected to them, check whether any static charge needs to be removed.

  Damage through electrostatic voltage is not covered by the guarantee!

- In compliance with the relevant interference suppression regulations (VDE 0871B), all interface cables and plugs must be screened and grounded at both ends!

IEEE-488-Bus:

The 24-pin GPIB bus connector is standardized and has the pin assignment shown in Fig.7.1

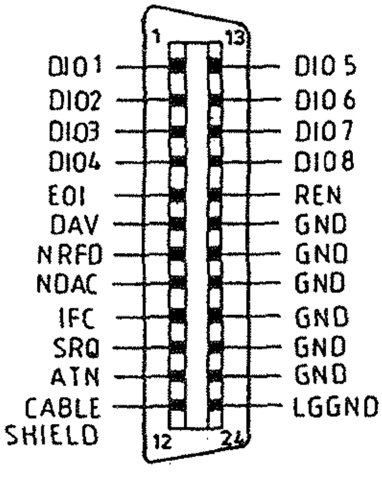


Fig. 7.1: IEEE connector
The connector has open collector outputs as shown in Fig. 7.2.

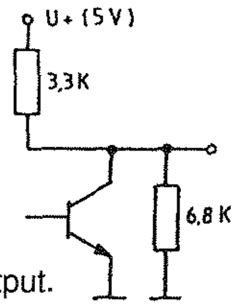
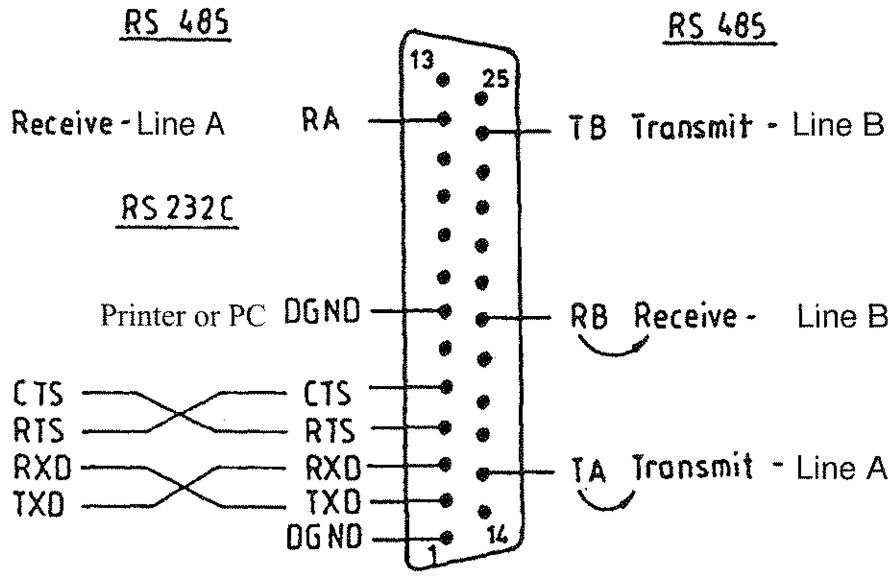


Fig. 7.2: Open-collector output.

Serial interfaces

The RS232C/RS485 serial interfaces are accessible via a 25-pin subminiature D-connector, whose pin assignment is shown in Fig. 7.3.

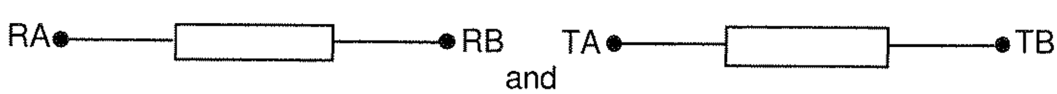


Full duplex:	RA,RB, TA, TB
Half duplex:	RA, RB

Low	=	A < B
High	=	A > B

Fig. 7.3: RS232C/RS485 connector

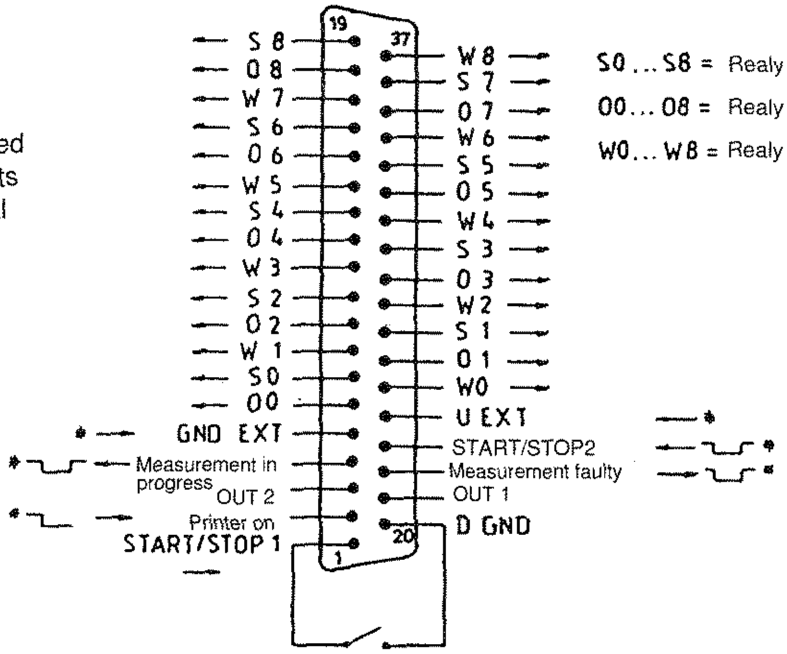
Terminating resistances are not present; they must be installed in the plug by the user, in accordance with the design (typical value: 150 Ω). Here, it should be ensured that the installation is performed on the transmission and reception sides:



Digital inputs/outputs

The digital control inputs and outputs are accessible via a 37-pin subminiature D-socket, whose pin assignment is shown in Fig. 7.4.

● electrically isolated optocoupler inputs and their external voltage supply



S0 ... S8 = Realy NO-contact
00 ... 08 = Realy NC-contact
W0 ... W8 = Realy common

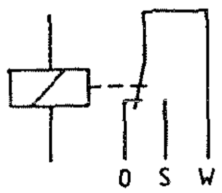


Fig. 7.4: Digital control inputs/outputs
The following signals are involved according to Fig. 7.4:

A) SØ ... S8/0Ø ... 08/WØ ... W8: relay outputs for comparator and classify functions. The numbering of the relay contacts corresponds with that of the ranges RGE0 ... RGE8.

B) "Measurement in progress": "active low" during measurement (until Stop <u>and</u> ⚡ - LED-off),

C) "Measurement error": "active low" in the case of measurement error (for ≥ 200 ms),

D) "Start/Stop1": pin1 to pin20 for starting measurement,

E) "Start/Stop2": wired as shown in Fig. 7.5 for starting measurement

F) "Printer on": wired as shown in Fig. 7.6 for printer enable (activated ≙ "pin2 = Low").

The inputs and outputs are optoelectronically decoupled. The electrical wiring of the outputs
B) and C) is shown in Fig. 7.5, and that of the outputs E) and F) in Fig. 7.6 .

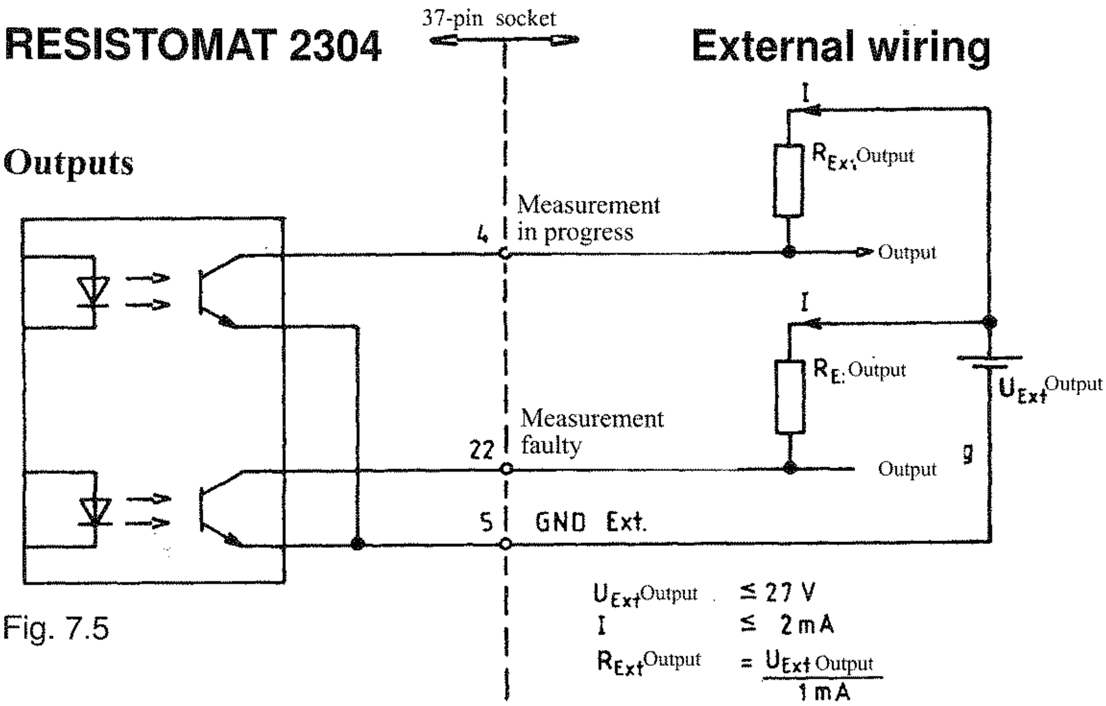


Fig. 7.5

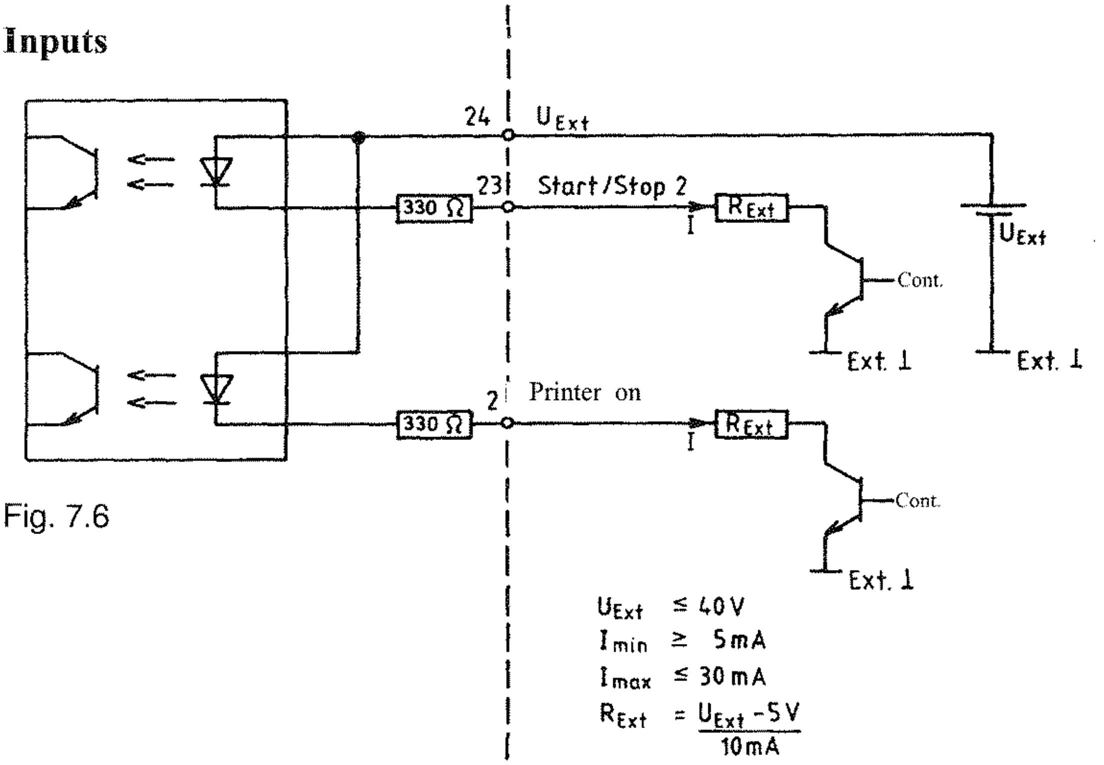


Fig. 7.6

Test unit connections

On the rear panel of the device, there is a second test-unit connection in parallel with the one on the front panel.
Its pin assignment is shown in Fig. 7.7

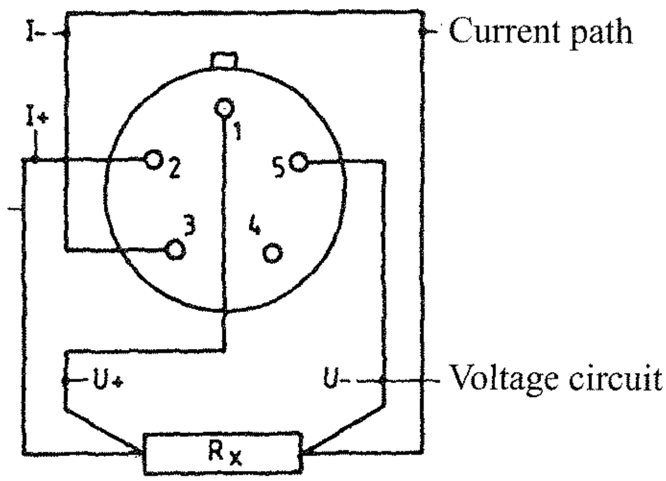


Fig.7.7: Test unit connections on rear panel
(External view of socket)

Pt100 connections

The Pt100 connection is on the rear panel of the device. Its pin assignment is shown in Fig. 7.8.

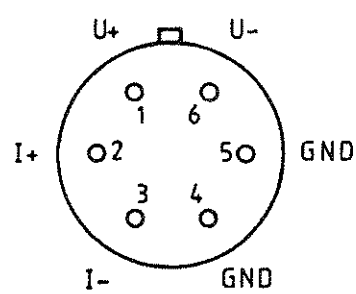


Fig.7.8: Pt100 connections
(External view of socket)

Error messages

ERR 0	:	Before measurement on load type Z is started, an overload or current error is already present.
ERR 1	:	Overload, range transgression, or U-cable rupture in the current path.
I	:	Occurs superimposed with other messages: current error, current in transient phase, or I-cable rupture in the current path.
MEAS	:	The measured value does not lie in the valid range; however, there is no overload.
T>>	:	The temperature in the device is too high (the measurement is stopped, and the measuring current set to 0).
VCOV	:	Overload of the amplifier channel C as shown in Fig. 1.5 (remedy: probably through zero compensation as described in Chap. 5.2.)

When MEAS. MODE = CONT. and LOAD TYPE = R, the measurement continues if an error occurs (except for T>>).

When MEAS. MODE = CONT. and LOAD TYPE = Z, the measurement is normally stopped whenever an error occurs.

Factory settings ("default parameters")

The following settings are valid for the cold start. After the *SEL* key is pressed (= access to the configuration and calibration menus) the settings listed below apply, with the exception of the calibration data and access monitoring entries which retain the current value.
The device is calibrated and tested at the factory, i.e. it is delivered with calibration and control entries.

Measurement range:	20 kΩ		
Range selection:	Manual		
Mesurement type:	Repetition		
Measurement current:	Large		
Load:	R		
Type of operation:	Bipolar		
Frequency:	50 Hz		
Resolution:	Medium		
Contrast:	54		
Beeper:	Off		
	With resolution:		
	low	medium	high
Average value:	1	1	5
MEAS. TIME ≙ TIME BASE:	1	5	9
Measurement pause:	1	1	1
Display mode:	Ohm		
Temperature compensation:	Off		
Recording:	Manual		
Temperature:	20 °C		
Co-efficient:	Nr. 5		

TC1:	1600 (ppm/K)	TC6:	4030
TC2:	1700	TC7:	4500
TC3:	2400	TC8:	4800
TC4:	3100	TC9:	6000
TC5:	3980	TC10:	6500
Individual measuring currents:	200 uΩ	...	20 kΩ
	10 A, 10 A, 1 A, 100 mA, 10 mA, 1 mA, 1 mA, 100 uA		
Comparator:	Off		
Type:	Comparator		
Bar display:	Off		
Rel. limit:	100 Ω ± 10 %		
Abs.limit:	corresponds to rel. limit		

Printer character set

	b0 b1 b2 b3	0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1	1 0 0 0	1 0 0 1	1 0 1 0	1 0 1 1	1 1 0 0	1 1 0 1	1 1 1 0	1 1 1 1
	h1	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
b4 b5 b6 b7	h2																
0 0 0 0	0	NUL		SP	0	■	P	■	p	Ç	É	á	░	└	╨	α	≡
0 0 0 1	1		DC1	!	1	A	Q	a	q	ü	æ	í	▒	┴	╤	β	±
0 0 1 0	2		DC2	"	2	B	R	b	r	é	Æ	ó	▓	┬	╥	Γ	≥
0 0 1 1	3	♥	DC3	■	3	C	S	c	s	â	ô	ú	│	├	╙	π	≤
0 1 0 0	4	♦	DC4	■	4	D	T	d	t	ä	ö	ñ	┤	─	╘	Σ	⌠
0 1 0 1	5	♣	§	%	5	E	U	e	u	à	ò	Ñ	╡	┼	╒	σ	⌡
0 1 1 0	6	♠		&	6	F	V	f	v	å	û	ª	╢	╞	╓	µ	÷
0 1 1 1	7	BEL		'	7	G	W	g	w	ç	ù	º	╖	╟	╫	τ	≈
1 0 0 0	8	BS	CAN	(	8	H	X	h	x	ê	ÿ	¿	╕	╚	╪	Φ	°
1 0 0 1	9	HT		)	9	I	Y	i	y	ë	Ö	⌐	╣	╔	┘	Θ	·
1 0 1 0	A	LF		*	:	J	Z	j	z	è	Ü	¬	║	╩	┌	Ω	·
1 0 1 1	B	VT	ESC	+	;	K	■	k	■	ï	¢	½	╗	╦	█	δ	√
1 1 0 0	C	FF	FS	,	<	L	■	l	■	î	£	¼	╝	╠	▄	∞	ⁿ
1 1 0 1	D	CR		-	=	M	■	m	■	ì	¥	¡	╜	═	▌	φ	²
1 1 1 0	E	SO		.	>	N	■	n	■	Ä	₧	«	╛	╬	▐	ε	■
1 1 1 1	F	SI		/	?	O	_	o	DEL	Å	ƒ	»	┐	╧	▀	∩	SP

■ :

national
special character

Fig. 7.6: Character set2 (IBM)

Installation
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Function keys - overview in alphabetical order

Key	Description
COMP / F1	Selection of the menu for performing the scaling factor calibration (COMPensation).
COOL / F2	Selection of the parameter assignment menu for recording a **COOL**ing curve.
DISPMOD / F3	Selection of the unit of measurement (**DISP**play**MOD**e)
EVAL / F5	Selection of the cooling curve protocol (**EVAL**uation).
• AUT	**AUT**omatic range selection, i.e. the device automatically selects the largest possible measurement range. (20 kΩ after power-on). When automatic range selection is active, the LED (light emitting diode) integrated in the button lights up.
L-REM	Entry of the **L**oad **REM**oval (= start of the internal stopwatch for the cooling curve); after this button is operated, the cooling curve F3 menu cannot be exited until the recording of the cooling curve is completed. With every access to the menu, the stopwatch is reset to zero.
PRINTER / F4	Selection of the menu for parameterizing the **PRINTER**.

INPUT F4	Selection of the **INPUT** of the reference variables for the measurement unit selected via **F3** (Ω/m, Ω/km or %) or the measurement variable (= specific resistance or = specific conductivity).
SELECT 1 F1	Selection of the measurement parameterizing menu (**SELECT**ion menu **1**)
SELECT 2 F2	Selection of the boundary conditions (**SELECT**ion menu **2**)
ENTER	Acknowledment of the current parameter setting and return to the next higher menu level.
g F3	Unit key for completng the entry of a numerical value of weight in **g** as the reference variable.
g/cm³ F5	Unit key for completing the entry of a numerical value of density in **g/cm³** as the reference variable.
LIM.ABS F1	Selection of the menu for setting the specified value and the comparator **LIM**iting values as **ABS**olute values in the selected measurement unit.
LIM.PER F2	Selection of the menu for setting the specified value as an absolute value and the comparator **LIM**iting values as **PER**centages of the specified value.

Key	Description
HW-CONF / F1	Selection of the menu for configurating the IEEE488 interface (**H**ard**W**are **CONF**iguration) or the operating mode/format menu for serial interfaces. After this function key is operated, two different setting menus could appear, depending on the type of interface selected.
INDIV. / F5	Selection of the menu for **INDIV**idual, range-dependent adjustment of the measuring current (0.1 mA ... 10 A), provided that the INDIV. option was also selected previously in the measuring current value list
kg / F1	Unit key for completing the entry of a numerical value of mass in **kg** as the reference variable.
km / F2	Unit key for completing the entry of a numerical value of length in **km** as the reference variable.
COEFF / F1	Selection of Table 3.17 with 10 preselectable temperature **COEFF**icients.
COMP / F2	Selection of the menu for parameterizing the **COMP**arator functions (including the bar display switch).
CONTROL / F1	Selection of the table for access monitoring, i.e. **CONTROL** of the access to the configuration menu performed via. the ' *SEL* switch
LOCAL / F5	Changeover from external device control via interface to keyboard operation.

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m / F1	Unit key for completing the entry of a numerical value of length in **m** as thereference variable.
mm² / F3	Unit key for completing the entry of a numerical value of cross-sectional area in **mm²** as the reference variable.
• MAN	**MAN**ual measurement range selection, i.e. the desired measurement range must be entered via the ·RGE key. If this operating mode is active, the LED integrated in the button lights up.
Meas-t / F4	Changeover of lines 2 (T1) or 5 (T2) in Fig. 3.29 to **MEAS**urement mode; here, only one measurement is performed in each case (measurement phase indicated through inverted display of the MEAS-t field).
RETURN / F5	Return to the next higher menu level.
RESET / F1	**RESET**s the subtotals as well as the total.
RESNUM / F5	**RESet**s the n**UM**erator.
• RGE	Start of the manual measurement range entry ("**R**an**GE**"). This is only possible if no measurement is currently in progress (the ·*STOP* LED lights up) and the measurement range is selected manually (the ·*MAN* LED lights up).
R-RESET / F1	Clears the measured value memory in the cooling curve menu.

Key	Description
INTERF / F3	Selection of the menu for parameterizing the **INTERF**ace.
STATCLA / F4	Selection of the **CLA**ssification evaluation **STAT**istics (9 classifications and summations).
STATCOM / F3	Selection of the **COM**parator evaluation **STAT**istics (< = > and summations).
SW-CONF / F2	Selection of the menu for setting the software parameters of the serial interfaces (**S**oft**W**are **CONF**iguration).
TC / F 1	Selection of the menu for parameterizing the **T**emperature **C**ompensation resp. for displaying the temperature of the test unit.
▲ ▼	Cursor keys for selecting the parameter to be set, i.e. the line containing the parameter. The selected parameter is displayed in inverted form.
◄ ►	Cursor keys for scrolling through the value list belonging to the selected parameter. When the ► key is pressed, the next listed value appears; when the ◄ key is pressed, the preceding listed value appears.
µΩ ..... kΩ	Unit keys for completing the entry of a numerical value of resistance in µΩ **...kΩ**.
+ / - / F2	Sign entry.

Manual 2304/05

The manual for type 2304 you can also use for type 2305
The handling and the instruction codes via interface are the same.
The difference between 2304 and 2305 is as following:

	2304	2305
Range	200uΩ to 20kΩ	2mΩ to 20 kΩ
Resolution	up to 1nΩ	up to 0.1uΩ
Accuracy	0.01%	0.05%
Max. Current	10A	1A
Weight	28kg	24kg
Powerrequirement	260VA	60VA