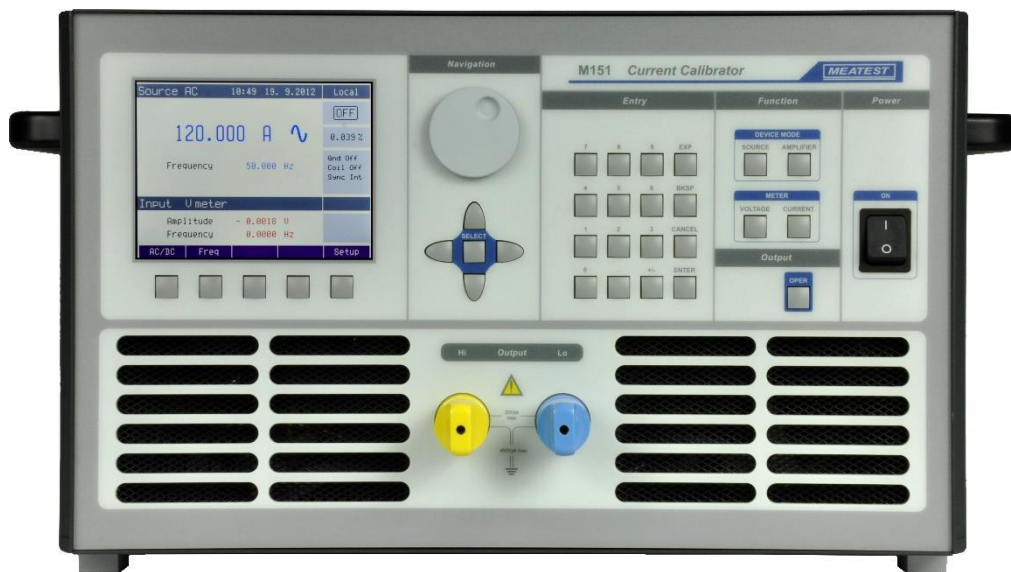


meatest

M151 Current Calibrator

Operation manual



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1 Basic information

M151 Current calibrator is accurate current source up to 120 A. It can be used for calibration of ammeters or as stable current source for precise measurement. The calibrator is equipped with a built-in multimeter that can be used for simulation of programmable transconductance or current amplifier. Alternatively can be used as voltage input real transconductance amplifier.

Basic features of the calibrator include generation of calibrated AC and DC current in the range of 8 mA to 120 A. Frequency range is 15 Hz to 1000 Hz.

Internal multimeter with ranges 200 mA, 20 V and 10 kHz can be used for simulation of programmable transconductance or current amplifier.

The calibrator includes many other features which facilitate easy use. For example it is currently displayed uncertainty of the output signal, calibration and testing procedures etc. The concept of calibrator control and indication of its status is based on large TFT color display, which provides all necessary information. The calibrator is controlled by opening menus on the display and selection from menus. Frequently used functions are assigned direct-control keys. The calibrator comes with standard IEEE488 bus and RS-232 serial line, which allow the calibrator to be controlled from a PC.

The calibrator is supported in the automated calibration system Caliber.

2 Preparation for operation

2.1 Inspecting package contents, selecting the installation location

Basic package includes the following items:

M151

- Current calibrator
- Power cord
- Spare fuse
- Operational manual
- Test report
- RS232 cable

The calibrator should be powered by 230/115 V – 50/60 Hz mains. It is a laboratory instrument whose parameters are guaranteed at 23 ± 3 °C. Before powering on the instruments, place it on a level surface. Do not cover the vents at the front side and the fan opening at the rear panel.

2.2 Power-on

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

Function	AC current
Current range	1 A
Set value	1 A
Frequency	50 Hz
Output terminals	OFF

GPIB address of the calibrator is factory-preset to 2. This value is valid until the user changes it.

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

2.3 Warm-up time

The calibrator works after it is switched on and the initial checks complete. Specified parameters are only guaranteed after the instrument warms up for 60 minutes. During this period, the instrument cannot be calibrated.

2.4 Replacement of fuse

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

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

2.5 Safety precautions

The instrument has been designed in Safety Class I according to EN 61010-1. The design reflects the requirements of A2 amendment of the standard.

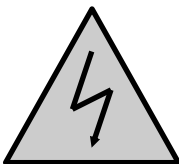
Safety is ensured by the design and by the use of specific component types.

The manufacturer is not 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, reference to the documentation

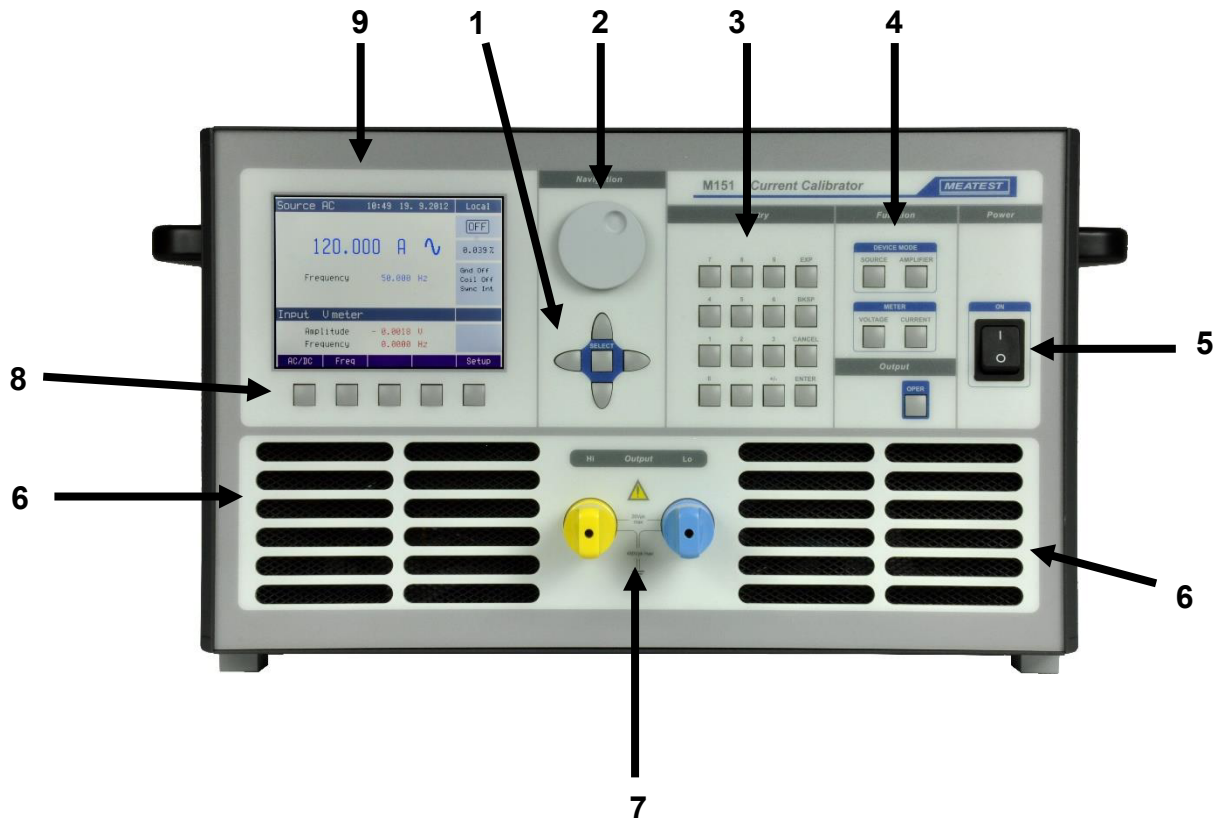


Warning - risk of electric shock

3 Description of controls

3.1 Front panel

The front panel of the calibrator includes a TFT color display, control keys and output terminals. The following picture shows the control part of the front panel.



1 Cursor keys

Using these keys, the cursor can be controlled within allowed limits on the display. The keyboard includes two keys (<, >) which allow the cursor to be set to the required position at the display. The cursor can be moved to the left or right. These keys are usually used to step through the options and to move from one option to another or between the menu levels. Numeric values can be set in some control modes as well. In these cases, the keys marked (\wedge , \vee) allow the user to increase or decrease the number at the cursor key.

The central key is used to select value you want to change (TAB).

2 Rotary knob

The rotary knob integrates several functions. By turning the knob to the left or right, the user can:

- step through the options
- enter numeric values

The function of the rotary knob can usually be performed by the cursor keys. The central key is used to confirm the selection (Select) or change the function of the rotary knob (value change or position change).

3 Numeric keyboard

The keyboard allows the entry of numeric values on the display. ENTER key is used to confirm the selection. CANCEL key can be used to cancel the entry.

4 Function keys

Function keys can be used to call-up the functions of the calibrator directly. The following keys are provided:

<i>function</i>	<i>key</i>
Source mode	SOURCE
Amplifier mode	AMPLIFIER
Voltage measurement	VOLTAGE
Current measurement	CURRENT
Output Operate/Standby	OPER

After the function mode is changed, the parameters of the respective function are restored. If the respective function was never used, the calibrator resets to its reference values.

5 Power switch

Turns instrument AC power ON and OFF.

6 Air intake

A cold air intake is used to bring relatively cool air into a calibrator.

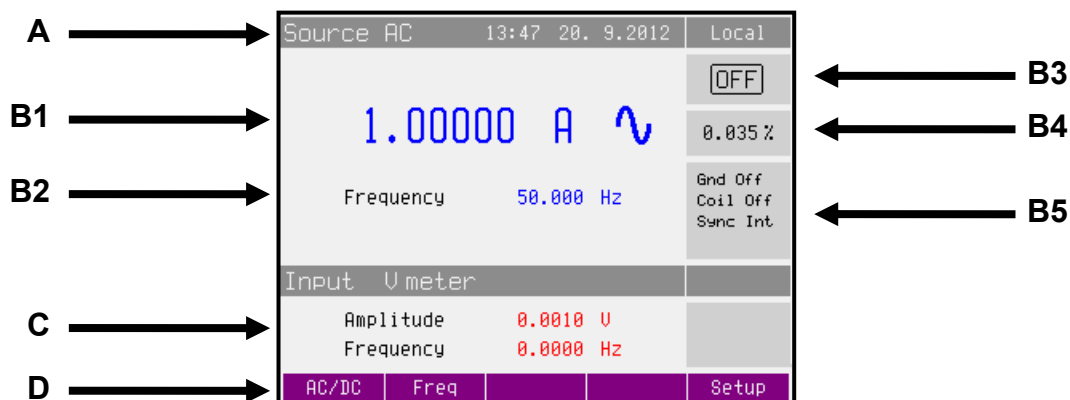
7 Current output

Current outputs HI and LO terminals.

8 Display keys

There are five keys below the display, whose meaning changes depending on the contents of the display. These keys usually call-up the “local Menu” (units, modes, etc.).

9 Display



The display is divided to three horizontal sections:

A. Upper information line

- Selected function (Source AC)
- Date and time
- Remote control state (Local – keyboard, Remote – computer)

B. Main area

This section displays the set-up values of generated signals and the data related to the calibrator status. The section includes the following types of data:

1. Main value

There is displayed main output value with the unit and indication of AC or DC (picture). There is displayed also actual position of cursor ▼▲ if the parameter is in edit mode. Position of cursor can be changed using keys <, > and parameter can be changed using keys ^, v, or using the rotary knob.

2. Auxiliary parameters



This section displays auxiliary parameters of actually selected function:

- Frequency (AC functions)
- Gain (Amplifier mode)
- Step (Amplifier mode)

3. Outputs state

Window displays whether output terminals are connected or not connected.

Symbols displayed in window:

-  - output terminals are not connected, output is off
-  - output terminals are connected, output is on

4. Specification

In the field specification of set-up output signal is shown. Uncertainty is related to the main parameter. Label BUSY instead of accuracy is displayed, if calibrator is not within specified parameters or if internal reconnection is in process. This can occur during changing the functions, changing set parameters, switching output terminals ON and OFF.

5. Information section

The information section located in the right part of the display and displays additional information related to the selected function:

- Information about the grounding method of output terminals: Gnd as set up using the menu „Calibrator“.
- Information about the use of turn coil as set up using the menu „Calibrator“.
- Information about sync mode (only AC output).

C. Meter's information section

D. Display softkeys

The functions of these keys change during operation (depends on actual display mode).

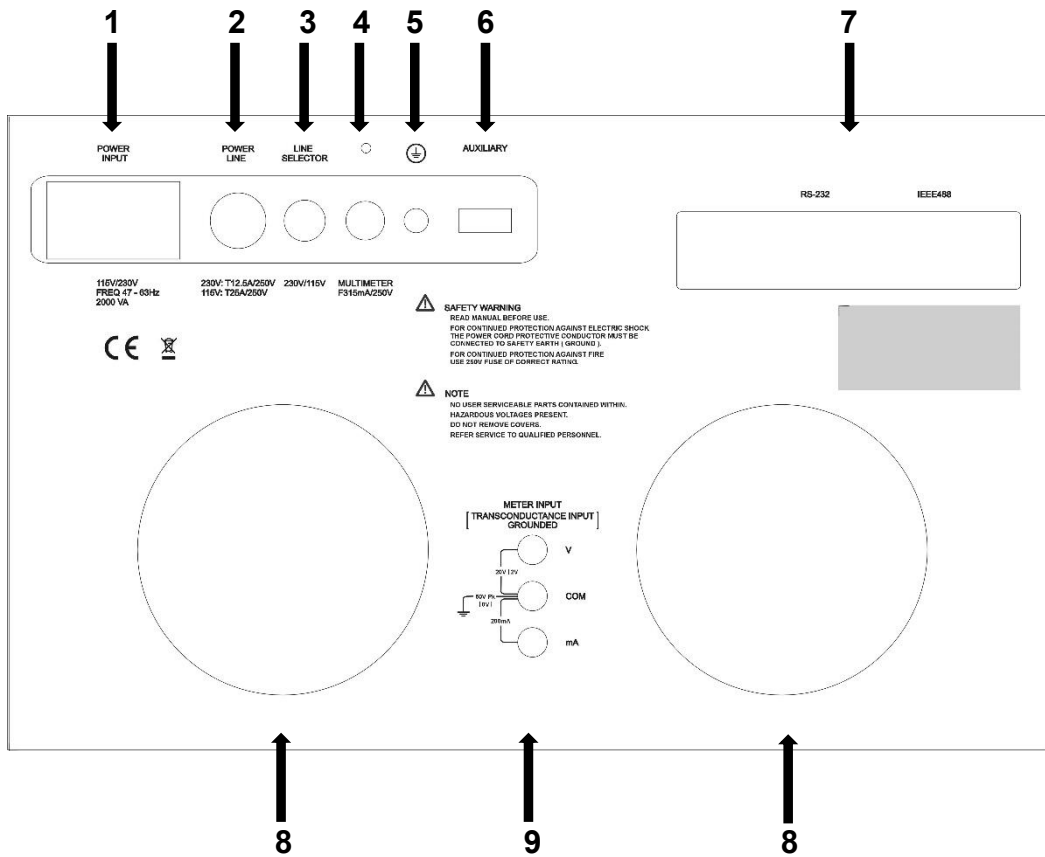
Colors on display

Common rules are used for applied color of labels and values.

1. Red color is applied, when displayed value is measured by the calibrator.
2. Blue color is applied for parameters or values, which can be set-up or modified directly from front panel keyboard or via Main menu.
3. Black color is used for fix values, labels, notes, parameters which cannot be modified and for other fix text with general information purpose.
4. Meaning of display keys is always shown the lowest line. If there is no description above display key, the key is not active in selected function.

3.2 Rear panel

Rear panel includes meter input terminals, ventilation holes, power cord socket, power line fuse, power line voltage selector 115/230V, fuse for internal multimeter, interface connectors GPIB and RS232 and metal central ground terminal.



- 1 power line entry
- 2 power line fuse
- 3 power line switch
- 4 fuse for internal multimeter (F315mA / 250V)
- 5 central ground terminal
- 6 expansion connector (service use only)
- 7 GPIB and RS-232
- 8 forced ventilation holes
- 9 common meter and transconductance input terminals

4 Control of the calibrator

4.1 Selection of function

After the power is switched on and the initial checks complete, the calibrator resets to its reference state:

Function:	Source AC
Current:	1A
Frequency:	50Hz

The state of the calibrator can be changed using the keys located at the front panel in one of the following ways:

1. *Change of function by pressing one of direct function keys*

After pressing one of the keys SOURCE, AMPLIFIER, VOLTAGE or CURRENT calibrator switches to the selected function and set the last set-up parameters. Whenever function is changed, calibrator always goes over to STANBY position. Output terminals are disconnected.

2. *Connection /disconnection of output terminals*

After pressing the OPER key, the output terminals of the calibrator are connected. To disconnect active terminals push the OPER key again.

3. *Select AC /DC current*

After pressing AC/DC softkey the calibrator changes AC to DC signal or DC to AC signal.

4. *Access to the Main menu*

After pressing the SETUP softkey the calibrator displays the basic level of the setup menu. In this menu you can change instruments setting and calibration data. Previous function is recalled after pressing Exit softkey.

4.2 Setting the value of output signal

Edit mode

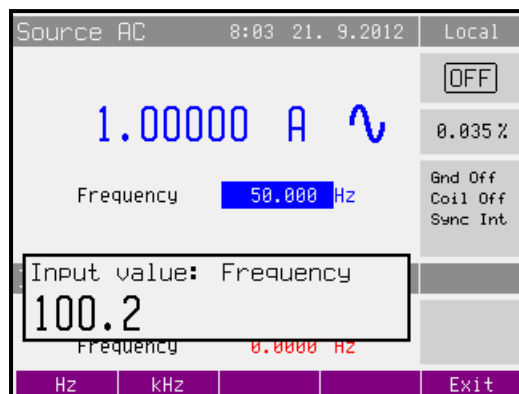
Parameters of output signal can be changed in Edit mode. Only parameters displayed in blue color can be changed. Display can be switched to edit mode in different ways:

- Pressing numeric key
- Pressing „Select“ key (in the middle of cursors keys)
- Pressing cursor key
- Pressing the rotary knob

In edit mode is edited value highlighted by blue background. Pressing the „Select“ key you can change among „blue“ parameters. Edit mode is finished by pressing „Exit“ softkey.

Entry of the value using numeric keyboard

- Use the numeric keyboard to select the desired value. After the first digit is entered, input box is displayed. In the upper row of the input box is the name of edited parameter. Using softkeys you can enter the new value in different units.
- Enter desired value.
- After the entry is complete press softkey with requested unit or press „Enter“ key. „Enter“ key inputs the value in basic units (A, Hz ...).



- Calibrator sets new value.
- The value is copied to the appropriate field in the screen and the input box disappears.

Entry of the value using cursor keys

- Press <, >, ^ or v key. The display now includes cursor marks which points to the active digit.
- ^ and v keys can be used to change the active digit. <, > keys can be used to change the position of the cursor marks
- To get to the default screen, press „Exit“ key. All values can be set using the keys or the rotary knob.

Entry of the value using the rotary knob

- Press the rotary knob. The display now includes cursor marks which points to the active digit.
- Turn the knob to change the active digit
- Press the rotary knob to change to the mode which allows changing the value of the active digit. ← and → symbols are displayed above the active digit. Active digit can be changed by turning the knob.
- Turn the knob to change the position of the active digit.
- To get to the default screen press „Exit“ key. All values can be set using the keys or the rotary knob.

Note:

- All parameters have limits (high and low). If the entered value is outside these limits error message is displayed („Value too large (small)“) and new value is not accepted.

4.3 Connection / disconnection of output terminals

After switching the AC power supply on the output terminals are disconnected in all modes.

Press the “OPER” key to connect the output signal to the terminals. Symbol displayed in window:



Press the “OPER” key again to disconnect the output terminals. Symbol displayed in window now:



Output terminals are disconnected automatically under following conditions:

- Function mode change
- Calibrator is overloaded.
- Synchronization is lost (AMPLIFIER)

4.4 SOURCE mode

The calibrator can generate calibrated current. Output terminals for current ranges are CURRENT OUTPUT HI – LO terminals.

Current setting range: 8 mA to 120 A

When 25-turn coil (option 151-25) is used, Current range is up to 3000 A.

Control in the SOURCE mode

- Press “SOURCE” key on the calibrator and then select AC or DC mode by pressing display key. The display shows the following data:
 - * main current through the CURRENT OUTPUT HI-LO terminals
 - * frequency, if AC current is selected
 - * uncertainty of current
- Set desired value of current using numeric keyboard, rotary knob or cursor keys. Output current is not yet connected to the output terminals.
- Connect the instrument to be calibrated to CURRENT OUTPUT HI-LO.
- Press OPER key.
- Green symbol is lit on the display to indicate the connection of output terminals.
- If Coil x25 or Coil user function is activated (see below – Main menu), the optional current coil must be connected to the output terminals. The calibrator can be used to calibrate clamp Amp meters up to 3000 A.

Overloading of output terminals

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

Setting the current in modes *I_{dc} Basic* and *I_{ac} Basic*

The calibrator allows several ways of setting the value of generated current.

1. Setting the current

- Repeatedly press the “Select” key (in the middle of cursor keys) until the current value appears in edit mode (grey background).
- The value can be set using numeric keyboard and confirmed by pressing mA or A softkey. The value can be set using cursor keys or rotary knob as well.

2. Setting the frequency (AC current only)

- Repeatedly press the “Select” key (in the middle of cursor keys) until the frequency value appears in edit mode (grey background).
- The value can be set using numeric keyboard and confirmed by pressing Hz softkey. The value can be set using cursor keys or rotary knob as well.

4.5 *AMPLIFIER mode – real TransConductance*

Calibrator generates output current proportional to the voltage connected to the input.

Current range: 8 mA to 120 A

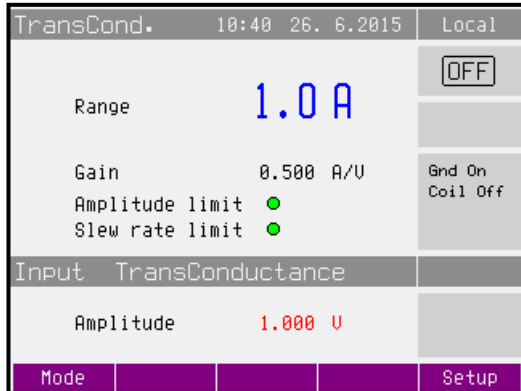
When 25-turn coil (option 151-25) is used, Current range is up to 3000 A.

Warning!

Lo output terminal and COM input terminal are grounded in real TransConductance mode regardless of setting item Current output Lo GND in the setup menu.

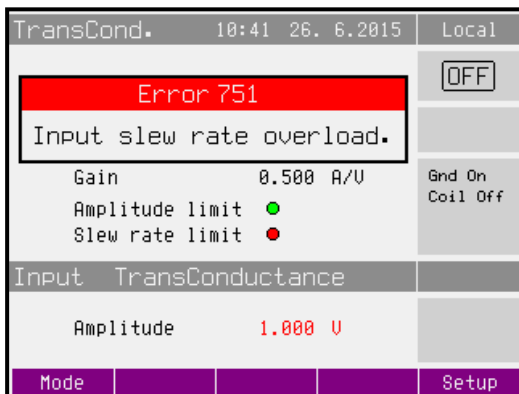
Control in the real TransConductance *AMPLIFIER mode*

- Press “AMPLIFIER” key on the calibrator The display shows the following data:
 - * range of the amplifier
 - * gain of the amplifier
 - * state of limits (amplitude and slew rate)

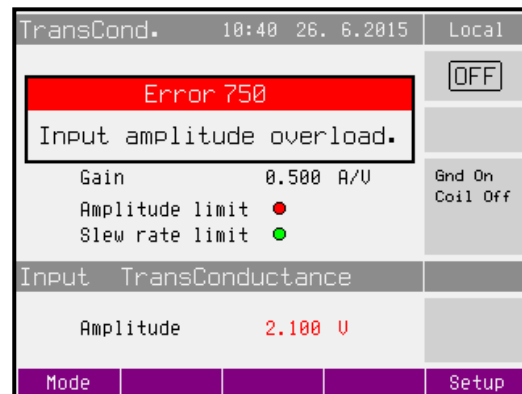


- Set required amplifier’s range.
- Connect control voltage signal to rear panel input terminals.
- If parameters of input signal are correct, both circles next to parameters will be turned green.
- Connect a load (or short circuit) to the output terminals.
- Press OPER key.
- Green symbol is lit on the display to indicate the connection of output terminals.
- If Coil x25 or Coil user function is activated (see below – Main menu), the optional current coil must be connected to the output terminals. The calibrator can be used to calibrate clamp Amp meters up to 3000 A.

If amplitude or slew rate of input signal exceed the threshold, output terminals are disconnected and error message is displayed.



- high amplitude



- high slew rate

4.6 AMPLIFIER mode - programmable TransConductance

The calibrator generates output current according to the input value measured by internal meter.

Current range: 8 mA to 120 A

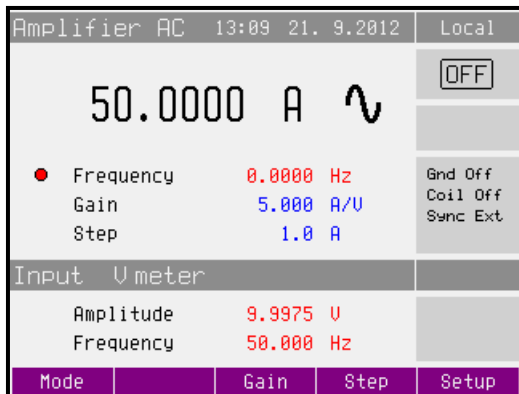
When 25-turn coil (option 151-25) is used, Current range is up to 3000 A.

Control in the AMPLIFIER mode

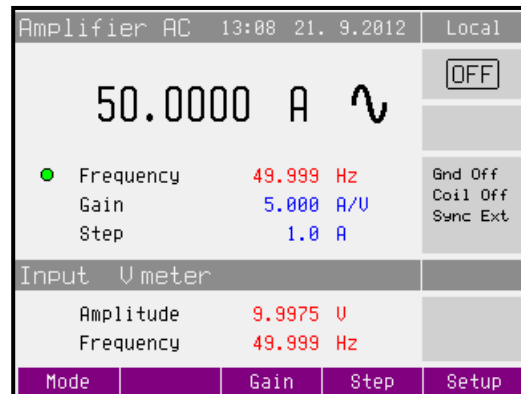
- Press “AMPLIFIER” key on the calibrator.
- Press “MODE” soft key and then select AMPLIFIER AC or DC mode. The display shows the following data:
 - * main current through the CURRENT OUTPUT HI-LO terminals
 - * frequency, if AC current is selected
 - * gain of simulated amplifier
 - * step of generated current (step 1.0 A means that output current is generated in entire amperes – 1A, 2A, ..., 120A)
- Select type of the input signal by pressing VOLTAGE or CURRENT meter key.
- Set required Gain and Step of the output current.
- Connect the control signal (voltage or current) to the meter terminals located on the rear panel.
- In case of internal frequency synchronization must be set also frequency of output current.
- In case of external or power supply frequency synchronization, wait until the frequency is synchronized (light green circle near the frequency value ●).
- Connect the instrument to be calibrated to CURRENT OUTPUT HI-LO.
- Press OPER key.

- Green symbol is lit on the display to indicate the connection of output terminals.
- If Coil x25 or Coil user function is activated (see below – Main menu), the optional current coil must be connected to the output terminals. The calibrator can be used to calibrate clamp Amp meters up to 3000 A.

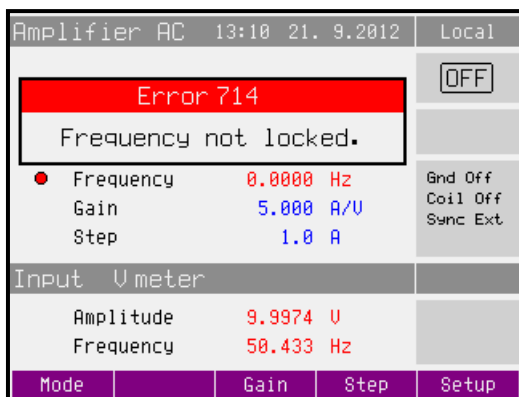
- frequency and phase aren't synchronized



- frequency and phase are synchronized



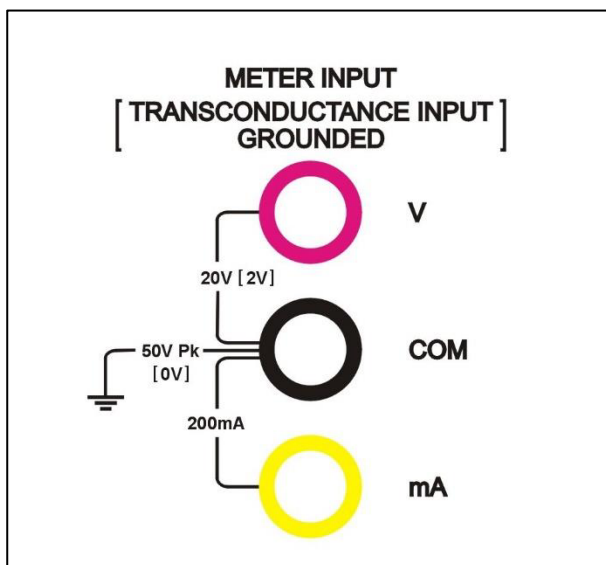
If synchronization is lost, output terminals are disconnected and error message is displayed.



5 Multimeter

The calibrator includes a built-in multimeter which can measure AC/DC voltage, AC/DC current and frequency. Measured signal must be connected to the terminals on the back side. Terminals mA, COM are for current measurements. Terminals V, COM are for voltage and frequency measurements.

Multimeter is DC coupled and measurement ranges are 20 V_{RMS} and 200 mA_{RMS}.



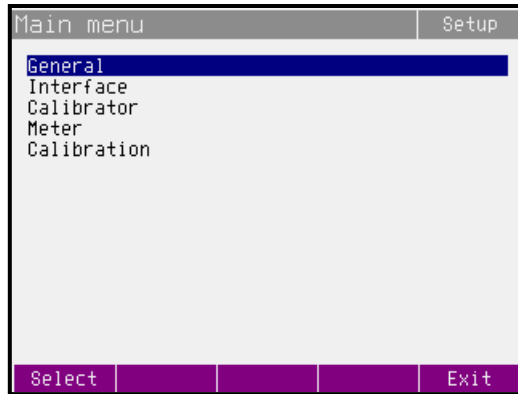
The multimeter is also used as a transconductance amplifier input. In this case COM terminal is grounded and input range is 2 V_{RMS}.

5.1 Function selection

- Measurement function should be selected in Main menu (item Meter) or VOLTAGE/CURRENT keys.
- Press UP, DOWN display keys or use the rotary knob to select one of the following functions:
 - * Voltage – AC voltage range 20 V/ 15 - 10000 Hz, DC voltage range 20 V
 - * Current – AC current range 200 mA / 15 - 10000 Hz , DC current range 200mA

6 Calibrator setup menu (Main menu)

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



Use ^ or v cursor key or the rotary knob to browse the menu options. Press „Select“ softkey or press in on the rotary knob to select highlighted item. Press „Exit“ softkey to leave the selected menu level.

New settings are retained when the calibrator is switched off.

The Main menu contains items:

- * General – general instruments settings (display, keyboard, time, date)
- * Interface – parameters of instruments remote control
- * Calibrator – parameters of signal generation
- * Meter – parameters of multimeter
- * Calibration – instruments calibration data

6.1 General Menu

Submenu contains basic parameters of display and keyboard.

1. Volume

This parameter sets the beeper volume. Cursor keys, rotary knob or numeric keyboard allow setting the value in the range of 0 to 15. Press the Write softkey to set the beeper volume and return to the General menu.

2. Brightness

This parameter sets the display brightness. Cursor keys, rotary knob or numeric keyboard allow setting the value in the range of 0 to 7. Press the Write softkey to set the display's brightness and return to the General menu.

3. Beeper

This parameter enables / disables the signalization of pressed key. Possible states are „Beep On“ and „Beep Off“. Press the Select softkey or press in on the rotary knob to set the selected state.

4. Calibration Password

This parameter sets the calibration password. Calibration password is a five-digit number, which must be entered to access the calibration mode. If the calibration password is set to 0, this information is displayed in the General menu. Other values are displayed as „Secret“.

You will be prompted to enter the present calibration password (use the numeric keyboard and confirm with Enter key). Now you can change the calibration password. Cursor keys, rotary knob or numeric keyboard allow setting the value in the range of 0 to 99999. Press the Write softkey to set the display's brightness and return to the General menu.

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

5. Time

Setting the real time. The parameter can be changed using cursor keys, rotary knob or numeric keyboard.

6. Date

Setting the date. The parameter can be changed using cursor keys, rotary knob or numeric keyboard.

7. Device Information

Viewing the device information. Displays the serial number and software version.

6.2 Interface Menu

Submenu contains remote control parameters.

1. Active interface

Sets the type of interface used to calibrator's remote control. By selecting an item from the list IEEE488, RS232 or Ethernet type can be selected. The calibrator can be remotely controlled only using the selected interface.

2. IEEE488 address

Sets the calibrator's IEEE488 (GPIB) address. Cursor keys, rotary knob or numeric keyboard allow setting the value in the range of 0 to 30. Address 02 is set by the manufacturer.

3. Baud rate

Sets the communication speed of RS232 bus. By selecting an item from the list 1200, 2400, 4800, 9600, 19200, 38400, 76800 or 115200 Bd can be selected.

6.3 Calibrator Menu

Submenu contains parameters that affect generated signal.

1. Current output Lo GND

This parameter allows connecting Lo terminals of current output to GND. In practice this means that Lo current terminals are grounded. By selecting an item from the list Gnd Off and Gnd On type can be selected.

It is recommended to ground output – Gnd On. If the meter to be calibrated has Lo terminal grounded, it is recommended to unground the corresponding calibrator's output to exclude ground loops.

Note

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

Warning!

Lo output terminal and COM input terminal are grounded in real TransConductance mode regardless of setting item Current output Lo GND in the setup menu.

2. *Current coil*

Sets the calibrator for connection the 25 –turn or user current coil (clamp ammeters calibration). The coil multiplies the output current either 25 times or user times depending on set parameter. By selecting an item from the list Coil Off, Coil x25 and Coil user type of connected current coil can be selected.

3. *Coil user multiplier*

Sets number of turns if user current coil is connected. Cursor keys, rotary knob or numeric keyboard allow setting the value in the range of 10 to 50. Press the Write softkey to set the number of turns and return to the General menu.

4. *Synchronization*

Sets the external synchronization of the output signal. By selecting an item from the list Internal (internal synchronization), Power line (synchronization to the power supply) or External (synchronization to the meter input terminal) type of frequency synchronization can be selected.

Note:

External synchronized signal has larger distortion than internal synchronized signal because of fine frequency tuning.

6.4 Meter Menu

Submenu contains parameters that affect measured signal.

1. Function

Sets the internal multimeter measuring function and range. By selecting an item from the list Voltage (AC/DC voltage 0-20V) and Current (AC/DC current 0-200mA). Frequency of the measured signal is displayed always.

6.5 Calibration Menu

Calibration password is required to access the Calibration Menu. Default calibration password is „0”. For more detail about calibration see the chapter 7.

7 Calibration mode

The calibrator includes calibration procedure, which allows recalibration of the calibrator. Recalibration can be performed using the keys and menu in the calibrator.

7.1 Calibration principles

The instrument can be calibrated:

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

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

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

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

AC current (Current AC) calibration is performed by setting 2 fixed points for all current ranges. The frequency is 55 Hz.

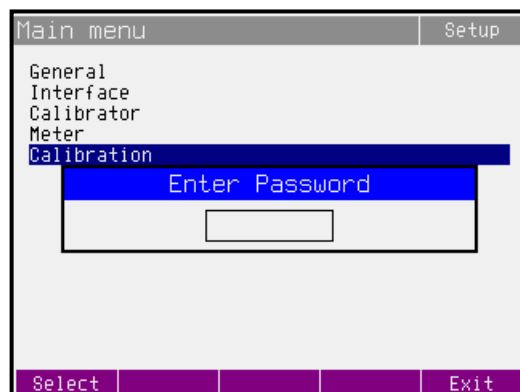
DC current (Current DC) calibration is performed by setting 2 fixed points for all current ranges and for both polarities (+ and -).

Multimeter (Meter) calibration consists in calibration of ranges 20V, 200mA and 10 kHz.

TransConductance amplifier (TransConductance) calibration consists in calibration of voltage input 2V, offset and current output.

7.2 Access to the calibration procedure

Calibration password is required to access the calibration procedure.

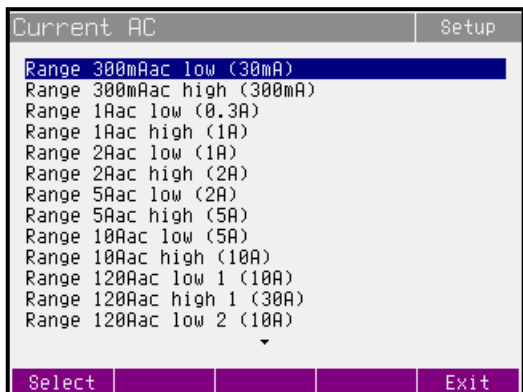


- Press Menu to open the Main menu.

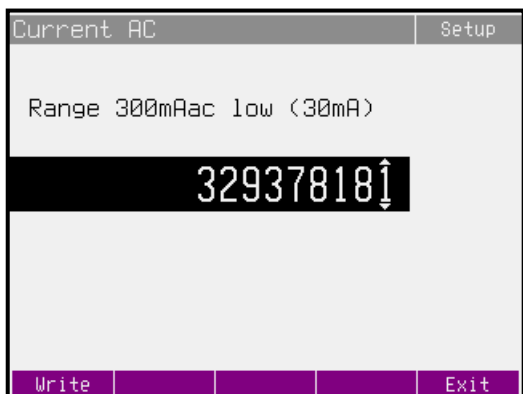
- Select the Calibration submenu and press the „Select“ softkey.
- Calibrator requests the entry of the calibration password.
- Enter the correct calibration code using numeric keyboard and press ENTER.
- If incorrect calibration code is entered, an error message “Bad calibration code!” appears on the display.

7.3 Selection of calibration type

After the calibration menu is displayed, one of partial calibrations can be selected. Use \wedge and \vee cursor keys to move the cursor through the list and confirm highlighted item by pressing Select



softkey. The following data are shown (the following example is valid for Current AC):



Softkeys have the following meaning:

- Write** new calibration value is entered into the memory, old value is lost. The calibrator returns to the previous menu.
- Skip** current calibration step is skipped, old value is retained in the memory. The calibrator returns to the previous menu.

Moreover, the display shows the range which is being calibrated (Range 300mAac), and the value to be set at the external standard multimeter (value in brackets 30mA).

Setting the new calibration data

Use cursor keys, rotary knob or numeric keyboard to set such main data on the display, when the output signal measured by external standard multimeter reaches the required calibration point. When the standard output value is reached, press Write softkey to write new calibration value to the calibration memory. If you press Exit softkey, the calibrator ignores the new value and old value is retained.

The procedure is repeated for all calibration points of the selected function. If you press Exit softkey the calibrator returns back to the previous menu level.

Termination of calibration

Calibration can be terminated by repeated press the Exit softkey until the calibrator returns to the Main menu.

Calibration points

Each function of the calibrator has assigned fixed calibration points which have to be set during the calibration.

Current AC function (Current AC)

<i>Nominal value[A]</i>	<i>Set limits [A]</i>	<i>Range [A]</i>
30 m	10 u	300 m
300 m	15 u	300 m
300 m	30 u	1
1	50 u	1
1	100 u	2
2	100 u	2
2	200 u	5
5	250 u	5
5	500 u	10
10	500 u	10
10	1 m	120#1
30	1.5 m	120#1
10	1 m	120#2
30	1.5 m	120#2
10	1 m	120#3
30	1.5 m	120#3
10	1 m	120#4
30	1.5 m	120#4

Table AC current

Current DC function (Current DC)

Nominal value [A]	Set limits [A]	Range [A]
30 m	10 u	300 m
300 m	15 u	300 m
-30 m	10 u	-300 m
-300 m	15 u	-300 m
300 m	30 u	1
1	50 u	1
-300 m	30 u	-1
-1	50 u	-1
1	100 u	2
2	100 u	2
-1	100 u	-2
-2	100 u	-2
2	200 u	5
5	250 u	5
-2	200 u	-5
-5	250 u	-5
5	500 u	10
10	500 u	10
-5	500 u	-10
-10	500 u	-10
10	1 m	30#1
30	1.5 m	30#1
-10	1 m	-30#1
-30	1.5 m	-30#1
10	1 m	30#2
30	1.5 m	30#2
-10	1 m	-30#2
-30	1.5 m	-30#2
10	1 m	30#3
30	1.5 m	30#3
-10	1 m	-30#3
-30	1.5 m	-30#3
10	1 m	30#4
30	1.5 m	30#4
-10	1 m	-30#4
-30	1.5 m	-30#4

Table DC current

Multimeter (Meter)

Nominal value [-]	Set limits [-]	Range [-]
0 V	100 uV	20 V
20 V	400 uV	20 V
0 mA	500 nA	200 mA
200 mA	5 uA	200 mA
10 kHz	200 mHz	10 kHz

Table Multimeter

TransConductance amplifier – input voltage, offset and output current

<i>Nominal value</i>	<i>Set limits</i>	<i>Range</i>
TransConductance input (DC)		
0 V	100 uV	2 V
2 V	200 uV	2 V
TransConductance offset (DC)		
0 mA	100 uA	1 A
0 mA	100 uA	1 A
0 mA	100 uA	1 A
0 mA	100 uA	1 A
TransConductance output (DC)		
300 mA	100 uA	300 mA
1 A	250 uA	1 A
2 A	750 uA	2 A
5 A	1,5 mA	5 A
10 A	3,5 mA	10 A
30 A	10 mA	30 A
30 A	10 mA	30 A
30 A	10 mA	30 A
30 A	10 mA	30 A

Table TransConductance

7.4 Full calibration procedure**Required instruments**

Following pages describe procedure of the full calibration. Following instruments are required for calibration:

- 8 1/2 digit multimeter type HP3458A or Fluke 8508A, or other type with accuracy 0.001 % on DC voltage
- Calibrator Meatest M142 or M140 with DC ranges 10V, 20mA and AC range 10V / 10 kHz.
- Resistance shunt 1 mΩ, 10 mΩ, 100 mΩ Burster 1280, or other type with accuracy 0.01% with known AC/DC difference in frequency range to 1000 Hz
- Counter HP 53181A, HO 53130, BM 642 or other with accuracy 0,001 %

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

Calibration procedure

1. Connect the calibrator and the multimeter to the mains and let them switched on for at least three hours in a laboratory at 23±1 °C.
2. Press Menu key to call up the Main menu, select Calibration end press Select softkey to enter the calibration menu.
3. Enter the calibration code and press Enter key (default calibration code is “0”).
4. **AC current ranges calibration**

- a) Select Current AC from the calibration menu and confirm by pressing Select softkey. Set the same function on external multimeter.
- b) Follow the instructions provided on the calibrator's display and the ACI table to adjust the calibrator's output in the calibration points.
- c) To adjust the calibrator's output in the calibration points, press Select softkey and use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the output voltage. Confirm correctly set value by pressing Write softkey. If you want to skip the calibration point whose calibration you have already entered, press Exit softkey.
- d) Resistance shunt should be used on 2, 5, 10 and 30 A ranges, if standard multimeter does not cover this range.

5. DC current ranges calibration

- a) Select Current DC from the calibration menu and confirm by pressing Select softkey. Set the same function on external multimeter.
- b) Follow the instructions provided on the calibrator's display and the DCI table to adjust the calibrator's output in the calibration points.
- c) To adjust the calibrator's output in the calibration points, press Select softkey and use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the output voltage. Confirm correctly set value by pressing Write softkey. If you want to skip the calibration point whose calibration you have already entered, press Exit softkey.
- d) Resistance shunt should be used on 2, 5, 10 and 30 A ranges, if standard multimeter does not cover this range.

6. Multimeter calibration

Built-in multimeter calibration consists of the calibration of 20 V voltage range, 200 mA current range and 10 kHz frequency range.

External calibrator of higher precision class should be used to calibrate the built-in multimeter (Meatest M142). If accurate external calibrator is not available an 8 1/2 digit multimeter is recommended for calibration.

- a) 20 V voltage range calibration
 - Select Meter from the calibration menu. Press Select softkey to select the first calibration point, 0 V.
 - Make short on calibrators input terminals METER INPUT V-COM.
 - Main value presents the calibration point. Leave value 0.000 and press Write softkey.
 - Select calibration point 20 V.
 - Connect external voltage 20 V DC to the calibrator input terminals METER INPUT V-COM. Exact value can be measured by parallel standard voltmeter.
 - Adjust main value on the display. It should be equal to the value measured by standard multimeter. Use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the main value. Confirm new value by pressing Write softkey.
- b) 20 mA DC current range calibration

- Select Meter from the calibration menu. Press Select softkey to select the first calibration point, 0 mA.
 - Make short on calibrators input terminals METER INPUT mA-COM.
 - Main value presents the calibration point. Leave value 0.000 and press Write softkey.
 - Select calibration point 200 mA.
 - Connect external current source 200 mA DC to the calibrator input terminals METER INPUT mA-COM. Exact value can be measured by serial standard ammeter.
 - Adjust main value on the display. It should be equal to the value measured by standard multimeter. Use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the main value. Confirm new value by pressing Write softkey.
- c) 10 kHz frequency range calibration
- Select calibration point 10 kHz.
 - Connect external AC voltage 10 kHz (voltage between 10 to 20 V) to the calibrator input terminals METER INPUT V-COM. Exact frequency value can be measured by parallel standard counter.
 - Adjust main value on the display. It should be equal to the value measured by standard counter. Use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the main value. Confirm new value by pressing Write soft key.

7. Real TransConductance amplifier calibration

Calibration of the TransConductance amplifier consists of the calibration of 2V input, output offset and output ranges. DC signal is used for all three steps.

External calibrator of higher precision class should be used to calibrate the built-in multimeter (Meatest M142). If accurate external calibrator is not available an 8 1/2 digit multimeter is recommended for calibration.

a) 2V input calibration

- Select TransConductance from the calibration menu and confirm by pressing Select softkey. Select TransConductance input and confirm by pressing Select softkey.
- Select first calibration point 0.000V.
- Make short on calibrators input terminals METER INPUT V-COM.
- Main value presents the calibration point. Leave value 0.000 and press Write softkey.
- Select calibration point 2 V.
- Connect external voltage 2 V DC to the calibrator input terminals METER INPUT V-COM. Exact value can be measured by parallel standard voltmeter.
- Adjust main value on the display. It should be equal to the value measured by standard multimeter. Use <, >, ∨, ∧ cursor keys, rotary knob or numeric keyboard to adjust the main value. Confirm new value by pressing Write softkey.

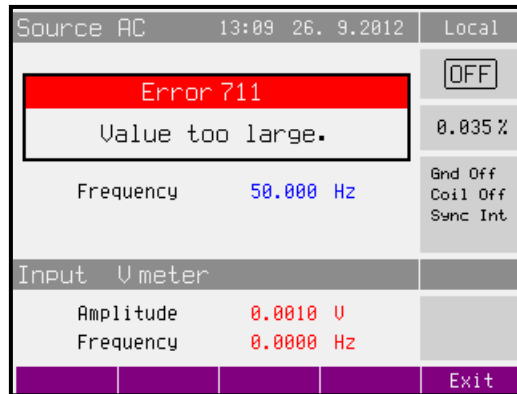
b) Output offset calibration (1A range)

- Select TransConductance offset from the calibration menu and confirm by pressing select softkey.
 - Select first offset calibration point.
 - Make short on calibrators input terminals METER INPUT V-COM.
 - Set current DC function on standard multimeter and connect multimeter to the HI – LO output terminals.
 - Adjust the calibrator's output according to TransConductance table using <, >, v, ^ cursor keys, rotary knob or numeric keyboard. Confirm correctly set value by pressing Write softkey. If you want to skip the calibration point whose calibration you have already entered, press Exit softkey.
 - Repeat the calibration procedure for all 4 offset values.
- c) Output current ranges calibration
- Select TransConductance output from the calibration menu and confirm by pressing select softkey.
 - Select first calibration point.
 - Connect external voltage 2 V DC to the calibrator input terminals METER INPUT V-COM. Exact value can be measured by parallel standard voltmeter.
 - Adjust the calibrator's output according to TransConductance table using <, >, v, ^ cursor keys, rotary knob or numeric keyboard. Confirm correctly set value by pressing Write softkey. If you want to skip the calibration point whose calibration you have already entered, press Exit softkey.
 - Repeat the calibration procedure for all 4 offset values.
 - Resistance shunt should be used on 2, 5, 10 and 30 A ranges, if standard multimeter does not cover this range.

8 Error messages

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

- Incorrect control using the front panel, i.e. attempts to force a prohibited mode, e.g. setting an out-of-range value, overloading of output terminals etc.,
- Incorrect control using GPIB or RS-232 interface.
- Calibrator's fault.



Sample error message which appears when too large value is attempted to set up is shown below. All error messages are displayed in the frame overlapped main screen.

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

ID	Error message	Description
-430	Deadlocked.	Remote interface error. A command was received which generates too much data to fit in the output buffer and the output buffer is full. Command execution continues but all data are lost.
-420	Unterminated.	Remote interface error. The calibrator was addressed to talk but a command has not been received which sends data to the output buffer.
-410	Interrupted.	Remote interface error. A command was received which sends data to the output buffer, but the output buffer contained data from a previous command. The output buffer is cleared when power has been off, or after reset command has been executed.
-363	Input buffer overrun	Remote interface error.
-220	Invalid parameter	Remote interface error. An invalid character string was received. Check to see if you have enclosed the character string in single or double quotes and that the string contains valid ASCII character.
-140	Character data	Remote interface error. Received command doesn't contain valid character parameter.
-120	Numeric data	Remote interface error. Received command doesn't contain valid numeric parameter.
-110	Command header	Remote interface error. Received command isn't valid.
501	Eeprom write.	Eeprom write failed.
502	Eeprom read.	Eeprom read failed.
503	Eeprom error.	Eeprom data lost. Check calibration data.
701,704	Output overload	Output signal over specified limits. Decrease signal level or decrease the load.
703	High temperature	Calibrator power stage overheated. Disconnect external load. Ambient temperature is too high or forced ventilation holes are blocked.
705	Input overload	Input signal over specified limits. Decrease signal level.
706	Current output overload	Current output terminals overloaded. Decrease signal level or decrease the load.
722	Unexpected crossing.	Error in internal communication.
721	Unknown function.	Error in internal communication.
730, 731	Calibrator not ready	Error in internal communication.
732	Internal cpu RESET	Calibrator will be restarted.
743	Interface receive	Error in internal communication.
745	Internal CPU timeout	Error in internal communication.
746, 747, 748	Slave error	Error in internal communication.
750	Input amplitude overload	Input signal amplitude in TransConductance amplifier mode is too high. Decrease signal level.
751	Input slew rate overload	Slew rate of input signal in TransConductance amplifier mode is too high. Decrease frequency or signal level.

9 Maintenance

The multifunction calibrator is electronic instrument with microprocessor control. All blocks which are heavily loaded during the operation are cooled by a fan.

Rules for correct operation

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

- *The calibrator can only be switched on and off by pressing the mains switch located at the front panel.*
- *Do not connect the calibrator to other voltage than set by the voltage selector.*
- *Do not block the vent openings located at the rear panel and front panel.*
- *The calibrator must not be operated in dusty environment. It was designed to be used in a laboratory.*
- *No liquid or small objects can be permitted to enter the calibrator through the vent openings.*
- *Do not switch the calibrator outside its operating temperature range.*
- *Connect the instruments to be calibrated to proper output terminals. There is no way of protecting the calibrator from the damage caused by some improper connections.*
- *Do not damage the output terminals by plugging in “bananas” thicker than the terminals were designed for.*
- *Whenever possible, use the setup menu to ground Lo output terminals (GndI On).*
- *Do not overload the power stages by leaving the calibrator switched on with the load connected for a long time.*
- *Ensure that used cables are suitable for the calibration current.*

Regular maintenance

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

The calibrator should be calibrated in the recommended 12-month intervals. A calibration center has to perform this calibration.

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 connection when grounding loops are formed)
- proximity to sources of intensive influence, whose products are spread through the mains or propagated by the electromagnetic field
- strong electrostatic or electromagnetic field which can cause major instability during calibration using higher impedance.

10 Verification test

Procedure recommended for verifying parameters of the calibrator is described in this chapter. During tests it is not necessary access to the interior of the instrument.

Required equipment

Following instruments are required for performance verification test:

- 8 1/2 digit multimeter type HP3458A or Fluke 8508A, or other type with accuracy 0.01 % on AC voltage
- Multifunction calibrator MEATEST M142 or M140 with DC ranges 20 V, 200 mA and AC range 20 V / 15 kHz.
- resistance shunt 1 m Ω , 10 m Ω , 100 m Ω Burster 1280, or other type with accuracy 0.01 %
- counter HP 53181A, HO 53130, BM 642 or other with accuracy 0,001 %

HP8903A Distortion analyzer and scope with bandwidth min. 20 MHz. 100 kHz bandwidth is recommended for THD measuring of AC signals.

Configuration of the calibrator

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

1. **Current coil** **Coil Off**
2. **Current sources GND** **GndI On**

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

In general, when calibrator is connected to the standard meter, ground loops can be arising through power line connection. Ground loops can result apparently worse noise, short term stability or non-harmonic distortion of output signal. If necessary use toroidal chokes to suppress these products.

Performance verification may be performed after warm-up period i.e. 1 hour after switching on. Calibrator have to be in temperature stabilize condition at minimum 8 hours before performance verification test is started.

Basic steps of the performance verification test

Verification procedure consists of following steps:

- **1 A DC current** test with linearity check
- **DC current** internal ranges 300 mA, 2 A, 5 A, 10 A, 30 A, 60 A, 120 A test
- **AC current** internal ranges 300 mA, 2 A, 5 A, 10 A, 30 A, 60 A, 120 A test
- **Frequency** nominal value 1 kHz test
- **Multimeter** internal ranges 20 VDC, 200 mADC, frequency 10 kHz test
- **TransConductance amplifier** – input, offset, output

Procedure

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

1. Connect the calibrator to the mains and let them switched on for at least one hour in a laboratory at 23 ± 1 °C.
2. Connect current input of standard multimeter to the current output terminals of the calibrator. Set appropriate parameters on the standard multimeter to meet its best accuracy.
3. Perform 1 A DC linearity, DC current, AC current tests according to the tables I, II, III. Deviations should not exceed specified limits.
4. Connect output terminals of the calibrator to the resistance shunt 100 m Ω and counter. Set output current 1 A AC, frequency 1 kHz.
5. Perform frequency test according to the table IV. Deviation should not exceed specified limit.
6. Connect input voltage terminals of calibrator's internal multimeter to the output terminals of the standard calibrator. Set appropriate value of frequency and DC voltage according to the table V.
7. Perform multimeter test in points FREQUENCY 10000 Hz and 20 VDC. Deviations should not exceed limits in the tables bellow.
8. Connect input current terminals of calibrator's internal multimeter to the output terminals of the standard calibrator. Set appropriate value of DC current according to the table V.
9. Perform multimeter test on range 200 mA DC according to the table V. Deviation should not exceed specified limit.
10. Connect output terminals of the calibrator to the resistance shunt 100 m Ω and distortion meter. Set output current 1 A AC and frequency 1000 Hz.
11. Check harmonic distortion of output signal. It should not exceed 0.05%.
12. Connect input current terminals of calibrator's internal multimeter to the output terminals of the standard calibrator. Connect standard multimeter to the calibrator output terminals.
13. Switch calibrator into real TransConductance amplifier mode and perform tests according to the table VI. Deviations should not exceed specified limits.

If calibrator is out of limits is in some points of this test, appropriate function and range should be recalibrated. It is not necessary to recalibrate all functions, but only this one, which does not meet specification. See chapter Calibration mode, where recalibration procedure is described.

Tables of limits

1 A DC Basic range with linearity test

Function	Range	Value (A)	Frequency (Hz)	Deviation allowed (μ A)
A-DC	1 A	0.4		200
A-DC	1 A	0.5		225
A-DC	1 A	0.6		250
A-DC	1 A	0.7		275
A-DC	1 A	0.8		300
A-DC	1 A	0.9		325
A-DC	1 A	1.0		350
A-DC	1 A	-0.4		200
A-DC	1 A	-0.5		225
A-DC	1 A	-0.6		250
A-DC	1 A	-0.7		275
A-DC	1 A	-0.8		300
A-DC	1 A	-0.9		325
A-DC	1 A	-1.0		350

Table I

DC current test

Function	Range	Value (A)	Frequency (Hz)	Deviation allowed (μ A)
A-DC	300.0 mA	0.3		105 μ
A-DC	300.0 mA	-0.3		105 μ
A-DC	2.0 A	2.0		700 μ
A-DC	2.0 A	-2.0		700 μ
A-DC	5.0 A	5.0		1.75 m
A-DC	5.0 A	-5.0		1.75 m
A-DC	10.0 A	10.0		4.5 m
A-DC	10.0 A	-10.0		4.5 m
A-DC	30.0 A	30.0		15.0 m
A-DC	30.0 A	-30.0		15.0 m
A-DC	60.0 A	60.0		30.0 m
A-DC	60.0 A	-60.0		30.0 m
A-DC	120.0 A	120.0		60.0 m
A-DC	120.0 A	-120.0		60.0 m

Table II

AC current test

Function	Range	Value (A)	Frequency (Hz)	Deviation allowed (μ A)
A-AC	300.0 mA	0.3	55	105 μ
A-AC	1.0 A	1.0	55	350 μ
A-AC	1.0 A	1.0	800	500 μ
A-AC	2.0 A	2.0	55	800 μ
A-AC	5.0 A	5.0	55	1.75 m
A-AC	10.0 A	10.0	55	4.5 m
A-AC	30.0 A	30.0	55	15.0 m
A-AC	60.0 A	60.0	55	30.0 m
A-AC	120.0 A	120.0	55	60.0 m

Table III

Frequency test

Function	Range	Value (Hz)	Frequency (Hz)	Deviation allowed (Hz)
FREQ	1 kHz	1000.0		5

Table IV

Multimeter test

Function	Range	Value	Frequency (Hz)	Deviation allowed
FREQ	10 kHz	10000.0 Hz		0.5 Hz
V-DC	20 V	20.0 V		4 mV
V-DC	20 V	-20.0 V		4 mV
A-DC	200 mA	0.2 A		40 μ A
A-DC	200 mA	-0.2 A		40 μ A

Table V

TransConductance amplifier

Function	Range	Value	Frequency (Hz)	Deviation allowed
V-DC	2 V	2.0 V		2 mV
V-DC	2 V	-2.0 V		2 mV
A-DC	300.0 mA	0.3		900 μ A
A-DC	300.0 mA	-0.3		900 μ A
A-DC	1.0 A	1.0		3 mA
A-DC	1.0 A	-1.0		3 mA
A-DC	2.0 A	2.0		6 mA
A-DC	2.0 A	-2.0		6 mA
A-DC	5.0 A	5.0		15 mA
A-DC	5.0 A	-5.0		15 mA
A-DC	10.0 A	10.0		30 mA
A-DC	10.0 A	-10.0		30 mA
A-DC	120.0 A #1	30.0		90 mA
A-DC	120.0 A #1	-30.0		90 mA
A-DC	120.0 A #2	60.0		180 mA
A-DC	120.0 A #2	-60.0		180 mA
A-DC	120.0 A #3	90.0		270 mA
A-DC	120.0 A #3	-90.0		270 mA
A-DC	120.0 A #4	120.0		360 mA
A-DC	120.0 A #4	-120.0		360 mA

Table VI

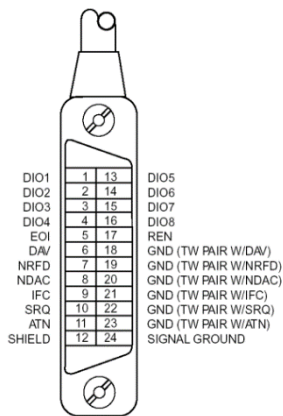
11 System control

The calibrator is equipped with RS232 serial line and IEEE488 bus. System connectors are located at the rear panel. For the remote control to work properly, interface parameters must be set in the system menu. For RS232 line communication speed can be set (1200 to 115200 Bd). For IEEE488 bus, an address from range 0 to 30 is allowed. The calibrator can be only controlled by one of interfaces at a time. It is therefore necessary to select one of the interfaces (RS232 /IEEE488) using the system menu.

11.1 IEEE488 bus properties

The instrument performs the following functions based on IEEE488 bus commands:

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



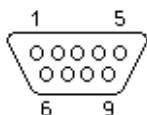
The instrument also recognizes the following general commands:

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

11.2 RS232 serial line setting

To transfer the data using RS232 bus, 8N1 data format is used, i.e. each data word includes 8 bits, no parity and one stop bit. The communication speed can be set using the system menu. Available values: 1200, 2400, 4800, 9600, 19200, 38400, 76800 and 115200 Bd.

RS-232 connector layout



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

9-pin connector D-SUB FEMALE

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

PC	D-Sub 1	D-Sub 2	Calibrator
Receiver	2	2	Transmitter
Transmitter	3	3	Receiver
Ground	5	5	Ground

Note:

It is not possible to send or receive data over RS232 when the calibrator is not in remote mode. You should use the command SYST:REM or SYST:RWL.

11.3 Command syntax

The commands described in this chapter can be issued through all buses (RS232/IEEE488).

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

KEYWORD and PARAMETERS.

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

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

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

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

E.g. CURR 100.5 ; OUTP ON

Note (only for RS232):

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

Description of abbreviations

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

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

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

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

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

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

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

OUTPut subsystem

This subsystem enables to activate or deactivate the calibrator output.

Keyword	Parameters
OUTPut	
[:STATe](?)	<CPD> { ON OFF }
:LOWCurrent (?)	<CPD> { FLOat GROund }
:CURCoil(?)	<CPD> { OFF X25 USER }
:USER(?)	<DNPD>
:SYNChronization(?)	<CPD> { INT LINE EXT }
:LOCKed?	<CPD> { 0 1 }

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

This command activates or deactivates output terminals.

- ON - activates the output
- OFF - deactivates the output

If query is sent, calibrator returns ON if the output is active or OFF if it is inactive

Example: OUTP ON - activates the output
 OUTP? - the calibrator returns ON or OFF

OUTP:LOWC(?) <CPD> { FLO | GRO }

This command connects or disconnects the Lo terminal of current output to/from GND terminal.

- FLOat ungrounds current output
- GROund grounds current output

If query is sent, calibrator returns GRO when the output is grounded or FLO when floating.

Example:
 OUTP:LOWC GRO
 OUTP:LOWC? Calibrator returns FLO or GRO

Warning!

Lo output terminal and COM input terminal are grounded in real TransConductance mode regardless of this item's setting.

OUTP:CURC(?) <CPD> { OFF | X25 | USER }

This command activates or deactivates the use of 25-turns or user current coil.

- OFF - deactivates the current coil
- X25 - activates the 25 turns current coil
- USER - activates the user current coil

If query is sent, calibrator returns USER if the user coil is activated X25 if the 25-turn coil is activated or OFF if the current coil is deactivated.

Example: OUTP:CURC X25 activates 25-turn current coil
 OUTP:CURC? Calibrator returns OFF, USER or X25

OUTP:CURC:USER(?) <DNPD>

This command sets the number of the turns.

Příkaz nastavuje hodnotu uživatelské závitové cívky.

<DNPD>

Parameter represents the number of the turns.

Example: OUTP:CURC:USER 50 sets the 50-turn current coil

OUTP:SYNC(?) <CPD> { INT | LINE | EXT }

This command sets mode of output frequency synchronization.

- INT – internal synchronization
- LINE – synchronization to power supply frequency
- EXT – synchronization to external signal

If query is sent, calibrator returns INT, LINE or EXT according to selected synchronization mode.

Example: OUTP:SYNC INT selects frequency synchronization to internal reference
 OUTP:SYNC? Calibrator returns INT, LINE or EXT

OUTP:SYNC:LOCK? <CPD> { 0 | 1 }

This query returns the actual state of frequency synchronization.

- 0 – output frequency is not locked (it is not possible to activate the output terminals)
- 1 – output frequency is locked to reference signal

Example: OUTP:SYNC:LOCK? calibrator returns 1 or 0

MEASure a CONFigure subsystem

This subsystem allows controlling the internal multimeter.

Keyword	Parameters
----------------	-------------------

MEASure?

CONFigure(?) <CPD> { VOLTage | CURRent }

MEAS?

This query returns value measured by the multimeter.

Calibrator returns the set values of amplitude and frequency using standard exponential format.

Example: 7.456 V / 50.1 Hz is returned as 7.456000e+000,5.010000e+001.

Example: MEAS? Calibrator returns measured value

CONF(?) <CPD> { VOLT | CURR }

This command sets the function of internal multimeter.

If query is sent, calibrator returns VOLT or CURR according to selected multimeter function.

Example: CONF VOLT sets the multimeter to function voltage

SOURce subsystem

This subsystem allows controlling the individual functions of the calibrator.

Keyword

Parameters

[SOURce]

:MODE? { CAC | CDC | AMAC | AMDC | TAMP }

:CAC

:CURRent(?) <DNPD>

:FREQuency(?) <DNPD >

:CDC

:CURRent(?) <DNPD>

:AMAC

:CURRent? <DNPD>

:FREQuency(?) <DNPD >

:AMDC

:CURRent? <DNPD>

:TAMP

:RANGe? <CPD> {0.3 | 1 | 2 | 5 | 10 | 30 | 60 | 120}

:GNU(?) <DNPD >

:GNI(?) <DNPD >

:STEP(?) <DNPD >

[SOUR]:MODE?

This command returns selected mode of the calibrator {CAC | CDC | AMAC | AMDC | TAMP}.

- CAC – Current AC mode
- CDC – Current DC mode
- AMAC – Current AC amplifier mode
- AMDC – Current DC amplifier mode
- TAMP – Real TransConductance amplifier mode

Example:

MODE?

[SOUR]:CAC:CURR(?) <DNPD>

This command sets the output current value in Current AC mode.

<DNPD>

Parameter represents the value of the output current expressed in A.

If query is sent, calibrator returns the value of output current using standard exponential format.

Example: 11.012 A is returned as 1.101200e+001.

Example:

Current 23.05A:

CAC:CURR 23.05

Note:

Command switches the calibrator in Current AC mode.

[SOUR]:CAC:FREQ(?) <DNPD>

This command sets the frequency in Current AC mode.

<DNPD>

Parameter represents the value of frequency expressed in Hz.

If query is sent, calibrator returns the value of frequency using standard exponential format.

Example: 50Hz is returned as 5.000000e+001.

Example:

Frequency 60Hz:

CAC:FREQ 60

Notes:

Command switches the calibrator in Current AC mode.

[SOUR]:CDC:CURR(?) <DNPD>

This command sets the output current value in Current DC mode.

<DNPD>

Parameter represents the value of the output current expressed in A.

If query is sent, calibrator returns the value of output voltage using standard exponential format.

Example: 11.012 A is returned as 1.101200e+001.

Example:

Current 23.05A:

CDC:CURR 23.05

Note:

Command switches the calibrator in Current DC mode.

[SOUR]:AMAC:CURR(?) <DNPD>

This command sets the output current value in AMAC mode.

<DNPD>

Parameter represents the value of the output current expressed in A.

If query is sent, calibrator returns the value of output current using standard exponential format.
Example: 11.012 A is returned as 1.101200e+001.

Example:

Current 23.05A:

AMAC:CURR 23.05

Note:

Command switches the calibrator in AMAC mode.

[SOUR]:AMAC:FREQ(?) <DNPD>

This command sets the frequency in AMAC mode.

<DNPD>

Parameter represents the value of frequency expressed in Hz.

If query is sent, calibrator returns the value of frequency using standard exponential format.
Example: 50Hz is returned as 5.000000e+001.

Example:

Frequency 60Hz:

AMAC:FREQ 60

Notes:

Command switches the calibrator in AMAC mode.

[SOUR]:AMDC:CURR(?) <DNPD>

This command sets the output current value in AMDC mode.

<DNPD>

Parameter represents the value of the output current expressed in A.

If query is sent, calibrator returns the value of output current using standard exponential format.
Example: 11.012 A is returned as 1.101200e+001.

Example:

Current 23.05A:

AMDC:CURR 23.05

Note:

Command switches the calibrator in AMDC mode.

[SOUR]:TAMP:RANG(?) <CPD> {0.3 | 1 | 2 | 5 | 10 | 30 | 60 | 120}

This command sets the range of real TransConductance amplifier.

<CPD>

Parameter represents the range. Ranges are from 0.3A up to 120A.

If query is sent, calibrator returns the selected range. Example: 10A range is returned as 10.

Example:

Range 10A:

TAMP:RANG 10

Note:

Command switches the calibrator in Real TransConductance amplifier mode.

[SOUR]:GNU(?) <DNPD>

This command sets the gain value in transconductance amplifier mode (AMAC and AMDC).

<DNPD>

Parameter represents the value of the gain expressed in A/V.

If query is sent, calibrator returns the value of output current using standard exponential format.

Example: 5.123 A/V is returned as 5.123000e+000.

Example:

Gain 8.05 A/V:

GNU 8.05

[SOUR]:GNI(?) <DNPD>

This command sets the gain value in current amplifier mode (AMAC and AMDC).

<DNPD>

Parameter represents the value of the gain expressed in A/A.

If query is sent, calibrator returns the value of output current using standard exponential format.

Example: 612 A/A is returned as 6.120000e+002.

Example:

Gain 600 A/A:

GNI 600

[SOUR]:STEP(?) <DNPD>

This command sets the output current step value in AMAC and AMDC mode.

<DNPD>

Parameter represents the value of the output current step expressed in A.

If query is sent, calibrator returns the value of output current using standard exponential format.

Example: 0.5 A is returned as 5.000000e-001.

Example:

Step 0.5 A:

STEP 0.5

SYSTem subsystem

The subsystem enables to control various functions from the MENU.

SYSTem

```

:DATE(?) <DNPD>,<DNPD>,<DNPD>
:TIME(?) <DNPD>,<DNPD>,<DNPD>
:ERRor?
:REMOte
:RWLock
:LOCal

```

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

This command sets system date of the calibrator.

```
<DNPD>,<DNPD>,<DNPD>
```

Represents date in format YYYY, MM, DD.

If query is sent, calibrator returns current value of system date in format YYYY,MM,DD.

where YYYY = year (2000..2099)

MM = month (01..12)

DD = day (01..31)

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

This command sets time of the calibrator.

```
<DNPD>,<DNPD>,<DNPD>
```

Represents time in format HH,MM,SS.

If query is sent, calibrator returns current value of system time in format HH,MM,SS.

where HH = hour (00..23)

MM = minute (00..59)

SS = second (00..59)

SYST:ERR?

Query the multimeter's error queue. Detected errors are placed in the queue. This query returns the first error from the queue. The queue is type "first in, first out". The error is deleted after reading.

The response is in the form of 'String Program Data', and consists of two elements: a code number and error message.

If all errors are read calibrator returns message 0,"No Error".

In case of overflow the error queue the last error in the queue is -350,"Queue overflow". Also the earliest errors remain in the queue, and the most recent error is discarded.

Example:

```
SYST:ERR?
```


SYST:REM

This command places the calibrator in the remote mode for RS232 operation. All keys on the front panel, except the LOCAL key, are disabled.

Note:

It is not possible to send or receive data over RS232 when the calibrator is not in remote mode.

SYST:RWL

This command places the calibrator in the remote mode for RS232 operation. All keys on the front panel, including the LOCAL key, are disabled.

SYST:LOC

This command returns the calibrator in the local mode. This command is for RS232.

STAT:QUES:EVEN?

This query returns the content of Questionable Data Event register. It is a decimal value which corresponds to the binary-weighted sum of all bits set in the register. Register is cleared after this query.

Example:

```
STAT:QUES:EVEN?
```

STAT:QUES:ENAB? <DNPD>

This command enables bits in the Questionable Data Enable register. Selected bits are summarized at bit 3 (QSS) of the IEEE488.2 Status Byte register.

<DNPD>

Parameter represents required value of Questionable Data Enable register.

If query is sent, calibrator returns the value of the register as a decimal number. Example: 64 is returned as 64.

Example:

Set bit 1 in the Questionable Data Enable register (other bits are 0):

```
STAT:QUES:ENAB 2
```

STAT:QUES:COND?

This query returns the content of Questionable Condition register. It is a decimal value which corresponds to the binary-weighted sum of all bits in the register. Register is not cleared after this query. The response to the query therefore represents an instantaneous 'Snapshot' of the register state, at the time that the query was accepted.

Example:

```
STAT:QUES:COND?
```

STAT:PRES

This command clears all bits in the Operation Data Enable register and in the Questionable Data Enable register.

Example:

```
STAT:PRES
```

IEEE488.2 Common Commands

I/D (instrument identification)

***IDN?**

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

The reply is formatted as follows:

MEATEST,M151,510001,1.22

Operation complete

***OPC**

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

Operation complete?

***OPC?**

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

Wait-to-Continue command

***WAI**

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

Reset

***RST**

This command resets the calibrator to its initial status.

Test operation

***TST?**

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

Status byte reading

***STB?**

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

Service Request Enable

***SRE <value>**

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

Service Request Enable reading

***SRE?**

This query returns the Service Request Enable Register number.

Event Status Register reading

***ESR?**

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

Event Status Enable setting

***ESE <value>**

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

Event Status Enable reading

***ESE?**

This query returns the Event Status Enable register.

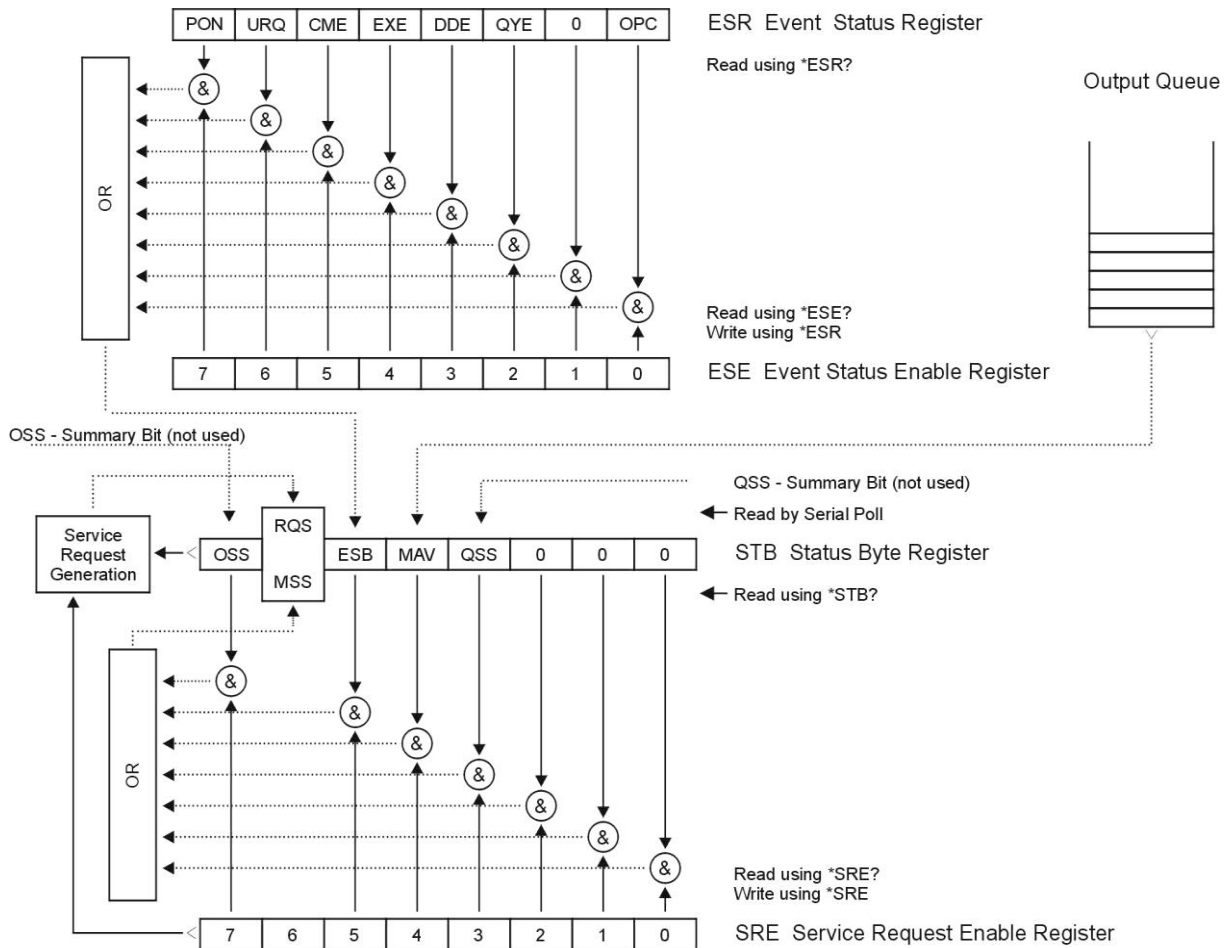
Clear status

***CLS**

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

11.4 Standard Status Data Structures

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



Status Register Overview

Status data structure contains following registers:

- STB – Status Byte Register
- SRE – Service Request Enable Register
- ESR – Event Status Register
- ESE – Event Status Enable Register
- Output Queue

STB Status Byte Register

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

Bit configuration of Status Byte Register:

- OSS Operation Summary Status, bit 7. SCPI-defined. The OSS bit is set to 1 when the data in the OSR (Operation Status Register) contains one or more enabled bits which are true.
- RQS Request Service, bit 6. The bit is read as a part of status byte only when serial message is sent.
- MSS Master Summary Status, bit 6. The MSS bit is set to 1 whenever bits ESB or MAV are 1 and enabled (1) in the SRE. This bit can be read using the *STB? command. His value is derived from STB and SRE status.
- ESB Event Summary Bit, bit 5. His value is derived from STB and SRE status. The ESB bit is set to 1 when one or more enabled ESR bits are set to 1.
- MAV Message Available, bit 4. The MAV bit is set to 1 whenever data is available in the IEEE488 Output Queue (the response on query is ready).
- QSS Questionable Summary Status, bit 3. SCPI-defined. The QSS bit is set to 1 when the data in the QSR (Questionable Status Register) contains one or more enabled bits which are true.

SRE Service Request Enable Register

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

ESR Event Status Register

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

Bit configuration of Event Status Register:

- PON Power On, bit 7. This event bit indicates that an off-to-on transition has occurred in the device’s power supply.
- URQ User Request, bit 6. Bit is not used and it is always “0”.
- CME Command Error, bit 5. This event bit indicates that an incorrectly formed command or query has been detected by the instrument.
- EXE Execution Error, bit 4. This event bit indicates that the received command cannot be executed, owing to the device state or the command parameter being out of limits.

- DDE** Device Dependent Error, bit 3. This event bit indicates that an error has occurred which is neither a Command Error, a Query Error, nor an Execution Error. A Device-specific Error is any executed device operation that did not properly complete due to some condition, such as overload.
- QYE** Query Error, bit 2. The bit is set if the calibrator is addressed as talker and output queue is empty or if control unit did not pick up response before sending next query.
- OPC** Operation Complete, bit 0. This event bit is generated in response to the *OPC command. It indicates that the device has completed all selected pending operations.

ESE Event Status Enable Register

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

It suppresses or allows bits in ESR register. Value „0“ of a bit of ESE register suppresses influence of appropriate bit of ESR register on value of sum bit of ESB status register. Setting of any unmask bit of ESR register results in setting of ESB status register. ESE register value can be modified by command *ESE followed by value of mask register (integer in range 0 –255). Reading of the register can be performed with command *ESE?. The register is automatically reset after switching on. The register is not reset with *CLS command.

Operation Status Register

Not used in the calibrator.

Questionable Status Register

Not used in the calibrator.

Output Queue

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

Error Queue

The Error Queue stores error messages. They are placed in a “first in, first out” queue. The queue is read destructively using the query command “SYSTem:ERRor?” to obtain a code number and error message. The query “SYSTem:ERRor?” can be used to read errors in the queue until it is empty, when the message “0, No Error” will be returned.

12 Specification

Uncertainties include long-term stability, temperature coefficient, linearity, load and line regulation and the traceability of factory and National calibration standards. Specified accuracy is valid after one hour warm up in temperature range 23 ± 3 °C. Specified accuracy is one year accuracy.

DC/AC current (sine amplitude)

Summary range:	8 mA to 120 A
Current resolution:	5½ dig.
Frequency range:	DC, 15 Hz to 1000 Hz
Frequency accuracy:	0.005%
Frequency resolution:	0.001 Hz below 500 Hz, 0.01 Hz below 1000 Hz
Distortion:	< 0.1 %
Output terminals isolation:	up to 450 Vpk against GND (protective earth)

Range	% value + % range	Max. compliance voltage (V)	% value + % range		Max. compliance voltage (V)	
			15 - 40 Hz 70 - 1000 Hz	40 - 70 Hz	15 - 400 Hz	400 - 1000 Hz
		DC				
0.008000 - 0.300000 A	0.0175 + 0.01	8 V	0.025 + 0.02	0.0175 + 0.01	5.5 V	3.5 V
0.30001 - 1.00000 A	0.0175 + 0.01	8 V	0.025 + 0.02	0.0175 + 0.01	5.5 V	3.5 V
1.00001 - 2.00000 A	0.0175 + 0.01	8 V	0.025 + 0.02	0.0175 + 0.01	5.5 V	3.5 V
2.00001 - 5.00000 A	0.0175 + 0.01	5 V	0.025 + 0.02	0.0175 + 0.01	3.5 V	3.5 V
5.0001 - 10.0000 A	0.021 + 0.015	5 V	0.04 + 0.02	0.021 + 0.015	3.5 V	3.5 V
10.0001 - 30.0000 A	0.025 + 0.015	5 V	0.05 + 0.02	0.025 + 0.015	3.5 V	3.5 V
30.0001 - 60.0000 A	0.025 + 0.015	5 V	0.05 + 0.02	0.025 + 0.015	3.5 V	3.5 V
60.0001 - 120.000 A	0.025 + 0.015	5 V	0.05 + 0.02	0.025 + 0.015	3.5 V	3.5 V

When option 151-25 Current Coil is used, add 0.3% to the accuracy specified in the table above. Output current is multiplied by factor 25 depending on applied coil range.

Multimeter

Function	Total range	Accuracy	Resolution / Range
AC voltage < 1 kHz	1 - 20 V	0.02 % + 0.02 %	100 µV / 20 V
AC voltage > 1 kHz	1 - 20 V	0.05 % + 0.05 %	100 µV / 20 V
DC voltage	0 - ±20 V	0.01 % + 0.01 %	100 µV / 20 V
AC current < 1 kHz	10 - 200 mA	0.02 % + 0.02 %	1 µA / 200 mA
AC current > 1 kHz	10 - 200 mA	0.05 % + 0.05 %	1 µA / 200 mA
DC current	0 - ±200 mA	0.01 % + 0.01 %	1 µA / 200 mA
Frequency	1 Hz - 10 kHz	0.005	10 µHz - 0.1 Hz

Real Transconductance amplifier – output current

Range	% value + % range	% value + % range	Max. compliance voltage (V)	Gain (A/V)
	DC AC < 70 Hz	70 – 1000 Hz		
0.008000 - 0.300000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	0.150
0.300001 - 1.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	0.500
1.000001 - 2.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	1.000
2.000001 - 5.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	2.500
5.000001 - 10.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	5.000
10.000001 - 30.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	15.00
30.000001 - 60.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	30.00
60.000001 - 120.000000 A	0.2 + 0.1	0.4 + 0.2	2 (3.5) *	60.00

* Specification is valid for compliance voltage <2V. Maximal allowed compliance voltage is 3.5 V.

Typical phase shift of transconductance amplifier is defined by formula:

$$t = 7 \times U \times I_m / I + 3,5 \text{ [us]}$$

where

t is time delay between input and output signal [us]

U is voltage on the M151 output (load) [V]

I_m is maximum current on selected range [A]

I is actual output current [A]

Example:

I_m = 10A range (Gain 5.0)

I = 5A current

V_{load} = 1 V

Freq = 55 Hz

Phase = 0.35°

t = 17,5us

Typical 24 hours phase shift stability is better than 0.01° (50 – 60 Hz).

Note:

Internal protection disconnects output terminals if amplitude of input signal exceed limit 2V RMS or if the slew rate of input signal exceeds limit 0.035 V/us.

General data

Warm up time:	15 min
Operating temperature:	+5 °C ... +40 °C
Storage temperature:	-10 °C ... +55 °C, humidity < 90 %
Reference temperature:	+20 °C ... +26 °C
Temperature coefficient:	10% of specification /°C (in range +5°C ... 20°C and 26°C ... 40°C)
Dimensions:	W 538 mm, H 283 mm, D 540 mm
Net weight:	42 kg
Power supply:	115/230V – 50/60 Hz
Power consumption:	max. 2000 VA
Safety class:	I, according EN 61010

13 Accessories

M151 Basic accessories (included in delivery)

- Power line cord 1 pc
- User's manual 1 pc
- Test report 1 pc
- Spare fuse 1 pc
- RS232 cable 1 pc
- 151-10 120 A test lead (black), 0.5 m ring terminals (M8)
- 151-11 120 A test lead (red), 0.5 m ring terminals (M8)

Options (extra ordered)

- 151-25 Current coil 25-turns
- IEEE488/IEEE488 GPIB cable, 2 m
- Caliber Universal application SW for instruments calibration.

Manufacturer

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www.meatest.com

**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 M-151 Current 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

Brno

September 25th, 2020

Place

Date

Signature