M – 141 *Portable Multifunction Calibrator*

MEATEST

Operation manual

Content

Basic information

     M-141 Multifunction Calibrator is a multifunction calibrator for use primarily as a mean of calibration in calibration laboratories. It can be used for calibration of any measuring instrument, which measures voltage, current, resistance and frequency. It generates harmonic and non-harmonic signals with accurate amplitude. The calibrator includes a function of simulation of thermocouple temperature sensors for testing of process meters.

     Basic features of the calibrator includes generation of calibrated DC and AC voltage in the range from 0 μV to 750 V, DC and AC current in the range from 0 μA to 2 A. Maximum precision of the calibrator is 0.01 % for DC voltage, 0.055 % for AC voltage, 0.018 % for DC current and 0.075 % for AC current. Maximum frequency range is 20 Hz to 1000 kHz. The calibrator is also source of fixed decade resistance values in range from 10 Ω to 100 MΩ with accuracy 0.01 %. In frequency mode the calibrator can generate squarewave signal in range from 0.1 Hz to 2 MHz

     Simulation of temperature sensors is another feature that can be used to calibrate thermometers and heat sensing units. The calibrator allows TC thermocouple temperature sensors of R, S, B, J, T, E, K, N type. Compensation of cold junction of thermocouple is achieved by entering the respective temperature using the calibrator's keyboard. The accuracy of simulated temperature sensors depends on the value and type of sensor and ranges and is from 0.1 ^{O}C to 4.3 ^{O}C . simulation RTD resistance temperature sensors of Pt/Ni type and

The calibrator includes many other features which facilitate easy use. For example relative deviation from set value of the output, currently displayed uncertainty of the output signal, calibration and testing procedures etc. The concept of the calibrator control and indication of its status is based on flat LCD display, which provides all necessary information. The calibrator is controlled by opening menus on the display and selection from menus. Frequently used functions are assigned direct-control keys. The calibrator is delivered with standard RS-232 serial line as standard (GPIB optionally), which allows the calibrator to be controlled from a PC.

     The calibrator can easily fit within calibration systems featuring MBASE/WinQbase software support.

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:

- Multifunction calibrator
- Power cord
- Spare fuse
- Operation manual
- Test report
- Test cable 1000V/20 A   2 pcs

Power line voltage setting

The calibrator should be powered from 230/115 V – 50/60 Hz mains. Its parameters are guaranteed at temperature range 23±5 °C. 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:

- 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.

Switch 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.
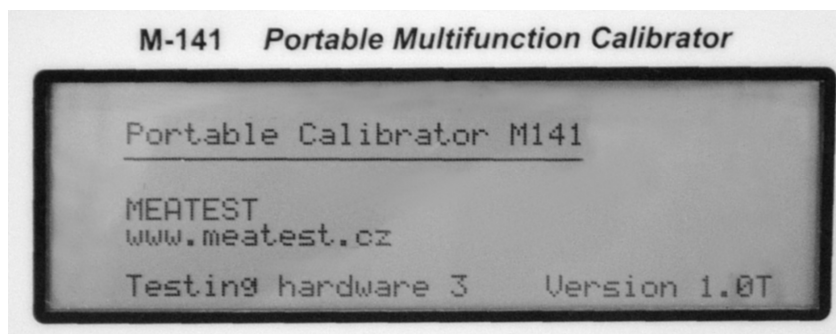
- The calibrator performs internal hardware checks for 5 seconds.

- 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.

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 re-calibrated. 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
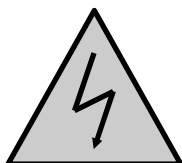
Warning - risk of electric shock

⚡ 　　　　　　　　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 bellow:
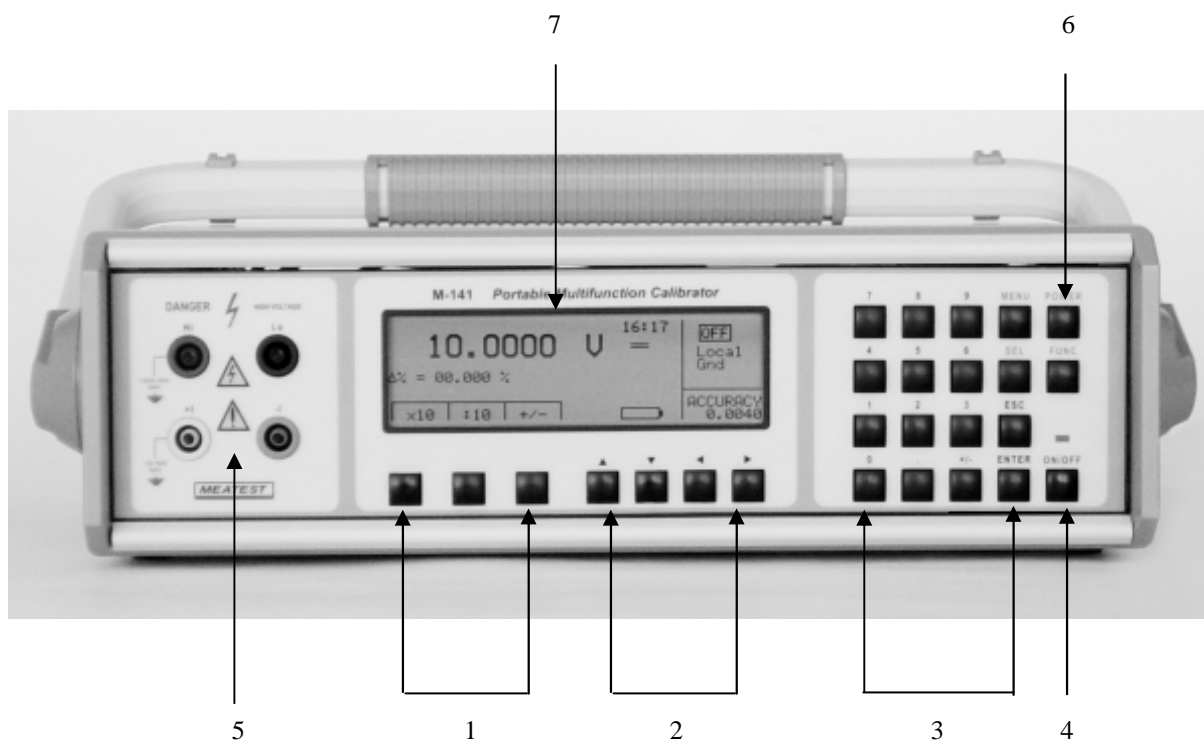
1　Display buttons

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.

2　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.

3   *Numerical keyboard*

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.

4   *Output terminal 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.

5   *Output terminals*

Output signal of the calibrator is connected to the output terminals. Current ranges are connected to **+I / -I** terminals. All other functions (voltage, resistance, frequency) are connected to **Hi / Lo** terminals.

GND terminal is located on the rear panel. It is connected to the protective terminal of the mains plug. Using the SETUP MENU, item GND, the output terminals of the calibrator can be set as grounded or floated. Grounding is done internally by connecting Lo and GND terminals using a relay. This circuit design is suitable for most calibrations, when the object (multimeter) being calibrated is floating.

Between terminals following maximal voltages are allowed:
Hi - GND protection terminal (housing):   1000VRMS
+I - GND protection terminal (housing):   10VRMS
Lo - GND protection terminal (housing):   10VRMS
- I - GND protection terminal (housing):   10VRMS

6   *POWER button*

When the calibrator is switched off, it can be switched on by pushing the button POWER. When the calibrator is switched on, it can be switched off be repeated pushing the same button. After the first pushing, request to switch the button POWER again is displayed. When the button is switched the second time, calibrator is switched off. If any other button is switched instead of POWER, calibrator is returned to the last set mode.

7   *Display*
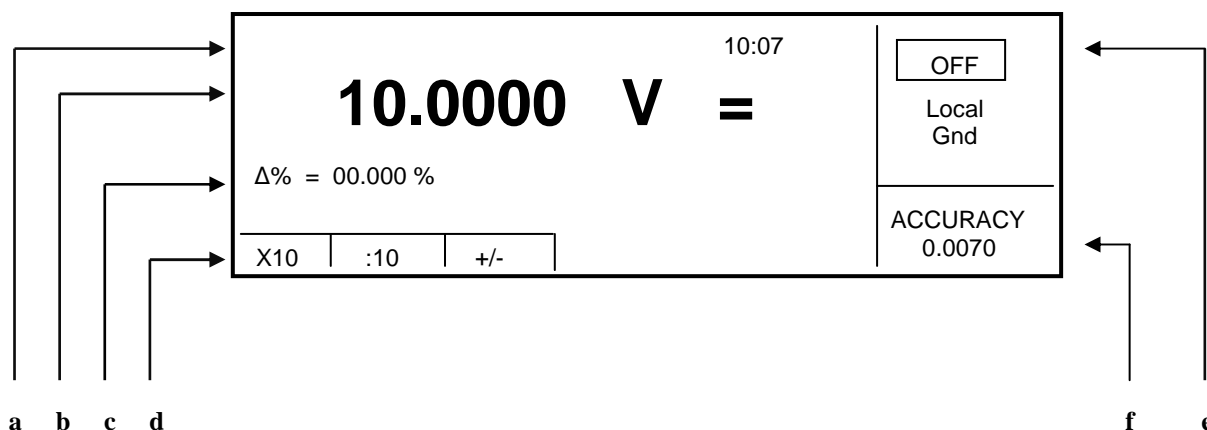
Display is graphically split into several fields, which display information about calibrator setting:

a)   *Information field*
It shows real time. Real time displaying can be canceled in SERVICE MENU.

b)   *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 ∧, ∨. Symbols of active cursor are displayed after pushing any of cursor buttons.

c)   *Auxiliary 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

d)   *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

e) *Information field*
In the field some next 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.

f) *Uncertainty fiend*
In the field there is displayed currently valid uncertainty of the main parameter of the output signal. It is calculated from full specification of the calibrator and it is displayed in %.

Rear panel

On the rear panel there are located power line socket with fuse and power line voltage selector, RS-232 connector (GPIB optionally), external temperature sensor connector and model plate number with serial number.

External temperature sensor connector

RTD connector (RTD option only)

Model plate

RS-232 connector   GPIB connector (optionally)

Power line socket

Power line selector
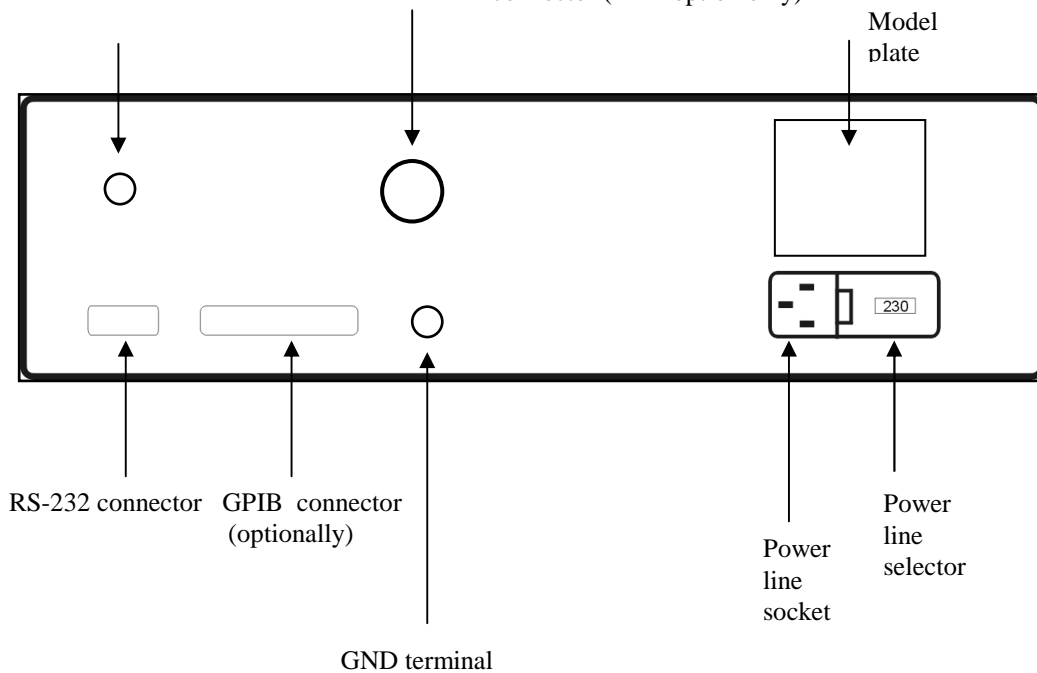
GND terminal

Control of the calibrator

Selection of function

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

1.   Change of function

By repeated pushing the button FUNC basic mode of the calibrator can be changed in the order DCV – ACV – DCI – ACI - resistance – frequency – TC simulation – RTD simulation.

2.   Connection /disconnection of output terminals

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

3.   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 [_ _ _ _ _ _ _ _].


```
┌─────────────────────────────────┬──────────────┐
│                                 │  ┌────────┐   │
│    10.0000   V =                │  │  OFF   │   │
│      [ 11.2345 _ _ _ _ _ ]      │  └────────┘   │
│  Δ% = 00.000 %                  │    Local      │
│                                 │    Gnd        │
│                                 │ ─────────────  │
│ ┌──────┬──────┬──────┐          │  ACCURACY     │
│ │ X10  │ :10  │ +/-  │          │  0.0070       │
│ └──────┴──────┴──────┘          │               │
└─────────────────────────────────┴──────────────┘
```

- 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 µV 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 $<$, $>$, $\wedge$ or $\vee$ button. The display now includes cursor marks, which point to the active digit.

- $\wedge$ and $\vee$ 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. All values can be set using the buttons or the potentiometer.

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 $+$ Δ %   for voltage, current, frequency mode .
the value indicated by the main display $+$ Δ ^{o}C   for TC sensor simulation

```
┌──────────────────────────────────┬──────────────┐
│                                   │  ┌────────┐  │
│                                   │  │  OFF   │  │
│     10.0000   V   =               │  └────────┘  │
│                                   │    Local     │
│  Δ% = 00.000 %                    │    Gnd       │
│  [ 3.56 _ _ _ _ _ _ ] _           ├──────────────┤
│ ┌───┬─────┬──────┬──────┐         │  ACCURACY    │
│ │ % │     │      │      │         │   0.0070     │
│ └───┴─────┴──────┴──────┘         │              │
└──────────────────────────────────┴──────────────┘
```

Maximum relative deviation which can be entered is ± 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 or the potentiometer as well.

Setting relative deviation using cursor keys

- keep pressing the button SEL until [_ _ _ _ _ _ _] symbols appear under the relative deviation value

- press <, >, ∧ or ∨ button. The display now includes cursor marks which point to the active digit

- ∧ and ∨ 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 (ACU), AC current (ACI)

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.

```
        10.0000   V ~              OFF

 Δ% = 00.000 %      f = 100.000 Hz    Local
                    [ 123.456 _ _ _ _ ]   Gnd

  Hz  |  kHz  | SHAPE               ACCURACY
                                     0.0070
```
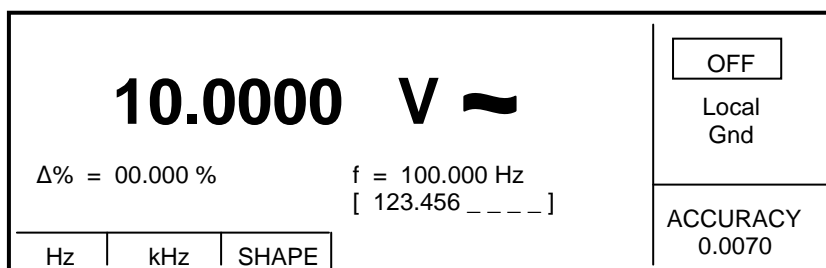
If too large or too small value is entered, the calibrator displays the maximum (minimum) value which is allowed for the selected function.

Frequency (F)

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, potentiometer or by changing the digit at the current cursor position. The setting procedure is described in the "Setting the value of output signal".

```
┌─────────────────────────────────────────┬─────────────┐
│                                          │    ┌─────┐  │
│                                          │    │ OFF │  │
│        10.0000   kHz                     │    └─────┘  │
│                                          │    Local    │
│                                          │     Gnd     │
│   Δ%  =  00.000 %                        │             │
│                                          ├─────────────┤
│                                          │  ACCURACY   │
│  ┌─────┬──────┬──────┐                   │   0.0050    │
│  │ X 10│ : 10 │      │                   │             │
│  └─────┴──────┴──────┘                   │             │
└─────────────────────────────────────────┴─────────────┘
```
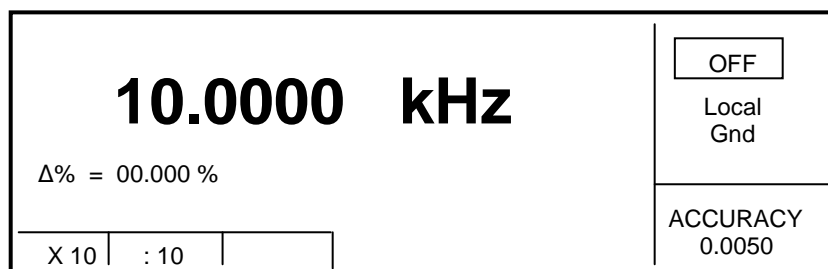
If frequency larger or smaller than the calibrator's range is entered, the calibrator displays an error message: „Value is too large (small)".

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

Generation of calibrated voltage

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 750 Vef can be present at the terminals.

DC voltage range is from 0 to 750 V.
AC voltage range is from 100 µV to 750 V.

Output voltage up to 20 V is available at AUXILIARY connector (pins 3, 4) as well.

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
  * uncertainty 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.

Control sequence when output voltage over 100 V is selected

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.

Overloading of terminals

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**

When the calibrator is controlled remotely, it is not possible to disconnect the output voltage using the buttons located at the front panel!

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

Generation of calibrated 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 2 A_{ef} can be driven by the terminals.

DC current range is 0 to 2 A
AC current range is 1μA to 2 A

When 50-turn coil (option 140-50) is used, maximal simulated AC current is 100 A.

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
        uncertainty 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.

⚠️ **CAUTION**

If GND terminal is connected to Lo, -I terminals, it is prohibited to connect external load to GND / Hi or GND / +I terminals. Such connection can damage the calibrator.

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.

Generation of non-harmonic shapes

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.

Displayed information

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.

```
  10.0000   Vpk ∧          │ OFF │
                             Local
                             Gnd
  Δ% = 00.000 %    f = 80.000 Hz
                           ─────────────
                           ACCURACY
  │ X 10 │ : 10 │ Shape │    0.30
```
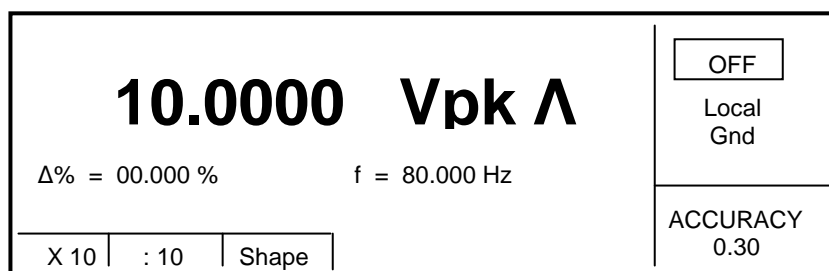
Resistance

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-wire connection.

Resistance range is 10, 100, 1k, 10k, 100k, 1M, 10M, 100M Ω.

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 Ω
   uncertainty 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.

```
                                │ OFF │
  10.0059  kΩ                    Local
                                 Gnd
                               ─────────────
                               ACCURACY
  │ X 10 │ : 10 │      │          0.015
```

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

Generation of frequency

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

    * uncertainty of frequency

- Set the frequency using numeric keyboard, cursor buttons or potentiometer. 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.

```
┌─────────────────────────────────────┬────────────────┐
│                                      │  ┌──────────┐  │
│                                      │  │   OFF    │  │
│      10.0000  kHz                    │  └──────────┘  │
│                                      │     Local      │
│   Δ% = 00.000 %                      │      Gnd       │
│                                      ├────────────────┤
│  ┌──────┬──────┬──────┐              │   ACCURACY     │
│  │ X 10 │ : 10 │      │              │    0.0050      │
│  └──────┴──────┴──────┘              │                │
└─────────────────────────────────────┴────────────────┘
```

Note:

Output impedance in frequency mode is 50 Ohm on Hi – Lo terminals.

Simulation of RTD temperature sensors (Option RTD)

Multifunction calibrator can simulate optionally resistance (RTD) temperature sensors.

When resistance temperature sensors are simulated appropriate resistance with value corresponding to set temperature is connected to the output terminals on rear panel connector RTD. Connection is four-wire type. Use connector attached to the delivery to connect unit under test to RTD connector.
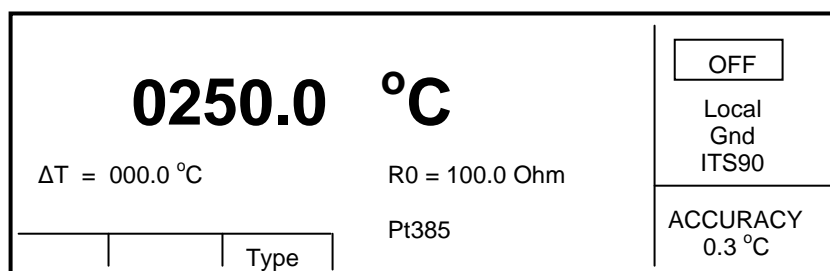
Temperature setting range: -250 to +850 ^{o}C for Pt temperature sensors
                                         -60 to +300 ^{o}C for Ni temperature sensors
Temperature scale: ITS 90, PTS 68
Rear panel RTD connector connection: Pin 1 - Li, Pin 2 – Lu, Pin 3 – Hi, Pin 6 - Hu

Setting the temperature

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

    *   main data of temperature in $^{\circ}$C or K
    *   sensor type thermocouples: Pt or Ni with nominal value in 100 $^{\circ}$C
    *   set value of absolute deviation in %, labeled $\Delta T = xxxx.x$ $^{\circ}$C (K)

    the auxiliary section shows:

    *   temperature scale type
    *   uncertainty of simulated temperature value of selected temperature sensor type

- Set the main value of temperature using numeric keyboard, cursor buttons or potentiometer. 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.

```
┌──────────────────────────────────────┬─────────────────┐
│                                       │  ┌───────────┐  │
│      0250.0   °C                      │  │   OFF     │  │
│                                       │  └───────────┘  │
│   ΔT = 000.0 °C        R0 = 100.0 Ohm │      Local      │
│                                       │       Gnd       │
│                                       │      ITS90       │
│                           Pt385       ├─────────────────┤
│   ┌────┬────┬──────┬──┐               │    ACCURACY     │
│   │    │    │ Type │  │               │     0.3 °C      │
└───┴────┴────┴──────┴──┴───────────────┴─────────────────┘
```

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.

Entry of R0 coefficient for resistance temperature sensors

For resistance temperature sensors, resistance at 0 $^{\circ}$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 center cursor button 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.

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 $^{\circ}$C depending on simulated sensor type
Sensor types: thermocouple 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 $^{\circ}$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 $^{\circ}$C (K)

  the auxiliary section shows:

  *   temperature scale type
  *   uncertainty of simulated temperature value of selected temperature sensor type

- Set the main value of temperature using numeric keyboard, cursor buttons or potentiometer. 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.

```
┌─────────────────────────────────────────┬──────────────┐
│                                          │   ┌──────┐   │
│      0450.0    ᵒC                        │   │ OFF  │   │
│                                          │   └──────┘   │
│                                          │    Local     │
│  ΔT = 000.0 ᵒC          RJ = 0000.0 ᵒC   │     Gnd      │
│                         [ _ _ _ _ _ _ _ ]│    ITS90     │
│                         TC type  K       ├──────────────┤
│  ┌────┬─────┬──────┐                     │   ACCURACY   │
│  │    │     │ Type │                     │    0.3 ᵒC    │
│  └────┴─────┴──────┘                     │              │
└─────────────────────────────────────────┴──────────────┘
```

Note:

Current capability in TC sensor simulation mode is 5 mA.

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 the temperature of output terminals, 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 service MENU.

Manual compensation

- By pushing the button MENU open servuci menu. With cursor buttons ∨, ∧ 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 ^{o}C.

- Write requested temperature of cold junction using numerical keyboard . Confirm the value by pushing the button ^{o}C (K).

```
┌──────────────────────────────────────┬──────────────┐
│                                       │   ┌────────┐ │
│      0450.0    °C                     │   │  OFF   │ │
│                                       │   └────────┘ │
│                                       │    Local     │
│                                       │    Gnd       │
│  Δ% = 00.000 %        RJ = 0023.0 °C  │    ITS90     │
│                       [_____]     ├──────────────┤
│   ┌───┬─────┬─────┐     TC type K     │   ACCURACY   │
│   │°C │     │     │                   │    0.3 °C    │
│   └───┴─────┴─────┘                   │              │
└──────────────────────────────────────┴──────────────┘
```

Automatic compensation

- Pushing the button MENU open service menu. With cursor buttons ∨, ∧ 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. Sensor has to be connected to the connector on rear panel.*

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:

```
┌─────────────────────────────────────────────┐
│                                             │
│        Coil  x50   .  .  .  .  .  . OFF     │
│        Gnd  .  .  .  .  .  .  .  . ON        │
│        Temp. scale   .  .  . ITS90          │
│        Temp. unit  .  .  .  .  .  . °C       │
│        RJ Temp.  .  .  .  .  . FIXED         │
│  ┌──────┬────────┬──────────┐               │
│  │ Calib│        │          │               │
│  └──────┴────────┴──────────┘               │
└─────────────────────────────────────────────┘
```

Use ∧ or ∨ 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 groud 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 ^{o}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.

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 uderlightning 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.

```
┌─────────────────────────────────────────────────┐
│                                                   │
│        Contrast   . . . . . . OFF                 │
│        Cal. code.  . . . .   000000               │
│        Cal. date   . . . .   01.2003              │
│        Serial No   . . . . . xxxxxx               │
│        Time   . . . . . .    16:54                │
│   ┌──────┬──────┬──────┬──────┐                   │
│   │ Calib │      │      │      │                   │
└───┴──────┴──────┴──────┴──────┴───────────────────┘
```

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 ....   xxxxx*

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 interruption can be performed in any point of the calibration procedure. However this particular calibration influences parameters of the calibrator.

Accuracy of the calibrator is guaranteed when full calibration was done.

---

calibration can be skipped.

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 750 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 Ohm to 120 MOhm.

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.

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.

```
┌────────────────────────────────────────┬──────────────┐
│                                        │  ┌────────┐  │
│                                        │  │  OFF   │  │
│                                        │  └────────┘  │
│        Set Calibration code            │    Local     │
│          [  0 0 0 0 0 0 ]              │    Gnd       │
│                                        │              │
│                                        ├──────────────┤
│   ┌────┬────┬────┬────┐                │              │
│   │    │    │    │    │                │              │
└───┴────┴────┴────┴────┴────────────────┴──────────────┘
```

- 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:

```
┌────────────────────────────────────────┬──────────────┐
│                                        │  ┌────────┐  │
│        Voltage  DC                     │  │  OFF   │  │
│        Voltage  AC                     │  └────────┘  │
│        Current  DC                     │    Local     │
│        Current  AC                     │    Gnd       │
│        Resistance                      │              │
│  ┌──────┬────┬────┬──────┐             ├──────────────┤
│  │ Sel. │    │    │      │             │              │
└──┴──────┴────┴────┴──────┴─────────────┴──────────────┘
```

- Use ∧ and ∨ 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):

```
┌──────────────────────────────────────────────────┬─────────────────┐
│                                                    │  ┌─────────┐    │
│   Voltage  DC              +0mV                    │  │  OFF    │    │
│   Range 10 mV            - 0mV                      │  └─────────┘    │
│                         +10 mV                     │     Local       │
│                         - 10 mV                    │     Gnd         │
│                          + 0 mV                    │                 │
│                                                    │                 │
│  ┌──────┬──────┬──────┬──────┐                     │                 │
│  │ Sel. │      │      │       │                    │                 │
│  └──────┴──────┴──────┴──────┘                     │                 │
└──────────────────────────────────────────────────┴─────────────────┘
```

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

```
┌──────────────────────────────────────────────────┬─────────────────┐
│                                                    │  ┌─────────┐    │
│   Voltage  DC          Range   10mV                │  │  OFF    │    │
│   Range 10 mV          Value   + 10 mV             │  └─────────┘    │
│        ▼                                           │     Local       │
│   10146350                                         │     Gnd         │
│        ▲                                           │                 │
│  ┌──────┬──────┬──────┬──────┐                     │                 │
│  │Write │ Skip │      │       │                    │                 │
│  └──────┴──────┴──────┴──────┘                     │                 │
└──────────────────────────────────────────────────┴─────────────────┘
```

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).

New calibration data setting

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 the 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 [V]	Tolerance [V]	Range [V]	Note
+0.0	2 u	10 m	zero calibration
- 0.0	2 u	-10 m	zero calibration
+10 m	4 u	10 m	slope calibration
- 10 m	4 u	-10 m	slope calibration
+ 0.0	2 u	100 m	zero calibration
- 0.0	2 u	-100m	zero calibration
+100 m	6 u	100 m	slope calibration
- 100 m	6 u	-100m	slope calibration
+ 0.0	5 u	1	zero calibration
- 0.0	5 u	-1	zero calibration
+1.0	12 u	1	slope calibration
-1.0	12 u	-1	slope calibration
+ 0.0	20 u	10	zero calibration
- 0.0	20 u	-10	zero calibration
+10	100 u	10	slope calibration
- 10	100 u	-10	slope calibration
+10	200 u	100	slope calibration
- 10	200 u	-100	slope calibration
+100	600 u	100	slope calibration
- 100	600 u	-100	slope calibration
+750	20 m	750	slope calibration
- 750	20 m	-7500	slope calibration

Table DCV

VOLTAGE AC

Nominal value [V]	Tolerance [V]	Range [V]	Frequency[Hz]
1 m	5 u	10 m	100
10 m	10 u	10 m	100
10 m	15 u	100 m	100
100 m	40 u	100 m	100
100 m	30 u	1	100
1.0	100 u	1	100
1.0	200 u	10	100
10	1 m	10	100
10	5 m	100	100
100	10 m	100	100
100	50 m	750	100
750	50 m	750	100

Table ACV

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

CURRENT DC

Nominal value [A]	Tolerance [A]	Range [A]	Note
+0.0	3 n	200 u	zero calibration
- 0.0	3 n	-200 u	zero calibration
+190 u	5 n	200 u	slope calibration
- 190 u	5 n	-200 u	slope calibration
+200 u	20 n	2 m	zero calibration
- 200 u	20 n	-2 m	zero calibration
+1.9 m	50 n	2 m	slope calibration
- 1.9 m	50 n	-2 m	slope calibration
+2 m	100 n	20 m	zero calibration
- 2 m	100 n	-20 m	zero calibration
+19 m	200 n	20 m	slope calibration
- 19m	200 n	-20 m	slope calibration
+20	1 u	200 m	zero calibration
- 20	1 u	-200 m	zero calibration
+190 m	2 u	200 m	slope calibration
- 190 m	2 u	-200 m	slope calibration
+200	20 u	2	zero calibration
- 200	20 u	-2	zero calibration
+1.9	50 u	2	slope calibration
- 1.9	50 u	-2	slope calibration

Table DCI

CURRENT AC

Nominal value [A]	Tolerance [A]	Range [A]	Frequency [Hz]
10 u	5 n	200 u	100
190 u	50 n	200 u	100
200u	40 n	2 m	100
1.9 m	200 n	2 m	100
2.0 m	200 n	20 m	100
19 m	2 u	20 m	100
20 m	2 u	200 m	100
190 m	20 u	200 m	100
200 m	20 u	2	100
1.9	200 u	2	100

Table ACI

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

RESISTANCE

Nominal value [Ω]	Tolerance [Ω]	Range [Ω]
10	0.01	10 – 50
100	0.005	10 – 50
1 k	0.005	10 – 50
10 k	0.005	50 - 100
100 k	0.005	50 - 100
1 M	0.01	50 - 100
10 M	0.01	100 – 400
100 M	0.01	100 – 400

Table R

Standard multimeter should be connected in four terminals way to the output terminals Hi-Lo.

RTD TEMPERATURE SENSOR SIMULATION

Nominal calibration point [Ω]	*Nominal resistance value [Ω]*	*Tolerance [%]*
SHORT	0-0.2 Ohm	
20	20	
40	40	
80	75	
150	150	
300	300	
600	590	
1k1	1k15	
2k2	2k19	
4k4	4k37	
8k8	8k6	
16k	16k7	
33k	33k	
66k	65k	
125k	129k	
250k	253k	
500k	503k	
1M	1M	
2M	2M	
4M	4M	
8M	7M8	
16M	15M6	
30M	30M	
60M	59M7	
120M	118M	

Table R

In column Tolerance requested accuracy of measurement of the resistance segment is shown. Standard multimeter has to be connected in four terminals way to the output terminals Hi-Lo for values bellow 10 kOhm.

Full calibration procedure

Following pages describe procedure of the full calibration.

Required instruments:

Following instruments are required for calibration:

- 81/2 digit multimeter type HP3458A or Wavetek 1281 or Fluke 8508A or other type with accuracy 0.002 % or better on DC voltage

- Resistance shunt 100 mΩ Burster 1280, or other type with accuracy 0.01%

- Counter HP 53181A, HO 53130, BM 642 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±1 ^{o}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 M-141 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 <, >, ∨, ∧ 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 M-141 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 <, >, ∨, ∧ 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 <, >, ∨, ∧ 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 mOhm 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 <, >, ∨, ∧ 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 mOhm should be used on 2A 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 multimetr, select 4W method. Make short on the standard multimetr terminals to correct zero if necessary.

     c)   Select fixed resistance values on the calibrator from 10 Ohm to 100 MOhm 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 multimetr, select 4W method for values bellow 10kOhm. Make short on the standard multimetr terminals to correct zero if necessary.

     c)   Select partial resistance segments in the calibrator from 20 Ohm to 120 MOhm 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/750V	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.

Calibrator's maintenance

M-141 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 2 A current range and1200V and 750 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 750 V AC and the maximum output current can reach 2 A AC.*

Regular 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 an 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:

- 81/2 digit multimeter type HP3458A or Wavetek 1281, or other type with accuracy 0.001 % on DC voltage

- resistance shunt 100 mΩ Burster 1280, or other type with accuracy 0.01%

- counter HP 53181A, HO 53130, BM 642 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):

- *Coil x50*   *OFF*
- *GND U*   *ON*

Note: If it is grounded neither calibrator nor standard meter, higher level can occur on the output terminals.

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, 750 V test

- **10 V AC** voltage range test with linearity checking

- **AC V** voltage internal ranges 10 mV, 100 mV, 1 V, 100 V, 750 V test

- **200 mA DC** current range test with linearity checking

- **DC I** current internal ranges 200 uA, 2 mA, 20 mA, 2A test

- **AC I** current internal ranges 200 uA, 2 mA, 20 mA, 200 mA, 2A test

- **Resistance** test in points 10, 100, 1k, 10k, 100k, 1M, 10M, 100M Ohm

- **Frequency** test at 1 kHz nominal value

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±1 $^{\circ}$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, linearity test on 10 VAC and tests on all other AC voltage ranges according to the tables I, II, III, IV. 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 100 mA DC, tests of all other current ranges DC I and ranges AC I according to the tables V, VI, VII. Measured deviation should not exceed the limits in tables.

6. Set function for resistance measuring on the standard multimeter, 4 wire 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%.

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

20 V DC basic voltage range with linearity testing

Function	Range	Value (V)	Frequency (Hz)	Max. deviation (% of value)
V-DC	10.0 V	2.0		0.008
V-DC	10.0 V	4.0		0.006
V-DC	10.0 V	6.0		0.005
V-DC	10.0 V	8.0		0.004
V-DC	10.0 V	10.0		0.004
V-DC	10.0 V	-2.0		0.008
V-DC	10.0 V	-4.0		0.006
V-DC	10.0 V	-6.0		0.005
V-DC	10.0 V	-8.0		0.004
V-DC	10.0 V	-10.0		0.004

Table I

DC voltage ranges

Function	Range	Value (V)	Frequency (Hz)	Max. deviation (% of value)
V-DC	10 mV	5 m		0.004
V-DC	10 mV	9 m		0.004
V-DC	10 mV	-5 m		0.004
V-DC	10 mV	-9 m		0.004
V-DC	100 mV	50 m		0.004
V-DC	100 mV	90 m		0.004
V-DC	100 mV	-50 m		0.004
V-DC	100 mV	-90 m		0.004
V-DC	1.0 V	-0.5		0.004
V-DC	1.0 V	1.0		0.004
V-DC	1.0 V	-0.5		0.004
V-DC	1.0 V	-1.0		0.004
V-DC	100.0 V	50.0		0.004
V-DC	100.0 V	100.0		0.003
V-DC	100.0 V	-50.0		0.004
V-DC	100.0 V	-100.0		0.003
V-DC	750.0 V	300.0		0.010
V-DC	750.0 V	700.0		0.010

Table II

20 V AC voltage basic range with linearity testing

Function	Range	Value (V)	Frequency (Hz)	Max. deviation (% of value)
V-AC	10.0 V	2.0	100	0.075
V-AC	10.0 V	4.0	100	0.050
V-AC	10.0 V	6.0	100	0.042
V-AC	10.0 V	8.0	100	0.037
V-AC	10.0 V	10.0	100	0.035

Table III

AC voltage ranges

Function	Range	Value (V)	Frequency (Hz)	Max. deviation (% of value)
V-AC	10 mV	0.010	1000	0.358
V-AC	100 mV	0.100	1000	0.142
V-AC	1.0 V	1.0	1000	0.030
V-AC	10.0 V	10.0	50	0.030
V-AC	10.0 V	10.0	300	0.030
V-AC	100.0 V	100.0	1000	0.030
V-AC	750.0 V	750.0	1000	0.036

Table IV

200 mA DC current basic range with linearity testing

Function	Range	Value (A)	Frequency (Hz)	Max. deviation (% of value)
A-DC	200.0 mA	0.04		0.025
A-DC	200.0 mA	0.08		0.018
A-DC	200.0 mA	0.12		0.015
A-DC	200.0 mA	0.16		0.014
A-DC	200.0 mA	0.18		0.013
A-DC	200.0 mA	-0.04		0.025
A-DC	200.0 mA	-0.08		0.018
A-DC	200.0 mA	-0.12		0.015
A-DC	200.0 mA	-0.16		0.014
A-DC	200.0 mA	-0.18		0.013

Table V

DC current ranges

Function	Range	Value (A)	Frequency (Hz)	Max. deviation (% of value)
A-DC	200.0 uA	0.00018		0.061
A-DC	200.0 uA	-0.00018		0.061
A-DC	2.0 mA	0.0018		0.025
A-DC	2.0 mA	-0.0018		0.025
A-DC	20.0 mA	0.018		0.013
A-DC	20.0 mA	-0.018		0.013

Table VI

AC current ranges

Function	Range	Value (A)	Frequency (Hz)	Max. deviation (% of value)
A-AC	200.0 uA	0.00018	100	0.161
A-AC	2.0 mA	0.0018	100	0.081
A-AC	20.0 mA	0.018	100	0.055
A-AC	20.0 mA	0.018	300	0.055
A-AC	20.0 mA	0.018	100	0.055
A-AC	20.0 mA	0.018	100	0.055
A-AC	200.0 mA	0.18	100	0.055
A-AC	2.0 A	1.8	100	0.055

Table VII

Resistance

Function	Range	Value (Ohm)	Frequency (Hz)	Max. deviation (% of value)
O-4W	10.0 Ohm	10.0	DC	0.130
O-4W	100.0 Ohm	10.0	DC	0.130
O-4W	100.0 Ohm	100.0	DC	0.015
O-4W	1000 Ohm	1000.0	DC	0.015
O-4W	10k Ohm	10000.0000	DC	0.015
O-4W	100k Ohm	100000.0000	DC	0.015
O-4W	1M Ohm	1.000000e+6	DC	0.050
O-4W	10M Ohm	1.000000e+7	DC	0.200
O-4W	100M Ohm	1.000000e+8	DC	0.500

Table VIII

Frequency

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

Table IX

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.

IEEE-488 bus properties

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

SH1, AH1, T5, L3, RL1, DC1, SR1
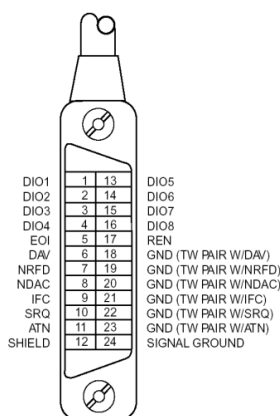
The instrument also recognizes the following general commands:

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

DIO1	1	13	DIO5
DIO2	2	14	DIO6
DIO3	3	15	DIO7
DIO4	4	16	DIO8
EOI	5	17	REN
DAV	6	18	GND (TW PAIR W/DAV)
NRFD	7	19	GND (TW PAIR W/NRFD)
NDAC	8	20	GND (TW PAIR W/NDAC)
IFC	9	21	GND (TW PAIR W/IFC)
SRQ	10	22	GND (TW PAIR W/SRQ)
ATN	11	23	GND (TW PAIR W/ATN)
SHIELD	12	24	SIGNAL GROUND

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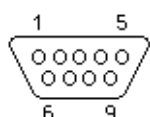
Pin	Name	Direction	Description
2	TXD	Output	Transmitter
3	RXD	Input	Receiver
5	GND	-	Ground

9-pin connector D-SUB FEMALE

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

PC	D-Sub 1	D-Sub 2	M-141
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 subsystém

This subsystem enables to activate or deactivate the M141output 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, M141 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 the 100A current range (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, M141 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 M141 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
            [: LEVEl]
                [: 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.
- TRIangel 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, M141 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, M141 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, M141 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 Ohms. "Technical Data" chapter lists the acceptable ranges.

If query is sent, M141 returns the calibration value of resistance using standard exponential format. Example: 100.5Ω is returned as 1.005000e+002.

Example :
Resistance 1kΩ 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, M141 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, M141 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"
- F or FAR sets „Kelvin"

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

If query is sent, M141 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, M141 returns the set temperature scale { TS68 | TS90 }.

[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, M141 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, M141 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, M141 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, M140 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, M141 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 Ohms.

If query is sent, M141 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, M141 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, M141 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:
MEATEST,M-141,412341,4.6

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?,
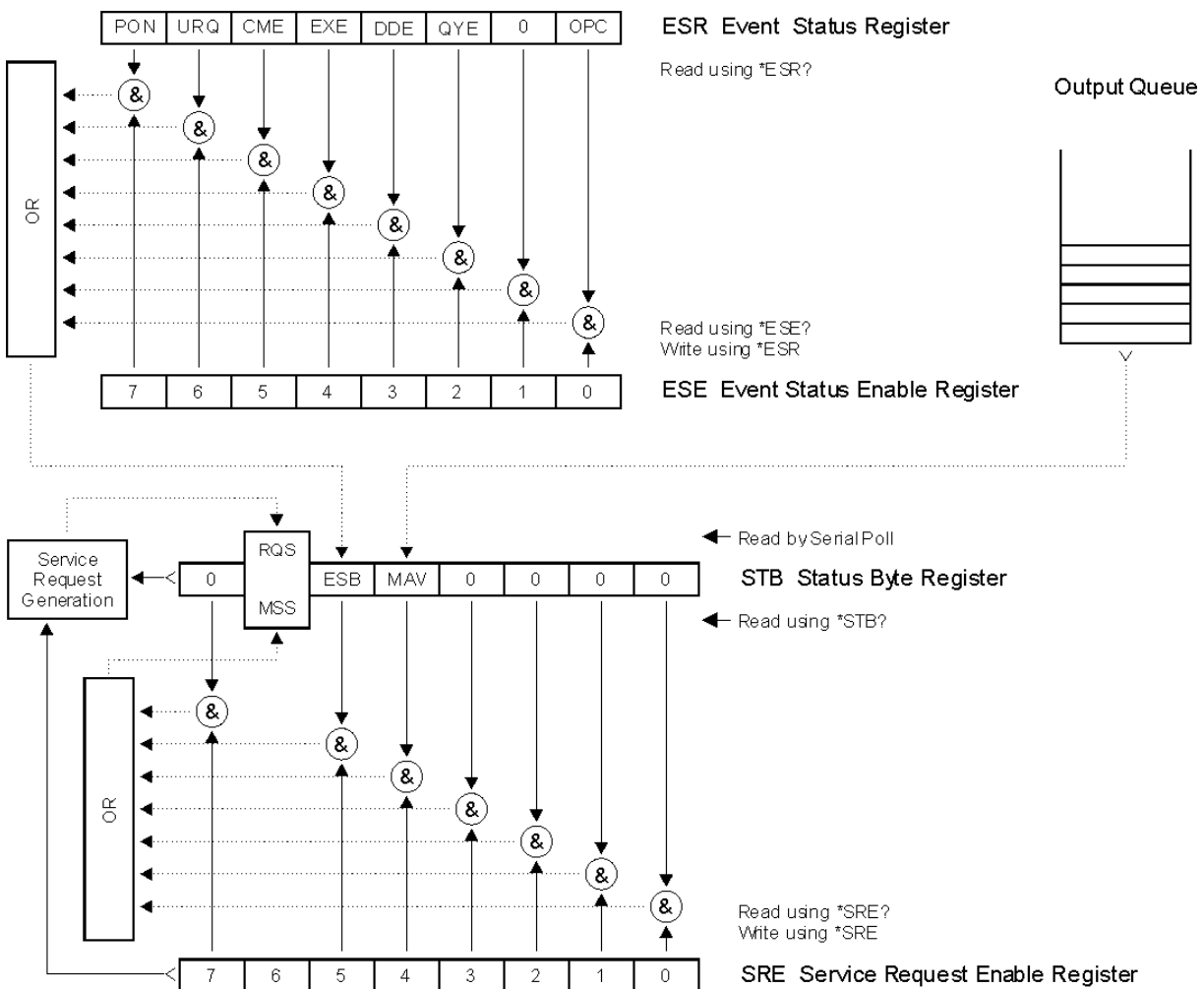
Status Register Overview

*SRE?, *SRE, *ESR?, *ESE?, *ESE a *CLS.

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 M141 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 M141.

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 use

Calibration of measurement instruments

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-wire 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.

Connecting the voltage input of the multimeter to the M141 voltage output:
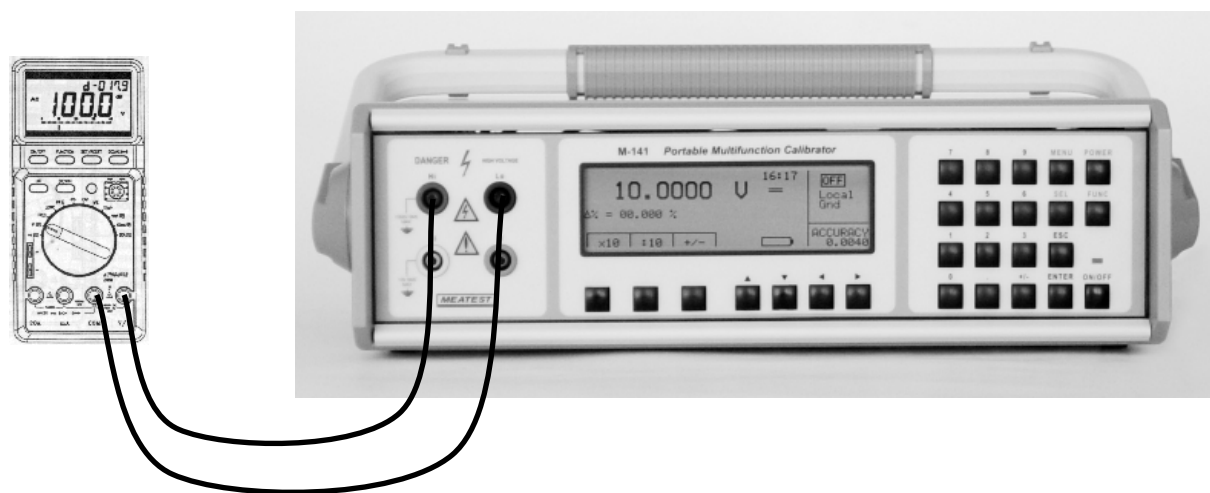
Current ranges

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 example1 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.

Connecting the ammeter to the current terminals:
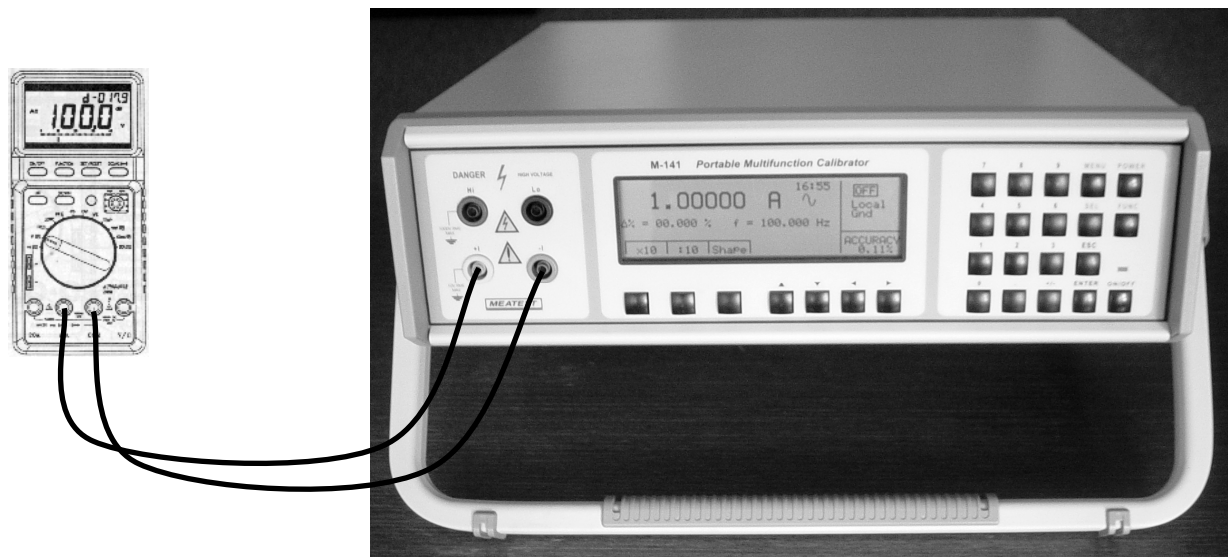
Optional current coil can extend the calibrator's current range to 100 A. The coil can be used for calibration of both DC and AC ammeters. The clamps of the ammeter must be positioned in angle 90° to the coil. When using the current coil, no steel or other magnetic objects must be present in the vicinity (50 cm) of the current coil, as they would deform the magnetic field and cause big calibration error.

Connection of current coil:
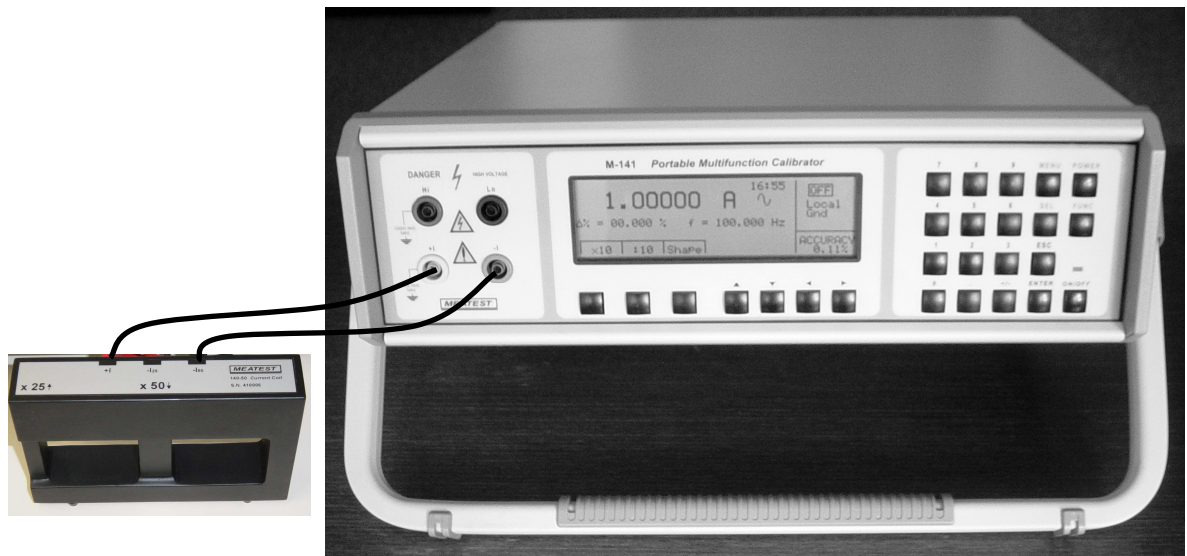
ATTENTION

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

Counters and oscilloscopes

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.

Specification

Bellow shown uncertainties are valid after specified warm-up time in temperature range 23 ± 2 °C. The uncertainties include long-term stability, temperature coefficient, linearity, load and line regulation and the traceability of factory and National calibration standards. Specified uncertainties are valid for one year after the last calibration. Specified uncertainties „of range" are related to the maximal value which cam be set on the range. All uncertainties are calculated for coefficient probability 95% in normal distribution.

Technical data

Voltage

Voltage range totally :	0 µV – 750 V DC, 1 mV – 750 V AC
Ranges :	100 mV, 1 V, 10 V, 100 V, 750 V
Frequency range :	1 mV - 10 V 20 Hz to 2 kHz,
	10 V – 100 V 40 Hz to 2 kHz
	100 V – 750 V 40 Hz to 1 kHz
Frequency resolution :	0.001 Hz to 1 kHz
	0.01 Hz to 2 kHz
Accuracy of frequency :	0.01%
Output waveform :	harmonic : sinus
	non-harmonic : triangle symmetrical, triangle A/ B , square, limited sin (with defined distortion k=13.45%) from 1 mV to 10 V, frequency range 20 to 80 Hz

DC voltage

Range	% of value + % of range
0.0000 µV – 10.0000 mV	0.05 + 0.005 + 10 µV
10.000 mV – 100.000 mV	0.01 + 0.001 + 10 µV
0.10000 mV – 1.00000 V	0.008 + 0.002
1.0000 V – 10.0000 V	0.008 + 0.002
10.000 V – 100.000 V	0.015 + 0.004
100.00 V – 750.00 V	0.018 + 0.004

AC voltage

Range	% of value + % of range	% of value + % of range
	20 Hz - 200 Hz	*200 Hz -2000 Hz*
1.0000 mV – 10.0000 mV	0.20 + 0.05 + 20 µV	0.20 + 0.10 + 20 µV
10.000 mV – 100.000 mV	0.10 + 0.03 + 20 µV	0.15 + 0.05 + 20 µV
0.10000 mV – 1.00000 V	0.05 + 0.005	0.07 + 0.01
1.0000 V – 10.0000 V	0.05 + 0.005	0.07 + 0.03
10.000 V – 100.000 V [*1]	0.05 + 0.010	0.07 + 0.03
100.00 V – 750.00 V [*2]	0.07 + 0.02	0.1 + 0.03

[*1] Voltage range 100 V from 40 Hz to 1000 Hz   [*2] Voltage range 750 V from 40 Hz to 1000 Hz

Auxiliary parameters

Range	10mV	100mV	1V	10V	100V	750V
THD[*3]	0.05 % + 200 µV	0.05 % + 300 µV	0.05 %	0.05 %	0.05 %	0.2 %
Maximum output current	5 mA	5 mA	10 mA	30 mA	10 mA	2 mA
Output impedance	< 10 mΩ	< 10 mΩ	< 10 mΩ	< 10 mΩ	< 100 mΩ	< 100 mΩ
Maximum capacitance load	500 pF	500 pF	500 pF	500 pF	300 pF	150 pF
Amplitude accuracy in non-harmonic mode (peak value)	0.3 % + 50 uV	0.3 % + 50 uV	0.3 %	0.3 %	--	--

[*3] Parameter includes harmonic distortion and non-harmonic noise in range to 1 MHz

Current

Current range totally :   0 µA – 2 A DC, 1 µA – 2 A AC
Ranges :   200 µA, 2 mA, 20 mA, 200 mA, 2A
Frequency range :   20 Hz to 1 kHz, accuracy of frequency 0.01%
Frequency resolution :   0.001 Hz
Output wave form :   harmonic :   sinus
                                 non-harmonic : triangle symmetric, triangle A/ B , square, limited sinus
                                 from 100 uA to 2 A, frequency range 20 to 80 Hz

DC current

Range	% of value + % of range
0.000 µA – 200.000 µA	0.05 + 0.0 + 20 nA
0.20000 mA – 2.00000 mA	0.025 + 0.005
2.0000 mA – 22.0000 mA	0.015 + 0.003
22.000 mA – 200.000 mA	0.015 + 0.003
0.20000 mA – 2 0000A	0.015 + 0.005

AC current

Range	% of value+% of range	% of value+% of range
	20 Hz – 200 Hz	*200 Hz – 1000 Hz*
1.000 µA – 200.000 µA	0.25 + 0.0 + 20 nA	0.30 + 0.10 + 20 nA
0.20000 mA – 2.00000 mA	0.10 + 0.01	0.20 + 0.05
2.0000 mA – 22.0000 mA	0.07 + 0.005	0.20 + 0.05
22.000 mA – 200.000 mA	0.07 + 0.005	0.20 + 0.05
0.20000 mA – 2 0000A	0.1 + 0.005	0.25 + 0.05

Auxiliary parameters

Range	200 µA	2 mA	20 mA	200 mA	2 A
Maximum inductive load	400 µH	400 µH	400 µH	400 µH	200 µH
Maximum voltage on the load (pk)	2 V	2 V	2 VAC, 7 VDC	2 V	2 V
THD[*4]	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %
Amplitude accuracy in non-harmonic mode (peak value)	0.3 % + 1 uA	0.3 % + 1 uA	0.3 %	0.3 %	0.3 %

[*4] Parameter includes harmonic distortion and non-harmonic noise in range to 1 MHz

Resistance

Range totally :   10 Ω to 100 MΩ in fix decade values
Maximum voltage/dissipation power :   50 Vef / 0.1 W

Range	Calibration uncertainty[%]	Tolerance [%]
10.0000 Ω	0.03 + 10 mΩ	0.2 + 100mΩ
100.000 Ω	0.05	0.2 + 100mΩ
1.00000 kΩ	0.02	0.2
10.0000 kΩ	0.02	0.2
100.000 kΩ	0.02	0.2
1.00000 MΩ	0.05	0.2
10.0000 MΩ	0.05	1
100.000 MΩ	0.5	2

RTD temperature sensor simulation (option)

Type :   Pt 100-1000, Ni 100-1000
Temperature scale :   ITS90, IPTS68
Temperature standard: IEC (1.385), US (1.391)
Accuracy

Temperature range	Pt100-Pt200	Pt201-Pt1000
-200.0 … 0.0 °C	0.2 °C	0.2 °C
0.1 … 850.0 °C	0.2 °C	0.2 °C

Temperature range	Ni100-Ni200	Ni201-Ni1000
-60.0 … 0.0 °C	0.2 °C	0.1 °C
0.1 … 300.0 °C	0.1 °C	0.1 °C

Ranges and accuracy of the thermocouple sensor simulation

Type :   R, S, B, J, T, E, K, N
Temperature scale :   ITS90, IPTS68

R	range [°C]	-50.0 – -0.1	0.0 – 399.9	400.0 – 999.9	1000.0 – 1767.0
	accuracy [°C]	2.5	2.0	1.2	1.2
S	range [°C]	-50.0 – -0.1	0.0 – 249.9	250.0 – 1399.9	1400.0 – 1767.0
	accuracy [°C]	2.2	2.1	1.5	1.5
B	range [°C]	400.0 – 799.9	800.0 – 999.9	1000.0 – 1499.9	1500.0 – 1820.0
	accuracy [°C]	2.7	1.5	1.4	1.3
J	range [°C]	-210.0 – -100.1	-100.0 – 149.9	150.0 – 699.9	700.0 – 1200.0
	accuracy [°C]	0.9	0.4	0.3	0.4
T	range [°C]	-200.0 – -100.1	-100.0 - -0.1	0.0 – 99.9	100.0 – 400.0
	accuracy [°C]	0.9	0.5	0.3	0.3
E	range [°C]	-250.0 - -100.1	-100.0 – 279.9	280.0 – 599.9	600.0 – 1000.0
	accuracy [°C]	1.7	0.3	0.2	0.3
K	range [°C]	-200.0 - -100.1	-100.0 – 479.9	480.0 – 999.9	1000.0 – 1372.0
	accuracy [°C]	0.8	0.4	0.4	0.5
N	range [°C]	-200.0 - -100.1	-100.0 – -0.1	0.0 – 579.9	580.0 – 1300.0
	accuracy [°C]	1.3	0.6	0.6	0.5

Uncertainties in the table are maximal uncertainties of TC sensor simulation. Actual uncertainty for each set value of simulated temperature is determined by uncertainty of relevant resistance. Actual temperature uncertainty is displayed on the calibrator display. Actual uncertainties are always lower than those in above table.

When automatic compensation of cold junction temperature via external Pt1000 sensor is used, summary uncertainty of simulated temperature is higher due to limited accuracy of measuring ambient temperature with the external sensor. This additional uncertainty is 0.2 °C in temperature range from 15 to 35 °C.

Frequency

Waveform :   square with fix amplitude 5Vpk-pk / 50 Ohm
Frequency range :   0.1 Hz to 2 MHz
Frequency resolution :   5 ½ digit
Uncertainty: 0.005%

General data

Reference temperature range :   23 °C ± 2 °C (for specified uncertainties)
                                    In temperature range 23 °C ± 5 ° uncertainties are 2 x higher
Warm-up time :   5 min
Working temperatures :   +5 °C … +40 °C
Temperature coefficient   Temperature coefficient for temperature outside of Tcal ±2
                                    °C between +5 °C to +40 °C is 0.15 x /°C
Storing temperatures :   -10 to 55 °C at relative humidity to 80 %
Pressure :   86000 to 106000 Pa
Power supply voltage :   115/230V - 50/60 Hz
Power consumption :   40 VA max
Dimensions :   325mm x 111mm x 316mm

Weight :   9 kg
Interface: RS232, (IEEE488 optionally)
Fuses :   Fuse T1L250 – 230 V, T2L250 – 115 V

Modifications

M-141   basic model with RS-232
M-141GPIB   model with both RS-232 and GPIB interface

Accessory (included in basic delivery)

- Power line cord   1 pc
- Operation manual   1 pc
- Test report   1 pc
- Spare fuse   1 pc
- Test cable   2 pcs
- Option RS-232   Cable RS-232
- RTD Test cable   1 pc (when option RTD simulator built-in only)

Options (extra ordered)
- Option 140-50   Current coil 25/50 turns
- Option 10   Test cable 20A/1000V (red)
- Option 11   Test cable 20A/1000V (black)
- Option GPIB   Cable GPIB IEEE488/IEEE488, 2m
- WinQbase/CALIBER   Application SW for automatic calibration of meters

Manufacturer

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