meatest

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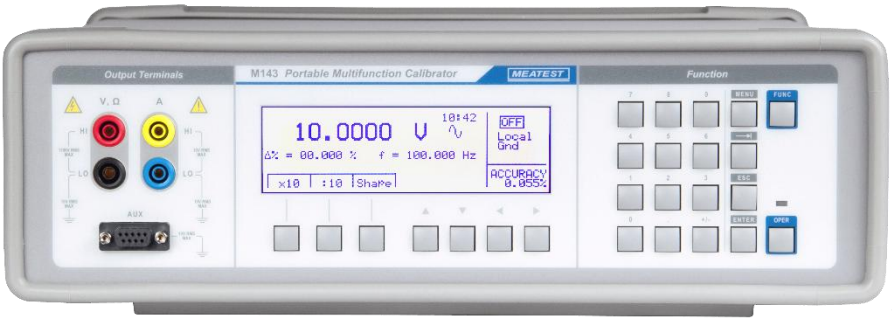
M143 Portable Multifunction Calibrator

user manual



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1. Introduction

Portable Multifunction Calibrator M143/143i is designed as universal calibration tool for electrical calibration laboratories and adjustment in manufacturing processes. It can be used for calibration and testing of measuring instrument which measure voltage, current, resistance and frequency. The calibrator sources harmonic and non-harmonic signals with accurate amplitude. It includes function of simulation of thermocouple temperature sensors for testing of process meters and as option function of RTD sensor simulation.

1.1. Front panel overview

Main control segments of the calibrator are:

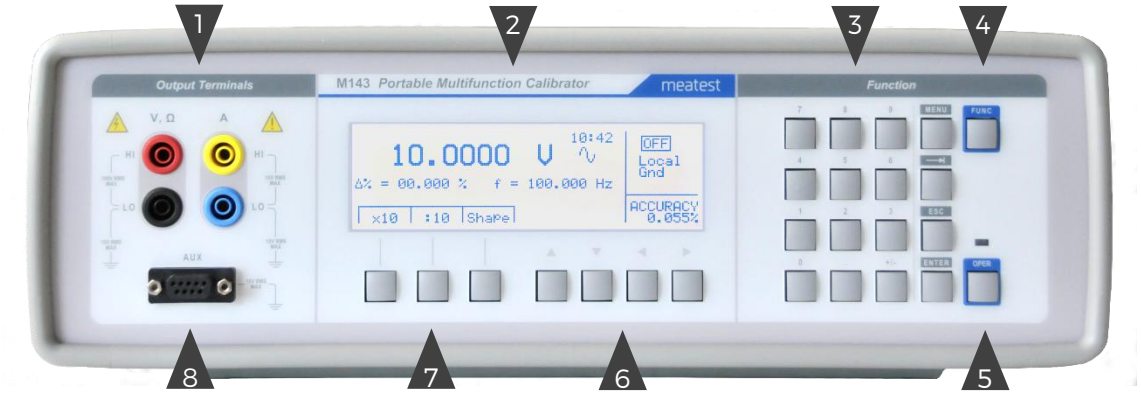


Figure 1 Front panel

1. Output terminals - Output signal is connected to the output terminals. Current ranges are connected to **A +I / -I** terminals. Voltage, resistance, TC sensor simulation and frequency functions are available at **V Hi / Lo** terminals.
2. Display
3. Numerical keypad - Numerical values can be entered from the keyboard. ENTER button is used to confirm the selection. ESC button can be used to cancel the entry.
   MENU button - Open Main menu of the instrument (parameters setting).
   ⇥ Select button – Select value you want to change.
   ESC button – Exit / Cancel button.
   Enter button – Confirmation button.
4. Button for function selection.
5. OPER button - Turns output ON/OFF according to selected function and parameters.
6. Cursor buttons - The keyboard includes two buttons (<, >) which allow the cursor to be set to the required position at the display. Remaining two buttons (∧, ∨) allow the user to increase or decrease the number at the cursor.
7. Display button output/input - Three buttons located under the display has alternative meaning. Their actually valid function is labeled on the display.
8. Auxiliary output/input - The auxiliary connector is aimed as input for Opt 143-90 external Pt1000 temperature sensor. Another function is output of RTD temperature sensor simulation using Opt 143-60.

1.1.1. Display in detail

Display is divided into several sections with following meaning:

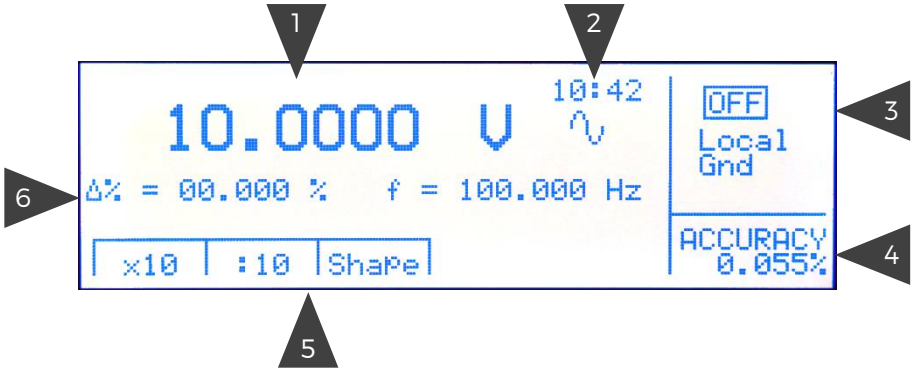


Figure 2 Display

1. Main field - Main value. Can be edited via numerical input or cursor keys or rotary. Symbol on the right represents signal shape.
2. Time field - displays time
3. Information field - In the field some additional information are displayed:
   - Output terminals - Symbol of output ON (rectangle symbol) or output OFF. In parallel LED diode is turning on/off above the OPER button.
   - Local/Remote control - In remote control label REM is displayed, in manual mode label LOCAL is shown.
   - 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.
   - Grounding of Lo/-I terminals.
   - Selected TC temperature sensor in TC sensor simulation mode.
4. Accuracy field - Currently valid accuracy of the main parameter. It is calculated from specification of the calibrator and it is displayed in %.
5. Display button field - Labels related to the display buttons. 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

6. Auxiliary parameter field - Auxiliary parameters of the output signal are displayed. To these parameters belong:
   - Set relative deviation in % (max ± 30.000 %)
   - Frequency of AC voltage/current
   - Temperature of cold junction in TC temperature sensor simulation mode, type of TC sensor

1.2. Rear panel overview

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

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

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

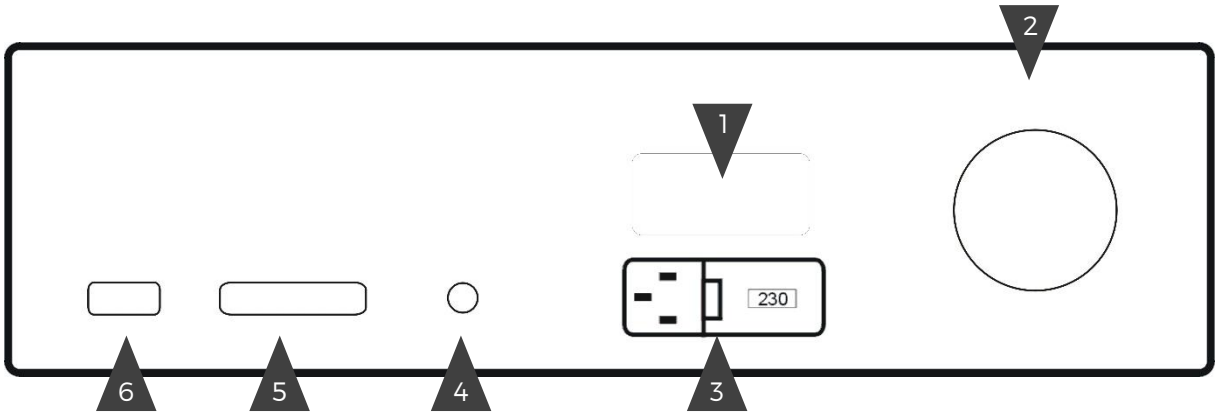


Figure 3 Rear panel

1. Model plate
2. Fan outlet cover
3. Power cord module
4. Grounding post
5. GPIB connector (optional)
6. RS-232 connector

1.3. Options and accessories

Every M143 Portable Multifunction Calibrator delivery includes following items:

- USB stick with user manual 1 pc
- Factory calibration certificate 1 pc
- Power cord (with European E-type plug, feel free to ask for other types when ordering) 1 pc
- Spare fuse 1 pc
- Test cable 1000 V / 20 A 2 pcs

Following accessory is not part of standard delivery and can be extra ordered:

- Option 143-90 Pt1000 Temperature sensor
- Option 143-60 Cable adapter

1.4. Remote control

The calibrator can be integrated into automated calibration systems (ATS) and generally controlled from remote computer via following remote control interfaces:

- RS232
- GPIB (IEEE488) (option)

When controlled remotely, maximum ratings of calibrator's output signals as well as all other specifications are the same as in manual mode.

Meatest software package WinQbase + Caliber is recommended for best automation results. This system is designed for automated and semi automated calibrations of digital and analogue meters including uncertainty calculation, result evaluation and certificate printing according to ISO 17025 standard.

1.4.1. Connection setup

Only one interface can be used for communication at any given time. Default active interface is RS232, other interfaces can be selected in MENU. To establish connection between the calibrator and computer, set interface settings in your computer accordingly:

RS232 connection settings

- COM port — see available COM ports in Windows Device Manager
- Baudrate RS232 — according to MENU->Interface->RS232 Baudrate (9600 by default)
- Data bits — 8
- Stop bits — 1
- Parity — None
- Handshake (XON/XOFF) — Off

GPIB connection settings

- GPIB Address — according to MENU ->GPIB Address (2 by default) (option)

1.4.2. SCPI commands and protocol

See M143 SCPI manual for complete SCPI reference, more details on communication setup and troubleshooting.

2. Getting started

Inspect package contents when unboxing the calibrator for the first time. See chapter 1.3 for complete list of accessories.

Place the instrument on a level surface before powering on and let it stabilize for at least one hour if the instrument has been stored outside of reference temperatures beforehand.

2.1. Safety precautions

The instrument has been designed according to IEC 61010-1 + A2 amendment of sthe standard. Safety is ensured by design and by use of specific components. The manufacturer is not liable for the damage caused by modification of the construction or replacement of parts with non-original ones.

Safety symbols used on the equipment:

Warning, risk of danger.

Warning - risk of electric shock. Hazardous voltage above 50 V DC or AC might be present.

Protective earth.

To prevent possible electrical shock or personal injury:

- Read carefully safety information before you use the Product.
- Do not alter the Product and use only as specified, or the protection supplied by the Product can be compromised.
- Do not use the Product if it is altered or damaged.
- Use this Product indoors only.
- Use power cord approved for local mains voltage and plug configuration and rated for the Product.
- Keep hands away from all Product terminals and exposed metal cable parts during operation. High voltage on those may be cause death or serious injury.
- 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, bottom panel and prevent dust and moisture contamination.
- Whenever possible ground Lo output terminals (GndU On, GndI On).
- Do not overload the power stages by leaving the calibrator switched on with the load connected for a long time especially on 20 A current range and 1000 V voltage ranges.

2.2. Power on and warm-up

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

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

Plug one end of the power cord into connector on the rear panel and connect the other end of the power cord into a wall outlet. Turn the calibrator on with mains switch right next to it.

Warm-up

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

2.3. Function setup

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

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

Once a function is selected, you can change the main value as well as auxiliary output parameters Function parameters can be edited in three ways:

- Numeric keypad. Write a value directly and confirm either by softkey with appropriate unit or ENTER button to set value in base unit (for example V).
- Cursor keys. Push ∧ or ∨ buttons to increment/decrement selected digit by one. Move through parameter digits using < and > buttons.
- Softkeys. Values of most parameters can be also changed by softkeys x10 and :10, which change value by order of magnitude and +/- softkey which switches polarity or Shape softkey that will change shape of signal.

Described methods change the main parameter by default. If there are any other parameters on display, you can switch between them using ⇥ (SEL) select button.

2.4. Signal output

Calibrator output can be turned on by pushing OPER button. Pressing it again turns output off. Output turns off automatically on calibrator startup and function switch. Output state is indicated by LED light above OPER button as well as rectangle on the top right side of the display when output is ON. When output is off - symbol OFF will be in that place instead.

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

2.5. What to do in case of failure

If an obvious failure occurs during the operation (e.g. the display is not lit, the fan is not turning), the calibrator must be switched off immediately. First, check the fuse located in the power cord receptacle. Procedure is following:

- 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 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 the manufacturer.

If an obvious fault is evidenced, e.g. a measurement range or an operating mode is not functional, the user cannot correct the fault. Contact the manufacturer.

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 fault is caused by 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 connections 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.

3. 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:

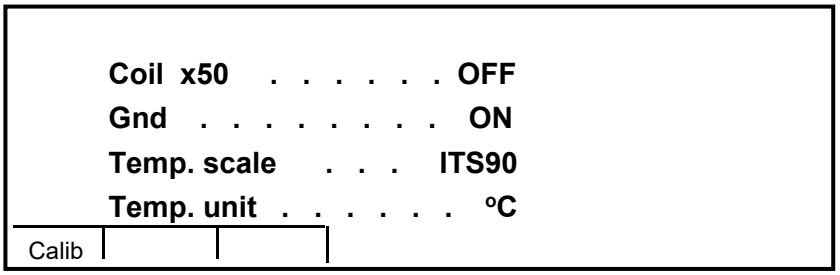


Figure 4 Setup menu display

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:

Coil x50	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.
GND	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.
Temp. scale	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.
Temp. unit	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.
RJ Temp.	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.
Interface	Displays the type of interface used to control the calibrator from a PC. By pressing GPIB or RS232 buttons, the respective type can be selected. The calibrator can be remotely controlled only using the selected interface. GPIB interface is delivered as option only. Note: GPIB can work only if option GPIB is installed in the calibrator. If not, use RS232 interface.
GPIB address	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.
RS232 baud rate	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.
Handshake	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.
Keyb. beep	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.
Beep. volume	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.
Display	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.
Contrast	Setting the contrast of the display. BY pushing the display button higher or low contrast can be set in range 00 to 31.
Cal. code	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.
Cal. date	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.
Serial nr.	Displays the serial number of the calibrator. The parameter cannot be changed
Time	Displays real time. The parameter can be changed using HOUR, MIN +, MIN - display buttons.
Date	Displays real time. The parameter can be changed using DAY, MONTH, YEAR display buttons.
Time on display	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.

3.1. Calibration menu

Calibration menu contains internal calibration constants and other tools for device adjustment and is therefore password protected. See chapter 6 for more details on M143 adjustment.

4. Control of the calibration

4.1. AC/DC 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 1000 V_{rms} can be present at the terminals. Real voltage ranges are as follows:

DC voltage range from 0 to 1000 V.

AC voltage range from 1 mV to 1000 V

Control in the voltage mode

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

Output voltage over 100 V

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

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

Output terminals overloading

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

It is not possible to disconnect the output voltage using the buttons located at the front panel when the calibrator is in remote mode! The calibrator must be first switched to local control mode by pressing the LOCAL button and then the output terminals can be disconnected!

Voltage ranges

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

It is not recommended to connect non-standard load to the voltage output. The calibrator is designed as a source of precise voltage for calibration of voltmeters. Output terminals should be loaded with high

and real impedance. Although the output is fitted with fast electronic and microprocessor protection, high capacitance or inductance loads can lead to oscillations of output amplifiers and result in damage.

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

Connect voltage input of the multimeter to the M143/143i voltage output:

Figure 5 Voltmeter calibration

4.2. AC/DC current

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

DC current range	from 0 to 20 A in M143	from 0 to 2 A in model M143i
AC current range	from 1μA to 20 A in M143	from 1μA to 2 A in model M143i

When Current coil 50/25 (option 140-50) is used, maximal simulated AC current is 1000 A (100 A in M143i).

Control in the current mode

- Press the button FUNC and select AC or DC current mode. The display shows the following data:
  main data of set current
  relative deviation
  accuracy of output current
  frequency (when AC current is generated)

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

Note: M143/143i current power stage is cooled by fan with variable speed. Variable noise can be heard when set to AC/DC current function, especially at range 20A.

Note: M143 can supply external load for limited period in range 10A to 20A.Default period is 5 minutes at 20 A and 15 minute at 10 A. It can vary depending on previous load conditions. Full recovery to starting condition takes about 5 minutes.

Overloading the terminals

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

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.

Connect ammeter to the output current terminals:

Figure 6 Ammeter calibration

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

Connection of current coil:

Figure 7 Current coil connection

4.3. Non-harmonic mode

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

The calibrator can generate the following shapes:

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

Generation of non-harmonic signals has some limitations:

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

Control in the non-harmonic mode

- Select AC voltage or AC current mode.
  The main section of the display shows the following data:
  main data of set current or voltage, unit of measurement
  relative deviation
  frequency
  selected SHAPE of the output signal
- Keep pressed SHAPE display button to select the desired shape of the output signal:
  The output terminals are automatically disconnected when the shape of the output signal is changed. Relative deviation is reset.

Information on display

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

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

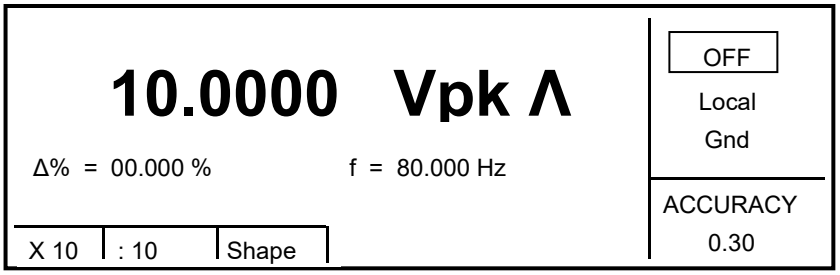


Figure 8 Non-harmonic mode display

4.4. Resistance

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

Resistance range is 10Ω, 100Ω, 1kΩ, 10kΩ, 100kΩ, 1MΩ, 10MΩ, 100MΩ.

Control in the resistance mode

- Press FUNC button and select resistance function.
  The display shows the set resistence:
  calibration value of set resistance in Ω
  accuracy of the resistance
- To change the resistance value press the display button x10 or: 10.
- Press the button OPER button to connect the resistance to the output terminals; the information section of the display shows rectangle symbol.
- Red LED is lit above the OPER button and indicates that the resistance is connected to the output terminals.
- Resistance mode is suitable for use in DC applications and AC applications to 10 kHz.

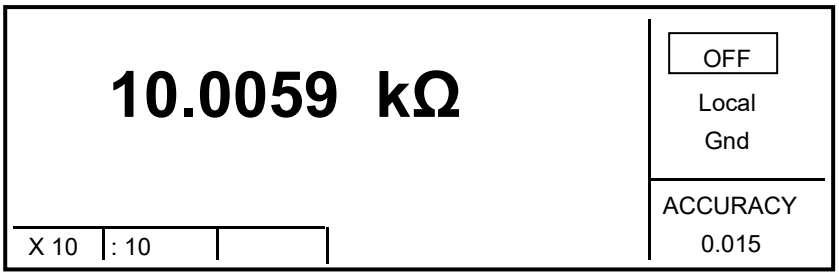


Figure 9 Resistance display

4.5. Frequency mode

Multifunction calibrator can generate square wave 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.

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

Control in the frequency mode

- Press FUNC button and select frequency mode.
  The display shows following data:
  set frequency as main parameter
  relative deviation of frequency
  accuracy of frequency
- Set the frequency using numeric keyboard or cursor buttons. Output signal is not yet connected to the output terminals.
- Connect the object of calibration to left Hi and Lo terminal.
- Press OPER button. Red LED is lit above the OPER button to indicate the connection of signal to the output connector; the information section of the display shows rectangle symbol.

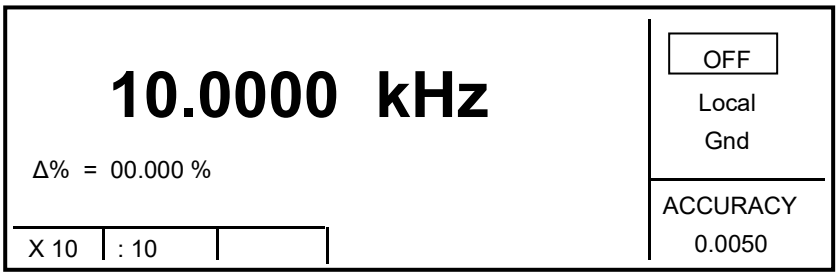


Figure 10 Frequency mode display

Note: Output impedance in frequency mode is 50 Ω on Hi – Lo terminals.

Counters and scopes

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

- Calibration of frequency functions up to 2 MHz using square wave 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 square wave output form. Frequency and amplitude can be set.
- The instrument to be calibrated is connected to the Hi – Lo output terminals.

4.6. Simulation of RTD temperature sensors (Option RTD)

Multifunction calibrator can optionally simulate resistance temperature sensors.

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

Temperature setting range:	-250 to +850 °C for Pt temperature sensors
	-60 to +300 °C for Ni temperature sensors
Temperature scale:	ITS 90, PTS 68
Front panel RTD connector connection:	D-SUB 09

Temperature setting

- Press FUNC button on the calibrator and select RTD sensor simulation function.
  The display shows following data:
  main data of temperature in °C or K
  sensor type thermocouples: Pt or Ni
  set value of absolute deviation in %, labeled ΔT = xxxx.x °C (K)
  the auxiliary section shows:
  temperature scale type
  accuracy of simulated temperature value of selected temperature sensor type
- Set the main value of temperature using numeric keyboard or cursor buttons. 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 OPER button. Red LED is lit above the OPER button to indicate that the output signal is connected to the output terminals. The display shows rectangle symbol of connected output terminals.

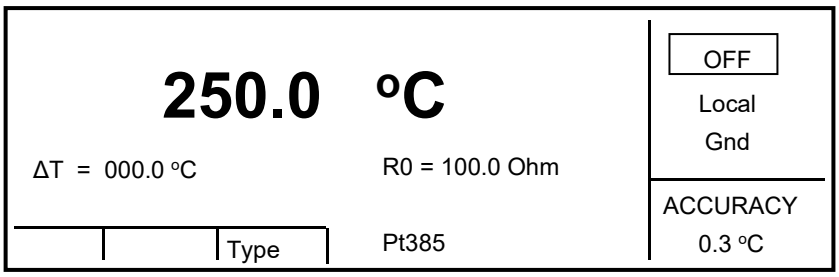


Figure 11 RTD simulation display

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

Switching between temperature sensor types

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

R0 coefficient for resistance temperature sensors setting

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

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

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

4.7. Simulation of TC temperature sensors

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

Temperature setting range: -250 to +1820 °C depending on simulated sensor type

Sensor types: M, R, S, B, J, T, E, K, N, C, D, G2

Temperature scale: ITS 90, PTS 68

Setting the temperature

- Press FUNC button on the calibrator and select TC sensor simulation.
  The display shows following data:
  main data of temperature in °C or K
  sensor type thermocouples: M, R, S, B, J, T, E, K, N, C, D, G2
  cold junction temperature of thermocouple sensors RJ
  set value of absolute deviation in %, labeled ΔT = xxxx.x °C (K)
  the auxiliary section shows:
  temperature scale type
  accuracy of simulated temperature value of selected temperature sensor type

- Set the main value of temperature using numeric keyboard or cursor buttons. Output terminals are disconnected. The information section of the display shows the symbol OFF which means that output terminals are disconnected.
- Connect the object to be calibrated to Hi - Lo terminals.
- Press OPER button. Red LED is lit above the OPER button to indicate that the output signal is connected to the output terminals. The display shows rectangle symbol of connected output terminals.

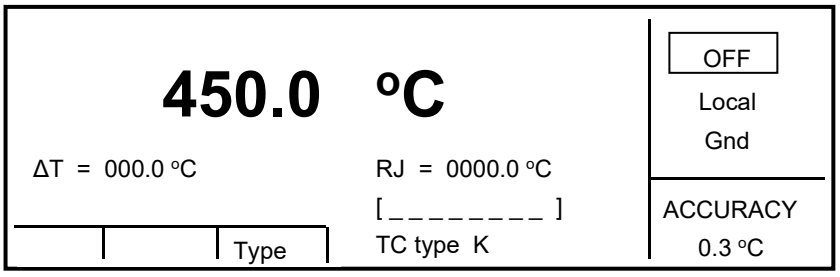


Figure 12 TC sensor simulation

Switching between temperature sensor types

- Press the button TYPE.
- Calibrator switches among thermocouples in order M, R, S, B, J, T, E, K, N, C, D, G2. Currently set type of thermocouples is displayed in form TC TYPE x, where x means type of thermocouple.

Cold junction temperature compensation RJ

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

Manual compensation

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

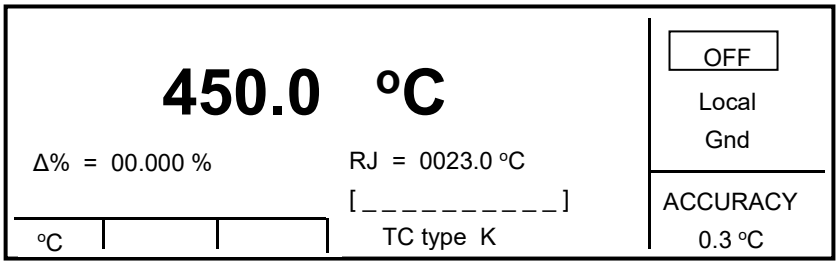


Figure 13 Manual RJ compensation display

Automatic compensation

- Connect Option 143-90 External temperature sensor to the AUX connector.
- Push the button MENU. With cursor buttons ∨, ∧ select function RJ Temp. and with display buttons select parameter MEAS.
- Push FUNC button and 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.

For temperature scale selection ITS90 / PTS68 use SETUP menu.

Burden current in TC sensor simulation mode is 2 mA.

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 pressing FUNC button and selecting TC function. Temperature sensors type R, S, B, J, T, E, K, N, C, D, G2, M can be simulated. Unit under test is connected to the Hi – Lo output terminals. The voltage between calibrator's –I and Lo outputs must not exceed 10 V.

5. Performance verification

Specifications of this calibrator are defined for 1 year period so it should be periodically tested (and adjusted if necessary) within the same period of time. If you don't have the necessary equipment or can't do the calibration on your own, please ask local Meatest representative to help you calibrate this device.

5.1. Required equipment

Following instruments are required for performance verification test:

- 8½ digit multimeter like Keysight 3458A, Fluke 8508A/8588A or similar with uncertainty 10 ppm or better on DC voltage, 100 ppm on AC voltage
- 10 mΩ or 100 mΩ resistance shunts Burster 1280 or similar with uncertainty 100 ppm or better
- Counter Keysight 53181A, HO 53130 or similar with uncertainty 10 ppm or better
- (optional for THD measurement) Distortion analyzer Keysight 8903A or oscilloscope with at least 20 MHz bandwidth

5.2. Verification procedure

1. Place the calibrator to the standard condition and let it switched on for at least one hour in a laboratory in reference conditions.
2. Set GND item in M143's Setup menu to ON in order to suppress mains noise during measurement. Use toroidal chokes to suppress ground loop noise if needed.
3. Connect output terminals of the calibrator to the input voltage terminals of the standard device. Set parameters which enables the most accurate measurement in standard device.
4. Use table in chapter 5.3 to verify all recommended test points. Measured deviation should not exceed the limits in tables.
    a. DC voltage test
    b. AC SINE voltage test
    c. (optional) harmonic distortion test at 1 V, 1 kHz. THD should not exceed 0.05%.
    d. DC current test
    e. AC current SINE test
    f. 4W resistance test
    g. Frequency test
    h. 4W RTD simulation test

5.3. Test points

Function	Range	Nominal	Min value	Max value	Unit	Test parameters
DC Voltage	10	-10.0000	-10.012	-9.988	mV	
		-5.0000	-5.0095	-4.9905	mV	
		5.0000	4.9905	5.0095	mV	
		10.0000	10.012	9.988	mV	
	100	-100.000	-100.017	-99.983	mV	
		-50.000	-50.012	-49.988	mV	
		-11.000	-11.0081	-10.9919	mV	
		11.000	10.9919	11.0081	mV	
		50.000	49.988	50.012	mV	
		100.000	99.983	100.017	mV	
	1	-1.00000	-1.00007	-0.99993	V	
		-0.50000	-0.50004	-0.49996	V	
		-0.11000	-0.11002	-0.10998	V	
		0.11000	0.10998	0.11002	V	
		0.50000	0.49996	0.50004	V	
		1.00000	0.99993	1.00007	V	
	10	-10.0000	-10.0007	-9.99935	V	
		-8.0000	-8.00053	-7.99947	V	
		-6.0000	-6.00041	-5.99959	V	
		-4.0000	-4.00029	-3.99971	V	
		-2.0000	-2.00017	-1.99983	V	
		2.0000	1.99983	2.00017	V	
		4.0000	3.999712	4.000288	V	
		6.0000	5.999592	6.000408	V	
		8.0000	7.999632	8.000368	V	
		10.0000	9.99935	10.00065	V	
	100	-100.000	-100.007	-99.993	V	
		-50.000	-50.004	-49.996	V	
		-11.000	-10.9983	-11.0017	V	
		11.000	10.99834	11.00166	V	
		50.000	49.996	50.004	V	
		100.000	99.993	100.007	V	
	1000	-950.00	-950.114	-949.886	V	
		-300.00	-300.051	-299.949	V	
		300.00	299.949	300.051	V	
		950.00	949.886	950.114	V	
Voltage AC	10	10.0000	9.955	10.045	mV	120 Hz
		10.0000	9.95	10.05	mV	1 kHz
		10.0000	9.95	10.05	mV	10 kHz
	100	11.000	10.939	11.061	mV	120 Hz
		100.000	99.85	100.15	mV	120 Hz
		100.000	99.78	100.22	mV	1 kHz
		100.000	99.78	100.22	mV	10 kHz
	1	0.11000	0.109895	0.110105	V	120 Hz
		1.00000	0.99945	1.00055	V	120 Hz

Function	Range	Nominal	Min value	Max value	Unit	Test parameters
		1.00000	0.9992	1.0008	V	1 kHz
		1.00000	0.9992	1.0008	V	10 kHz
	10	2.0000	1.9985	2.0015	V	120 Hz
		4.0000	3.9975	4.0025	V	120 Hz
		6.0000	5.9965	6.0035	V	120 Hz
		8.0000	7.9955	8.0045	V	120 Hz
		10.0000	9.9945	10.0055	V	120 Hz
		10.0000	9.99	10.01	V	1 kHz
		10.0000	9.99	10.01	V	10 kHz
	100	11.000	10.9845	11.0155	V	120 Hz
		100.000	99.94	100.06	V	120 Hz
		100.000	99.9	100.1	V	1 kHz
	1000	300.00	299.59	300.41	V	120 Hz
		950.00	949.135	950.865	V	120 Hz
		950.00	948.75	951.25	V	1 kHz
Current DC	200	-190.000	-190.115	-189.885	µA	
		-20.000	-20.03	-19.97	µA	
		20.000	19.97	20.03	µA	
		190.000	189.885	190.115	µA	
	2	-1.90000	-1.90058	-1.89943	mA	
		-0.21000	-0.21015	-0.20985	mA	
		0.21000	0.209848	0.210153	mA	
		1.90000	1.899425	1.900575	mA	
	22	-19.0000	-19.0035	-18.9966	mA	
		-10.0000	-10.0021	-9.9979	mA	
		-2.1000	-2.10092	-2.09909	mA	
		2.1000	2.099085	2.100915	mA	
		10.0000	9.9979	10.0021	mA	
		19.0000	18.99655	19.00345	mA	
	200	-190.000	-190.035	-189.966	mA	
		-160.000	-160.03	-159.97	mA	
		-120.000	-120.024	-119.976	mA	
		-80.000	-80.018	-79.982	mA	
		-40.000	-40.012	-39.988	mA	
		40.000	39.988	40.012	mA	
		80.000	79.982	80.018	mA	
		120.000	119.976	120.024	mA	
		160.000	159.97	160.03	mA	
		190.000	189.9655	190.0345	mA	
	2	-1.9000	-1.90039	-1.89962	A	
		-0.2100	-0.21013	-0.20987	A	
		0.2100	0.209869	0.210132	A	
		1.9000	1.899615	1.900385	A	
	20	-19.000	-19.021	-18.979	A	
		-2.100	-2.1041	-2.0959	A	
		2.100	2.0959	2.1041	A	

Function	Range	Nominal	Min value	Max value	Unit	Test parameters
		19.000	18.979	19.021	A	
Current AC	200	10.000	9.955	10.045	µA	120 Hz
		190.000	189.505	190.495	µA	120 Hz
		190.000	189.42	190.58	µA	1 kHz
	2	0.21000	0.20959	0.21041	mA	120 Hz
		1.90000	1.8979	1.9021	mA	120 Hz
		1.90000	1.8977	1.9023	mA	1 kHz
	20	2.1000	2.09753	2.10247	mA	120 Hz
		10.0000	9.992	10.008	mA	120 Hz
		19.0000	18.9857	19.0143	mA	120 Hz
		19.0000	18.977	19.023	mA	1 kHz
	200	21.000	20.9753	21.0247	mA	120 Hz
		100,000	99.92	100.08	mA	120 Hz
		190.000	189.857	190.143	mA	120 Hz
		190.000	189.77	190.23	mA	1 kHz
	2	0.21000	0.20969	0.21031	A	120 Hz
		1.90000	1.898	1.902	A	120 Hz
		1.90000	1.89615	1.90385	A	1 kHz
	20	2.1000	2.0928	2.1072	A	120 Hz
		19.0000	18.959	19.041	A	120 Hz
		19.0000	18.9425	19.0575	A	1 kHz
Resistance 2 W	10	10	9.945	10.055	Ω	DC
	100	100	99.98	100.02	Ω	DC
	1000	1000	999.8	1000.2	Ω	DC
	10	10	9.998	10.002	kΩ	DC
	100	100	99.980	100.020	kΩ	DC
	1	1	0.9995	1.0005	MΩ	DC
	10	10	9.995	10.005	MΩ	DC
	100	100	99.5	100.5	MΩ	DC
FREQ	20	10	9.9995	1.0005	KHz	
	200	100	99.995	100.005	KHz	
	2	1	0.99995	1.00005	MHz	

Function	Value (˚C)	Limits of measured resistance		Unit	Test parameters
		Min value	Max value		
RTD Simulator	-50.0	80.1149	80.5149	Ω	D68, Pt385, R_0=100 Ω
	0.0	99.8	100.2	Ω	D68, Pt385, R_0=100 Ω
	100.0	138.3	138.7	Ω	D68, Pt385, R_0=100 Ω
	600.0	313.394	313.794	Ω	D68, Pt385, R_0=100 Ω
	-50.0	802.949	803.349	Ω	D68, Pt385, R_0=1 000 Ω
	0.0	999.8	1000.2	Ω	D68, Pt385, R_0=1 000 Ω
	100.0	1384.8	1385.2	Ω	D68, Pt385, R_0=1 000 Ω
	600.0	3135.742	3136.14	Ω	D68, Pt385, R_0=1 000 Ω

Table 1 Test points

6. Adjustment

Adjustment is done through MENU > Calib. This menu item is password protected, default factory set calibration code is “000000”.

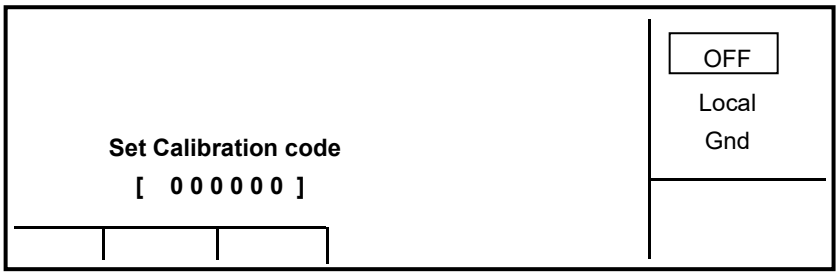


Figure 14 Manual RJ compensation display

Note: 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. The calibration can only be controlled using the front panel buttons and menu on the calibrator.

6.1. Calibration menu structure

Calibration data are sorted in a tree structure with following hierarchy:

1. Functions (f.e. Voltage DC)
2. Ranges (f.e. 10 mV)
3. Calibration points (f.e. 10146350)

After the calibration menu is displayed, any of partial calibrations can be selected. Use ∧ and ∨ 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:

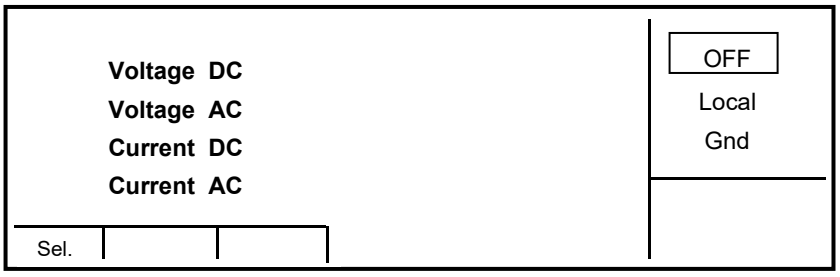


Figure 15 Calibration menu with out-of-date calibration data

Once range level of the tree structure is reached, calibration points are displayed in following format:

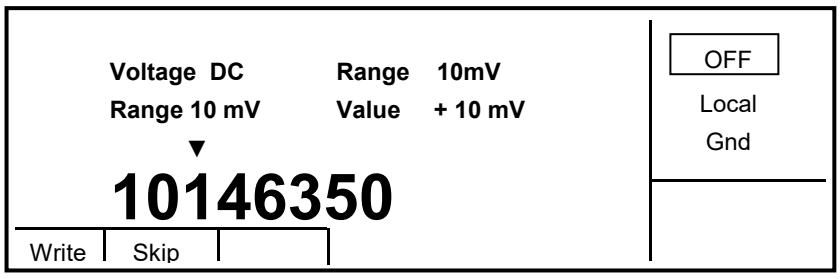


Figure 16 Calibration point adjustment – direct

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).

Calibration value adjustment

Use ∧, ∨, <, > 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.

6.2. Calibration points

Each function of the calibrator has assigned fixed calibration points which have to be set during the calibration. For RESISTANCE function calibration data of the fixed resistances must be entered.

TC function does not require any calibration, as the output voltage or resistance is based on arithmetic interpolation using standard tables of temperature sensor values.

Function	Range	Nominal value			
		Offset +	Offset –	Full range +	Full range -
Voltage DC	10 mV	+0 mV	-0 mV	10 mV	-10 mV
	100 mV	+10 mV	-10 mV	+100 mV	-100 mV
	1 V	+0.1 V	-0.1V	+1 V	-1 V
	10 V	+1 V	-1 V	+10 V	-10 V
	100 V	+10 V	-10 V	+100 V	-100 V
	1000 V	-	-	+750 V	-750 V
Current DC	200 µA	+0.0 µA	-0.0 µA	+190 µA	-190 µA
	2 mA	+0.2 mA	-0.2 mA	+1.9 mA	-1.9 mA
	20 mA	+2 mA	-2 mA	+19 mA	-19 mA
	200 mA	+20 mA	-20 mA	+190 mA	-190 mA
	2 A	+0.2 A	-0.2 A	+1.9A	-1.9A
	20 A[1]	+2 A	-2 A	+10 A	-10 A

1. 20 A – Model 143i only

Table 2 Calibration points - DC voltage and current

Function	Range	Nominal value	
		Offset 400 Hz	Full range 400 Hz
Voltage AC	10 mV	1 mV	10 mV
	100 mV	10 mV	100 mV
	1 V	0.1 V	1 V
	10 V	1 V	10 V
	100 V	10 V	100 V
	1000 V	190 V	750 V
Function	**Range**	**Offset 120 Hz**	**Offset 120 Hz**
Current AC	200 µA	10 µA	190 µA
	2 mA	0.200 mA	1.9mA
	20 mA	2.0 mA	19 mA
	200 mA	20 mA	190 mA
	2 A	0.200 A	1.9 A
	20 A[2]	2.0 A	10 A

2. 20 A – Model 143i only

Table 3 Calibration points - AC voltage and current

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

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

6.2.1. Resistance

Fixed resistance nominals: 0 Ω, 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ, 100 MΩ, 1 GΩ

Measured in 4W up to 100 kΩ and in 2W from 330 kΩ up.

Nominal value	Tolerance
10 Ω	0.010 Ω
100 Ω	0.010 Ω
1 kΩ	0.05 Ω
10 kΩ	0.2 Ω
100 kΩ	2 Ω
1 MΩ	50 Ω
10 MΩ	1 kΩ
100 MΩ	50 kΩ

Table 4 Resistance calibration points

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

6.2.2. Temperature

Nominal value	Tolerance
0 ˚C	0.05 ˚C
50 ˚C	0.05 ˚C

Table 5 Temperature calibration points

External temperature sensor should be inserted into temperature chamber with defined temperature.

6.2.3. RTD Temperature sensor similation

Range	Nominal	Type of measurement
SHORT	0-0.2 Ω	4W
20 Ω	20 Ω	4W
40 Ω	40 Ω	4W
80 Ω	75 Ω	4W
150 Ω	150 Ω	4W
300 Ω	300 Ω	4W
600 Ω	590 Ω	4W
1k1 Ω	1.15 kΩ	4W
2k2 Ω	2.19 kΩ	4W
4k4 Ω	4.37 kΩ	4W
8k8 Ω	8.6 kΩ	4W
16 kΩ	16.7 kΩ	2W
33 kΩ	33 kΩ	2W
66 kΩ	65 k Ω	2W
125 kΩ	129 kΩ	2W
250 kΩ	253 kΩ	2W
500 kΩ	503 kΩ	2W
1 MΩ	1 MΩ	2W
2 MΩ	2 MΩ	2W
4 MΩ	4 MΩ	2W
8 MΩ	7.8 MΩ	2W
16 MΩ	15.6 MΩ	2W
30 MΩ	30 MΩ	2W
60 MΩ	59.7 MΩ	2W
120 MΩ	118 MΩ	2W

Table 6 Calibration points - RTD simulator

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

7. Maintenance

This chapter explains how to perform the routine maintenance to keep your device in optimal operating conditions.

7.1. Fuse replacement

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

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

7.2. External surface cleaning

To keep the device in mint condition, clean the case and front panel keys using a soft cloth slightly dampened with either water or a non-abrasive mild cleaning solution that is not harmful to plastics.

7.3. Error messages

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

Code	Error message	Description
01 02	Overload 1V! Overload 10V!	Voltage terminals are shorted and/or external voltage has been detected. Voltage output has been disconnected. Increase load impedance to specified limits and/or disconnect external source of current from output terminals.
04	Overload I output!	Current terminals are open and/or external voltage has been detected. Current output has been disconnected. Decrease load impedance to specified limits and/or disconnect external source of current from output terminals.
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!	Value requested through remote control is out of specified limits.
14	Communication error	Communication error on GPIB/RS-232.
15	Check sum error!	Fail data loading into internal memory.
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 was entered, calibration cannot start. Enter correct calibration code.
21	Time warm up!	Attempt to start calibration before 60 minutes warm up period. Let the calibrator turned on for at least 60 minutes in order to enter calibration menu.
40	Value too large!	Requested value is higher than specified limits.
41	Value too small!	Requested value is lower than specified limits.
42	Deviation too large!	Requested deviation is out of specified limits. Select value between ±30 %.
44	Unable +/-!	Change of polarity is not allowed. Negative polarity is allowed only in DC and temperature functions.
45	Unable – polarity!	Negative polarity is not allowed. Negative polarity is allowed only in DC and temperature functions.
51	High temperature!	20 A amplifier overheated. Output stage is overloaded. Do not use 20 A range for at least 10 minutes. Check if the ventilation holes are free.

Table 7 Error code overview

8. Specifications

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

Ambient conditions

Reference conditions:	+21 – +25 °C
Operating conditions:	+10 – +40 °C, max. altitude 3 km
Storage conditions:	-10 – +55 °C, max. altitude 12 km
Relative humidity:	< 80 % to 30 °C, < 70 % to 40 °C, < 40 % to 50 °C
Temperature coefficient:	In extended temperature range +10 °C to +40 °C multiply accuracy parameters 0.15x / °C

General

Warm-up time:	60 minutes
Power supply:	115/230 V – 50/60 Hz
EMC compliance:	Safety class I according to IEC 61010 ed. 2
	ESD class I according to EN 61326
	Overvoltage CAT II
	Pollution Degree 2
Dimensions (W x H x D):	390 x 128 x 430 mm
Weight:	11 kg

8.1. Voltage

8.1.1. DC / AC sine wave voltage

DCV range summary: 0.0000 mV – 1000.00 V

ACV range summary: 1.0000 mV_{rms} – 1000.00 V_{rms}

Voltage ranges: 100 mV, 1 V, 10 V, 100 V, 1000 V

Frequency range in AC mode: 1 mV – 10 V from 20 Hz to 10 kHz,
10 V – 1000 V from 40 Hz to 1 kHz

Available AC units: RMS, peak, peak-peak, average

Frequency accuracy: 0.01%

DCV / ACV accuracy [% of value]

Range	DC	AC 20 Hz – 400 Hz	AC 400 Hz – 10 000 Hz
0.0000 mV[*3] – 10.0000 mV	0.05 + 7 µV	0.2 + 25 µV	0.2 + 30 µV
10.000 mV - 100.000 mV	0.01 + 7 µV	0.1 + 50 µV	0.15 + 70 µV
0.10000 V – 1.00000 V	0.006 + 10 µV	0.05 + 50 µV	0.07 + 100 µV
1.0000 V – 10.0000 V	0.006 + 50 µV	0.05 + 500 µV	0.07 + 3 mV
10.000 V – 100.000 V	0.006 + 1 mV	0.05 + 10 mV [*4]	0.07 + 30 mV [*4]
100.00 V – 1000.00 V	0.01 + 20 mV	0.07 + 200 mV [*4]	0.1 + 300 mV [*4]

3. Range is for DCV. For ACV range is 1.0000 mV – 10.0000 mV
4. Limited to 40 Hz – 1 kHz, sine waveform only.

Auxiliary parameters

Range	THD [*5]	Max. DC/AC Current	Max. load capacitance	Output impedance	Overload protection
10 mV	0.05 % + 200 µV	3 / 3 mA	3 nF	< 10 mΩ	60 Vpk
100 mV	0.05 % + 300 µV	5 / 5 mA	3 nF	< 10 mΩ	60 Vpk
1 V	0.1 %	20 / 10 mA	3 nF	< 10 mΩ	60 Vpk
10 V	0.1 %	50 / 50 mA	10 nF	< 10 mΩ	60 Vpk
100 V	0.1 %	20 / 10 mA	10 nF	< 100 mΩ	250 Vpk
1000 V	0.2 %	2 / 1.5 mA	3 nF	< 100 mΩ	1500 Vpk

5. Includes non- linear distortion and non- harmonic noise up to 100 kHz.

8.1.2. Non-sine wave current

DCV range summary: 100.000 µApk – 2.000 00 Apk

Waveform type: saw, triangle, square sym, truncated sin

Frequency range: 20.000 to 80.000 Hz

Amplitude accuracy: 0.3 %

(peak value)

Frequency accuracy: 0.01 %

8.2. Current

8.2.1. DC / AC sine wave current

DCI/ACI Range summary: M143: 0.000 µA – 20.000 A DC, 1.000 µA – 20.000 A AC

M143i: 0.000 µA – 2.0000 A DC, 1.000 µA – 2.0000 A AC

Internal ranges: 200 µA, 2 mA, 20 mA_{AC} (22 mA_{DC}), 200 mA, 2 A (20 A in model M143)

Current resolution: 5½ digit

Frequency range: M143/143i: 1 µA - 2A range 20 Hz to 1 kHz

M143: 2 A - 20 A range 20 Hz to 1 kHz

Frequency accuracy: 0.01%

Frequency resolution: 5½ digit

DCI / ACI accuracy [% of value]

Range	DC	AC 20 Hz – 200 Hz	AC 200 Hz – 1 kHz
1.000 µA[*6] – 200.000 µA	0.05 + 20 nA	0.25 + 20 nA	0.2 + 200 nA
0.20000 mA – 2.00000 mA	0.025 + 100 nA	0.1 + 200 nA	0.1 + 400 nA
2.0000 mA – 20.0000 mA[*7]	0.015 + 600 nA	0.07 + 1 µA	0.1 + 4 µA
20.000 mA – 200.000 mA	0.015 + 6 µA	0.07 + 10 µA	0.1 + 40 µA
0.2000 A – 2.0000 A	0.015 + 100 µA	0.1 + 100 µA	0.15 + 1 mA
2.0000 A – 20.000 A [*8]	0.1 + 2 mA	0.2 + 3 mA	0.25 + 10 mA

6. Range is for DCV. For ACV range is 1.0000 mV – 10.0000 mV
7. In DC range is 22 mA
8. M143i version lacks 20A amplifier and so is limited to 2A.

Auxiliary parameters

Range	THD [*10]	Max. DC/AC Voltage	Max. load Inductance	Overload protection
200 µA	0.15 %	2 / 2 V	400 µH	15 Vpk
2 mA	0.1 %	2 / 2 V	400 µH	15 Vpk
20 mA	0.1 %	7 / 2 V	400 µH	15 Vpk
200 mA	0.1 %	2 / 2 V	400 µH	15 Vpk
2 A	0.2 %	2 / 2 V	200 µH	15 Vpk
20 A [*9 *12]	0.3 % [*11]	2 / 2 V	200 µH	15 Vpk

9. M143i version lacks 20A amplifier and so is limited to 2A.
10. Includes non-linear distortion and non- harmonic noise up to 100 kHZ
11. Up to 0.6% below 30 Hz
12. Continuous output up to 10 A is not time-limited. Maximum duration at 20 A is 5 minutes, 15 minutes at 10 A. Cooldown takes typically around 5 minutes.

8.2.2. NON-SINE Wave Current

Current range: 100.000 $µA_{pk}$ – 2.000 00 A_{pk}

Waveform type: saw, triangle, square sym, truncated sin

Frequency range: 20.000 to 80.000 Hz

Amplitude accuracy: (peak value) 0.3 %

Frequency accuracy: 0.01 %

8.3. Resistance

Number of resistances: 8

Range: 10 Ω to 100 M Ω

Calibration value resolution: 5 digits

Maximal test voltage: 50 V_{rms} or 0.1W, what is lower

Type of connection: two-terminal

Resistance (2W)

Nominal value	Max. deviation	Accuracy
10 Ω	5 %	0.03 % + 25 mΩ
100 Ω	1 %	0.05 %
1 kΩ	0.5 %	0.02 %
10 kΩ	0.5 %	0.02 %
100 kΩ	0.5 %	0.02 %
1 MΩ	0.5 %	0.05 %
10 MΩ	1 %	0.05 %
100 MΩ	5 %	0.5 %

Compliance voltage 50 Vrms, maximum dissipation power 0.1 W.

8.4. Temperature sensor simulation

Sensor types: RTDs, thermocouples

8.4.1. Thermocouple Temperature Sensor Simulation

TC sensor types: R, S, B, J, T, E, K, N, C, D, G2, M

Temperature range summary: -250.0 °C to +1820.0 °C (by sensor type)

Type	Range	Accuracy [13]
R	-50 – 1767 ˚C	1.2 – 2.5 ˚C
S	-50 – 1767 ˚C	1.5 – 2.2 ˚C
B	400 – 1820 ˚C	1.3 – 2.7 ˚C
J	-210 – 1200 ˚C	0.3 – 0.9 ˚C
T	-200 – 400 ˚C	0.3 – 0.9 ˚C
E	-250 – 1000 ˚C	0.2 – 1.7 ˚C
K	-200 – 1372 ˚C	0.4 – 0.8 ˚C
N	-200 – 1300 ˚C	0.5 – 1.3 ˚C
C	0 – 2315 ˚C	0.6 – 1.2 ˚C
D	0 – 2315 ˚C	0.6 – 1.1 ˚C
G2	0 – 2315 ˚C	0.6 – 5.0 ˚C
M	-50 – 1410 ˚C	0.2 – 0.3 ˚C

13. Accuracy in manual CJ compensation mode.

Cold junction compensation

CJ comp. temperature range: -5.0 °C to 50.0 °C

CJ compensation modes: manual

automatic using 143-90 external temperature sensor

Temp. measurement accuracy: 0.2 % + 0.35 °C (with 143-90 sensor)

8.4.2. RTD resistance temperature

RTD sensor types:	Pt 1.385, Pt 1.392, Ni
RTD range summary:	-50.0 °C to +850.0 °C depending on sensor type
Range of R0 coefficient:	100 Ω to 1000 Ω
Type of connection:	four-terminal
Temperature scale:	IPTS68, ITS90
Temperature units:	°C, °F
Resolution:	0.1 °C/°F

RTD temperature sensor simulation (4W)[14]

Type	Range	Accuracy
Pt100 – Pt200	-200.0 – 850.0 ˚C	0.2 ˚C
Pt200 – Pt1000	-200.0 – 850.0 ˚C	0.2 ˚C
Ni100 – Ni200	-60.0 – 300.0 ˚C	0.1 – 0.2 ˚C
Ni200 – Ni1000	-60.0 – 300.0 ˚C	0.1 ˚C

14. RTD temperature sensor simulator is an optional extra. Pt standards: IPTS68 and ITS90.

8.5. Frequency Output

Waveform type:	positive $5V_{pk}$
Amplitude accuracy:	10 %
Output resistance:	50 Ω ± 5 %
Frequency range:	0.100 0 Hz to 2.000 00 MHz
Frequency accuracy:	0.005 %

9. Revisions

9.1. Change 1

Parameter	Original	Updated	
Frequency range in AC mode	1 mV - 10 V from 20 Hz to 2 kHz	1 mV - 10 V from 20 Hz to 10 kHz	Chapter 8.1.1.
THD	0.05%/1V, 0.05%/10V, 0.05%/100V, 0.1%/1000V	0.1%/1V, 0.1%/10V, 0.1%/100V, 0.2%/1000V	Chapter 8.1.1. - Auxiliary parameters
Maximal compliance voltage (pk)	1V/20A	2V/20A	Chapter 8.2.1. - Auxiliary parameters
THD	0.4%/20A	0.3%/20A	Chapter. 8.2.1. - Auxiliary parameters

9.2. Change 2

Parameter	Original	Updated	
Calibration frequency for AC voltage	100 Hz	400 Hz	Chapter 6.2.
Calibration frequency for AC current	100 Hz	120 Hz	Chapter 6.2.
Test points for +-8V DC, 300 VDC and 950 VDC	--	--	Chapter 5.3.
Added specification table for TC with extended specification	--	--	Chapter 8.4.1.
Added new types of TC	--	Types C, D, G2, M	Chapter 4.7. and Chapter 8.4.1.

9.3. Change 3

Parameter	Original	Updated	
Test points	--	Test points have been reworked and new testing points have been added for all functions.	Chapter 5.3.
Note for 2.0000 mA – 20.0000 mA	--	Added note	Chapter 8.2.1. - DCI / ACI accuracy
New subchapter - Cold junction compensation	--	Thermocouple Temperature Sensor Simulation chapter have been reworked Accuracy for external temperature sensor 143-90 have been added	Chapter 8.4.1.

Certificate of conformity

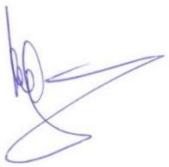
According to EN ISO/IEC 17050-1:2010 standard as well as 2014/30/EU and 2014/35/EU directives of European Parliament and European Council, MEATEST, spol. s r. o., manufacturer of Portable Multifunction Calibrator M143/143i based in Železná 3, 619 00 Brno, Czech Republic, declares that its product conforms to following specifications:

Safety requirements

- EN 61010-1 ed. 2:2010 + A1:2016 + COR1:2019-03

Electromagnetic compatibility

- EN 61000 part 3-2 ed. 5:2019
- EN 61000 part 3-3 ed. 3:2014
- EN 61000 part 4-2 ed. 2:2009
- EN 61000 part 4-3 ed. 3:2006 +A1:2008+A2:2011+Z1:2010
- EN 61000 part 4-4 ed. 3:2013
- EN 61000 part 4-5 ed. 3:2015 + A1:2018
- EN 61000 part 4-6 ed. 4:2014
- EN 61000 part 4-11 ed. 2:2005
- EN 61326-1 ed. 3:2020

Brno	March 25th, 2024	
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