meatest

EN, rev. 02

9010+ Multifunction Calibrator

user manual

Content

List of tables

List of figures

1. Introduction

Multifunction calibrator 9010+ is designed as universal calibration tool for electrical calibration laboratories, covering most of their workload like multimeters, clamp meters, ohm meters, power meters and power analysers, energy meters, transducers, insulation testers, process meters, scopes and many others. High load capacity of voltage output (up to 50 mA) allows for calibration of high-consumption analogue meters. Installed harmonic and non-harmonic shape signals allow for testing meter sensitivity to distorted signals by a signal with various crest factor.

Advancing from previous M14x calibrator series, 9010+ can now calibrate even 1 GHz scopes, 1.5 kV insulation testers and 1 MW power meters. On the other hand we kept all the popular functions including complete transducer and external sensor calibration (strain gauge, pressure, torsion, force, etc.) using built-in multimeter, automatic uncertainty calculation, remote control and easy recalibration.

1.1. Front panel overview

Main control segments of the calibrator are:

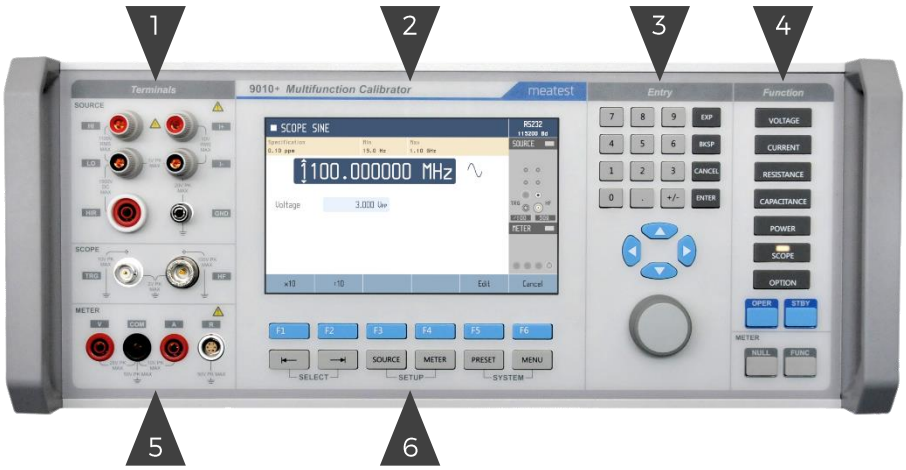

Figure 1 Front panel

1. Output terminals
2. Display
3. Numeric and navigation keys
4. Function keys
5. Input terminals
6. Softkeys (sky blue) and menu keys (grey)

1.1.1. Terminals in detail

All input and output terminals are located on left side of front panel. Labels between terminals show overall maximum voltage ratings in standby. Maximum voltage ratings during operation are usually lower and exceeding them might cause damage to the calibrator! See Specifications for detailed ratings.

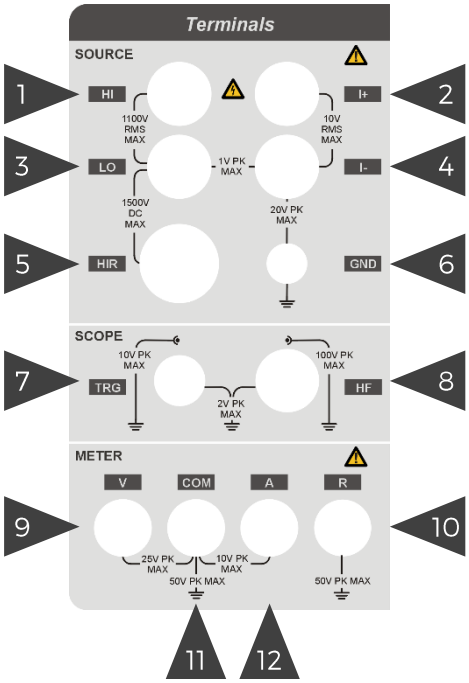

Figure 2 Input/output terminals

1. HI. Outputs set voltage in VOLTAGE and POWER functions, set resistance in 2W mode of RESISTANCE and CAPACITANCE functions and force signal in 4W RESISTANCE mode. All signals are relative to LO.
2. I+. Outputs set current in CURRENT and POWER functions and senses RESISTANCE in 4W mode. All signals are relative to I-.
3. LO. Acts as zero potential in VOLTAGE, POWER, 2W RESISTANCE, 2W CAPACITANCE and HVR functions. Also provides zero potential to force signal in 4W RESISTANCE mode.
4. I-. Acts as zero potential in CURRENT and POWER functions. Also provides zero potential to sense signal in 4W RESISTANCE mode. I- terminal is floating up to 20 V_{pk} relative to the Ground, SETUP menu allows you to ground this terminal with relay.
5. HIR. Outputs set resistance in HVR function (option HVR).
6. GND. Ground potential, galvanically connected with housing and mains PE wire.
7. TRG. Used as external trigger for SCOPE functions (option SCO).
8. SCO. Outputs all SCOPE function signals through N-type coaxial connector (option SCO).
9. V. Measures voltage and frequency signals in METER function, relative to COM (option MER).
10. R. Connector for 9000-60 Adapter and 91 Cold Junction Compensator only, don‘t connect any other cables to this terminal! 9000-60 adapter is used for measurement of RTDs and 4W resistance in METER function (option MER), 91 adapter is used for cold junction compensation of thermocouples. Adapter terminals are described on the adapters themselves.
11. COM. Acts as zero potential for all METER functions (option MER).
12. A. Measures current signals in METER function, relative to COM (option MER).

1.1.2. Display in detail

Display is divided into several sections with following meaning:

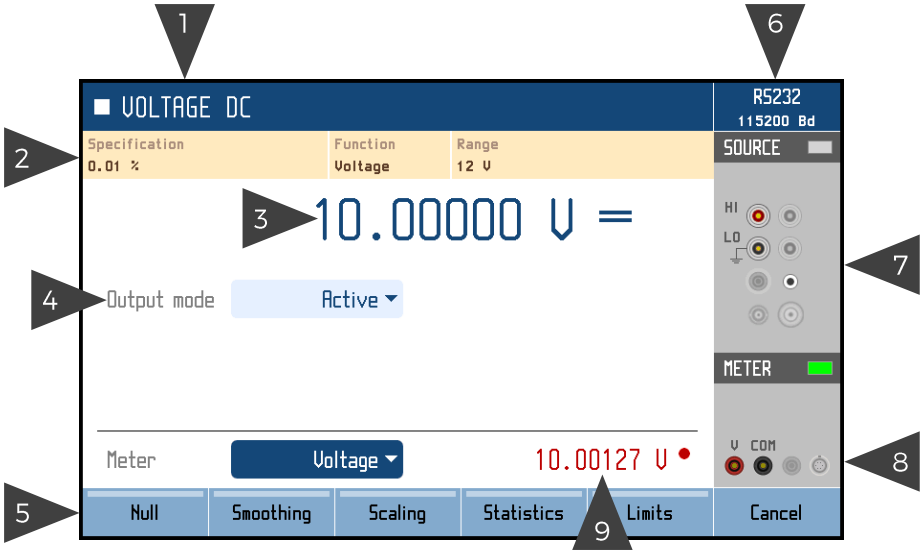

Figure 3 Display

1. Selected function. Symbol on the left indicates system status (■ standby, ↻ settling in, ▶ running). There may be additional Warning symbols on the right:
   a. Warm-up in progress. Calibrator is fully operational but it may be outside specifications.
   b. Overheated. Output terminals cannot be switched on until temperature falls below safe limit. Set 10V DC and wait a few minutes until the symbol disappears.
   c. Other error. Some functions may not be operational and/or outside specifications. Go to "MENU/Information/Device status" to get detailed information.
2. Tooltip. Shows additional information about selected parameter or main value. Information may include uncertainty, range, description, limits (burden current, compliance voltage), etc. Tooltip is hidden when no parameter is selected.
3. Main value. Can be edited via numerical input, cursor keys or rotary knob. Symbol on the right represents signal shape.
4. Auxiliary parameters. You can switch between parameters (and main value) using |← and →| buttons. Every function has different set of auxiliary parameters.
5. Softkey labels. Softkeys below the display change their function dynamically based on current workspace, these labels describe Softkey functions at any given time.
6. Remote control. Shows active interface and its main parameter.
7. Output status. Indicates output status (grey means OFF, green means ON) and shows diagram of active output terminals.
8. Input status. Indicates meter status (grey means disconnected, green means measuring) and shows diagram of active input terminals.
9. Meter reading. Meter function can be changed using FUNC button in METER group.

1.1.3. Keys in detail

There are 3 button groups in total on the front panel. Softkeys and menu buttons under the display, function buttons on the right and numeric entry buttons with rotary knob and cursor buttons in between.

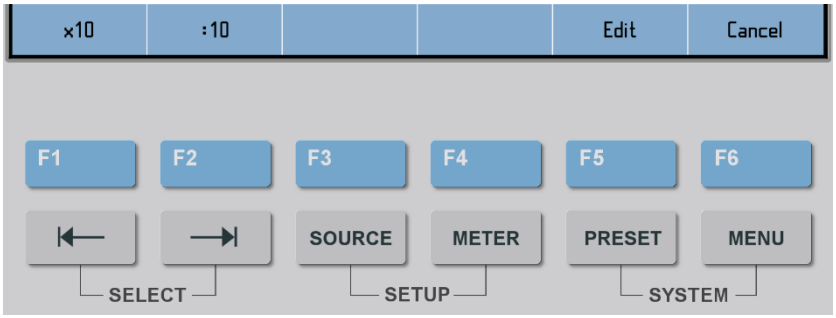

Figure 4 Softkeys and menu buttons

1. SELECT. Selects previous/next parameter on display. Selected parameter can be edited and relevant tooltip is shown (if enabled). Press CANCEL to deselect a parameter.
2. SETUP. Enters/exits device menu. Device menu contains additional function parameters, see chapter 3.2 or SETUP subchapters in chapter 4 for more details.
3. SYSTEM. Enters/exits main menu. Main menu contains all device-related settings, see menu structure in chapter 3.
4. Softkeys. Buttons with context-specific functions. Current functions are shown on display, just above the buttons.

Function buttons

1. Function buttons. Directly selects a calibrator function or toggles function mode if the function is already selected (f.e. pushing VOLTAGE button in voltage DC mode switches to voltage AC mode).
2. OPER. Turns output on according to selected function and parameters.
3. STBY. Turns output off.
4. NULL. Sets meter readout to zero by shifting offset of active meter function.
5. FUNC. Toggles meter function.

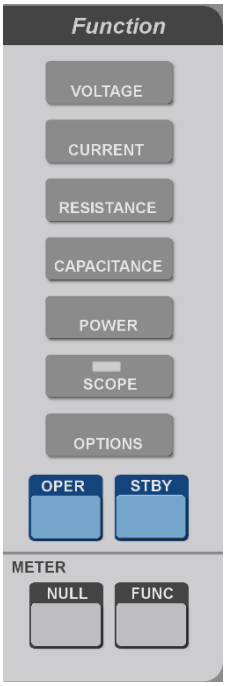

Figure 5 Function buttons

Entry buttons

Numeric and navigation buttons have dual function. In menus these buttons are used to list through items (▲ and ▼ buttons, knob rotation), select an item (ENTER button, OK softkey or knob push), enter a value or exit menu item (CANCEL button, EXIT/CLOSE softkey).

Outside menus, numeric and navigation buttons are used to edit values of selected parameters. If no parameter is selected, pressing any numeric or navigation button will select function's main parameter. Values can be edited with cursor keys and rotary knob as well. Use ◀ and ▶ buttons to shift through digits and ▲ and ▼ buttons to increment or decrement that digit. Knob rotation works as either ▲ / ▼ or ◀ / ▶ buttons, knob push toggles between the two modes.

1.2. Rear panel overview

There is located power line entry module with power line fuse, power line voltage selector 115/230V and power line switch. On the bottom side interface connectors RS-232, MSI and optionally LAN, USB and IEEE488 on the rear panel.

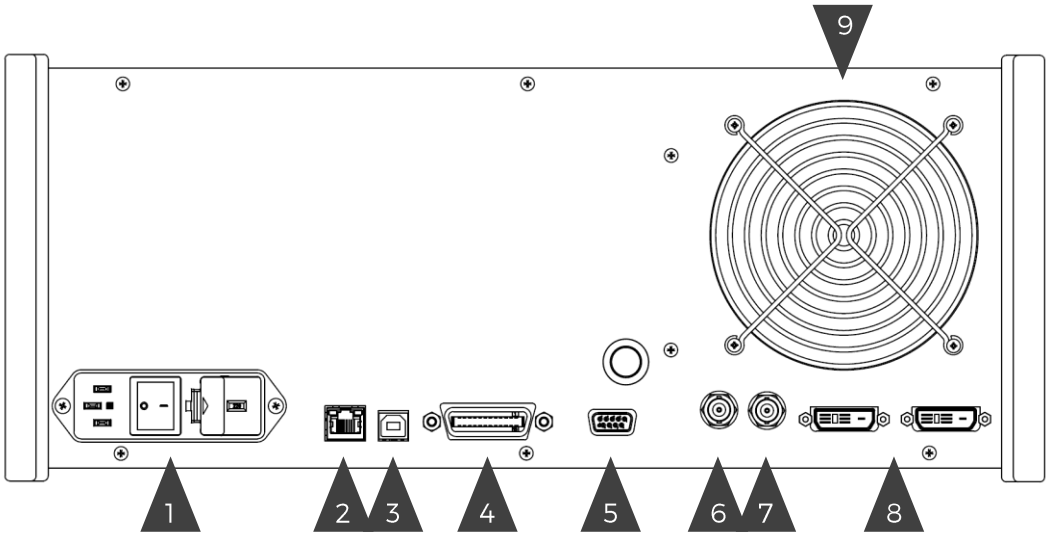

Figure 6 Rear panel

1. Power cord module with power switch, fuse holder and 115/230 V voltage selector
2. RJ-45 (Ethernet) connector for remote control
3. USB connector for remote control
4. GPIB IEEE-488 connector for remote control
5. RS-232 connector
6. External signal synchronization input
7. External signal synchronization output
8. MSI connectors (2x) for control or synchronization with other Meatest devices
9. Fan outlet cover

1.3. Options and accessories

Every 9010+ 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 (3.15A, 6.3A) 2 pcs
- RS232 cable 1 pc
- Test lead black 1 pc
- Test lead red 1 pc

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

- Option 91 Pt100 Cold junction compensator
- ISO17025 calibration certificate

9010+ Multifunction calibrator can be ordered with integrated options as listed in Table 1. Integrated options can be fitted only by manufacturer and certified service providers.

Option	Description	Additional accessory
SC1	Scope extension for calibration of oscilloscopes up to 1.1 GHz	N/BNC Coaxial adapter
SCO	Scope extension for calibration of oscilloscopes up to 400 MHz.	N/BNC Coaxial adapter
HVR	High voltage resistance extension for calibration of insulation testers on megaohmmeters up to 1.5 kV.	191-11 Cable for HV measurement up to 5 kV
MER	Multimeter extension for calibration of transducers and simulation of strain gauges and other industrial sensors.	9000-60 Cable adapter for R4W/RTD measurement

Table 1 Integrated options

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
- USB
- GPIB (IEEE488)
- LAN

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->Interface->Active bus. To establish connection between the calibrator and computer, set interface settings in your computer accordingly:

RS232 and USB connection settings

- COM port — see available COM ports in Windows Device Manager
- Baudrate USB — according to MENU > Interface > USB Baudrate (9600 by default)
- 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->Interface->GPIB Address (2 by default)

LAN connection settings

DHCP service discovery is active by default and is recommended for easiest connection. If you prefer to use fixed IP address or change any other default settings, go to MENU->Interface->LAN Settings.

LAN communication uses Telnet protocol. Default log-in for Telnet client is "9010+_SNxxxxxx 23", where "xxxxxx" stands for serial number and 23 is default communication port.

1.4.2. SCPI commands and protocol

See 9010 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 61010-1:2011 + A1. 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.

See User Manual.

Protective earth.

Fuse.

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.
- Use test leads rated for at least 1000 V and 30 A in all core functions and at least 2000 V in HVR high voltage resistance function.
- 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.

2.2. Power on and warm-up

The calibrator must be powered by 230/115 V – 50/60 Hz mains. Before connecting the instrument to the mains, check the position of the mains voltage selector located on the rear panel. Set appropriate voltage selector position either 115 V or 230 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. You should see following splash screen on display.

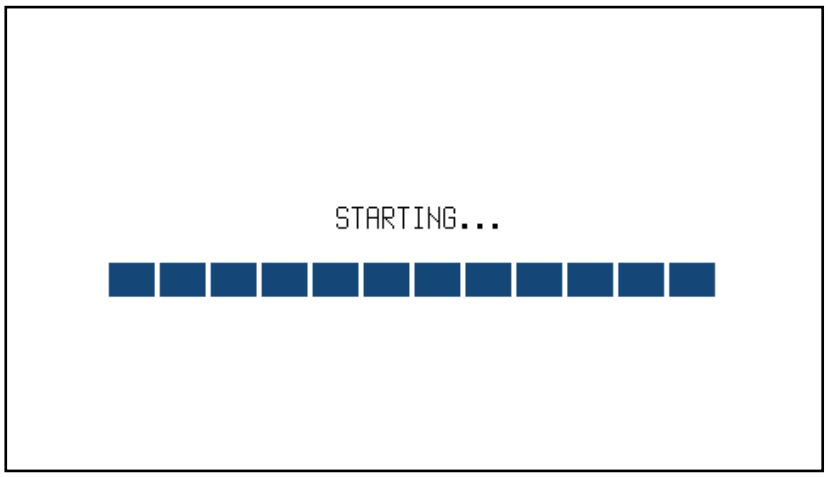

Figure 7 Starting Screen

Calibrator then performs internal hardware checks for app. 5 seconds and then starts in Startup state (called Preset). Startup preset can be customized and up to 99 other presets can be defined and recalled later at any time. By default the Startup preset is set to VDC function, 10 V with output switched off.

Warm-up

Specified parameters are guaranteed 30 minutes after switching the calibrator on and stabilizing it in reference conditions.

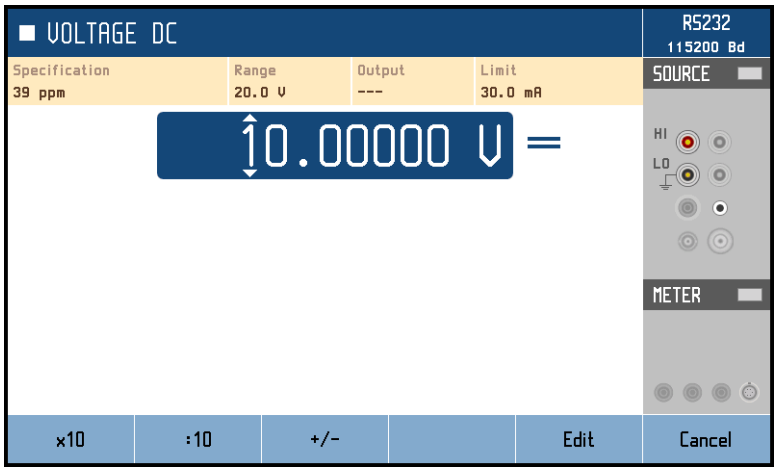

Figure 8 Factory default screen

2.3. Function setup

Calibrator output (source) function can be set using FUNCTION buttons. Push any FUNCTION button to change function or push the button repeatedly to scroll through function modes if available (for example DC and AC in voltage function).

Once a function is selected, you can change the main value as well as auxiliary output parameters like frequency in AC modes or phase shift in AC power function. 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 and rotary button. Push ▲▼ buttons or turn rotary knob to increment/decrement selected digit by one. Move through parameter digits using ◀ ▶ buttons or push the rotary knob to switch to digit selection mode, rotate to a new digit and confirm with another push.
- 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.

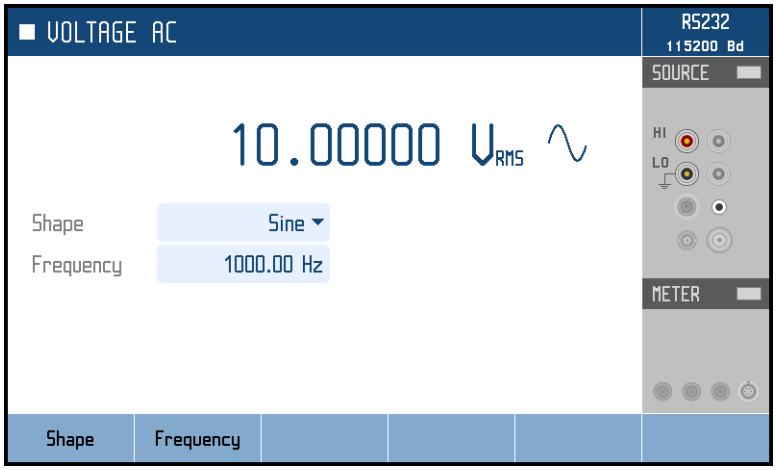

Figure 9 Main and auxiliary parameters

Described methods change the main parameter by default. If there are any other parameters on display, you can switch between them using ↤ and ↦ select buttons. Picture above shows AC voltage function with main value 10 V_{rms} and two auxiliary parameters: signal shape and frequency. Both auxiliary parameters have their dedicated softkey for fast access.

Additional settings are available under setup buttons SOURCE and METER. These buttons are shortcuts to relevant sections of Device menu. See chapter 3.2 or SETUP subchapters in chapter 4 for more details.

2.4. Signal output

Calibrator output can be turned on by pushing OPER button. STBY button turns output off. Output turns off automatically on calibrator startup and function switch. Output state is indicated by LED light in OPER button as well as green rectangle next to Source label on the right side of the display. Diagram below Source label shows which terminals are currently being used.

Signal input

With MER option installed you can also take advantage of integrated multimeter and its measurement capabilities. Meter input can be activated and deactivated by pushing FUNC button. Similarly to calibrator output, meter input state is indicated by LED light in FUNC button and green rectangle next to Meter label.

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. Menu reference

Four buttons on the front panel give access to main menu sections:

- Source. Shortcut to section of Menu > Device related to currently selected source function.
- Meter. Shortcut to Menu > Device > Meter
- Preset. Save or recall predefined calibrator configurations. See chapter 3.6 for more details.
- Menu. Access to main menu.

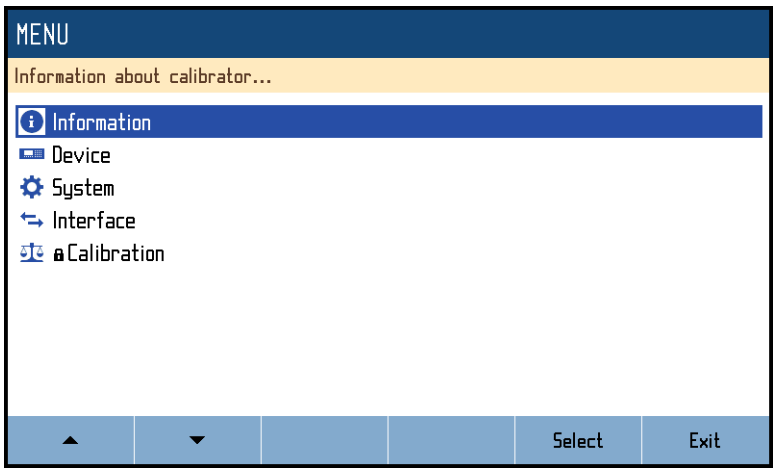

Figure 10 Main menu

Main menu is the most comprehensive setup tool of the calibrator, containing information like serial number, calibration date or display brightness as well as remote control interface setup or calibration constants.

Short tooltip in yellow box shows basic description of selected item. Main menu items are described in detail in chapters 3.1 – 3.5.

3.1. Information menu

Information menu contains general device data which cannot be modified by the user:

- Manufacturer - Model - Serial number	Device identification
- Software version - Hardware version - Internal options	Device configuration
- External options	List of externa options
- Expiration of Calibration validity - Current date - Device status	Device readiness info. Calibration expiration date is equal to last calibration date plus calibration interval, see menu item Calibration for more details.
- Testing tools	Display and keyboard diagnostics
- Modules	List of internal electronic modules and their status

3.2. Device menu

Device menu is divided according to calibrator functions that gives access to additional function related settings and unlock code function. Unlock code function will allow you to enable, disable or set some calibrator properties after entering a password.

Sections of currently used functions can be accessed directly using SOURCE and METER shortcut buttons on front panel. Picture below shows DC power section as an example of device menu.

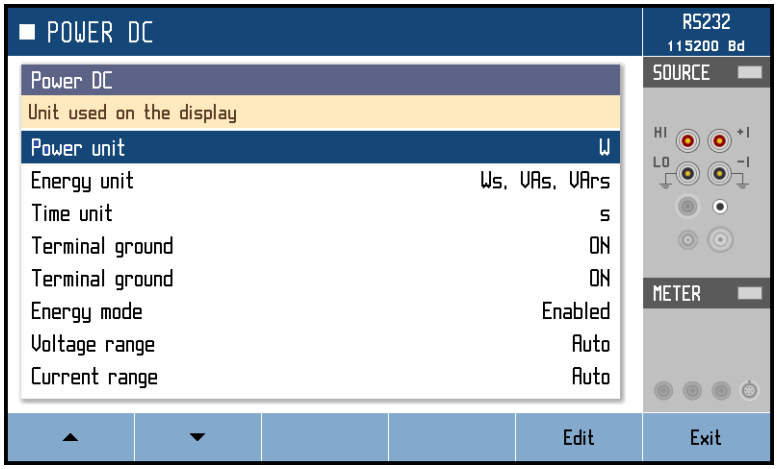

Figure 11 Device/Setup menu

3.3. System menu

System menu contains general, user-accessible device settings:

- Language — Language version of user interface
- Display backlight — [0 – 100 %]
- Button light intensity — [0 – 100 %]
- Beeper volume — [0 – 100 %]
- Keyboard beep — [On/Off]
- Show tooltips on display — Turns yellow menu tooltip On/Off
- Form of specification — [Auto/Absolute/%/ppm]
- Date & Time — Password protected submenu with following items
    - Time — System time in HH:MM:SS format
    - Date — System date in selected format
    - Format — Date format [M/D/Y, M-D-Y, D/M/Y, D.M.Y, D-M-Y, Y/M/D, Y.M.D]
    - Show date & time on display — [On/Off]

3.4. Interface menu

Interface menu contains remote control connection settings:

Menu item	Range / format	Default value
Active bus	RS232/GPIB/USB/LAN	RS232
RS232 Baudrate	1200 – 115200	9600
GPIB Address	0 – 31	2
USB Baudrate	1200 – 115200	9600
LAN Settings		
> DHCP	On/Off	On
> IP Address	IPv4 format; locked with DHCP On	192.168.001.100
> Subnet mask	IPv4 format; locked with DHCP On	255.255.255.000
> Default gateway	IPv4 format; locked with DHCP On	255.255.255.255
> Port number	0 – 9999	23
> Host name	14 alphanumeric characters; locked with DHCP Off	9010+_SN750011

3.5. 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 9010+ adjustment. Calibration menu has following items:

1. Data. Contains current calibration data. Structure of this menu is described in chapter 6.1.
2. Backup. Calibration data backup. See below for more details.
3. Password. Changes calibration password. Calibration password gives access to Calibration menu and Date/Time settings in Information menu.
4. Calibration date. Calibration date is updated automatically upon calibration data adjustment or just by manual confirmation (if calibration doesn‘t require adjustment).
5. Calibration interval. Recommended interval is 12 months.

Backup function allows you to save and recall entire sets of calibration data. Calibration data are also saved automatically when any calibration value gets changed, creating a record with “Auto” storage (or overwriting an existing one if the last change occurred within last 90 days). Use softkeys to save and recall previously stored calibration data sets:

1. Back up. Saves currently used calibration data, overwriting existing record on selected Location. Only empty records and records with Calibration access and Manual storage can be overwritten.
2. Try. Loads selected record temporarily, original calibration data will be restored on next calibrator startup.
3. Load. Loads selected record permanently.
4. Delete. Deletes record. Only records with Calibration access and Manual storage can be deleted.

3.6. Preset menu

Preset feature allows you to save and recall one of up to 100 calibrator configurations so that you can get to work quickly instead of setting up the calibrator every single time. Push PRESET button to show list of saved presets:

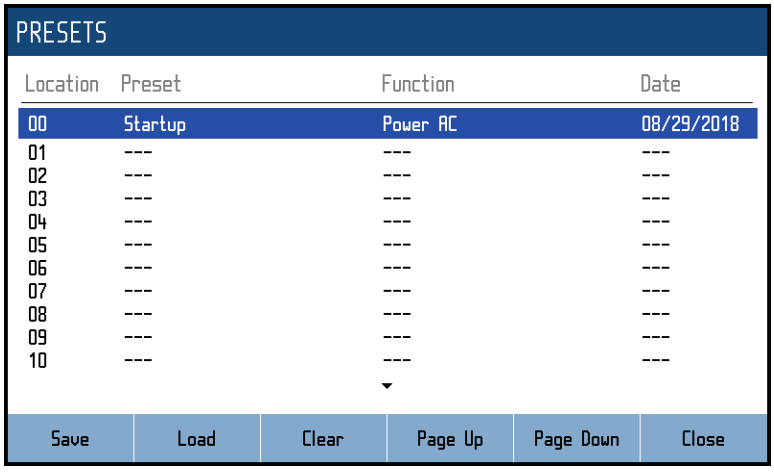

Figure 12 Preset function

To recall a predefined configuration, select its preset from the list and push Load softkey. Configuration will be loaded with output turned off for safety reasons.

Similarly you can save a configuration by choosing Location 0 – 99 from the list and pushing Save softkey. Preset includes configuration of:

- Function and mode (for example AC Power)
- Main value (for example 10 VA)
- Auxiliary parameters (for example 50 Hz, 10 V, 1 A, 0 °)
- Additional Device/Setup menu parameters of current Source and Meter function

While editing functions, parameters are stored in temporary RAM until another preset is selected or the device is restarted. Preset doesn’t include harmonic distortion parameters nor main menu settings except those mentioned above. For harmonic preset feature see chapter 4.1.3.

4. Calibration examples

4.1. AC/DC Voltage

4.1.1. DC and SINE Voltage

1. Connect the voltmeter to the calibrator as shown on the figure below.
2. Select appropriate function and range on the voltmeter
3. Push VOLTAGE function key on the calibrator. DC mode is automatically set. Push VOLTAGE key once more if AC voltage is requested.

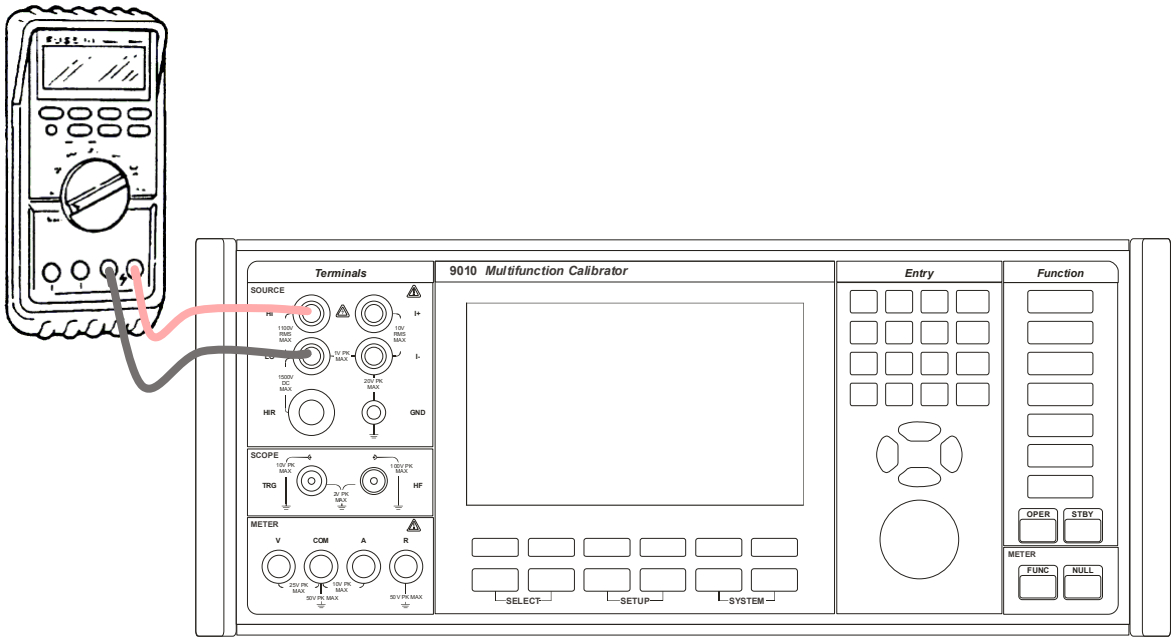

Figure 13 Voltmeter calibration

4. In AC mode push SELECT function repeatedly to activate window Frequency and set requested frequency.
5. Set output voltage value using cursor keys, rotary button or numerical keyboard.
6. Switch output terminals on by pushing key OPER. Output voltage is presented on the output terminals, OPER key is lit and indication SOURCE on the screen is green.
7. Push STBY key to switch output off.

4.1.2. Non-sinusoidal Voltage

Calibrator can source non-sinusoidal waveforms with pre-defined shape. Output is limited to 200 V and 1 kHz. Following waveforms are implemented:

- Limit. Sine — sinusoidal with defined distortion 13.22 %
- Square — squarewave symmetrical
- Triangle — symmetrical
- Ramp Up
- Ramp Down
- Harmonic — adjustable harmonic products

To select requested waveform push the soft key SHAPE, highlight requested item using softkeys ▲▼, cursor keys or rotary button and confirm with ENTER.

4.1.3. Harmonic

Calibrator has unique feature of creation by customer defined output AC signal. Definition on the signal is based on setting of amplitude and phase shift of harmonic products related to basic, fundamental frequency. Number of harmonic products is limited to 50 but maximum frequency of harmonic product cannot exceed 5 kHz. Amplitude of individual harmonic products cannot be higher than 30 % of amplitude of fundament signal.

Harmonic product editing

1. Push the key SELECT to make active window Harmonic.
2. Push the EDIT soft key. Table with list of harmonic products appears. Set amplitude and phase of requested harmonic product. Use key SELECT to move active window between Amplitude and Phase.
3. When all harmonic products are set push soft key EXIT to return back to basic screen. Distortion of sine wave signal has been adjusted.

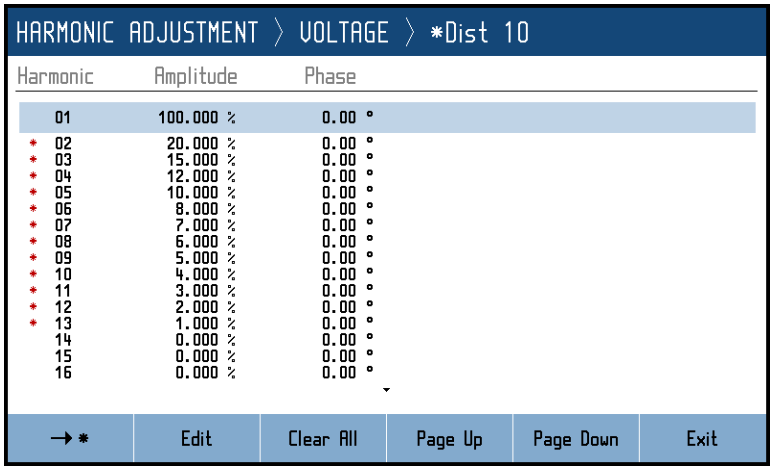

Figure 14 Harmonic products setting

To reset all harmonic products setting use soft key CLEAR ALL. All higher harmonic products are set to zero except fundamental component. When non-zero distortion is set, star sign will appear in window Harmonic ahead Sine label.

To move between pages of harmonic products use soft keys PAGE UP and PAGE DOWN.

Signal preview

The formed signal can be displayed either in frequency or time domain.

Push the soft key Bar to display relative level of harmonic products setting in frequency domain. Fundamental component is displayed in yellow, higher harmonics in red colour.

Push the soft key PREWIEV to see the signal waveform in time domain.

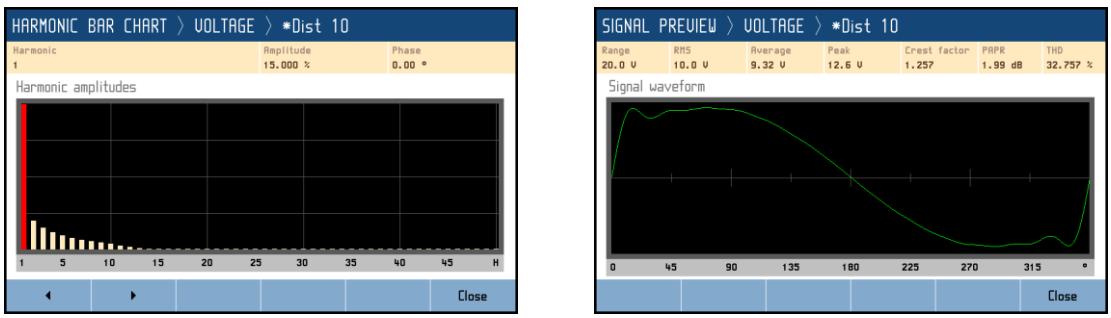

Figure 15 Signal preview

Preset feature

Harmonic preset feature works similarly as normal preset feature. Harmonic preset allows you to save and recall one of up to 22 configurations. First preset is 00 Sine and it can't be changed or saved.

If the preset is being edited and not saved, an * appears in front of the name on the main panel.

Harmonic preset is selected either from the main screen of the VAC, IAC, PAC functions from "Harmonic" drop-down menu or from the HARMONIC PRESET screen after activating the LOAD key.

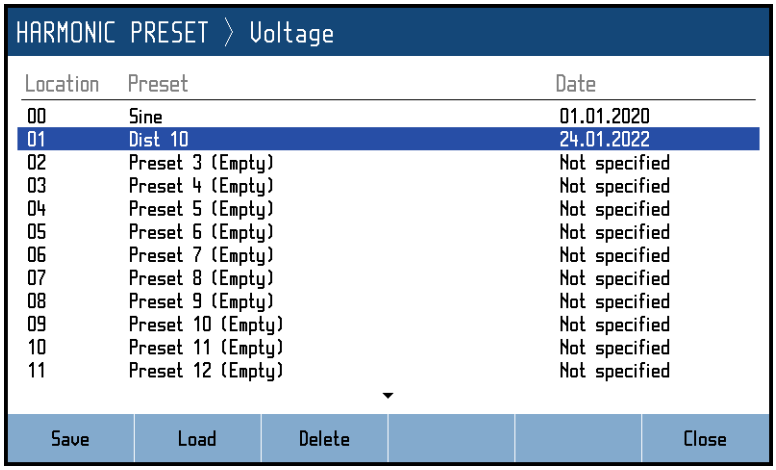

Figure 16 List of harmonic presets

4.1.4. Passive and Active Output

20 mV and 200 mV DC ranges can operate in either passive or active output mode, all other ranges operate in active output mode only.

Active output is formed by electronic amplifier. The output offers higher load current up to 5 mA however with a little bit worse uncertainty. Passive mode is formed by resistance divider with output resistance 50 Ω. Output signal is less noisy and with better uncertainty however maximal output current is given by its output impedance. See specification for detailed differences.

Push SELECT key until field Output mode is not activated. Change setting from Active to Passive using soft key arrow keys, soft key List or rotary knob.

4.1.5. Voltage SETUP

Voltage function SETUP can be activated using SETUP SOURCE key. Following screen will appear:

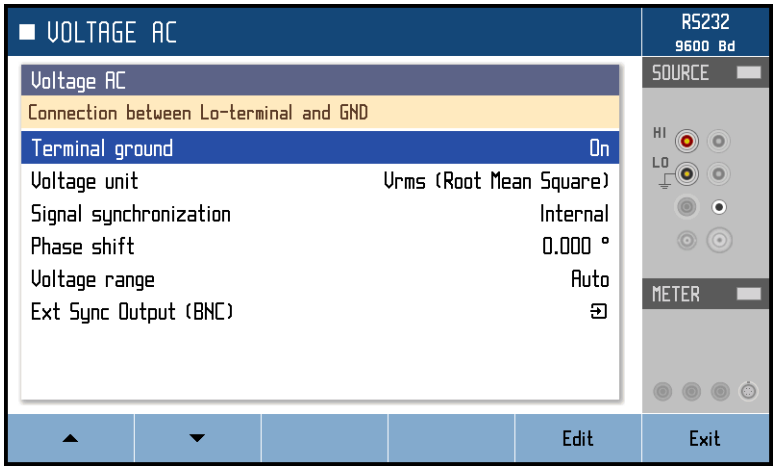

Figure 17 Voltage SETUP screen

SETUP offers additional voltage function settings. Use ▲▼ keys and EDIT soft key to change following items:

Terminal ground	On/Off	Voltage LO output terminal grounded/floating
[AC only] Voltage unit	Root Mean Square/Peak/Peak-Peak/Average	
[AC only] Signal synchronization	Internal	frequency and phase is given by internal oscillator
	Power Line	synchronized to power line voltage
	BNC	synchronized to rear panel EXT SYNC INPUT connector
	External Master	synchronized to Master unit via rear panel MSI connector
[AC only] Phase shift	x.xxx Degrees (°)	phase shift between voltage output and synchronization signal
[DC only] Output mode	Active/Passive	Selects output mode in 20mV and 200mV DC ranges
Voltage range	Auto/20mV/200mV/2V/20V/100V/280V/1000V	
[AC only] Ext Sync Output (BNC)	Mode	Switches function of rear panel Ext Sync Output BNC. Both outputs generate squarewave signal with rising edge phase-locked to internal AC reference. "Sync output" is phase and frequency reference of main output signal, used to synchronize with other devices. Sync output frequency is limited to 1200 Hz (2400 Hz if main signal frequency is 19200 Hz or more). Higher frequencies are divided by powers of two so that Sync output frequency is always kept below 1200 Hz (2400 Hz for main frequency of 19200 Hz or more). "Sample output" is meant to trigger an external voltmeter to synchronize sampling measurements with main output, useful for calibration of 9010+. "Sample multiplier" set to "Auto" multiplies main signal frequency up to 850 Hz by factors 2048 – 64, keeping the sample output at around 30 – 65 kHz. Main signal frequency above 850 Hz gets multiplied by factors 32 – 8, rising sample output frequency up to its limit of 5 MHz. Fixed Sample multipliers multiply previously described Sync output instead of main signal frequency.
	Sample state	On/Off. Turning Sample state ON will cause sampling signal to start when reference signal passes through zero.
	Sample multiplier	Auto/8/16/32/64/128/256/512/1024/2048

4.2. AC/DC Current

4.2.1. DC and SINE Current

1. Connect the ammeter to the calibrator as shown on the figure below.
2. Select appropriate function and range on the ammeter (multimeter)
3. Push CURRENT function key on the calibrator. DC mode is automatically set. Push CURRENT key once more if AC current is requested.

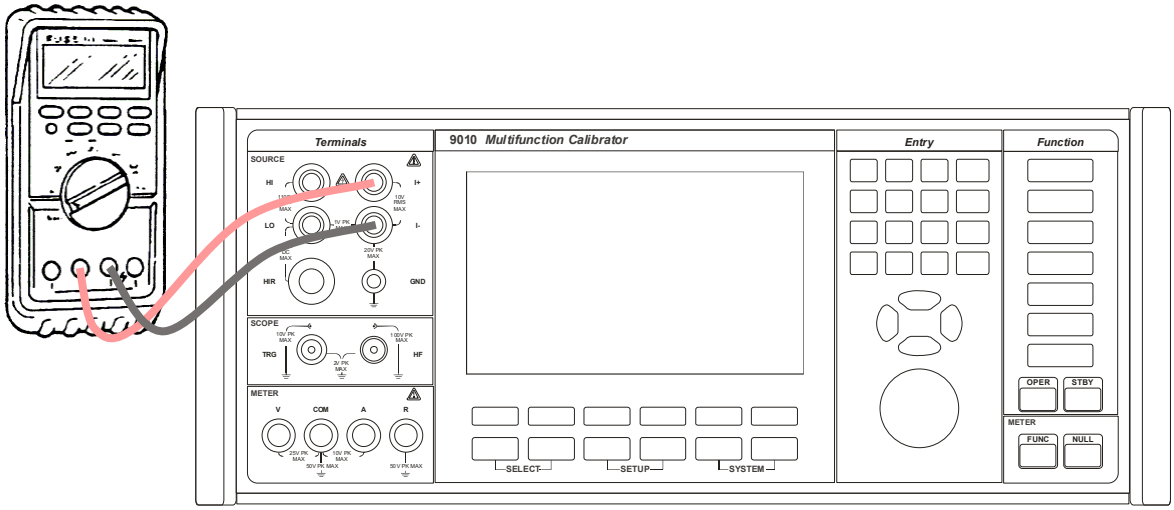

Figure 18 Ammeter calibration

4. In AC mode push SELECT function repeatedly to activate window Frequency and set requested frequency.
5. Set output current value using cursor keys, rotary button or numerical keyboard.
6. Switch output terminals on by pushing key OPER. Output current is presented on the output terminals, OPER key is lit and indication SOURCE on the screen is green.
7. Push STBY key to switch output off.

30A range output time limit

9010+ display shows time counter when 30A range is selected. Time buffer decreases with output turned on and automaticaly turns output off as it drops to zero. With output off, time buffer replenishes at a rate of 1s per 5s in real time. Maximum limit is 5 – 30 minutes based on set current value, specifically:

$$time[s] = 172710 / (current[I]^2 - 324{,}3)$$

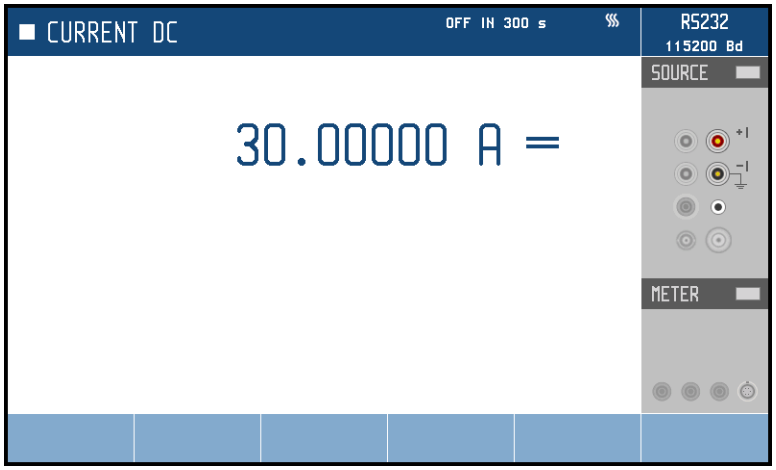

Figure 19 30A range output time limit

4.2.2. Non-sinusoidal Current

Calibrator can source non-sinusoidal waveforms with pre-defined shape. Output is limited to 100 µA – 2 A and 1 kHz. Following waveforms are implemented:

- Limit. Sine — sinusoidal with defined distortion 13.22 %
- Square — squarewave symmetrical
- Triangle — symmetrical
- Ramp Up
- Ramp Down
- Harmonic — adjustable harmonic products

To select requested waveform push the soft key SHAPE, highlight requested item using softkeys ▲▼, cursor keys or rotary button and confirm with ENTER.

4.2.3. Harmonic

Calibrator has unique feature of sourcing by customer defined waveform signal. Definition on the signal is based on setting of amplitude and phase shift of harmonic products related to basic, fundamental frequency. Number of harmonic products is limited to 50 but maximum frequency of harmonic product cannot exceed 5 kHz. Amplitude of individual harmonic products cannot be higher than 30 % of amplitude of fundament signal.

See chapter 4.1.2. and 4.1.3. for setting waveform parameters.

4.2.4. Current SETUP

Current function SETUP can be activated using SETUP SOURCE key. Following screen will appear:

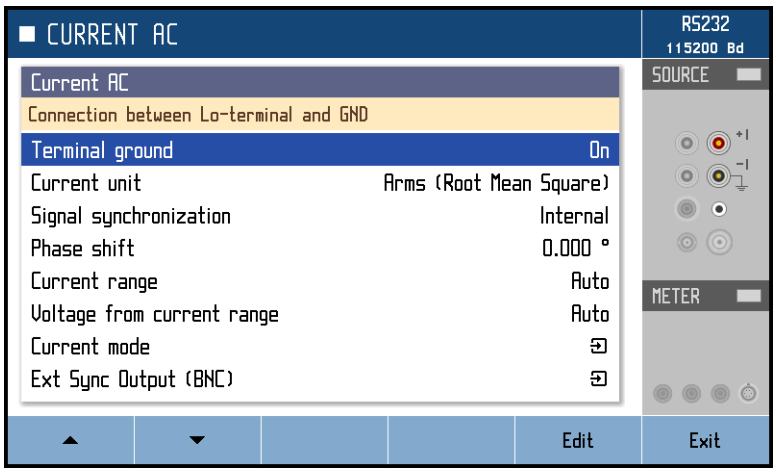

Figure 20 Current SETUP screen

SETUP offers additional current function settings. Use ▲▼ keys and EDIT key to change the following:

Terminal ground	On/Off	Current LO output terminal grounded/floating
Current unit	Root Mean Square/Peak/Peak-Peak/Average	
[AC only] Signal synchronization	Internal	frequency and phase is given by internal oscillator
	Power Line	synchronized to power line voltage
	BNC	synchronized to rear panel EXT SYNC INPUT connector
	External Master	synchronized to Master unit via rear panel MSI connector
[AC only] Phase shift	x.xxx Degrees (°)	phase shift between current output and synchronization signal
Current range	Normal - Auto/200µA/2mA/20mA/200mA/2A/30A. VFC - Auto/50mV/500mV/5V Coil – 50xNormal Range will be automatically selected based on selected mode.	
Current mode	Current mode	Normal/Voltage from current/Coil
	Equivalent coefficient (V/A)	with current mode set to Voltage from Current this defines ratio between generated voltage and set current
	Number of Coil turns	with current mode set to Coil, both display and remote control current values get multiplied by this number
	Coil uncertainty	with current mode set to Coil, both display and remote control uncertainty values get increased by this number
[AC only] Ext Sync Output (BNC)	Mode	Switches function of rear panel Ext Sync Output BNC. Both outputs generate squarewave signal with rising edge phase-locked to internal AC reference. “Sync output” is phase and frequency reference of main output signal, used to synchronize with other devices. Sync output frequency is limited to 1200 Hz (2400 Hz if main signal frequency is 19200 Hz or more). Higher frequencies are divided by powers of two so that Sync output frequency is always kept below 1200 Hz (2400 Hz for main frequency of 19200 Hz or more). “Sample output” is meant to trigger an external meter to synchronize sampling measurements with main current output, useful for calibration of 9010+. “Sample multiplier” set to “Auto” multiplies main signal frequency up to 850 Hz by factors 2048 – 64, keeping the sample output at around 30 – 65 kHz. Main signal frequency above 850 Hz gets multiplied by factors 32 – 8, rising sample output frequency up to its limit of 5 MHz. Fixed Sample multipliers multiply previously described Sync output instead of main signal frequency.
	Sample state	On/Off. Turning Sample state ON will cause sampling signal to start when reference signal passes through zero.
	Sample multiplier	Auto/8/16/32/64/128/256/512/1024/2048

4.3. Resistance

Basic version of the calibrator offers continuously adjustable resistance decade LVR, based on resistance simulation using electronic circuits. The function is designed for calibration of standard resistance function of various multimeters which use low level signals. The mode is signed VARIABLE. FIXED mode offers set of fixed decadic resistors with higher accuracy.

Calibrator can be equipped with high resistance option HVR, designed for calibration of insulation meters, megaohmmeters.

Push RESISTANCE function key to select resistance function.

4.3.1. LVR Low resistance decade VARIABLE mode

Low resistance decade can be used in two-wire or four-wire connection. Two-wire connection uses output terminals labelled HI and LO. Four-wire connection uses terminals HI and LO as “power” terminals and +I and -I as “sense“ terminals.

Note: four-wire method of connection offers lower uncertainty of calibration especially for low resistance values due to by the principle excluded test lead resistance influence.

Low resistance mode function is based on electronic simulator of resistance. It has limited working conditions. Maximum test voltage is 20 V. See specification for test voltage and test current limitations.

If HVR High resistance decade option is installed push RESISTANCE function key repeatedly until RESITANCE LVR mode is selected. Push MODE soft key to display list of modes. Select Variable and confirm with ENTER. Connect the ohmmeter (multimeter) to the calibrator as shown below.

1. Select appropriate function and range on the ohmmeter (multimeter)
2. Set requested mode of connection either two-wire or four-wire. Use WIRE soft key to switch between both modes. Set up requested resistance value.
3. Switch output terminals on by pushing key OPER.
4. Push STBY key to switch output off.

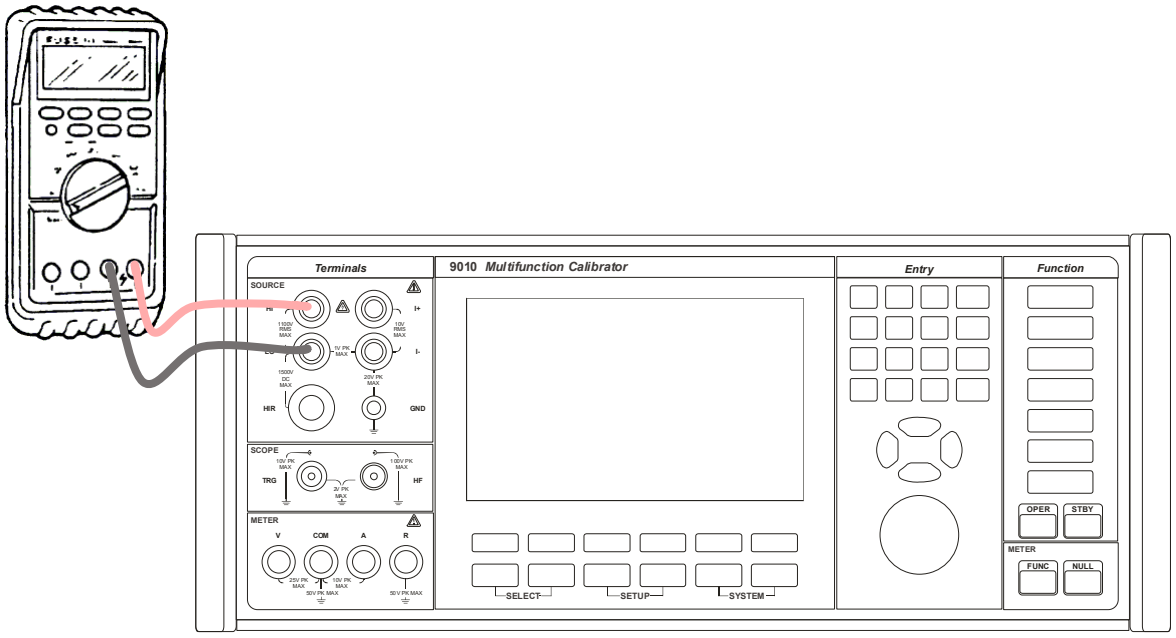

Figure 21 Two-wire resistance calibration

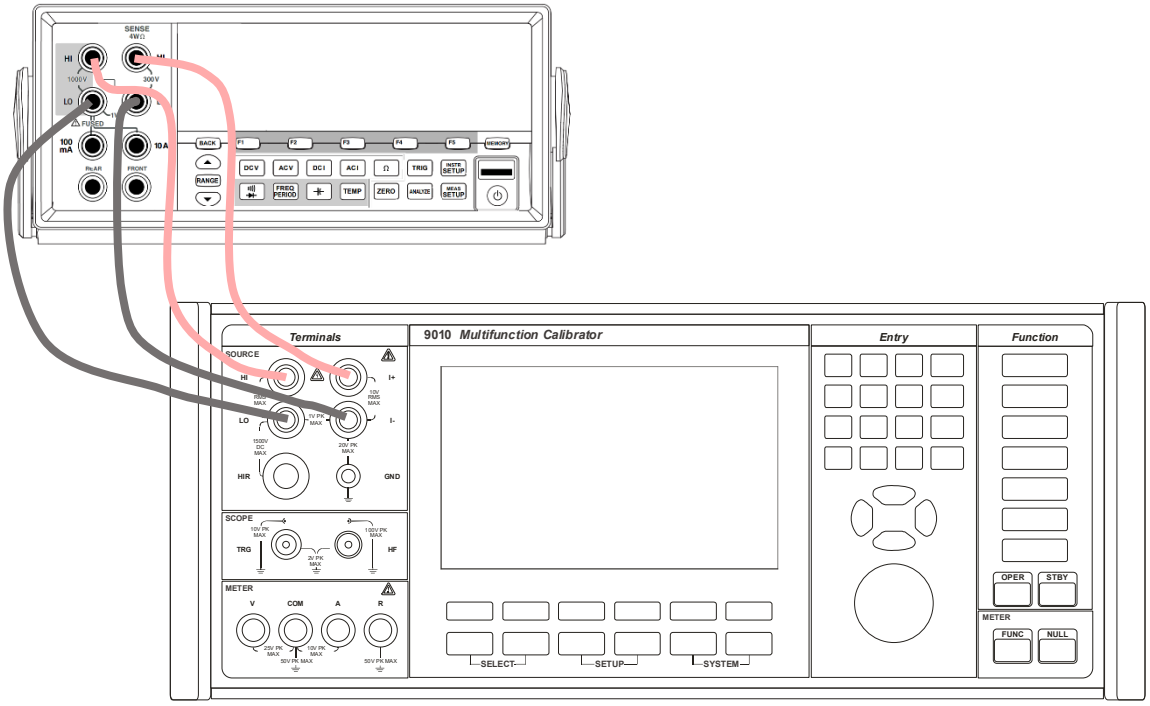

Figure 22 Four-wire resistance calibration

4.3.2. LVR Low resistance decade FIXED mode

Fixed mode offers high accuracy of sourced resistance however range of resistance is limited to fix decadic values. Exact calibration value is always displayed on the display.

Push MODE soft key to display list of modes. Select **Fixed** item and confirm with ENTER. Push WIRE soft key to select either two-wire or four-wire connection.

Selection of individual fix value positions can be done using softkeys▲▼, or cursor keys or using rotary button. Numerical keypad is not active in this mode. Calibration value is displayed on the display.

4.3.3. HVR High voltage resistance extension

High resistance decade offers fully programmable series connected resistance with maximum working voltage 1500 V. The decade is applicable on DC voltage. Do not use AC test signal. High resistance decade is available only in two-wire configuration.

Push MODE soft key to display list of modes. Select High resistance item and confirm with ENTER.

1. Connect the ohmmeter (multimeter) to the calibrator as shown on the figure below.
2. Select appropriate function and range on the ohmmeter (multimeter)
3. Push RESISTANCE function key on the calibrator. Push MODE soft key and select position High resistance decade.
4. Set requested resistance value.
5. Switch output terminals on by pushing key OPER.
6. Push STBY key to switch output off.

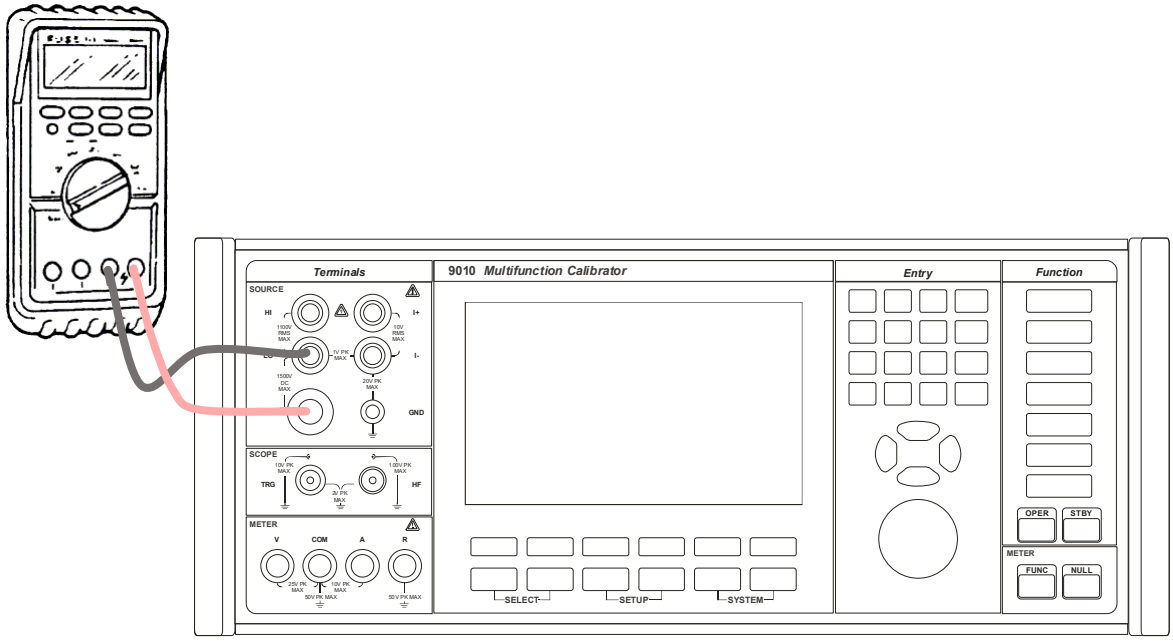

Figure 23 High resistance calibration

4.3.4. Resistance SETUP

Resistance SETUP can be activated using SETUP SOURCE key. Following parameters are available:

- Terminal ground On/Off
  LO output terminals is internally connected to PE wire when parameter is set to ON.

4.4. Capacitance

Calibrator contains continuously adjustable decade, based on capacitance simulation using electronic circuits. The function is designed for calibration of standard resistance function of various multimeters which use low level signals. The mode is signed VARIABLE.

Except the VARIABLE mode the calibrator offers more accurate resistance in FIXED mode. In this mode only fix nominal decadic values are available.

4.4.1. Capacitance VARIABLE mode

Low resistance mode is available in two- terminal connection only with maximum test from 2 to 5 V depending on set value. See specification for test voltage and test current limitations.

Push MODE soft key to display list of modes. Select Variable and confirm with ENTER.

1. Connect the multimeter to the calibrator as shown below.
2. Select appropriate function and range on the multimeter.
3. Push CAPACITANCE function key on the calibrator.
4. Switch output terminals on by pushing key OPER.
5. Push STBY key to switch output off.

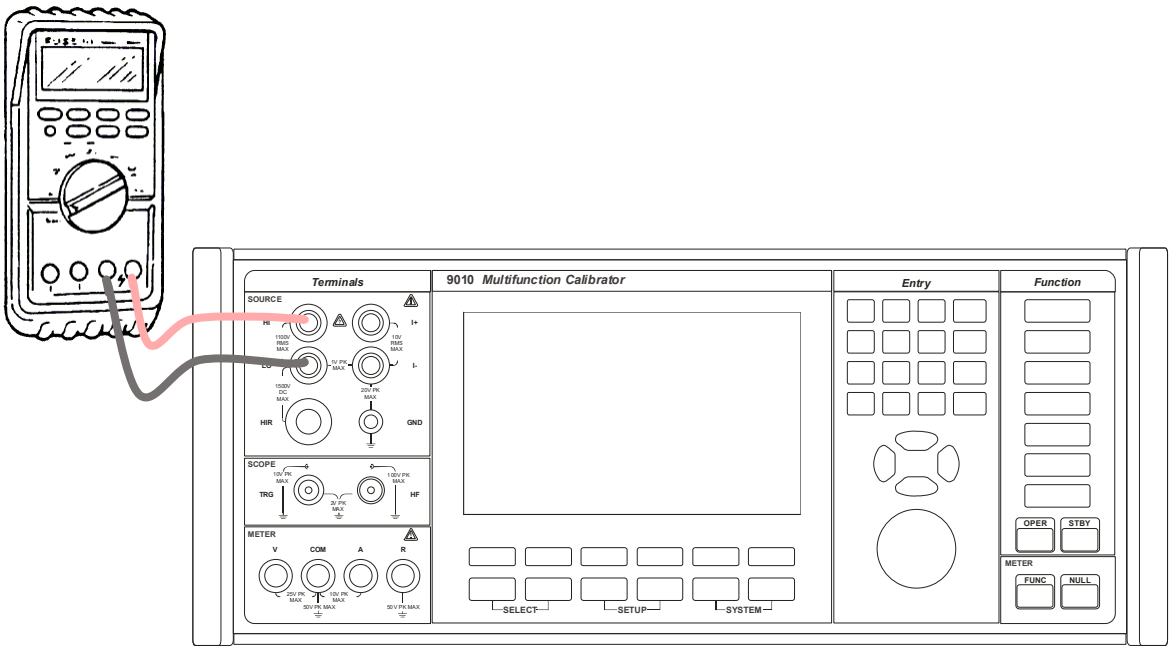

Figure 24 Capacitance calibration

Warning: If you are using RCL meter with 4TP connection or grounded equipment, proceed with caution. Due to using simulation principle it is necessary to swap Hi and Lo terminal. High terminal of RCL must be inserted into Lo terminal of calibrator and Lo terminal of RCL must be inserted into Hi terminal of calibrator. Do not try to solve this issue with isolation transformer otherwise accuracy of calibrator will be disturbed.

4.4.2. Capacitance FIXED mode

Fixed mode offers high accuracy of sourced capacitors with fix nominal values.

Push MODE soft key to display list of modes. Select Fixed item and confirm with ENTER. Selection of individual fix value positions can be done using softkeys ▲▼, or cursor keys or using rotary button. Numerical keypad is not active in this mode.

4.4.3. Capacitance SETUP

Capacitance SETUP can be activated using SETUP SOURCE key. Following parameters are available:

- Terminal ground
  LO output terminals are internally connected to PE wire when parameter is set to ON.

4.5. Electric power meters, analyzers and energy meters

Calibrator can supply output voltage and current at the same time. The function is designed for calibration of electric power meters and power analyzers. Push function key POWER to select Power/energy mode.

4.5.1. DC and SIN mode

Only output voltage and current can be set in DC mode. In AC mode frequency of the output signal and phase shift between voltage and current can set as well.

Figure 25 AC Power

1. Connect power meter to the calibrator as shown on the figure below.
2. Push POWER function key on the calibrator. Push POWER key once more to switch between DC and AC mode.
3. Set output voltage, current, frequency and phase shift using soft keys beneath the display or switch active field on the display for direct value entry using SELECT keys.
4. Push OPER key to connect output terminals. Calibrator is sourcing voltage and current.
5. Push STBY key to switch output off.

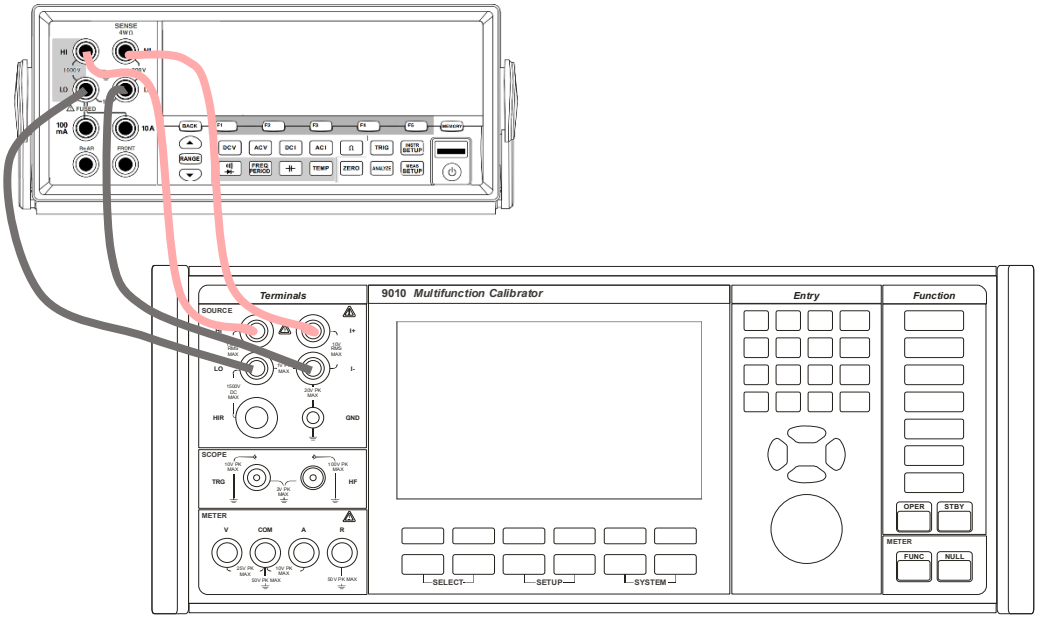

Figure 26 Power meter calibration

Calibrator features with floating current channel. Setting of grounded or floating output can be done in SETUP menu.

Sign of AC wave indicates SIN mode without distortion.

4.5.2. Harmonic mode

In Harmonic mode any distortion represented with amplitude and phase shift can be set in output signal. Harmonic content of output voltage can be set independently.

Select Power mode using POWER key. Push Harmonic soft key. Following screen will appear:

Figure 27 Harmonic mode

See chapter 4.1.3 for individual harmonic component editing, previewing, saving, and loading. Star sign in field Harmonic indicates that for the output signal has been defined harmonic distortion. Label without star sign means that the output signal is pure sin wave.

4.5.3. Energy mode

In Energy mode calibrator is sourcing output signal for defined period. Select Power mode using POWER key. Push Energy soft key. Following screen will appear:

Figure 28 Energy mode

Set requested time for which output signals should be connected to the output terminals. Use SELECT soft key to move active window. Both SINE and Harmonic mode can be applied in Energy mode.

4.5.4. Power/Energy parameters

Except main power value parameter, softkeys below the display can directly edit auxiliary parameters:

Figure 29 Power/Energy soft keys

Harmonic softkey enables setting of non-sinusoidal waveform with harmonic distortion. Move active line to position Harmonic using SELECT keys. Soft keys meaning is changed enabling setting of higher harmonic content. See chapter 4.1.3 for more details.

Energy softkey activates line for entering either requested energy portion in field ENERGY or requested time in field TIME.

Except one-touch buttons calibrator has its own parameter setting under SETUP. Push SOURCE SETUP key to call out menu with parameter setting.

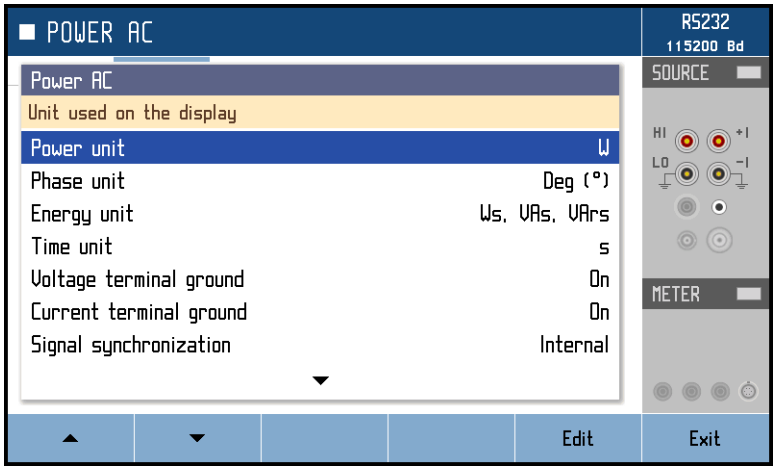

Figure 30 Power SETUP screen

Following items can be modified:

[AC only] Power unit	W/VA/VAr	
[AC only] Phase unit	Degrees (°) or Cos (Lead, Lag)	
[AC only] Energy unit	Ws/VAs/VArs/Wh/VAh/VArh	
Time unit	s (second) / hms (format hh:mm:ss)	
Voltage terminal ground	On/Off	Voltage LO output terminal grounded/floating
Current terminal ground	On/Off	Current LO output terminal grounded/floating
[AC only] Signal synchronization	Internal	frequency and phase is given by internal oscillator
	Power Line	synchronized to power line voltage
	BNC	synchronized to rear panel EXT SYNC INPUT connector
	External Master	synchronized to Master unit via rear panel MSI connector
[AC only] Phase shift	x.xxx Degrees (°) or Cos (Lead, Lag).	Phase shift between voltage and current
Energy mode	Timer	Upon activation, power output runs for predefined amount of time and then turns off automatically.
	Free run	Power output runs indefinitely upon activation and counts amount of energy delivered.
Voltage range	Auto/2V/20V/100V/280V	
Current range	Normal - Auto/200µA/2mA/20mA/200mA/2A/30A. VFC - Auto/50mV/500mV/5V Coil – 50xNormal Range will be automatically selected based on selected mode.	
Switch delay	Switch-on delay	Delayed switch-on of the current channel after voltage connection, range 0 to 60 s. This "extra" delay is indicated by a symbol on the main panel when switching the terminals on and off. ⏱
	Switch-off delay	Delayed switch-off of the current channel after voltage connection, range 0 to 60 s.
Current mode	Current mode	Normal/Voltage from current/Coil
	Equivalent coefficient (V/A)	with current mode set to Voltage from Current this defines ratio between generated voltage and set current
	Number of Coil turns	with current mode set to Coil, both display and remote control current values get multiplied by this number
	Coil uncertainty	with current mode set to Coil, both display and remote control uncertainty values get increased by this number
[AC only] Ext Sync Output (BNC)	Mode	Switches function of rear panel Ext Sync Output BNC. Both outputs generate squarewave signal with rising edge phase-locked to internal AC voltage reference. “Sync output” is phase and frequency reference of main output signal, used to synchronize with other devices. Sync output frequency is limited to 1200 Hz (2400 Hz if main signal frequency is 19200 Hz or more). Higher frequencies are divided by powers of two so that Sync output frequency is always kept below 1200 Hz (2400 Hz for main frequency of 19200 Hz or more). “Sample output” is meant to trigger an external voltmeter to synchronize sampling measurements with main voltage output, useful for calibration of 9010+. “Sample multiplier” set to “Auto” multiplies main signal frequency up to 850 Hz by factors 2048 – 64, keeping the sample output at around 30 – 65 kHz. Main signal frequency above 850 Hz gets multiplied by factors 32 – 8, rising sample output frequency up to its limit of 5 MHz. Fixed Sample multipliers multiply previously described Sync output instead of main signal frequency.
	Sample state	On/Off. Turning Sample state ON will cause sampling signal to start when reference signal passes through zero.
	Sample multiplier	Auto/8/16/32/64/128/256/512/1024/2048

4.5.5. Voltage from current function

The function enables to source output voltage from current terminals. Two synchronous voltage outputs are practically available in this mode. Simple resistance converter is used for transformation inside the calibrator. Range of output voltage is 5 mV to 5 V, AC or DC. Using setting of equivalent coefficient appropriate range of simulated current can be set.

Note: The function is useful for those wattmeter's calibration which sensing current terminals use millivolt input.

4.6. SCO & SC1 scope extensions

Calibrator can be equipped with either SCO or SC1 scope option for calibration of oscilloscopes. Both scope options feature following modes:

Mode	Description	Application	Range	Terminal
Voltage - Low	DC and Low freq. voltage up to 100 kHz and 10.5 V_{pk}	LF calibration of vertical sensitivity	0 – 10.5 V_{pk}	N connector
Voltage – High	DC and Low freq. voltage up to 1 kHz and 200 V_{pk}	LF calibration of vertical sensitivity	0 – 200 V_{pk}	HI – LO terminals
Sine	High freq. sinewave with adjustable amp. up to 1.5 V_{pk}	Frequency flatness of vertical channel	15 Hz – 400 MHz (SCO) 15 Hz – 1.1 GHz (SC1)	N connector
Pulse	Pulse width modulation with adjustable amp. and ratio	Time base calibration	1 – 50 %	N connector
Time marker	Time markers with adjustable ratio and amplitude	Time base calibration	0.1 Hz – 400 MHz	N connector
Input impedance meter	Resistance measurement of 50Ω and 1MΩ scope inputs	Input impedance test	100 Ω, 2 MΩ	N connector

Table 2 Scope option modes

Select SCOPE function using SCOPE key, following screen will appear:

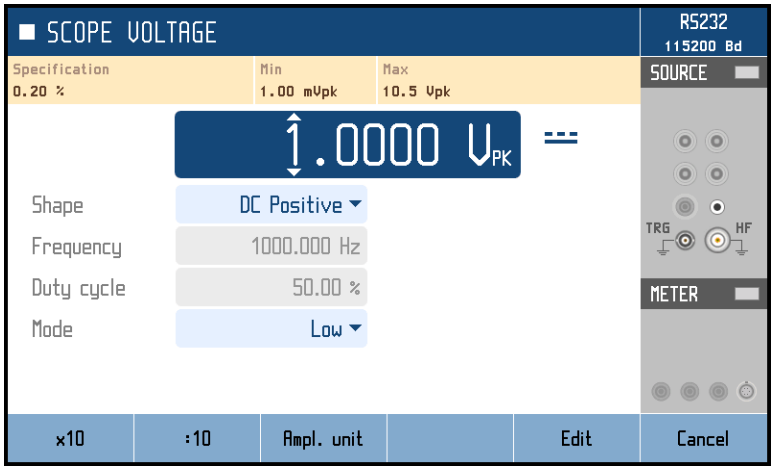

Figure 31 Scope option

Push the SCOPE key repeatedly to swap between Voltage – SINE – PWM – Time marker mode.

4.6.1. Low frequency and DC calibration

DC and squarewave calibrated signals are available in this mode. Requested mode Voltage can be selected after pushing soft key Shape. Following list of waveforms is displayed:

- DC Positive DC positive voltage with adjustable level
- DC Negative DC negative voltage with adjustable level
- Positive square Positive square wave signal with adjustable duty cycle ratio and frequency

- Negative square Negative square wave signal with adjustable duty cycle ratio and frequency
- Symmetric square Symmetric square wave signal with adjustable duty cycle ratio and frequency

Low mode output

Voltage mode has two submodes Low and High. In Low mode output signal is connected to the front panel coaxial connector. This mode offers frequency range to 100 kHz for square wave signals.

High mode output

In High mode output signal is connected to HI – LO output terminals. It is identical to ACV function.

Displayed units of amplitude can be set by pressing ↦| SELECT key to enter main value edit mode, then pressing Unit softkey and choosing one of the following units: V_{rms} (root mean square), V_{pk} (peak), V_{pp} (peak – peak), V_{avg} (average), dBu (dB microvolt), dBV (dB volt), dBm (dB miliwatt).

To calibrate an oscilloscope:

1. Connect the oscilloscope to N connector (Low mode) or to HI – LO terminals (Low) mode.
2. Set appropriate mode Low/High using Mode softkey.
3. Select requested waveform using soft key Shape and confirm with Enter.
4. Set requested frequency, amplitude, duty cycle ratio.
5. Push the OPER key to connect signal to the output terminals.

4.6.2. Sine mode

Sine mode offers calibrated sinewave voltage with low distortion and stabilized amplitude. Output impedance is 50Ω. Select the Sine mode by pushing the SCOPE key until screen with Sine mode is displayed. Following values are available for setting:

- Frequency in Hz
- Amplitude in preselected unit Vrms, Vpk, Vpp, Vavg, dBμ, dBV, dBm

Push the OPER key to connect signal to the output terminals (N connector).

Output resistance can be set to Low Z or 50 Ω in frequency range 20 Hz to 100 kHz. Low Z range means output impendence is lower than 0.5 Ω. Fix output resistance 50 Ω is only available for frequency above 100 kHz.

4.6.3. Pulse mode

In Pulse mode repeated pulses with defined frequency and duty cycle ratio. Pulse width is displayed on the screen as well. Output impedance is 50Ω. Select the Pulse mode by pushing the SCOPE key until screen with Pulse mode is displayed. Following values are available for setting:

- Frequency in Hz
- Amplitude in preselected unit Vrms, Vpk, Vpp, Vavg, dBμ, dBV, dBm
- Duty cycle ratio

Push the OPER key to connect signal to the output terminals. Indicated pulse width is calculated by formula $\Delta = 1/f * R/100$ [s], where f is frequency of output signal and R is duty cycle ratio in %.

4.6.4. Time marker mode

Time marker mode sources time pulses with defined width and adjustable period (frequency). Amplitude of the time markers can be adjusted in several predefined levels. Output impedance is 50Ω. Select the Time Marker mode by pushing the SCOPE key until screen with Time Marker mode is displayed. Following values are available for setting:

- Period in μs, ms, s
- Marker width in terms of duty cycle ratio in predefined levels 1, 10, 20, 30, 40, 50 % up to 4 MHz, in predefined levels 10, 20, 30, 40, 50 % up in range 4 MHz to 10 MHz and 2 ns width spikes above 10 MHz
- Amplitude in preselected unit Vrms, Vpk, Vpp, Vavg, dBμ, dBV, dBm in predefined levels 50 mV, 100 mV, 500 mV, 1V peak

Push the OPER key to connect signal to the output terminals (N connector).

4.6.5. Oscilloscope input impedance measurement

Oscilloscope input impedance can be measured by scope option itself. Press R-meter softkey in any scope option function mode to activate impedance measurement function:

Figure 32 SCO option input impedance measurement

Impedance is measured at HF terminal (N connector). 50Ω oscilloscope inputs shall be measured in 100Ω range, 1MΩ inputs shall be measured in 2MΩ range.

4.6.6. Scope SETUP

Scope SETUP can be activated using SETUP SOURCE key. Following screen will appear:

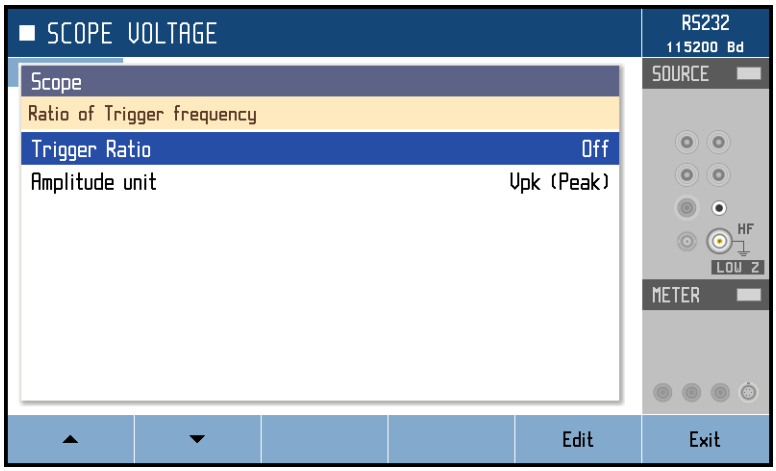

Figure 33 SCO option Device/Setup menu

4.6.7. Triggering

Output voltage of the SCOPE option can be triggered by external signal connected to coaxial BNC connector on the front panel. Square wave signal with amplitude over 1 Vpk is expected. Input resistance of the triggering input is 50 Ω. Only one parameter selection is available for triggering signal, Trigger Ratio.

To change setting push the SETUP key in SCOPE function, chose item Trigger Ratio and select one of values Off, /1, /10, /100. The number indicates nominal ratio of the frequency between triggering and output signal.

Output impedance

Scope option has two impedance configurations of HF coaxial output connector, 50 Ω and Low Z output impedance. Requested setting can be selected in Scope SETUP, item Impedance. In Low Z mode output impedance is close to zero Ω, typ. < 1Ω, in 50 Ω mode is output impedance set to 50 Ω ± 2 %. Setting of output impedance is indicated in the field SOURCE on the display using labels „LOW Z“ and „50 Ω“.

Amplitude unit

Last item in the SETUP menu is selection of displayed units. Change of unit can be performed also in individual subfunctions using soft key Ampl. Unit.

4.7. Temperature sensor simulation

Calibrator can simulate various, most frequently used temperature sensors, both resistance RTD type and thermocouple TC type. The function is accessible after function selection key OPTION pushing followed by selection of type of sensor.

4.7.1. RTD temperature sensor simulation

In TEMPERATURE RTD function calibrator simulates resistance temperature sensor by connecting such resistance to the output terminals which corresponds set temperature. Following screen appears after the function selection:

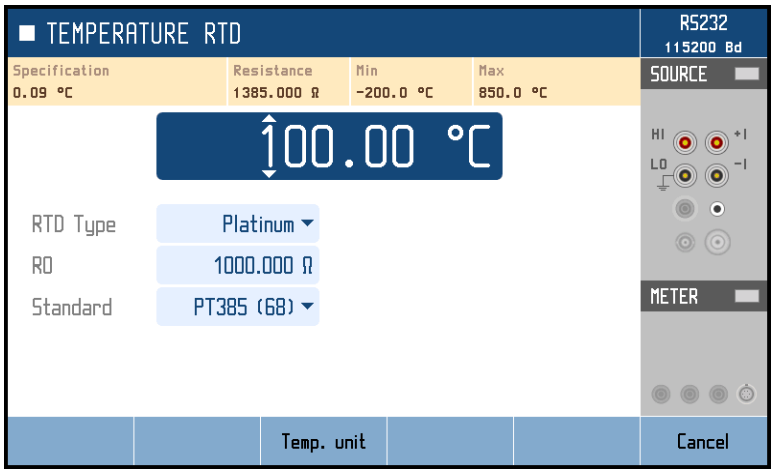

Figure 34 RTD temperature sensor simulation

To simulate an RTD temperature sensor:

1. Connect thermometer input to HI – LO, +I – -I terminals.
2. Select RTD type sensor using RTD Type soft button, either Platinum or Nickel.
3. Set nominal resistance of the sensor at 0. °C R0. For Pt 100 sensor the value is 100.000 Ω. Use R0 soft button.
4. Select a predefined temperature scale or create a custom scale and select „PT user“ to access it.
5. Enter requested temperature value into main field on the display to simulate temperature sensor.
6. Push the OPER key. Calculated resistance corresponding to the set temperature is connected to the output terminals. Real resistance value is displayed in yellow information line in upper part of the display. If the line is hidden, push any key for value setting cursor key, rotary button or SELECT arrow key.

Resistance is connected to HI – LO and +I – -I terminals in 4W configuration. HI – LO terminals are “power” terminals, +I – -I terminals are “sense” terminals.

RTD Simulation SETUP

TEMPERATURE RTD function has related SETUP function. The SETUP can be opened by pushing the key SOURCE SETUP. It contains following items:

- Temperature unit selection, °C, °F or K

- Terminal ground, enables internally LO output terminal grounding
  Coefficients of „PT User“ scale. RTD calculation formula is
  $R_{sim} = R0 * (1 + T*(A + T*(B + T*C(T-100.0))))$, where T is temperature in °C and R0 is nominal resistance of temperature sensor at 0 °C.

4.7.2. Thermocouple temperature sensor simulation

In TEMPERATURE TC function calibrator simulates thermocouple temperature sensor by sourcing such DC voltage to the output terminals which corresponds set temperature and selected type of sensor. Following screen appears after the function selection:

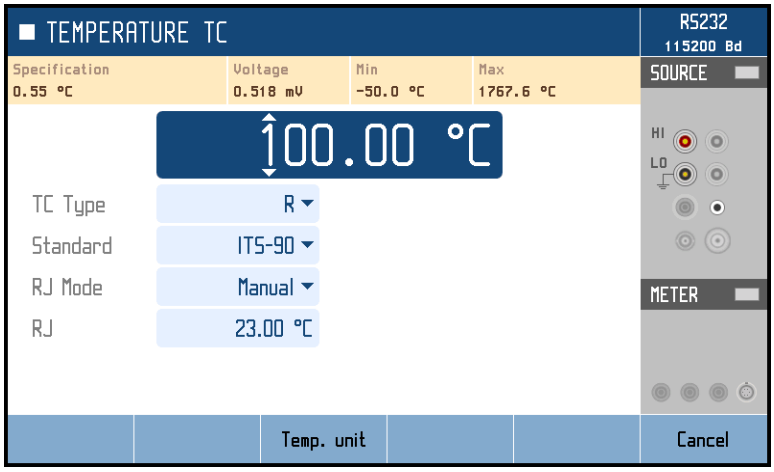

Figure 35 TC temperature sensor simulation

To simulate a TC temperature sensor:

1. Connect thermometer input to HI – LO output terminals.
2. Select TC Type sensor, one of following R, S, B, J, T, E, K, N, M, C, D, G2
3. Select requested temperature standard PTS-68 or ITS-90
4. Select Manual RJ mode and enter cold junction temperature into RJ field. With MER option and Adapter 91 connected as in picture below you can also use Auto compensation mode:

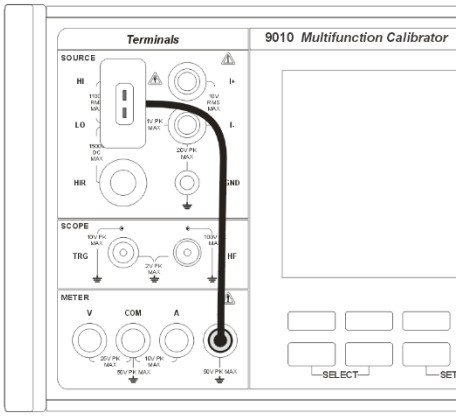

Figure 36 Thermocouple simulation using Adapter 91

5. Enter requested temperature value into main field on the display to simulate temperature sensor.
6. Push the OPER key to activate output. Real DC voltage level is displayed in yellow information line in upper part of the display. If the line is hidden, push any key for value setting cursor key, rotary button or SELECT arrow key.

TC temperature sensor simulation SETUP

TEMPERATURE TC function has related SETUP function. The SETUP can be opened by pushing the key SOURCE SETUP. It contains following items:

- Temperature unit selection, °C, °F or K
- Terminal ground, enables internally LO output terminal grounding
- Output mode either passive (more accurate) or active (higher current available)

4.8. MER multimeter extension

4.8.1. Input terminals

The calibrator is equipped with built-in process multimeter. The multimeter offers directly basic measurement of output signal of various transmitters, evaluation units, energy counters, etc. without need of any other measuring instrument. Except it, the multimeter serves as thermometer for External reference junction adapter used for automatic compensation of cold junction temperature when thermocouple sensor is simulated.

Multimeter field appears on the screen after pushing the key METER FUNC. Information line with multimeter readings and basic setting is displayed then in bottom part of the screen.

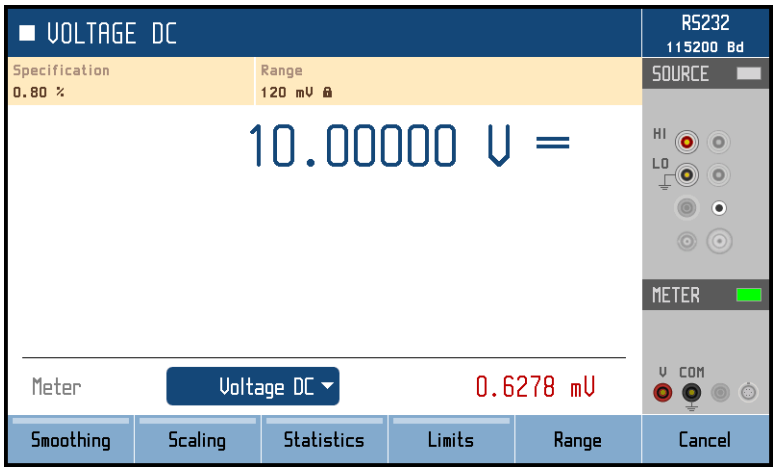

Figure 37 Process multimeter

To measure external signal:

1. Connect source of signal to the input terminals:
    - Use A and COM terminals for current measurement.
    - Use 9000-60 adapter connected to R terminal to measure resistance and RTD temperature sensors.
    - Use V and COM terminals for all other meter functions. When measuring thermocouples with auto cold junction compensation, connect Adapter 91 as follows:

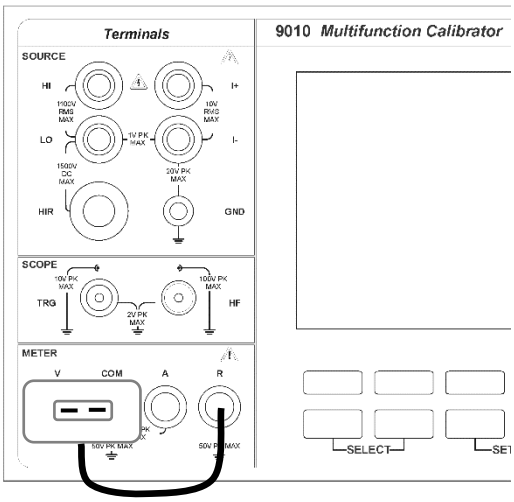

Figure 38 Thermocouple measurement using Adapter 91

2. Select requested function. Use SELECT arrows key and rotary button or cursor keys.
3. Multimeter starts measuring of the input signal.

Null button

Reading on the display can be nulled at any time with NULL button. When Null function is active, LED key NULL lit and symbol NULL is displayed in METER information field on the screen. To cancel nulling function push NULL key again.

4.8.2. Softkey functions

Multimeter function has direct access to several subfunctions. Push SELECT key until active window Meter is selected. Meaning of soft keys beneath the display is changed. Soft keys enables fast access to following functions:

Figure 39 Multimeter softkeys

- Smoothing — Smoothing filter activation
- Scaling — Allow to scale measurements relative to a reference value
- Statistics — Statistical data can be displayed
- Limits — Limits of band setting
- Range — Auto or fix range selection

Smoothing

The function enables activation of smoothing filter and setting integration time in terms of number of samples which are averaged. Set item Smoothing to ON to activate the filter.

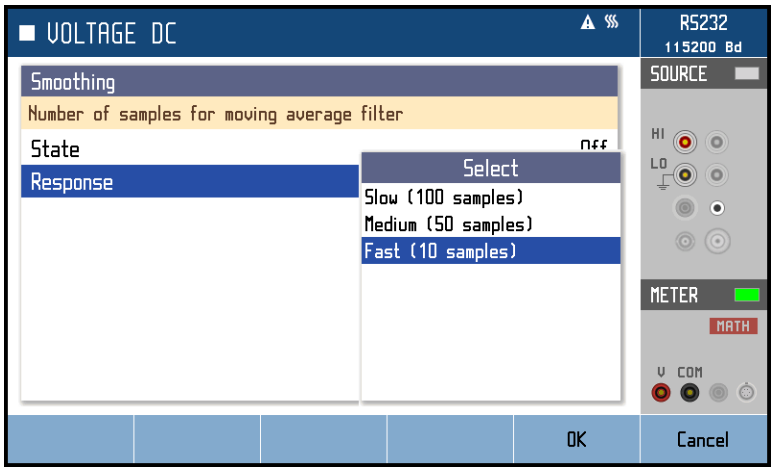

Figure 40 Meter smoothing filter

Scaling

The Scaling function allows recalculation of multimeter readings. Press Scaling softkey to set scaling parameters:

- Scaling. Use this item to turn scaling ON. Scaling is automatically turned off after each meter function change (for example changing from DCV to ACV).
- Function. „%“ shows relative value and „Scale“ shows absolute value, based on formulas

$$\text{Rel. value [\%]} = (\text{reading} - \text{Reference}) / \text{Reference} \cdot 100$$ and $$\text{Abs. value} = \text{Gain} \cdot \text{reading} + \text{Offset}$$.

- Gain, Offset and % Reference. Scaling formula parameters.
- Custom unit and Custom unit label. Custom unit with length up to 4 alphanumerical characters can be defined. Use navigation buttons or rotary knob to enter requested letters, switch between uppercase and lowercase using A ↔ a softkey and enable this feature by turning Custom unit ON.

Statistics

Reading of the multimeter are statistically evaluated when STATISTICS function is switch on. Use Statistics soft key to display statistic parameters. Symbol MATH is displayed in METER information field. Following data are displayed:

- Min — Minimum reading
- Max — Maximum reading
- Span — Max-Min difference
- Average — Average value from all collected readings
- St. deviation — Standard deviation of the collected readings
- Count — Number of readings

STATISTICS function can be disabled by pushing soft button Statistics or readings can be reset by pushing soft key Clear.

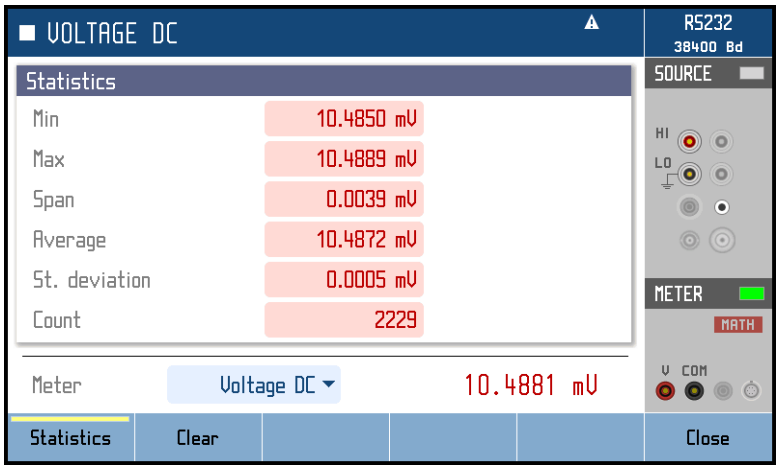

Figure 41 Meter statistics function

Limits

LIMITS function displays indication whether reading is inside or outside predefined limits. Lower and upper limit must be entered before switching the function ON. Default value is 0.000000 for both values. Indication of reading versus limits is displayed in METER field using LIMIT label with arrows showing if the reading is below, inside or up. The LIMITS function is applicable in all meter functions.

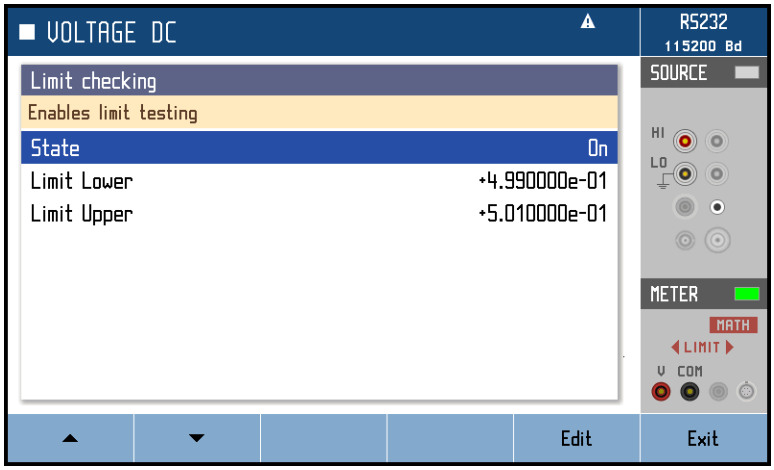

Figure 42 Meter limits function

4.8.3. Meter SETUP

The multimeter has related SETUP menu offering selection of parameters shown in table below. Push METER SETUP key to display SETUP screen.

Item	Subitem (if any)	Values	Meaning
Function	Voltage DC, Current DC, Lo Current DC, Frequency, Resistance, RTD, TC		Selected meter function
Ranges	Voltage DC	Auto/12mV/120mV/1.2V/12V	Fixed range or autorange selection
	Current DC	Auto/2.4mA/24mA	
	Lo Current DC	Auto/100µA/1mA	
	Resistance	Auto/2kΩ/20kΩ	
	Frequency	Auto/10kHz/100kHz	
	RTD	Auto/2kΩ/20kΩ	
	TC	Auto/12mV/120mV	
Terminal ground	On/Off		COM terminal grounding
Input impedance	10MΩ/High Z (over 1GΩ)		Selection of voltmeter input resistance.
Frequency input	Passive / Active (pull up)		Way of sensing input signal
AC filter	100Hz/100kHz		Input bandwidth
Temperature unit	˚C/˚F/K		Temperature unit
TC	Type	R/S/B/J/T/E/K/N/M/C/D/G2	TC type
	Standard	PTS-68/ITS-90	Temperature scale selection
	RJ mode	Manual/External	Cold junction compensation
	RJ Value	xx.xx ˚C	Cold junction temperature
RTD	Type	Platinum/Nickel	RTD type
	Standard	PT385 (68)/PT385 (90)/PT3916/PT3926/PT User	Temperature scale selection
	R0	xxx.xxx Ω	Sensor resistance at 0˚C
	RTD Coefficient A	x.xxxxxx	Approximation coefficients
	RTD Coefficient B	x.xxxxxx	
	RTD Coefficient C	x.xxxxxx	
Integration time	50/60/100/200/400/800 ms		Reading refresh rate
Auto offset	On/Off		Automatic offset correction
Mathematics	Smoothing		See details in chapter 4.8.2
	Scaling		
	Statistics		
	Limit checking		

Table 3 Multimeter SETUP

Direct access to the mathematic parameters is also using soft keys beneath display: Smoothing, Scaling, Statistics and Limits. The mathematic functions which have been switch on have indication with yellow bar in soft key description in the bottom line. MATH label is simultaneously displayed in METER field showing that mathematic function has been applied.

4.9. External Options

9010+ supports connection of external options through two MSI bus connectors. Multiple devices can be daisy chained in one connector.

Press OPTION for Function menu and then press OPTIONS soft key to search for external options. List of all externally connected options that are supported will show up:

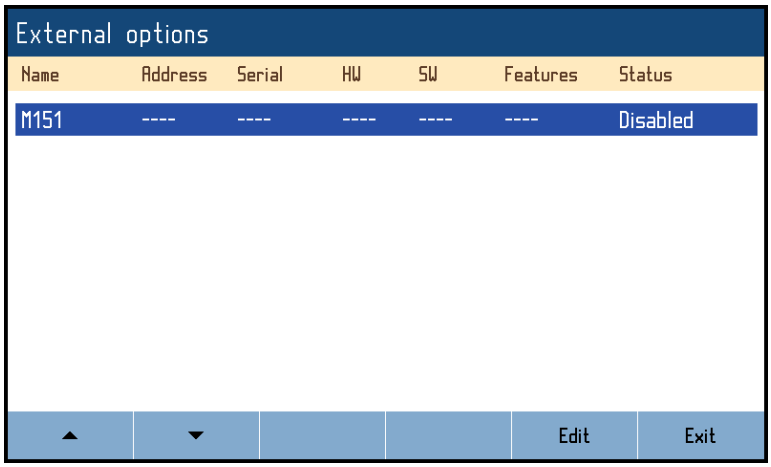

Figure 43 External options

Status – status:

Connected – device has been connected successfully
Not found – device doesn‘t respond when address is entered
Disabled – device is disabled by the user
Old HW – device has outdated HW and cannot be used as an option
Old SW – device has outdated SW – find out the possibility to update the SW
No feature – device does not have the required properties (missing HW)

The EDIT soft key can be used to change the device address or to disable the device:

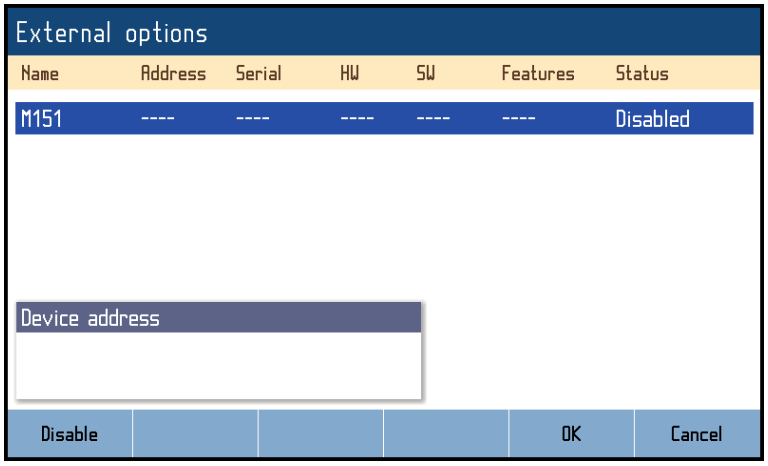

Figure 44 Address of external option

The address can be in the range from 0 to 199 (every instrument must have unique address). When DISABLE soft key is pressed, the calibrator will not try to identify the device.

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 Fluke 8508A/8588A or similar with uncertainty10 ppm or better on DC voltage, 100 ppm on AC voltage
- Single Channel LF Power Meter / Power Analyzer 1000V/30A like Zimmer LMG6100, LMG500 or similar with uncertainty 0.025 % or better.
- Counter Keysight 53181A or similar with uncertainty 1 ppm or better.
- LCR meter type Keysight U4980A or similar with uncertainty 0.1 % at 1 kHz or better
- Megaohmmeter Quadtech 1865 or similar with resistance range up to 100 GΩ or more (when HVR option is installed)
- RF voltmeter/wattmeter type Thermal Power Sensor Rohde&Schwarz NRP-Z51 or equivalent with 50Ω characteristic impedance (when SCO option is installed)

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 22 °C to 24 °C.
2. Set Terminal ground item in 9010+'s SOURCE SETUP menu to ON in order to suppress mains noise during measurement.
3. Connect output/input 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 Low frequency SINE voltage test
    c. DC current test
    d. AC current SINE test
    e. AC power and phase test
    f. Variable resistance LVR test
    g. Fixed resistance LVR test
    h. Variable capacitance test
    i. Fixed capacitance test
    j. High Voltage Resistance Variable (HVR option only)
    k. High Voltage Resistance Fixed (HVR option only)
    l. Frequency test (1 MHz)
    m. HF voltage test (SCO option only)
    n. Non-sinusoidal voltage test
    o. Meter test covering DC voltage, DC current, frequency and resistance tests

5.3. Test points

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
DC Voltage	20	-19	-19.0119	-18.9881	mV	8½ digit DMM	DC
		-10	-10.011	-9.989	mV		
		10	9.989	10.011	mV		
		19	18.9881	19.0119	mV		
	20	-19	-19.0021	-18.9979	mV		DC, passive output
		-10	-10.0018	-9.9982	mV		
		10	9.9982	10.0018	mV		
		19	18.9979	19.0021	mV		
	200	-190	-190.013	-189.987	mV		DC
		-100	-100.012	-99.989	mV		
		100	99.989	100.012	mV		
		190	189.987	190.013	mV		
	200	-190	-190.004	-189.996	mV		DC, passive output
		-100	-100.003	-99.997	mV		
		100	99.997	100.003	mV		
		190	189.996	190.004	mV		
	2	-1.9	-1.90003	-1.89997	V		DC
		-1	-1.00002	-0.99998	V		
		1	0.999983	1.000017	V		
		1.9	1.899972	1.900028	V		
	20	-19	-19.0002	-18.9998	V		
		-2.1	-2.10006	-2.09994	V		
		2.1	2.099944	2.100056	V		
		4	3.999925	4.000075	V		
		6	5.999905	6.000095	V		
		8	7.999885	8.000115	V		
		10	9.999865	10.00014	V		
		12	11.99985	12.00016	V		
		14	13.99983	14.00018	V		
		16	15.99981	16.0002	V		
		18	17.99979	18.00022	V		
		19	18.99978	19.00023	V		
		20	19.99977	20.00024	V		
	100	22	21.9995	22.0005	V		
		90	89.9985	90.0015	V		
	280	110	109.998	110.0021	V		
		200	199.9966	200.0034	V		
	1000	300	299.991	300.001	V		
		900	899.979	900.022	V		
AC Voltage SINE	20	10	9.96	10.037	mV	8½ digit DMM	1 kHz
		19	18.952	19.048	mV		
	200	100	99.61	100.39	mV		
		190	189.3	190.71	mV		

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
	2	1	0.99975	1.00026	V		
		1.9	1.8996	1.9004	V		
	20	2.1	2.098964	2.101036	V		
		4	3.9987	4.0013	V		
		6	5.9983	6.0017	V		
		8	7.998	8.002	V		
		10	9.9977	10.0023	V		
		12	11.9974	12.0026	V		
		14	13.9971	14.0029	V		
		16	15.9967	16.0033	V		
		18	17.99642	18.0036	V		
		19	18.9963	19.0037	V		
		20	19.9961	20.0039	V		
	100	22	21.991	22.009	V		
		90	89.9788	90.0212	V		
	280	110	109.9702	110.0298	V		
		200	199.954	200.046	V		
	1000	300	299.895	300.105	V		
		750	749.76	750.24	V		
DC Current	200	-190	-190.058	-189.942	μA	8½ digit DMM	DC
		-100	-100.04	-99.96	μA		
		100	99.96	100.04	μA		
		190	189.942	190.058	μA		
	2	-1.9	-1.90034	-1.89967	mA		
		-1	-1.0002	-0.9998	mA		
		1	0.9998	1.0002	mA		
		1.9	1.89967	1.90034	mA		
	20	-19	-19.0013	-18.9987	mA		
		-10	-10.0016	-9.9984	mA		
		10	9.9984	10.0016	mA		
		19	18.9975	19.0025	mA		
	200	-190	-190.024	-189.976	mA		
		-100	-100.015	-99.985	mA		
		100	99.985	100.015	mA		
		190	189.976	190.024	mA		
	2	-1.9	-1.90035	-1.89965	A		
		-1	-1.00021	-0.99979	A		
		1	0.99979	1.00021	A		
		1.9	1.89965	1.90035	A		
	20.5	-19	-19.0053	-18.9948	A		
		-10	-10.003	-9.997	A		
		10	9.997	10.003	A		
		19	18.9948	19.0053	A		

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
	30	-29	-29.0298	-28.9703	A		
		-21	-21.0218	-20.9783	A		
		21	20.9783	21.0218	A		
		29	28.9703	29.0298	A		
AC Current SINE	200	100	99.795	100.205	μA	8½ digit DMM	1 kHz
	2	1	0.999	1.0011	mA		
		1.9	1.89819	1.90182	mA		
	20	10	9.994	10.006	mA		
		19	18.9904	19.0096	mA		
	200	100	99.94	100.06	mA		
		190	189.904	190.096	mA		
	2	1	0.99942	1.00058	A		
		1.9	1.89899	1.90101	A		
	20.5	10	9.9885	10.0115	A		120 Hz
		19	18.9818	19.0183	A		
	30	21	20.9698	21.0302	A		
		29	28.9602	29.0398	A		
AC Power & Phase	200	200	199.87	200.13	VA	Power meter	100V/2A/50Hz/PF=1
	5740	4000	3995.91	4004.09	VA		200V/20A/50Hz/PF=1
	200	200	199.08	200.92	VA		100V/2A/50Hz/PF=0.5
	5740	4000	3981.39	4018.61	VA		200V/20A/50Hz/PF=0.5
Variable Resistance LVR	0	0	-0.002	0.002	Ω	8½ digit DMM	4W
	10	10	9.996	10.005	Ω		
	33	30	29.9905	30.0095	Ω		
	100	100	99.987	100.013	Ω		
	330	300	299.967	300.033	Ω		
	1	1	0.99988	1.00012	kΩ		
	3.3	3	2.9997	3.0003	kΩ		
	10	10	9.99907	10.00093	kΩ		
	33	30	29.997	30.003	kΩ		
	100	100	99.99067	100.0093	kΩ		2W
	330	300	299.967	300.033	kΩ		
	1	1	0.999847	1.000153	MΩ		
	3.3	3	2.99952	3.00048	MΩ		
	10	10	9.99797	10.00203	MΩ		
	33	30	29.9397	30.0603	MΩ		
	100	100	99.7997	100.2003	MΩ		
	330	300	299.097	300.9	MΩ		
	1000	1000	989.99	1010.001	MΩ		

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
Fixed Resistance LVR (min and max relative to calibration values)	0	0	-0.0005	+0.0005	Ω	8½ digit DMM	4W
	0.1	0.1	-0.0005	+0.0005	Ω		
	1	1	-0.0005	+0.0005	Ω		
	10	10	-0.001	+0.001	Ω		
	100	100	-0.003	+0.003	Ω		
	1	1	-0.000015	+0.000015	kΩ		
	10	10	-0.00015	+0.00015	kΩ		
	100	100	-0.0015	+0.0015	kΩ		2W, low voltage mode
	1	1	-0.00003	+0.00003	MΩ		
	10	10	-0.0013	+0.0013	MΩ		
	100	100	-0.1	+0.1	MΩ		
	1000	1000	-2.5	+2.5	MΩ		
Variable Capacitance	1	1	0.985	1.02	nF	LCR meter (see correct connection of meter)	1 kHz
	3.3	3	2.97	3.03	nF		
	10	10	9.95	10.05	nF		
	33	30	29.85	30.15	nF		
	100	100	99.5	100.5	nF		
	330	300	298.5	301.5	nF		100 Hz
	1	1	0.995	1.005	µF		
	3.3	3	2.985	3.015	µF		
	10	10	9.95	10.05	µF		
	33	30	29.85	30.15	µF		
	100	100	99.5	100.5	µF		
	330	300	298.5	301.5	µF	8½ digit DMM	Ramp method
	1000	1000	995	1005	µF		
	11	3	2.985	3.015	mF		
	11	11	10.923	11.077	mF		
	120	30	29.7	30.3	mF		
	120	100	99	101	mF		
Fixed Capacitance (min and max relative to calibration values)	1	1	-0.0125	+0.0125	nF	LCR meter	1 kHz
	10	10	-0.035	+0.035	nF		
	100	100	-0.25	+0.25	nF		
	1	1	-0.0025	+0.0025	µF		100 Hz
	10	10	-0.035	+0.035	µF		
	100	100	-0.45	+0.45	µF		

Table 4 List of main test points

5.3.1. HVR, SCO and MER test points

HVR functions	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
High Voltage Resistance	200	100	99.8	100.2	kΩ	8½ digit DMM	2W, DC
	200	190	189.62	190.38	kΩ		
	1000	900	898.20	901.80	kΩ		
	2	1.9	1.8943	1.9057	MΩ		
	10	9	8.9730	9.0270	MΩ		
	20	19	18.905	19.095	MΩ		
	200	90	89.55	90.45	MΩ		
	200	190	189.05	190.95	MΩ		
	1000	900	895.50	904.50	MΩ		
	2	1.9	1.881	1.919	GΩ	Megohmmeter	2W, 500 V_{dc}
	10	9	8.91	9.09	GΩ		
	100	100	cal. val. -3	cal. val. +3	GΩ		
SCO functions	**Range**	**Nominal**	**Min value**	**Max value**	**Unit**	**Standard unit**	**Test parameters**
SINE mode Frequency	400	1	0.999975	1.000025	MHz	Counter	-
SINE mode Voltage	1500	10	9.5	10.5	mV	RF voltmeter	10 MHz
	1500	100	97.25	102.75	mV		
	1500	800	779.75	820.25	mV		
	1500	100	96.45	103.55	mV		100 MHz
	1500	800	773.35	826.65	mV		
	1500	100	96.05	103.95	mV		400 MHz
	1500	800	770.15	829.85	mV		
LF mode DC Voltage	10.5	0.1	0.09985	0.10015	V	8½ digit DMM	-
	10.5	1	0.99895	1.00105	V		
	10.5	10	9.98995	10.01005	V		
SC1 functions	**Range**	**Nominal**	**Min value**	**Max value**	**Unit**	**Standard unit**	**Test parameters**
SINE mode Frequency	1 100	1	0.999999	1.000001	MHz	Counter	-
SINE mode Voltage	1500	10	9.5	10.5	mV	RF voltmeter	10 MHz
	1500	100	97.25	102.75	mV		
	1500	800	779.75	820.25	mV		
	1500	100	96.45	103.55	mV		100 MHz
	1500	800	773.35	826.65	mV		
	1500	100	96.05	103.95	mV		400 MHz
	1500	800	770.15	829.85	mV		
	1500	100	97.25	102.75	mV		600 MHz
	1500	800	779.75	820.25	mV		
	1500	100	96.45	103.55	mV		800 MHz
	1500	800	773.35	826.65	mV		
	1500	100	96.05	103.95	mV		1 000 MHz
	1500	800	770.15	829.85	mV		
	1000	100	96.05	103.95	mV		1 100 MHz
	1000	800	770.15	829.85	mV		

MER functions	Range	Nominal	Min value	Max value	Unit	Setup and connection scheme
Voltage	12	10	9.9969	10.0031	mV	Set both source and meter functions to Voltage DC. Connect Hi to V and Lo to COM terminals on 9010+. Use standard 8½ digit DMM to measure voltage at Hi/Lo terminals.
	120	100	99.990	100.010	mV	
	1.2	1	0.9999	1.0001	V	
	12	10	9.999	10.001	V	
Lo Current	100	100	99.96	100.04	µA	Set both source and meter functions to Current DC. Connect I+ to A terminals on 9010+. Use standard 8½ digit DMM to measure current between COM/I- terminals.
	1	1	0.9997	1.0003	mA	
Current	2.4	2	1.9989	2.0011	mA	
	24	20	19.9962	20.0038	mA	
Frequency	100	1	0.99995	1.00005	kHz	Set source to Voltage AC, 1 V, 1 kHz. Connect Hi to V and Lo to COM terminals on 9010+. Use standard counter to measure frequency at Hi/Lo terminals.
Resistance	2	1	0.99979	1.00021	kΩ	Set both source and meter functions to resistance. Use 9000-60 adapter to connect meter to source terminals (Hu to Hi, Lu to Lo, Hi to I+ and Li to I-). Use standard 8½ digit DMM to measure resistance at source terminals.
	20	10	9.998	10.002	kΩ	

Table 5 List of options' test points

6. Adjustment

Adjustment is done through MENU > Calibration > Data. This menu item is password protected, default factory set calibration code is “9010”.

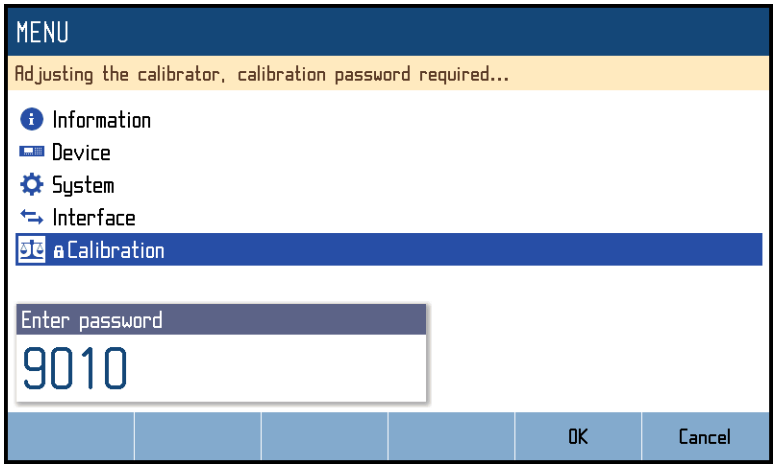

Figure 45 Password entry

6.1. Calibration menu structure

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

1. Function groups (source and measurement)
2. Functions (f.e. Voltage DC)
3. Ranges (f.e. 10 V)
4. Calibration points (f.e. zero offset)

As with any other menu you can navigate through the tree structure using cursor buttons, rotary knob or softkeys. ⌇ symbol indicates calibration tree branches with out-of-date or otherwise invalid calibration data:

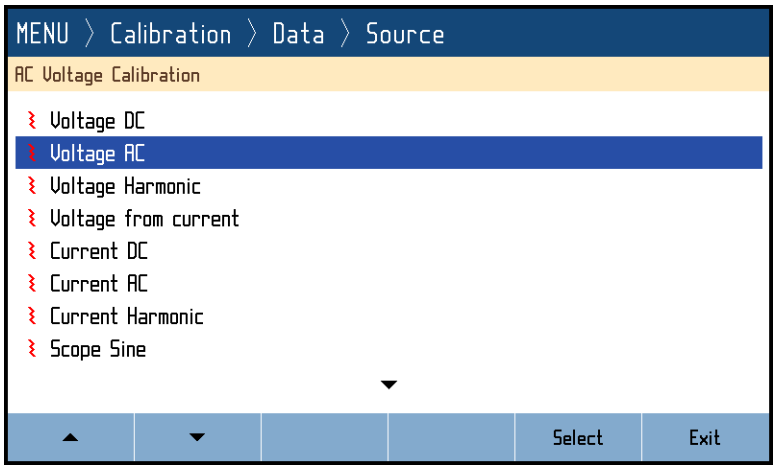

Figure 46 Calibration menu with out-of-date calibration data

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

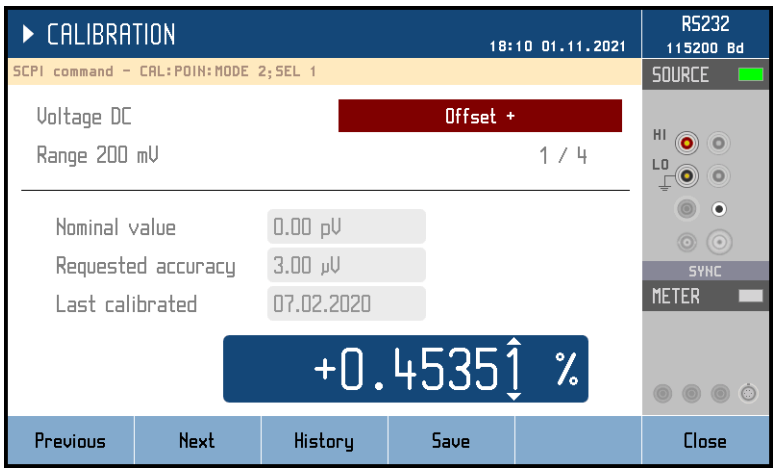

Figure 47 Calibration point adjustment – direct

Upper part shows selected function and range on the left, selected calibration point on the left and remote control command used to access this specific point in tooltip bar on top. Lower part of the display shows:

- Nominal value
- Requested accuracy of used calibration standard
- Last calibration date of this point
- Calibration value (only this can be modified)

History of each calibration point can be recalled using History softkey. History shows all previously saved values in a table, including date and relative drift from the first value ever recorded.

6.2. Calibration point adjustment

Two different approaches to calibration value adjustment are applied in 9010+:

- Values denoted in % or without any unit (mostly used in source functions with continuous ranges like V_{dc} function in fig. 42 above) show relative position within selected range. Such points can be adjusted by changing the value so that the standard readout gets as close to nominal value as possible.
- Values with other units (mostly used in meter functions or fixed source standards) can be calibrated indirectly by typing in meter readout. Figure 43 below shows an example of 100Ω point of fixed resistance function which has been adjusted by measuring resistance on output terminals with standard meter and typing in the standard readout (99.9955 Ω)

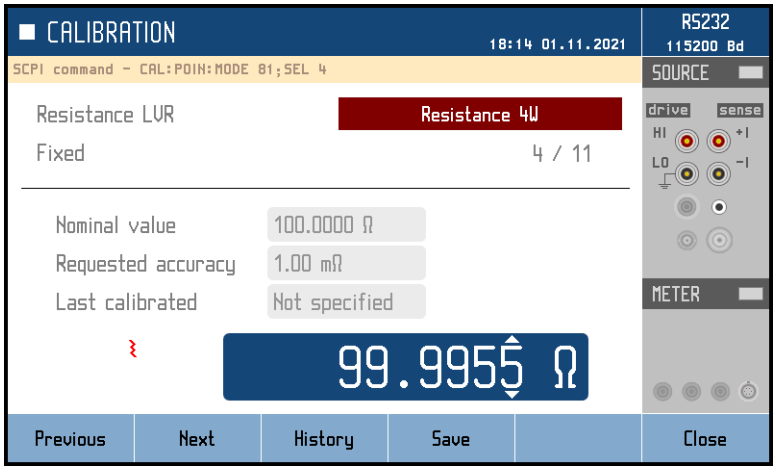

Figure 48 Calibration point adjustment – indirect

In both cases the procedure starts by connecting required standard to relevant terminals as shown on the right side of display. Meter functions measure all the time, source functions have to be switched on first using OPER key. Then adjust the main value accordingly and confirm with SAVE softkey.

HISTORY softkey allows you to check all previous values of this specific calibration point, PREVIOUS and NEXT softkeys navigate through other calibration points in selected range.

It is strongly recommended to periodically adjust all calibration points at once and in order as described in chapter 6.3 in order to maintain instrument specifications. That said, the instrument can be also adjusted partially, i.e. in particular functions or ranges only. If adjustment of next calibration point is not possible (f.e. when required standard is not available), the point can be skipped and old calibration data can be confirmed. However, specification can no longer be guaranteed in that range or function.

6.3. List of calibration points

Process of adjustment mostly involves changing offsets and slopes of individual ranges and other factors like amplitude linearity or frequency flatness coefficients of SCO option functions.

6.3.1. Voltage and current DC functions

Function	Range	Nominal value			
		Offset +	Offset –	Full range +	Full range -
Voltage DC	20 mV pas.	0.000 mV	0.000 mV	+19.000 mV	-19.000 mV
	200 mV pas.	0.000 mV	0.000 mV	+190.000 mV	-190.000 mV
	20 mV	0.000 mV	0.000 mV	+19.000 mV	-19.000 mV
	200 mV	0.000 mV	0.000 mV	+190.000 mV	-190.000 mV
	2 V	0.000 000 V	0.000 000 V	+1.900 000 V	-1.900 000 V
	20 V	0.000 00 V	0.000 00 V	+19.000 00 V	-19.000 00 V
	100 V	0.000 0 V	0.000 0 V	+100.000 0 V	-100.000 0 V
	280 V	+190.000 0 V	-190.000 0 V	+280.000 0 V	-280.000 0 V
	1000 V	0.000 0 V	0.000 0 V	+750.000 0 V	-750.000 0 V
Voltage from Current	50 mV	-	-	50.0 mV	-
	500 mV	-	-	500 mV	-
	5 V	-	-	5.00 V	-
Current DC	200 µA	0.000 µA	0.000 µA	+190.000 µA	-190.000 µA
	2 mA	0.000 00 mA	0.000 00 mA	+1.900 00 mA	-1.900 00 mA
	20 mA	0.000 0 mA	0.000 0 mA	+19.000 0 mA	-19.000 0 mA
	200 mA	0.000 mA	0.000 mA	+190.000 mA	-190.000 mA
	2 A	0.000 00 A	0.000 00 A	+1.900 00 A	-1.900 00 A
	20.5 A	0.000 0 A	0.000 0 A	+19.000 0 A	-19.000 0 A
	30 A	21.000 0 A	-21.000 0 A	+29.000 0 A	-29.000 0 A

Table 6 Calibration points – DC voltage and current

6.3.2. Voltage and current AC functions

Function	Range	Nominal value	
		Offset 1 kHz	Full range 1 kHz
Voltage AC	20 mV	1.900 mV	19.000 mV
	200 mV	19.000 mV	190.000 mV
	2 V	0.190 00 V	1.900 00 V
	20 V	1.900 0 V	19.000 0 V
	100 V	19.000 V	100.000 V
	280 V	70.000 V	280.000 V
	1000 V	190.000 V	750.000 V
Voltage Harmonic	20 mV	1.9 mV	19.0 mV
	200 mV	19.0 mV	190 mV
	2 V	190 mV	1.90 V
	20 V	1.90 V	19.0 V
	100 V	19.0 V	100 V
	280 V	100 V	280 V
	1000 V	280 V	750 V
Current AC	200 µA	19.000 µA	190.000 µA
	2 mA	0.190 00 mA	1.900 00 mA
	20 mA	1.900 0 mA	19.000 0 mA
	200 mA	190.00 mA	190.000 mA
	2 A	0.190 00 A	1.900 00 A
	20.5 A	1.900 0 A	19.000 0 A
	30 A	21.000 0 A	29.000 0 A
Current Harmonic	200 µA	19.0 µA	190 µA
	2 mA	190 µA	1.9 mA
	20 mA	1.9 mA	19 mA
	200 mA	19 mA	190 mA
	2 A	190 mA	1.9 A
	20 A	1.9 A	19 A

Table 7 Calibration points – AC voltage and current

6.3.3. Low-voltage resistance functions

Fixed resistance nominals: 0 Ω, 0.1 Ω, 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ, 100 MΩ, 1 GΩ

Range	Nominal (low range)	Extended (full range)
33 Ω	10 Ω	0 Ω, 33 Ω
100 Ω	33 Ω	100 Ω
330 Ω	100 Ω	330 Ω
1 kΩ	330 Ω	1 kΩ
3.3 kΩ	1 kΩ	3.3 kΩ
10 kΩ	3.3 kΩ	10 kΩ
33 kΩ	10 kΩ	33 kΩ
100 kΩ	33 kΩ	100 kΩ
330 kΩ	100 kΩ	330 kΩ
1 MΩ	330 kΩ	1 MΩ
3.3 MΩ	1 MΩ	3.3 MΩ
10 MΩ	3.3 MΩ	10 MΩ
33 MΩ	10 MΩ	33 MΩ
100 MΩ	33 MΩ	100 MΩ
330 MΩ	100 MΩ	330 MΩ
1000 MΩ	330 MΩ	1000 MΩ

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

Table 8 Calibration points – Variable resistance

6.3.4. Capacitance functions

Fixed capacitance nominals: 1 nF, 10 nF, 100 nF, 1 µF, 10 µF, 100 µF

Range	Nominal (full range)	Extended (low range)	Extended (over range)	Measurement signal
1 nF	1 nF	0.5 nF	1.7 nF	1 kHz
3.3 nF	3.3 nF	1.7 nF	5.5 nF	1 kHz
10 nF	10 nF	5.5 nF	17 nF	1 kHz
33 nF	33 nF	17 nF	55 nF	1 kHz
100 nF	100 nF	55 nF	170 nF	120 Hz
330 nF	330 nF	170 nF	550 nF	120 Hz
1 µF	1 µF	550 nF	1.7 µF	120 Hz
3.3 µF	3.3 µF	1.7 µF	5.5 µF	120 Hz
10 µF	10 µF	5.5 µF	17 µF	120 Hz
33 µF	33 µF	17 µF	55 µF	120 Hz
100 µF	100 µF	55 µF	-	120 Hz
1 mF	-	-	1 mF	constant discharge
10 mF	-	1.1 mF	9 mF	constant discharge
120 mF	-	11 mF	90 mF	constant discharge

Table 9 Calibration points – Variable capacitance

6.3.5. HVR option

Range	Nominal values
100 kΩ	175 Ω, 230 Ω, 330 Ω, 530 Ω, 925 Ω, 1.68 kΩ, 3.14 kΩ, 6 kΩ, 11.5 kΩ, 22.5 kΩ, 44 Ω, 86.2 kΩ
1 MΩ	168 kΩ, 328 kΩ, 640 kΩ
10 MΩ	1.25 MΩ, 2.45 MΩ, 4.78 MΩ, 9.36 MΩ
100 MΩ	18.2 MΩ, 35.5 MΩ, 69.6 MΩ
1 GΩ	135 MΩ, 236 MΩ, 430 MΩ, 780 MΩ
10 GΩ	1.39 GΩ, 2.7 GΩ, 4.7 GΩ, 8.3 GΩ
100 GΩ fixed	100 GΩ

Table 10 Calibration points – HVR option

6.3.6. SCO option

SINE functions	Nominal values		
Amplitude linearity	0 dBm, +5 dBm, 10 dBm, +15 dBm		
Frequency response without attenuator	0 dBm in all 7 calibration points between 1 and 400 MHz		
Frequency response with attenuator	-5 dBm to – 20 dBm in 10 calibration points between 1 and 400 MHz		
LF Load correction	1V/ 1kHz with 50 Ω load		
Frequency correction	10 MHz		
VOLTAGE functions	Range	Nominal value	
		Offset	Full range
Voltage DC	0.5 V	0 mV	500 mV
	10 V	0 mV	10 V

Table 11 Calibration points – SCO option

6.3.7. SC1 option

SINE functions	Nominal values		
Amplitude linearity	0 dBm, +5 dBm, 10 dBm, +15 dBm		
Frequency response without attenuator	0 dBm in all 11 calibration points between 1 and 1 100 MHz		
Attenuator frequency response	-5 dBm to -20 dBm in 22 calibration points between 1 and 1 100 MHz		
LF Load correction	1V/ 1kHz with 50 Ω load		
Frequency correction	10 MHz		
VOLTAGE functions	Range	Nominal value	
		Offset	Full range
Voltage DC	0.5 V	0 mV	500 mV
	10 V	0 mV	10 V

Table 12 Calibration points – SC1 option

6.3.8. MER option

Function	Range	Nominal value		
		Offset	Full range +	Full range -
Voltage DC	12 mV	0.000 mV	+10.000 mV	-10.000 mV
	120 mV	0.000 mV	+100.000 mV	-100.000 mV
	1.2 V	0.000 000 V	+1.000 000 V	-1.000 000 V
	12 V	0.000 00 V	+10.000 00 V	-10.000 00 V
Lo DC Current	100 µA	0.000 µA	100.000 µA	-
	1 mA	0.000 0 mA	1.000 0 mA	-
Current DC	2.4 mA	0.000 0 mA	2.000 0 mA	-
	24 mA	0.000 0 mA	20.000 0 mA	-
Resistance	2 kΩ	0.000 00 kΩ	1.000 00 kΩ	-
	20 kΩ	0.000 0 kΩ	10.000 0 kΩ	-
Frequency	1 kHz	-	1.000 00 kHz	-
HVR option meter	1500 V	0 V	900 V	-

Table 13 Calibration points – MER option

7. Maintenance

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

7.1. Fuse replacement

9010+ calibrator has 2 user-replaceable fuses, both located on rear panel. Replace the fuses as follows:

1. Switch the calibrator off and disconnect power cord from it
2. Locate the fuse to be replaced: Mains fuse is in fuse/voltage selector case next to mains connector.
3. Use flat screwdriver to open voltage selector cover to get to the fuse holder.
4. Remove the fuse, check if it's blown and replace it with new fuse of the same rating if needed.

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. Firmware update

Internal firmware can be updated by user. It is recommended check for firmware updates every 6 months or so to get the latest UI improvements, new features and bug fixes. To do this:

1. Go to www.meatest.com/drivers-updates and find firmware update file (.upl) for your device. If your device is not listed, contact Meatest support and ask for firmware update file for your device.
2. Check if the update file version is greater than yours, installed FW version can be found in MENU > Information > Software version. If the installed version is the same, stop the update process.
3. Download Uploader program from the same website and install it if you haven't already.
4. Connect the instrument to your PC using RS232 cable and use Uploader to update your instrument's firmware. The calibrator will be restarted once the update is finished.
5. Check installed FW version.

7.4. Error messages

The following table lists an overview of error codes that you might come across when operating the calibrator manually. Complete list of errors is available in SCPI manual.

Error code groups	Description and most notable error codes
1000-5999	Internal errors are detected by internal processors. Try updating internal firmware to the latest version as described in chapter 7.3 and if the error persists, please report this error to the Service Center.
6000-6999	User interface errors prevent the user from entering incorrect values from keyboard and accessing unavailable features.
	6032: Device is locked in remote control mode. Press "Go to Local" softkey to exit.
7000-7099	Errors caused by missing or damaged hardware. Restart the instrument and if the error persists, please report this error to the Service Center.
	7021: Source function is unavailable. Ask Meatest for possible upgrades.
	7022: Meter function is unavailable. Ask Meatest for MER option upgrade.
7100-7999	Protective element has been triggered and output/input has been shut off in order to prevent calibrator damage. Check for excessive load and/or external voltage at terminals. If the error persists, please report this error to the Service Center.
	7100, 7101, 7103-7106, 7109, 7110: Output overload. Decrease load to specified limits and/or disconnect external source of excessive voltage from output terminals.
	7102, 7107, 7108: Input overload. Decrease test signal voltage/current.
	7111: I+, I- terminals are open. Current output has been disconnected.
	7112: Hi-Lo terminals are shorted. Voltage output has been disconnected.
8000-8999	Calibration data errors can occur when working with calibration data. They also diagnose calibration backup errors.
9000-10999	Preset errors usually come up when trying to create, modify or delete a device or harmonic setup preset in a way which would corrupt preset data like reusing existing names, deleting actively used presets or exceeding memory capacity. See chapter 3.6 for more details.
11000-11999	Exceeding the limits of internal meters: The instrument contains a number of internal meters that monitor voltage and current limits at the terminals, the temperatures of some important parts of the device, and other meters. Some of these errors may disconnect the output terminals.
	11007: Hi-Lo terminals are shorted. Voltage output has been disconnected.
	11008: HVR voltage overload. HVR output has been disconnected.
	11028: I+, I- terminals are open. Current output has been disconnected.

Table 14 Error code overview

8. Specifications

All absolute uncertainty specifications in this document are defined at a confidence interval of 95%, extension coefficient k = 2. Uncertainties include 12 months long-term stability, temperature coefficient, linearity, load and line regulation and the traceability of factory and National calibration standards. Recommended recalibration interval is 1 year.

Temperature and humidity stabilization and additional 30-minute warm-up in reference conditions are required in order to reach these specifications.

Ambient conditions

Reference conditions:	+21 – +25 °C, max. 70% relative humidity
Operating conditions:	+13 – +33 °C, max. 70% relative humidity, max. altitude 3 km
Storage conditions:	-10 – +55 °C, max. altitude 12 km
Temperature coefficient:	10 % of specifications per °C outside T_{ref}

General

Warm-up time:	30 minutes
Power supply:	115/230 V ± 10 % – 50/60 Hz, 450 VA max.
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):	435 x 175 x 620 mm
Weight:	24 kg (basic version)

8.1. Voltage

DCV range summary:	0.00000 mV – 1050.000 V	
ACV range summary:	1.00000 mV_{rms} – 1050.000 V_{rms}	
Voltage ranges:	auto, 20 mV, 200 mV, 2 V, 20 V, 100 V, 280 V, 1050 V	
Range limits:	150 – 1050 V for 1050V range, 5 – 100 % of range otherwise	
Available AC units:	RMS, peak, peak-peak, average	
Frequency range:	15.000 Hz – 300.00 kHz	below 2 V
	15.000 Hz – 100.000 kHz	for 2 V – 20 V
	15.000 Hz – 30.000 kHz	for 20 V – 200 V
	15.000 Hz – 10.0000 kHz	for 200 V – 280 V
	20.000 Hz – 1000.00 Hz	above 280 V
Frequency uncertainty:	10 ppm	
Voltage output modes:	passive 50Ω output, available in DC up to 200 mV	
	active output, available in entire range of both DC and AC	

DCV Absolute Uncertainty [ppm]

Range	90 days	1 year
0.00000 – 20.00000 mV	95 + 10 µV / 28 + 1.5 µV [*1]	100 + 10 µV / 30 + 1.5 µV [*1]
20.0001 – 200.0000 mV	14 + 10 µV / 14 + 1.5 µV [*1]	15 + 10 µV / 15 + 1.5 µV [*1]
0.200001 – 2.000000 V	11 + 5 µV	12 + 5 µV
2.00001 – 20.00000 V	9 + 35 µV	10 + 35 µV
20.0001 – 100.0000 V	14 + 150 µV	15 + 150 µV
100.0001 – 280.0000 V	14 + 400 µV	15 + 400 µV
280.001 – 1050.000 V	18 + 3.5 mV	20 + 3.5 mV

1. In passive output mode.

ACV Absolute Uncertainty [ppm]

Range	15 Hz – 10 kHz		10 kHz – 30 kHz		30 kHz – 100 kHz		100 kHz – 300 kHz	
	90 days	1 year	90 days	1 year	90 days	1 year	90 days	1 year
1.0000 – 20.0000 mV	1200 + 25 µV	1500 + 25 µV	1200 + 30 µV	1500 + 30 µV	2300 + 35 µV	2500 + 35 µV	4500 + 300 µV	5000 + 300 µV
20.0000 – 200.0000 mV	300 + 40 µV	350 + 40 µV	450 + 60 µV	500 + 60 µV	750 + 100 µV	800 + 100 µV	4600 + 500 µV	5000 + 500 µV
0.200000 – 2.000000 V	140 + 90 µV	165 + 90 µV	230 + 100 µV	250 + 100 µV	580 + 200 µV	600 + 200 µV	4600 + 800 µV	5000 + 800 µV
2.00000 – 20.00000 V	120 + 700 µV	160 + 700 µV	280 + 1.2 mV	300 + 1.2 mV	480 + 4 mV	500 + 4 mV	N/A	N/A
20.0001 – 100.0000 V	160 + 5 mV	180 + 5 mV	380 + 14 mV	400 + 14 mV	N/A	N/A	N/A	N/A
100.0001 – 280.0000 V [*2]	160 + 10 mV	180 + 10 mV	280 + 40 mV	300 + 40 mV	N/A	N/A	N/A	N/A
280.000 – 1050.000 V [*3]	280 + 30 mV	300 + 30 mV	N/A	N/A	N/A	N/A	N/A	N/A

2. Frequency is limited to 15 – 10000 Hz above 200 V.
3. Frequency is limited to 20 – 1000 Hz.

Distortion and Load Characteristics

Parameter	Range	20mV	200mV	2V	20V	100 V	280V	1050V
THD + noise [4]	15 – 45 Hz	0.05 % + 200 µV	0.05 % + 300 µV	0.15 %	0.15 %	0.15 %	0.15 %	0.25 %
	45 – 10000 Hz	0.05 % + 200 µV	0.05 % + 300 µV	0.05 %	0.05 %	0.05 %	0.05 %	0.20 %
	10 – 30 kHz	0.25 % + 200 µV	0.25 % + 300 µV	0.12 %	0.15 %	0.3 %	0.3 %	N/A
	30 – 100 kHz	0.35 % + 230 µV	0.35 % + 300 µV	0.22 %	0.3 %	N/A	N/A	N/A
	100 – 300 kHz	1.5 % + 500 µV	1 % + 700 µV	0.7 %	N/A	N/A	N/A	N/A
Burden current	DC active	1 mA	5 mA	30 mA	50 mA	50 mA	50 mA	5 mA
	45 – 10000 Hz	0.5 mA_{rms}	4 mA_{rms}	30 mA_{rms}	50 mA_{rms}	50 mA_{rms}	40 mA_{rms}	3 mA_{rms}
	10 – 30 kHz	0.5 mA_{rms}	4 mA_{rms}	10 mA_{rms}	10 mA_{rms}	10 mA_{rms}	10 mA_{rms}	N/A
	30 – 100 kHz	0.5 mA_{rms}	2 mA_{rms}	5 mA_{rms}	5 mA_{rms}	N/A	N/A	N/A
	100 – 300 kHz	100 Ω min. load	100 Ω min. load	1 mA	N/A	N/A	N/A	N/A

4. THD in bandwidth up to 500 kHz or 10 lowest harmonics.

Non-sinusoidal waveforms

Waveforms: symmetrical square, ramp up, ramp down, triangle, truncated sinus with THD 13.45 %, harmonics

Voltage range: 1.00000 mV_{rms} – 200.0000 V_{rms} (282 V_{pk} max.)

Frequency range: 15.000 – 1000.00 Hz

Peak value uncertainty: 0.21 % + 70 μV_{pk}

8.2. Current

DCI range summary: 0.0000 µA – 30.00000 A

ACI range summary: 10.0000 μA_{rms} – 30.00000 A_{rms}

Current ranges: auto, 200 µA, 2 mA, 20 mA, 200 mA, 2 A, 20.5 A, 30 A

Range limits: 5 – 100 % of range

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

Frequency range: 15.000 Hz – 10.0000 kHz below 200 mA

15.000 Hz – 5.0000 kHz for 200 mA – 2 A

15.000 Hz – 1000.00 Hz above 2 A

Frequency uncertainty: 10 ppm

DCI Absolute Uncertainty [ppm]

Range	90 days	1 year
0.0000 – 200.0000 µA	180 + 20 nA	200 + 20 nA
0.200000 – 2.000000 mA	140 + 50 nA	150 + 50 nA
2.00000 – 20.00000 mA	90 + 600 nA	100 + 600 nA
20.0000 – 200.0000 mA	90 + 5 µA	100 + 5 µA
0.200000 – 2.000000 A	150 + 50 µA	160 + 50 µA
2.00000 – 20.50000 A	230 + 500 µA	250 + 500 µA
20.50000 – 30.00000 A	430 + 750 µA	450 + 750 µA

5. 30 – 5 min maximum continuous output time. Depleted time regenerates 5x slower. See chapter 4.2.1.

ACI Absolute Uncertainty [ppm]

Range	15 Hz – 1 kHz		1 kHz – 5 kHz		5 kHz – 10 kHz	
	90 days	1 year	90 days	1 year	90 days	1 year
10.0000 – 200.0000 µA	1 100 + 80 nA	1 250 + 80 nA [*6]	2 600 + 150 nA	3 000 + 150 nA [*6]	4 600 + 200 nA	5 000 + 200 nA [*6]
0.200000 – 2.000000 mA	800 + 200 nA	850 + 200 nA	1300 + 500 nA	1 500 + 500 nA	3 600 + 600 nA	4 000 + 600 nA
2.00000 – 20.00000 mA	380 + 2 µA	400 + 2 µA	900 + 4 µA	1 000 + 4 µA	1 800 + 6 µA	2 000 + 6 µA
20.0000 – 200.0000 mA	380 + 20 µA	400 + 20 µA	900 + 50 µA	1 000 + 50 µA	1 800 + 100 µA	2 000 + 100 µA
0.200000 – 2.00000 A	460 + 100 µA	480 + 100 µA	900 + 500 µA	1 000 + 500 µA	N/A	N/A
2.00000 – 20.50000 A	700 + 4 mA	750 + 4 mA	N/A	N/A	N/A	N/A
20.50000 – 30.00000 A [*5]	N/A	1 200 + 5 mA	N/A	N/A	N/A	N/A

6. Accuracy not specified below 10 µA.

Distortion and Load Characteristics

Parameter	Range	200µA	2mA	20mA	200mA	2A	30A
Max. inductive load	15 Hz – 10 kHz	1 H	100 mH	100 mH	10 mH	1 mH	500 µH
THD + noise [*7]	15 Hz – 1 kHz	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	0.3 %
	1 kHz – 5 kHz	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	N/A
	5 kHz – 10 kHz	0.5 %	0.4 %	0.4 %	0.4 %	N/A	N/A
Compliance voltage	DC	5 V	5 V	10 V	10 V	5 V	5 V
	15 Hz – 1 kHz	4 V_{rms}	4 V_{rms}	5 V_{rms}	5 V_{rms}	3.5 V_{rms}	3 V_{rms}
	1 kHz – 5 kHz	4 V_{rms}	4 V_{rms}	5 V_{rms}	5 V_{rms}	3.5 V_{rms}	N/A
	5 kHz – 10 kHz	2 V_{rms}	2 V_{rms}	2 V_{rms}	2 V_{rms}	N/A	N/A
Load adder [*8]	DC, 15 Hz – 45 Hz	50 nA/V	50 nA/V	50 nA/V	100 nA/V	100 µA/V	500 µA/V
	45 Hz – 1 kHz	70 nA/V	70 nA/V	70 nA/V	100 nA/V	100 µA/V	500 µA/V
	1 kHz – 5 kHz	1.5 µA/V	1.5 µA/V	1.5 µA/V	2 µA/V	200 µA/V	N/A
	5 kHz – 10 kHz	2 µA/V	2 µA/V	2 µA/V	3 µA/V	N/A	N/A

7. THD in bandwidth up to 100 kHz
8. Additional uncertainty for compliance voltage above 0.5 V_{rms}

Non-sinusoidal waveforms

Waveforms: symmetrical square, ramp up, ramp down, triangle, truncated sinus with THD 13.45 %, harmonics

Current range: 100.0000 μA_{rms} – 2.000000 A_{rms} (2.82 A_{pk} max.)

Frequency range: 15.000 – 1000.00 Hz

Peak value uncertainty: 0.21 % + 700 nA_{pk}

8.2.1. Voltage from current terminals

Voltage range: 0.00000 mV – 5.000000 V

Coefficient range: 0.000002 – 10.000000 V/A

Waveform: DC, sinusoidal

Frequency range: DC, 15.000 Hz – 400.00 Hz

Distortion: < 0.1 % in 100 kHz bandwidth

V from I output specifications

Range [*9]	Absolute uncertainty [ppm]	Source impedance
50.00000 mV	500 + 20 µV	2.2 Ω
500.0000 mV	500 + 200 µV	22 Ω
5.000000 V	500 + 1 mV	220 Ω

9. AC values selectable in 5 – 100 % of range.

8.2.2. Current coil (option 140-50)

Applicable multiplier: 2 – 200

Max. simulated current: multiplier × 30 A (1025 A with 140-50 Current Coil)

Frequency range: 45 – 65 Hz

Uncertainty adder: user defined (0.3 % by default)

8.3. Resistance

Measurement modes: 4W, 2W

8.3.1. Continuous resistance mode

Resistance range summary: 0.0000 Ω – 1.000000 MΩ in 4W mode

0.0000 Ω – 1.100000 GΩ in 2W mode

2W compensation: 0.0 – 1000.0 mΩ

Continuous resistance ranges, uncertainties and limits

Nominal range [*10]	4W uncertainty [ppm]		2W uncertainty [ppm]		Applicable test current [*11]
	90 days	1 year	90 days	1 year	
0.0000 – 10.0000 Ω	250 + 2 mΩ	300 + 2 mΩ	250 + 32 mΩ	300 + 32 mΩ	0.4 – 100 mA
10.0001 – 33.0000 Ω	210 + 2 mΩ	250 + 2 mΩ	210 + 32 mΩ	250 + 32 mΩ	0.4 – 100 mA
33.0001 – 100.0000 Ω	130 + 2 mΩ	150 + 3 mΩ	120 + 32 mΩ	150 + 32 mΩ	0.4 – 100 mA
100.0001 – 200.0000 Ω	90 + 3 mΩ	100 + 3 mΩ	90 + 33 mΩ	100 + 33 mΩ	0.4 – 30 mA
200.001 – 1000.000 Ω	90 + 3 mΩ	100 + 3 mΩ	90 + 33 mΩ	100 + 33 mΩ	0.4 – 10 mA
1000.001 – 2000.000 Ω	80 + 30 mΩ	90 + 30 mΩ	80 + 60 mΩ	90 + 60 mΩ	0.1 – 6 mA
2.00001 – 10.00000 kΩ	80 + 30 mΩ	90 + 30 mΩ	80 + 60 mΩ	90 + 60 mΩ	20 – 2000 µA
10.00001 – 20.00000 kΩ	80 + 300 mΩ	90 + 300 mΩ	80 + 330 mΩ	90 + 330 mΩ	4 – 1000 µA
20.0001 – 100.0000 kΩ	80 + 300 mΩ	90 + 300 mΩ	80 + 330 mΩ	90 + 330 mΩ	1 – 200 µA
100.0001 – 200.0000 kΩ	80 + 3 Ω	100 + 3 Ω	90 + 3 Ω	100 + 3 Ω	1 – 100 µA
200.001 – 330.000 kΩ	80 + 3 Ω	100 + 3 Ω	90 + 3 Ω	100 + 3 Ω	1 – 60 µA
330.001 – 1000.000 kΩ	120 + 3 Ω	150 + 3 Ω	120 + 3 Ω	150 + 3 Ω	0.2 – 20 µA
1000.001 – 2000.000 kΩ			130 + 30 Ω	150 + 30 Ω	0.04 – 10 µA
2.00001 – 3.30000 MΩ			130 + 30 Ω	150 + 30 Ω	0.04 – 6 µA
3.30001 – 10.00000 MΩ			180 + 30 Ω	200 + 30 Ω	10 – 2000 nA
10.00001 – 20.00000 MΩ			1600 + 300 Ω	2000 + 300 Ω	10 – 1000 nA
20.0001 – 33.0000 MΩ			1600 + 300 Ω	2000 + 300 Ω	10 – 600 nA
33.0001 – 100.0000 MΩ			1600 + 300 Ω	2000 + 300 Ω	10 – 180 nA
100.0001 – 200.0000 MΩ			2500 + 3 kΩ	3000 + 3 kΩ	10 – 100 nA
200.001 – 330.000 MΩ			2500 + 3 kΩ	3000 + 3 kΩ	10 – 60 nA
330.001 – 1100.000 MΩ			8500 + 10 kΩ	10000 + 10 kΩ	4 – 20 nA

10. Range boundaries are based on calibration values of fixed resistance mode standards and as such may deviate from nominal values by up to 5%.
11. Absolute uncertainty is valid for test currents which gives min 100 mV across set resistance. For example, min test current is 10 mA at 10 Ω resistance to meet uncertainty specification. For test currents lower, the floor adder increases by multiplication factor k = Floor (Ω) x I at 100mV / Iactual. For example, for 10 Ω resistance and 1 mA test current, the floor adder is: 2 mΩ x 10mA/1mA =20 mΩ instead of 2 mΩ. For test currents higher than 10 mA and lower than specified 100 mA the adder

8.3.2. Fixed resistance mode

Resistance range summary: 0.0000 Ω – 100.0000 kΩ in 4W mode
0.0000 Ω – 1.000000 GΩ in 2W mode

Fixed resistance uncertainties

Nominal value	Calibration value uncertainty		Tolerance from nominal		Maximum load
	4W	2W	4W	2W	
0.0000 Ω	< 0.5 mΩ	25 mΩ	± 10 mΩ	± 1 Ω	500 mA_{pk}
0.1000 Ω	0.5 mΩ	25 mΩ	± 2 %	± 1 Ω	500 mA_{pk}
1.0000 Ω	0.5 mΩ	25 mΩ	± 2 %	± 1 Ω	400 mA_{pk}
10.0000 Ω	1 mΩ	30 mΩ	± 2 %	± 1 Ω	300 mA_{pk}
100.0000 Ω	3 mΩ	30 mΩ	± 2 %	± 2 %	100 mA_{pk}
1000.000 Ω	15 ppm	40 ppm	± 2 %	± 2 %	20 V_{pk}
10.00000 kΩ	15 ppm	20 ppm	± 2 %	± 2 %	20 V_{pk}
100.0000 kΩ	15 ppm	15 ppm	± 2 %	± 2 %	100 V_{pk}
1000.000 kΩ	-	30 ppm	-	± 2 %	100 V_{pk}
10.00000 MΩ	-	130 ppm	-	± 5 %	100 V_{pk}
100.0000 MΩ	-	1000 ppm	-	± 10 %	100 V_{pk}
1000.000 MΩ	-	2500 ppm	-	± 15 %	100 V_{pk}

8.3.3. HVR high voltage resistance option

Resistance range summary: 100.00 kΩ – 10.000 GΩ continuous, 100 GΩ fixed standard
Test voltage measurement: 0.0 – 1500.0 V_{dc}

Resistance ranges and uncertainties

Range	Max. test voltage	Resistance uncertainty	Test voltage measurement uncertainty
100.00 – 199.99 kΩ	800 V_{dc}	0.2 %	0.3 % + 2 V
200.0 – 999.9 kΩ	1100 V_{dc}	0.2 %	0.3 % + 2 V
1.0000 – 1.9999 MΩ	1150 V_{dc}	0.3 %	0.5 % + 5 V
2.000 – 9.999 MΩ	1150 V_{dc}	0.3 %	0.5 % + 5 V
10.000 – 19.999 MΩ	1500 V_{dc}	0.5 %	0.5 % + 5 V
20.00 – 199.99 MΩ	1500 V_{dc}	0.5 %	0.5 % + 5 V
200.0 – 999.9 MΩ	1500 V_{dc}	0.5 %	0.5 % + 5 V
1.0000 – 1.9999 GΩ	1500 V_{dc}	1 %	1 % + 5 V
2.000 – 10.000 GΩ	1500 V_{dc}	1 %	1 % + 5 V
100 GΩ	1500 V_{dc}	3 %	1.5 % + 5 V

8.4. Capacitance

Measurement modes: 2W

8.4.1. Continuous capacitance mode

Range summary: 0.800000 nF – 120.0000 mF

Maximum load: 5 V_{pk} or 150 mA_{pk}, whichever comes first

Capacitance ranges, loads and uncertainties

Range[12]	Uncertainty		Max. test frequency
	90 days	1 year	
0.800000 – 2.000000 nF	0.5 % + 15 pF	0.5 % + 15 pF	1000 Hz
2.00001 – 3.30000 nF	0.5 % + 15 pF	0.5 % + 15 pF	1000 Hz
3.30001 – 20.00000 nF	0.45 %	0.5 %	1000 Hz
20.0001 – 33.0000 nF	0.45 %	0.5 %	1000 Hz
33.0001 – 100.0000 nF	0.45 %	0.5 %	500 Hz
100.0001 – 200.0000 nF	0.45 %	0.5 %	300 Hz
0.200001 – 2.000000 µF	0.45 %	0.5 %	300 Hz
2.00001 – 3.30000 µF	0.45 %	0.5 %	300 Hz
3.30001 – 10.00000 µF	0.45 %	0.5 %	300 Hz
10.00001 – 20.00000 µF	0.45 %	0.5 %	300 Hz
20.0001 – 33.0000 µF	0.45 %	0.5 %	300 Hz
33.0001 – 100.0000 µF	0.45 %	0.5 %	300 Hz
100.0001 – 200.0000 µF	0.45 %	0.5 %	50 Hz
0.200001 – 1.100000 mF	0.45 %	0.5 %	15 Hz
1.100001 – 2.000000 mF	0.45 %	0.5 %	8 Hz
2.00001 – 11.00000 mF	0.45 %	0.5 %	5 Hz
11.00001 – 20.00000 mF	0.6 %	0.7 %	1 Hz
20.0001 – 120.0000 mF	0.8 %	1.0 %	0.5 Hz

12. Range boundaries up to 1.1 mF are based on calibration values of fixed capacitance mode standards and as such may deviate from nominal values by up to 10 %.

8.4.2. Fixed capacitance mode

Range summary: 1.000000 nF – 100.0000 µF

Maximum load: 25 V_{pk} or 150 mA_{pk}, whichever comes first

Tolerance from nominal: ± 10 %

Capacitance uncertainties

Nominal value	Calibration value uncertainty	Max. test frequency
1.000000 nF	1.25 %	1000 Hz
10.00000 nF	0.35 %	1000 Hz
100.0000 nF	0.25 %	500 Hz
1.000000 µF	0.25 %	300 Hz
10.00000 µF	0.35 %	300 Hz
100.0000 µF	0.45 %	300 Hz

8.5. Power and energy

Voltage range summary:	0.200000 V – 1050.0000 V
Current range summary:	0.200000 mA – 30.00000 A
Electric power range:	0.04000 mW – 30.0000 kW
Frequency range:	DC, 15.000 Hz – 1000.00 Hz
Energy period range:	2.000 s – 3600.000 s
Phase shift range:	0.00° – 359.99°
Phase shift uncertainty:	0.15° at 200 Hz and below
	0.25° above 200 Hz
	0.5° in 1050V range, 20 – 500 Hz

8.5.1. DC power

Uncertainty of DC power is determined by formula $dP = \sqrt{(dU^2 + dI^2 + 0.01^2)}$, where:

- dP is uncertainty of output power in %
- dU is uncertainty of set voltage in %, as per DCV specifications in chapter 8.1
- dI is uncertainty of set current in %, as per DCI specifications in chapter 8.2

DC power calculation example

This example calculates uncertainty of 4 W (20 V, 200 mA). Individual items in formula are calculated like this:

- dU = 0.0035 % + 40 µV = 0.0037 % of 20 V value
- dI = 0.015 % + 6 µA = 0.018 % of 200 mA value

DC power uncertainty is then calculated as $dP = \sqrt{(0.0037^2 + 0.018^2 + 0.01^2)} = 0.021$ %, which is also the best DC accuracy achievable.

8.5.2. AC power

Uncertainty of AC power is determined by formula $dP = \sqrt{(dU^2 + dI^2 + dPF^2 + 0.03^2)}$, where:

- dP is uncertainty of output power in %
- dU is uncertainty of set voltage in %, as per ACV specifications in chapter 8.1
- dI is uncertainty of set current in %, as per ACI specifications in chapter 8.2
- dPF is uncertainty of power factor in %

dPF is based on type of power units used, calculated by following formulas:

- $dPF = [1 - \cos(\varphi + d\varphi) / \cos(\varphi)] \cdot 100$ for active power
- $dPF = [1 - \sin(\varphi + d\varphi) / \sin(\varphi)] \cdot 100$ for reactive power
- $dPF = 0$ for apparent power

where:

- φ is set phase shift between voltage and current
- dφ is uncertainty of set phase shift

AC power calculation example

This example is based on following parameters:

- Function: AC active power
- Set value: 500 W (100 V, 10 A, 60° phase shift), 50 Hz

Individual items in formula are then calculated like this:

- dU = 0.025 % + 0.010 % of range = 0.045 % of 100 V value
- dI = 0.05 % + 0.01 % of range = 0.06 % of 10 A value
- dPF = [1 – cos (60 + 0.15) / cos 60] · 100 = 0.45 %

AC power uncertainty is then calculated as $dP = \sqrt{(0.045^2 + 0.06^2 + 0.45^2 + 0.03^2)} = 0.46\ \%$

Standalone Power Factor (PF) specifications

Range: -1.0000 – +1.0000

Uncertainty is determined by formula $\boxed{dPF = abs\,[\cos(\varphi + d\varphi) / \cos(\varphi)] + 0.0005}$, where:

- φ is set phase shift between voltage and current
- dφ is uncertainty of set phase shift

8.5.3. DC and AC electric energy

Electric energy uncertainties are determined by the same formulas as power with addition of time period uncertainty of 0.01 % + 0.3 s. Final formulas are therefore:

- $\boxed{dE = \sqrt{(dU^2 + dI^2 + dt^2 + 0.01^2)}}$ for DC
- $\boxed{dE = \sqrt{(dU^2 + dI^2 + dPF^2 + dt^2 + 0.03^2)}}$ for AC

where dt is calculated as 0.01 + 30/set period.

AC energy calculation example

This example is based on following parameters:

- Function: AC energy
- Set power:460 W (230 V, 2 A, 0° phase shift), 50 Hz
- Set period:5 minutes

Individual items in formula are then calculated like this:

- dU = 0.03 % + 12 mV = 0.035 % of 230 V value
- dI = 0.07 % + 200 µA = 0.08 % of 2 A value
- dPF = [1 – cos (0 + 0.15) / cos 0] · 100 = 0.0003 %
- dt = 0.01 % + 0.3 s = 0.11 % of 5 minute period

AC energy uncertainty is then calculated as $dE = \sqrt{(0.035^2 + 0.08^2 + 0.0003^2 + 0.11^2 + 0.03^2)} = 0.14\ \%$

8.6. Harmonics

Harmonic products may be added in all AC functions of the calibrator (voltage, current, power, energy).

Fundamental signal specifications

Max. peak amplitude of single fundamental harmonic:	$\sqrt{2}$ × full range
Amplitude uncertainty:	0.2 % of fundamental harmonic range
Max. frequency:	1 kHz
Min. frequency uncertainty:	25 ppm
V-from-I phase uncertainty:	0.2° at 70 Hz and below 0.5° above 70 Hz

Harmonic product specifications

Number of products:	50
Amplitude range:	0.00 – 30.00 % of full range of fundamental harmonic
Amplitude uncertainty:	0.2 % of fundamental harmonic range
Max. frequency:	5 kHz
Phase shift range:	0.00 – 360.00 °
Phase shift uncertainty:	5 µs (typical)

Amplitude limitation of complex distorted signal

Max peak amplitude:	$\sqrt{2}$ × full range of fundamental harmonic

8.7. Temperature sensor simulation

Sensor types: RTDs, thermocouples

8.7.1. RTD resistance temperature sensor simulation

Temperature range summary: -200.00 °C – 800.00 °C

Temperature scales: Pt 3850 IPTS68, Pt 3851 ITS90, Pt 3916, Pt 3926, Ni 120, custom

Range of R0 setting: 20 – 2000 Ω

Ranges and uncertainties of RTD sensor simulation [˚C]

Type	Temperature range						
	-200 – -190	-190 – -100	-100 – 0	0 – 250	250 – 460	460 – 630	630 – 800
Pt3850 R_0: 100 Ω	0.05	0.06	0.07	0.09	0.12	0.14	0.18
Pt3851 R_0: 100 Ω	0.05	0.06	0.08	0.10	0.12	0.15	0.18
Pt3926 R_0: 100 Ω	0.06	0.06	0.08	0.10	0.12	0.15	
Pt3916 R_0: 100 Ω	0.06	0.06	0.08	0.10	0.12	0.15	
Pt385 R_0: 200 Ω	0.04	0.05	0.08	0.09	0.12	0.14	
Pt385 R_0: 500 Ω	0.04	0.04	0.05	0.08	0.12	0.15	
Pt385 R_0: 1000 Ω	0.03	0.04	0.05	0.09	0.11	0.14	
Type	**-80 – 0**	**0 – 100**	**100 – 260**				
Ni 120	0.05	0.08	0.14				

8.7.2. Thermocouple Temperature Sensor Simulation

Temperature range summary: -250.00 – 2315.00 °C (by sensor type)

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

Cold junction comp. modes: off, manual, automatic

Ranges and uncertainties of TC sensor simulation [˚C]

R	range	-50 – 100	100 – 400	400 – 1000	1000 – 1767
	uncertainty	0.96	0.55	0.44	0.39
S	range	-50 – 100	100 – 250	250 – 1400	1400 – 1767
	uncertainty	0.90	0.56	0.49	0.40
B	range	400 – 800	800 – 1000	1000 – 1500	1500 – 1820
	uncertainty	0.90	0.54	0.48	0.41
J	range	-210 – -100	-100 – 150	150 – 700	700 – 1200
	uncertainty	0.30	0.25	0.18	0.18
T	range	-200 – -100	-100 – 0	0 – 100	100 – 400
	uncertainty	0.30	0.26	0.21	0.18
E	range	-250 – -100	-100 – 280	280 – 600	600 – 1000
	uncertainty	0.45	0.23	0.19	0.19
K	range	-200 – -100	-100 – 480	480 – 1000	1000 – 1372
	uncertainty	0.35	0.25	0.23	0.24
N	range	-200 – -100	-100 – 0	0 – 580	580 – 1300
	uncertainty	0.45	0.30	0.26	0.23
M	range	-50 – 50	50 -100	100 – 470	470 – 1410
	uncertainty	0.25	0.22	0.21	0.20
C	range	0 – 100	100 – 280	280 – 1370	1370 – 2315
	uncertainty	0.37	0.34	0.34	0.47
D	range	0 – 100	100 – 280	280 – 1830	1830 – 2315
	uncertainty	0.45	0.37	0.34	0.47
G_2	range	100 – 200	200 – 430	430 – 2080	2080 – 2315
	uncertainty	0.72	0.49	0.35	0.39

Automatic cold junction compensation (Adapter 91)

Sensor type: Pt100

Temperature uncertainty: 0.1 °C with calibration constants saved in 9010+,
0.3 °C otherwise

Typical sensor stability: < 0.05 °C/year

8.8. SCO 400 MHz scope option

Scope option function overview

Function	Frequency range	Voltage range	Output terminals	Nominal output impedance
Voltage LF Low Mode	DC, 0.1 Hz – 100 kHz	0 – 10.5 V_{pk}	N connector	50 Ω
Voltage LF High Mode	DC, 15 Hz – 1 kHz	0 – 200 V_{pk}	HI – LO output terminals	0 Ω
SINE mode (levelled)	15 Hz – 400 MHz	1.4 mV_{pk} – 1.5 V_{pk}	N connector	50 Ω
Pulse Width Mode (PWM)	0.1 Hz – 400 MHz	50 mV_{pk} – 1 V_{pk}	N connector	50 Ω
Time Marker Mode	0.1 Hz – 400 MHz	50 mV_{pk} – 1 V_{pk}	N connector	50 Ω

Trigger output

Waveform: positive square wave
Amplitude: > 1 V_{pk} / 50 Ω
Division ratio: off, 1, 10, 100
Rise time: < 1 ns

8.8.1. Voltage LF low mode

Output terminal: coaxial N connector
Waveforms: DC (positive, negative), square wave (symmetrical, positive, negative)
Frequency range: 0.100000 Hz – 100.0000 kHz
Frequency uncertainty: 25 ppm
Duty cycle range: 1.00 – 99.00 %
Amplitude range: DC: 0.000 mV – 10.500 V
Square wave: 1.000 mV_{pk} – 10.500 V_{pk}
Amplitude uncertainty: 0.1 % + 50 µV at 10 kHz and below
0.2 % + 50 µV above 10 kHz
Max. load current: 20 mA (1 V_{pk} at 50Ω load)
Rise time: < 200 ns

8.8.2. Voltage LF high mode

Output terminal: 4mm terminals HI – LO
Waveforms: DC (positive, negative), symmetrical square wave
Frequency range: 15.00000 – 1000.000 Hz
Frequency uncertainty: 25 ppm
Amplitude range: DC: 0.000 mV – 200.00 V
Square wave: 1.000 mV_{pk} – 200.00 V_{pk}
Amplitude uncertainty: DC: as per DCV specifications
Square wave: 0.3 % + 50 µV
Max. load current: as per ACV specifications

8.8.3. Sine mode (levelled)

Output terminal: coaxial N connector
Waveform: sinusoidal
Frequency range: 15.00000 Hz – 400.00 MHz
Frequency uncertainty: 2.5 ppm
Amplitude range: 1.400 mV_{pk} – 1.5000 V_{pk}

Parameters and uncertainties

Parameter	15 Hz – 100 kHz	100 – 500 kHz	0.5 – 10 MHz	10 – 100 MHz	100 – 400 MHz
Harmonic distortion	-55 dB	-38 dB (<10 dBm)	-38 dB (<10 dBm)	-38 dB (<10 dBm)	-30 dB (<10 dBm)
Flatness	< 0.2 %	< 0.5 % + 100 μV_{pk}	< 1.2 % + 100 μV_{pk}	< 2.0 % + 100 μV_{pk}	< 2.5 % + 100 μV_{pk}
Amplitude uncertainty	0.5 % + 350 μV_{pk}	2.0 % + 250 μV_{pk}	2.5 % + 250 μV_{pk}	3.3 % + 250 μV_{pk}	3.7 % + 250 μV_{pk}

8.8.4. Pulse width mode (PWM)

Output terminal: coaxial N connector
Waveform: positive square wave
Frequency range: 0.100000 Hz – 400.000 MHz
Frequency uncertainty: 2.5 ppm
Pulse width range: 2.5 ns – 5 s
Duty cycle ratios: 1 %, 10 %, 20 %, 30 %, 40 %, 50 % below 2.5 MHz
10 %, 20 %, 30 %, 40 %, 50 % for 2.5 – 25 MHz
50 % above 25 MHz
Amplitude range: 50, 100, 500 and 1000 mV_{pk} / 50 Ω
Amplitude uncertainty: 10 %
Jitter: < 2 ns
Rise time: < 1 ns

8.8.5. Time marker mode

Output terminal: coaxial N connector
Waveform: 2 ns spike below 400 ns
PWM square wave at 400 ns and above
Time period range: 2.50000 ns – 10.000 s
Time period uncertainty: 2.5 ppm
Amplitudes: 50, 100, 500 and 1000 mV_{pk} / 50 Ω
Amplitude uncertainty: 10 %
Jitter: < 2 ns
Rise time: < 1 ns

8.8.6. Input impedance measurement

Input terminal: coaxial N connector
Ranges: 100 Ω, 2 MΩ
Measurement uncertainty: 0.1 % of value in 10 % – 100 % of range

8.9. SC11 100 MHz scope option

8.9.1. Sine mode (levelled)

Output terminal: coaxial N connector
Waveform: sinusoidal
Frequency range: 15.00000 Hz – 1 100.00 MHz
Frequency uncertainty: 0.1 ppm
Amplitude range: 1.400 mV_{pk} – 1.5000 V_{pk}
(above 1 GHz 1.0000 V_{pk})

Parameters and uncertainties

Parameter	15 Hz – 100 kHz	100 – 500 kHz	0.5 – 10 MHz	10 – 100 MHz	100 – 600 MHz	0.6 – 1.1 GHz
Harmonic distortion	-55 dB	-33 dB (<10 dBm)	-33 dB (<10 dBm)	-33 dB (<10 dBm)	-30 dB (<10 dBm)	-30 dB (<10 dBm)
Flatness	< 0.2 %	< 0.5 % + 100 μV_{pk}	< 1.2 % + 100 μV_{pk}	< 2.0 % + 100 μV_{pk}	< 2.5 % + 100 μV_{pk}	< 4.5 % + 100 μV_{pk}
Amplitude uncertainty	0.5 % + 350 μV_{pk}	2.0 % + 250 μV_{pk}	2.5 % + 250 μV_{pk}	3.3 % + 250 μV_{pk}	3.7 % + 250 μV_{pk}	6.5 % + 250 μV_{pk}

8.9.2. Pulse width mode (PWM)

Output terminal: coaxial N connector
Waveform: 0.1 Hz – 400 MHz positive square wave
400 MHz – 1 100 MHz sine
Frequency range: 0.100000 Hz – 1 100.000 MHz
Frequency uncertainty: 0.1 ppm
Pulse width range: 2.5 ns – 5 s
Duty cycle ratios: 1 %, 10 %, 20 %, 30 %, 40 %, 50 % below 2.5 MHz
10 %, 20 %, 30 %, 40 %, 50 % for 2.5 – 25 MHz
50 % above 25 MHz
Amplitude range: 50, 100, 500 and 1000 mV_{pk} / 50 Ω
Amplitude uncertainty: 10 %
Jitter: < 2 ns
Rise time: < 1 ns

8.9.3. Time marker mode

Output terminal: coaxial N connector
Waveform: 2 ns spike below 400 ns
PWM square wave at 400 ns and above
Time period range: 2.50000 ns – 10.000 s
Time period uncertainty: 0.1 ppm
Amplitudes: 50, 100, 500 and 1000 mV_{pk} / 50 Ω
Amplitude uncertainty: 10 %
Jitter: < 2 ns
Rise time: < 1 ns

8.9.4. Input impedance measurement

Input terminal: coaxial N connector

Ranges: 100 Ω, 2 MΩ

Measurement uncertainty: 0.1 % of value in 10 % – 100 % of range

8.10. MER integrated multimeter option

Functions: DCV, DCI, frequency, resistance, TC, RTD

Terminal ratings: 25 V_{pk} max between V and COM

10 V_{pk} max between A and COM

50 V_{pk} max between COM and PE

> 1 MΩ between COM and PE

MER functions, ranges and absolute 1 year uncertainties

Function	Range	Uncertainty [13]	Resolution / Range
DC voltage	± 12 mV	50 ppm + 3 µV	0.01 µV
	± 120 mV	50 ppm + 5 µV	0.1 µV
	± 1.2 V	50 ppm + 50 µV	1 µV
	± 12 V	50 ppm + 500 µV	10 µV
DC current	± 100 µA	200 ppm + 20 nA	1 nA
	± 1 mA	200 ppm + 100 nA	10 nA
	± 2.4 mA	150 ppm + 800 nA	100 nA
	± 24 mA	150 ppm + 800 nA	100 nA
Frequency	1 Hz – 100 kHz	50 ppm	10 µHz – 0.1 Hz
Resistance	2 kΩ	200 ppm + 10 mΩ	1 mΩ
	20 kΩ	200 ppm + 50 mΩ	10 mΩ

13. Excluding zero offset. Make zero correction to achieve described uncertainty.

8.10.1. RTD temperature measurement with 9000-60

Temperature range: -200.00 – 800.00 °C

Ranges and uncertainties of RTD sensor measurement [°C]

Type	Temperature range						
	-200 – -190	-190 – -100	-100 – 0	0 – 250	250 – 460	460 – 630	630 – 800
Pt3850 R_0: 100 Ω	0.10	0.12	0.14	0.18	0.24	0.28	0.36
Pt3851 R_0: 100 Ω	0.10	0.12	0.16	0.20	0.24	0.30	0.36
Pt3926 R_0: 100 Ω	0.12	0.12	0.16	0.20	0.24	0.30	
Pt3916 R_0: 100 Ω	0.12	0.12	0.16	0.20	0.24	0.30	
Pt385 R_0: 200 Ω	0.08	0.10	0.16	0.18	0.24	0.28	
Pt385 R_0: 500 Ω	0.08	0.08	0.10	0.16	0.24	0.30	
Pt385 R_0: 1000 Ω	0.08	0.08	0.10	0.18	0.22	0.28	

Type	-80 – 0	0 – 100	100 – 260
Ni 120	0.15	0.24	0.42

8.10.2. TC temperature measurement

Temperature range: -250.00 – 1820.00 °C

Cold junction comp. modes: Manual

Ranges and uncertainties of TC sensor measurement [˚C]

R	range	-50 – 100	100 – 400	400 – 1000	1000 – 1767
	uncertainty	0.96	0.55	0.72	0.76
S	range	-50 – 100	100 – 250	250 – 1400	1400 – 1767
	uncertainty	0.91	0.56	0.79	0.79
B	range	400 – 800	800 – 1000	1000 – 1500	1500 – 1820
	uncertainty	0.89	0.54	0.48	0.81
J	range	-210 – -100	-100 – 150	150 – 700	700 – 1200
	uncertainty	0.31	0.22	0.29	0.29
T	range	-200 – -100	-100 – 0	0 – 100	100 – 400
	uncertainty	0.30	0.26	0.23	0.28
E	range	-250 – -100	-100 – 280	280 – 600	600 – 1000
	uncertainty	0.45	0.25	0.25	0.25
K	range	-200 – -100	-100 – 480	480 – 1000	1000 – 1372
	uncertainty	0.35	0.33	0.34	0.37
N	range	-200 – -100	-100 – 0	0 – 580	580 – 1300
	uncertainty	0.45	0.30	0.36	0.36
M	range	-50 – 50	50 -100	100 – 470	470 – 1410
	uncertainty	0.25	0.22	0.32	0.32
C	range	0 – 100	100 – 280	280 – 1370	1370 – 2315
	uncertainty	0.37	0.34	0.61	0.96
D	range	0 – 100	100 – 280	280 – 1830	1830 – 2315
	uncertainty	0.46	0.38	0.63	0.94
G2	range	100 – 200	200 – 430	430 – 2080	2080 – 2315
	uncertainty	1.00	0.67	0.46	0.51

9. Revisions

9.1. Change 1

Parameter	Original	Updated	
VAC	4600 + 300 µV 5000 + 300 µV	4600 + 500 µV 5000+ 500 µV	Chapter 8.1. – ACV Absolute uncertainty [ppm]
VAC	280 + 15 mV 300 + 15 mV	280 + 30 mV 300 + 30 mV	Chapter 8.1. – ACV Absolute uncertainty [ppm]
Peak value uncertainty	0.21 % of range + 70 µVpk	21 % + 70 µVpk	Chapter 8.1. - Non-sinusoidal waveforms
Peak value uncertainty	0.21 % of range + 700 nApk	0.21 % + 700 nApk	Chapter 8.2. - Non-sinusoidal waveforms

CE 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 9010+ Multifunction Calibrator, 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. 2:2013
- EN 55011 ed. 4:2015 + A1:2016 + A11:2020

Brno	September 25th, 2020	
Place	Date	Signature