meatest

EN, rev. 21 FW ver. 1.014

M151 Current Calibrator

user manual

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1. Introduction

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.

1.1. Front panel overview

Main control segments of the calibrator are:

Figure 1 Front panel

1. Display and display keys
2. Rotary knob and Cursor keys
3. Numeric keys
4. Function keys
5. Power switch
6. Air intake
7. Current output

1.1.1. Display in detail

Display is divided into several sections with following meaning:

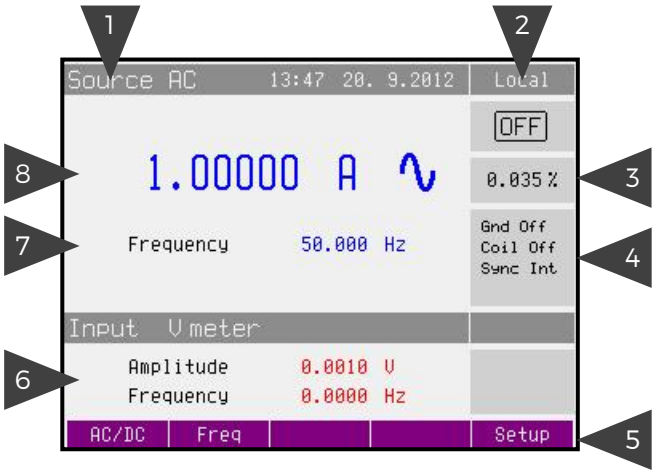


Figure 2 Display

1. Selected function.
2. Output status. Indicates output status (grey means OFF OFF green means ON)
3. Specification. 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
4. Information section. Additional information related to the selected function:
    a. Information about the grounding method of output terminals: Gnd as set up using the menu „Calibrator“.
    b. Information about the use of turn coil as set up using the menu „Calibrator“.
    c. Information about sync mode (only AC output).
5. Display softkeys. Display keys below the display change their function dynamically based on current workspace, these labels describe Softkey functions at any given time.
6. Meter’s information section
7. Auxiliary parameters. You can switch between parameters (and main value) using display keys. Every function has different set of auxiliary parameters.
8. Main value. Can be edited via numerical input, cursor keys or rotary knob. Symbol on the right represents signal shape.

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.

1.1.2. Keys in detail

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 (∧, ∨) 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).

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

1. step through the options
2. 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).

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.

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

1. Source mode SOURCE
2. Amplifier mode AMPLIFIER
3. Voltage measurement VOLTAGE
4. Current measurement CURRENT
5. 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.

Power switch - Turns instrument AC power ON and OFF.

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.).

1.2. Rear panel overview

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.

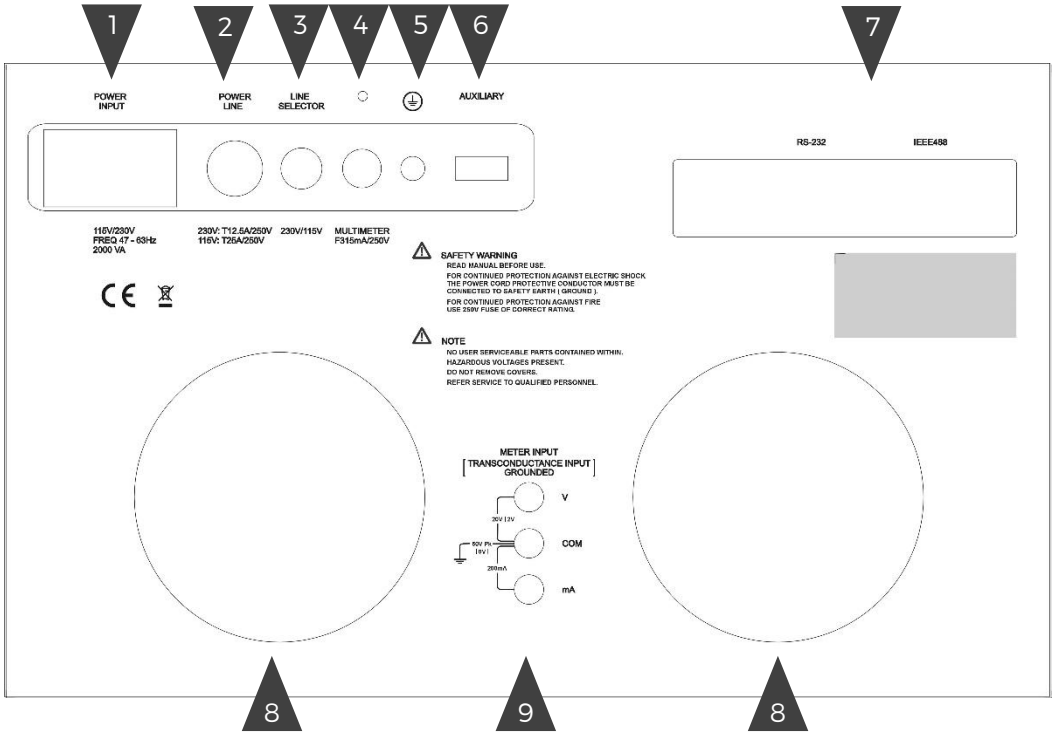


Figure 3 Rear panel

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

1.3. Options and accessories

Every M151 Current Calibrator delivery includes following items:

- USB stick with user manual 1 pc
- Factory calibration certificate 1 pc
- Power cord 1 pc
- Spare fuse 1 pc
- Cable 151-10 1 pc
- Cable 151-11 1 pc

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

- 151-25 Current Coil
- 0950 Current Coil
- IEEE488/IEEE488 (GPIB cable, 2 m)
- Caliber Universal application SW for instruments calibration.

1.4. Remote control

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

- RS232
- GPIB (IEEE488)

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

RS232 connection settings

- COM port — see available COM ports in Windows Device Manager
- Baudrate RS232 — according to MENU->Interface menu->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 menu ->GPIB Address (2 by default)

1.4.2. SCPI commands and protocol

See M151 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 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, risk of danger.

Protective earth.

2.2. Power on and warm-up

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.

- 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.

Warm-up

The calibrator works after it is switched on and the initial checks complete. Specified parameters are only guaranteed after the instrument warms up for 15 minutes. During this period, the instrument cannot be calibrated.

2.3. Function setup

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:

- **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.
- **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.
- **Select AC /DC current.** After pressing AC/DC softkey the calibrator changes AC to DC signal or DC to AC signal.
  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.

2.4. Signal output

Calibrator output can be switched on/off by pushing OPER button. Output turns off automatically on calibrator startup and function switch. Output status is indicated by rectangle below LOCAL (or REMOTE) label on the right side of the display.  indicates that output is on, 

indicates output is off.

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 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.

3. 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 ∨ 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.

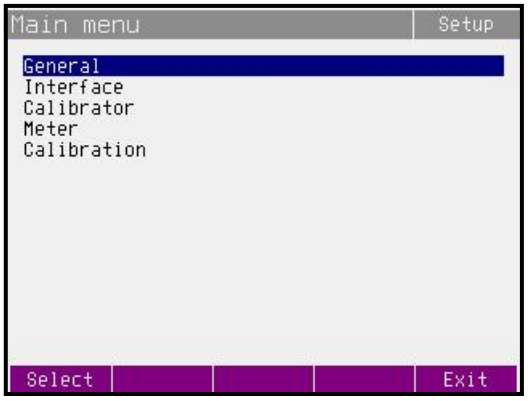


Figure 4 Main menu

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

3.1. General Menu

Submenu contains basic parameters of display and keyboard.

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

- **Date** - Setting the date. The parameter can be changed using cursor keys, rotary knob or numeric keyboard.
- **Device Information** - Viewing the device information. Displays the serial number and software version.

3.2. Interface Menu

Submenu contains remote control parameters.

- **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.
- **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.
- **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.

3.3. Calibrator Menu

Submenu contains parameters that affect generated signal.

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

3.4. Meter Menu

Submenu contains parameters that affect measured signal.

- **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.

3.5. 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.

4. Calibration examples

4.1. 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

1. Set desired value of current using numeric keyboard, rotary knob or cursor keys. Output current is not yet connected to the output terminals.
2. Connect the instrument to be calibrated to CURRENT OUTPUT HI-LO.
3. Press OPER key.
4. Green symbol is lit on the display to indicate the connection of output terminals.
5. 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 Idc Basic and Iac 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.

4.2. 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)

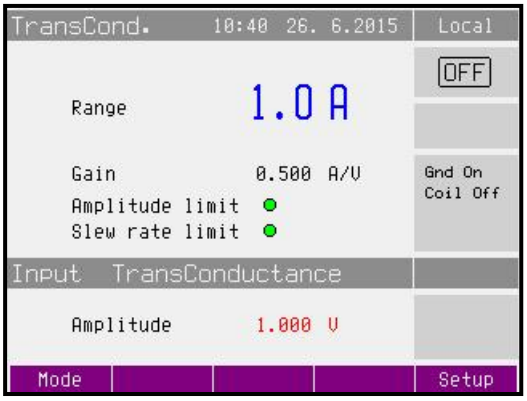


Figure 5 Transconductance AMPLIFIER

1. Set required amplifier's range.
2. Connect control voltage signal to rear panel input terminals.
3. If parameters of input signal are correct, both circles next to parameters will be turned green.
4. Connect a load (or short circuit) to the output terminals.
5. Press OPER key.
6. Green symbol is lit on the display to indicate the connection of output terminals.
7. 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.

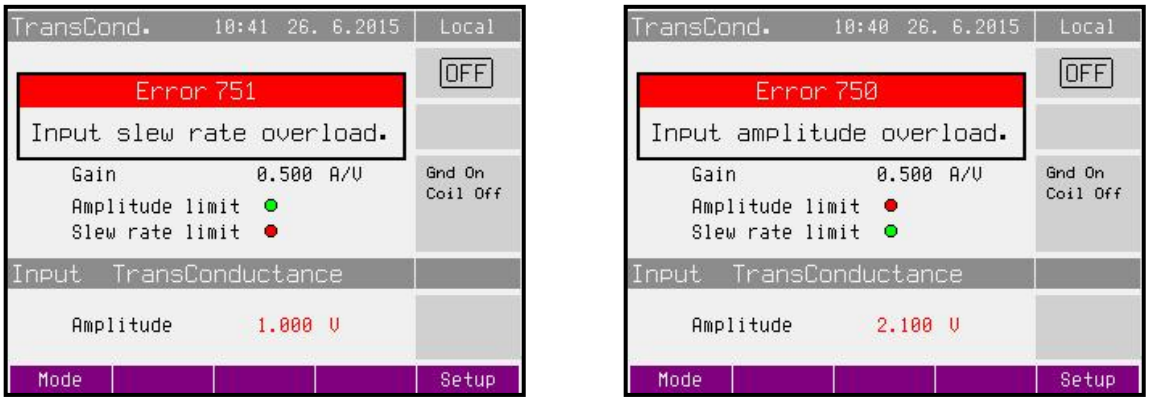


Figure 6 Transconductance AMPLIFIER – Slew rate and high amplitude

4.3. 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.

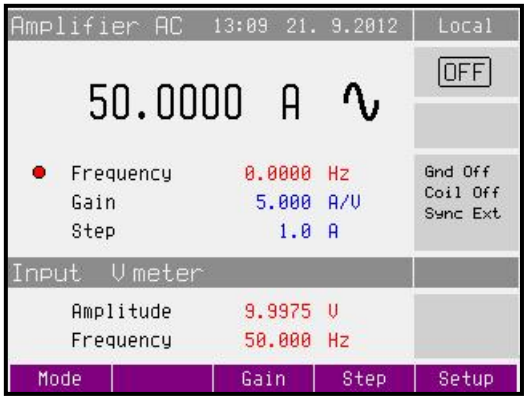
Control in the AMPLIFIER mode

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)

1. Select type of he input signal by pressing VOLTAGE or CURRENT meter key.
2. Set required Gain and Step of the output current.
3. Connect the control signal (voltage or current) to the meter terminals located on the rear panel.
4. In case of internal frequency synchronization must be set also frequency of output current.
5. In case of external or power supply frequency synchronization, wait until the frequency is synchronized (light green circle near the frequency value ●).
6. Connect the instrument to be calibrated to CURRENT OUTPUT HI-LO.
7. Press OPER key.
8. Green symbol is lit on the display to indicate the connection of output terminals.
9. 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.



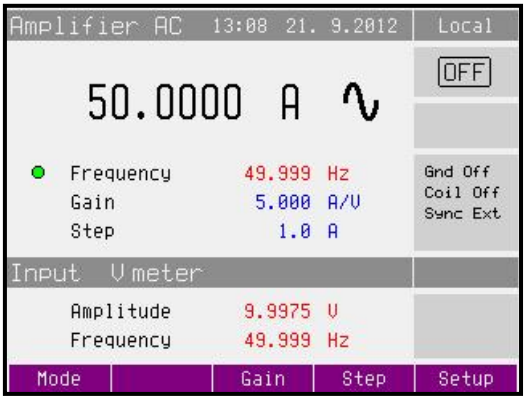


Figure 7 Transconductance AMPLIFIER - frequency and phase synchronization

- frequency and phase aren’t synchronized - frequency and phase are synchronized

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

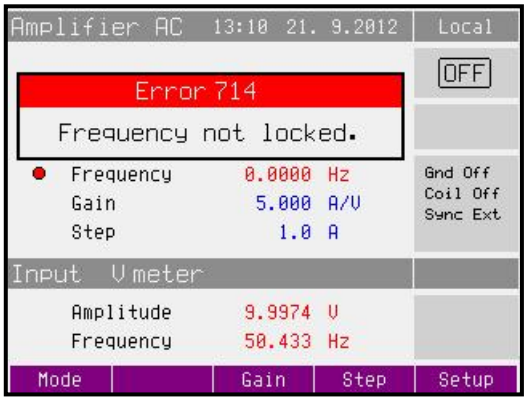


Figure 8 Synchronization error

4.4. 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}.

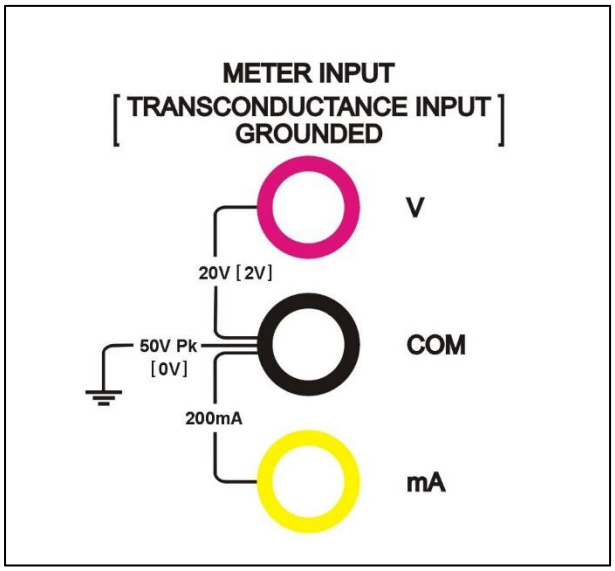


Figure 9 Meter input

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

4.4.1. 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

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 Keysight 3458A or Fluke 8588A, or other type with AC voltage measurement accuracy 0.01 % or better
- Multifunction calibrator MEATEST 9000, 9010 or 9010+ with DC ranges 20 V, 200 mA and AC range 20 V / 15 kHz.
- resistance shunt 1 mΩ, 10 mΩ, 100 mΩ Burster 1280, or other type with accuracy 0.01 %
- counter Keysight 53210A or other with accuracy 0.001 %
- [optional] HP8903A Distortion analyzer and with min. bandwidth 100 kHz.

5.2. Verification procedure

1. Place the calibrator to reference laboratory conditions and let it switched on for at least one hour. Note: Stabilization may take up to 8 hours if the calibrator was previously stored in very different temperature and humidity conditions.
2. Set Terminal ground item in M151's SOURCE SETUP menu to ON in order to suppress mains noise during measurement. Note: Ground loops may cause noise or distortion in leads connecting the calibrator and the standard meter.
3. Connect front panel 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 current output test
    b. AC current output test
    c. AC frequency test
    d. Multimeter test
    e. Transconductance amplifier test
5. [optional] Verify that THD of output signal at 1 A, 1000 Hz does not exceed 0.05%.

5.3. Test points

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
DC Current	300	300	299.9175	300.0825	mA	8½ digit DMM (use current shunt where required)	DC
		-300	300.0825	299.9175	mA		
	1	0.4	0,3998	0,4002	A		
		0.5	0,499775	0,500225	A		
		0.6	0,59975	0,60025	A		
		0.7	0,699725	0,700275	A		
		0.8	0,7997	0,8003	A		
		0.9	0,899675	0,900325	A		
		1	0,99965	1,00035	A		
		-0.4	-0,4002	-0,3998	A		
		-0.5	-0,500225	-0,499775	A		
		-0.6	-0,60025	-0,59975	A		
		-0.7	-0,700275	-0,699725	A		
		-0.8	-0,8003	-0,7997	A		
		-0.9	-0,900325	-0,899675	A		
		-1	-1,00035	-0,99965	A		
	2	2	1.9993	2.0007	A		
		-2	-2.0007	-1.9993	A		
	5	5	4.99825	5.00175	A		
		-5	-5.00175	-4.99825	A		
	10	10	9.9955	10.0045	A		
		-10	-10.0045	-9.9955	A		
	30	30	29.985	30.015	A		
		-30	-30.015	-29.985	A		
	60	60	59.97	60.03	A		
		-60	-60.03	-59.97	A		
	120	120	119.94	120.06	A		
		-120	-120.06	-119.94	A		
AC Current	300	300	300.0001	299.9999	mA	8½ digit DMM (use current shunt where required)	55 Hz
	1	1	1.00035	0.99965	A		
	1	1	1.0005	0.9995	A		800 Hz
	2	2	2.0008	1.9992	A		55 Hz
	5	5	5.00175	4.99825	A		
	10	10	10.0045	9.9955	A		
	30	30	30.015	29.985	A		
	60	60	60.03	59.97	A		
	120	120	120.06	119.94	A		
Frequency	1	1	0.995	1.005	kHz	Frequency counter	1 A AC

Table 1 List of main test points

5.3.1. Multimeter test points

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
Voltage	20	20	19.996	20.004	mV	Meatest 9000	DC
		-20	-20.004	-19.996	mV		
Current	200	2	200.04	199.96	mA		
		20	-199.96	-200.04	mA		
Frequency	10	10	9.9995	10.0005	kHz		5 V AC

Table 2 List of multimeter test points

5.3.2. Transconductance amplifier test points

Function	Range	Nominal	Min value	Max value	Unit	Standard unit	Test parameters
TC Amplifier Voltage Measurement	2	2	1.998	2.002	V	8½ digit DMM (use current shunt where required)	DC
		-2	-2.002	-1.998	V		
TC Amplifier Current Output	300	300	299.1	300.9	mA		
		-300	-300.9	-299.1	mA		
	1	1	0.997	1.003	A		
		-1	-1.003	-0.997	A		
	2	2	1.994	2.006	A		
		-2	-2.006	-1.994	A		
	5	5	4.985	5.015	A		
		-5	-5.015	-4.985	A		
	10	10	9.97	10.03	A		
		-10	-10.03	-9.97	A		
	120 #1	30	29.91	30.09	A		
		-30	-30.09	-29.91	A		
	120 #2	60	59.82	60.18	A		
		-60	-60.18	-59.82	A		
	120 #3	90	89.73	90.27	A		
		-90	-90.27	-89.73	A		
	120 #4	120	119.64	120.36	A		
		-120	-120.36	-119.64	A		

Table 3 List of Transconductance amplifier test points

6. Adjustment

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

6.1. 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.

6.2. Access to the calibration procedure

Calibration password is required to access the calibration procedure.

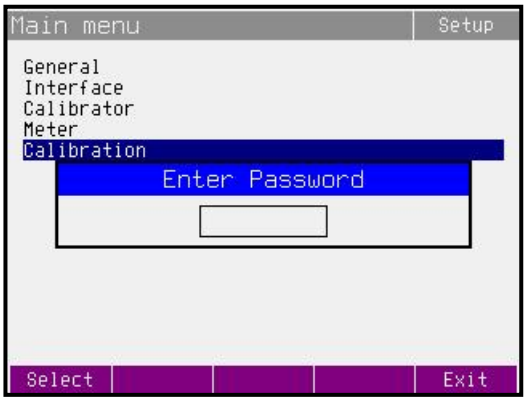


Figure 10 Calibration menu

- 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.

6.3. Selection of calibration type

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

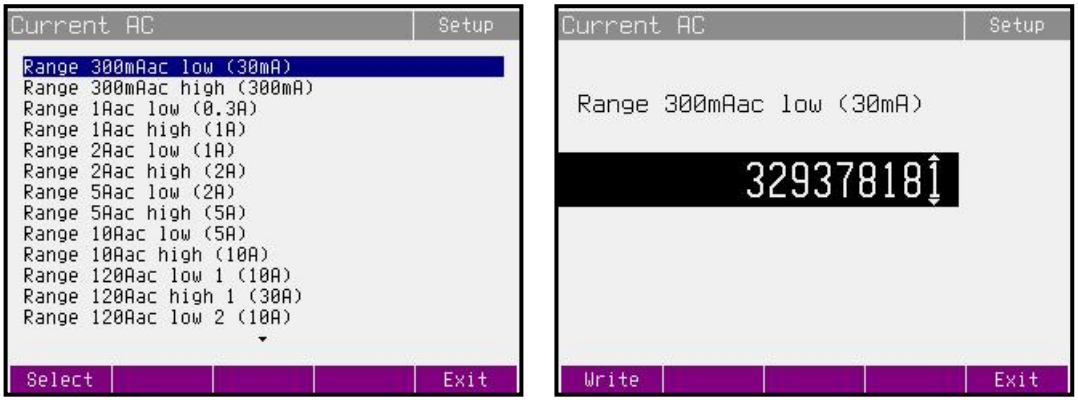


Figure 11 Calibration menu – Current AC

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.

6.4. List of calibration points

6.4.1. Current functions

Function	Range	Offset	Full range
Current AC	300 mA	30 mA	300 mA
	1 A	300 mA	1 A
	2 A	1 A	2 A
	5 A	2 A	5 A
	10 A	5 A	10 A
	120#1 A	10 A	30 A
	120#2 A	10 A	30 A
	120#3 A	10 A	30 A
	120#4 A	10 A	30 A
Current DC	300 mA	30 mA	300 mA
	-300 mA	-30 mA	-300 mA
	1 A	300 mA	1 A
	-1 A	-300 m	-1 A
	2 A	1 A	2 A
	-2 A	-1 A	-2 A
	5 A	2 A	5 A
	-5 A	-2 A	-5 A
	10 A	5 A	10 A
	-10 A	-5 A	-10 A
	30#1 A	10 A	30 A
	-30#1 A	-10 A	-30 A
	30#2 A	10 A	30 A
	-30#2 A	-10 A	-30 A

Table 4 Calibration points – AC / DC Current

6.4.2. Meter function

Function	Range	Offset	Full range
Multimeter (Meter)	20 V	0 V	20 V
	200 mA	0 mA	200 mA
	10 kHz	-	10 kHz

Table 5 Calibration points – Multiemeter

6.4.3. Transconductance amplifier – input voltage, offset and output current

Function	Range	Offset	Full range
Voltage AC Measurement (Input)	2 V	0 V	2 V
Current AC Output	300 mA	-	300 mA
	1 A	-	1 A
	2 A	-	2 A
	5 A	-	5 A
	10 A	-	10 A
	30 A #1	0 A	30 A
	30 A #2	0 A	30 A
	30 A #3	0 A	30 A
	30 A #4	0 A	30 A

Table 6 Calibration points – Transconductance amplifier

7. Maintenance

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

7.1. Replacement of fuse

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

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

7.2. 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.

7.3. Regular maintenance

The calibrator does not require any special maintenance of electrical or mechanical parts. If is 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.

7.4. 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.

7.5. Error messages

If an error occurs during the calibrator's operation or control, error message is displayed.

The following table lists include 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.

8. Specification

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 15-minute warm-up in reference conditions are required in order to reach these specifications.

Ambient conditions

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)

General

Warm up time:	15 min
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

8.1. DC/AC current (sine amplitude)

Summary range:	8 mA to 120 A
Compliance voltage:	8 V_{PK} max. up to 2 A and 400 Hz, 5 V_{PK} otherwise
Frequency range:	DC, 15 Hz to 1000 Hz
Frequency accuracy:	50 ppm
Frequency resolution:	0.001 Hz below 500 Hz, 0.01 Hz below 1000 Hz
Distortion:	< 0.1 %
Output terminals isolation:	up to 450 V_{PK} against GND (protective earth)

DC/AC Current Absolute Uncertainty [% value + % range]

Range	DC, 40 - 70 Hz	15 - 40 Hz, 70 – 1000 Hz
8.000 – 300.000 mA	0.0175 + 0.01	0.025 + 0.02
0.30001 - 1.00000 A		
1.00001 - 2.00000 A		
2.00001 - 5.00000 A		
5.0001 - 10.0000 A	0.021 + 0.015	0.04 + 0.02
10.0001 - 30.0000 A	0.025 + 0.015	0.05 + 0.02
30.0001 - 60.0000 A		
60.0001 - 120.000 A		

Add 0.3 % uncertainty when using 151-25 Current Coil to calibrate clamp meters.

8.2. Multimeter

Multimeter resolution: 5½ dig.

Multimeter Absolute Uncertainty [% of value + absolute]

Function	Range	DC	1 – 1000 Hz	1 – 10 kHz
Voltage	20 V	0.01 % + 2 mV	0.02 % + 4 mV	0.05 % + 10 mV
Current	200 mA	0.01 % + 20 µA	0.02 % + 40 µA	0.05 % + 100 µA
Frequency	1 Hz - 10 kHz	-	50 ppm	

AC ranges are specified from 5 % of range.

8.3. Real Transconductance amplifier

Output accuracy:	0.2 % + 0.1 % of range in DC and AC up to 70 Hz
	0.4 % + 0.2 % of range in AC above 70 Hz
Compliance voltage:	3.5 V_{RMS} max.; output accuracy specified up to 2 V_{RMS}
Input voltage range:	0 – 2 V_{RMS}
Amplifier gain:	[Range maximum / 2] A/V
Slew rate limit:	0.035 V/µs
Phase shift (typical)	[14 × Compliance voltage / Input voltage + 3.5] µs
Phase shift stability (24h, typical)	< 0.01° between 40 and 70 Hz

Phase shift calculation example: In scenario where 10A range is selected, RTA is driven by 0.5 V, 55 Hz signal and load draws 1 V_{RMS} of compliance voltage from RTA output, phase shift is calculated as 14 × 1 / 0.5 + 3.5 = 31.5 µs. This can be converted to degrees as 360 × 55 × 0.0000315 = 0.62 °.

9. Revisions

9.1. Change 1 (19.09.2025)

- Visual overhaul
- Updated Performance verification (Chapter 5.)

CE Certificate of conformity

According to EN ISO/IEC 17050-1:2010 standard as well as European Parliament and European Council directives 2011/65/EU + amendment 2015/863, 2012/19/EU, 2014/30/EU and 2014/35/EU, 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. 3:2020

Brno	September 25th, 2020	
Place	Date	Signature