

# MC143/143i

*Portable Multifunction Calibrator*

Operation manual

**Powertek**



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## Basic information

MC143/143i Portable Multifunction Calibrator is a multifunction calibrator for use mean of calibration in calibration laboratories and adjustment in manufacturing processes. It can be used for calibration and testing of measuring instrument which measure voltage, current, resistance and frequency. The calibrator sources harmonic and non-harmonic signals with accurate amplitude. It includes function of simulation of thermocouple temperature sensors for testing of process meters and as option function of RTD sensor simulation.

The calibrator covers DC and AC voltage in the range from 0  $\mu$ V to 1000 V and DC and AC current in the range from 0  $\mu$ A to 20 A (2A in MC143i version). Best accuracy is 0.006 % for DC voltage, 0.055 % for AC voltage, 0.018 % for DC current and 0.075 % for AC current. Applicable frequency range is 20 Hz to 1000 kHz. The calibrator has built-in fix decade standard resistors in range from 10  $\Omega$  to 100 M $\Omega$  with accuracy 0.01 %. In frequency mode the calibrator can generate square wave signal in range from 0.1 Hz to 2 MHz.

Simulation of temperature sensors can be used for testing and calibration of evaluation parts of thermometers, panel meters, regulators, etc. The calibrator offers basic thermocouple sensor simulation of type R, S, B, J, T, E, K, N. Compensation of cold junction of thermocouple is achieved by entering ambient temperature using the front panel keyboard or automatically using external Pt1000 sensor from MC143 accessory. The accuracy of simulated temperature sensors depends on value, type of sensor and simulated temperature point and varies from 0.1  $^{\circ}$ C to 4.3  $^{\circ}$ C. Simulation of RTD resistance temperature sensors is an extra ordered option. It offers simulation of Pt/Ni types.

The calibrator some other features which facilitate easy use like relative deviation from set value of the output, currently displayed accuracy of the output signal, calibration and testing procedures etc. The calibrator is controlled by opening menus on the display and selection from menus.

The calibrator is delivered with standard RS-232 serial line as standard (GPIB optionally in model MC143), which allows the calibrator to be controlled from a PC. The calibrator is fully compatible to Powertek calibration software package WinQbase/CALIBER.

Main difference between MC143 full version and MC143i light version is in AC/DC current range. While MC143 model can supply currents up to 20 A, model MC143i is limited to 2 A.

## **ATTENTION !**

***The calibrator generates life-threatening high voltage.***

***The calibrator can only be used in line with this Manual.***

## Preparation for operation

### Content inspection

Basic package includes the following items:

- MC143/143i Portable Multifunction Calibrator
- Power line Cord
- Spare fuse 1 pcs
- Operation manual
- Powertek Test report
- Test cable 1000V/20 A 2 pcs
- Option 143-90 Pt1000 Temperature sensor
- Option 143-60 Cable Adapter (optionally)

### Power line voltage setting

The calibrator is designed for operation from 115/230 V – 50/60 Hz power line voltage. Before the first connecting the calibrator to the mains, check the position of the mains voltage selector located at the rear panel. If the set voltage differs from your power line voltage power line selector must be switched over as described below:

- Insert flat end of a screwdriver to the slot in power line socket on the rear panel. Wind with the screwdriver slightly to pull out the holder with fuse and selector contacts.
- Place the contacts in such position, that correct power line voltage can be read in the rear window.
- Push the holder back to the power line socket. In the window correct voltage (115 or 230 V) must be seen. Use position 115V for nominal mains voltage 110 to 130 V and 230V position for range 220 to 240 V.

### Switching on

- Plug one end of the power cord into the connector located at the rear panel and connect the other end of the power cord into a wall outlet.
- Switch on the mains switch located at the rear panel. Front panel display is lit.
- The calibrator performs internal hardware checks for 5 seconds.
- After the tests conclude, the calibrator resets to its reference state, i.e. the following parameters are set:

Function	DC voltage
Range	10 V
Set value	10 V
Output terminals	OFF

*Note:* The calibrator resets to its reference status in case of power switching off and switching on.

*Note:* After switching on fan located on the rear panel works for some time depending on temperature conditions. Noise coming out of the ventilation hole can be heard.

## Warm-up time

The calibrator works after it is switched on and the initial checks complete. Specified parameters are guaranteed after the instrument warms up for 5 minutes. During this period, the instrument cannot be recalibrated. The display shows “cannot access the calibration” message if calibration is attempted during this period.

## Fuse replacement

The calibrator includes a fuse located in the mains connector at the rear panel. Replace the fuse as follows:

- Switch off the calibrator.
- Remove the end of power cord from the mains connector at the rear panel.
- Insert the blade of a flat screwdriver into the opening cut in the mains voltage selector and pull out the fuse holder.
- Remove the fuse and replace it with new fuse of the same rating.

## Safety precautions

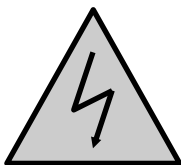
The instrument has been designed in Safety Class I according to EN 61010-1. The design reflects the requirements of A2 amendment of the standard. Safety is ensured by the design and by the use of specific component types.

The manufacturer is not responsible for a damage caused by modification of the construction or replacement of parts with non-original ones.

Used safety symbols used on the instrument



**Warning, reference to the documentation**



**Warning - risk of electric shock**



**Danger - high voltage**

## Description of controls

### Front panel

The front panel of the calibrator includes a flat LCD display, control buttons and output terminals. Control parts are shown on the picture below:

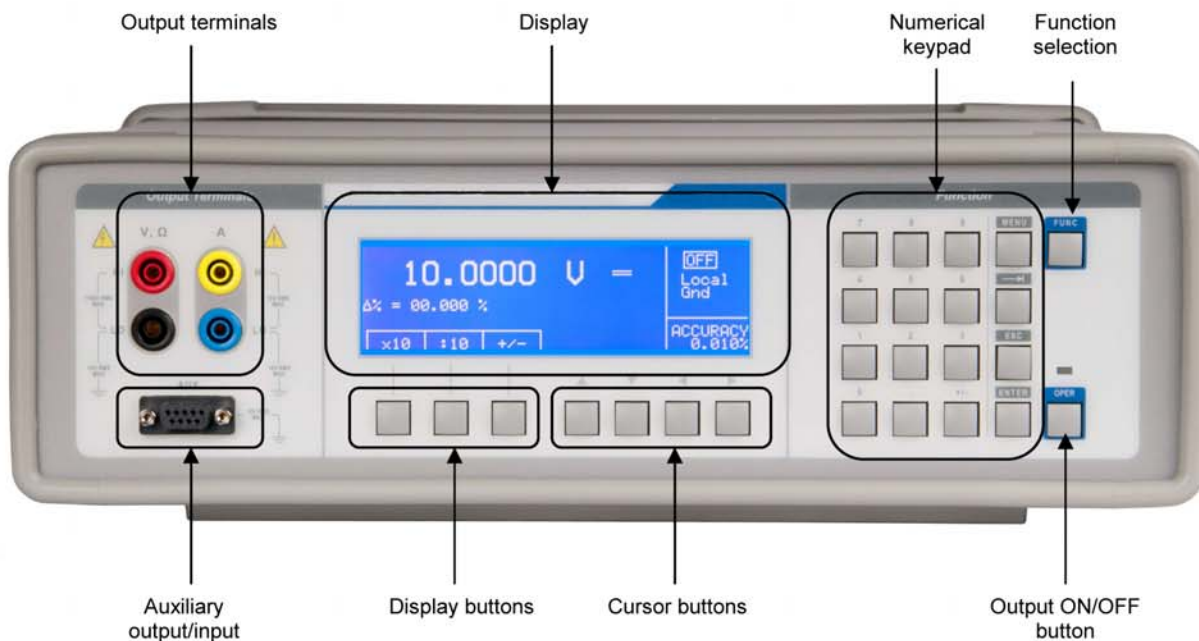


Fig. 1 MC143/143i Front panel

#### Display buttons

Three buttons located under the display has alternative meaning. Their actually valid function is labeled on the display. They are used usually to enter into MENU, changing the ranges, recording values, etc.

#### Cursor buttons

With the cursor buttons active position of the cursor and numerical value as well can be set. The keyboard contains two buttons for setting of vertical position of the cursor (<, >). The position can be step left or right. Their are mostly used for moving in MENU, jumping between two menus of different level or setting active position in numerical value. With the rest two buttons (∧, ∨) value can be incremented or decremented.

#### Numerical keypad

Numerical values can be entered from the keyboard. For confirmation of set value ENTER button is intended. With CANCEL button already set value can be cancelled.

#### Output ON/OFF button



With ON/OFF button signal can be connected to the output terminals. Switching on the output terminals is indicated with red LED diode in parallel with symbol ON or OFF displaying on the display.

**Output terminals**

Output signal is connected to the output terminals. Current ranges are connected to **A +I / -I** terminals. Voltage, resistance, TC sensor simulation and frequency functions are available at **V Hi / Lo** terminals.

**AUX Connector**

The auxiliary connector is aimed as input for Opt 143-90 external Pt1000 temperature sensor. Another function is output of RTD temperature sensor simulation using Opt 143-60.

**Function selection button**

Main button for function selection.

**Display**

**Main field**

On the line, there is with double size numbers displayed main parameter of the calibrator output signal, following with its unit. With the symbols **▼▲** there is indicated also active position of the cursor. Cursor position can be set with cursor buttons **<, >** set value with the buttons **^, v**. Symbols of active cursor are displayed after pushing any of cursor buttons.

**Time/Date field**  
Displays real time/date

**Information field**

In the field some additional information are displayed, which are related to the set function:

- Symbol of OUTPUT ON or OUTPUT OFF output terminals. In parallel LED diode is turning on/off above the button ON/OFF
- Information about local/remote control. In remote control label REM is displayed, in manual mode label LOCAL is shown.
- Information about output current simulated by current coil Opt. 140-50, if the coil is connected to the output current terminals. Access to this function is through SETUP MENU.
- Information about grounding of Lo/-I terminals.
- Information about selected TC temperature sensor in mode TC sensor simulation.

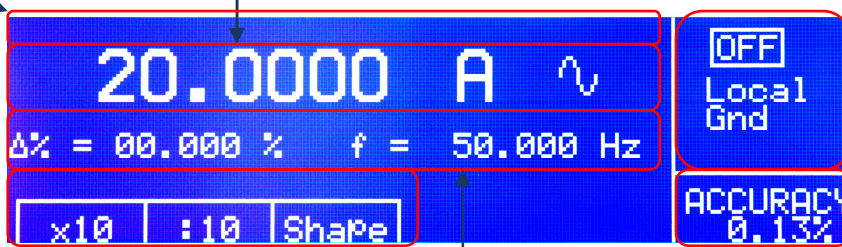


Fig. 2 MC143/143i Display

**Accuracy field**

In the field there is displayed currently valid accuracy of the main parameter of the output signal. It is calculated from full specification of the calibrator and it is displayed in %.

**Auxiliary parameter field**

In two lines auxiliary parameters of the output signal are displayed. To these parameters belong:

- Set relative deviation in %
- Frequency of AC voltage/current
- Temperature of cold junction in TC temperature sensor simulation mode, type of TC sensor

**Display button field**

In the line labels related to the display buttons are shown. Meaning is as follows:

Symbol	Button function	Note
x 10	10 x increasing the value	for functions U, I, R, F
: 10	10 x decreasing the value	For functions U, I, R, F
Shape	Waveform selection	U, I functions
+/-	Polarity of output signal	For functions DC U, DC I
Calib	Enter to the calibration mode	Available in MENU
Type	TC sensor type setting	For temperature sensor simulation

Tab 1 Display buttons

## Rear panel

On the rear panel there are located power line entry module with line socket, fuse, power line voltage selector and mains switch, RS-232 connector (GPIB connector optionally), grounding post and model plate number with serial number. The grounding post is galvanically connected to metal parts of housing and protection earth terminal in power line socket

In the left part of the panel ventilation hole with fan is located. Don't cover the hole otherwise there is risk of damage by overheating.

Between output terminals and protection earth potential following maximal voltages are allowed:

Hi - GND :	1100VRMS
+I - GND :	10VRMS
Lo - GND:	10VRMS
-I - GND :	10VRMS

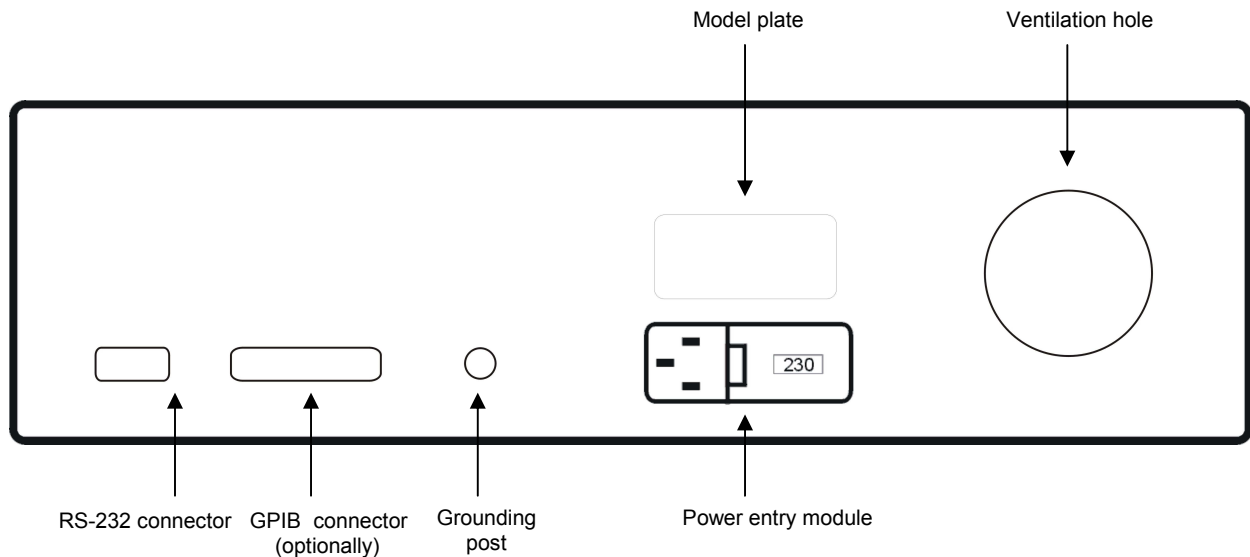


Fig. 3 MCI43/143i Rear panel

## Control of the calibrator

### Selection of function

After the power is switched on and the initial checks complete, the calibrator sets to its default mode, i.e. DC voltage function, output value of 10 V with output terminals disconnected. The mode of the calibrator can be changed using the buttons located at the front panel in one of the following ways:

- **Change of function**

By pushing the button FUNC table with available functions is displayed. Requested function can be selected using cursor buttons or directly by pushing numerical button with number of the function, with confirmation by ENTER. Following functions are available:

1. DC voltage
2. DC current
3. AC voltage
4. AC current
5. Resistance
6. Frequency
7. TC temperature sensor simulation
8. RTD temperature sensor simulation (optionally)

*Note:* when numerical button 1 to 8 is pushed instead of cursor buttons, calibrator is switched to the selected function directly.

- **Connection /disconnection of output terminals**

After pressing the ON/OFF button, the output terminals of the calibrator are connected/disconnected.

- **Entry to the setup menu**

After pressing the SETUP button SETUP MENU appears on the display and the display buttons allow the entry to the calibration mode (CALIB). Previous mode is restored by pressing the ESC display button.

### Output signal value

All function modes allow several methods of setting the main value of the output signal:

#### Entry of the value using numeric keyboard

- use the numeric keyboard to select the desired value. After the first digit is entered, symbols of unit of measurements are displayed above the display buttons. The monitor line displays the symbols [ \_ \_ \_ \_ \_ ].

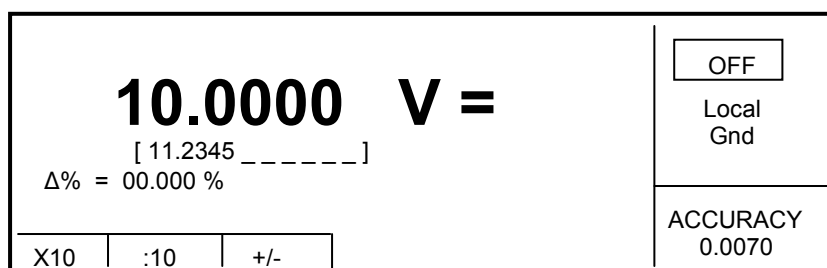


Fig. 4 10VDC Display

- after the entry is complete (the value is displayed on the monitor line), press the display button below the desired unit of measurement (V, mV or  $\mu\text{V}$  in the example below)
- the value is copied to the main display and the monitor line disappears.

### Entry of the value using cursor buttons

- press <, >, ^ or v button. The display now includes cursor marks, which point to the active digit.
- ^ and v buttons can be used to change the active digit. <, > buttons can be used to change the position of the cursor marks
- to get to the default screen, press ESC button or keep pressing the center cursor button until there is no [ \_ \_ \_ \_ \_ ] under any value.

### Reverse polarity

In DC voltage and DC current modes, the polarity of the output value can be reversed by pressing +/- display button. „ - “ symbol appears in front of the main data value.

## Relative deviation

All function modes of the calibrator except frequency mode allow a relative deviation of output value from the main data to be set using a separate display. Relative deviation is displayed in the “auxiliary field” section of the display and it is designated with „  $\Delta\% = 00.0000\%$  “ symbol. The relative deviation can be entered using one of the methods described above.

### Setting relative deviation using numeric keyboard

- keep pressing the center cursor button until [ \_ \_ \_ \_ \_ ] symbols appear under the relative deviation value in the “minor data” section of the display
- enter the desired deviation and confirm the value by pressing “ % “ display button or by pressing ENTER on the numeric keyboard
- the auxiliary line below the main data on the display displays the total value of output signal including the unit of measurement

the value of the signal at output terminals is:

the value indicated by the main display +  $\Delta\%$   
the value indicated by the main display +  $\Delta^\circ\text{C}$

for voltage, current, frequency mode .  
for TC sensor simulation

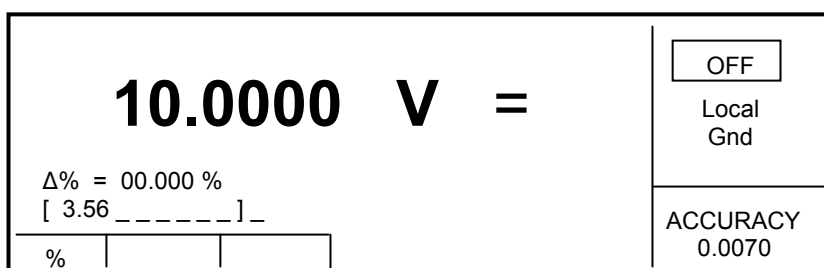


Fig. 5 Relative deviation setting

Maximum relative deviation which can be entered is  $\pm 30.000\%$ . The deviation can be positive or negative. If negative deviation is desired, press the display button labeled +/- . If positive deviation is then desired, press “ +/- “ button again. The polarity of the relative deviation can be reversed using the cursor buttons.

### **Setting relative deviation using cursor keys**

- keep pressing the button SEL until [ \_ \_ \_ \_ \_ ] symbols appear under the relative deviation value
- press <, >, ^ or v button. The display now includes cursor marks which point to the active digit
- ^ and v buttons can be used to change the active digit. <, > buttons can be used to change the position of the cursor marks
- to get to default mode press the button SEL until symbols [ \_ \_ \_ \_ \_ ] are displayed under any item. The same status can be achieved by pressing the button ESC.

If non-zero deviation is entered, also main value can be further changed. Output signal is always recalculated from both these values.

### **Change of value by factor of ten**

All functions except TC simulation of the calibrator allow the increase of the output value by 10 or reduction of the output value by 10. If the change results in overflow or underflow of calibrator's range, an error message appears:

Value too large !                      if the resulting value is too large

Value too small !                      if the resulting value is too small

### **Range change**

- Press the display button labeled “ x10 “ if you want to increase the range, “ :10 “ to decrease the range.
- The main value shown on the display is increased 10x (reduced 10x)

In resistance function appropriate fix values are connected to the output terminals.

## **Connection / disconnection of output terminals**

After switching on the output terminals are disconnected in all modes. Press the ON/OFF button to connect the output signal to the terminals. Red LED above the OUTPUT button is lit and the information field on the display shows the symbol ON .

Press the ON/OFF button again to disconnect the output terminals. Red LED goes off and the information field on the display shows the symbol OF.

During mode change, output terminals are always disconnected. Output terminals are disconnected also when changing between voltage and current ranges or when changing between AC and DC ranges is performed.

Voltage over 100 V is indicated also with acoustic interrupted signal.

## Setting the frequency

Frequency can only be selected in AC voltage mode, AC current mode and frequency mode. In each mode the frequency has a slightly different meaning and the frequency is therefore set in a different manner.

### AC voltage, AC current

Set value of frequency is shown in the Auxiliary field of the display in ACV, ACI modes.

#### Frequency change

- First select the AC voltage or AC current mode by repetitive pressing the button FUNC. Frequency value „f = xxx.xx Hz“ appears in the Auxiliary field of the display.
- Press the button SEL until [ \_ \_ \_ \_ \_ ] symbols appear under the frequency value. Numeric keyboard can be used to enter the desired value. Press “ Hz “ or “ kHz “ to confirm the value.

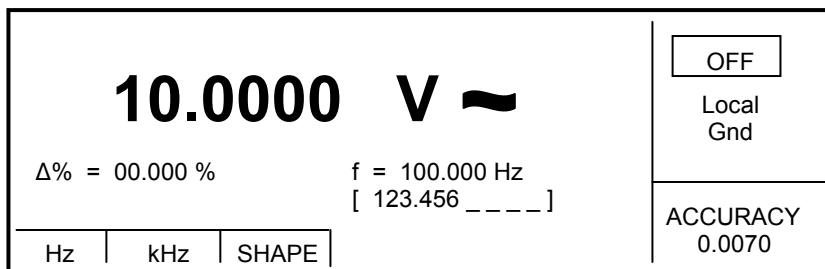


Fig. 6 Frequency change

If too large or too small value is entered, the calibrator displays the maximum (minimum) value which is allowed for the selected function.

### Frequency function

Set value of frequency is the main data on the display and the main parameter of the signal. Main data can be set by direct entry using the numeric keyboard or by changing the digit at the current cursor position. The setting procedure is described in the “Setting the value of output signal”.

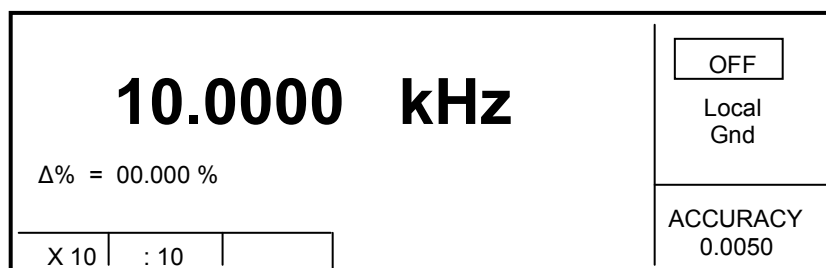


Fig. 7 Frequency function

If frequency larger or smaller than the calibrator's range is entered, the calibrator displays an error message: „Value is too large (small)“.

Output waveform in frequency mode is always squarewave with TTL amplitude 0 – 5 V.

## AC/DC voltage function

The multifunction calibrator provides calibrated DC and AC voltage. Output terminals for voltage ranges are labeled “ Hi “ and “ Lo “ at the front panel. Depending on the setting of the calibrator, voltage up to 1000 V<sub>rms</sub> can be present at the terminals. Real voltage ranges are as follows:

DC voltage range	from 0 to 1000 V.
AC voltage range	from 1 mV to 1000 V

### Control in the voltage mode

- Press FUNC button on the calibrator until DC or AC voltage mode will appears. The display shows the following data:
  - main data of set voltage
  - relative deviation
  - accuracy of output voltage
  - frequency (when AC voltage is generated)
- Set the desired value of voltage, including polarity when necessary, frequency and relative deviation. The signal is yet not connected to the output terminals. The information section of the display shows the symbol OFF which informs about the disconnection of output terminals.
- Press ON/OFF button.
- Red LED is lit above the OUTPUT terminals to signal the connection of the signal to the output terminals; the information section of the display shows the symbol ON.
- Calibrated voltage corresponding to set parameters is present at the output terminals.

### Output voltage over 100 V

When output voltage over 100 V is selected, the information section of the display shows the symbol which informs that a life-threatening voltage will be present at the output terminals. If the output terminals are currently connected, they will be disconnected when output voltage over 100 V is selected. ON/OFF button must be pressed to reconnect the output signal to the output terminals. After the ON/OFF button is pressed, an interrupted beep is sound, OUTPUT LED is lit and the information section of the display shows the symbol notifying the user about the connection of the dangerous output signal to the output terminals.

Voltage, polarity, frequency, absolute and relative deviation can be set without the outputs being disconnected. The output terminals are automatically disconnected when changing between AC and DC ranges or when changing the function mode.

## Output terminals overloading

If the output terminals are overloaded or short-circuited in the voltage mode, the calibrator disconnects the signal from the output terminals and reports „Overload U output“ error.



### ATTENTION DANGEROUS VOLTAGE

*When working with voltages over 50 V, rules for work with dangerous voltage must be adhered to.*

***Never touch the measurement circuit when voltage over 50 V is set and output terminals are connected!***



### ATTENTION DANGEROUS VOLTAGE

*It is not possible to disconnect the output voltage using the buttons located at the front panel when the calibrator is in remote mode !*

***The calibrator must be first switched to local control mode by pressing the LOCAL button and then the output terminals can be disconnected !***

## AC/DC current

The multifunction calibrator provides calibrated DC and AC current. Output terminals for voltage ranges are labeled “ +I “ and “ -I “ at the front panel. The terminals can carry high current and are the only terminals to which the calibrated object can be connected. Depending on the setting of the calibrator, current up to 20 A<sub>ef</sub> can be driven by the terminals.

DC current range	from 0 to 20 A in MC143	from 0 to 2 A in model MC143i
AC current range	from 1μA to 20 A in MC143	from 1μA to 2 A in model MC143i

When Current coil 50/25 (option 140-50) is used, maximal simulated AC current is 1000 A (100 A in MC143i).



## Control in the current mode

- Press the button FUNC until AC or DC current mode will appear. The display shows the following data:
  - main data of set current
  - relative deviation
  - accuracy of output current
  - frequency (when AC current is generated)
- Set the desired value of current, including polarity when necessary, frequency and relative deviation. The signal is yet not connected to the output terminals. The information section of the display shows the symbol OFF which informs about the disconnection of output terminals.
- Connect the load or short the output terminals labeled +I, -I.
- Press OUTPUT button.
- Red LED is lit above the OUTPUT terminals to signal the connection of the signal to the output terminals; the information section of the display shows the symbol ON.
- Calibrated current corresponding to set parameters is driven by the output terminals.
- If COILx50 function is activated (see below - Setup functions menu), the optional 50-turn coil must be connected to output terminals. The calibrator can be used to calibrate clamp ammeters to 100 A ammeters.

*Note: MÔ143/143i current power stage is cooled by fan with variable speed. Variable noise can be heard when set to AC/DC current function, especially at range 20A.*

*Note: MÔ143 can supply external load for limited period in range 10A to 20A. Default period is 5 minutes at 20 A and 15 minute at 10 A. It can vary depending on previous load conditions. Full recovery to starting condition takes about 5 minutes.*

## Overloading the terminals

When external circuit connected to current output terminals is disconnected or there is higher voltage at the load than permitted, the calibrator disconnects the output terminals and displays „Overload I output“ message. The same message can be displayed when 50-turn coil is used for AC current output at frequencies above 80 Hz. It depends on the set current and the type of ammeter connected.

## Non-harmonic mode

The multifunction calibrator can generate non-harmonic periodic signals with predefined shape. To allow the setting of a non-harmonic output shape, the calibrator must be switched to ACV or ACI mode. In both cases, an indication of the type of output shape is displayed beside the main set value. Press the display button SHAPE to change the shape of the output signal.

The calibrator can generate the following shapes:

- SINE sinus (harmonic)
- PWM SYM squarewave - symmetrical, with adjustable duty cycle
- RAMP A ramp, symmetrical positive
- RAMP B ramp, symmetrical negative
- TRIANGLE triangular, symmetrical
- LIM SINE sinus with amplitude limitation (truncated sin) with defined distortion k=13.45%

Generation of non-harmonic signals has some limitations:

- non-harmonic signals can be generated in frequency range 20 Hz to 80 Hz
- maximal non-harmonic current is 2A, maximal voltage is 10V

### Control in the non-harmonic mode

- Select AC voltage or AC current mode. The main section of the display shows the following data:

main data of set current or voltage, unit of measurement  
relative deviation  
frequency  
selected SHAPE of the output signal

- Keep pressed SHAPE display button to select the desired shape of the output signal:

The output terminals are automatically disconnected when the shape of the output signal is changed. Relative deviation is reset.

### Information on display

When non-harmonic output shape is selected, the display shows additional information:

- Besides the main amplitude data, „pk“ index is displayed, notifying that the displayed main value is the peak value.
- Symbol which displays the shape of the output signal is displayed.

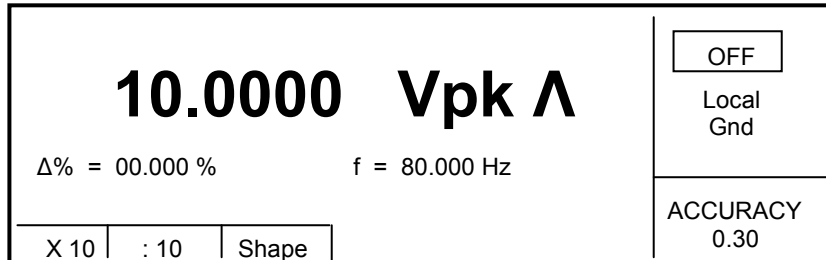


Fig.8 Non-harmonic mode display

## Resistance

Multifunction calibrator is equipped with fix resistance positions values with decade nominal values. The positions are created with stable resistors. Their value cannot be adjusted. The resistance feature is available on Hi – Lo terminals in two-terminal connection.

Resistance range is 10 $\Omega$ , 100 $\Omega$ , 1k $\Omega$ , 10k $\Omega$ , 100k $\Omega$ , 1M $\Omega$ , 10M $\Omega$ , 100M $\Omega$ .

### Control in the resistance mode

- Press FUNC button until resistance function will appear. The display shows the set resistance.

calibration value of set resistance in  $\Omega$   
accuracy of the resistance

- To change the resistance value press the display button x10 or :10.
- Press the button ON/OFF to connect the resistance to the output terminals.
- Red LED is lit above the ON/OFF button and indicates that the resistance is connected to the output terminals.

Resistance mode is suitable for use in DC applications and AC applications to 10 kHz.



Fig.9 Resistance display

## Frequency mode

Multifunction calibrator can generate squarewave TTL leveled signal with 4 digit resolution frequency. The signal is available in frequency mode on output terminals Hi – Lo. Frequency range is from 0.1 Hz to 2 MHz.

### Control in the frequency mode

- Press FUNC button until frequency mode is selected.. The display shows following data:
  - set frequency as main parameter
  - relative deviation of frequency
  - accuracy of frequency
- Set the frequency using numeric keyboard or cursor buttons. Output signal is not yet connected to the output terminals.
- Connect the object to be calibrated to FREQ terminal.
- Press ON/OFF button. Red LED is lit above the OUTPUT terminals to indicate the connection of signal to the output connector.



Fig.10 Frequency mode display

Note: Output impedance in frequency mode is 50  $\Omega$  on Hi – Lo terminals.

## Simulation of RTD temperature sensors (Option RTD)

Multifunction calibrator can optionally simulate resistance temperature sensors.

When resistance temperature sensors are simulated appropriate resistance with value corresponding to set temperature is connected to the output terminals on the front panel connector RTD. Connection is four-terminal type. Use connector attached to the delivery to connect unit under test to RTD connector.

Temperature setting range: -250 to +850  $^{\circ}\text{C}$  for Pt temperature sensors

-60 to +300  $^{\circ}\text{C}$  for Ni temperature sensors

Temperature scale: ITS 90, PTS 68

Front panel RTD connector connection: D-SUB 09

### Temperature setting

- Press FUNC button on the calibrator until RTD sensor simulation function will appear. The display shows following data:

main data of temperature in  $^{\circ}\text{C}$  or K  
 sensor type thermocouples: Pt or Ni  
 set value of absolute deviation in %, labeled  $\Delta T = \text{xxxx.x } ^{\circ}\text{C (K)}$

the auxiliary section shows:

temperature scale type  
 accuracy of simulated temperature value of selected temperature sensor type

- Set the main value of temperature using numeric keyboard or cursor buttons. The information section of the display shows the symbol OFF which means that output terminals are disconnected.
- Connect the object to be calibrated to RTD connector.
- Press ON/OFF button. Red LED is lit above the OUTPUT terminal to indicate that the output signal is connected to the output terminals. The display shows ON symbol of connected output terminals.

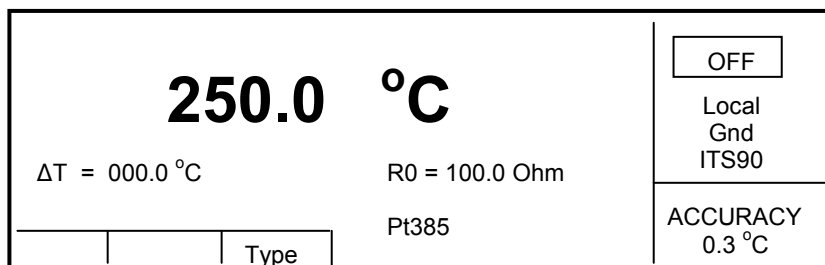


Fig.11 RTD simulation display

Note: Maximal power dissipation in the simulator is 0.2 W.

## Switching between temperature sensor types

- Press Display button Type.
- Each press of the button selects Pt1.385, Pt1.392 or Ni resistance thermometer. The display shows current setting as Pt385 / Pt392 / Ni.

## R0 coefficient for resistance temperature sensors setting

For resistance temperature sensors, resistance at 0 °C labeled R0 can be set. The range is 100 Ω to 1 kΩ for all types of resistance temperature sensors.

- Select the resistance temperature sensor mode and keep pressing the TAB cursor button in numerical keyboard until [ \_ \_ \_ \_ \_ ] symbols appear under the R0 coefficient value (R0 = xxxx Ω).
- Set the value using numeric keyboard and confirm by pressing “Ω” display button or by pressing ENTER.

*Note: For temperature scale selection ITS90 / PTS68 use SETUP menu.*

## Simulation of TC temperature sensors

When thermocouples are simulated, the simulated voltage corresponding to set temperature, sensor type and temperature of cold end of thermocouple is connected to Hi - Lo terminals.

Temperature setting range:	-250 to +1820 °C depending on simulated sensor type
Sensor types:	K, N, R, S, B, J, T, E
Temperature scale:	ITS 90, PTS 68

## Setting the temperature

- Press FUNC button on the calibrator until TC sensor simulation will appear. The display shows following data:

main data of temperature in °C or K  
 sensor type thermocouples: K, N, R, S, B, J, T, E  
 cold junction temperature of thermocouple sensors RJ  
 set value of absolute deviation in %, labeled ΔT = xxxx.x °C (K)

the auxiliary section shows:

temperature scale type  
 accuracy of simulated temperature value of selected temperature sensor type

- Set the main value of temperature using numeric keyboard or cursor buttons. Output terminals are disconnected. The information section of the display shows the symbol OFF which means that output terminals are disconnected.
- Connect the object to be calibrated to Hi - Lo terminals.

- Press ON/OFF button. Red LED is lit above the OUTPUT terminal to indicate that the output signal is connected to the output terminals. The display shows ON symbol of connected output terminals.

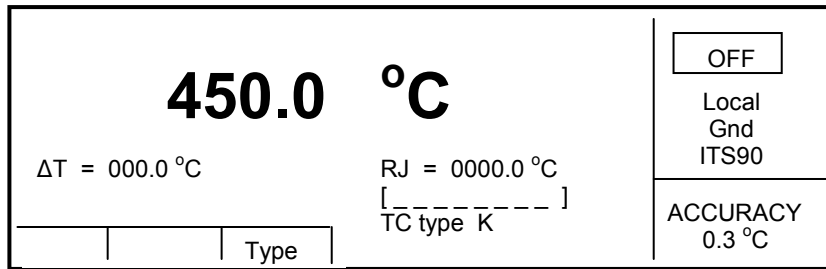


Fig.12 TC sensor simulation

### Switching between temperature sensor types

- Press the button TYPE.
- Calibrator switches among thermocouples in order K, N, R, S, B, J, T, E. Currently set type of thermocouples is displayed in form TC TYPE x, where x means type of thermocouple.

### Cold junction temperature compensation RJ

Temperature of cold junction can be compensated either manually or automatically. If manual mode is selected, temperature of cold junction is entered from front panel keyboard. If automatic compensation is selected, calibrator measure via internal Pt temperature meter ambient temperature, displays the measured value and compensate output voltage related to the set temperature with measured temperature of the terminals. Switching between automatic and manual mode is one item in setup MENU.

#### Manual compensation

- Open SETUP menu by pushing the button MENU. With cursor buttons  $\downarrow$ ,  $\uparrow$  select position RJ Temp. and with display buttons select parameter FIXED.
- By repeated pushing the button FUNC select TC simulation function.
- Push the button SEL until symbol [-----] appears under the RJ value. RJ value has form RJ = xxxx.x °C.
- Write requested temperature of cold junction using numerical keyboard. Confirm the value by pushing the button °C (K).

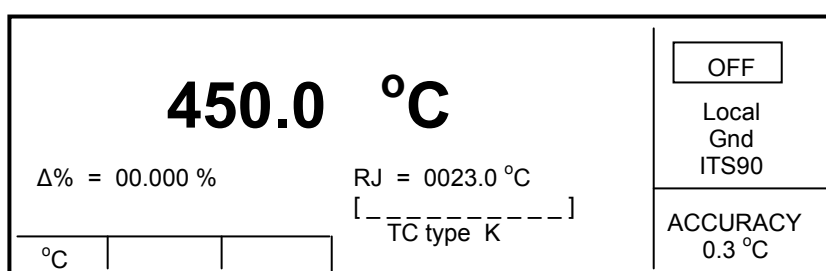


Fig.13 Manual RJ compensation display

### Automatic compensation

- Connect Option 143-90 External temperature sensor to the AUX connector.
- Push the button MENU. With cursor buttons  $\downarrow$ ,  $\uparrow$  select function RJ Temp. and with display buttons select parameter MEAS.
- By repeated pushing the button FUNC select TC simulation function.
- Temperature of the output terminals is displayed in the field RJ. Output voltage is compensated with measured value.

*Note:* As sensor for measuring of ambient temperature external Pt1000 sensor is used. This sensor is part of standard delivery.

*Note:* For temperature scale selection ITS90 / PTS68 use SETUP menu.

*Note:* Burden current in TC sensor simulation mode is 2 mA.

## Setup menu

Multifunction calibrator allows other, less frequently used parameters to be set. Setup menu is used to set these parameters. Setup menu is opened by pressing MENU display button. If output terminals are connected, they are disconnected and the following display appears:

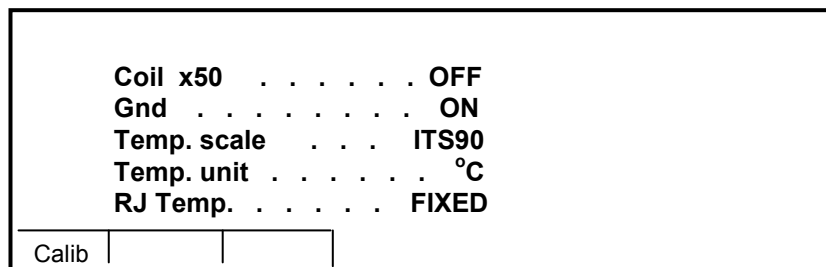


Fig.14 Setup menu display

Use  $\uparrow$  or  $\downarrow$  cursor button to browse the menu options. Active option is always inverted and when changed, the descriptions of display buttons change as well. Display buttons show how the parameter can be set. Press ESC button twice to save the parameters when new setting is completed. New setting is saved and refreshed when the calibrator is switched off and switched on. Setup menu offers following options:

#### 1. **Coil x50 .... xx ON/OFF**

This parameter can be set on when 50-turn current coil is going to be used for clamp ammeter calibration. The coil multiplies the output current. OFF is set as default.

#### 2. **GND .... xx ON/OFF**

This parameter connects Lo terminal the ground terminal (housing). In practice this means that Lo terminal is grounded. By pressing the display buttons, the terminal can be grounded or ungrounded. ON is set as default.

It is recommended to set the parameter to ON. If the calibrated UUT has Lo terminal grounded, it is better to unground the outputs of the calibrator, GND OFF to exclude ground loops.

*Note: If neither the calibrator's output nor the meter's inputs are grounded, signal/noise ratio can arise at the calibrator's output.*

### 3. **Temp.scale .... xx ITS90/PTS68**

This parameter allows the temperature scale for temperature sensors to be selected. Pressing the display buttons allows to switch between ITS90 and PTS68 temperature scales. ITS90 is set by the manufacturer.

### 4. **Temp.unit .... xx °C/K**

This parameter allows the temperature unit for simulation of temperature sensors to be selected. Pressing the display buttons allows to switch between °C and K. °C is set by the manufacturer.

### 5. **RJTemp. .... xx FIXED/MEAS.**

Setting of method of cold junction temperature of TC sensors compensation. By pushing the display button FIXED or MEAS item can be chosen. In FIX mode cold junction temperature must be entered manually from the keyboard. In MEAS mode temperature of output terminals is measured by internal thermometer. Output voltage related to the set temperature is corrected by the measured value.

### 6. **Interface .... xx GPIB/RS232**

Displays the type of interface used to control the calibrator from a PC. By pressing GPIB or RS232 buttons, the respective type can be selected. The calibrator can be remotely controlled only using the selected interface. GPIB interface is delivered as option only.

*Note: GPIB can work only if option GPIB is installed in the calibrator. If not, use RS232 interface.*

### 7. **GPIB address .... xx UP/DOWN**

Displays the calibrator's address at the GPIB bus. UP, DOWN display buttons can be used to select any valid GBIP address in the range of 00 to 30. The address 02 is set by the manufacturer. GPIB interface is delivered as option only.

### 8. **RS232 baud rate .... xx UP/DOWN**

Indicates the communication speed of RS232 bus. UP/DOWN display buttons can be used to select 150, 300, 600, 1200, 2400, 4800, 9600, 19200. Perfect communication with the PC requires equal values set at the PC and the calibrator.

### 9. **Handshake .... xx OFF/Xon-Xoff**

Indicates the communication handshake. Display buttons can be used to select OFF or Xon/Xoff. Perfect communication with the PC requires equal values set at the PC and the calibrator.

### 10. **Keyb.beep .... xx ON/OFF**

This parameter allows the acoustic indication of pressed buttons to be switched off or on. ON and OFF display buttons can be used to switch the indication off or on. ON is set by the manufacturer.

This parameter does not control the acoustic indication of output voltages over 100 V and identification of errors.

### 11. **Beep.volume .... xx HIGH/LOW**

This parameter allows the volume of acoustic indication to be set in two loudness. This parameter controls the volume of keyboard beep (if switched on), indication of output voltages over 100 V and identification of errors when controlling the calibrator.

### 12. **Display .... xx UP/DOWN**



This parameter sets the underlighting of the display. Positions always OFF, OFF 30s after last pushing a button, OFF 300s after the last pushing a button, permanently ON is offered.

13. **Contrast .... xx UP/DOWN**

Setting the contrast of the display. BY pushing the display button higher or low contrast can be set in range 00 to 31.

14. **Cal.code .... 000000**

Access to the calibration code. Calibration code is a five-digit number, which must be entered to access the calibration mode. If the calibration code is set to "000000", this information is displayed in the Setup menu. Calibration code can be changed. New calibration code can be directly entered using numeric keyboard and confirmed by pressing ENTER. If non-zero calibration code is set, correct calibration code must be entered to access the calibration mode. Non-zero calibration code is not displayed further on the display.

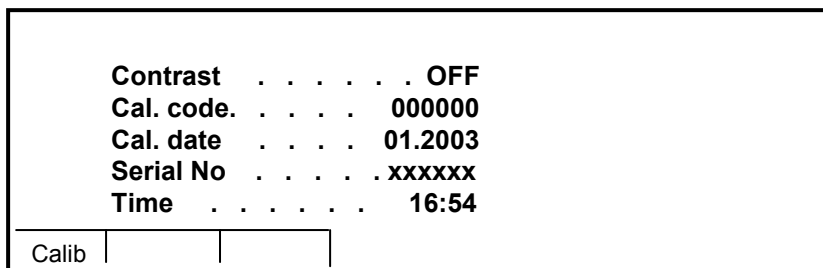


Fig.15 Calibration password change

The purpose of the calibration code is to prevent unauthorized users from changing the calibration of the instrument.

*Note: It is advisable to write down actual calibration code if changed. If you forget the calibration code, you have to send the calibrator to the manufacturer.*

15. **Cal.date .... xx.yyyy**

Displays the date of last calibration of the calibrator (month/year). The parameter cannot be changed, as it is automatically recorded when leaving the calibration mode.

16. **Serial No .... xxxxxx**

Displays the serial number of the calibrator. The parameter cannot be changed.

17. **Time .... xx:yy**

Displays real time. The parameter can be changed using HOUR, MIN +, MIN - display buttons.

18. **Date .... xx.yy.zzzz**

Displays real time. The parameter can be changed using DAY, MONTH, YEAR display buttons.

19. **Time on display .... xx ON/OFF**

If the item is set to ON, time and date are displayed in the upper part of the display. If OFF is set, time and date are not displayed. ON is set by the manufacturer.

## Calibration mode

The multifunction calibrator is equipped with calibration procedure, which allows re-calibration of the calibrator. Zero point and slope of the characteristics of individual generation and measurement ranges are set during the calibration in predefined order. The calibration can only be controlled using the front panel buttons and menu on the calibrator.

### Calibration principles

The calibrator can be calibrated:

- completely, i.e. all functions are calibrated in all recommended points
- partially, i.e. only selected functions are calibrated in all recommended points
- partially, i.e. only selected functions are calibrated in selected points

Complete calibration consists of all partial calibrations performed in the order defined by the calibration menu. If an item of the calibration menu, e.g. "VOLTAGE DC" is selected, it is not necessary to calibrate all ranges defined by the calibration algorithm. If new calibration of all ranges is not possible (e.g. the required standard is not available), old calibration data can be confirmed, i.e. current step of the calibration can be skipped.

Full calibration consists of following steps:

**DC voltage** calibration is performed by setting the zero and slope of the scale in all ranges and in both signal polarities (+ and -) (except the 1000 V range, where zero correction is not necessary).

**AC voltage** calibration is performed by setting the zero and slope of the scale in all ranges at 100 Hz.

**DC current** calibration is performed by setting the zero and slope of the scale in all ranges and in both signal polarities (+ and -).

**AC current** calibration is performed by setting the zero and slope of the scale in all ranges at 100 Hz.

**Resistance** calibration is based on writing and saving new calibration values of the fixed resistors.

**RTD temperature sensor simulation** calibration. The procedure is based on measuring and saving into calibration memory of partial resistors in range from 20  $\Omega$  to 120 M $\Omega$ .

**Frequency function** does not require any adjustment. Also **TC temperature sensor simulation** function need no other adjustment as it is calculated from DC voltage ranges 10 and 100 mV.

*Note: TC sensor simulation does not need recalibration. It is derived from DC voltage scale using mathematic formulas.*

*Note: Calibration process can be interrupted in any point of the calibration procedure. Accuracy of the calibrator is guaranteed when full calibration has been performed.*

### Access to the calibration procedure

Calibration code is required to access the calibration procedure.

- Press MENU button to open the setup menu.
- Press CALIB display button.
- If an attempt is made to access the calibration procedure within 60 minutes after the calibrator was switched on, the calibrator refuses to open the calibration menu and displays following message:

Err 21 Time warm up !

If the calibrator is already switched on for at least 60 minutes, it requests calibration code.

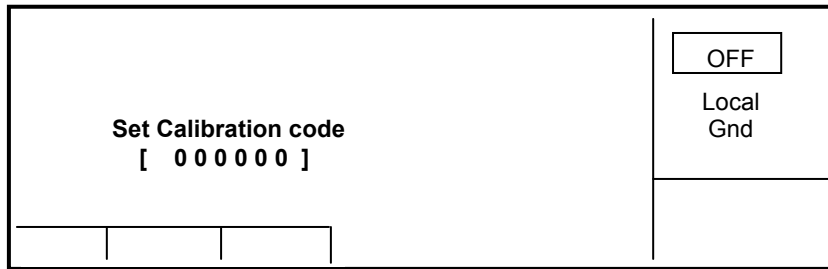


Fig.16 Calibration password entering

- Enter correct calibration code using numeric keyboard and press ENTER.
- If incorrect calibration code is entered, an error message appears on the display for approximately 3 seconds:

Err 20 Bad calib. code!

- If correct calibration code is entered, calibration menu will appear:

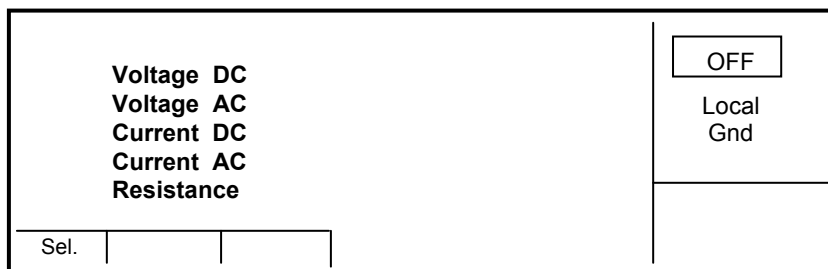


Fig.17 Calibration menu

- Use  $\wedge$  and  $\vee$  cursor buttons to move the cursor through the list:

- |    |            |                                   |
|----|------------|-----------------------------------|
| 1. | VOLTAGE DC | All DC voltage ranges calibration |
| 2. | VOLTAGE AC | All AC voltage ranges calibration |
| 3. | CURRENT DC | All DC current ranges calibration |
| 4. | CURRENT AC | All AC current ranges calibration |
| 5. | RESISTANCE | Resistance calibration            |

## Selection of calibration type

After the calibration menu is displayed, any of partial calibrations can be selected. Use  $\wedge$  and  $\vee$  cursor buttons to move the cursor through the list. Having selected the required function to be calibrated, press SEL display button. Following data are shown (the example bellow is valid for VOLTAGE DC range):

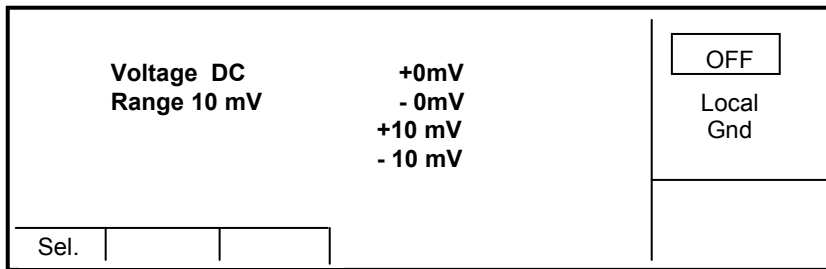


Fig.18 10 mVDC calibration points

The table lists calibration points. Having selected the required calibration point using SEL display button following data are shown.

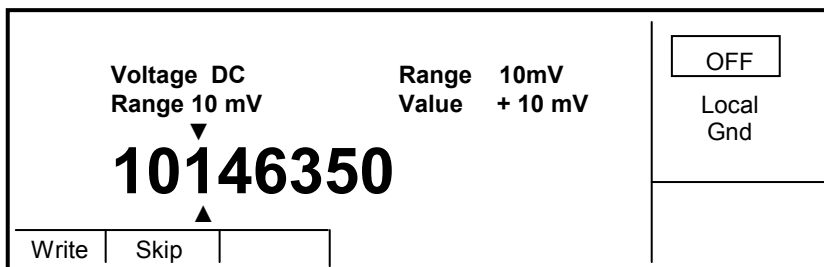


Fig.19 New calibration value entering

Display buttons have following meaning:

- |       |  |
|-------|--|
| WRITE | new calibration value is entered into the memory, old value is irreversibly lost |
| SKIP  | current calibration step is skipped, old value is retained in the memory         |

Moreover, the display shows the range which is being calibrated (RANGE), and the value to be set at the external standard multimeter (VALUE).

### **Next calibration point selection**

Use  $\wedge$ ,  $\vee$ ,  $<$ ,  $>$  cursor buttons to set such main value on the display, when the output signal measured by external standard multimeter reaches the required calibration point. When the standard output value is reached, press "WRITE" to write new calibration value to the calibration memory. If you press "SKIP" button, the calibrator ignores the new value and old value is retained. After pressing the button "WRITE" (or "SKIP"), calibrator moves on to the next calibration point.

The procedure is repeated for all calibration points of the selected function. If the button ESC is pressed before completing the calibration, the calibrator returns to the basic calibration menu.

### **Termination of calibration**

The calibration can be closed in following cases:

- complete calibration has been performed, new calibration data have been saved, the program is returned to the calibration menu,

- calibration of selected function and selected ranges has been performed, new calibration data have been saved, the program is returned to the calibration menu,
- the calibration has been started but no calibration data have been entered, the program is returned to the calibration menu after ESC display button has been pressed.

Press ESC display button to terminate the calibration. The calibrator returns to the state it was in before the calibration has been started.

## Calibration points

Each function contains fixed calibration points which have to be set during the calibration. For VOLTAGE DC, VOLTAGE AC, CURRENT DC, CURRENT AC the output signal value is set using the keyboard. For RESISTANCE function calibration data of the fixed resistances must be entered. T function does not require any calibration, as the output voltage or resistance is based on arithmetic interpolation using standard tables of temperature sensor values.

### VOLTAGE DC

Nominal value	Tolerance	Range	Note
+0.0 mV	2 $\mu$ V	10 mV	zero calibration
- 0.0 mV	2 $\mu$ V	-10 mV	zero calibration
+10 mV	4 $\mu$ V	10 mV	slope calibration
- 10 mV	4 $\mu$ V	-10 mV	slope calibration
+ 0.0 mV	2 $\mu$ V	100 mV	zero calibration
- 0.0 mV	2 $\mu$ V	-100 mV	zero calibration
+100 mV	6 $\mu$ V	100 mV	slope calibration
- 100 mV	6 $\mu$ V	-100 mV	slope calibration
+ 0.0 V	5 $\mu$ V	1 V	zero calibration
- 0.0 V	5 $\mu$ V	-1 V	zero calibration
+1.0 V	12 $\mu$ V	1 V	slope calibration
-1.0 V	12 $\mu$ V	-1 V	slope calibration
+ 0.0 V	20 $\mu$ V	10 V	zero calibration
- 0.0 V	20 $\mu$ V	-10 V	zero calibration
+10 V	100 $\mu$ V	10 V	slope calibration
- 10 V	100 $\mu$ V	-10 V	slope calibration
+10 V	200 $\mu$ V	100 V	slope calibration
- 10 V	200 $\mu$ V	-100 V	slope calibration
+100 V	600 $\mu$ V	100 V	slope calibration
- 100 V	600 $\mu$ V	-100 V	slope calibration
+750 V	20 mV	1000 V	slope calibration
- 750 V	20 mV	-1000 V	slope calibration

Table II DC voltage calibration points

**VOLTAGE AC**

Nominal value	Tolerance	Range	Frequency
1 mV	5 $\mu$ V	10 mV	100 Hz
10 mV	10 $\mu$ V	10 mV	100 Hz
10 mV	15 $\mu$ V	100 mV	100 Hz
100 mV	40 $\mu$ V	100 mV	100 Hz
100 mV	30 $\mu$ V	1 V	100 Hz
1.0 V	100 $\mu$ V	1 V	100 Hz
1.0 V	200 $\mu$ V	10 V	100 Hz
10 V	1 mV	10 V	100 Hz
10 V	5 mV	100 V	100 Hz
100 V	10 mV	100 V	100 Hz
100 V	50 mV	1000 V	100 Hz
750 V	50 mV	1000 V	100 Hz

Table III AC voltage calibration points

ACV function calibration is possible also on another set frequency. Specification in whole frequency range is guaranteed only when recommended frequency is used.

**CURRENT DC**

Nominal value	Tolerance	Range	Note
+0.0 $\mu$ A	3 nA	200 $\mu$ A	zero calibration
- 0.0 $\mu$ A	3 nA	-200 $\mu$ A	zero calibration
+190 $\mu$ A	5 nA	200 $\mu$ A	slope calibration
- 190 $\mu$ A	5 nA	-200 $\mu$ A	slope calibration
+200 $\mu$ A	20 nA	2 mA	zero calibration
- 200 $\mu$ A	20 nA	-2 mA	zero calibration
+1.9 mA	50 nA	2 mA	slope calibration
- 1.9 mA	50 nA	-2 mA	slope calibration
+2 mA	100 nA	20 mA	zero calibration
- 2 mA	100 nA	-20 mA	zero calibration
+19 mA	200 nA	20 mA	slope calibration
- 19mA	200 nA	-20 mA	slope calibration
+20 mA	1 $\mu$ A	200 mA	zero calibration
- 20 mA	1 $\mu$ A	-200 mA	zero calibration
+190 mA	2 $\mu$ A	200 mA	slope calibration
- 190 mA	2 $\mu$ A	-200 mA	slope calibration
+200 mA	20 $\mu$ A	2 A	zero calibration
- 200 mA	20 $\mu$ A	-2 A	zero calibration
+1.9 A	50 $\mu$ A	2 A	slope calibration
- 1.9 A	50 $\mu$ A	-2 A	slope calibration
+2.0 A	1 mA	20 A	zero calibration
-2.0 A *	1 mA	-20 A	zero calibration
+10.0 A *	2 mA	20 A	slope calibration
-10.0 A *	2 mA	-20 A	slope calibration

Table IV DC current calibration points

\* model MC143 only

**CURRENT AC**

Nominal value	Tolerance	Range	Frequency
10 $\mu$ A	5 nA	200 $\mu$ A	100 Hz
190 $\mu$ A	50 nA	200 $\mu$ A	100 Hz
200 $\mu$ A	40 nA	2 mA	100 Hz
1.9 mA	200 nA	2 mA	100 Hz
2.0 mA	200 nA	20 mA	100 Hz
19 mA	2 $\mu$ A	20 mA	100 Hz
20 mA	2 $\mu$ A	200 mA	100 Hz
190 mA	20 $\mu$ A	200 mA	100 Hz
200 mA	20 $\mu$ A	2 A	100 Hz
1.9 A	200 $\mu$ A	2 A	100 Hz
2.0 A	1 mA	20 A	100 Hz
10 A	3 mA	20 A	100 Hz

Table V AC current calibration points

To calibrate AC Voltage and AC current function is possible also at another set frequency. Specification in whole frequency range is guaranteed only when recommended frequency is used.

**RESISTANCE**

Nominal value [ $\Omega$ ]	Tolerance [ $\Omega$ ]
10 $\Omega$	0.010 $\Omega$
100 $\Omega$	0.010 $\Omega$
1 k $\Omega$	0.05 $\Omega$
10 k $\Omega$	0.2 $\Omega$
100 k $\Omega$	2 $\Omega$
1 M $\Omega$	50 $\Omega$
10 M $\Omega$	1 k $\Omega$
100 M $\Omega$	50 k $\Omega$

Table VI Resistance calibration points

Standard multimeter should be connected in four terminals way to the output terminals V,  $\Omega$  Hi-Lo.

**RTD TEMPERATURE SENSOR SIMULATION**

Nominal calibration point	Nominal resistance value	Tolerance of calibration value [%]	Type of measurement
SHORT	0-0.2 $\Omega$	10 m $\Omega$	4W
20 $\Omega$	20 $\Omega$	0.05	4W
40 $\Omega$	40 $\Omega$	0.02	4W
80 $\Omega$	75 $\Omega$	0.01	4W
150 $\Omega$	150 $\Omega$	0.01	4W
300 $\Omega$	300 $\Omega$	0.01	4W
600 $\Omega$	590 $\Omega$	0.01	4W
1k1 $\Omega$	1.15 k $\Omega$	0.01	4W
2k2 $\Omega$	2.19 k $\Omega$	0.01	4W
4k4 $\Omega$	4.37 k $\Omega$	0.01	4W
8k8 $\Omega$	8.6 k $\Omega$	0.01	4W
16 k $\Omega$	16.7 k $\Omega$	0.01	2W
33 k $\Omega$	33 k $\Omega$	0.02	2W
66 k $\Omega$	65 k $\Omega$	0.02	2W
125 k $\Omega$	129 k $\Omega$	0.05	2W
250 k $\Omega$	253 k $\Omega$	0.05	2W
500 k $\Omega$	503 k $\Omega$	0.1	2W
1 M $\Omega$	1 M $\Omega$	0.2	2W
2 M $\Omega$	2 M $\Omega$	0.2	2W
4 M $\Omega$	4 M $\Omega$	0.5	2W
8 M $\Omega$	7.8 M $\Omega$	0.5	2W
16 M $\Omega$	15.6 M $\Omega$	1	2W
30 M $\Omega$	30 M $\Omega$	2	2W
60 M $\Omega$	59.7 M $\Omega$	5	2W
120 M $\Omega$	118 M $\Omega$	5	2W

Table VII RTD simulator calibration points

In column Tolerance requested accuracy of measurement of the resistance segment is shown. Standard multimeter has to be connected in four terminal connection (4W) to the output terminals Hi-Lo for values below 10 k $\Omega$  and in two terminal connection (2W) for values above 10 k $\Omega$ .



## Full calibration procedure

Following pages describe procedure of the full calibration.

### Required instruments:

Following instruments are required for calibration:

- 8 1/2 digit multimeter type HP3458A or Fluke 8508A or other type with accuracy 0.002 % or better on DC voltage
- Resistance shunt 10 mΩ and 100 mΩ Burster 1240/1280, or other type with accuracy 0.01%
- Counter HP 53181A, HO 53130 or other with accuracy 0,001 %

HP8903A Distortion analyzer and scope with bandwidth min. 20 MHz are recommended for THD measuring of AC signals.

### Calibration procedure

1. Switch calibrator and standard multimeter on for at least three hours in laboratory at  $23\pm 1$  °C.
2. Press MENU display button to call up the setup menu and then CALIB display button to call up the calibration menu.
3. Enter the calibration code and press ENTER (default calibration code is "000000").
4. **DC voltage ranges calibration**
  - a) Connect the voltage input terminals of the multimeter to the Hi - Lo calibrator output terminals.
  - b) Select VOLTAGE DC from the calibration menu and confirm by pressing SEL button.
  - c) Switch MC143/143i output terminals ON.
  - d) Follow the instructions provided on the calibrator display. Refer to the DCV table in chapter Calibration points adjust the output level of the calibrator to meet nominal value displayed on the standard multimeter. Use predefined calibration points.
  - e) To adjust the output level in the calibration points use <, >, v, ^ cursor buttons. Confirm set value by pressing WRITE display button. If you want to skip the calibration point whose calibration you have already entered, press SKIP display button.
  - f) Switch output terminals OFF
5. **AC voltage ranges calibration**
  - a) Select VOLTAGE AC from the calibration menu and confirm by pressing SEL button.
  - b) Switch MC143/143i output terminals ON.
  - c) Follow the instructions provided on the display and the ACV table to adjust the calibrator output in the calibration points.
  - d) To adjust the output level in the calibration points use <, >, v, ^ cursor buttons. Confirm set value by pressing WRITE display button. If you want to skip the calibration point whose calibration you have already entered, press SKIP display button.
  - e) Switch output terminals OFF. Disconnect multimeter and calibrator.

**6. DC current ranges calibration**

- a) Connect current input terminals of the multimeter to the +I - I output terminals of the calibrator. Select CURRENT DC from the calibration menu.
- b) Select DC current measurement range on the standard multimeter by pressing the button SEL. Switch output terminals ON.
- c) Follow the instructions provided on the display and the DCI table to adjust the calibrator output in the calibration points.
- d) To adjust the output level in the calibration points use <, >, v, ^ cursor buttons. Confirm set value by pressing WRITE display button. If you want to skip the calibration point whose calibration you have already entered, press SKIP display button.
- e) Resistance shunt 100 mΩ should be used on 2A range, if standard multimeter does not cover this range with required accuracy.
- f) Switch output terminals OFF.

**7. AC current ranges calibration**

- a) Select CURRENT AC from the calibration menu. Set the same function on external multimeter.
- b) Follow the instructions provided on the display and the ACI table to adjust the calibrator output in the calibration points.
- c) To adjust the output level in the calibration points use <, >, v, ^ cursor buttons. Confirm set value by pressing WRITE display button. If you want to skip the calibration point whose calibration you have already entered, press SKIP display button.
- d) Resistance shunt 100 mΩ should be used on 2A range and 10 mΩ on 20A range if standard multimeter does not cover this range with required accuracy.
- e) Switch output terminals OFF. Disconnect multimeter and calibrator.

**8. Resistance ranges calibration**

- a) Select RESISTANCE function in calibration menu by pressing the button SEL.
- b) Set Resistance function on the standard multimeter, select 4W method. Make short on the standard multimeter terminals to correct zero if necessary.
- c) Select fixed resistance values on the calibrator from 10 Ω to 100 MΩ and measure them by standard multimeter. Write measured values from the numerical keyboard to the calibrator. New calibration value confirm by pressing the button WRITE.

**9. RTD temperature sensor simulation**

- a) Select RTD temperature sensor function in calibration menu by pressing the button SEL.
- b) Set Resistance function on the standard multimeter, select 4W method for values below 10kΩ. Make short on the standard multimeter terminals to correct zero if necessary.
- c) Select partial resistance segments in the calibrator from 20 Ω to 120 MΩ and measure them by standard multimeter. Write measured values from the numerical keyboard to the calibrator. New calibration value confirm by pressing the button WRITE.

## Error messages

If an error occurs in the calibrator during the operation or control, error message is displayed on the display. Errors can be caused by:

- incorrect control using the front panel, i.e. attempts to set prohibited mode, e.g. setting an out-of-range value, overloading of output terminals etc.,
- fault of the calibrator, e.g. internal communication error during the communication between individual functional blocks,
- incorrect control using the GPIB or RS-232 bus.

Following table lists all error messages, their meaning and simple troubleshooting.

Error No	Error message	Meaning	Solution
01	Overload 1V !	Overloading of voltage output on range 1V	Output current is too high. Increase load resistance.
02	Overload 10V !	Overloading of voltage output on range 10V/100V/1000V	Output current is too high. Increase load resistance.
04	Overload I output !	Overloading of current output	Voltage across external load is too high. Decrease load resistance.
10	Interface error !	Remote connection error	Enter correct data format on GPIB/RS-232.
11	Bad command !	Unknown command GPIB/RS-232	Use only defined commands..
13	Over range !	Overcrossed range in remote control mode	In remote control mode value out of allowed limits was send to the calibrator. Enter correct value.
14	Communication error	Communication error on GPIB/RS-232	General communication error in remote control mode.
15	Check sum error !	Fail data loading into internal memory	For service purpose only.
16	Interrupted !	Interrupted command IEEE488.2	Enter full data format.
17	Unterminated !	Wrong syntax IEEE488.2	Enter correct data format.
18	Deadlocked !	Wrong syntax IEEE488.2	Enter correct data format.
20	Bad calib. code !	Wrong calibration code	Wrong calibration code was entered, calibration cannot start. Enter correct calibration code
21	Time warm up !	Attempt to start calibration before warm up	Attempt to start calibration before 60 minutes warm up period. Let the calibrator turned on for at least 60 minutes.
40	Value too large !	Maximum value is out of limit	Maximum value is out of limit
41	Value too small !	Minimum value is out of limit	Attempt to set value under possible range. Set correct value.
42	Deviation too large !	Deviation is too high	Set deviation is out of limit -30% to +30%. Set correct value.
44	Unable +/- !	Change of polarity is not allowed	Attempt to change polarity, where it is not allowed. For functions ACV, ACI only.
45	Unable - polarity !	Negative polarity is not allowed.	Attempt to set negative polarity, where it is not allowed.. For functions ACV, ACI only.
51	High temperature!	20 A amplifier overheated	Output stage is overloaded. Do not use 20 A range for at least 10 minutes. Check if the ventilation holes are free.

Table VIII Error messages

## Maintenance

MC143/143i Multifunction calibrator is electronic instrument, which does not require any special kind of maintenance. It is equipped with electronic protection circuits, which protect the instrument against overloading.

### Rules for correct operation

Especially the following rules should be adhered to guarantee correct operation of the calibrator:

- *The calibrator may be switched on and off only by pressing the POWER button located on the front panel.*
- *Do not connect the calibrator to other voltage than set by the voltage selector.*
- *Do not block the vent openings located at the rear panel and bottom panel.*
- *The calibrator must not be operated in dusty environment.*
- *No liquid or small objects can be permitted to enter the calibrator through the vent openings.*
- *Do not switch the calibrator outside its operating temperature range.*
- *Connect the instruments to be calibrated to proper output terminals. There is no way of protecting the calibrator from the damage caused by some improper connections.*
- *Do not damage the output terminals by plugging in "bananas" thicker than the terminals were designed for.*
- *Whenever possible, use the setup menu to ground Lo output terminal (GND ON setup function).*
- *Do not overload the power stages by leaving the calibrator switched on with the load connected for a long time, especially on 20 A current range and 1000 V voltage ranges.*
- *If the instruments to be calibrated are not connected to calibrator's output terminals using original cables, ensure that cables suitable for the calibration voltage and current are used. Maximum output voltage can reach 1000 V<sub>rms</sub> and the maximum output current can reach 20 A<sub>rms</sub>.*

### Periodical maintenance

The calibrator does not require any special maintenance of electrical or mechanical parts. If it gets dirty, the housing and the display may be cleaned by a wool rag moistened with alcohol.

Recommended re-calibration period is 12-month intervals.

### What to do in case of failure

If a simple failure occurs during the operation (e.g. the display is not lit), switched off the calibrator. Check the fuse located in the power socket on the rear panel. Procedure is as follows:

- Remove the end of power cord from the mains connector at the rear panel.
- Insert the blade of a flat screwdriver into the opening cut in the mains voltage selector and pry pull out the fuse holder.
- Remove the fuse. Replace it with new fuse of the same rating if the fuse was broken.

- Replace the fuse holder, reconnect the power cord and switch on the calibrator. If the problem persists, contact manufacturer.

If an obvious fault is evidenced, e.g. a measurement range or an operating mode is not functional, the user cannot repair the calibrator by himself. Contact the manufacturer in this case.

Hidden faults can cause different symptoms and be caused by different causes. Usually, they cause instability of some parameter. Hidden defects can be caused by unacceptable distortion, degraded insulation etc. In this case contact the manufacturer.

Sometimes it seems that the calibrator has hidden defect, when the rules for correct operation are not adhered to. In this case, the failure is caused with the operator. Most frequent cases of false "hidden defects":

- mains voltage out of tolerance limits or unstable
- wrong grounding of the measurement circuit (bad connection of the ground terminal of the mains outlet, or several ground connection when grounding loops are formed)
- proximity to sources of intensive influence, whose products are spread through the mains or propagated by the electromagnetic field
- strong electrostatic or electromagnetic field which can cause major instability during calibration using higher impedance.

## Verification test

Procedure recommended for verifying parameters of the calibrator is described in this chapter.

### **Required equipment**

Following instruments are required for performance verification test:

- 8 1/2 digit multimeter type HP3458A or Fluke 8508A, or other type with accuracy 0.001 % on DC voltage
- resistance shunts 10/100 mΩ Burster 1280, or other type with accuracy 0.01%
- counter HP 53181A, HO 53130 or other with accuracy 0,001 %

HP8903A Distortion analyzer and scope with bandwidth min. 20 MHz are recommended for THD measuring of AC signals.

### **Configuration of the calibrator**

Calibrator can be tested directly from the front panel terminals. To suppress influence of noise or interference with power line frequency in measuring circuit it is recommended following setting of the calibrator (in SETUP MENU):

<b>Coil x50</b>	<b>OFF</b>
<b>GND U</b>	<b>ON</b>

*Note: If it is grounded neither calibrator nor standard meter, higher noise level can occur on the output terminals. It is recommended to provide calibration and verification tests with parameter **GND U ON***

Setting of the other parameters do not influence accuracy of the calibrator. Accuracy of AC voltage and AC current is defined for sinusoidal output signal.

Verification test should be provided after placing the calibrator to the temperature stabilized condition for at minimum 4 hours before verification test is started.

## **Basic steps of the performance verification test**

Verification procedure consists of following steps:

- **10 V DC** voltage range test with linearity checking
- **DCV** voltage internal ranges 10 mV, 100 mV, 1 V, 100 V, 1000 V test
- **AC V** voltage internal ranges 10 mV, 100 mV, 1 V, 100 V, 1000 V test
- **200 mA DC** current range test with linearity checking
- **DC I** current internal ranges 200 uA, 2 mA, 20 mA, 2A, 20A test
- **AC I** current internal ranges 200 uA, 2 mA, 20 mA, 200 mA, 2A, 20A test
- **Resistance** test in points 10Ω, 100Ω, 1kΩ, 10kΩ, 100kΩ, 1MΩ, 10MΩ, 100MΩ
- **Frequency** test at 1 kHz nominal value
- **RTD simulator** test (for models with RTD option)

## **Verification procedure**

Following part describes procedure of performance verification test. Recommended testing points are the same as the points in tables of allowed limits (see tables bellow).

1. Place the calibrator to the standard condition and let it switched on for at least one hour in a laboratory at  $23 \pm 1$  °C.
2. Connect voltage output of the calibrator (Hi – Lo) to the input voltage terminals of the standard multimeter. Set on the multimeter the parameters which enables the most accurate measurement.
3. Perform linearity test on voltage range 10V, tests of all other voltage ranges DC V, tests on all other AC voltage ranges according to the tables. Measured deviation should not exceed the limits in tables.
4. Connect current output of the calibrator (+I - -I) to the input current terminals of the standard multimeter. Set on the multimeter the parameters which enables the most accurate measurement.
5. Perform linearity test on the range 200 mA DC, tests of all other current ranges DC I and ranges AC I according to the tables. Measured deviation should not exceed the limits in tables.
6. Set function for resistance measuring on the standard multimeter, four-terminal connection. Measure the fix resistances of resistance function of the calibrator according to the table VIII. Measured deviation should not exceed the limits in tables.
7. Set AC voltage, output 1V, frequency 1 kHz on the calibrator. Connect standard counter to the output terminals Hi – Lo.
8. Test output frequency of the calibrator according to the table IX. Measured deviation should not exceed the limits in tables.
9. Measure harmonic distortion of the signal on Hi – Lo terminals. Use the same setting on the calibrator as in previous step. Measured deviation should not exceed value 0.05%.
10. Perform test of RTD simulator. Connect standard multimeter to the Opt 143-60 RTD Simulator Cable Adapter using four-terminal connection. Set multimeter to four terminal resistance function.
11. Set parameter type of temperature sensor simulation to Pt385 in MC143/143i and parameter R0 to 100 Ω. Switch output terminals to ON and measure resistance at Opt. 143-60. Measured deviation should not exceed the limits in tables.

New calibration (adjusting) should be performed if in any of previous steps deviation out of limits is found. Partial calibration of the outlimit function/range is usually enough. Information about calibration procedure in more details are described in the chapter Calibration mode.

## Verification test - tables of limits

### 10 V DC basic voltage range with linearity test

Function	Range	Value	Max. deviation (% of value)
V-DC	10 V	2.0000 V	0.0085
V-DC	10 V	4.0000 V	0.0072
V-DC	10 V	6.0000 V	0.0068
V-DC	10 V	8.0000 V	0.0046
V-DC	10 V	10.0000 V	0.0065
V-DC	10 V	-2.0000 V	0.0085
V-DC	10 V	-4.0000 V	0.0072
V-DC	10 V	-6.0000 V	0.0068
V-DC	10 V	-8.0000 V	0.0046
V-DC	10 V	-10.0000 V	0.0065

Table IX 10 VDC verification test

### DC voltage ranges

Function	Range	Value	Max. deviation (% of value)
V-DC	10 mV	5.0000 mV	0.190
V-DC	10 mV	9.0000 mV	0.128
V-DC	10 mV	-5.0000 mV	0.190
V-DC	10 mV	-9.0000 mV	0.128
V-DC	100 mV	50.000 mV	0.024
V-DC	100 mV	90.000 mV	0.018
V-DC	100 mV	-50.000 mV	0.024
V-DC	100 mV	-90.000 mV	0.018
V-DC	1 V	-0.50000 V	0.008
V-DC	1 V	1.00000 V	0.007
V-DC	1 V	-0.50000 V	0.008
V-DC	1 V	-1.00000 V	0.007
V-DC	100 V	50.000 V	0.008
V-DC	100 V	100.000 V	0.007
V-DC	100 V	-50.000 V	0.008
V-DC	100 V	-100.000 V	0.007
V-DC	1000 V	300.00 V	0.0107
V-DC	1000 V	950.00 V	0.0102

Table X DC voltage verification test

### AC voltage ranges

Function	Range	Value	Frequency	Max. deviation (% of value)
V-AC	10 mV	10.0000 mV	120 Hz	0.450
V-AC	100 mV	100.000 mV	120 Hz	0.150
V-AC	1 V	1.00000 V	120 Hz	0.055
V-AC	10 V	2.0000 V	120 Hz	0.075
V-AC	10 V	6.0000 V	120 Hz	0.058
V-AC	10 V	10.0000 V	120 Hz	0.055
V-AC	10 V	10.0000 V	1000 Hz	0.100
V-AC	100 V	100.000 V	120 Hz	0.060
V-AC	1000 V	950.00 V	120 Hz	0.091

Table XI AC voltage verification test

**200 mA DC current basic range with linearity test**

Function	Range	Value	Max. deviation (% of value)
A-DC	200 mA	40.000 mA	0.0300
A-DC	200 mA	80.000 mA	0.0225
A-DC	200 mA	120.000 mA	0.0200
A-DC	200 mA	160.000 mA	0.0187
A-DC	200 mA	180.000 mA	0.0183
A-DC	200 mA	-40.000 mA	0.0300
A-DC	200 mA	-80.000 mA	0.0225
A-DC	200 mA	-120.000 mA	0.0200
A-DC	200 mA	-160.000 mA	0.0187
A-DC	200 mA	-180.000 mA	0.0183

Table XII 200 mADC verification test

**DC current ranges**

Function	Range	Value	Max. deviation (% of value)
A-DC	200 $\mu$ A	180.000 $\mu$ A	0.061
A-DC	200 $\mu$ A	-180.000 $\mu$ A	0.061
A-DC	2 mA	1.80000 mA	0.0306
A-DC	2 mA	-1.80000 mA	0.0306
A-DC	20 mA	18.0000 mA	0.0183
A-DC	20 mA	-18.0000 mA	0.0183
A-DC	200 mA	180.000 mA	0.0183
A-DC	200 mA	-180.000 mA	0.0183
A-DC	2 A	1.8000 A	0.0206
A-DC	2 A	-1.8000 A	0.0206
A-DC	20 A	18.000 A	0.101
ADC	20 A	-18.000 A	0.101

Table XIII DC current verification test

**AC current ranges**

Function	Range	Value	Frequency	Max. deviation (% of value)
A-AC	200 $\mu$ A	180.000 $\mu$ A	120 Hz	0.261
A-AC	2 mA	1.80000 mA	120 Hz	0.111
A-AC	20 mA	4.0000 mA	120 Hz	0.095
A-AC	20 mA	10.0000 mA	300 Hz	0.140
A-AC	20 mA	18.0000 mA	120 Hz	0.076
A-AC	200 mA	180.000 mA	120 Hz	0.076
A-AC	2 A	1.80000 A	120 Hz	0.106
A-AC	20 A	18.0000 A	120 Hz	0.217

Table XIV AC current verification test



**Resistance**

Function	Range	Value	Frequency	Max. deviation (% of value)
O-4W	10.0 $\Omega$	10.0 $\Omega$	DC	0.550
O-4W	100.0 $\Omega$	10.0 $\Omega$	DC	0.050
O-4W	100.0 $\Omega$	100.0 $\Omega$	DC	0.020
O-4W	1000 $\Omega$	1000.0 $\Omega$	DC	0.020
O-4W	10k $\Omega$	10 000 $\Omega$	DC	0.020
O-4W	100k $\Omega$	100 000 $\Omega$	DC	0.020
O-4W	1M $\Omega$	1 000 000 $\Omega$	DC	0.050
O-4W	10M $\Omega$	10 000 000 $\Omega$	DC	0.050
O-4W	100M $\Omega$	100 000 000 $\Omega$	DC	0.500

Table XV Resistance verification test

**Frequency**

Function	Range	Value (Hz)	Max. deviation (% of value)
FREQ	1 MHz	1 000 000	0.005

Table XVI Frequency verification test

**RTD simulator (optionally)**

Function	Value ( $^{\circ}\text{C}$ )	Limits of measured resistance ( $\Omega$ )
RTD Pt385/100 $\Omega$	-50.0	80.31 $\pm$ 0.030
RTD Pt385/100 $\Omega$	0.0	100.00 $\pm$ 0.035
RTD Pt385/100 $\Omega$	100.0	138.50 $\pm$ 0.048
RTD Pt385/100 $\Omega$	600.0	313.71 $\pm$ 0.110

Table XVII RTD simulator verification test

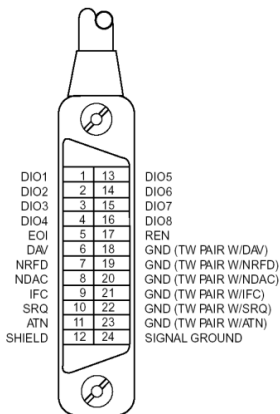
## Interface

The calibrator is equipped with RS232 serial line as standard (standardized IEEE-488 bus as option). System connectors are located at the rear panel. For the remote control to work properly, interface parameters must be set in the system menu. For RS232 line communication speed can be set (150 to 19200 Bd), software handshake XON/XOFF. For IEEE-488 bus, an address from range 0 to 30 is allowed. The calibrator can be only controlled by one of interfaces at a time. It is therefore necessary to select one of the interfaces (GPIB/RS232) using the system menu.

### GPIB (IEEE-488) bus description

The instrument performs the following functions based on GPIB bus commands:

**SH1, AH1, T5, L3, RL1, DC1, SR1**



The instrument also recognizes the following general commands:

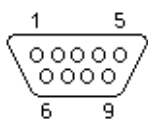
DCL	Device Clear	reset the calibrator
SDC	Selected Device Clear	reset the calibrator
EOI	End or Identify Message Terminator	close the message
GTL	Go To Local	close remote control mode
LLO	Local Lock Out	local control locked
SPD	Serial Poll Disable	close serial message status
SPE	Serial Poll Enable	release serial message status

Fig. 20 GPIB connector

### RS232 serial line setting

To transfer the data using RS232 bus, 8N1 data format is used, i.e. each data word includes 8 bits, no parity and one stop bit. The communication speed can be set using the system menu. Available values: 150, 300, 600, 1200, 2400, 4800, 9600 and 19200 Bd. Software handshake (communication control) XON/XOFF can be set to control the transfer of the data through the bus.

RS-232 connector layout



Pin	Name	Direction	Description
2	TXD	Output	Transmitter
3	RXD	Input	Receiver
5	GND	-	Ground

Fig. 21 9-pin connector D-SUB FEMALE

Cable between the calibrator and PC (configuration 1:1)

PC	D-Sub 1	D-Sub 2	M7 143/143i
Receiver	2	2	Transmitter
Transmitter	3	3	Receiver
Ground	5	5	Ground

## Command syntax

The commands described in this chapter can be issued through both buses (IEEE-488 and RS232).

All commands listed in this chapter are explained in two columns:

KEYWORD and PARAMETERS.

KEYWORD column includes the name of the command. Each command includes one or more keywords. If a keyword is in brackets ( [ ] ), it is not mandatory. Non-mandatory commands are used only to achieve compatibility with language standard SCPI.

Capitals designate the abbreviated form of the commands; extended form is written in lowercase.

Command parameters are in brackets (<>); each parameter is separated using a comma. Parameters in brackets ( [ ] ) are not mandatory. Line ( | ) means "or" and is used to separate several alternative parameters.

Semicolon ';' is used to separate more commands written on one line.

E.g. VOLT 2.5 ; OUTP ON

### Note:

Each command must end in <cr> or <lf>. Both codes <crlf> can be used at the same time. The calibrator performs all commands written on one line of the program after it receives <cr>, <lf> or <crlf> code. Without this code, the program line is ignored.

## Description of abbreviations

<DNPD> = Decimal Numeric Program Data, this format is used to express decimal number with or without the exponent.

<CPD> = Character Program Data. Usually, it represents a group of alternative character parameters. E.g. {ON | OFF | 0 | 1}.

<SPD> = String Program Data. String value consisting from more parts. It is used for date/time setting.

? = A flag indicating a request for the value of the parameter specified by the command. No other parameter than the question mark can be used.

(?) = A flag indicating a request for the parameter specified by the command. This command permits a value to be set as well as requested.

<cr> = carriage return. ASCII code 13. This code executes the program line.

<lf> = line feed. ASCII code 10. This code executes the program line.

### OUTPut subsystem

This subsystem enables to activate or deactivate the MC143/143i output and switch on/off current coil function.

Keyword	Parameters
OUTPut	
[:STATe](?)	<CPD> { ON   OFF   0   1 }
: ISElection(?)	<CPD> { HIGHi   HI50turn }

**OUTP [:STAT](?) <CPD> { ON | OFF | 0 | 1 }**

This command activates or deactivates output terminals.

- ON or 1 - activates the output
- OFF or 0 - deactivates the output

If query is sent, MC143/143i returns ON if the output is active or OFF if it is inactive

Example:       OUTP 1 <cr> - activates the output  
               OUTP ? <cr> - the calibrator returns ON or OFF

**OUTP :ISEL(?) <CPD> { HIGH | HI50 }**

This command activates or deactivates setting using a 50-turn coil.

- HIGH - deactivates the 50-turn coil
- HI50 - activates the 50-turn coil (up to 100A range)

If query is sent, MC143/143i returns HIGH if the 50-turn coil is deactivated or HI50 if it is activated.

Example:       OUTP :ISEL HI50 <lf> activates the 50-turn coil  
               OUTP :ISEL ? <lf> the calibrator returns HIGH or HI50

**SOURce subsystem**

This subsystem allows to control the individual functions of MC143/143i calibrator.

**Keyword****Parameters**

[SOURce]	
:FUNcTION	
[:SHAPE](?)	<CPD> { DC   SINusoid   RMPA   RMPB   TRIangle   LIMS   SQUare }
:VOLTage	
[:LEVEl]	
[:IMMediate]	
[:AMPLitude](?)	<DNPD >
:CURRent	
[:LEVEl]	
[:IMMediate]	
[:AMPLitude](?)	<DNPD>
:RESistance	
[:LEVEl]	
[:IMMediate]	
[:AMPLitude](?)	<DNPD>
:EARTh(?)	<CPD> { ON   OFF   0   1 }
:FREQuency	
[:CW ](?)	<DNPD>
:TEMPerature	
:UNITS(?)	<CPD> { C   CEL   F   FAR }
:SCALE(?)	<CPD> { TS68   TS90 }
:THERmocouple	
[:LEVEl]	
[:IMMediate]	
[:AMPLitude](?)	<DNPD>
:TYPE(?)	<CPD> { B   E   J   K   N   R   S   T }
:RJUN	
:RSElect(?)	<CPD> { REAL   SIMulated }
:SIMulated(?)	<DNPD>

```

: PRT
  [: LEVE]
    [: IMMEDIATE]
      [: AMPLITUDE] (?)      <DNPD>
: TYPE (?)                  <CPD> { PT385 | PT392 | NI }
: NRESistance (?)          <DNPD>

```

**[SOUR] :FUNC [:SHAP](?) <CPD> { DC | SIN | RMPA | RMPB | TRI | LIMS | SQU }**

This command sets the shape of the output signal. At the same time, the respective function must be set. E.g. for :VOLT or :CURR function, FUNC DC, FUNC SIN, or other signal shape must be set. Some functions (:RES) do not require any other settings.

- DC sets a DC output signal for voltage, current or power modes.
- SINusoid sets AC output signal for voltage, current or power modes.
- RMPA sets AC output signal - ramp shape A- for voltage or current modes. The amplitude can be set. - The output switches between -amplitude a +amplitude.
- RMPB sets AC output signal - ramp shape B - for voltage or current modes. The amplitude can be set. - The output switches between -amplitude a +amplitude.
- TRlangel sets AC output signal - triangular shape - for voltage or current modes. The amplitude can be set. -The output switches between -amplitude a +amplitude.
- LIMSinusoid sets AC output signal - sinus shape with limitation of amplitude- for voltage or current modes. The amplitude can be set. -The output switches between -amplitude a +amplitude.
- SQUare sets digital frequency output.

If query is sent, MC143/143i returns a string containing { DC | SIN | RMPA | RMPB | TRI | LIMS | SQU } depending on the current setting. If resistance or temperature sensor simulation is set, NONE is returned.

**[SOUR] :VOLT [:LEVE] [:IMM] [:AMPL] (?) <DNPD>**

This command activates the generation of DC or AC voltage (depending on the DC or SIN parameter of the FUNC command).

<DNPD>

The command represents the value of DC or AC voltage expressed in Volts. Negative value is accepted for DC voltage. "Technical Data" chapter lists the acceptable ranges.

If query is sent, MC143/143i returns the set value of current using standard exponential format. Example: 20.547mV is returned as -2.054700e-002. Positive numbers are sent without "+" sign.

Examples:

DC voltage 5V:

```
FUNC DC;:VOLT 5<lf>
```

AC voltage 5V, 100Hz:

```
FUNC SIN;:VOLT 5;:FREQ 100<lf>
```

**[SOUR] :CURR [:LEVE] [:IMM] [:AMPL] (?) <DNPD>**

This command activates the generation of DC or AC current (depending on the DC or SIN parameter of the FUNC command).

<DNPD>

The command represents the value of DC or AC current expressed in Amperes. Negative value is accepted for DC current. "Technical Data" chapter lists the acceptable ranges.

If query is sent, MC143/143i returns the set value of current using standard exponential format. Example: 20.547mA is returned as -2.054700e-002. Positive numbers are not preceded with "+" sign.

Examples::

DC current 18mA:

```
FUNC DC;;CURR 0.018<lf>
```

AC current 18mA, 100Hz:

```
FUNC SIN;;CURR 0.018;;FREQ 100<lf>
```

### **[SOUR] :RES [:LEVE] [:IMM] [:AMPL] (?) <DNPD>**

This command activates the generation of a resistance.

<DNPD>

The command represents the value of the resistance in  $\Omega$ . "Technical Data" chapter lists the acceptable ranges.

If query is sent, MC143/143i returns the calibration value of resistance using standard exponential format. Example: 100.5 $\Omega$  is returned as 1.005000e+002.

Example :

Resistance 1k $\Omega$  setting:

```
RES 1000<lf>
```

### **[SOUR] :EART(?) <CPD> { ON | OFF | 0 | 1 }**

This command connects or disconnects the voltage Lo terminal to/from GND terminal.

- ON or 1 grounds the voltage output
- OFF or 0 ungrounds the voltage output

If query is sent, MC143/143i returns ON when the output is grounded or OFF when ungrounded.

Example:

Grounding of the voltage output terminal Lo

```
EART : VOLT 1 <lf>
```

### **[SOUR] :FREQ [:CW] (?) <DNPD>**

This command sets the frequency being generated.

Examples:

AC voltage frequency :

```
FUNC :SIN ; :VOLT <DNPD>; :FREQ <DNPD> <lf>
```

AC current frequency :

```
FUNC :SIN ; :CURR <DNPD>; :FREQ <DNPD> <lf>
```

Digital frequency :

```
FUNC :SQU ; :FREQ <DNPD> <lf>
```

<DNPD>

It represents the frequency in Hz. "Technical Data" chapter lists the acceptable ranges which depend on the selected function mode.

If query is sent, MC143/143i returns the set value of the current using standard exponential format. Example: 200.5Hz is returned as 2.005000e+002.

**[SOUR] :TEMP :UNIT(?) <CPD> { C | CEL | F | FAR }**

This command sets the unit of measurement of temperature.

- C or CEL sets „Centigrade“
- K or FAR sets „Kelvin“

The unit of measurement remains valid after the calibrator is switched off.

If query is sent, MC143/143i returns the set unit of measurement { C | K }.

**[SOUR] :TEMP :SCAL (?) <CPD> { TS68 | TS90 }**

This command sets one of temperature scales. The setting influences the simulation of resistance temperature sensors and thermocouples.

- TS68 sets IPTS-68 temperature scale
- TS90 sets ITS-90 temperature scale

The temperature scale remains valid after the calibrator is switched off.

If query is sent, MC143/143i returns the set temperature scale { TS68 | TS90 }.

**[SOUR] :TEMP :THER :RJUN :REAL? <DNPD>**

This command send the temperature of external temperature sensor Pt1000.

<DNPD>

Represents the temperature expressed in the units set by the 'UNIT' command. "Technical Data" chapter lists the acceptable ranges.

Example: to read the temperature of temperature sensor:

```
:TEMP :THER :RJUN :REAL?<lf>
```

MC143/143i returns the temperature using standard exponential format. Example: 20.5°C is returned as 2.050000e+001.

**[SOUR] :TEMP :THER :TYPE (?) <CPD> { B | E | J | K | N | R | S | T }**

This command sets the type of thermocouple to be simulated.

If query is sent, MC143/143i returns the set type thermocouple { B | E | J | K | N | R | S | T }.

Examples:

TC type K setting, temperature 200°C, ITS-90 temperature scale:

```
:TEMP:UNIT C;:TEMP:SCAL TS90;:TEMP:THER:TYPE K;:TEMP:THER 200 <lf>
```

**[SOUR] :TEMP :THER :RJUN :RSEL(?) <CPD> { REAL | SIM }**

This command sets type of getting the cold end of thermocouple RJ temperature. The RJ temperature can be either measured by internal thermometer or simulated.

- REAL sets measured RJ temperature
- SIM sets simulated RJ temperature

If query is sent, MC143/143i returns the set type of RJ temperature { REAL | SIM }.

**[SOUR] :TEMP :THER :RJUN :SIM(?) <DNPD>**

This command sets the temperature of cold end of thermocouple RJ.

<DNPD>

Represents the temperature expressed in the units set by the 'UNIT' command. "Technical Data" chapter lists the acceptable ranges.

Example: to set the temperature of cold end of thermocouple to 25°C:

```
:TEMP :THER :RJUN :SIM 25 <lf>
```

If query is sent, MC143/143i returns the set temperature using standard exponential format. Example: 20.5°C is returned as 2.050000e+001.

**[SOUR] :TEMP :PRT [:LEVE] [:IMM] [:AMPL] (?) <DNPD>**

This command activates the simulation of resistance temperature sensors (resistance generation).

<DNPD>

Represents the temperature expressed in the units set by the 'UNIT' command. "Technical Data" chapter lists the acceptable ranges.

If query is sent, MC143/143i returns the set temperature using standard exponential format. Example: 20.5°C is returned as 2.050000e+001.

**[SOUR] :TEMP :PRT :TYPE (?) <CPD> { PT385 | PT392 | NI }**

This command sets the type of resistance temperature sensor to be simulated.

Example: to activate the simulation of platinum resistance temperature sensor at 350°C approximated using PT385 table (Europe):

```
:TEMP :PRT 350; :TEMP :PRT :TYPE PT385 <cr>
```

If query is sent, MC143/143i returns the set type of approximation table { PT385 | PT392 | NI }.

**[SOUR] :TEMP :PRT :NRESistance (?) <DNPD>**

This command sets the nominal resistance of the resistance temperature sensor at 0°C. 100Ω to 1kΩ can be set.

<DNPD>

Represents the nominal resistance in Ω.

If query is sent, MC143/143i returns the set value of nominal resistance using standard exponential format. Example: 100Ω is returned as 1.000000e+002.

### **SYSTem subsystem**

The subsystem enables to control various functions from the MENU.

SYSTem

```
:DATE(?) <DNPD>,<DNPD>,<DNPD>
```

```
:TIME(?) <DNPD>,<DNPD>,<DNPD>
```

**SYST :DATE(?) <DNPD>,<DNPD>,<DNPD>**

This command sets system date of the calibrator.

<DNPD>,<DNPD>,<DNPD>

Represents date in format YYYY, MM, DD.

If query is sent, MC143/143i returns current value of system date in format YYYY,MM,DD.



where YYYY = year (2000..2099)  
MM = month (01..12)  
DD = day (01..31)

**SYST :TIME(?) <DNPD>,<DNPD>,<DNPD>**

This command sets time of the calibrator.

<DNPD>,<DNPD>,<DNPD>

Represents time in format HH,MM,SS.

If query is sent, MC143/143i returns current value of system time in format HH,MM,SS.

where HH = hour (00..23)  
MM = minute (00..59)  
SS = second (00..59)

**I/D (instrument identification)****\*IDN?**

This command returns the identification of the manufacturer, model, serial number and firmware revision.

The reply is formatted as follows:

M-143/143i ,670011,1.000

**Operation complete****\*OPC**

This command sets the OPC bit in the ESR (Event Status Register) when all pending operations are complete.

**Operation complete?****\*OPC?**

This command returns "1" to the output queue after all pending operations are complete.

**Wait-to-Continue command****\*WAI**

Prevents the instrument from executing any further commands or queries until all previous remote commands have been executed.

**Reset****\*RST**

This command resets the calibrator to its initial status.

**Test operation****\*TST?**

This command launches an internal self-test. Return the self-test result ("0" for pass or "1" for fail).

**Status byte reading (IEEE488 only)****\*STB?**

This query returns number in range 0 to 255 with information about content of register STB, which carries the MSS bit status.

**Service Request Enable reading (IEEE488 only)****\*SRE <value>**

This command sets condition of the Service Request Enable register. Since bit 6 is not used, the maximum value is 191.

**Service Request Enable reading (IEEE488 only)****\*SRE?**

This query returns the Service Request Enable Register number.

**Event Status Register reading (IEEE488 only)****\*ESR?**

This query returns the contents of the Event Status Register and clears the register.

**Event Status Enable setting (IEEE488 only)****\*ESE <value>**

This command programs the Event Status Enable register bits. Parameter "value" is number in range 0 – 255.

**Event Status Enable reading (IEEE488 only)****\*ESE?**

This query returns the Event Status Enable register.

**Clear status (IEEE488 only)****\*CLS**

This command clears the Event Status Register and the Status Byte Register except the MAV bit and output queue. Output line is not reset.

**Remote control****\*REM**

This command activates the remote control. When the calibrator is controlled by GPIB bus, it goes to the remote control mode automatically. When remote control is active, the calibrator ignores all controls from the front panel, except LOCAL button.

***Local control***

**\*LOC**

This command activates the local control (using front panel buttons). When the calibrator is controlled by GPIB bus, it goes to the local control mode automatically.

***Local control lock***

**\*LLO**

This command locks out the local control; the calibrator cannot be returned to local control by pressing LOCAL button. Return to local control can only be performed by a command sent through the bus, or by switching the calibrator off and on.

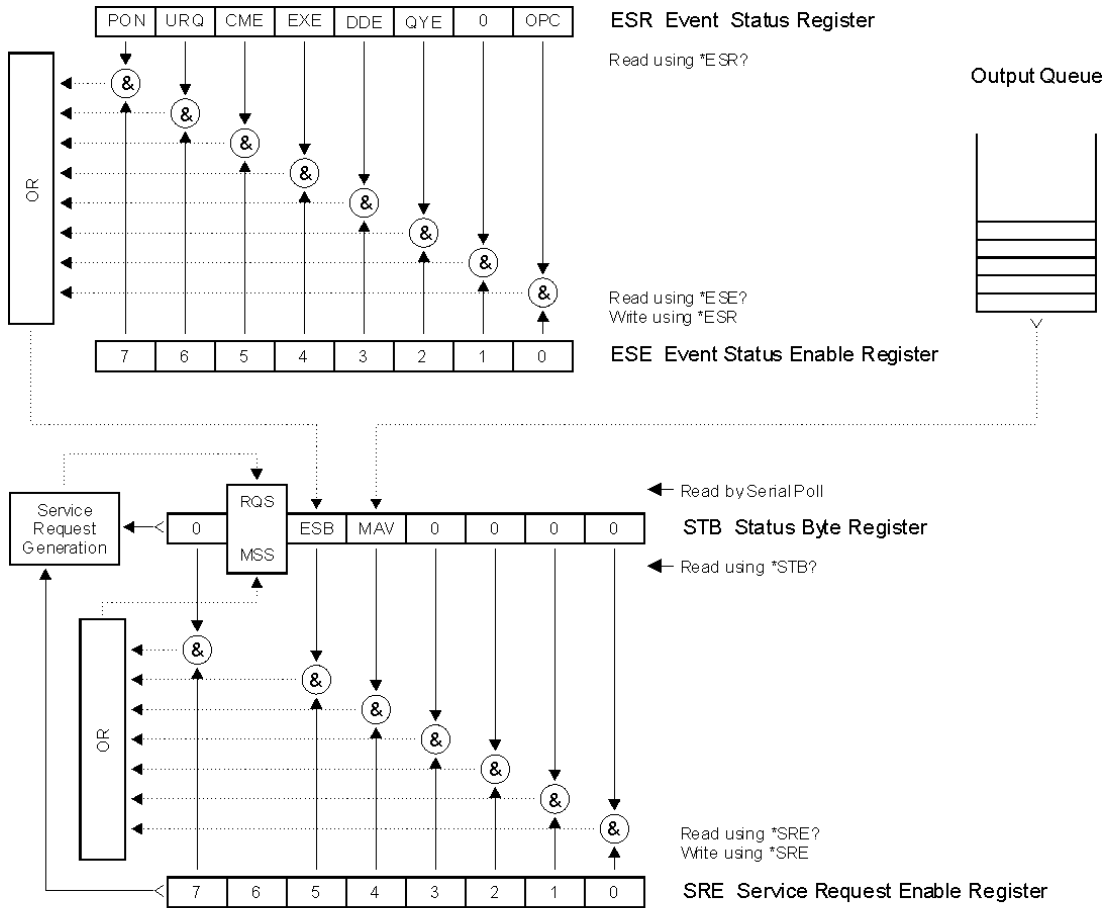
***Local control unlock***

**\*UNL**

This command cancels the „\*LLO“ command. Unlocked calibrator can be returned to local control mode by pressing LOCAL button.

## Standard Status Data Structures

Calibrator meets standard protocol according to the standard IEEE488.2. The protocol can be used for checking of error and status behavior of the calibrator. It enables single-wire transmitting of SRQ command. The conditions on which SRQ signal (local control request) is sent can be set with parameters \*STB?, \*SRE?, \*SRE, \*ESR?, \*ESE?, \*ESE a \*CLS.



Status Register Overview

Fig. 22 Status data structure of M140

- Calibrator contains following registers:
- STB – Status Byte Register
  - SRE – Service Request Enable Register
  - ESR – Event Status Register
  - ESE – Event Status Enable Register
  - Output Queue

### STB Status Byte Register

STB is main register where information from other status registers and from output queue is collected. Value of STB register is reset after switching on the calibrator or after sending command \*CLS. This command reset the STB register except bit MAV, which remains set if the output queue is not empty. STB register value can be read via serial message or through general query \*STB? .

Bit configuration of Status Byte Register :

RQS Request Service, bit 6. The bit is read as a part of status byte only when serial message is sent.

- MSS** Master Summary Status, bit 6. The MSS bit is set to 1 whenever bits ESB or MAV are 1 and enabled (1) in the SRE. This bit can be read using the \*STB? command. His value is derived from STB and SRE status.
- ESB** Event Summary Bit, bit 5. His value is derived from STB and SRE status. The ESB bit is set to 1 when one or more enabled ESR bits are set to 1.
- MAV** Message Available, bit 4. The MAV bit is set to 1 whenever data is available in the MC143/143i IEEE488 Output Queue (the response on query is ready).

### **SRE Service Request Enable Register**

The Service Request Enable Register suppresses or allows the STB bits. "0" value of a SRE bit means, that the bit does not influence value of MSS bit. Value of any unmask STB bit results in setting of the MSS bit to the level "1". SRE bit 6 is not influenced and its value is "0". The SRE register value can be set via the command \*SRE followed by mask register value (0 – 191). The register can be read with the command \*SRE?. The register is automatically resets after switching the calibrator on. The register is not reset by the command \*CLS.

### **ESR Event Status Register**

Every bit of the EventStatusRegister corresponds to one event. Bit is set when the event is changed and it remains set also when the event passed. The ESR is cleared when the power is turned on (except bit PON which is set), and every time it is read via command \*ESR? Or cleared with \*CLS.

Bit configuration of Event Status Register :

- PON** Power On, bit 7. This event bit indicates that an off-to-on transition has occurred in the device's power supply.
- URQ** User Request, bit 6. Bit is not used and it is always "0".
- CME** Command Error, bit 5. This event bit indicates that an incorrectly formed command or query has been detected by the MC143/143i.
- EXE** Execution Error, bit 4. This event bit indicates that the received command cannot be executed, owing to the device state or the command parameter being out of limits.
- DDE** Device Dependent Error, bit 3. This event bit indicates that an error has occurred which is neither a Command Error, a Query Error, nor an Execution Error. A Device-specific Error is any executed device operation that did not properly complete due to some condition, such as overload.
- QYE** Query Error, bit 2. The bit is set if the calibrator is addressed as talker and output queue is empty or if control unit did not pick up response before sending next query.
- OPC** Operation Complete, bit 0. This event bit is generated in response to the \*OPC command. It indicates that the device has completed all selected pending operations.

### **ESE Event Status Enable Register**

The Event Status Enable Register allows one or more events in the Event Status Register to be reflected in the ESB summary-message bit. This register is defined for 8 bits, each corresponding to the bits in the Event Status Register. The Event Status Enable Register is read with the common query \*ESE?. Data is returned as a binary-weighted value. The Event Status Enable Register is written to by the common command, \*ESE. Sending the \*ESE common command followed by a zero clears the ESE. The Event Status Enable Register is cleared upon power-on.

It suppresses or allows bits in ESR register. Value „0“ of a bit of ESE register suppresses influence of appropriate bit of ESR register on value of sum bit of ESB status register. Setting of any unmask bit of ESR register results in setting of ESB status register. ESE register value can be modified by command \*ESE followed by value of mask register (integer in range 0 –255). Reading of the register can be performed with

command \*ESE?. The register is automatically reset after switching on. The register is not reset with \*CLS command.

## ***Output Queue***

The Output Queue stores response messages until they are read from control unit. If there is at minimum one sign in the output queue, MAV register (message available) is set. The Output Queue is cleared upon power-on and after reading all signs from output queue.

## Examples of application

The calibrator can be used for direct calibration of various instruments, which measure electrical values. Thanks its low weight and small dimensions it is suitable also for field applications.

### Multimeters

The calibrator can be used for calibration of digital and analogue multimeters (DCV, ACV, DCI, ACI, resistance, temperature sensors, frequency).

#### Voltage ranges

Thanks to low output impedance and high output current, the calibrator can be used for calibration of analogue voltmeters and millivoltmeters having low input impedance. Voltage output is connected to Hi/Lo terminals. The calibrator does not allow the four-terminal connection of the instrument to be calibrated.

It is not recommended to connect non-standard load to the voltage output. The calibrator is designed as a source of precise voltage for calibration of voltmeters. Output terminals should be loaded with high and real impedance. Although the output is fitted with fast electronic and microprocessor protection, high capacitance or inductance loads can lead to oscillations of output amplifiers and result in damage.

The instrument to be calibrated can be connected directly to the front panel terminals with test cables, which are a part of basic delivery. If L terminal of device under test is not grounded it is recommended to ground Lo terminal on the calibrator GND ON, see chapter SETUP MENU.

Connect voltage input of the multimeter to the MC143/143i voltage output:



Fig. 23 Voltmeter calibration

#### Current ranges

All DC and AC current ranges are connected to calibrator's +I/-I terminals.

When using the current output under heavy load (10 to 20 A), the runtime is limited to 0 to 60 s. The runtime depends on the set current and it is controlled by the microprocessor. The user cannot extend the runtime; if longer runtime is required, the output terminals must be unloaded, some time must elapse (for example 1 min.) and the load can then be connected again.

When feeding 0.2 to 2 A current to the output terminals, the output voltage must not exceed approx. 2 Vef. If the current causes higher voltage on the load, the calibrator disconnects the output terminals and displays an error message.

When ammeters are being calibrated using currents over 1 A, it is important to connect the terminals properly, paying attention both to the calibrator's output terminals and the instrument's input terminals. Excessive contact resistance can heat up the terminals and cause calibration errors. Excessive and unstable contact resistance has non-linear characteristic and can distort the output AC current.

It is not recommended to connect non-standard load to the current output. The calibrator is designed for use in calibration of ammeters. Output terminals should be loaded with low and real impedance. Although the output is fitted with fast electronic and microprocessor protection, high capacitance or inductance can lead to oscillations of output amplifiers and result in damage.

If L terminal of the instrument to be calibrated is not grounded, the Lo terminal should be grounded GND ON, see „Setup menu“ chapter.

Connect ammeter to the output current terminals:



Fig. 24 Ammeter calibration

Optional current coil can extend the calibrator's current range to 1000 A. The coil can be used for calibration of both DC and AC ammeters. The clamps of the ammeter must be positioned in angle 90° to the coil. When using the current coil, no steel or other magnetic objects must be present in the vicinity (50 cm) of the current coil, as they would deform the magnetic field and cause big calibration error.

Connection of current coil:



Fig. 25 Current coil connection



## Counters and scopes

The calibrator can be used for basic calibration of the frequency ranges of multimeters and simple counters. The calibrator provides the following functions:

- calibration of frequency functions up to 2 MHz using squarewave signal. The function is activated with repetitive pressing the FUNC button and selecting the Frequency mode. Only value of frequency can be set.
- calibration of vertical sensitivity from 1 mV to 10 V in the frequency range 1 kHz. ACV function is used with squarewave output form. Frequency and amplitude can be set.  
The instrument to be calibrated is connected to the Hi – Lo output terminals.

## Thermometers (without sensor)

The calibrator can be used for calibration of transducers used in thermometers and heat meters, which use a thermocouple sensor. The block connected to the sensor is checked, as it is disconnected from the transducer and the calibrator's output is connected to the transducer's input instead. Simulation of thermal sensor is activated by repeated pressing FUNC button until TC function is selected. Temperature sensors type K, N, R, S, B, J, T, E can be simulated. Unit under test is connected to the Hi – Lo output terminals.

### ATTENTION

**The voltage between calibrator's –I and Lo outputs must not exceed 10 V.**

## Specification

Bellow shown accuracy is valid after specified warm-up time in temperature range  $23 \pm 2 \text{ }^\circ\text{C}$ . The accuracy includes long-term stability, temperature coefficient, linearity, load and line regulation and the traceability of factory and National calibration standards. Specified accuracy is valid for one year after the last calibration. Specified accuracy „of range“ are related to the maximal value which can be set on the range.

### DC / AC SINE Wave Voltage

Voltage range summary : 0.0000 mV – 1000.00 V DC, 1.0000 mV – 1000.00 V AC  
 Internal ranges : 100 mV, 1 V, 10 V, 100 V, 1000 V  
 Resolution of voltage setting: 5½ digit  
 Frequency range in AC mode : 1 mV - 10 V from 20 Hz to 2 kHz, 10 V – 1000 V from 40 Hz to 1 kHz  
 Accuracy of frequency: 0.01%  
 Resolution of frequency setting : 5½ digit

#### Voltage accuracy

DC Voltage		AC Voltage		
Range	% of value + % of range	Range	% of value + % of range	% of value + % z range
---	---	---	20.000 Hz – 400.000 Hz <sup>†1</sup>	400.000 Hz -2000.00 Hz <sup>†1</sup>
0.0000 mV – 10.0000 mV	0.050 + 0.070	1.0000 mV – 10.0000 mV	0.20 + 0.25	0.20 + 0.30
10.000 mV – 100.000 mV	0.010 + 0.0070	10.000 mV – 100.000 mV	0.10 + 0.05	0.15 + 0.07
0.10000 V – 1.00000 V	0.006 + 0.0010	0.10000 V – 1.00000 V	0.05 + 0.005	0.07 + 0.01
1.0000 V – 10.0000 V	0.006 + 0.0005	1.0000 V – 10.0000 V	0.05 + 0.005	0.07 + 0.03
10.000 V – 100.000 V	0.006 + 0.0010	10.000 V – 100.000 V	0.05 + 0.010	0.07 + 0.03
100.00 V – 1000.00 V	0.010 + 0.0020	100.00 V – 1000.00 V	0.07 + 0.020	0.10 + 0.03

<sup>†1</sup> Voltage ranges 100 and 1000V from 40 Hz to 1kHz.

#### Auxiliary parameters

range	10mV	100mV	1V	10V	100V	1000V
THD <sup>†2</sup>	0.05 % + 200 µV	0.05 % + 300 µV	0.05 %	0.05 %	0.05 %	0.10 %
Maximal output current <sup>†3</sup>	3 mADC 3 mAAC	5 mADC 5 mAAC	20 mADC 10 mAAC	50 mADC 50 mAAC	20 mADC 10 mAAC	2 mADC 1.5 mAAC
Output impedance	< 10 mΩ	< 10 mΩ	< 10 mΩ	< 10 mΩ	< 100 mΩ	< 100 mΩ
Maximal capacitance load	3 nF	3 nF	3 nF	10 nF	10 nF	3 nF
Overload protection H against L terminal (pk)	60 V	60 V	60 V	60 V	250 V	1500 V

<sup>†2</sup> The parameter includes non-linear distortion and non-harmonic noise in frequency range to 100 kHz.

<sup>†3</sup> The parameter shows maximal output current while output voltage in specification.

### NON-SINE Wave Voltage

Voltage range : 1.0000 mV<sub>pk</sub> – 10.0000 V<sub>pk</sub>  
 Waveform type : saw, triangle, square sym, truncated sin  
 Frequency range : 20.000 to 80.000 Hz  
 Accuracy of amplitude (peak value): 0.3 %  
 Frequency accuracy: 0.01 %

### DC / AC SINE Wave Current

Current range summary : MC143: 0.000 µA – 20.000 A DC, 1.000 µA – 20.000 A AC  
 MC143i: 0.000 µA – 2.0000 A DC, 1.000 µA – 2.0000 A AC  
 Internal ranges : 200 uA, 2 mA, 20 mA, 200 mA, 2 A (20 A in model MC143)  
 Resolution of current setting: 5½ digit  
 Frequency range in AC mode : MC143/143i: 1 µA - 2A range 20 Hz to 1 kHz  
 MC143: 2 A - 20 A range 20 Hz to 500 Hz  
 Frequency accuracy: 0.01%  
 Resolution of frequency setting : 5½ digit

**Current accuracy**

DC Current		AC Current		
Range	% of value + % of range	Range	% of value + % of range	% of value + % z range
			20.000 Hz – 200.000 Hz	200.000 Hz -1000.00 Hz
0.000 $\mu$ A – 200.000 $\mu$ A	0.050 + 0.010	1.000 $\mu$ A – 200.000 $\mu$ A	0.25 + 0.010	0.20 + 0.10
0.20000 mA – 2.00000 mA	0.025 + 0.005	0.20000 mA – 2.00000 mA	0.10 + 0.010	0.10 + 0.02
2.0000 mA – 20.0000 mA	0.015 + 0.003	2.0000 mA – 20.0000 mA	0.07 + 0.005	0.10 + 0.02
20.000 mA – 200.000 mA	0.015 + 0.003	20.000 mA – 200.000 mA	0.07 + 0.005	0.10 + 0.02
0.2000 A – 2.0000 A	0.015 + 0.005	0.2000 A – 2.0000 A	0.10 + 0.005	0.15 + 0.05
2.0000 A – 20.000 A <sup>7</sup>	0.1 + 0.01	2.0000 A – 20.000 A	0.20 + 0.015	0.25 + 0.05

**Auxiliary parameters**

Range	200 $\mu$ A	2 mA	20 mA	200 mA	2 A	20 A <sup>6,7</sup>
Maximal inductive load	400 $\mu$ H	400 $\mu$ H	400 $\mu$ H	400 $\mu$ H	200 $\mu$ H	200 $\mu$ H
Maximal compliance voltage (pk)	2 V	2 V	2 VAC, 7 VDC	2 V	2 V	1.5 V
THD <sup>4</sup>	0.15 %	0.10 %	0.10 %	0.10 %	0.20 %	0.40 % <sup>5</sup>
Overload protection +I against – I terminals (pk)	15 V	15 V	15 V	15 V	15 V	15 V

<sup>4</sup> Parameter includes non-linear distortion and non-harmonic noise in frequency range to 100 kHz.

<sup>5</sup> Frequency range 30 Hz to 500 Hz. Distortion in frequency range 20 Hz to 30 Hz and 500 Hz to 1000 Hz is max. 0.6%.

<sup>6</sup> Limited period is in range 10 A to 20 A for which can MC143 supply continuously external load. The period is 5 minutes at 20 A and 15 minutes at 10 A. It can vary depending on previous load conditions. Full recovery to starting conditions takes about 5 minutes.

<sup>7</sup> 20A range in model MC143 only.

**NON-SINE Wave Current**

Current range : 100.000  $\mu$ A<sub>pk</sub> – 2.000 00 A<sub>pk</sub>  
 Waveform type : saw, triangle, square sym, truncated sin  
 Frequency range : 20.000 to 80.000 Hz  
 Amplitude accuracy (peak value) : 0.3 %  
 Frequency accuracy : 0.01 %

**Resistance**

Number of resistances: 8  
 Range : 10  $\Omega$  to 100 M $\Omega$   
 Calibration value resolution : 5 dig  
 Maximal test voltage : 50 V<sub>rms</sub> or 0.1W, what is lower  
 Type of connection : two-terminal

**Resistance accuracy**

Nominal value ( $\Omega$ )	10 $\Omega$	100 $\Omega$	1 k $\Omega$	10 k $\Omega$	100 k $\Omega$	1 M $\Omega$	10 M $\Omega$	100 M $\Omega$
Max. calibration difference to nominal value (%)	5	1	0.5	0.5	0.5	0.5	1	5
Accuracy of calibration value (%)	0.05+ 50 m $\Omega$	0.05	0.02	0.02	0.02	0.05	0.05	0.5

**TC / RTD<sup>8</sup> Temperature Sensor Simulation**

TC sensor types : R, S, B, J, T, E, K, N  
 TC temperature simulation range : -250.0  $^{\circ}$ C to +1 820.0  $^{\circ}$ C depending on type  
 TC cold junction compensation : fixed in range -5.0  $^{\circ}$ C to 50.0  $^{\circ}$ C  
 automatic using external temperature sensor  
 TC compensation accuracy: 0.2  $^{\circ}$ C  
 RTD sensor types : Pt 1.385, Pt 1.392, Ni  
 RTD temperature simulation range : -50.0  $^{\circ}$ C to +850.0  $^{\circ}$ C depending on sensor type  
 Range of R<sub>0</sub> coefficient : 100  $\Omega$  to 1000  $\Omega$   
 Type of connection: four-terminal  
 Temperature scale : IPTS68, ITS90  
 Temperature units :  $^{\circ}$ C,  $^{\circ}$ F  
 Resolution of temperature setting : 0.1  $^{\circ}$ C/ $^{\circ}$ F

**TC/RTD sensor simulation accuracy <sup>\*10</sup>**

TC sensor simulation			RTD sensor simulation <sup>*8</sup>		
Thermocouple type	Temperature simulation range (°C)	Accuracy (°C)	Temperature sensor type	Temperature range (°C)	Accuracy (°C) <sup>*9</sup>
R	-50.0 to +1767.0	1.2 to 2.5	Pt100 - Pt200	-200.0 ... 0.0	0.2
S	-50.0 to +1767.0	1.5 to 2.2	Pt100 - Pt200	0.0 ... 850.0	0.1
B	400.0 to +1820.0	1.3 to 2.7	Pt200 - Pt1000	-200.0 ... 0.0	0.1
J	-210.0 to +1200.0	0.3 to 0.9	Pt200 - Pt1000	0.0 ... 850.0	0.1
T	-200.0 to +400.0	0.3 to 0.9	Ni100 - Ni200	-60.0 ... 0.0	0.2
E	-250.0 to +1000.0	0.2 to 1.7	Ni100 - Ni200	0.0 ... 300.0	0.1
K	-200.0 to +1372.0	0.4 to 0.8	Ni200 - Ni1000	-60.0 ... 0.0	0.1
N	-200.0 to +1300.0	0.5 to 1.3	Ni200 - Ni1000	0.0 ... 300.0	0.1

<sup>\*8</sup> Option 143-60 RTD temperature sensor simulation is available as extra ordered option.

<sup>\*9</sup> Specification is valid for four-terminal connection.

<sup>\*10</sup> Specified accuracy relates to specified temperature simulation range. Exact value of accuracy for set temperature is shown on the MC143/143i display.

**Frequency Output**

Waveform type :	positive 5V <sub>pk</sub>
Amplitude accuracy :	10 %
Output resistance:	50 Ω ± 5 %
Frequency range :	0.100 0 Hz to 2.000 00 MHz
Frequency accuracy :	0.005 %

**Content of Delivery**

MC143/143i Portable Multifunction Calibrator	1 pc	OOpt 143-90 Pt1000 External Temperature Sensor	1 pc
Test Lead 1000V/20 A length 1m,	2 pcs	OOpt 143-60 RTD Simulator Cable Adapter (optionally)	1 pc
Power Line Cord	1 pc	RRS232 Cable	1 pc
Powertek Calibration Certificate	1 pc	OOperation Manual	1 pc
Spare fuse	1 pc		

**General Data**

Reference temperature range :	23 °C ± 2 °C (for a bove shown accuracy)
Relative humidity :	< 80 % to 30 °C, < 70 % to 40 °C, < 40 % to 50 °C
Temperature coefficient :	In extended temperature range +10 °C to +40 °C multiply accuracy parameters 0.15x / °C
Absolute accuracy definition : linearity,	MC143/143i specifications include stability, temperature coefficient, line and load regulation, and the traceability of the external standards used for calibration.

Protection fuses: T4L250 for 115V, T3.15L250 for 230V

Safety standard compliance :	EN/IEC 61010-2:2011
EMC standard compliance:	EN 61326-1 ed. 2:2013
	EN 61000 part 3-2 ed. 3:2006 +A1:2010+A2:2010
	EN 61000 part 3-3 ed. 2:2009
	EN 61000 part 4-2 ed. 2:2009
	EN 61000 part 4-3 ed. 3:2006 +A1:2008+A2:2011
	EN 61000 part 4-4 ed. 3:2013
	EN 61000 part 4-5 ed. 2:2007
	EN 61000 part 4-6 ed. 3:2009
	EN 61000 part 4-11 ed.2:2005

Range of working temperatures :	+10 °C ... +40 °C
Range of storing temperatures :	- 10 °C ... +55 °C
Power supply :	115/230V - 50/60 Hz
Power consumption :	250 VA max
Dimensions (W x H x D) :	325 x 111 x 316 mm
Weight :	9 kg
Interface :	RS232, (IEEE488 as option)

**Powertek**

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