Operating manual
Installation Tester
BENNING IT 110 / BENNING IT 120

1. Preface

Congratulations on your purchase of this BENNING instrument and its accessories. The development of this instrument was based on long and rich experience.

BENNING IT 110/ BENNING 120 is a professional, multifunctional, hand-held test instrument intended for all measurements performed for total inspection of electrical installations in buildings. The following measurements and tests can be performed:

- Voltage, frequency and phase rotation (phase sequence)
- Continuity (LowΩ resistance and continuity function)
- Insulation resistance
- RCD
- Loop impedance
- Line impedance
- IMD testing (BENNING IT 120 only)
- TRUE RMS current (BENNING IT 120 only)
- Resistance to earth (BENNING IT 120 only)
- Illumination (BENNING IT 120 only)

A large graphic matrix display with backlight offers easy to read results, indications, measurement parameters and messages.

BENNING IT 110/ BENNING IT 120 is equipped with all accessories necessary for comfortable testing. It is kept in a soft carrying bag together with all accessories.

2. Safety and operational considerations

2.1 Warnings and notes

In order to reach high level of operator's safety while carrying out various tests and measurements using the BENNING instrument, as well as to keep the test equipment undamaged, it is necessary to consider the following general warnings:

- The symbol ⚠ at the BENNING IT 110/ BENNING IT 120 means: "Read the Instruction manual with special care to safety operation". The symbol requires an action!
- If the test equipment is used in a manner not specified here, the protection provided by the BENNING IT 110/ BENNING IT 120 may be impaired.
- Read this user manual carefully, otherwise use of the BENNING IT 110/ BENNING IT 120 may be dangerous for the operator, for the instrument or for the equipment under test.
- Do not use the BENNING IT 110/ BENNING IT 120 or accessories if any damage is noticed.
- If a fuse has blown, follow the instructions in the instruction manual to replace it.
- Consider all generally known precautions in order to avoid risk of electric shock while dealing with hazardous voltages.
- Do not use the BENNING IT 110/ BENNING IT 120 in supply systems with voltages higher than 550 V.
- Service intervention or adjustment procedure is allowed to be carried out only by competent authorised persons.
- Use only standard or optional test accessories supplied by your distributor.
- Consider that older and some of new optional test accessories compatible with this BENNING IT 110/ BENNING IT 120 meet only overvoltage category CAT III / 300 V. It means that maximal allowed voltage between test terminals and earth is 300 V.
- Disconnect any measuring accessory and power off the BENNING IT 110/ 120 before opening battery/fuse compartment cover, hazardous voltage inside.

2.2 Batteries

- ⚠ When battery cells have to be replaced or before opening the battery/fuse compartment cover, disconnect any measuring accessory connected to the BENNING IT 110/ BENNING IT 120 and power off the instrument. Hazardous voltage inside!
- Insert cells correctly, otherwise the BENNING IT 110/ BENNING IT 120 will not operate and the batteries could be discharged.
- If the BENNING IT 110/ BENNING IT 120 is not used for a long period of time remove the batteries from their compartment.
- Alkaline or rechargeable Ni-Cd or Ni-MH battery cells (size AA) can be used. The operating hours are given for cells with a nominal capacity of 2100 mAh.
- Do not recharge alkaline battery cells, danger of explosion!

2.3 Charging

The battery is charged whenever the power supply adapter is connected to the BENNING IT 110/ BENNING IT 120. In-built protection circuits control the charging procedure and assure maximal battery lifetime. Power supply socket polarity is shown in figure 2.1.

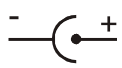


Abb. 2.1: Power supply socket polarity

Note:
- Use only the power supply adapter delivered by the manufacturer or distributor of the BENNING IT 110/ BENNING IT 120 to avoid possible fire or electric shock.

2.4 Precautions on charging of new battery cells or cells unused for a longer period

Unpredictable chemical processes can occur during charging of new battery cells or cells that were unused for a longer period of time (more than 3 months). Ni-MH and Ni-Cd cells are affected to a various degree (sometimes called as memory effect). As a result the operation time of the BENNING IT 110/ BENNING IT 120 can be significantly reduced at the initial charging/discharging cycles.

Therefore it is recommended:
- to completely charge the battery (at least 14h with in-built charger).
- to completely discharge the battery (can be performed with normal work with the instrument).
- to repeat the charge/discharge cycle for at least two times (four cycles are recommended).

When using external intelligent battery chargers one complete discharging/charging cycle is performed automatically.

After performing this procedure a normal battery capacity is restored. The operation time of the BENNING IT 110/ 120 now meets the data in the technical specifications.

Note:
- The charger in the BENNING IT 110/ BENNING IT 120 is a pack cell charger. This means that the cells are connected in series during charging so all of them must be in a similar state (similarly charged, same type and age).
- Even one deteriorated battery cell (or just of an another type) can cause an improper charging of the entire battery pack (heating of the battery pack, significantly decreased operation time).
- If no improvement is achieved after performing several charging/discharging cycles, the state of individual battery cells should be determined (by comparing battery voltages, checking them in a cell charger, etc). It is very likely that only some of the cells are deteriorated.
- The effects described above should not be mixed with normal battery capacity decrease over time. All charging batteries lose some of their capacity when repeatedly charged/discharged. The actual decrease of capacity versus number of charging cycles depends on the battery type and is provided in the technical specification from the battery manufacturer.

2.5 Standards applied

The BENNING IT 110/ 120 is manufactured and tested in accordance with the following regulations:

- Safety requirements	EN 61010-1:2001	
- Electromagnetic compatibility (emission and immunity to interference)	EN 61326:2002	
- Electrical safety in low voltage distribution systems Equipment for testing, measuring or monitoring of protective measures Measurements according to the European Standard	EN 61557:	
General requirements		Part 1

Insulation resistance		Part 2
Loop resistance / loop impedance		Part 3
Resistance of earth, PE and equipotential bonding conductors		Part 4
Resistance to earth		Part 5
Residual current devices (RCD) in TT and TN systems		Part 6
Phase sequence		Part 7
Combined measuring equipment		Part 10
Illumination measurement according to standard	DIN 5032	Part 7

3. Instrument description

3.1 Front panel

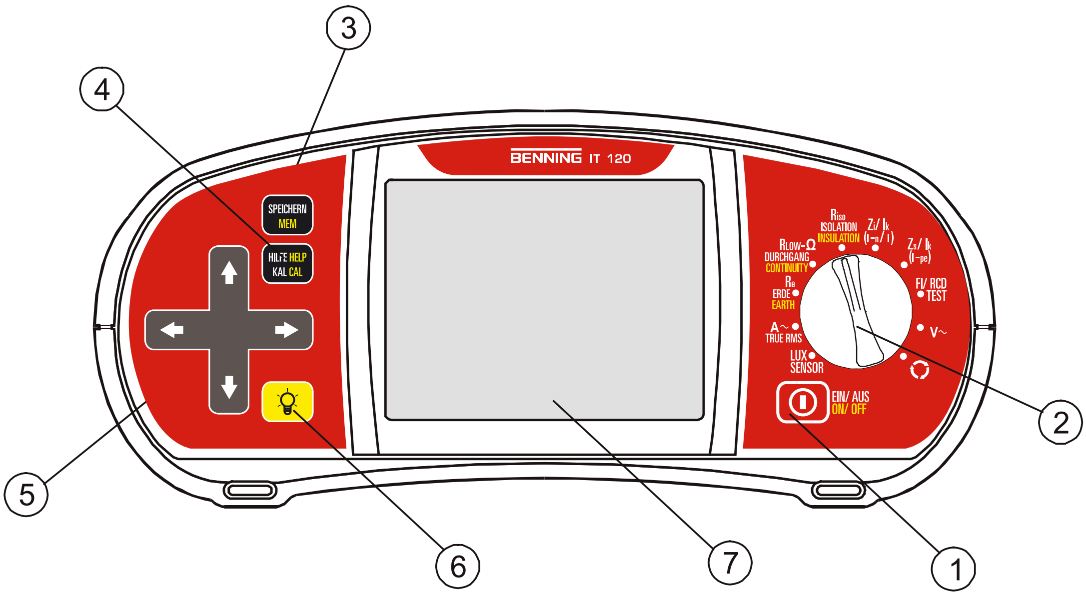


Fig. 3.1: Front panel, example: BENNING IT 120

Legend:

1 ON/OFF key, to switch on or off the BENNING IT 110/ BENNING IT 120
The BENNING IT 110/ BENNING IT 120 is automatically switched off 10 minutes after the last key was pressed or the function selector switch rotated.

2 Function selector switch.

3 BENNING IT 110: CAL key, to compensate test lead resistance in lowΩ resistance measurement.
BENNING IT 120: Press MEM key to save, recall or delete measurement results.

4 BENNING IT 110: HELP key, to access help menus.
BENNING IT 120:
HELP/CAL key, to access the help menus. The CAL function is enabled in lowΩ resistance measurement to compensate test lead resistance.

5 Jogger keypad with cursors and TEST keys
The TEST key also acts as the PE touching electrode.

6 Key to change backlight level and contrast
High level backlight is automatically shut off 20 seconds after the last strike of any key or function selector switch rotation in order to extend the service life of the battery.

7 128 x 64-dots matrix display with backlight

3.2 Connector panel

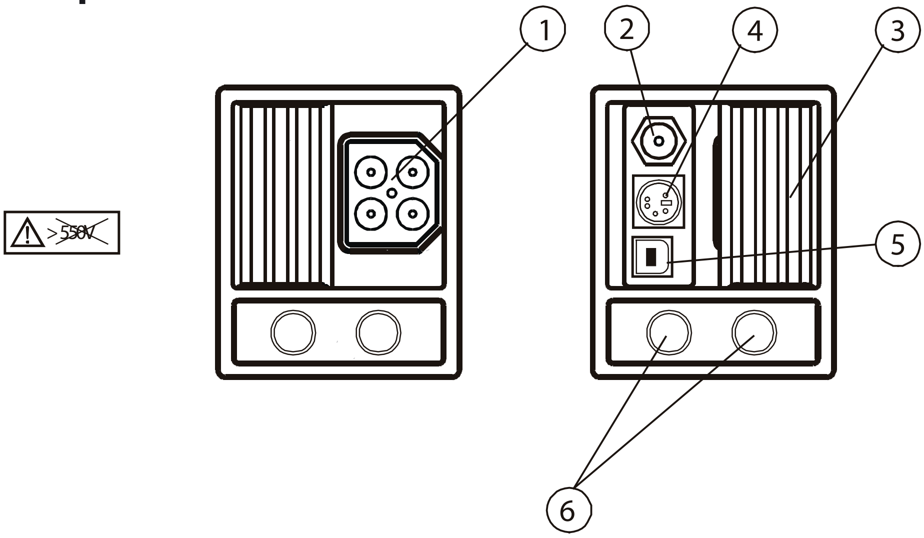


Fig. 3.2: Connector panel

Legend:

1 Test connector
Warning! Maximal allowed voltage between test terminals and earth is 600 V. Maximal allowed voltage between test terminals is 550 V.
2 Power supply socket
3 Protection connector cover (prevents the simultaneous connection of test cable and charger)
BENNING IT 120 only: In resistance to earth function test, the connector terminals are used as follows:
- L/L1 black test lead is used for the auxiliary earth electrode (H).
- N/L2 blue test lead is used for the earth electrode (E).
- PE/L3 green test lead is used for the probe (S).

4 RS 232 connector (BENNING IT 120 only)
5 USB connector (BENNING IT 120 only)
6 Current clamp input

3.3 Back panel

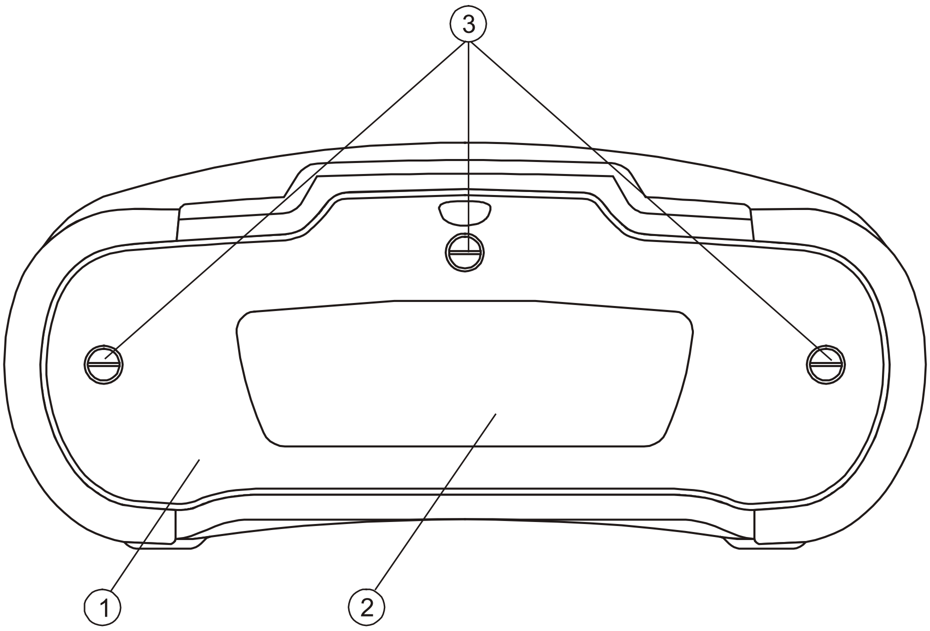


Fig. 3.3: Back Panel

Legend:
1 Battery/fuse compartment cover
2 Information label
3 Fixing screws for battery/fuse compartment cover

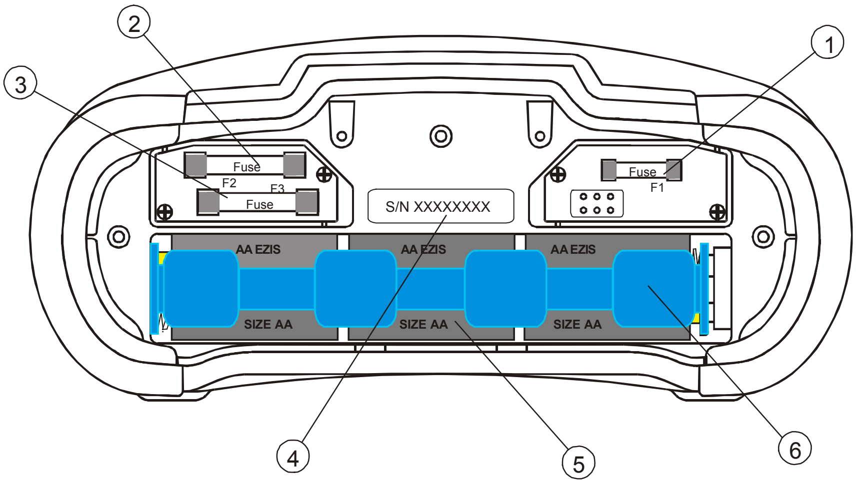


Fig. 3.4: Battery and fuse compartment

Legend:
1 Fuse F1
2 Fuse F1
3 Fuse F1
4 Serial number label, a further serial number label is located outside next to the information label
5 Battery cells (size AA)
6 Battery holder

3.4 Bottom view

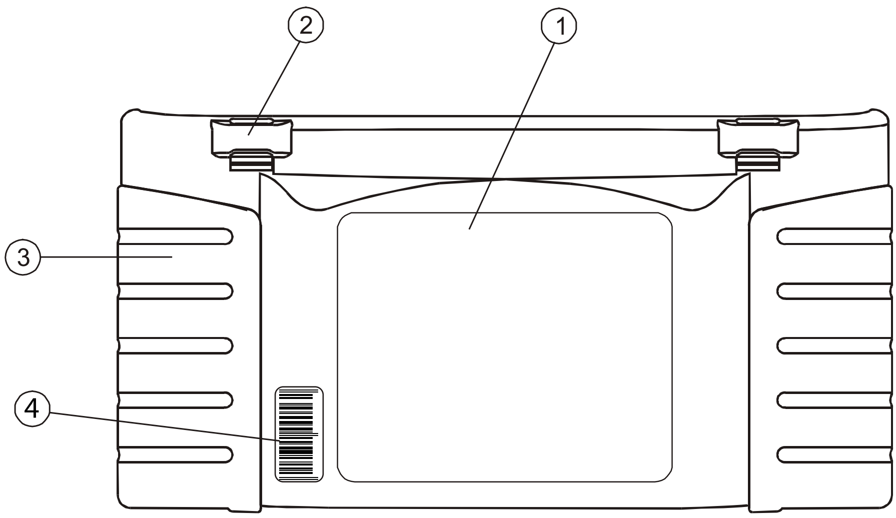
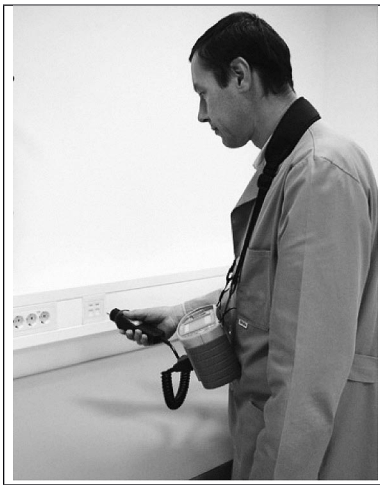


Fig. 3.5: Bottom view

Legend:
1 Information label
2 Neck belt openings
3 Screw
4 Serial number label with barcode

3.5 Carrying the BENNING IT 110/ BENNING IT 12

With the neck carrying belt supplied as standard, various possible ways of carrying the BENNING IT 110/ BENNING IT 120 are available.



The BENNING IT 110/ BENNING IT 120 is hung around operator‘s neck only
- quick placing and displacing.

The BENNING IT 110/ BENNING IT 120 can be used even placed in a soft carrying bag - the test cable is connected to the instrument through the front aperture.

3.6 BENNING IT 110/ BENNING IT 120 set and accessories

3.6.1 Standard set

	BENNING IT 110	**BENNING IT 120**
Instrument	Soft carrying bag Neck carrying belt, 2 pcs.	Soft carrying bag Neck carrying belt, 2 pcs.
Measuring accessories)*	Universal test cable Tip commander Schuko plug cable Three test tips 3 alligator clips	Universal test cable Tip commander Schuko plug cable Three test tips 3 alligator clips
Documentation	Short instructions	Short instructions
Batteries	6 Ni-MH rechargeable cells Power supply adapter	6 Ni-MH rechargeable cells Power supply adapter
Cable		RS232 cable USB cable
CD-ROM	Instruction manual Short instructions	Instruction manual Short instructions BENNING PC-WIN IT 120 Software

3.6.2 Optional accessories

	BENNING IT 110	BENNING IT 120
Optional accessories		Current clamp adapter CC 2 (item no. TN 044110) LUXmeter probe, type B (item no. TN 044111) LUXmeter probe, type C (item no. TN 044112) Earth resistance set consisting of 2 earth rods and 3 test leads (item no. TN 044113)

4. Operation of the BENNING IT 110/ BENNING IT 120

4.1 Meaning of symbols and messages on the display of the BENNING IT 110/ BENNING IT 120

The display is divided into four sections:

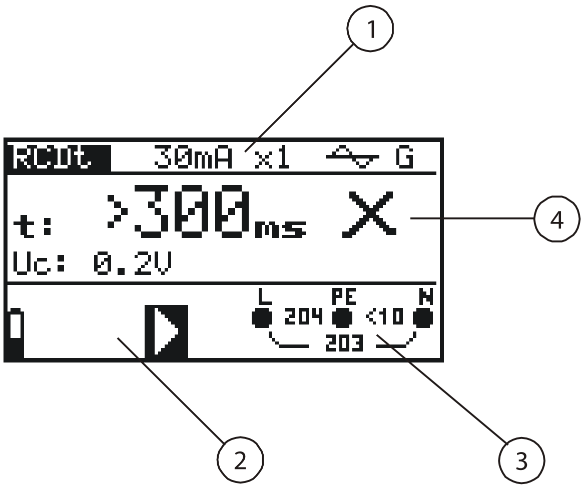


Fig. 4.1: Display outlook

Legend:

1 Function and parameter line
In the top display line the measuring function/sub-function and parameters are displayed.

2 Message field
In this field battery status and warnings/messages related to the actual measurement are displayed.

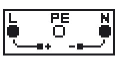
3 Online voltage and output monitor

4 Result field
In this field the main and sub-results together with the PASS/FAIL/ABORT status are displayed.

4.1.1 Online voltage and output terminal monitor

Online voltage is displayed together with test terminal indication. All three test terminals are used for selected measurement.

Online voltage is displayed together with test terminal indication. L and N test terminals are used for selected measurement.



Polarity of test voltage applied to the output terminals, L and N.

 Unknown supply system.

 L – N polarity changed.

 Frequency out of range.

4.1.2 Message field – battery status

 Battery power indication.

 Low battery indication. Battery pack is too weak to guarantee correct result. Replace the batteries.

 Charging is running (if power supply adapter is connected).

4.1.3 Message field – measurement warnings/messages

 **Warning!** High voltage is applied to the test terminals.

 **Warning!** Phase voltage on the PE terminal! Stop all the measurements immediately and eliminate the fault before proceeding with any activity.

 Measurement is running. Consider any displayed warnings.

 Measurement can be performed after pressing the TEST key. Consider any displayed warning after starting the measurement.

 Measurement prohibited! Consider any displayed warnings and check online voltage/terminal monitor.

 Test lead resistance in lowΩ resistance measurement is compensated.

 RCD tripped during the measurement. The trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or capacitive connection between L and PE conductors.

 RCD not tripped during the measurement.

 BENNING IT 110/ BENNING IT 120 overheated.
The temperature of internal components in the BENNING IT 110/ BENNING IT 120 reached the top limit. Measurement is prohibited until the temperature is lower than that limit.

 Battery capacity is too low to guarantee correct result. Replace the batteries.

Fuse F1 (continuity circuit) blown or not inserted.

Single fault condition in IT system.

Noise voltage is present between H and E or S test terminals.

Resistance of auxiliary earth electrode is too high.

Probe resistance is too high.

Resistance of auxiliary earth electrode and probe too high.

4.1.4 Result field

Measurement passed.

Measurement failed.

Measurement is aborted. Check the conditions at the input terminal.

4.1.5 Other messages

HARD RESET	Instrument settings and measurement parameters/limits are set to initial (factory) values. For more information refer to chapter 4.5.4 Recalling original settings.
Probe	LUXmeter probe is turned off or disconnected from the instrument.
First measurement	The first stored measurement result is displayed.
Last measurement	The last stored measurement result is displayed.
Memory full	All memory locations are occupied.
Already saved	Measurement results already saved.
CHECK SUM ERROR	Important memory contents lost or damaged. Contact your distributor or manufacturer for further information.

4.1.6 Sound warnings

Shortest sound	Pressed key deactivated. Sub-function is not available.

Short sound	Pressed key activated. Measurement has been started after pressing the TEST key. Consider any displayed warnings during measurement.
Long sound	Measurement prohibited. Consider any displayed warnings and check online voltage/terminal monitor.
Periodic sound	**Warning!** Phase voltage on the PE terminal! Stop all the measurements immediately and eliminate the fault before proceeding with any activity.

4.1.7 Function and parameter line

Fig. 4.2: Function selector switch and respective parameter line, example: BENNING IT 120

Legend:
1 Main function name
2 Function or sub-function name
3 Measuring parameters and limit values

4.1.8 Selecting measurement function/ sub-function

The following measurements can be selected with the function selector switch:

- Voltage and frequency
- Insulation resistance
- Resistance / continuity testing
- RCD
- Loop impedance
- Line impedance
- Phase rotation (phase sequence)
- Resistance to earth (BENNING IT 120 only)
- TRUE RMS current (BENNING IT 120 only)
- Illumination (BENNING IT 120 only)

The function/sub-function name is highlighted on the display by default.
The sub-function can be selected by using the ↑ and ↓ keys in the function/parameter line.

4.2 Setting measurement parameters and limits

By using the ← and → keys select the parameter/limit value you want to edit. The selected parameter can be set by using the ↑ and ↓ keys.
Once the measurement parameters are set the settings are kept until new changes are made or the original settings are recalled.

4.3 Help menu

Help menus are available in all functions. The Help menu contains schematic diagrams for illustration how to properly connect the BENNING IT 110/ BENNING IT 120 to electric installation. After selecting the measurement you want to perform, press the HELP key in order to view the respective Help menu.
Press the HELP key again to see further Help screens if available or to return to the function menu.

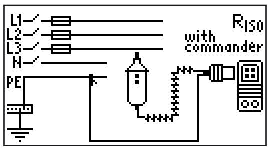


Fig. 4.3: Example of help menu

4.4 Setup menu

In the **Setup** menu the following actions can be taken:

- Supply system selection
- Prospective short/fault current scaling factor adjustment
- Language selection
- Communication port settings

To enter the **Setup** menu press the backlight key and rotate the function selector switch in any direction at the same time.

Rotate function selector switch again to leave the **Setup** menu or setup sub-menus.

Fig. 4.4: Setup menu

4.4.1 Supply system setup

The BENNING IT 110/ 120 enables tests and measurements in the following supply systems:

- TN (TT) system
- IT system
- Reduced low voltage system (2 x 55 V)
- Reduced low voltage system (3 x 63 V)

Select SYSTEMS in the **Setup** menu by using the ↑ and ↓ keys and press the TEST key to enter the **Supply system** setup menu.

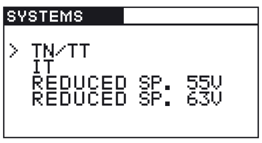


Fig. 4.5: Supply systems selecting menu

By using the ↑ and ↓ keys select the supply system and press the TEST key to accept the setting.

4.4.2 Prospective short/fault current scaling factor adjustment

Select SET ISC FACTOR in the **Setup** menu by using the ↑ and ↓ keys and press the TEST key to enter the **Prospective short/fault current scaling factor** adjustment menu.

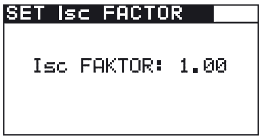


Fig. 4.6: Scaling factor adjustment menu

Use the ↑ and ↓ keys to adjust the scaling factor. Press the TEST key to accept the new setting. More information about the prospective short/fault current scaling factor can be found in chapters 5.3 and 5.4.

4.4.3 Language selection

Select SET LANGUAGE in the **Setup** menu by using the ↑ and ↓ keys and press the TEST key to enter the **Language** selecting menu.

Fig. 4.7: Language selection menu

Select language you want to use by using the ↑ and ↓ keys. Press the TEST key to accept the new setting.

4.4.4 Communication port settings (BENNING IT 120 only)

Select SET COMMUNICATION PORT in the **Setup** menu by using the ↑ and ↓ keys and press the TEST key to enter the **Communication** menu.

Fig. 4.8: Communication menu

By using the ↑ and ↓ keys select the communication port you want to use. If RS232 communication port is selected, use the ← and → keys to select the desired baud rate. USB port has a baud rate set to 115200bps. Press the TEST key to accept the new setting.

Warning!
- Only one port can be active at one time.

4.4.5 Recalling original settings

The following parameters and settings can be set to initial (factory) values:

- Test parameters and limit values
- Contrast
- Prospective short/fault current scaling factor
- Supply system
- Communication port (BENNING IT 120 only)

In order to recall the original setting press and hold the ➔ key and switch on the instrument. “Hard reset” message will be displayed for a while.

Instrument settings, measurement parameters and limits are set to their initial values as follows:

Instrument settings	**Default value**
Contrast	50 %
Prospective short/fault current scaling factor	1,00
Supply system	TN/TT
Communication port	RS 232
Function **Sub-function**	**Parameter / limit value**
CONTINUITY	Sub-function: RLOW
LowΩ resistance	High limit resistance value: 2.0 Ω
Continuity	High limit resistance value: 20.0 Ω
INSULATION RESISTANCE	Nominal test voltage: 500 V Low limit resistance value: 1 MΩ
IMPEDANCE (ZI) (Zs)	Fuse type: none selected (F) Fuse current rating: none selected (A) Fuse trip-out current: none selected (ms)
RCD	Sub-function: RCD Uc
Contact voltage – RCD Uc Trip-out time – RCD t Trip-out current – RCD III Autotest – RCD AUTO	Nominal differential current: $I_{\Delta N}$=30 mA RCD type and test current starting polarity:<∿ G Limit contact voltage: 50 V Nominal differential current multiplier: ×1
LOOP IMPEDANCE	Testing RCDs with nominal differential current ≥ 10 mA
RESISTANCE TO EARTH (BENNING IT 120 ONLY)	High limit resistance value: 50 Ω
ILLUMINATION (BENNING IT 120 only)	Low limit illumination value: 300 lux

4.5 Display contrast adjustments

When low-level backlight is activated press and hold BACKLIGHT key until the **Display contrast** adjustment menu is displayed.

Fig. 4.9: Contrast adjustment menu

Use the ↑ and ↓ keys to adjust the contrast level. Press the TEST key to accept the new setting.

5 Measurements

5.1 Insulation resistance (R_{ISO})

Insulation resistance measurement is performed in order to assure safety against electric shock. Using this measurement the following items can be determined:

- Insulation resistance between installation conductors and protective conductor/earth
- Insulation resistance of non-conductive rooms (walls and floors)
- Insulation resistance of earth cables
- Resistance of semi-conductive (antistatic) floors

How to perform insulation resistance measurement:

Step 1 Select the $\mathbf{R_{ISO}}$, Isolation/Insulation function with the function selector switch. The following menu is displayed:

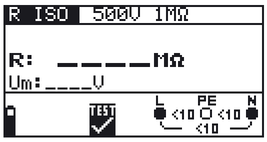


Fig. 5.1: Insulation resistance measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters and limit values:

- Nominal test voltage
- Low limit resistance value

Step 3 Connect test cable to the item under test. Follow the connection diagram shown in figure 5.2 to perform insulation resistance measurement. Use the **Help** function if necessary.

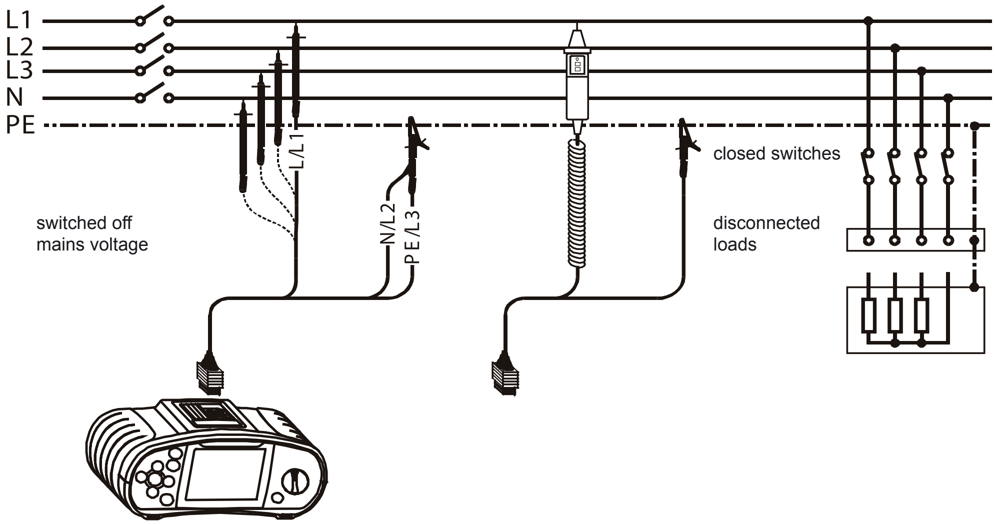


Fig. 5.2: Connection of universal test cable and tip commander

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press and hold the TEST key until result is stabilised. Actual measured results are shown on the display during measurement.
After the TEST key is released the last measured results are displayed, together with the PASS/FAIL indication (if applicable).

Fig. 5.3: Example of insulation resistance measurement results

Displayed results:
R: Insulation resistance
Um: Test voltage of the BENNING IT 110/ BENNING IT 120

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results. (BENNING IT 120 only)

Warning:

- Insulation resistance measurement should only be performed on de-energised objects!
- When measuring insulation resistance between installation conductors all loads must be disconnected and all switches closed.
- Do not touch the test object during the measurement or before it is fully discharged. Risk of electric shock!
- When an insulation resistance measurement has been performed on a capacitive object automatic discharge may not be done immediately. Warning message and actual voltage is displayed during discharge, until voltage drops below 10 V.
- Do not connect test terminals to external voltage higher than 600 V (AC or DC) in order not to damage the BENNING IT 110/ BENNING IT 120.

Note:
- In case of voltage higher than 10 V (AC or DC) between test terminals, the insulation resistance measurement will not be performed.

5.2 Insulation monitoring in IT systems (R_{ISO}, BENNING IT 120 only)

The active parts of IT systems are insulated either to earth or by means of a sufficiently high impedance.
In normal cases, the high impedance is formed by capacitances of the conductors to earth plus capacitances between the windings of the power transformer. Only minor leakage currents are to be expected in IT systems.
IT systems offer additional protection to earth fault.
In case of a first fault, it is not necessarily required to switch off the system. It is however recommended to remove the fault as quickly as possible. In case of a second fault, the system must be switched off immediately.
Modern systems are equipped with insulation monitoring devices (IMD) for localising the first fault to prevent the „second fault“ from occurring at all. The signal is triggered when the insulation value falls below the threshold. Typical limit values are at about 50 kΩ.

BENNING IT 120 enables:

- the measurement of residual current in case of a first fault (ISFL).
- simulation of a leakage current to check the alarm trip limit of the monitoring device. (IMD CHECK).
- the measurement of the leakage current through the insulation resistance at IMD check (in case of first fault).

Note:
- To enable these measurement, „IT“ (IT system) must be set in the setup menu.

How to perform the first fault current measurement:

Step 1 Select the RISO, Isolation/Insulation function with the function selector switch. Use the ↑/ ↓ keys to select the **ISFL (first fault current)** function. The following menu is displayed:

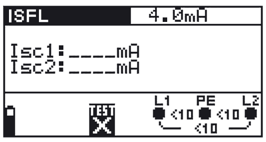


Fig. 5.4: Fault current measurement menu

Connect the test cable to the BENNING IT 120 instrument.

Step 2 Set the following limit value:

- First fault, current high limit value (→,↑,↓; *without, 3,0-20 mA)

Step 3 Connect test cable to the item under test. Follow the connection diagram shown in figure 5.5 to perform current fault measurement. Use the **Help** function if necessary.

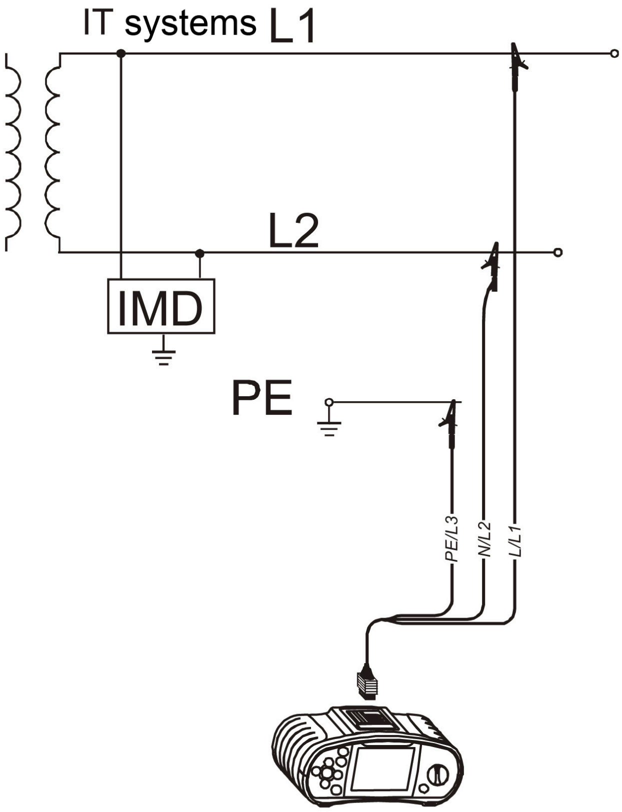


Fig. 5.5: Connection of the universal test cable (IMD = insulation monitoring device)

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press and hold the TEST key. Actual measured results are shown on the display during measurement. After the measurement is completed, the last measured results are displayed, together with the PASS/FAIL indication (✓; x) (if applicable).

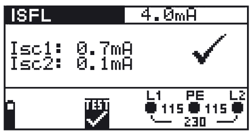


Fig. 5.6: Example of a first fault current measurement result

Displayed results:

I_{SC1}: First fault current between L1 and PE lines
I_{SC2}: First fault current between L2 and PE lines

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results.

How to check the alarm trip limit of insulation monitoring devices:

Step 1 Select the RISO, Isolation/Insulation function with the function selector switch. Use the ↑/↓ keys to select **IMD CHECK** function. The following menu is displayed:

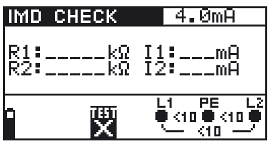


Fig. 5.6: IMD check menu

Connect the test cable to the BENNING IT 120.

Step 2 Set the following limit value:

Alarm trip limit (current) (→,↑,↓,)

Step 3 Connect test cable to the item under test. Follow the connection diagram shown in figure 5.5 to perform the check. Use the **Help** function if necessary.

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. Use the keys ← and → to decrease the simulated insulation resistance until the insulation monitoring device alarms a bad insulation.

The actual values of insulation resistance and fault current between the conductors L1 and PE are displayed together with PASS/FAIL (✓; x) (if applicable).

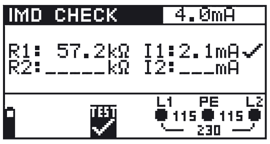


Fig. 5.7: Simulation of the first fault between L1 and PEE

Step 5 Use the key ↓ to simulate the insulation resistance or fault current between the conductors L2 and PE. Repeat step 4. The actual values of insulation resistance and fault current between the conductors L2 and PE are displayed together with PASS/FAIL (✓; x) (if applicable).

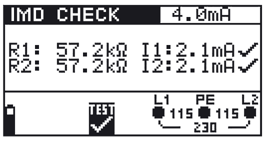


Fig. 5.8: Simulation of the first fault between L2 and PE

Displayed results:

R1 Limit value (trips the alarm) of the insulation resistance between L1 and PE.
I1 First fault current (at the limit value of the insulation resistance) between L1 and PE.
R2 Limit value (trips the alarm) of the insulation resistance between L2 and PE.
I2 First fault current (at the limit value of the insulation resistance) between L2 and PE.

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results.

Note:
- It is recommended to disconnect all appliances from the power supply before the test is started. The result may be influenced by connected appliances!

5.3 Resistance/ continuity testing (R_{LOW})

Two **Resistance/ Continuity** testing sub-functions are available:
- LowΩ resistance measurement
- Continuity measurement

5.3.1 LowΩ resistance (R_{LOW})

This test is used to ensure electric safety and correct connection of all protective conductors, earth conductors or bonding conductors. The measurement of LowΩ resistance is performed with automatic pole reversal of the test voltage and the test current of more than 200 mA. This measurement completely complies with the EN 61557-4 regulations.

5.3.2 Continuity testing (CONTINUITY)

Continuous lowΩ resistance measurement is performed without pole reversal of the test voltage and a lower test current (few mA). In general, this function serves as an ordinary Ω-meter with low-test current. The function can also be used to test inductive components.

How to perform LowΩ resistance measurement:

Step 1 Select R_{LOW}-Ω, Durchgang/Continuity with the function selector switch. Use the ▲/▼ keys to select **RLOW**. The following menu is displayed:

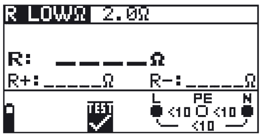


Fig. 5.10: LowΩ resistance measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following limit value:

- High limit resistance value

Step 3 Before performing the lowΩ measurement, compensate test lead resistance as follows:

1. Short test lead first as shown in figure 5.11.

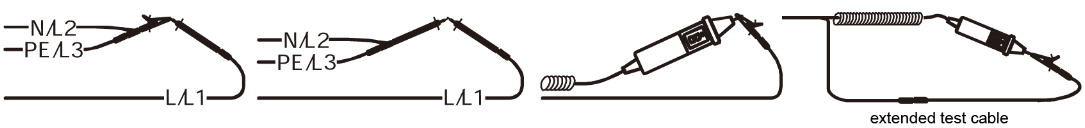


Fig. 5.11: Shorted test leads

2. Press the TEST key in order to perform regular measurement. Result close to 0.00 Ω is displayed.

3. Press the CAL key. After performing test lead compensation, the compensated test lead indicator (Co) is displayed.

4. In order to annul potential compensation follow the procedure described in this step with open test leads. After annulling compensation, the compensation indicator disappears.

Compensation performed in this function is also considered in the **Continuity measurement**.

Step 4 Connect test cable to the item under test. Follow the connection diagram shown in figures 5.6 and 5.7 to perform **LowΩ resistance** measurement. Use the **Help** function if necessary..

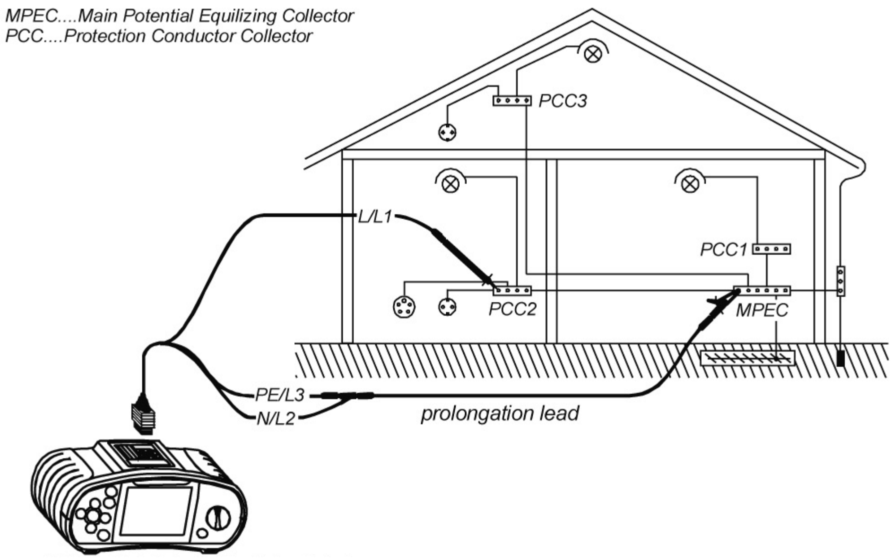


Fig. 5.12: Connection of universal test cable and optional probe test lead (extension)

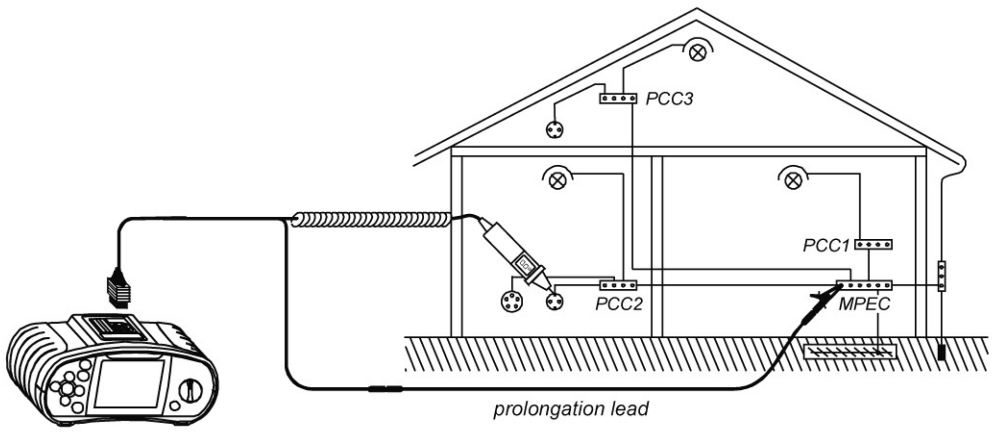


Fig. 5.13: Connection of tip commander and optional probe test lead (extension)

Step 5 Check the displayed warnings and online voltage/terminal monitor before starting measurement. If OK, press the TEST key. After performing, the measurement results appear on the display together with the PASS/FAIL indication (if applicable).

Fig. 5.14: Example of LowΩ resistance measurement results

Displayed results:
R: Main LowΩ resistance result (average of R+ and R- results)
R+: LowΩ resistance sub-result with positive voltage at L terminal
R-: LowΩ resistance sub-result with positive voltage at N terminal.

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Warning:
- LowΩ resistance measurement should only be performed on de-energised objects!
- Parallel impedances or transient currents may influence test results.

Note:
- If voltage between test terminals is higher than 10 V the RlowΩ measurement will not be performed.

How to perform Continuity measurement:

Step 1 Select R_{LOW}-Ω , Durchgang/Continuity with the function selector switch. Use the ↑/↓ keys to select the **Continuity** function. The following menu is displayed:

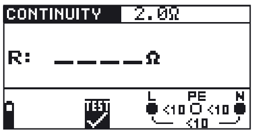


Fig. 5.15: Continuity measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following limit value:

- High limit resistance value

Step 3 Connect test cable to the item under test. Follow the connection diagram shown in figures 5.10 and 5.11 to perform **Continuity** measurement. Use the **Help** function if necessary.

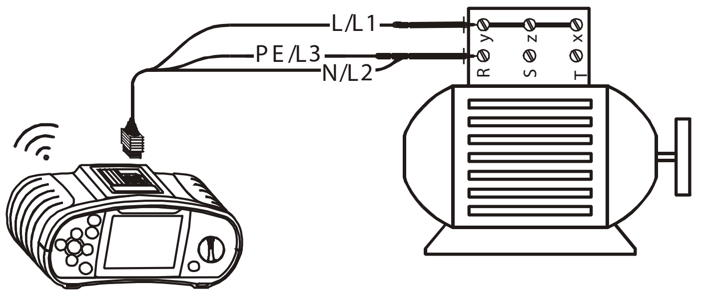


Fig. 5.16: Connection of universal test cable

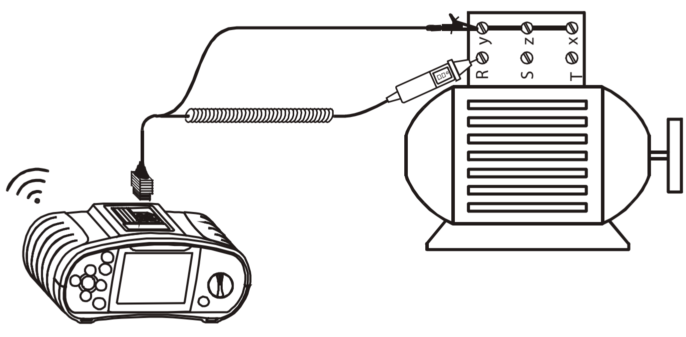


Fig. 5.17: Connection of tip commander

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key to start the measurement. Actual measuring result with PASS/FAIL indication (if applicable) is shown on the display during measurement.

To stop measurement at any time press the TEST key again. The last measured result is displayed, together with the PASS/FAIL indication (if applicable).

Fig. 5.18: Example of Continuity measurement result

Displayed result:
R: Continuity resistance

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Warning:
- Continuity measurement should only be performed on de-energised objects!

Note:
- If voltage between test terminals is higher than 10 V the continuity measurement cannot be performed.
- Before performing continuity measurement compensate test lead resistance if necessary. The compensation is performed in **LowΩ function**.

5.4 Testing RCDs (FI/RCD)

When testing RCDs, the following sub-functions can be performed:

- Contact voltage measurement
- Trip-out time measurement
- Trip-out current measurement
- RCD autotest

In general the following parameters and limits can be set when testing RCDs:

- Limit contact voltage
- Nominal differential RCD trip-out current
- Multiplier of nominal differential RCD trip-out current
- RCD type
- Test current starting polarity

5.4.1 Limit contact voltage

Safety contact voltage is limited to 50 V AC for standard domestic area. In special environments (hospitals, wet places, etc.) contact voltages up to 25 V AC are permitted.
Limit contact voltage can be set in UC Contact voltage function only!

5.4.2 Nominal differential trip-out current

Nominal residual current is the rated trip-out current of the RCD. The following RCD current ratings can be set: 10 mA, 30 mA, 100 mA, 300 mA, 500 mA and 1000 mA.

5.4.3 Multiplier of nominal residual current

Selected nominal differential current can be multiplied by ½; 1; 2 or 5.

5.4.4 RCD type and test current starting polarity

The BENNING IT 110/ BENNING IT 120 enables testing of general (non-delayed) and selective (time-delayed, marked with $\boxed{S}$ symbol) RCDs, which are suited for:

- Alternating residual current (AC type, marked with ∿ symbol)
- Pulsating DC residual current (A type, marked with ∿ symbol)

Test current starting polarity can be started with the positive half-wave at 0° or with the negative half-wave at 180°.

Fig. 5.19: Test current started with the positive or negative half-wave

5.4.5 Testing selective (time-delayed) RCDs

Selective RCDs demonstrate delayed response characteristics. Trip-out performance is influenced due to the pre-loading during measurement of contact voltage. In order to eliminate pre-loading a time delay of 30 s is inserted before performing trip-out test.

5.4.6 Contact voltage (Uc)

Leakage current flowing to the PE terminal causes a voltage drop across earth resistance, which is called contact voltage. This voltage is present on all accessible parts connected to the PE terminal and should be lower than the safety limit voltage.
The contact voltage is measured without tripping-out the RCD. R_L is a fault loop resistance and is calculated as follows:

$$R_L = \frac{U_C}{I_{\Delta N}}$$

Displayed contact voltage relates to the rated differential current of the RCD and is multiplied by a safety factor. See the table 5.1 for detailed contact voltage calculation.

RCD type	Contact voltage Uc
G G	$Uc \sim 1{,}05 \times I_{\Delta N}$
S S	$Uc \sim 1{,}05 \times 2 \times I_{\Delta N}$
G G	$Uc \sim 1{,}05 \times \sqrt{2} \times I_{\Delta N}$
S S	$Uc \sim 1{,}05 \times 2 \times \sqrt{2} \times I_{\Delta N}$

Table 5.1: Relationship between Uc and $I_{\Delta N}$

G = non-delayed fault current
S = time-delayed fault current (selective)

How to perform contact voltage measurement:

Step 1 Select **FI/ RCD TEST (RCD)** with the function selector switch. Use the ↑/↓ keys to select Uc (contact voltage).The following menu is displayed:

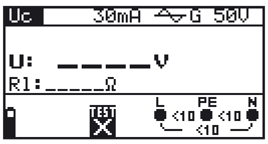


Fig. 5.20: Contact voltage measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters and limit values:

- Nominal residual current
- RCD type
- Limit contact voltaget

Step 3 Follow the connection diagram shown in figure 5.21 to perform contact voltage measurement. Use the **Help** function if necessary

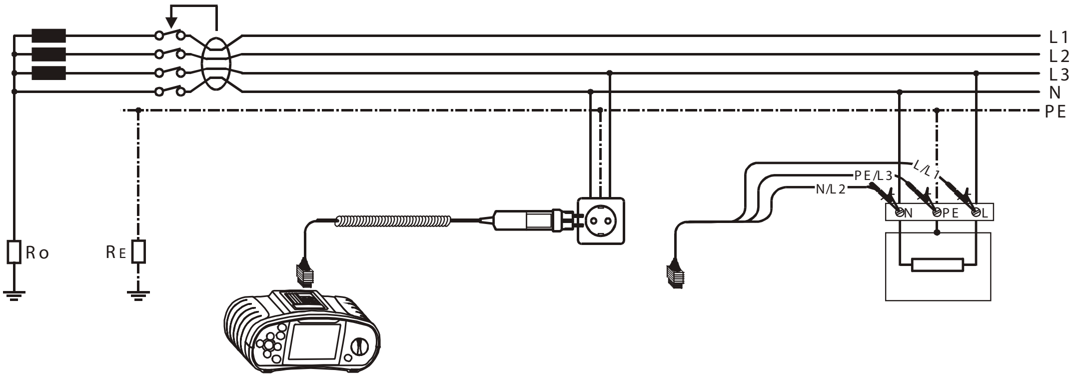


Fig. 5.21: Connection of plug test cable or universal test cable

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results with PASS/FAIL indication appear on the display.

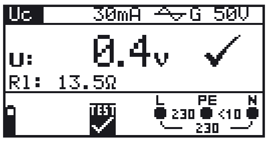


Fig. 5.22: Example of contact voltage measurement results

Displayed results:
U: Contact voltage
Rl: Loop impedance (fault loop resistance)

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results. (BENNING IT 120 only)

Note:
- Parameters set in this function are also kept for other RCD functions.
- The measurement of contact voltage does not normally trip an RCD. However, the trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or via a capacitive connection between L and PE conductors.

5.4.7 Trip-out time (RCDt)

Trip-out time measurement is used to verify the effectiveness of the RCD. This is achieved by a test simulating an appropriate fault condition. Trip-out times vary between standards and are listed below.

Trip-out times according to EN 61008 / EN 61009:

	½×$I_{\Delta N}$ *)	$I_{\Delta N}$	2×$I_{\Delta N}$	5×$I_{\Delta N}$
General (non-delayed) RCDs	t_Δ < 300 ms	t_Δ < 300 ms	t_Δ < 150 ms	t_Δ < 40 ms
Selective (time-delayed) RCDs	t_Δ < 500 ms	130 ms < t_Δ < 500 ms	60 ms < t_Δ < 200 ms	50 ms < t_Δ < 150 ms

Trip-out times according to IEC 60364-4-41:

	½×$I_{\Delta N}$ *)	$I_{\Delta N}$	2×$I_{\Delta N}$	5×$I_{\Delta N}$
General (non-delayed) RCDs	t_Δ < 999 ms	t_Δ < 999 ms	t_Δ < 150 ms	t_Δ < 40 ms
Selective (time-delayed) RCDs	t_Δ < 999 ms	130 ms < t_Δ < 999 ms	60 ms < t_Δ < 200 ms	50 ms < t_Δ < 150 ms

Trip-out times according to BS 7671:

	½×$I_{\Delta N}$ *)	$I_{\Delta N}$	2×$I_{\Delta N}$	5×$I_{\Delta N}$
General (non-delayed) RCDs	t_Δ < 1999 ms	t_Δ < 300 ms	t_Δ < 150 ms	t_Δ < 40 ms
Selective (time-delayed) RCDs	t_Δ < 1999 ms	130 ms < t_Δ < 500 ms	60 ms < t_Δ < 200 ms	50 ms < t_Δ < 150 ms

*) Test current of ½×$I_{\Delta N}$ cannot cause trip-out of the RCDs.

How to perform trip-out time measurement:

Step 1 Select **FI/ RCD TEST** (RCD) with the function selector switch. Use the ▲/▼. keys to select **RCDt (trip-out time of the RCD)**. The following menu is displayed:

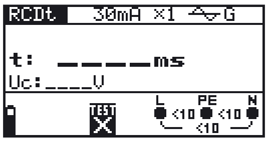


Fig. 5.23: Trip-out time measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters:

- Nominal differential trip-out current
- Nominal differential trip-out current multiplier
- RCD type, and
- Test current starting polarity

Step 3 Follow the connection diagram shown in figure 5.21 (see the chapter Contact voltage) to perform trip-out time measurement.

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results with PASS/FAIL indication appear on the display.

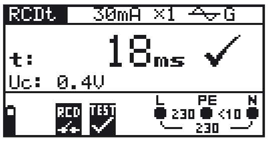


Fig. 5.24: Example of trip-out time measurement results

Displayed results:
t: Trip-out time
Uc: Contact voltage

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results. (BENNING IT 120 only)

Note:
- Parameters set in this function are also kept for other RCD functions.
- RCD trip-out time measurement will be performed only if contact voltage at nominal differential current is lower than the set limit contact voltage.
- The measurement of contact voltage in pre-test does not normally trip an RCD. However, the trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or via a capacitive connection between L and PE conductors.

5.4.8 Trip-out current (RCD ◢)

A continuously rising residual current is used for the evaluation of an RCD. After the measurement has been started, the test current generated by the instrument is continuously increased, starting at $0{,}2\times I_{\Delta N}$ to $1{,}1\times I_{\Delta N}$ (to. bis $1{,}5\times I_{\Delta N}$ for pulsating DC residual currents), until the RCD is tripped.

How to perform trip-out current measurement:

Step 1 Select FI/ RCD TEST (RCD) with the function selector switch. Use the keys ▲/▼ to select **Trip-out current (RCD)**. The following menu is displayed:

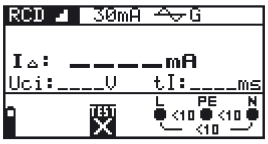


Fig. 5.25: Trip-out current measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 By using cursor keys the following parameters can be set in this measurement:

- Nominal residual current
- RCD type
- Test current starting polarity

Step 3 Follow the connection diagram shown in figure 5.21 (see the chapter **Contact voltage**) to perform trip-out current measurement. Use the **Help** function if necessary.

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results with PASS/FAIL indication appear on the display.

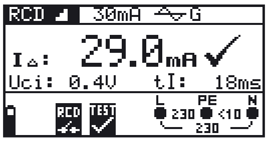


Fig. 5.26: Example of trip-out current measurement result

Displayed results:
I_{Δ}: Trip-out current
U_{Ci}: Contact voltage
tI: Trip-out time

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Note:
- Parameters set in this function are also kept for other RCD functions.
- RCD trip-out time measurement will be performed only if contact voltage at nominal differential current is lower than the set limit contact voltage.
- The measurement of contact voltage in pre-test does not normally trip an RCD. However, the trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or via a capacitive connection between L and PE conductors.

5.4.9 AUTO test

The purpose of the autotest function is to perform complete RCD testing and measurement of the relevant parameters (contact voltage, loop impedance (fault loop resistance) and trip-out time at different fault currents) in one set of automatic tests, controlled by the BENNING IT 110/ BENNING IT 120. If any false parameter is noticed during autotest, the individual parameter test has to be used for further investigation.

How to perform RCD autotest:

Step 1 Select **FI/ RCD TEST** (RCD) with the function selector switch. Use the ↑/↓ keys to select **RCD autotest** function. The following menu is displayed:

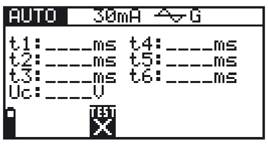


Fig. 5.27: RCD autotest menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters:

- Nominal differential trip-out current
- RCD type

Step 3 Follow the connection diagram shown in figure 5.20 (see the chapter **Contact voltage**) to perform the RCD autotest. Use the **Help** function if necessary.

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. The autotest sequence starts to run as follows:

1. Trip-out time measurement with the following measurement parameters:
- Test current $½\times I_{\Delta N}$
- Test current started with the positive half-wave at 0°

Measurement does not normally trip an RCD. The following menu is displayed:

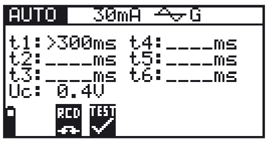


Fig. 5.28: Step 1 RCD autotest results

After performing step 1 the RCD autotest sequence automatically proceeds with step 2.

2. Trip-out time measurement with the following measurement parameters:
- Test current $½\times I_{\Delta N}$
- Test current started with the negative half-wave at 180°

Measurement does not normally trip an RCD. The following menu is displayed:

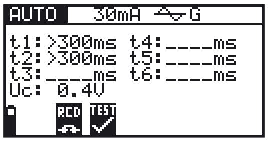


Fig. 5.29: Step 2 RCD autotest results

After performing step 2 the RCD autotest sequence automatically proceeds with step 3.

3. Trip-out time measurement with the following measurement parameters:
- Test current $I_{\Delta N}$
- Test current started with the positive half-wave at 0°

Measurement normally trips an RCD within allowed time period. The following menu is displayed:

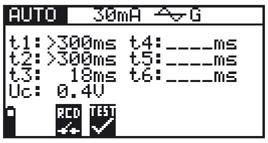


Fig. 5.30: Step 3 RCD autotest results

After re-switching the RCD the autotest sequence automatically proceeds with step 4.

4. Trip-out time measurement with the following measurement parameters:
- Test current $I_{\Delta N}$
- Test current started with the negative half-wave at 180°

Measurement normally trips an RCD within allowed time period. The following menu is displayed:

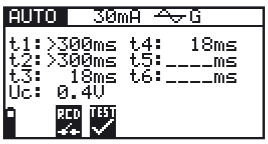


Fig. 5.31: Step 4 RCD autotest results

After re-switching the RCD the autotest sequence automatically proceeds with step 5.

5. Trip-out time measurement with the following measurement parameters:
- Test current $5\times I_{\Delta N}$
- Test current started with the positive half-wave at 0°

Measurement normally trips an RCD within allowed time period. The following menu is displayed:

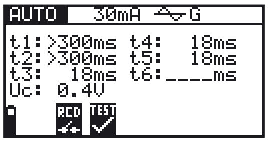


Fig. 5.32: Step 5 RCD autotest results

After re-switching the RCD, the autotest sequence automatically proceeds with step 6.

6. Trip-out time measurement with the following measurement parameters:
- Test current $5\times I_{\Delta N}$
- Test current started with the negative half-wave at 180°

Measurement normally trips an RCD within allowed time period. The following menu is displayed:

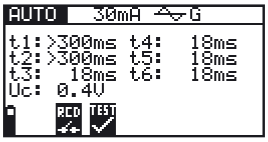


Fig. 5.33: Step 6 RCD autotest results

Displayed results:

t1: Step 1 trip-out time result ($\frac{1}{2}\times I_{\Delta N}$, 0°)
t2: Step 2 trip-out time result ($\frac{1}{2}\times I_{\Delta N}$, 180°)
t3: Step 3 trip-out time result ($I_{\Delta N}$, 0°)
t4: Step 4 trip-out time result ($I_{\Delta N}$, 180°)
t5: Step 5 trip-out time result ($5\times I_{\Delta N}$, 0°)
t6: Step 6 trip-out time result ($5\times I_{\Delta N}$, 180°)
Uc: Contact voltage

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Note:
- The measurement of contact voltage in pre-test does not normally trip an RCD. However, the trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or via a capacitive connection between L and PE conductors.
- The autotest sequence stops when the trip-out time is outside the allowed time period.

5.5 Loop impedance and prospective short-circuit current (Zs/ Ik)

Two loop impedance measuring sub-functions are available:
- The Zl sub-function performs measurements in supply systems without RCDs.
- The Zs_{rcd} sub-function performs measurements in supply systems with RCDs installed (with nominal differential trip-out current 10 mA)

5.5.1 Loop impedance (loop resistance, Zl)

The loop impedance is a complex AC impedance within the fault loop when a short-circuit to exposed conductive parts occurs (conductive connection between phase conductor and protective earth conductor). For measuring the loop impedance (loop resistance), the BENNING IT 110/ BENNING IT 120 uses a 2.5 A test current.
The prospective short-circuit current (fault current) is calculated on the basis of the measured loop impedance (loop resistance) as follows:

$$I_{PFC} = \frac{U_n \, x \text{ Skalierungsfaktor}}{R_{L-PE}}$$

where

U_n	
115 V	$(100\text{ V} \le U_{L-PE} < 160\text{ V})$
230 V	$(160\text{ V} \le U_{L-PE} \le 264\text{ V})$

Because of different definitions of the prospective short-circuit current (fault current) I_{PFC} in different countries, the user can set the scaling factor in the **Setup** menu (see chapter 4.4.2).

PFC=Prospective Fault Current

How to perform the loop impedance measurement:

Step 1 Select Zs/Ik (L-PE) (loop impedance) with the function selector switch. Use the ↑/↓ keys to select the Zl sub-function. The following menu is displayed:

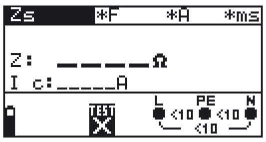


Fig. 5.34: Loop impedance measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters:
- Fuse type
- Fuse current rating
- Fuse trip-out time

Appendix A contains a list of different fuse types.

Step 3 Follow the connection diagram shown in figure 5.35 to perform loop impedance measurement. Use the **Help** function if necessary.

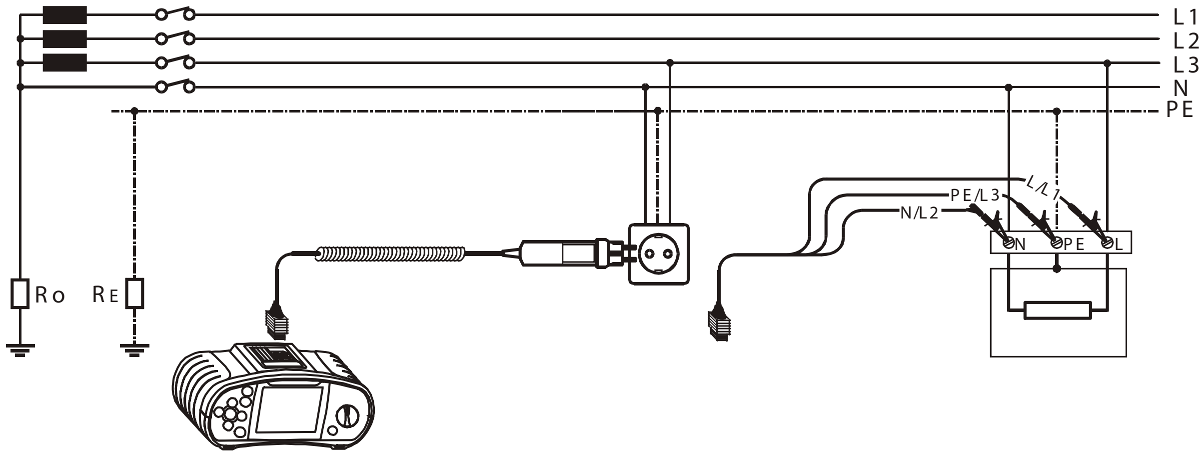


Fig. 5.35 Connection of plug cable and universal test cable

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results appear on the display together with the PASS/FAIL indication (if applicable).

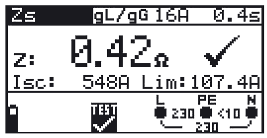


Fig. 5.36: Example of loop impedance measurement results

Displayed results:
Z: Loop impedance
I_{sc}: Prospective short-circuit current
Lim: Low limit of prospective short-circuit current value

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Note:
- L and N test terminals are reversed automatically if L/L1 and N/L2 test leads (universal test cable) are connected in reversed way, or terminals of the tested wall plug are reversed, or plug commander is turned around.
- The specified accuracy of tested parameters is valid only if the mains voltage is stable during the measurement.
- The low limit prospective short-circuit current value depends on fuse type, fuse current rating, fuse trip-out time and IPSC scaling factor.
- Loop impedance measurement trips an RCD.

5.5.2 Loop impedance (Zs$_{rcd}$)

Zs$_{rcd}$ sub-function performs measurements in supply systems equipped with an RCD. The measurement current is small enough to prevent the RCD from tripping.
Modern measurement methods allow for stable and reliable results despite low measured signals.

The prospective fault current is calculated on the basis of measured resistance as follows:

$$I_{PFC} = \frac{U_n \text{ x Skalierungsfaktor}}{R_{L-PE}}$$

where

U_n
115 V (100 V ≤ U_{L-PE} < 160 V)
230 V (160 V ≤ U_{L-PE} ≤ 264 V)

Because of different definitions of the prospective fault current I_{PFC} in different countries, the user can set the scaling factor in the **Setup** menu (see chapter 4.4.2).

How to perform the loop impedance measurement:

Step 1 Select **Zs/Ik (L-PE)** (loop impedance) with the function selector switch. Use the ↑/↓ keys to select the **Zsrcd** sub-function. The following menu is displayed:

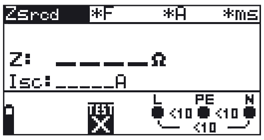


Fig. 5.37: Loop impedance measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters:

- Fuse type
- Fuse current rating
- Fuse trip-out time

Appendix A contains a list of different fuse types.

Step 3 Follow the connection diagram shown in figure 5.35 to perform loop impedance measurement. Use the Help function if necessary.

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results appear on the display together with the PASS/FAIL indication (if applicable).

Fig. 5.38: Example of loop impedance measurement results

Displayed results:
Z Loop impedance
I_{sc} Prospective short-circuit current
Lim Low limit of prospective short-circuit current value

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Note:
- Measurement of the loop impedance (Zsrcd) does not normally trip an RCD. However, the trip limit may be exceeded as a result of leakage current flowing to the PE protective conductor or via a capacitive connection between L and PE conductors.

- The specified accuracy of tested parameters is valid only if the mains voltage is stable during the measurement.

5.6 Line impedance and prospective short-circuit current (Zl/ Ik)

Line impedance is a complex AC impedance within the current loop when a short-circuit to the neutral conductor occurs (conductive connection between phase conductor and neutral conductor in single-phase system or between two phase conductors in three-phase system). A 2.5 A test current is used to perform line impedance measurement.
Prospective short-circuit current is calculated as follows:

$$I_{PSC} = \frac{U_n \times \text{Skalierungsfaktor}}{R_{L\text{ - }N(L)}}$$

where

U_n	
115 V	(100 V $\leq U_{L\text{-}PE} <$ 160 V)
230 V	(160 V $\leq U_{L\text{-}PE} \leq$ 264 V)
400 V	(264 V $< U_{L\text{-}PE} \leq$ 440 V)

Because of different definitions of the prospective short-circuit current IPSC in different countries the user can set the scaling factor in the **Setup** menu (See chapter 4.4.2).

How to perform line impedance measurement:

Step 1 Select **Zl/Ik (L-N/ L)** (line impedance) with the function selector switch. The following menu is displayed:

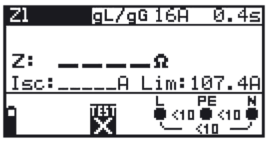


Fig. 5.9: Line impedance measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Set the following measuring parameters:

- Fuse type
- Fuse current rating
- Fuse trip-out time

Appendix A contains a list of different fuse types.

Step 3 Follow the connection diagram shown in figure 5.40 to perform phase-neutral or phase-phase line impedance measurement. Use the Help function if necessary.

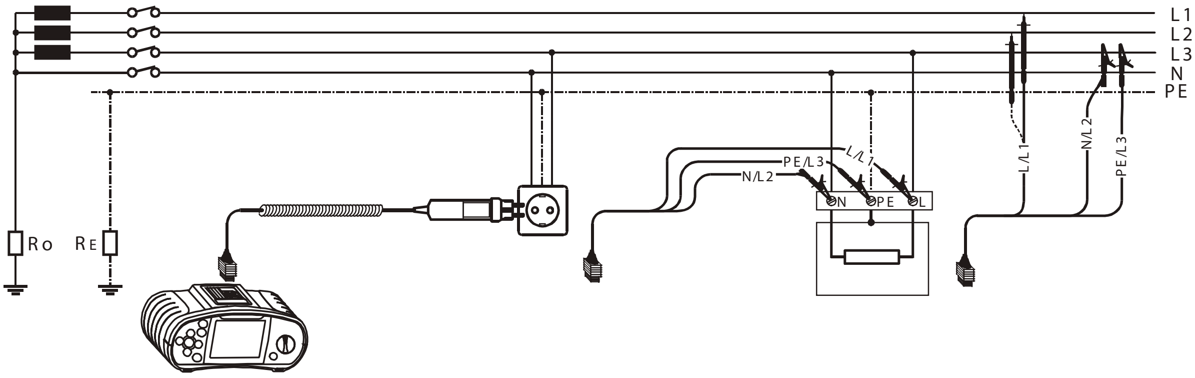


Fig. 5.40: Phase-neutral or phase-phase line resistance measurement

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results appear on the display together with the PASS/FAIL indication (if applicable).

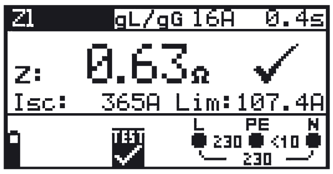


Fig. 5.41: Example of line impedance measurement results

Displayed results:
Z Line impedance
I_{sc} Prospective short-circuit current
Lim Low limit of prospective short-circuit current value

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

Note:
- The low limit prospective short-circuit current value depends on fuse type, fuse current rating, fuse trip-out time and I_{PSC}-scaling factor.
- The specified accuracy of tested parameters is valid only if the mains voltage is stable during the measurement.

5.7 Phase rotation (phase sequence)

When connecting three-phase loads (motors and other electro-mechanical machines) to three-phase mains installations, the correct phase rotation has to be ensured. To this end, check the phase rotation direction (phase sequence) before the connection is made.

How to test phase sequence

Step 1 Select ↻ function (phase rotation) with the function selector switch. The following menu is displayed:

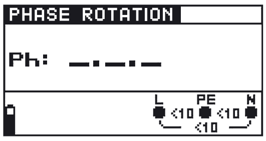


Fig. 5.42: Phase sequence test menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120

Step 2 Follow the connection diagram shown in figure 5.43 to test phase sequence.

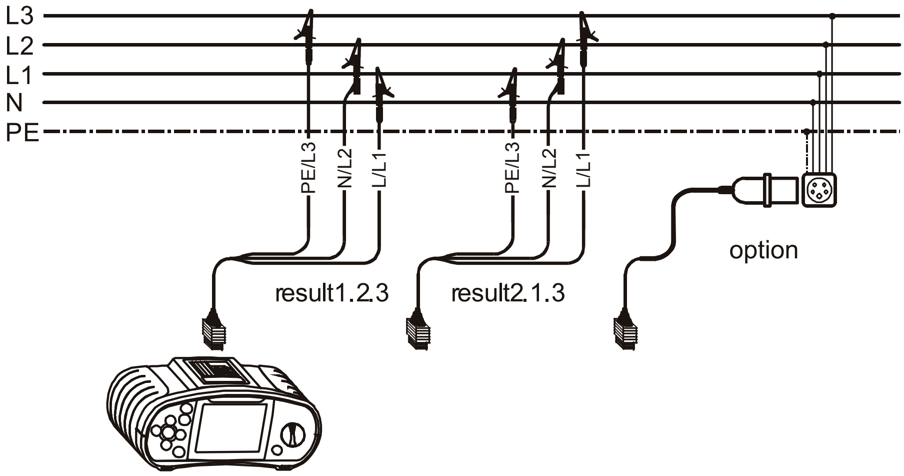


Fig. 5.43: Connection of universal test cable and optional three phase cable

Step 3 Check the displayed warnings and online voltage/terminal monitor. Continuous test is running. The actual result is shown on the display during the test. All three-phase voltages are displayed in order of their sequence represented by the numbers 1, 2 and 3.

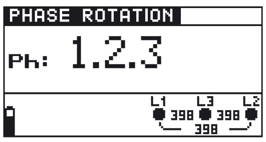


Fig. 5.44: Example of phase sequence test result

Displayed result:
Ph Phase sequence
1.2.3 Correct connection (clockwise phase rotation)
2.3.1 Wrong connection (anticlockwise phase rotation)
-.-.- Irregular voltages

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

5.8 Voltage and frequency (V~)

How to perform voltage and frequency measurement:

Step 1 Select VOLTAGE V~ function with the function selector switch. The following menu is displayed:

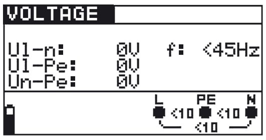


Fig. 5.45: Voltage and frequency measurement menu

Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Follow the connection diagram shown in figure 5.46 to perform voltage and frequency measurement.

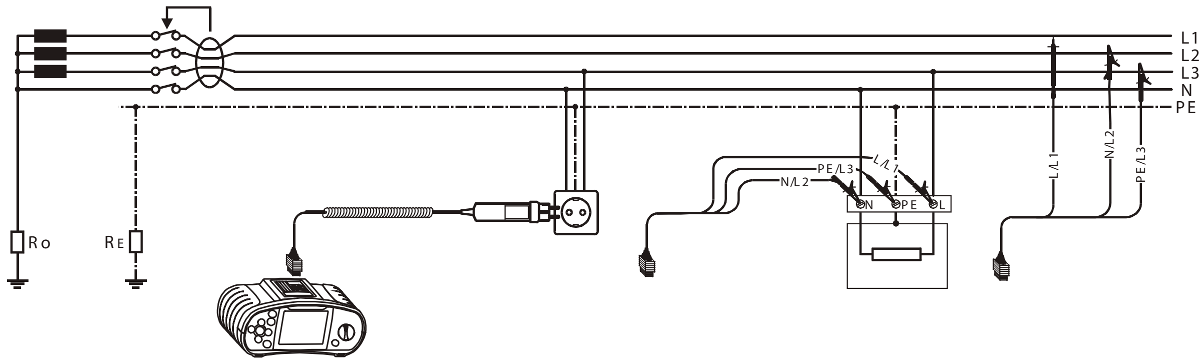


Fig. 5.46: Connection diagram

Step 3 Check the displayed warnings and online voltage/terminal monitor. Continuous test is running. Actual results are shown on the display during measurement.

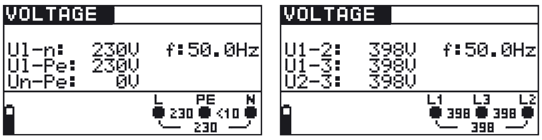


Fig. 5.47: Examples of voltage and frequency measurements

Displayed results:
Ul-n Voltage between phase and neutral conductor
Ul-pe Voltage between phase and protective conductor
Un-pe Voltage between neutral and protective conductor

When testing three-phase system the following results are displayed:
U1-2 Voltage between phases L1 and L2,
U1-3 Voltage between phases L1 and L3,
U2-3 Voltage between phases L2 and L3.

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results (BENNING IT 120 only).

5.9 Testing the PE terminal

In new or adapted installations it may occur that the PE conductor is reversed with the phase conductor - this is a very dangerous situation! It is therefore important to test if there is phase voltage at the PE terminal.
This test has to be performed before tests where mains supply voltage is applied to the instrument circuitry or before the installation is used.

How to test the PE terminal

Step 1 Connect the test cable to the BENNING IT 110/ BENNING IT 120.

Step 2 Follow the connection diagrams in figures 5.48 and 5.49 to test the PE terminal.

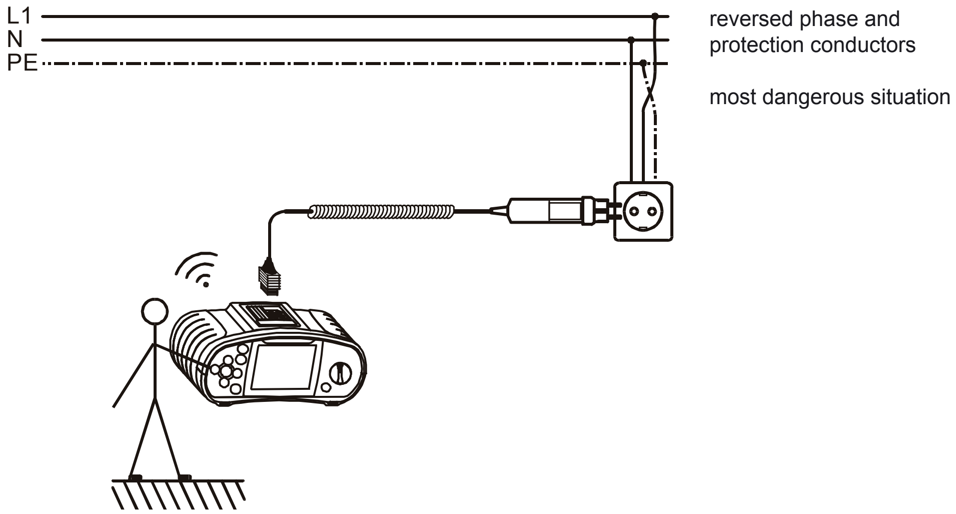


Fig. 5.48: Connection of plug cable and mains outlet with reversed L and PE conductors

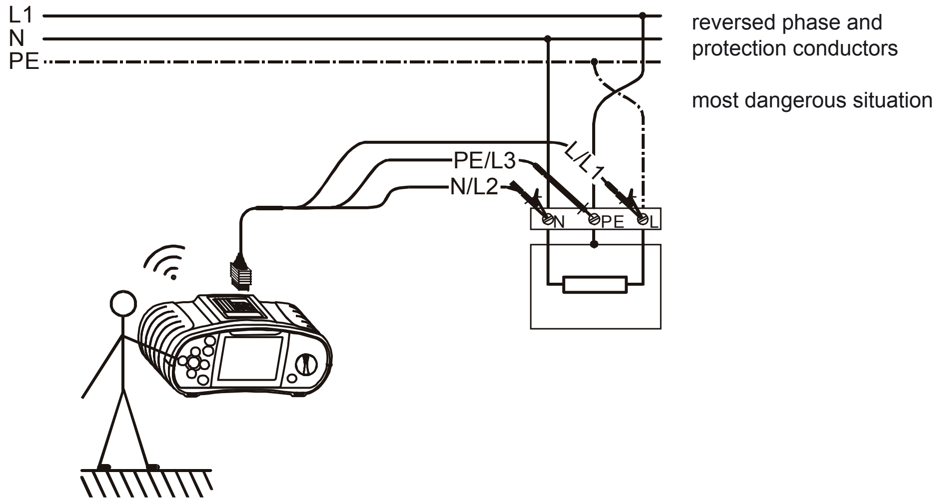


Fig. 5.49: Connection of universal test cable to load connection terminals with reversed L and PE conductors

Step 3 Touch the PE test probe (TEST key) for a few seconds. If the PE terminal is connected to phase voltage, a warning note is displayed and the instrument buzzer activated.

Warning:

- If phase voltage is detected on the tested PE terminal, stop all measurements immediately and take care that the fault is eliminated before proceeding with any activity.

Note:
- The PE terminal can only be tested when the function selector switch is set as follows: ZI/Ik (L-N/ L); Zs/Ik (L/ PE); FI/ RCD TEST.
- For correct testing of the PE terminal, the TEST key has to be touched for a few seconds.
- Make sure to stand on a non-isolated floor while carrying out the test, otherwise the test result may be wrong.

5.10 Resistance to earth (R_E) (BENNING IT 120 only)

The BENNING IT 120 allows resistance to earth measurement using 3-wire measuring method. Consider the following instructions when performing resistance to earth measurement:

- The probe (S) is positioned between the earth electrode (E) and auxiliary earth electrode (H) in the earth reference plane (see figure 5.51).
- The distance from the earth electrode (E) to the auxiliary earth electrode (H) must be at least 5 times the depth or length of the earthing electrode rod (see fig. 5.51).

How to perform resistance to earth measurement:

Step 1 Select R_E, ERDE/ EARTH function with the function selector switch. The following menu is displayed:

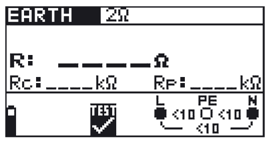


Fig. 5.50: Earth resistance measurement menu

Connect the measuring cables to the BENNING IT 120.

Step 2 Set the following measuring parameters and limit values:

- High limit resistance value

Step 3 Follow the connection diagram shown in figure 5.51 to perform resistance to earth measurement. Use the Help function if necessary.
(Measuring cables: H = black, S = green, E = blue)

PAS...potential equalisation panel

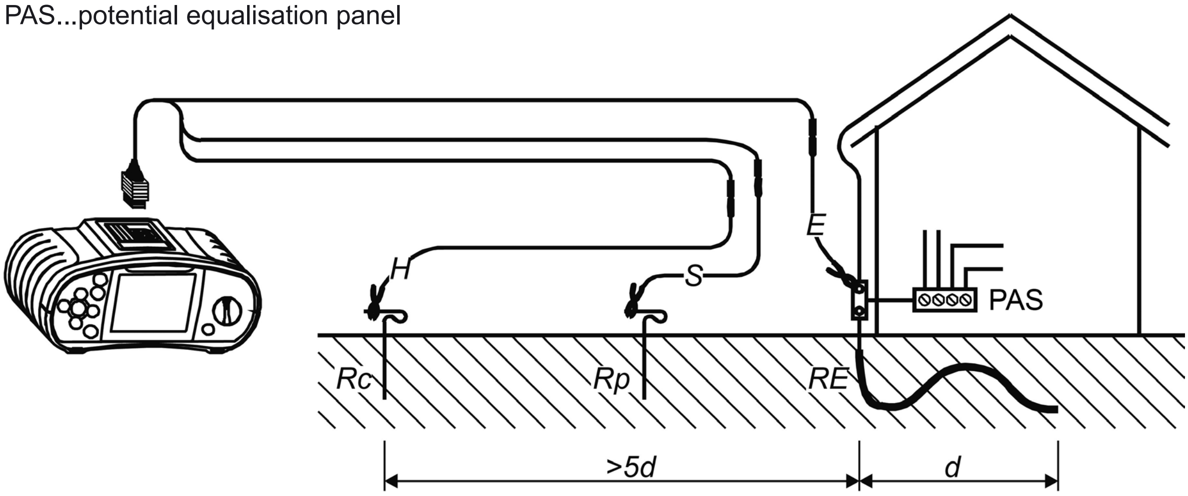


Fig. 5.51: Measurement with the earth resistance measurement set – 20 m

Step 4 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key. After performing, the measurement results appear on the display together with the PASS/FAIL indication (if applicable).

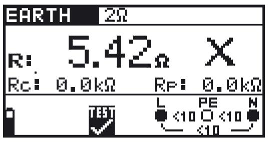


Fig. 5.52: Example of resistance to earth measurement results

Displayed results:
R: Resistance to earth
$R_{C:}$ Auxiliary earth electrode resistance
$R_{P:}$ Probe resistance

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results.

Note:
- If the voltage between the test terminals H and E is higher than 30 V the earth measurement will not be performed.
- If the value for the auxiliary earth electrode or the probe resistance is too high (100*RE or > 50 kΩ), the respective warning symbol will be displayed in the message field. The measurement results may be affected!
- If a noise voltage higher than approx. 5 V is present between the H and E or S test terminals, a warning symbol will be displayed in the message field. The measurement results may be affected!

5.11 TRUE RMS current (A~) (BENNING IT 120 only)

This function enables measuring of AC currents in a wide range from 0.5 mA to 20 A. Load currents can be measured quickly and reliably. The TRUE RMS functions guarantees a correct test result even for non-sinusoidal signals. The current clamp adapter BENNING CC 2 can be used for measuring load currents between 0.5 A and 20 A.

How to perform TRUE RMS current measurement:

Step 1 Select A~ TRUE RMS (current) function with the function selector switch. The following menu is displayed:

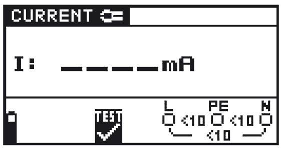


Fig. 5.53: TRUE RMS current measurement menu

Connect the current clamp to the BENNING IT 120.

Step 2 Follow the connection diagram shown in fig. 5.54 to perform the TRUE RMS current measurement. Use the **Help** function if necessary.

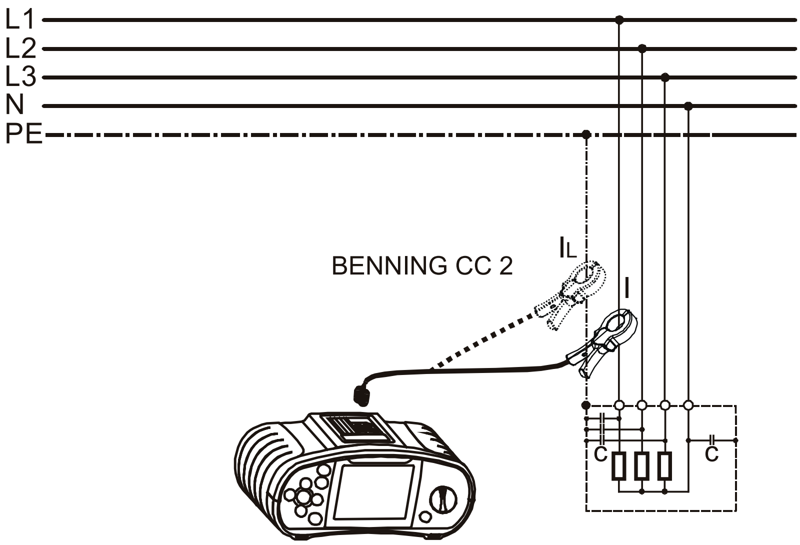


Fig. 5.54: Current clamp connection

Step 3 Check the displayed warnings and online voltage/terminal monitor before starting the measurement. If OK, press the TEST key to start the measurement. The measuring result is shown on the display during measurement.
To stop measurement at any time press the TEST key again. The last measured result is displayed.

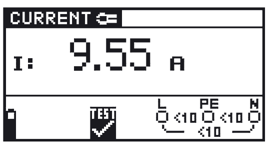


Fig. 5.55: Example of TRUE RMS current measurement result

Displayed results:
I TRUE RMS current

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results.

Note:
- Only current clamps with a transformation ratio of 1000:1 should be connected. We recommend to use the current clamp adapter BENNING CC 2 which can take measurements from 0,5 A - 20 A.
- An additional error of the connected current clamp has to be included into the measuring error!

Warning!
Do not apply voltage to this terminal. The maximum permissible continuous current of this terminal is 20 mA ^= 20 A measuring current!

5.12 Illumination measurement (LUX) (BENNING IT 120 only)

The illumination measurement can be performed with the appropriate LUXmeter probes (type B, type C). The probe is connected to the RS232 port.

How to perform illumination measurement:

Step 1 Select **LUXSENSOR** with the function selector switch, the following menu is displayed:

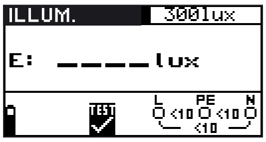


Fig. 5.56: Illumination measurement menu

Connect the LUXmeter probe to the instrument.

Step 2 Set the following limit value:

- Low limit illumination value

Step 3 Turn on the LUXmeter probe (ON/OFF key, green LED is lit). Position the LUXmeter probe in such a way that the measured light falls in parallel onto the light sensor. Follow the connection diagram shown in figure 5.57 to perform illumination measurement. Use the **Help** function if necessary.

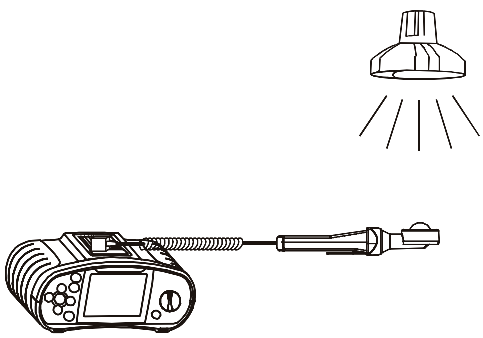


Fig. 5.57: Correct LUXmeter probe positioning

Step 4 Check the displayed warnings before starting measurement. If OK, press the TEST key to start the measurement. Actual measuring result with PASS/FAIL indication (if applicable) is shown on the display during measurement.
To stop measurement at any time press the TEST key again. The last measured result is displayed, together with the PASS/FAIL indication (if applicable).

Fig. 5.58: Example of illumination measurement result

Displayed results:
E: Illumination

Save displayed results for documentation purposes. Refer to chapter 6.1 for further information on setting functions and saving of measurement results. (BENNING IT 120 only).

Note:
- Shadow and irregular incidence affect the measurement result!

6 Working with measurement results (BENNING IT 120 only)

After the measurement is completed, all displayed measurement results and parameters can be stored. It is possible to classify, save and recall the measured values directly at the place of measurement; they can also be transmitted to the PC for further processing and recording.

The measurement results are stored on memory locations with a three-level structure (like a directory tree):

- Object - 1st structure level (the highest level),
- Block - 2nd structure level,
- Fuse - 3rd structure level (the lowest level).

The memory structure of the instrument is already pre-programmed (see fig. 6.1).

```
OBJECT 001
        ➢ BLOCK 001
                ➢ FUSE 001
                ➢ FUSE 002
                .
                .
                .
                ➢ FUSE 999

        ➢ BLOCK 002
                ➢ FUSE 001
                ➢ FUSE 002
                .
                .
                .
                ➢ FUSE 999
        .
        .
        .
        ➢ BLOCK 999
                ➢ FUSE 001
                ➢ FUSE 002
                .
                .
                .
                ➢ FUSE 999
OBJECT 002
.
.
.
OBJECT 999
```

Fig. 6.1: Memory organisation pre-programmed in BENNING IT 120

6.1 Saving measurement results

How to save measurement results:

Step 1 Perform the desired measurement as described in the respective chapter. Press the MEM key, the following menu is displayed:

Fig. 6.2: Save results menu

Step 2 By using the ↑/ ↓ keys set the cursor to the OBJECT line (max. 999).
Use the ←/ → keys to enter the desired element OBJECT xxx.

By using the ↑/ ↓ keys set the cursor to the BLOCK line (max. 999).
Use the ←/ → keys to enter the desired element BLOCK xx.

By using the ↑/ ↓ keys set the cursor to the FUSE line (max. 999).
Use the ←/ → keys to enter the desired element FUSE xx.

In **No.** line the number of saved results is displayed.

Step 3 Press the MEM key to save the results. “Saved to memory” message is displayed for a while. After saving the results the instrument returns to measurement menu.

Note:
- Each measurement result can be saved only once.
- Any number of measurement results can be stored in the FUSE structure level.
- For changing between „Saving measurement results“, „Recalling measurement results“ or „Deleting measurement results“ shortly operate the selector switch (2)!
- Memory size: 500 measurement results

6.2 Recalling measurement results

In Memory menu the results can be recalled or deleted from the memory
Press the MEM key to enter the Memory menu:

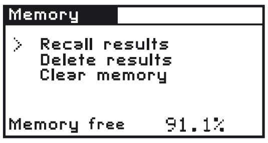


Fig. 6.3: Memory menu

How to recall saved results:

Step 1 By using the ↑/ ↓ keys set the cursor to RECALL RESULTS.
Press the TEST key, the following menu is displayed:

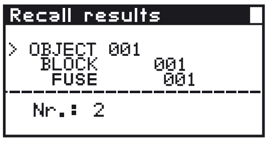


Abb. 6.4: Recall results menu

Step 2 By using the ↑/ ↓ keys set cursor to OBJECT line.
Use the ←/ → keys to enter the desired element OBJECT xx.

By using the ↑/ ↓ keys set cursor to BLOCK line.
Use the ← / → keys to enter the desired element BLOCK xx.

By using the ↑/ ↓ keys set cursor to FUSE line.
Use the ←/ → keys to enter the desired element FUSE xx.

In **No.** line the number of saved results is displayed.

Step 3 Set cursor to the No. line by using the ↑/ ↓ keys.

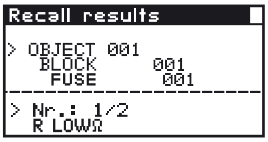


Fig. 6.5: Recall results menu

Use the ←/ → keys to select the function for which you want to view results. Press the TEST key to confirm.

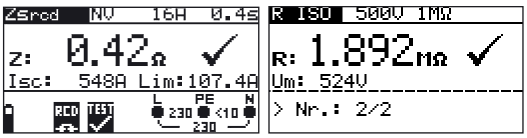


Fig. 6.6: Examples of recall results menu

By using the ←/ → keys other saved results can be viewed under the same object, block and fuse items. Press ↑ or ↓ to return to RECALL RESULTS menu.

Note:
No measurement results can be recalled if the switch is set to „V~“
Exit the memory recall: Use the „MEM“ key (several times) or the selector switch.

6.3 Deleting measurement results

When deleting results the following actions can be taken:

- Individual results can be deleted
- Results under the same structure item can be deleted
- All saved results can be deleted
- Exit the menu by turning the selector switch or by using the „MEM“ key

How to delete individual saved results:

Step 1 To enter the Memory menu press the MEM key.
By using the ↑/ ↓ keys set cursor to DELETE RESULTS. Press the TEST key, the following menu is displayed:

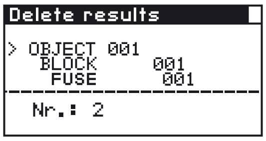


Fig. 6.7: Delete results menu

Step 2 By using the ↑/ ↓ keys set cursor to OBJECT line.
Use the ←/ → keys to enter the desired element OBJECT xx.

By using the ↑/ ↓ keys set cursor to BLOCK line.
Use the ←/ → keys to enter the desired element BLOCK xx.

By using the ↑/ ↓ keys set cursor to FUSE line.
Use the ←/ → keys to enter the desired element FUSE xx.

In No. line the number of saved results is displayed.

Step 3 Set cursor to the No. line by using the ↑/ ↓ keys set.

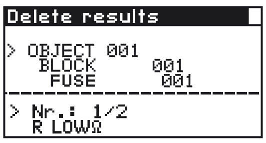


Fig. 6.8: Delete results menu

Use the ←/ → keys to select the function for which you want to view results. The selected measurement result is shown when the TEST key is pressed, and it is deleted when the TEST key is pressed again. Deletion can be aborted - without deleting the selected results - by pressing the MEM key once or several times.

How to delete saved results under the same structure item:

Step 1 To enter the Memory menu press the MEM key.
By using the ↑/ ↓ keys set cursor to DELETE RESULTS.
Press the TEST key, the following menu is displayed:

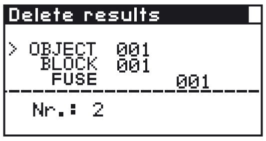


Fig. 6.9: Delete results menu

Step 2 **Deleting measurement results from the 3rd structure level (FUSE)**

By using the ↑/ ↓ keys set cursor to FUSE line. Use the ←/ → keys to enter the desired element FUSE xx.

In No. line the number of saved results is displayed.

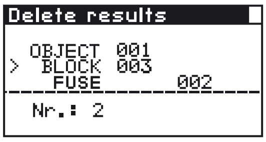


Fig. 6.10: Deleting results from the 3rd level

Continue with instructions under Step 3.

Deleting measurement results from the 2rd structure level (BLOCK)

By using the ↑/ ↓ keys set cursor to OBJECT line. Use the ←/ → keys to enter the desired element OBJECT xxx

In ***No***. line the number of saved results in the 1st structure level is displayed.

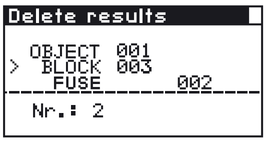


Fig. 6.11: Deleting results from the 2nd level

Continue with instructions under Step 3.

Deleting measurement results from the 1rd structure level (OBJECT)

By using the ↑/ ↓ keys set cursor to OBJECT line. Use the ←/ → keys to enter the desired element OBJECT xxx

In No. line the number of saved results in the 1st structure level is displayed.

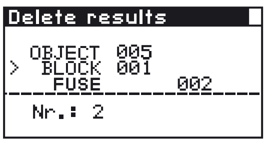


Fig. 6.12: Deleting results from the 1st level

Step 3 Use the ←/ → keys to select the function for which you want to view results. The selected measurement result is shown when the TEST key is pressed, and it is deleted when the TEST key is pressed again. Deletion can be aborted - without deleting the selected results - by pressing the MEM key once or several times.

How to delete all saved results

Step 1 To enter the Memory menu press the MEM key.
By using the ↑/ ↓ keys set the cursor to CLEAR MEMORY.
Press the TEST key, the following menu is displayed:

Fig. 6.13: Clear memory menu

Step 2 Press the TEST key to clear the complete memory. Deletion can be aborted - without deleting the selected results - by pressing the MEM key once or several times.

7 RS232 and USB communication (BENNING IT 120 only)

The instrument includes both RS232 and USB communication ports. Stored results can be sent to PC for additional activities.

7.1 BENNING PC-Win IT 120 Software

The BENNING PC-Win IT 120 Software allows:

- to document measurement results
- to create simple measuring protocols
- to export measurement results to „Spreadsheet“ programmes.

How to download saved results to PC

Step 1 Connect the BENNING IT 120 to the PC using the USB or RS232 cable. Make sure that the correct communication port is selected (refer to chapter 4.4.4).

Step 2 Start the BENNING PC-Win IT 120 software.

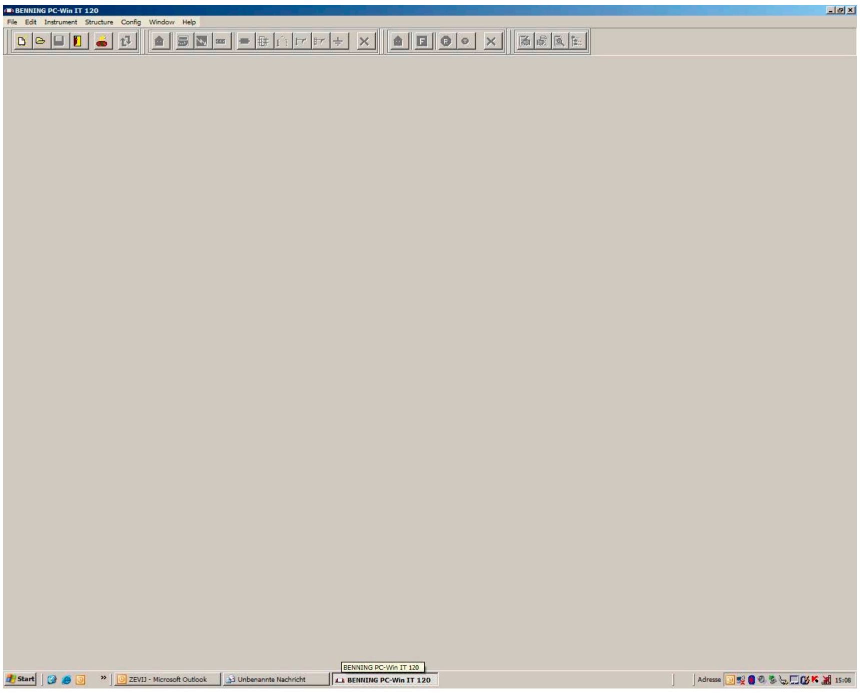


Fig. 7.1: BENNING PC-Win IT 120

Step 3 Click on the symbol to transmit the data stored in the BENNING IT 120. After the results are downloaded the following PC memory structure is displayed.

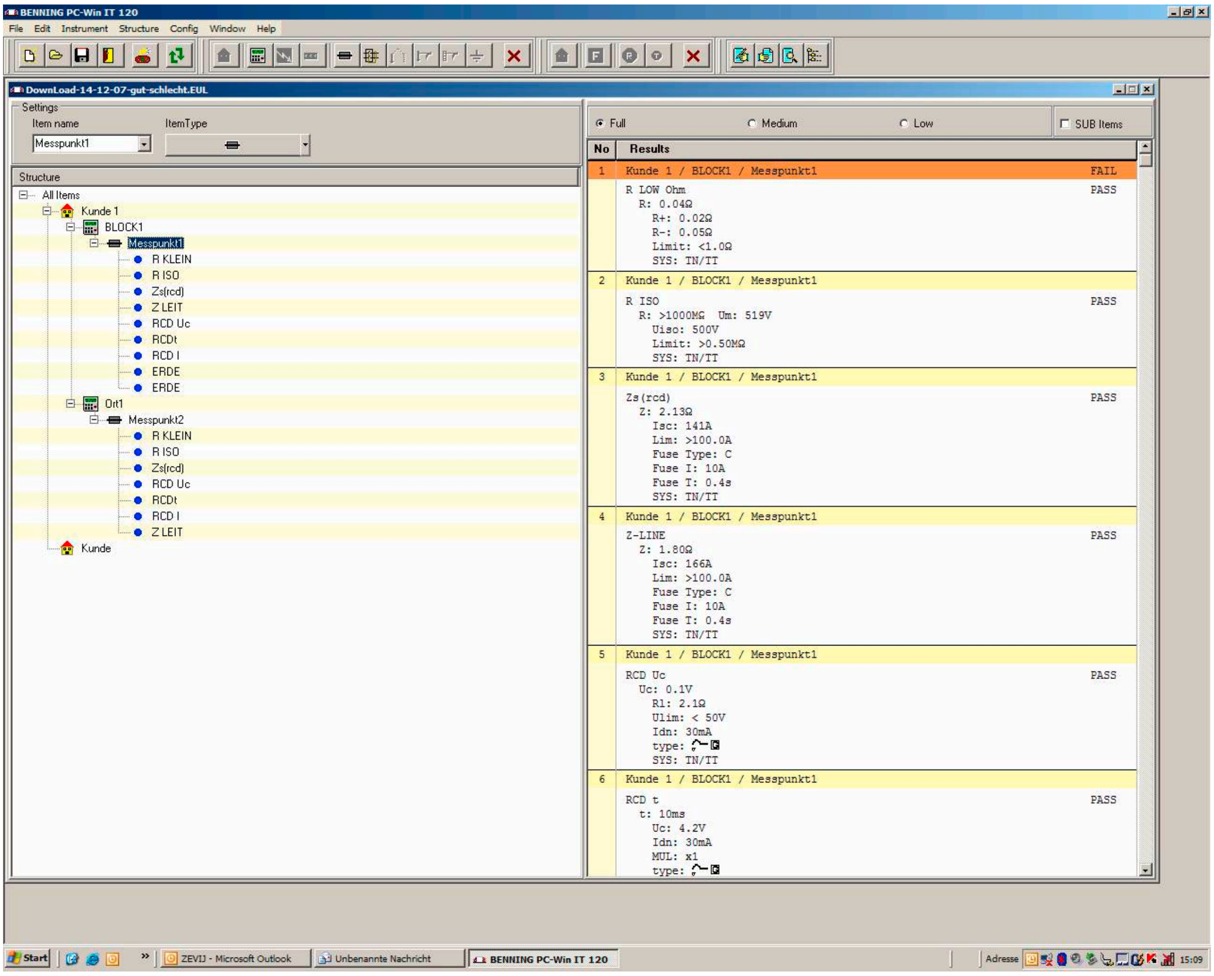


Fig. 7.2: Example of downloaded results

Step 4 Edit downloaded structure for documentation purposes.

8 Maintenance

8.1 Replacing fuses

There are three fuses under the back cover of the BENNING IT 110/ BENNING IT 120.

- F1
  M 0,315 A / 250 V, 20×5 mm, T.Nr.: 757211
  This fuse protects internal circuitry of lowΩ resistance function if test probes are connected to the mains supply voltage by mistake..

- F2, F3
  F 4 A / 500 V, 32×6,3 mm, T.Nr.: 757212
  General input protection fuses of test terminals L/L1 and N/L2.

Warning:

- ⚠ Disconnect any measuring accessory and power off the instrument before opening battery/ fuse compartment cover, hazardous voltage inside.
- Replace blown fuse with original type only, otherwise the instrument may be damaged and/or operator's safety impaired.

Position of fuses can be seen in figure 3.4 in chapter 3.3 "Back panel".

8.2 Cleaning

No special maintenance is required for the housing. To clean the surface of the instrument use a soft cloth slightly moistened with soapy water or alcohol. Then leave the instrument to dry totally before use.

Warning:

- Do not use liquids based on petrol or hydrocarbons.
- Do not spill cleaning liquid over the instrument.

8.3 Periodic calibration

It is essential that the test instrument is regularly calibrated in order technical specification listed in this manual can be guaranteed. We recommend an annual calibration. The calibration should be done by an authorised technical person only. Please contact your dealer for further information.

8.4 Service

For repairs under warranty, or at any other time, please contact your distributor.
Manufacturer's address:
BENNING Elektrotechnik & Elektronik GmbH & Co. KG
Service Center
Robert-Bosch-Str. 20
D - 49397 Bocholt
Unauthorised persons are not permitted to open the BENNING IT 110/ BENNING IT 120. There are no user replaceable components inside the BENNING IT 110/ BENNING IT 120, except three fuses, refer to chapter 8.1 „Replacing fuses".

9 Technical specifications

9.1 Insulation resistance

Insulation resistance (nominal voltages 100 V_{DC} and 250 V_{DC})
Measuring range according to EN61557-2: 0,017 MΩ to 199,9 MΩ

Measuring range (MΩ)	Resolution (MΩ)	Accuracy
0,000 (0,017) - 1,999	0,001	± (5 % of reading + 3 digits)
2,00 - 99,99	0,01	
100,0 - 199,9	0,1	

Insulation resistance (nominal voltages 500 V_{DC} and 1000 V_{DC})
Measuring range according to EN61557-2: 0,015 MΩ to 999 MΩ

Measuring range (MΩ)	Resolution (MΩ)	Accuracy
0,000 (0,015) - 1,999	0,001	± (2 % of reading +3 digits)
2,00 - 99,99	0,01	
100,0 - 199,9	0,1	
200,0 – 999	1	± (10 % of reading)

The stated accuracy applies if a universal test cable is used. If a tip commander is used, the accuracy applies to max. 200 MΩ.

Voltage

Measuring range (V)	Resolution (V)	Accuracy
0 ÷ 1200	1	± (3 % of reading +3 digits)

Nominal voltages	100 V_{DC}, 250 V_{DC}, 500 V_{DC}, 1000 V_{DC}
Open circuit voltage	-0 % / + 10 % of nominal voltage
Measuring current	min. 1 mA at R_N=U_N×1 kΩ/V
Short-circuit current	max. 3 mA
The number of possible tests with a new set of batteries	up to 1800
Auto discharge after test	

In case the instrument gets moistened the results could be impaired. In such case it is recommended to dry the instrument and accessories for at least 24 hours.

9.2 Insulation monitoring in IT systems

First fault current

Fault current (simulated resistance 390 Ω (±1 %))

Measuring range (mA)	Resolution (mA)	Accuracy
0.0 ÷ 9.9	0,01	± (5 % of reading +2 digits)
10 ÷ 20	1	± (5 % of reading)
20 ÷ 99	1	Indicative

Testing the alarm trip limit

First fault current (at the limit value of the insulation resistance)

Measuring range (mA)	Resolution (mA)	Accuracy
0.0 ÷ 9.9	0,01	± (5 % of reading +2 digits)
10 ÷ 20	1	± (5 % of reading)
10 ÷ 99	1	Indicative

Adjustable limit value of the insulation resistance 19.0 kΩ (±6 %) ÷ 650 kΩ (±15 %)

9.3 Resistance/ continuity testing

9.3.1 LowΩ resistance measurement

Measuring range according to EN61557-4: 0,16 Ω bis 1999 Ω

Measuring range (mA)	Resolution (mA)	Accuracy
0,00 (0,16) - 19,99	0,01	± (3 % of reading + 3 digits)
20,0 - 99,9	0,1	± (3 % of reading)
100 - 1999	1	

Open-circuit voltage 6,5 V_{DC} - 9 V_{DC}
Measuring current min. 200 mA into load resistance of 2 Ω
Test lead compensation up to 5 Ω
The number of possible tests
with a new set of batteries bis zu 5500
Automatic polarity reversal of the test voltage

9.3.2 Continuity

Measuring range (mA)	Resolution (mA)	Accuracy
0,0 - 99,9	0,1	± (5 % of reading + 3 digits)
100 - 1999	1	

Open-circuit voltage 6,5 V_{DC} - 9 V_{DC}
Short-circuit current max. 8,5 mA
Test lead compensation up to 5 Ω

9.4 RCD

9.4.1 General data

Nominal residual current 10 mA, 30 mA, 100 mA, 300 mA, 500 mA, 1000 mA
Accuracy of
nominal residual current measurement -0 / +0,1·I_Δ; $I_\Delta = I_{\Delta N}$, $2\times I_{\Delta N}$, $5\times I_{\Delta N}$
-0,1·I_Δ / +0; $I_\Delta = ½\times I_{\Delta N}$
Test current shape Sine-wave (AC), pulsed (A)
RCD type: general (G, non-delayed), selective (S, time-delayed)

Test current starting polarity 0° or 180°
Voltage range 100 V - 264 V (45 Hz - 65 Hz)
RCD test current selection (r.m.s. value calculated to 20 ms) according to IEC 61009:

	½×$I_{\Delta N}$		1×$I_{\Delta N}$		2×$I_{\Delta N}$		5×$I_{\Delta N}$		RCD IΔ	
$I_{\Delta N}$ (mA)	AC	A	AC	A	AC	A	AC	A	AC	A
10	5	3,5	10	20	20	40	50	100	✓	✓
30	15	10,5	30	42	60	84	150	212	✓	✓
100	50	35	100	141	200	282	500	707	✓	✓
300	150	105	300	424	600	848	1500	2120	✓	✓
500	250	175	500	707	1000	1410	2500	3500	✓	✓
1000	500	350	1000	1410	2000	*)	*)	*)	✓	✓

*) not available

9.4.2 Contact voltage

Measuring range according to EN61557-6: 3.0 up to 99,9 V at 50 V
Measuring range according to EN61557-6: 3.0 up to 49 V at 25 V

Measuring range (mA)	Resolution (mA)	Accuracy
0,0 (3,0) - 9,9	0,1	(-0 % / +10 %) of reading +2 digits
10,0 - 99,9	0,1	(-0 % / +10 %) of reading

Test current max. 0,5×$I_{\Delta N}$
Limit contact voltage 25 V, 50 V

Fault loop resistance at contact voltage is calculated as. $R_L = \frac{U_C}{I_{\Delta N}}$.
R_L: 0,00 Ω - 10,00 KΩ

9.4.3 Trip-out time

Measuring ranges according to EN61557

General (non-delayed) RCDs

Measuring range (ms)	Resolution (ms)	Accuracy
0 - 300 (½×$I_{\Delta N}$, $I_{\Delta N}$)	1	±3 ms
0 - 150 (2×$I_{\Delta N}$)	1	
0 - 40 (5×$I_{\Delta N}$)	1	

Selective (time-delayed) RCDs

Measuring range (ms)	Resolution (ms)	Accuracy
0 - 500 (½×$I_{\Delta N}$, $I_{\Delta N}$)	1	± 3 ms
0 - 200 (2×$I_{\Delta N}$)	1	
0 - 150 (5×$I_{\Delta N}$)	1	

Test current ½×$I_{\Delta N}$, $I_{\Delta N}$, 2×$I_{\Delta N}$, 5×$I_{\Delta N}$
Multiplier 5 is not available if $I_{\Delta N}$=1000 mA (general RCDs) or $I_{\Delta N} \geq$ 500 mA (selective RCDs).
Multiplier 2 is not available if $I_{\Delta N}$=1000 mA (selective RCDs).

9.4.4 Trip-out current

Measuring ranges according to EN61557
Trip-out current ($I_{\Delta N}$=10 mA)

Measuring range I_{Δ}	Resolution I_{Δ}	Accuracy
0,2×$I_{\Delta N}$ - 1,1×$I_{\Delta N}$ (AC-Typ)	0,05×$I_{\Delta N}$	±0,1×$I_{\Delta N}$
0,2×$I_{\Delta N}$ - 2,2×$I_{\Delta N}$ (A-Typ)	0,05×$I_{\Delta N}$	±0,1×$I_{\Delta N}$

Trip-out current ($I_{\Delta N}$≥30 mA)

Measuring range I_{Δ}	Resolution I_{Δ}	Accuracy
0,2×$I_{\Delta N}$ - 1,1×$I_{\Delta N}$ (AC-Typ)	0,05×$I_{\Delta N}$	±0,1×$I_{\Delta N}$
0,2×$I_{\Delta N}$ - 1,5×$I_{\Delta N}$ (A-Typ)	0,05×$I_{\Delta N}$	±0,1×$I_{\Delta N}$

Trip-out time

Measuring range (ms)	Resolution (ms)	Accuracy
0 - 300	1	±3 ms

Contact voltage
Measuring range according to EN61557: 1,0 bis 99,9 V

Measuring range (V)	Resolution (V)	Accuracy
0,0 (3,0) - 9,9	0,1	(-0% / +10 %) of reading +2 digits
10,0 - 99,9	0,1	(-0% / +10 %) of reading

9.5 Loop impedance and prospective short-circuit current

Function **Loop impedance (loop resistance)**
Measuring range according to EN61557-3: 0,26 Ω up to 1999 Ω

Measuring range (Ω)	Resolution (Ω)	Accuracy
0,00 (0,25) - 19,99	0,01	± (5 % of reading + 5 digits)
20,0 - 99,9	0,1	
100 - 1999	1	

Prospective fault current

Measuring range (A)	Resolution (A)	Accuracy
0,00 - 19,99	0,01	Consider accuracy of the fault loop resistance measurement
20,0 - 99,9	0,1	
100 - 999	1	
1,00 kA - 9,99 kA	10	
10,0 - 24,4 kA	100	

Test current (at 230 V) 2,5 A (10 ms)
Nominal voltage range 100 V - 264 V (45 Hz - 65 Hz)

Zs rcd function
Measuring range according to EN61557: 1,37 Ω up to 1999 Ω

Measuring range (Ω)	Resolution (Ω)	Accuracy *)
0,00 (0,25) - 19,99	0,01	± (10 % of reading + 25 digits)
20,0 - 99,9	0,1	± 10 % of reading
100 - 1999	1	±10 % of reading

*) Accuracy may be impaired by heavy mains voltage noise.

RCD not tripped if $I_{\Delta N} \geq 10$ mA
Test current (at 230 V) max. 0,24 A (max. period 150 µs)

9.6 Line impedance and prospective short-circuit current

Measuring range according to EN61557-3: 0,26 Ω up to 1999 Ω

Measuring range (Ω)	Resolution (Ω)	Accuracy
0,00 (0,25) - 19,99	0,01	±(5% of reading + 5 digits)
20,0 - 99,9	0,1	
100 - 1999	1	

Prospective short-circuit current

Measuring range (A)	Resolution (A)	Accuracy
0,00 ÷ 19,99	0,01	Consider accuracy of line resistance measurement
20,0 ÷ 99,9	0,1	
100 ÷ 999	1	
1,00 kA ÷ 9,99 kA	10	
10,0 ÷ 24,4 kA	100	

Test current (at 230 V) 2,5 A (10 ms)
Nominal voltage range 100 V - 440 V (45 Hz - 65 Hz)

9.7 Phase rotation (phase sequence)

Nominal mains voltage range 100 V_{AC} - 440 V_{AC} / 45 Hz - 65 Hz
Result displayed 1.2.3 oder 2.1.3

9.8 Voltage and frequency

Measuring range (V)	Resolution (V)	Accuracy
0 - 500	1	± (2% des Ablesewerts +2 Digits)

Nominal frequency range 45 Hz - 65 Hz

Measuring range (Hz)	Resolution (Hz)	Accuracy
45.0 ÷ 65.0	0,1	± 2 digits

Nominal voltage range 10 V - 500 V

9.9 Online voltage monitor

Measuring range (V)	Resolution (V)	Accuracy
10 - 500	1	± (2 % of reading +2 digits)

If voltage greater than 500 V is applied to the test terminals, online voltage monitor is used as voltage indicator only.

9.10 Resistance to earth (BENNING IT 120 only)

Measuring range according to EN61557-5: 0,04 Ω up to 1999 Ω

<table>
<tr><th>Measuring range (Ω)</th><th>Resolution (Ω)</th><th>Accuracy</th></tr>
<tr><td>0.00 (0,02) ÷ 19.99</td><td>0.01</td><td rowspan="3">± (2% of reading +3 digits)</td></tr>
<tr><td>20.0 ÷ 99.9</td><td>0.1</td></tr>
<tr><td>100 ÷ 1999</td><td>1</td></tr>
</table>

Auxiliary earth electrode resistance R_{Cmax}	$100 \times R_E$ or 50 kΩ (lower value)
Probe resistance R_{Pmax}	$100 \times R_E$ or 50 kΩ (lower value)
Additional errors at R_{Cmax} or R_{Pmax}	± (10 % of reading + 10 digits)
Additional errors at 3 V noise voltage (50 Hz)	± (5 % of reading + 10 digits)
Open circuit voltage	< 45 V_{AC}
Short-circuit current	< 20 mA
Frequency	125 Hz

Automatic measurement of auxiliary electrode resistance and probe resistance.
Automatic measurement of voltage noise.

9.11 TRUE RMS CURRENT (BENNING IT 120 only)

<table>
<tr><th>Measuring range (A)</th><th>Resolution (A)</th><th>Accuracy</th></tr>
<tr><td>0.0 ÷ 99.9 mA</td><td>0.1 mA</td><td>± (5 % of reading +3 digits)</td></tr>
<tr><td>100 ÷ 999 mA</td><td>1 mA</td><td rowspan="2">± (5 % of reading)</td></tr>
<tr><td>1.00 ÷ 19.99 A</td><td>0.01 A</td></tr>
</table>

Maximum continuous input current 20 mA ≙ 20 A meas. current!
Additional current clamp error has to be considered.

9.12 Illumination (BENNING IT 120 only)

9.12.1 Illumination (LUXmeter probe type B)

<table>
<tr><th>Measuring range (lux)</th><th>Resolution (lux)</th><th>Accuracy</th></tr>
<tr><td>0.01 ÷ 19.99</td><td>0.01</td><td rowspan="4">± (5% of reading +2 digits)</td></tr>
<tr><td>20.0 ÷ 199.9</td><td>0.1</td></tr>
<tr><td>200 ÷ 1999</td><td>1</td></tr>
<tr><td>2.00 ÷ 19.99 k</td><td>10</td></tr>
</table>

Measurement principle	silicon photodiode with V(λ) filter
Spectral response error	3.8 % according to CIE curve
Cosine error	2.5 % up to an incident angle of +/- 85 deg.

Overall accuracy matched to DIN 5032 class B standard

9.12.2 Illumination (LUXmeter probe type C)

Measuring range (lux)	Resolution (lux)	Accuracy
0.01 ÷ 19.99	0.01	± (10 % of reading +3 digits)
20.0 ÷ 199.9	0.1	
200 ÷ 1999	1	
2.00 ÷ 19.99 k	10	

Measurement principle	silicon photodiode
Cosine error	2.5 % up to an incident angle of +/- 85 deg.

Overall accuracy matched to DIN 5032 class C standard

9.13 General data

Power supply voltage	9 V_{DC} (6×1,5 V battery cells, size AA)
Power supply adapter	12 V - 15 V / 400mA
Operation	typical 15 h
Plug commander (optional)	
Overvoltage category	CAT III / 300 V
Overvoltage category	CAT III / 600 V
Protection classification	double insulation
Pollution degree	2
Protection degree	IP 42
Display	128x64 dots matrix display with backlight
Memory size	500 measurement results
Dimensions (w x h x d)	23 cm x 10.3 cm x 11.5 cm
Weight (without batteries)	1.17 kg
Reference conditions	
Temperature range	10 °C - 30 °C
Humidity range	40% - 70 % RH
Operating conditions	
Working temperature range	0 °C - 40 °C
Maximum relative humidity	95% 0 °C to 40 °C (non-condensing)
Storage conditions	
Temperature range	-10 °C to +70 °C
Maximum relative humidity	90% (-10 °C to + 40 °C) 80% RH (40 °C to 60 °C)

The accuracy is stated for 1 year under reference conditions. The temperature coefficient outside this limit value is 0.2 % of the measured value per °C and 1 digit.

10 Appendix A

Low-voltage fuses (fuse-links) acc. to DIN EN 60269. VDE 0636 (e.g. l.v. h.b.c.) and circuit-breakers acc. to DIN EN 60898. VDE 0641
Melting times or trip-out time are depending on current-time characteristics and trip-out current
Fuse links are classified in utilisation categories (e.g. gL-gG)
Circuit-breakers were formerly characterised with a letter, today, the same letter is also the type designation
The current-time characteristics (see data in the fuse base table below) are identical for fuse type NV and gG (indicated in display) and gL-gG (entry in table)!
Fuse-link
gL = Whole area line protection (obsolete designation)
gG = Whole area appliance protection (obsolete designation)
gL-gG = Cable and line protection, discriminating characteristics

Circuit-breaker type
B = Area of instantaneous tripping 3 - 5 x I_N
C = Area of instantaneous tripping 5 - 10 x I_N
K = Area of instantaneous tripping 8 - 15 x I_N
D = Area of instantaneous tripping 10 - 20 x I_N

10.1 Fuse base tables

Fuse, utilisation class / type	Fuse, total clearing time	Fuse, rated current	Prospective short-circuit current (A), low value
gL-gG (NV, gG)	35 ms	2 A	32,5
gL-gG (NV, gG)	35 ms	4 A	65,6
gL-gG (NV, gG)	35 ms	6 A	102,8
gL-gG (NV, gG)	35 ms	10 A	165,8
gL-gG (NV, gG)	35 ms	13 A	193,1
gL-gG (NV, gG)	35 ms	16 A	206,9
gL-gG (NV, gG)	35 ms	20 A	276,8
gL-gG (NV, gG)	35 ms	25 A	361,3
gL-gG (NV, gG)	35 ms	32 A	539,1
gL-gG (NV, gG)	35 ms	35 A	618,1
gL-gG (NV, gG)	35 ms	40 A	694,2
gL-gG (NV, gG)	35 ms	50 A	919,2
gL-gG (NV, gG)	35 ms	63 A	1217,2
gL-gG (NV, gG)	35 ms	80 A	1567,2
gL-gG (NV, gG)	35 ms	100 A	2075,3
gL-gG (NV, gG)	35 ms	125 A	2826,3
gL-gG (NV, gG)	35 ms	160 A	3538,2
gL-gG (NV, gG)	35 ms	200 A	4555,5
gL-gG (NV, gG)	35 ms	250 A	6032,4
gL-gG (NV, gG)	35 ms	315 A	7766,8
gL-gG (NV, gG)	35 ms	400 A	10577,7
gL-gG (NV, gG)	35 ms	500 A	13619
gL-gG (NV, gG)	35 ms	630 A	19619,3
gL-gG (NV, gG)	35 ms	710 A	19712,3
gL-gG (NV, gG)	35 ms	800 A	25260,3
gL-gG (NV, gG)	35 ms	1000 A	34402,1
gL-gG (NV, gG)	35 ms	1250 A	45555,1
gL-gG (NV, gG)	0,1 s	2 A	22,3
gL-gG (NV, gG)	0,1 s	4 A	46,4
gL-gG (NV, gG)	0,1 s	6 A	70
gL-gG (NV, gG)	0,1 s	10 A	115,3

gL-gG (NV, gG)	0,1 s	13 A	144,8
gL-gG (NV, gG)	0,1 s	16 A	150,8
gL-gG (NV, gG)	0,1 s	20 A	204,2
gL-gG (NV, gG)	0,1 s	25 A	257,5
gL-gG (NV, gG)	0,1 s	32 A	361,5
gL-gG (NV, gG)	0,1 s	35 A	453,2
gL-gG (NV, gG)	0,1 s	40 A	464,2
gL-gG (NV, gG)	0,1 s	50 A	640
gL-gG (NV, gG)	0,1 s	63 A	821,7
gL-gG (NV, gG)	0,1 s	80 A	1133,1
gL-gG (NV, gG)	0,1 s	100 A	1429
gL-gG (NV, gG)	0,1 s	125 A	2006
gL-gG (NV, gG)	0,1 s	160 A	2485,1
gL-gG (NV, gG)	0,1 s	200 A	3488,5
gL-gG (NV, gG)	0,1 s	250 A	4399,6
gL-gG (NV, gG)	0,1 s	315 A	6066,6
gL-gG (NV, gG)	0,1 s	400 A	7929,1
gL-gG (NV, gG)	0,1 s	500 A	10933,5
gL-gG (NV, gG)	0,1 s	630 A	14037,4
gL-gG (NV, gG)	0,1 s	710 A	17766,9
gL-gG (NV, gG)	0,1 s	800 A	20059,8
gL-gG (NV, gG)	0,1 s	1000 A	23555,5
gL-gG (NV, gG)	0,1 s	1250 A	36152,6
gL-gG (NV, gG)	0,2 s	2 A	18,7
gL-gG (NV, gG)	0,2 s	4 A	38,8
gL-gG (NV, gG)	0,2 s	6 A	56,5
gL-gG (NV, gG)	0,2 s	10 A	96,5
gL-gG (NV, gG)	0,2 s	13 A	117,9
gL-gG (NV, gG)	0,2 s	16 A	126,1
gL-gG (NV, gG)	0,2 s	20 A	170,8
gL-gG (NV, gG)	0,2 s	25 A	215,4
gL-gG (NV, gG)	0,2 s	32 A	307,9
gL-gG (NV, gG)	0,2 s	35 A	374
gL-gG (NV, gG)	0,2 s	40 A	381,4
gL-gG (NV, gG)	0,2 s	50 A	545
gL-gG (NV, gG)	0,2 s	63 A	663,3
gL-gG (NV, gG)	0,2 s	80 A	964,9
gL-gG (NV, gG)	0,2 s	100 A	1195,4
gL-gG (NV, gG)	0,2 s	125 A	1708,3
gL-gG (NV, gG)	0,2 s	160 A	2042,1
gL-gG (NV, gG)	0,2 s	200 A	2970,8
gL-gG (NV, gG)	0,2 s	250 A	3615,3
gL-gG (NV, gG)	0,2 s	315 A	4985,1
gL-gG (NV, gG)	0,2 s	400 A	6632,9
gL-gG (NV, gG)	0,2 s	500 A	8825,4
gL-gG (NV, gG)	0,2 s	630 A	11534,9
gL-gG (NV, gG)	0,2 s	710 A	14341,3
gL-gG (NV, gG)	0,2 s	800 A	16192,1
gL-gG (NV, gG)	0,2 s	1000 A	19356,3

gL-gG (NV, gG)	0,2 s	1250 A	29182,1
gL-gG (NV, gG)	0,4 s	2 A	15,9
gL-gG (NV, gG)	0,4 s	4 A	31,9
gL-gG (NV, gG)	0,4 s	6 A	46,4
gL-gG (NV, gG)	0,4 s	10 A	80,7
gL-gG (NV, gG)	0,4 s	13 A	100
gL-gG (NV, gG)	0,4 s	16 A	107,4
gL-gG (NV, gG)	0,4 s	20 A	145,5
gL-gG (NV, gG)	0,4 s	25 A	180,2
gL-gG (NV, gG)	0,4 s	32 A	271,7
gL-gG (NV, gG)	0,4 s	35 A	308,7
gL-gG (NV, gG)	0,4 s	40 A	319,1
gL-gG (NV, gG)	0,4 s	50 A	464,2
gL-gG (NV, gG)	0,4 s	63 A	545
gL-gG (NV, gG)	0,4 s	80 A	836,5
gL-gG (NV, gG)	0,4 s	100 A	1018
gL-gG (NV, gG)	0,4 s	125 A	1454,8
gL-gG (NV, gG)	0,4 s	160 A	1678,1
gL-gG (NV, gG)	0,4 s	200 A	2529,9
gL-gG (NV, gG)	0,4 s	250 A	2918,2
gL-gG (NV, gG)	0,4 s	315 A	4096,4
gL-gG (NV, gG)	0,4 s	400 A	5450,5
gL-gG (NV, gG)	0,4 s	500 A	7515,7
gL-gG (NV, gG)	0,4 s	630 A	9310,9
gL-gG (NV, gG)	0,4 s	710 A	11996,9
gL-gG (NV, gG)	0,4 s	800 A	13545,1
gL-gG (NV, gG)	0,4 s	1000 A	16192,1
gL-gG (NV, gG)	0,4 s	1250 A	24411,6
gL-gG (NV, gG)	5 s	2 A	9,1
gL-gG (NV, gG)	5 s	4 A	18,7
gL-gG (NV, gG)	5 s	6 A	26,7
gL-gG (NV, gG)	5 s	10 A	46,4
gL-gG (NV, gG)	5 s	13 A	56,2
gL-gG (NV, gG)	5 s	16 A	66,3
gL-gG (NV, gG)	5 s	20 A	86,7
gL-gG (NV, gG)	5 s	25 A	109,3
gL-gG (NV, gG)	5 s	32 A	159,1
gL-gG (NV, gG)	5 s	35 A	169,5
gL-gG (NV, gG)	5 s	40 A	190,1
gL-gG (NV, gG)	5 s	50 A	266,9
gL-gG (NV, gG)	5 s	63 A	319,1
gL-gG (NV, gG)	5 s	80 A	447,9
gL-gG (NV, gG)	5 s	100 A	585,4
gL-gG (NV, gG)	5 s	125 A	765,1
gL-gG (NV, gG)	5 s	160 A	947,9
gL-gG (NV, gG)	5 s	200 A	1354,5
gL-gG (NV, gG)	5 s	250 A	1590,6
gL-gG (NV, gG)	5 s	315 A	2272,9
gL-gG (NV, gG)	5 s	400 A	2766,1

gL-gG (NV, gG)	5 s	500 A	3952,7
gL-gG (NV, gG)	5 s	630 A	4985,1
gL-gG (NV, gG)	5 s	710 A	6423,2
gL-gG (NV, gG)	5 s	800 A	7252,1
gL-gG (NV, gG)	5 s	1000 A	9146,2
gL-gG (NV, gG)	5 s	1250 A	13070,1
B	35 ms	6 A	30
B	35 ms	10 A	50
B	35 ms	13 A	65
B	35 ms	16 A	80
B	35 ms	20 A	100
B	35 ms	25 A	125
B	35 ms	32 A	160
B	35 ms	40 A	200
B	35 ms	50 A	250
B	35 ms	63 A	315
B	0,1 s	6 A	30
B	0,1 s	10 A	50
B	0,1 s	13 A	65
B	0,1 s	16 A	80
B	0,1 s	20 A	100
B	0,1 s	25 A	125
B	0,1 s	32 A	160
B	0,1 s	40 A	200
B	0,1 s	50 A	250
B	0,1 s	63 A	315
B	0,2 s	6 A	30
B	0,2 s	10 A	50
B	0,2 s	13 A	65
B	0,2 s	16 A	80
B	0,2 s	20 A	100
B	0,2 s	25 A	125
B	0,2 s	32 A	160
B	0,2 s	40 A	200
B	0,2 s	50 A	250
B	0,2 s	63 A	315
B	0,4 s	6 A	30
B	0,4 s	10 A	50
B	0,4 s	13 A	65
B	0,4 s	16 A	80
B	0,4 s	20 A	100
B	0,4 s	25 A	125
B	0,4 s	32 A	160
B	0,4 s	40 A	200
B	0,4 s	50 A	250
B	0,4 s	63 A	315
B	5 s	6 A	30
B	5 s	10 A	50
B	5 s	13 A	65

B	5 s	16 A	80
B	5 s	20 A	100
B	5 s	25 A	125
B	5 s	32 A	160
B	5 s	40 A	200
B	5 s	50 A	250
B	5 s	63 A	315
C	35 ms	0,5 A	5
C	35 ms	1 A	10
C	35 ms	1,6 A	16
C	35 ms	2 A	20
C	35 ms	4 A	40
C	35 ms	6 A	60
C	35 ms	10 A	100
C	35 ms	13 A	130
C	35 ms	16 A	160
C	35 ms	20 A	200
C	35 ms	25 A	250
C	35 ms	32 A	320
C	35 ms	40 A	400
C	35 ms	50 A	500
C	35 ms	63 A	630
C	0,1 s	0,5 A	5
C	0,1 s	1 A	10
C	0,1 s	1,6 A	16
C	0,1 s	2 A	20
C	0,1 s	4 A	40
C	0,1 s	6 A	60
C	0,1 s	10 A	100
C	0,1 s	13 A	130
C	0,1 s	16 A	160
C	0,1 s	20 A	200
C	0,1 s	25 A	250
C	0,1 s	32 A	320
C	0,1 s	40 A	400
C	0,1 s	50 A	500
C	0,1 s	63 A	630
C	0,2 s	0,5 A	5
C	0,2 s	1 A	10
C	0,2 s	1,6 A	16
C	0,2 s	2 A	20
C	0,2 s	4 A	40
C	0,2 s	6 A	60
C	0,2 s	10 A	100
C	0,2 s	13 A	130
C	0,2 s	16 A	160
C	0,2 s	20 A	200
C	0,2 s	25 A	250
C	0,2 s	32 A	320

C	0,2 s	40 A	400
C	0,2 s	50 A	500
C	0,2 s	63 A	630
C	0,4 s	0,5 A	5
C	0,4 s	1 A	10
C	0,4 s	1,6 A	16
C	0,4 s	2 A	20
C	0,4 s	4 A	40
C	0,4 s	6 A	60
C	0,4 s	10 A	100
C	0,4 s	13 A	130
C	0,4 s	16 A	160
C	0,4 s	20 A	200
C	0,4 s	25 A	250
C	0,4 s	32 A	320
C	0,4 s	40 A	400
C	0,4 s	50 A	500
C	0,4 s	63 A	630
C	5 s	0,5 A	2,7
C	5 s	1 A	5,4
C	5 s	1,6 A	8,6
C	5 s	2 A	10,8
C	5 s	4 A	21,6
C	5 s	6 A	32,4
C	5 s	10 A	54
C	5 s	13 A	70,2
C	5 s	16 A	86,4
C	5 s	20 A	108
C	5 s	25 A	135
C	5 s	32 A	172,8
C	5 s	40 A	216
C	5 s	50 A	270
C	5 s	63 A	340,2
K	35 ms	0,5 A	7,5
K	35 ms	1 A	15
K	35 ms	1,6 A	24
K	35 ms	2 A	30
K	35 ms	4 A	60
K	35 ms	6 A	90
K	35 ms	10 A	150
K	35 ms	13 A	195
K	35 ms	16 A	240
K	35 ms	20 A	300
K	35 ms	25 A	375
K	35 ms	32 A	480
K	0,1 s	0,5 A	7,5
K	0,1 s	1 A	15
K	0,1 s	1,6 A	24
K	0,1 s	2 A	30

K	0,1 s	4 A	60
K	0,1 s	6 A	90
K	0,1 s	10 A	150
K	0,1 s	13 A	195
K	0,1 s	16 A	240
K	0,1 s	20 A	300
K	0,1 s	25 A	375
K	0,1 s	32 A	480
K	0,2 s	0,5 A	7,5
K	0,2 s	1 A	15
K	0,2 s	1,6 A	24
K	0,2 s	2 A	30
K	0,2 s	4 A	60
K	0,2 s	6 A	90
K	0,2 s	10 A	150
K	0,2 s	13 A	195
K	0,2 s	16 A	240
K	0,2 s	20 A	300
K	0,2 s	25 A	375
K	0,2 s	32 A	480
K	0,4 s	0,5 A	7,5
K	0,4 s	1 A	15
K	0,4 s	1,6 A	24
K	0,4 s	2 A	30
K	0,4 s	4 A	60
K	0,4 s	6 A	90
K	0,4 s	10 A	150
K	0,4 s	13 A	195
K	0,4 s	16 A	240
K	0,4 s	20 A	300
K	0,4 s	25 A	375
K	0,4 s	32 A	480
D	35 ms	0,5 A	10
D	35 ms	1 A	20
D	35 ms	1,6 A	32
D	35 ms	2 A	40
D	35 ms	4 A	80
D	35 ms	6 A	120
D	35 ms	10 A	200
D	35 ms	13 A	260
D	35 ms	16 A	320
D	35 ms	20 A	400
D	35 ms	25 A	500
D	35 ms	32 A	640
D	0,1 s	0,5 A	10
D	0,1 s	1 A	20
D	0,1 s	1,6 A	32
D	0,1 s	2 A	40
D	0,1 s	4 A	80

D	0,1 s	6 A	120
D	0,1 s	10 A	200
D	0,1 s	13 A	260
D	0,1 s	16 A	320
D	0,1 s	20 A	400
D	0,1 s	25 A	500
D	0,1 s	32 A	640
D	0,2 s	0,5 A	10
D	0,2 s	1 A	20
D	0,2 s	1,6 A	32
D	0,2 s	2 A	40
D	0,2 s	4 A	80
D	0,2 s	6 A	120
D	0,2 s	10 A	200
D	0,2 s	13 A	260
D	0,2 s	16 A	320
D	0,2 s	20 A	400
D	0,2 s	25 A	500
D	0,2 s	32 A	640
D	0,4 s	0,5 A	10
D	0,4 s	1 A	20
D	0,4 s	1,6 A	32
D	0,4 s	2 A	40
D	0,4 s	4 A	80
D	0,4 s	6 A	120
D	0,4 s	10 A	200
D	0,4 s	13 A	260
D	0,4 s	16 A	320
D	0,4 s	20 A	400
D	0,4 s	25 A	500
D	0,4 s	32 A	640
D	5 s	0,5 A	2,7
D	5 s	1 A	5,4
D	5 s	1,6 A	8,6
D	5 s	2 A	10,8
D	5 s	4 A	21,6
D	5 s	6 A	32,4
D	5 s	10 A	54
D	5 s	13 A	70,2
D	5 s	16 A	86,4
D	5 s	20 A	108
D	5 s	25 A	135
D	5 s	32 A	172,8

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