



Operating manual
Installation Tester
BENNING IT 110 / BENNING IT 120 B

BENNING

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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 B 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 (Low Ω resistance and continuity function)
- Insulation resistance
- RCD
- Loop impedance
- Line impedance
- TRUE RMS current (BENNING IT 120 B only)
- Resistance to earth (BENNING IT 120 B only)
- Illumination (BENNING IT 120 B only)


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

BENNING IT 110/ BENNING IT 120 B 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 B 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 B may be impaired.
- Read this user manual carefully, otherwise use of the BENNING IT 110/ BENNING IT 120 B 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 B 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 B 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 B 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/ BENNING IT 120 B before opening battery/fuse compartment cover, hazardous voltage inside.

Warnings concerning measuring functions

Insulating resistance

- Carry out measurements of the insulating resistance at discharged objects only!
- Disconnect all loads and close all switches for measuring the insulating resistance between conductors of the system.
- Do not touch the object during the measurement or before it is completely discharged! Danger 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 the test cables to an external voltage higher than 600 V (AC or DC), because this might damage the tester!

Resistance/ continuity test

- Carry out the low-impedance measurement/ continuity test at discharged objects only!
- The test result might be influenced by parallel impedances or transient currents.

Testing the PE connection

- If phase voltage is detected at the PE connection to be tested, immediately interrupt all measurements and make sure that the error is corrected before going on with other work at the object!

Remarks concerning the measuring functions

General

- The $\overset{\text{TEST}}{\times}$ symbol means that the selected measurement cannot be carried out due to irregular conditions at the input terminal.
- Carry out measurements of insulating resistance, resistance/ continuity test and earth resistance at discharged objects only!
- The PASS/ FAIL indication is activated when a limiting value has been defined. Choose a limiting value which is appropriate for evaluating the measuring results.
- If only two of three cables are connected to the electrical system to be tested, only the voltage indication between these two cables is valid.

Insulating resistance

- If the voltage between the testing terminals is higher than 10 V (AC or DC), the measurement of the insulating resistance will not be carried out.

Resistance/ continuity Test

- If the voltage between the testing terminals is higher than 10 V, the resistance measurement/ continuity test cannot be carried out.
- Before carrying out the low-impedance measurement, the test cable resistance has to be compensated (if necessary). This compensation is done by means of the **Low Ω** function.

Residual current protection (FI/RCD)

- Parameters set in this function are also kept for other RCD functions.
- 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.
- Compared to the loop impedance R_L (contact voltage subresult), the measurement of the loop impedance Z_{Rcd} offers increased accuracy.
- The tripping time and tripping current measurement is only carried out when the contact voltage at nominal differential current is lower than the preset limiting value of the contact voltage.
- The autotest sequence stops when the trip-out time is outside the allowed time period.

Loop impedance

- 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 I_{PSC} scaling factor.
- Loop impedance (Z_s) measurement trips an RCD.
- Measurement of the loop impedance (Z_{Rcd}) 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.

Line impedance

- 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.

Resistance to earth (BENNING IT 120 B only)

- If the voltage between the test terminals H and E is higher than 30 V the earth measurement will not be performed.
- 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!

TRUE RMS current (BENNING IT 120 B only)

- 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!

Luminous intensity (BENNING IT 120 B only)

- Shadow and irregular incidence affect the measurement result!
- Please observe that artificial light sources reach their full capacity after a certain time only. For this reason, they should be switched on for the respective time before carrying out measurements.

Testing the PE connection

- The PE terminal can only be tested when the function selector switch is set as follows: $Z_{V/IK}$ (LN/L); $Z_{s/IK}$ (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.

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 B and power off the instrument. Hazardous voltage inside!
- Insert cells correctly, otherwise the BENNING IT 110/ BENNING IT 120 B will not operate and the batteries could be discharged.
- If the BENNING IT 110/ BENNING IT 120 B 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 B. 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 B 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 B 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/ BENNING IT 120 B now meets the data in the technical specifications.

Note:

- The charger in the BENNING IT 110/ BENNING IT 120 B 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/ BENNING IT 120 B 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

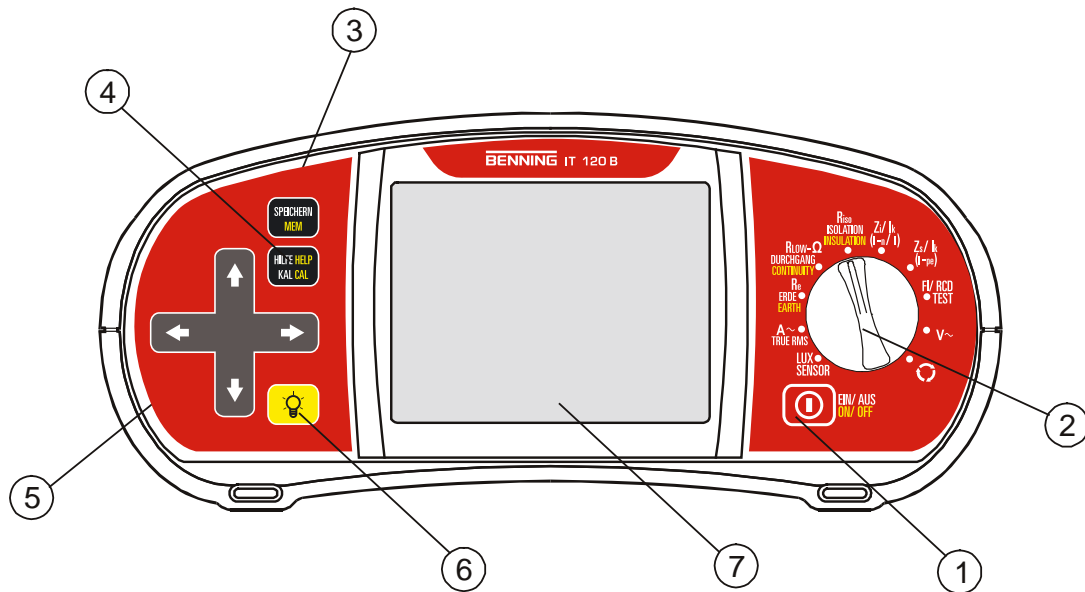


Fig. 3.1: Front panel, example: BENNING IT 120 B

Legend:

- ❶ ON/OFF key, to switch on or off the BENNING IT 110/ BENNING IT 120 B
The BENNING IT 110/ BENNING IT 120 B is automatically switched off 10 minutes after the last key was pressed or the function selector switch rotated.
- ❷ Function selector switch.
- ❸ BENNING IT 110: CAL key, to compensate test lead resistance in low Ω resistance measurement.
BENNING IT 120 B: Press MEM key to save, recall or delete measurement results.
- ❹ BENNING IT 110: HELP key, to access help menus.
BENNING IT 120 B: HELP/CAL key, to access the help menus. The CAL function is enabled in low Ω resistance measurement to compensate test lead resistance.
- ❺ Jogger keypad with cursors and TEST keys
The TEST key also acts as the PE touching electrode.
- ❻ 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.
- ❼ 128 x 64-dots matrix display with backlight

3.2 Connector panel

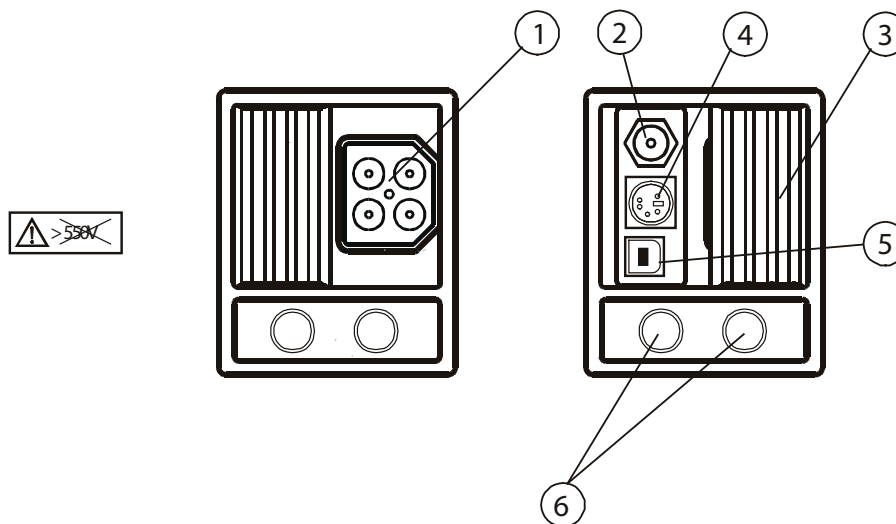


Fig. 3.2: Connector panel

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 B 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 B only)
- ⑤ USB connector (BENNING IT 120 B only)
- ⑥ Current clamp input

3.3 Back panel

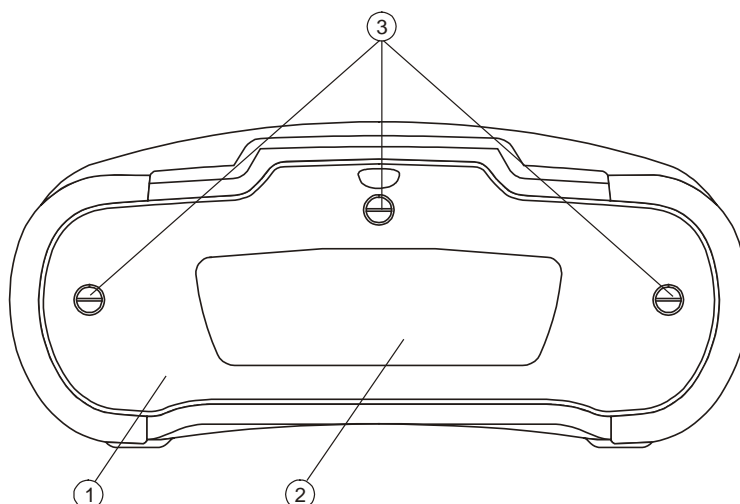


Fig. 3.3: Back Panel

Legend:

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

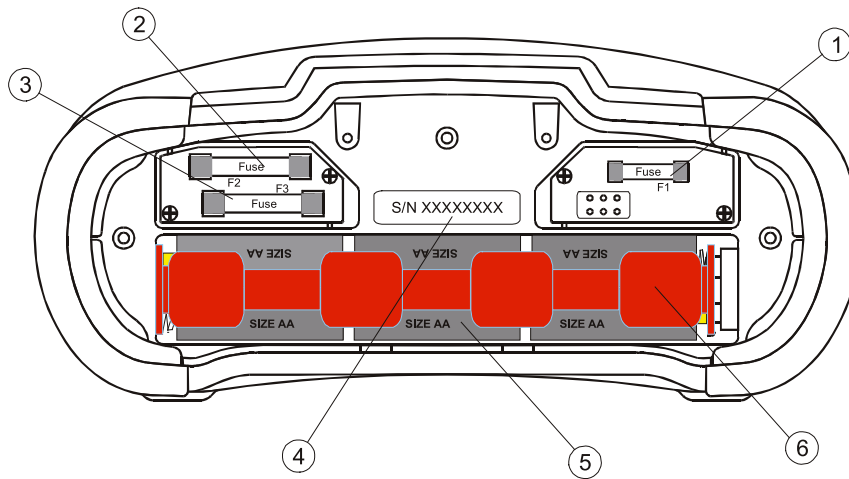


Fig. 3.4: Battery and fuse compartment

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

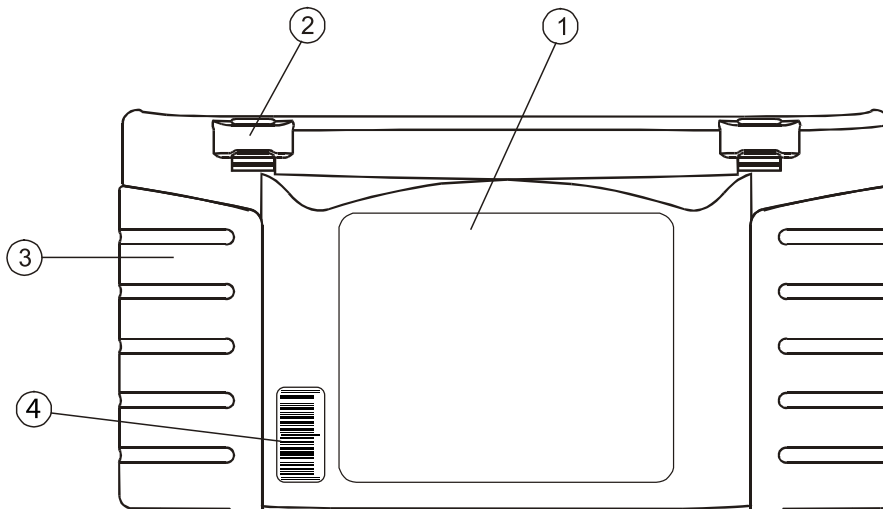


Fig. 3.5: Bottom view

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 120 B

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



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



The BENNING IT 110/ BENNING IT 120 B 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 B set and accessories

3.6.1 Standard set

| | BENNING IT 110 | BENNING IT 120 B |
|--------------------------------|--|--|
| <i>Instrument</i> | Soft carrying bag Neck carrying belt, 2 pcs. | Soft carrying bag Neck carrying belt, 2 pcs. |
| <i>Measuring accessories*)</i> | 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 |
| <i>Documentation</i> | Short instructions | Short instructions |
| <i>Batteries</i> | 6 Ni-MH rechargeable cells Power supply adapter | 6 Ni-MH rechargeable cells Power supply adapter |
| <i>Cable</i> | | RS232 cable USB cable |
| <i>CD-ROM</i> | Instruction manual Short instructions | Instruction manual Short instructions BENNING PC-WIN IT 120 B Software |

3.6.2 Optional accessories

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

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

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

The display is divided into four sections:

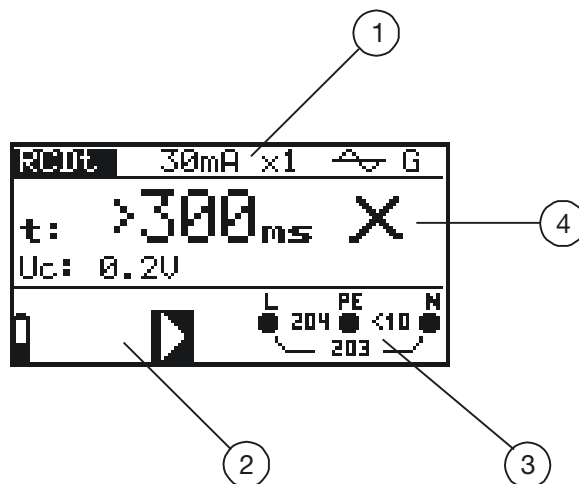


Fig. 4.1: Display outlook

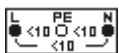
Legend:

- ❶ Function and parameter line
In the top display line the measuring function/sub-function and parameters are displayed.
- ❷ Message field
In this field battery status and warnings/messages related to the actual measurement are displayed.
- ❸ Online voltage and output monitor
In this field the main and sub-results together with the PASS/FAIL/ABORT status are displayed.
- ❹ 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 low Ω 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 B overheated. The temperature of internal components in the BENNING IT 110/ BENNING IT 120 B 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 B

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 B only)
- TRUE RMS current (BENNING IT 120 B only)
- Illumination (BENNING IT 120 B only)

The function/sub-function name is highlighted on the display by default.

The sub-function can be selected by using the \uparrow and \downarrow keys in the function/parameter line.

4.2 Setting measurement parameters and limits

By using the \leftarrow and \rightarrow keys select the parameter/limit value you want to edit. The selected parameter can be set by using the \uparrow and \downarrow 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 B 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.

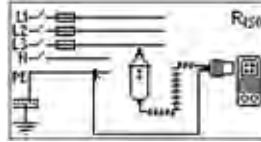


Fig. 4.3: Example of help menu

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
- Activating/ deactivating the COMMANDER (switchable probe tip)

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.

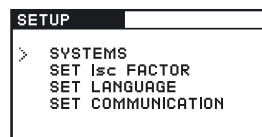


Fig. 4.4: Setup menu

4.4.1 Supply system setup

The BENNING IT 110/ BENNING IT 120 B 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.

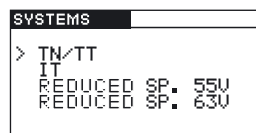






Fig. 4.5: Supply systems selecting menu

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.

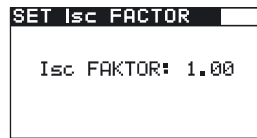


Fig. 4.6: Scaling factor adjustment menu

Use the \uparrow and \downarrow 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 \uparrow and \downarrow keys and press the TEST key to enter the **Language** selecting menu.

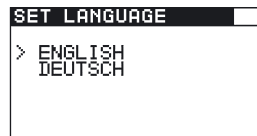


Fig. 4.7: Language selection menu

Select language you want to use by using the \uparrow and \downarrow keys. Press the TEST key to accept the new setting.

4.4.4 Communication port settings (BENNING IT 120 B only)

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



Fig. 4.8: Communication menu

By using the \uparrow and \downarrow keys select the communication port you want to use. If RS232 communication port is selected, use the \leftarrow and \rightarrow 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 Activating/ deactivating the COMMANDER (switchable probe tip)

In the **Settings** menu, select the COMMANDER option by means of the \uparrow and \downarrow keys and press the TEST key to activate or to deactivate the COMMANDER.

The **inactive** setting blocks the keys of the COMMANDER (except for the background lighting key). Now, the measurement can only be started or stored by means of the keys at the BENNING IT 110/ BENNING IT 120 B.

The **inactive** setting blocks the keys of the COMMANDER.

Note:

- It is useful to deactivate the COMMANDER, if strong sources of interference might affect the functioning of the COMMANDER.

4.4.6 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 B only)

In order to recall the original setting press and hold the \rightarrow 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 | Parameter / limit value |
| Sub-function | |
| CONTINUITY | Sub-function: RLOW |
| Low Ω 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 M Ω |
| 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: $\triangleleft \nabla$ G Limit contact voltage: 50 V Nominal differential current multiplier: $\times 1$ |
| LOOP IMPEDANCE | Testing RCDs with nominal differential current ≥ 10 mA |
| RESISTANCE TO EARTH (BENNING IT 120 B only) | High limit resistance value: 50 Ω |
| ILLUMINATION (BENNING IT 120 B 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 R_{ISO} , ISOLATION/ INSULATION function with the function selector switch. The following menu is displayed:

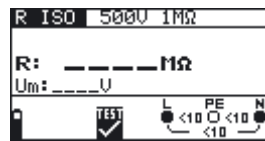


Fig. 5.1: Insulation resistance measurement menu

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

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.

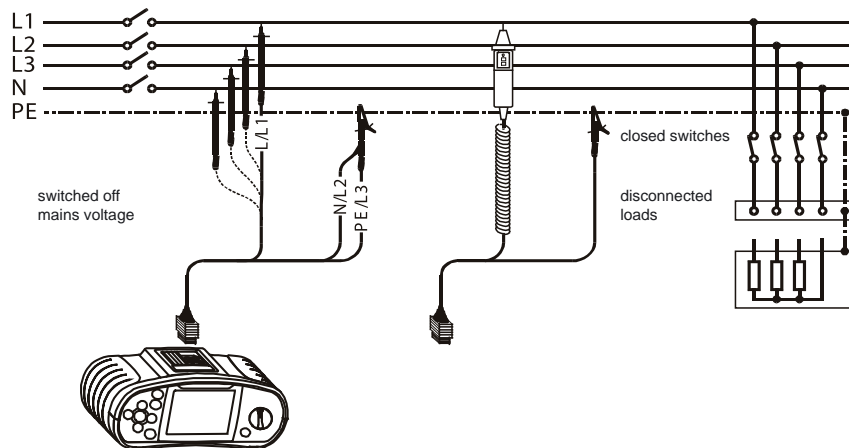


Fig. 5.2: Connection of universal test cable and tip commander

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).

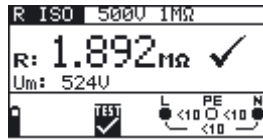


Fig. 5.3: Example of insulation resistance measurement results


Displayed results:

R: Insulation resistance

Um: Test voltage of the BENNING IT 110/ BENNING IT 120 B

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 B 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 B.

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 Resistance/ continuity testing (R_{LOW})

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

- Low Ω resistance measurement
- Continuity measurement

5.2.1 Low Ω resistance (RLOW)

This test is used to ensure electric safety and correct connection of all protective conductors, earth conductors or bonding conductors. The measurement of Low Ω 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.

How to perform Low Ω resistance measurement:

Step 1 Select R_{LOW} - Ω , DURCHGANG/ CONTINUITY with the function selector switch. Use the \uparrow/\downarrow keys to select **RLOW**. The following menu is displayed:

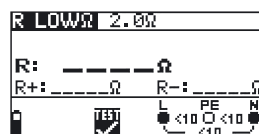


Fig. 5.4: Low Ω resistance measurement menu

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

Step 2 Set the following limit value:
- High limit resistance value

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

1. Short test lead first as shown in figure 5.5.



Fig. 5.5: 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 **Low Ω resistance** measurement. Use the **Help** function if necessary..

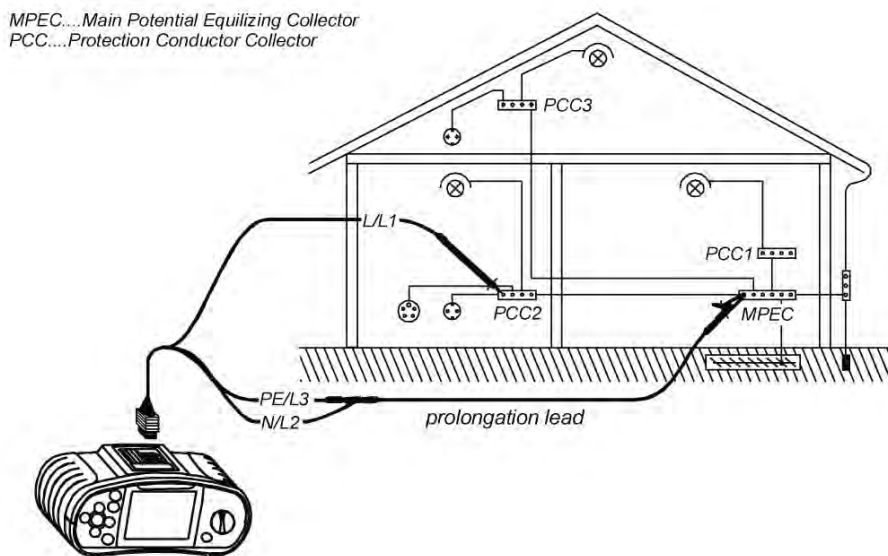


Fig. 5.6: Connection of universal test cable and optional probe test lead (extension)

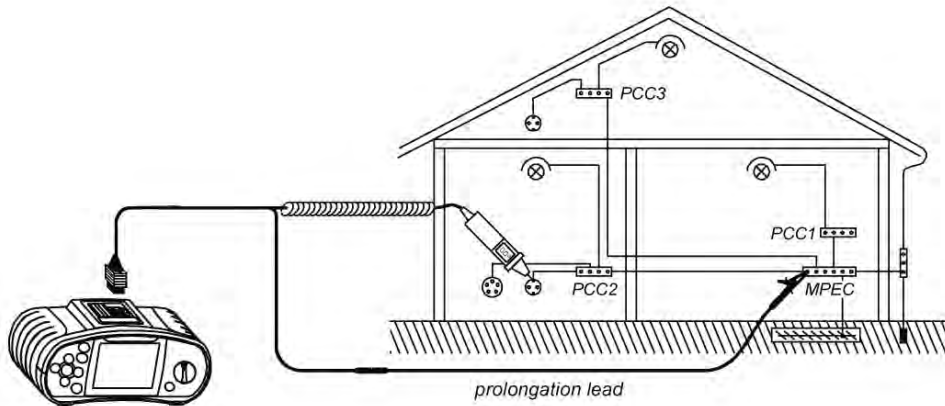


Fig. 5.7: Connection of tip commander and optional probe test lead (extension)

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. 5.8: 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 B 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 R_{lowΩ} measurement will not be performed.

5.2.2 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 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:

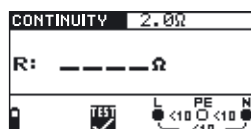


Fig. 5.9: Continuity measurement menu

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

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.

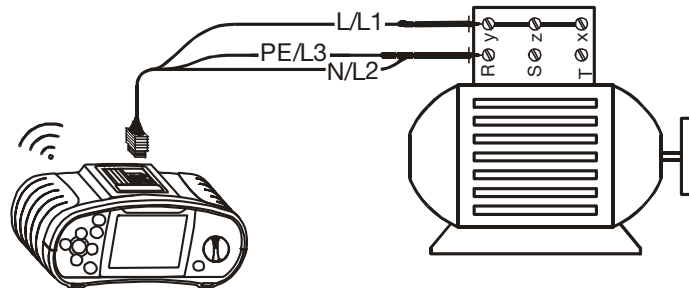


Fig. 5.10: Connection of universal test cable

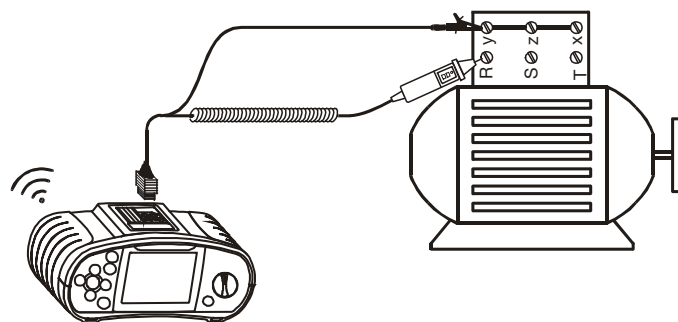


Fig. 5.11: Connection of tip commander

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).

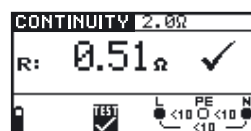


Fig. 5.12: Example of Continuity measurement result

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 **Low Ω function**.

5.3 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

5.3.1 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!

5.3.2 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.

5.3.3 Multiplier of nominal residual current

Selected nominal differential current can be multiplied by $\frac{1}{2}$; 1; 2 or 5.

5.3.4 RCD type and test current starting polarity

The BENNING IT 110/ BENNING IT 120 B enables testing of general (non-delayed, G) and selective (time-delayed, S) RCDs, which are suited for:

- Alternating residual current (AC type, marked with \sphericalangle symbol)
- Pulsating DC residual current (A type, pulsed current-sensitive, marked with \wedge symbol)
- Smooth DC residual current (type B, universal current sensitive, marked with the \equiv symbol)

For RCDs of the types A and AC, the fault current can be started with the positive half-wave at 0° or with the negative half-wave at 180°.

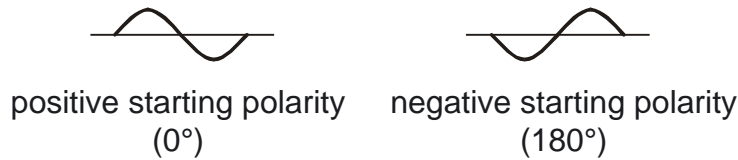


Fig. 5.13: Test current started with the positive or negative half-wave

For RCDs of type B, the fault current can be started with positive $\overset{+}{\text{---}}$ or negative $\overset{-}{\text{---}}$ polarity. During automatic testing (AUTO), the polarity is reversed automatically.

5.3.5 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.

5.3.6 Contact voltage (U_c)

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 U _c proportional to | Nominal fault current I _{ΔN} |
|----------|----------|--|---------------------------------------|
| AC | G | 1.05 × I _{ΔN} | Any |
| AC | S | 2 × 1.05 × I _{ΔN} | |
| A | G | 1.4 × 1.05 × I _{ΔN} | ≥ 30 mA |
| A | S | 2 × 1.4 × 1.05 × I _{ΔN} | |
| A | G | 2 × 1.05 × I _{ΔN} | < 30 mA |
| A | S | 2 × 2 × 1.05 × I _{ΔN} | |
| B | G | 2 × 1.05 × I _{ΔN} | Any |
| B | S | 2 × 2 × 1.05 × I _{ΔN} | |

Table 5.1: Relationship between U_c and I_{ΔN}

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 $\blacktriangle/\blacktriangledown$ keys to select U_c (contact voltage). The following menu is displayed:

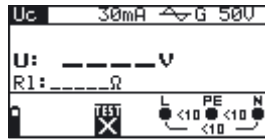


Fig. 5.14: Contact voltage measurement menu

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

Step 2 Set the following measuring parameters and limit values:

- Nominal residual current
- RCD type
- Limit contact voltage

Step 3 Follow the connection diagram shown in figure 5.15 to perform contact voltage measurement. Use the **Help** function if necessary

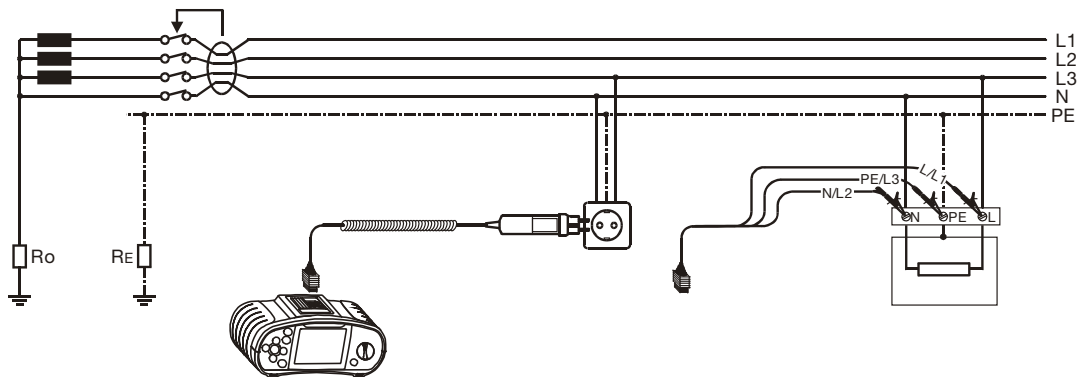


Fig. 5.15: Connection of plug test cable or universal test cable

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. 5.16: Example of contact voltage measurement results

Displayed results:

- U:** Contact voltage
- RI:** 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 B 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.

5.3.7 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:

| | $\frac{1}{2} \times I_{\Delta N}^{*)}$ | $I_{\Delta N}$ | $2 \times I_{\Delta N}$ | $5 \times I_{\Delta N}$ |
|-------------------------------|--|--|---|---|
| General (non-delayed) RCDs | $t_{\Delta} < 300 \text{ ms}$ | $t_{\Delta} < 300 \text{ ms}$ | $t_{\Delta} < 150 \text{ ms}$ | $t_{\Delta} < 40 \text{ ms}$ |
| Selective (time-delayed) RCDs | $t_{\Delta} < 500 \text{ ms}$ | $130 \text{ ms} < t_{\Delta} < 500 \text{ ms}$ | $60 \text{ ms} < t_{\Delta} < 200 \text{ ms}$ | $50 \text{ ms} < t_{\Delta} < 150 \text{ ms}$ |

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

| | $\frac{1}{2} \times I_{\Delta N}^{*)}$ | $I_{\Delta N}$ | $2 \times I_{\Delta N}$ | $5 \times I_{\Delta N}$ |
|-------------------------------|--|--|---|---|
| General (non-delayed) RCDs | $t_{\Delta} < 999 \text{ ms}$ | $t_{\Delta} < 999 \text{ ms}$ | $t_{\Delta} < 150 \text{ ms}$ | $t_{\Delta} < 40 \text{ ms}$ |
| Selective (time-delayed) RCDs | $t_{\Delta} < 999 \text{ ms}$ | $130 \text{ ms} < t_{\Delta} < 999 \text{ ms}$ | $60 \text{ ms} < t_{\Delta} < 200 \text{ ms}$ | $50 \text{ ms} < t_{\Delta} < 150 \text{ ms}$ |

Trip-out times according to BS 7671:

| | $\frac{1}{2} \times I_{\Delta N}^{*)}$ | $I_{\Delta N}$ | $2 \times I_{\Delta N}$ | $5 \times I_{\Delta N}$ |
|-------------------------------|--|--|---|---|
| General (non-delayed) RCDs | $t_{\Delta} < 1999 \text{ ms}$ | $t_{\Delta} < 300 \text{ ms}$ | $t_{\Delta} < 150 \text{ ms}$ | $t_{\Delta} < 40 \text{ ms}$ |
| Selective (time-delayed) RCDs | $t_{\Delta} < 1999 \text{ ms}$ | $130 \text{ ms} < t_{\Delta} < 500 \text{ ms}$ | $60 \text{ ms} < t_{\Delta} < 200 \text{ ms}$ | $50 \text{ ms} < t_{\Delta} < 150 \text{ ms}$ |

*) Test current of $\frac{1}{2} \times I_{\Delta N}$ 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 \uparrow/\downarrow keys to select **RCDt (trip-out time of the RCD)**. The following menu is displayed:



Fig. 5.17: Trip-out time measurement menu

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

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 5.15 (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.

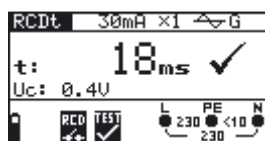


Fig. 5.18: Example of trip-out time measurement results

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 B 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.

5.3.8 Trip-out current (RCD )

An ever increasing fault current serves to test the limiting sensitivity for the FI/RCD tripping. The device increases the testing current in small steps over the whole range as follows:

| RCD type | Increasing fault current | | Wave form |
|---|---------------------------|---------------------------|-------------------|
| | Initial value | Final value | |
| AC | $0.2 \times I_{\Delta N}$ | $1.1 \times I_{\Delta N}$ | Sine AC |
| A ($I_{\Delta N} \geq 30 \text{ mA}$) | $0.2 \times I_{\Delta N}$ | $1.5 \times I_{\Delta N}$ | Pulsating |
| A ($I_{\Delta N} = 10 \text{ mA}$) | $0.2 \times I_{\Delta N}$ | $2.2 \times I_{\Delta N}$ | |
| B | $0.2 \times I_{\Delta N}$ | $2.2 \times I_{\Delta N}$ | Direct current DC |

The maximum testing current is ID (tripping current) or equals the final value, if the FI/RCD has not tripped.

How to perform trip-out current measurement:

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

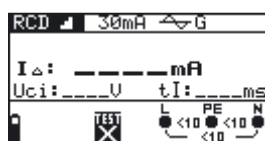


Fig. 5.19: Trip-out current measurement menu

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

- 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 5.15 (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. 5.20: 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 B 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.

5.3.9 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 B. 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:

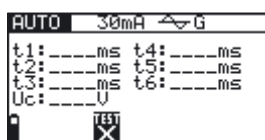


Fig. 5.21: RCD autotest menu

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

Step 2 Set the following measuring parameters:

- Nominal differential trip-out current
- RCD type

Step 3 Follow the connection diagram shown in figure 5.15 (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 $\frac{1}{2} \times I_{\Delta N}$
- Test current started with the positive half-wave at 0°

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

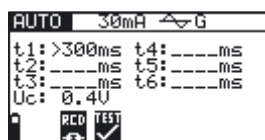


Fig. 5.22: Step 1 RCD autotest results

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 $\frac{1}{2} \times I_{\Delta N}$
- Test current started with the negative half-wave at 180°

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

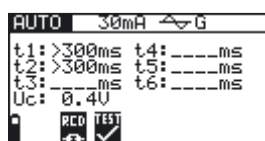


Fig. 5.23: Step 2 RCD autotest results

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:

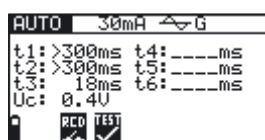


Fig. 5.24: Step 3 RCD autotest results

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. 5.25: 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:

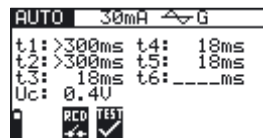


Fig. 5.26: Step 5 RCD autotest results

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:

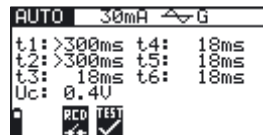


Fig. 5.27: Step 6 RCD autotest results

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.
- When setting the following parameters, the automatic testing sequence will be finished already after having measured the time t4:
 FI/RCD of type A, nominal fault current $I_{\Delta N}$: 300 mA, 500 mA, 1000 mA
 FI/RCD of type B, nominal fault current $I_{\Delta N}$: 300 mA, 500 mA
- When setting the following parameters, the automatic testing sequence will be finished already after having measured the time t2:
 FI/RCD of type B, nominal fault current $I_{\Delta N}$: 1000 mA

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

Two loop impedance measuring sub-functions are available:

- The ZI sub-function performs measurements in supply systems without RCDs.
- The Zs_{r_{cd}} sub-function performs measurements in supply systems with RCDs installed (with nominal differential trip-out current 10 mA)

5.4.1 Loop impedance (loop resistance, ZI)

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 B 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:

$$I_{PFC} = \frac{U_n \times \text{scaling factor}}{R_{L-PE}}$$

where

| U_n | Voltage range |
|-------|--|
| 115 V | $100 \text{ V} \leq U_{L-PE} < 160 \text{ V}$ |
| 230 V | $160 \text{ V} \leq U_{L-PE} \leq 264 \text{ V}$ |

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 \uparrow/\downarrow keys to select the ZI sub-function. The following menu is displayed:



Fig. 5.28: Loop impedance measurement menu

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

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 5.29 to perform loop impedance measurement. Use the **Help** function if necessary.

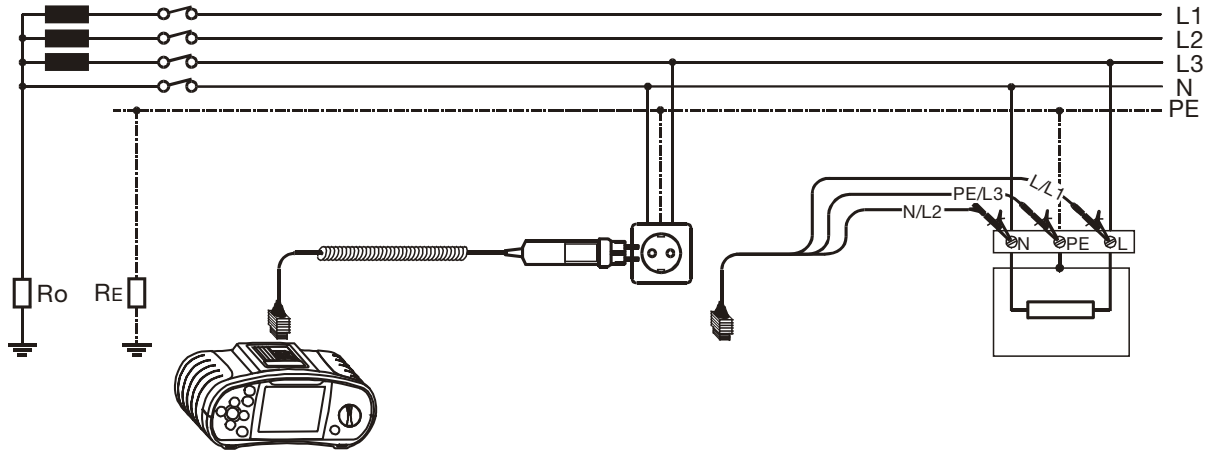


Fig. 5.29 Connection of plug cable and universal test cable

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. 5.30: 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 b 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 I_{PSC} scaling factor.

- Loop impedance (Zs) measurement trips an RCD.

5.4.2 Loop impedance (Z_{sRcd})

Z_{sRcd} 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:

$$I_{PFC} = \frac{U_n \times \text{scaling factor}}{R_{L-PE}}$$

where

| U _n | Voltage range |
|----------------|-----------------------------------|
| 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/lk (L-PE)** (loop impedance) with the function selector switch. Use the **▲/▼** keys to select the **Z_{sRcd}** sub-function. The following menu is displayed:



Fig. 5.31: Loop impedance measurement menu

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

- 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 5.29 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. 5.32: 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 B only).

Note:

- Measurement of the loop impedance (Z_{sRcd}) 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.

5.5 Line impedance and prospective short-circuit current (ZI/ 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:

$$I_{PFC} = \frac{U_n \times \text{scaling factor}}{R_{L-N(L)}}$$

where

| U _n | Voltage range |
|----------------|-----------------------------------|
| 115 V | 100 V ≤ U _{L-PE} < 160 V |
| 230 V | 160 V ≤ U _{L-PE} ≤ 264 V |
| 400 V | 264 V < U _{L-PE} ≤ 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 **ZI/ik (L-N/ L)** (line impedance) with the function selector switch. The following menu is displayed:

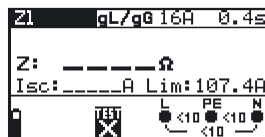


Fig. 5.33: Line impedance measurement menu

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

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 5.34 to perform phase-neutral or phase-phase line impedance measurement. Use the Help function if necessary.

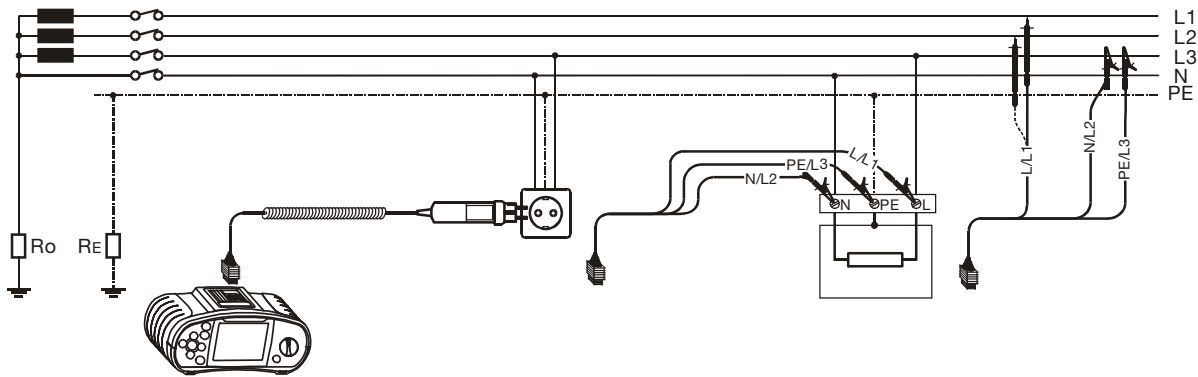


Fig. 5.34: Phase-neutral or phase-phase line resistance measurement

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).

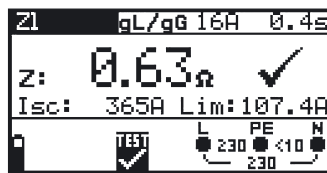


Fig. 5.35: Example of line impedance measurement results

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 B 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.

5.6 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 \odot function (phase rotation) with the function selector switch. The following menu is displayed:

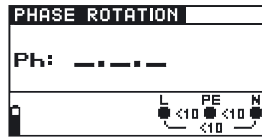


Fig. 5.36: Phase sequence test menu

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

Step 2 Follow the connection diagram shown in figure 5.37 to test phase sequence.

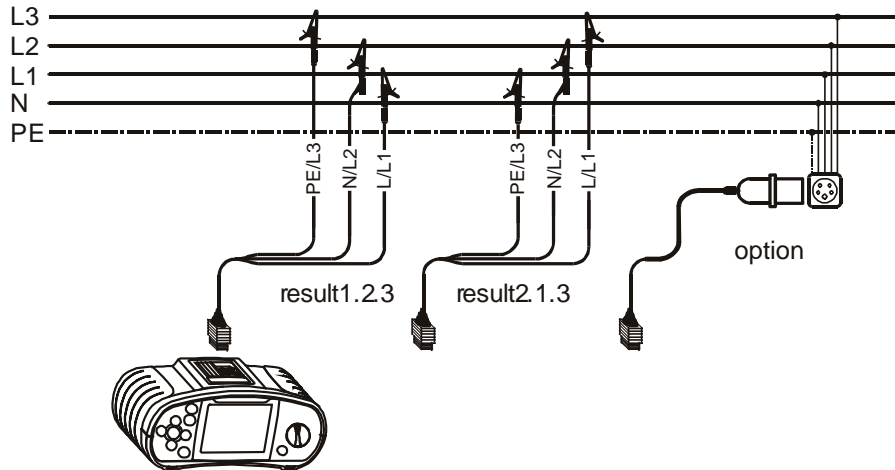


Fig. 5.37: Connection of universal test cable and optional three phase cable

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.

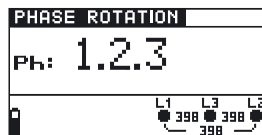


Fig. 5.38: Example of phase sequence test result

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 B only).

5.7 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:

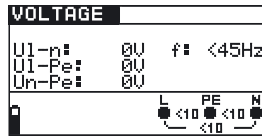


Fig. 5.39: Voltage and frequency measurement menu

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

Step 2 Follow the connection diagram shown in figure 5.40 to perform voltage and frequency measurement.

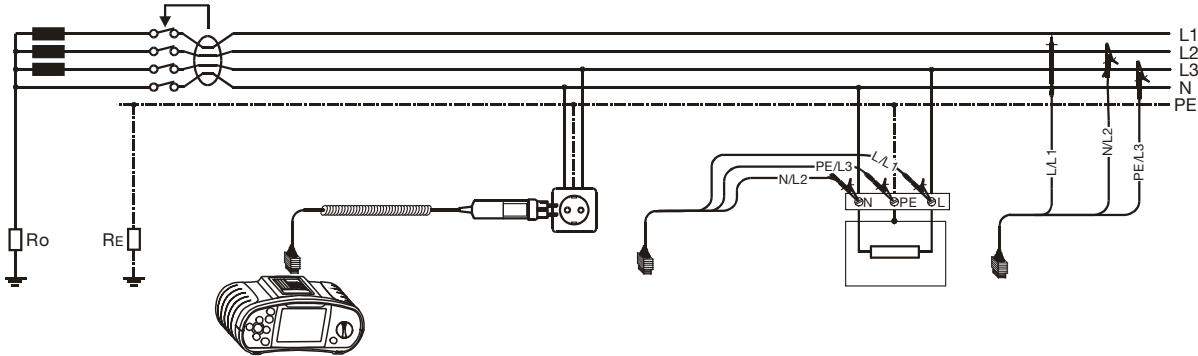


Fig. 5.40: Connection diagram

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

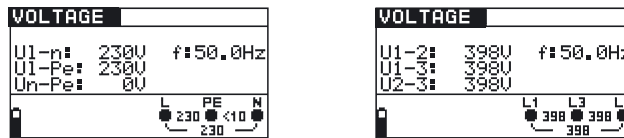


Fig. 5.41: Examples of voltage and frequency measurements

Displayed results:

- U1-n** Voltage between phase and neutral conductor
- U1-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 B only).

5.8 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 B.

Step 2 Follow the connection diagrams in figures 5.42 and 5.43 to test the PE terminal.

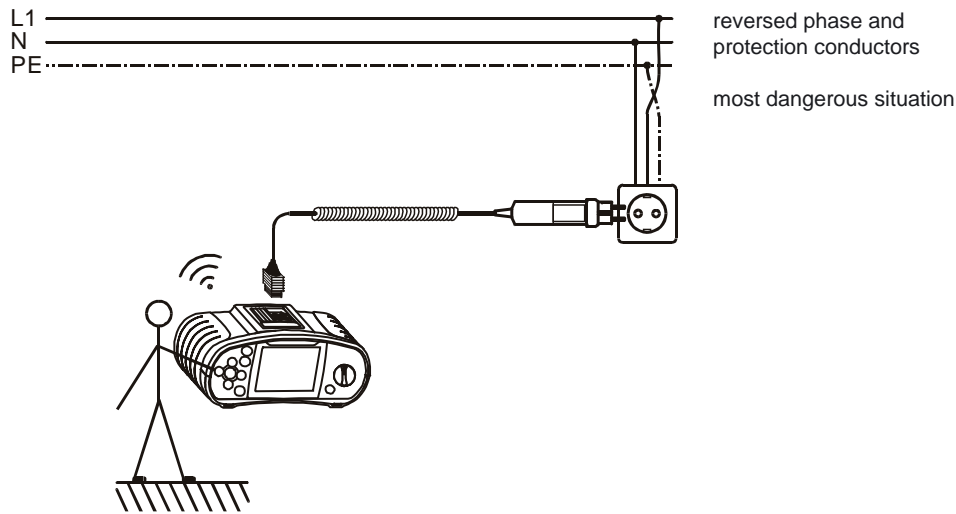


Fig. 5.42: Connection of plug cable and mains outlet with reversed L and PE conductors

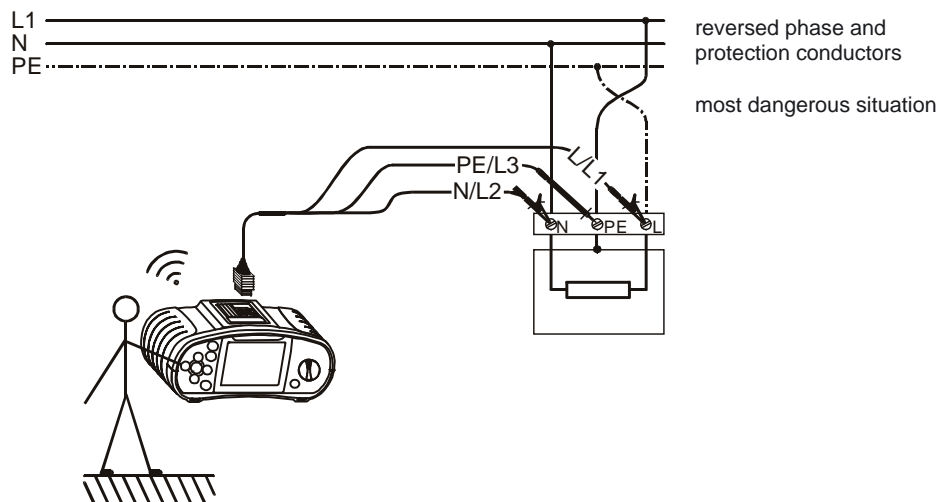


Fig. 5.43: Connection of universal test cable to load connection terminals with reversed L and PE conductors

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: $Z_{V/k}$ (L-N/L); $Z_{s/lk}$ (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.

5.9 Resistance to earth (R_E) (BENNING IT 120 B only)

The BENNING IT 120 B allows resistance to earth measurement using 3-wire measuring method (earthing set). 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 5.45).
- 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. 5.45).

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:

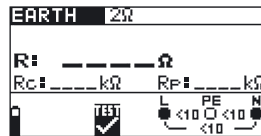


Fig. 5.44: Earth resistance measurement menu

Connect the measuring cables to the BENNING IT 120 B.

Step 2 Set the following measuring parameters and limit values:

- High limit resistance value

Step 3 Follow the connection diagram shown in figure 5.45 to perform resistance to earth measurement. Use the Help function if necessary.
(Measuring cables: H = black, S = green, E = blue)

S...potential equalisation panel

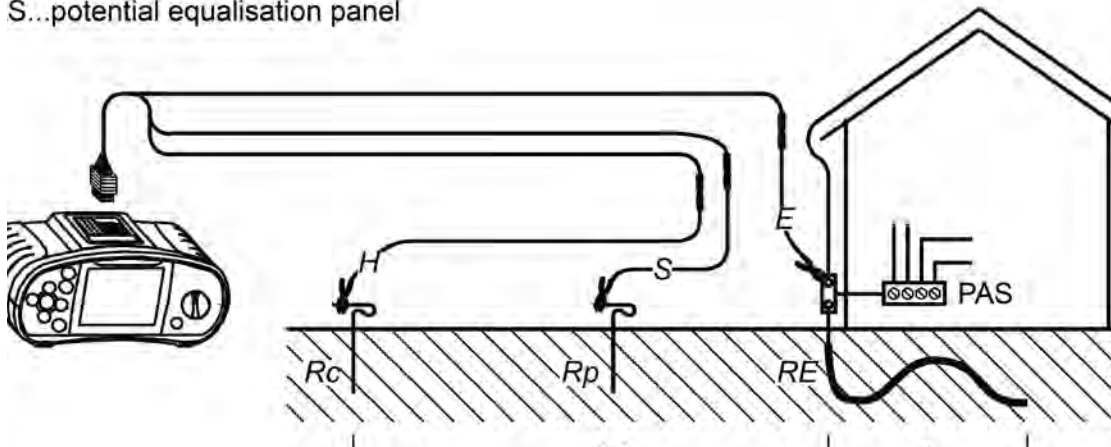


Fig. 5.45: Measurement with the earthing set – 20 m

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).

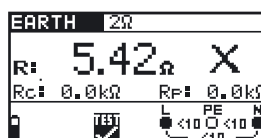


Fig. 5.46: Example of resistance to earth measurement results

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 “~V” will be displayed in the message field. The measurement results may be affected!

5.10 TRUE RMS current (A~) (BENNING IT 120 B 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. 5.47: TRUE RMS current measurement menu

Connect the current clamp to the BENNING IT 120 B.

Step 2 Follow the connection diagram shown in fig. 5.48 to perform the TRUE RMS current measurement. Use the **Help** function if necessary.

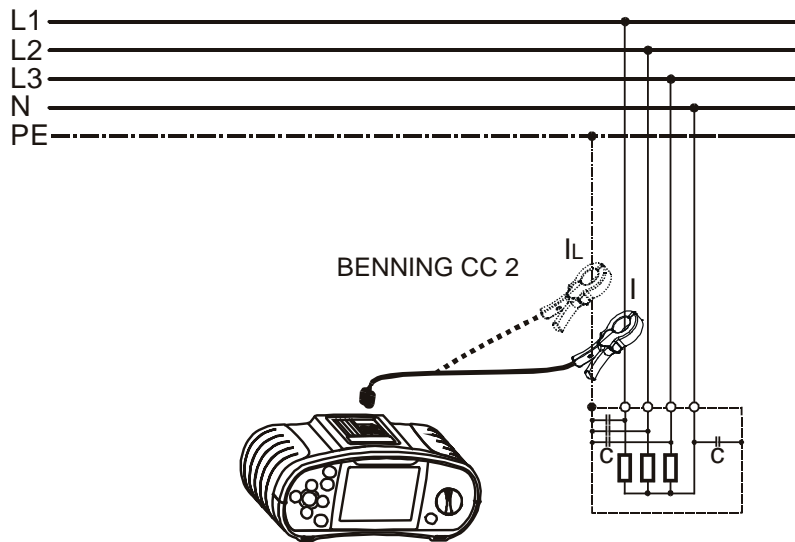


Fig. 5.48: Current clamp connection

- 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. 5.49: 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 $\hat{=}$ 20 A measuring current!

5.11 Illumination measurement (LUX) (BENNING IT 120 B only)

The illumination measurement can be performed with the appropriate luxmeter probes (BENNING Luxmeter type B). 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:

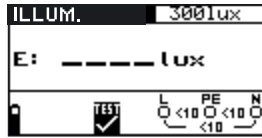


Fig. 5.50: Illumination measurement menu

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 5.51 to perform illumination measurement. Use the **Help** function if necessary.

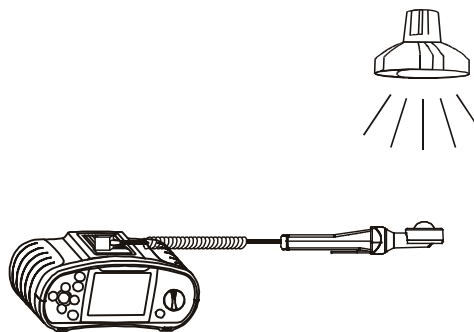


Fig. 5.51: Correct luxmeter probe positioning

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. 5.52: 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 B only).

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

6 Working with measurement results (BENNING IT 120 B 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).

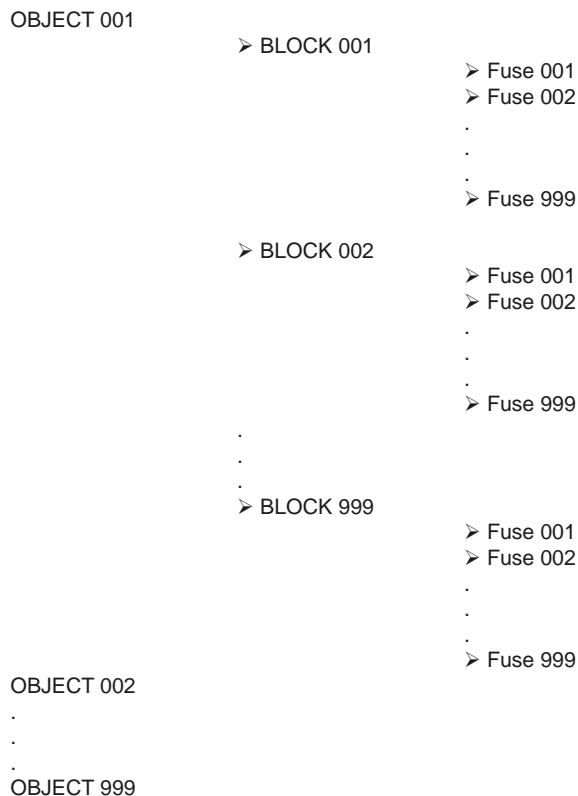


Fig. 6.1: Memory organisation pre-programmed in BENNING IT 120 B

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 \uparrow/\downarrow keys set the cursor to the OBJECT line (max. 999). Use the \leftarrow/\rightarrow keys to enter the desired element OBJECT xxx.

By using the \uparrow / \downarrow keys set the cursor to the BLOCK line (max. 999).
Use the \leftarrow / \rightarrow keys to enter the desired element BLOCK xx.

By using the \uparrow / \downarrow keys set the cursor to the FUSE line (max. 999).
Use the \leftarrow / \rightarrow 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:

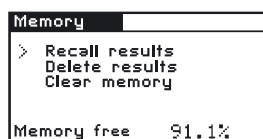


Fig. 6.3: Memory menu

How to recall saved results:

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

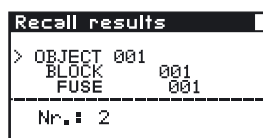


Abb. 6.4: Recall results menu

Step 2 By using the \uparrow / \downarrow keys set cursor to OBJECT line.
Use the \leftarrow / \rightarrow keys to enter the desired element OBJECT xx.

By using the \uparrow / \downarrow keys set cursor to BLOCK line.
Use the \leftarrow / \rightarrow keys to enter the desired element BLOCK xx.

By using the \uparrow / \downarrow keys set cursor to FUSE line.
Use the \leftarrow / \rightarrow 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 \uparrow / \downarrow keys.

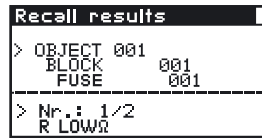


Fig. 6.5: Recall results menu

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

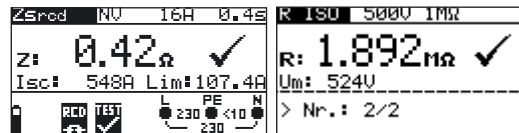


Fig. 6.6: Examples of recall results menu

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:

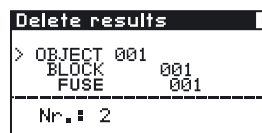


Fig. 6.7: Delete results menu

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 \uparrow / \downarrow keys set.

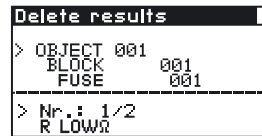


Fig. 6.8: Delete results menu

Use the \leftarrow / \rightarrow 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 \uparrow / \downarrow keys set cursor to DELETE RESULTS.
Press the TEST key, the following menu is displayed:

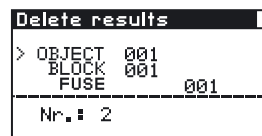


Fig. 6.9: Delete results menu

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

Step 2 By using the \uparrow / \downarrow keys set cursor to FUSE line. Use the \leftarrow / \rightarrow keys to enter the desired element FUSE xx.

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

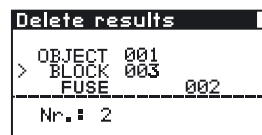


Fig. 6.10: Deleting results from the 3rd level

Continue with instructions under Step 3.

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

By using the \uparrow / \downarrow keys set cursor to OBJECT line. Use the \leftarrow / \rightarrow keys to enter the desired element OBJECT xxx

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

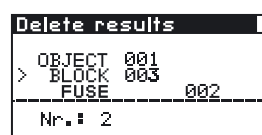


Fig. 6.11: Deleting results from the 2nd level

Continue with instructions under Step 3.

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

By using the \uparrow / \downarrow keys set cursor to OBJECT line. Use the \leftarrow / \rightarrow keys to enter the desired element OBJECT xxx

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

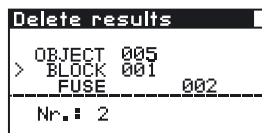


Fig. 6.12: Deleting results from the 1st level

Step 3 Use the \leftarrow / \rightarrow 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 \uparrow / \downarrow 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 B 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 B Software

The BENNING PC-Win IT 120 B 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 B 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 B software.

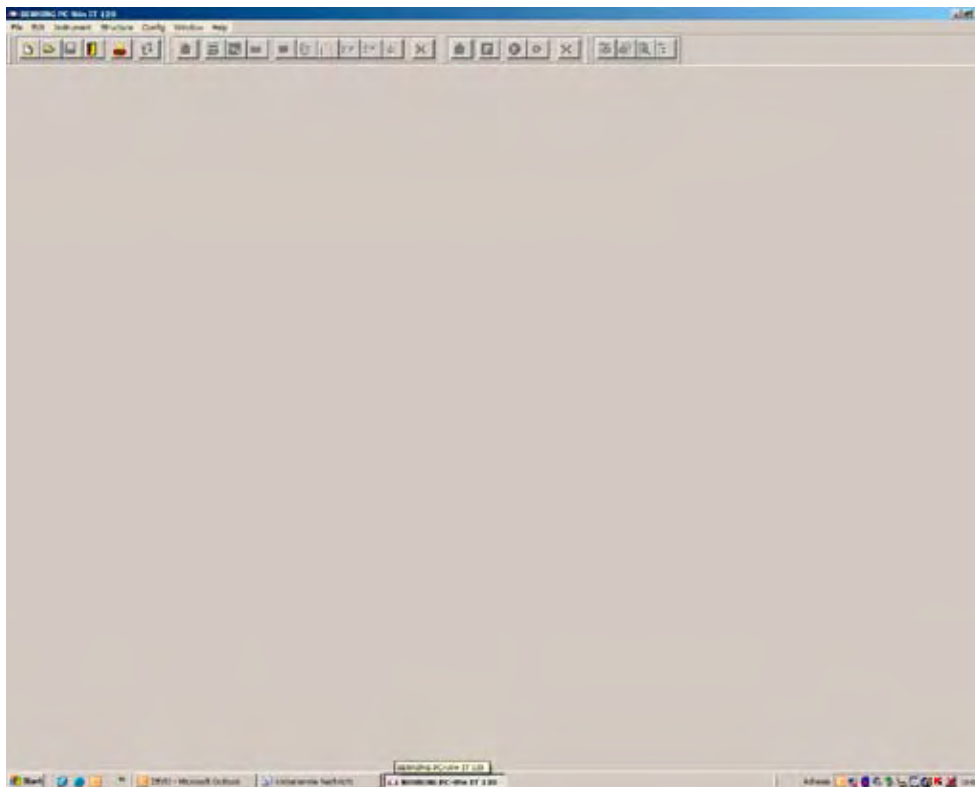



Fig. 7.1: BENNING PC-Win IT 120 B

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

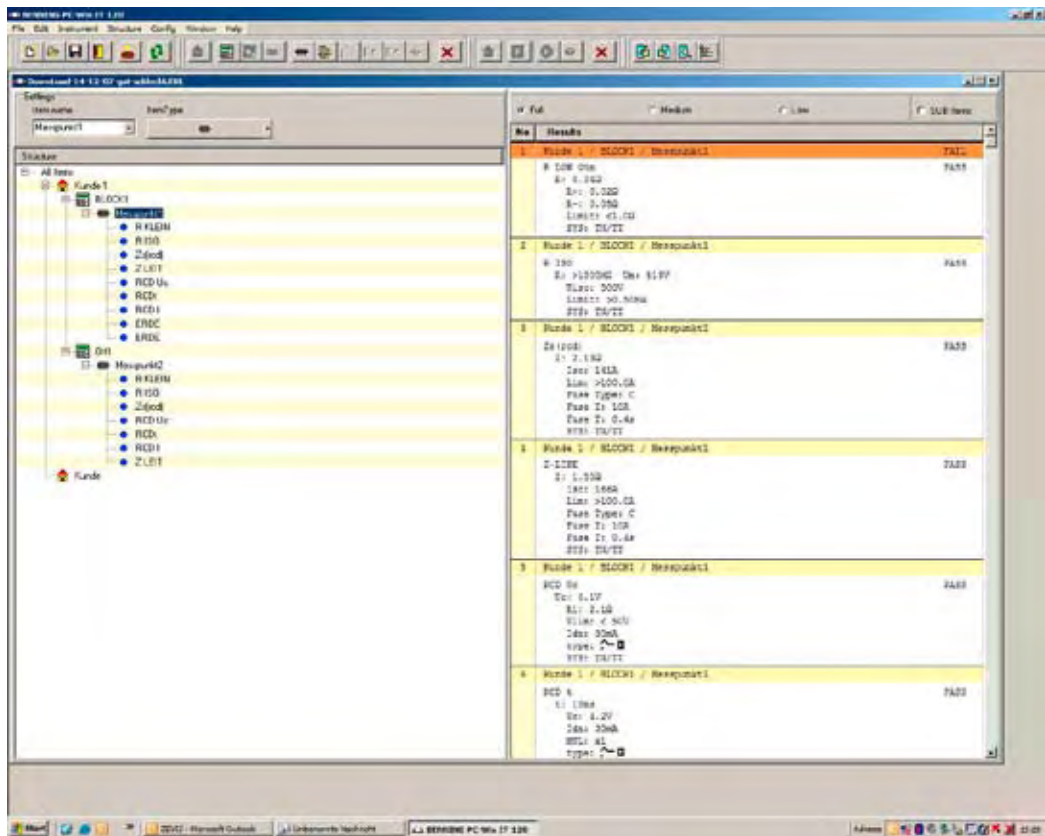


Fig. 7.2: Example of downloaded results

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 B.

- F1
M 0.315 A / 250 V, 20×5 mm, T.Nr.: 757211
This fuse protects internal circuitry of low Ω 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 B. There are no user replaceable components inside the BENNING IT 110/ BENNING IT 120 B, 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 Resistance/ continuity testing

9.2.1 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
Automatic polarity reversal of the test voltage

bis zu 5500

9.2.2 Continuity

| Measuring range (mA) | Resolution (mA) | Accuracy |
|----------------------|-----------------|-------------------------------|
| 0.0 - 99.9 | 0.1 | ± (5 % of reading + 3 digits) |
| 100 - 1999 | 1 | |

Open-circuit voltage
Short-circuit current
Test lead compensation

6.5 V_{DC} - 9 V_{DC}
max. 8.5 mA
up to 5 Ω

9.3 RCD

9.3.1 General data

Nominal residual current
Accuracy of
nominal residual current measurement
Test current shape
RCD type:
Test current starting polarity
Voltage range
RCD test current selection (r.m.s. value calculated to 20 ms) according to IEC 61009:

10 mA, 30 mA, 100 mA, 300 mA, 500 mA, 1000 mA
-0 / +0.1·I_Δ; I_Δ = I_{ΔN}, 2×I_{ΔN}, 5×I_{ΔN}
-0.1·I_Δ / +0; I_Δ = ½×I_{ΔN}
Sine-wave (AC type), pulsed (A type), smooth
direct current (B type)
general (G, non-delayed), selective (S, time-delayed)
0° or 180°
100 V - 264 V (45 Hz - 65 Hz)

| I _{ΔN} (mA) | I _{ΔN} × ½ | | | I _{ΔN} × 1 | | | I _{ΔN} × 2 | | | I _{ΔN} × 5 | | | RCD I _Δ | | |
|----------------------|---------------------|------|-----|---------------------|------|------|---------------------|------|-----|---------------------|-----|------|--------------------|---|----|
| | AC | A | B | AC | A | B | AC | A | B | AC | A | B | AC | A | B |
| 10 | 5 | 3.5 | 5 | 10 | 20 | 20 | 20 | 40 | 40 | 50 | 100 | 100 | ✓ | ✓ | ✓ |
| 30 | 15 | 10.5 | 15 | 30 | 42 | 60 | 60 | 84 | 120 | 150 | 212 | 300 | ✓ | ✓ | ✓ |
| 100 | 50 | 35 | 50 | 100 | 141 | 200 | 200 | 282 | 400 | 500 | 707 | 1000 | ✓ | ✓ | ✓ |
| 300 | 150 | 105 | 150 | 300 | 424 | 600 | 600 | 848 | *) | 1500 | *) | *) | ✓ | ✓ | ✓ |
| 500 | 250 | 175 | 250 | 500 | 707 | 1000 | 1000 | 1410 | *) | 2500 | *) | *) | ✓ | ✓ | ✓ |
| 1000 | 500 | 350 | 500 | 1000 | 1410 | *) | 2000 | *) | *) | *) | *) | *) | ✓ | ✓ | *) |

*) not available
Type AC: sinusoidal testing current
Type A: pulsating testing current
Type B: testing current is a smooth direct current

9.3.2 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. $0.5 \times I_{\Delta N}$ |
| 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 K Ω

9.3.3 Trip-out time

Measuring ranges according to EN61557

General (non-delayed) RCDs

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

Selective (time-delayed) RCDs

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

Test current $\frac{1}{2} \times I_{\Delta N}$, $I_{\Delta N}$, $2 \times I_{\Delta N}$, $5 \times I_{\Delta N}$
 The multiplier $5 \times I_{\Delta N}$ is not available for $I_{\Delta N} = 1000$ mA (FI/RCD of type AC) or $I_{\Delta N} \geq 300$ mA (FI/RCD of types A, B).
 The multiplier $2 \times I_{\Delta N}$ is not available for $I_{\Delta N} = 1000$ mA (FI/RCD of type A) or $I_{\Delta N} \geq 300$ mA (FI/RCD of type B).
 The multiplier $1 \times I_{\Delta N}$ is not available for $I_{\Delta N} = 1000$ mA (FI/RCD of type B).

9.3.4 Trip-out current

Measuring ranges according to EN61557

Trip-out current ($I_{\Delta N} = 10$ mA)

| Measuring range I_{Δ} | Resolution I_{Δ} | Accuracy |
|---|----------------------------|-------------------------------|
| $0.2 \times I_{\Delta N} - 1.1 \times I_{\Delta N}$ (AC type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} - 2.2 \times I_{\Delta N}$ (A type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} - 2.2 \times I_{\Delta N}$ (B type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |

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

| Measuring range I_{Δ} | Resolution I_{Δ} | Accuracy |
|---|----------------------------|-------------------------------|
| $0.2 \times I_{\Delta N} - 1.1 \times I_{\Delta N}$ (AC type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} - 1.5 \times I_{\Delta N}$ (A type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} - 2.2 \times I_{\Delta N}$ (B type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |

Measurement range according to EN61557-6

Trip-out measurement is not available for $I_{\Delta N} = 1000$ mA (RCD type B)

Trip-out time

| Measuring range (ms) | Resolution (ms) | Accuracy |
|----------------------|-----------------|----------|
| 0 - 300 (AC, A type) | 1 | ± 3 ms |
| 0 - 140 (B type) | 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 |

9.4 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)

Z_{srcd} 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 $I_{\Delta N} \geq 10 \text{ mA}$

Test current (at 230 V) max. 0.24 A (max. period 150 μs)

9.5 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 | $\pm(5\%$ 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 \div 19.99 | 0.01 | Consider accuracy of line resistance measurement |
| 20.0 \div 99.9 | 0.1 | |
| 100 \div 999 | 1 | |
| 1.00 kA \div 9.99 kA | 10 | |
| 10.0 \div 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)

9.6 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

9.7 Voltage and frequency

| Measuring range (V) | Resolution (V) | Accuracy |
|---------------------|----------------|--------------------------------------|
| 0 - 500 | 1 | $\pm(2\%$ des Ablesewerts +2 Digits) |

Nominal frequency range

45 Hz - 65 Hz

| Measuring range (Hz) | Resolution (Hz) | Accuracy |
|----------------------|-----------------|----------------|
| 45.0 \div 65.0 | 0.1 | ± 2 digits |

Nominal voltage range

10 V - 500 V

9.8 Online voltage monitor

| Measuring range (V) | Resolution (V) | Accuracy |
|---------------------|----------------|---------------------------------|
| 10 - 500 | 1 | $\pm(2\%$ 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.

9.9 Resistance to earth (BENNING IT 120 B only)

Measuring range according to EN61557-5: 0.04 Ω up to 1999 Ω

| Measuring range (Ω) | Resolution (Ω) | Accuracy |
|------------------------------|-------------------------|----------------------------------|
| 0.00 (0.02) \div 19.99 | 0.01 | \pm (2 % of reading +3 digits) |
| 20.0 \div 99.9 | 0.1 | |
| 100 \div 1999 | 1 | |

Auxiliary earth electrode resistance $R_{C_{max}}$ 100 $\times R_E$ or 50 k Ω (lower value)

Probe resistance $R_{P_{max}}$ 100 $\times R_E$ or 50 k Ω (lower value)

Additional errors at $R_{C_{max}}$ or $R_{P_{max}}$ \pm (10 % of reading + 10 digits)

Additional errors at 3 V noise voltage (50 Hz) \pm (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.

9.10 TRUE RMS CURRENT (BENNING IT 120 B only)

| Measuring range (A) | Resolution (A) | Accuracy |
|---------------------|----------------|----------------------------------|
| 0.0 \div 99.9 mA | 0.1 mA | \pm (5 % of reading +3 digits) |
| 100 \div 999 mA | 1 mA | \pm (5 % of reading) |
| 1.00 \div 19.99 A | 0.01 A | |

Maximum continuous input current 20 mA \triangleq 20 A meas. current!

Additional current clamp error has to be considered.

9.11 Illumination (BENNING IT 120 B only)

9.11.1 Illumination (BENNING Luxmeter type B)

| Measuring range (lux) | Resolution (lux) | Accuracy |
|-----------------------|------------------|----------------------------------|
| 0.01 \div 19.99 | 0.01 | \pm (5 % of reading +2 digits) |
| 20.0 \div 199.9 | 0.1 | |
| 200 \div 1999 | 1 | |
| 2.00 \div 19.99 k | 10 | |

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 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, CAT IV / 300 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 Fuse base tables

Low-voltage fuses (fuse-links) acc. to DIN EN 60269. VDE 0636 (e.g. I.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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
|--------------------------------|---------------------------|---------------------|--|

| | | | |
|----------------|-------|--------|---------|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

| Fuse, utilisation class / type | Fuse, total clearing time | Fuse, rated current | Prospective short-circuit current (A), low value |
|--------------------------------|---------------------------|---------------------|--|
| 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 |

11 Appendix B IT Systems

11.1 Applicable standards

EN 60364-4-41, EN 60364-6, EN 60364-7-710, BS 7671

11.2 Basic information

The IT system is an power supply network which is isolated from the protective conductor. It is an ungrounded power supply network. Either the network is not connected to earth directly or it is connected to earth via a relatively high impedance. It is mainly used in areas requiring addition protection against electrical accidents. A typical area of application are medical operating rooms.

Normally, the network is connected to earth via the high impedance and consists of the capacitances of the lines connected to earth as well as of the capacitances between the primary and secondary windings of the IT transformer. Occasionally, Y capacitors (EMC) are used in the mains area of the connected devices. The maximum leakage current can be limited by choosing an appropriate transformer as well as the laying of lines and choosing an optimum earthing with high impedance.

Depending on the area of application, additional impedance to earth can be generated as shown in figure 11.1 or by means of specific devices for charge control. The minimum impedance value should be 100 Ω .

An IT network offers additional protection against electrical accidents. If the insulation of a line towards the protective conductor fails due to device failures, incorrect use or improper proceeding, the network will continue to be safe, but will be converted into a TN/TT system. However, the occurrence of another fault would be dangerous. For this reason, the insulation must be monitored permanently and must be restored immediately after a failure has been detected.

In addition to other protective mechanisms, the IT system normally contains an insulation monitoring device (IMD) or a system which emits a warning, if the insulating resistance or the impedance value falls below the preset limiting value. The limiting value depends on the respective environment. A typical value for installations in medical rooms is 55 k Ω .

In some countries, it is not sufficient to monitor only the insulating resistance of the IT system. In this case, the network capacity must be continuously monitored as well.

IEC 60364-4-41 (©IEC): In IT systems, the live parts must be isolated from earth or must be connected to earth via a sufficiently high impedance. This connection can be made either at the neutral conductor, at the star point of the network or at an artificial star point. The latter can be connected directly to the earthing, if the resulting impedance to the earthing is high enough for the given system frequency. If there is no neutral conductor or star point available, the mains conductor can be connected to earth via a high impedance.

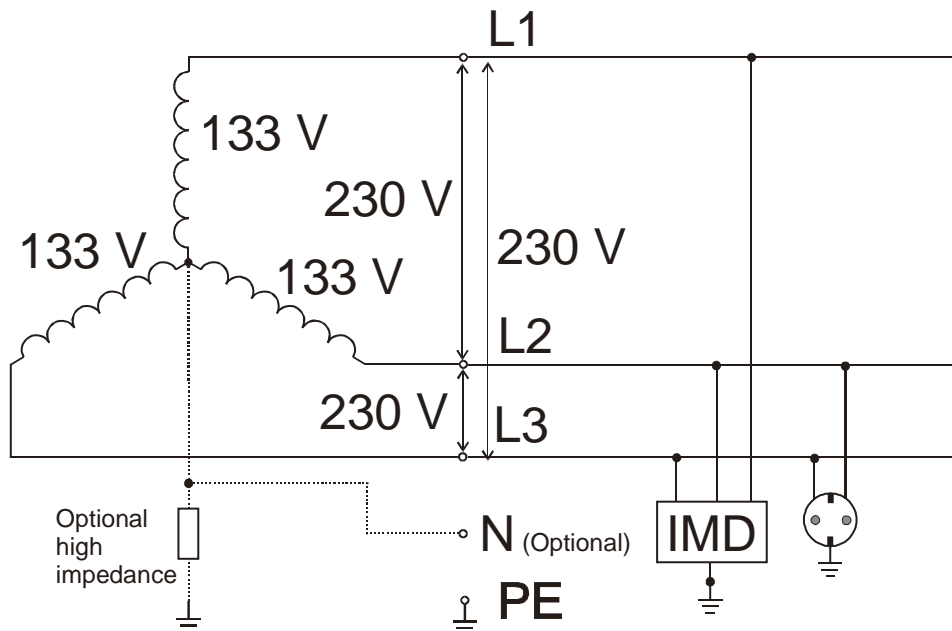


Figure 11.1: General IT System

- three-phase star connection, optionally delta connection
- optional neutral conductor
- single-phase connection is possible as well
- different mains voltages (not only three phases 230 V as shown above)
- The faulty connection of an arbitrary conductor to the protective conductor is considered to be the first fault and is admissible. However, the fault must be eliminated as rapidly as possible.
- IEC 60364-4-41: The following monitoring devices and protective devices can be used in IT systems:
 - insulation monitoring devices (IMDs),
 - residual current monitors (RCMs),
 - insulation fault detection systems,
 - overcurrent protection,
 - residual current protection devices (FI/RCD)

Note:

- If a residual current protection device (FI/RCD) is used, the triggering of this device in case of a first fault due to capacitive leakage currents cannot be excluded.

The test procedures for IT systems slightly differ from the normal test procedures for TN/TT systems.

11.3 Measuring guidelines

Before testing, the user has to select the IT system in the device. To know how to select the IT system, refer to chapter 4.5.1 „Selecting the Power Supply Network“. After having selected the IT system, the device can be used immediately. The selected IT system remains stored in the device even if the device is switched off.

The table below contains the functions of the BENNING IT 120 B as well as remarks concerning the compatibility with IT systems.

| IT system function | Remarks |
|---|--|
| Continuity test | |
| R low- Ω | independent of the selected power supply network |
| continuity test | |
| Insulation | independent of the selected power supply network |
| Line impedance | |
| line impedance | impedance Z_{L1-L2} . |
| prospective short-circuit current | I_{PSC} for nominal U_{L1-L2} . |
| Fault loop impedance | |
| fault loop impedance | |
| prospective fault current | |
| Voltage, frequency | symbols adapted to the IT system |
| Phase shift | automatic recognition of three-phase mains |
| FI / RCD functions | |
| contact voltage U_c | not applicable |
| tripping time | bridging, see figure 11.3 |
| tripping current | |
| automatic testing | |
| Resistance to earth | independent of the selected power supply network |
| PE conductor test key (TEST key) | active, but does not influence testing, if a voltage is detected |

11.3.1 Voltage

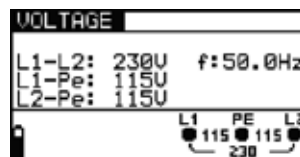


Figure 11.2: Example of voltage and frequency measurements

Shown results for a single-phase system:

L1-L2 voltage between external conductors,

L1-PE voltage between external conductor 1 and protective conductor,

L2-PE voltage between external conductor 2 and protective conductor.

11.3.2 Line impedance

For further information, please refer to chapter 5.5 „Line impedance and prospective short-circuit current“. The measuring method is the same, but the indication of the terminal voltage corresponds to the IT system.

11.3.3 FI/RCD testing

The FI/RCD test is carried out in the same way as it is done in a TN/TT system (see chapter 5.3 „Residual current protection devices (FI/RCD)“). However, there is the following exception:

- The contact voltage measurement is irrelevant.

The test circuit with bridging should correspond to the circuit shown in figure 11.3.

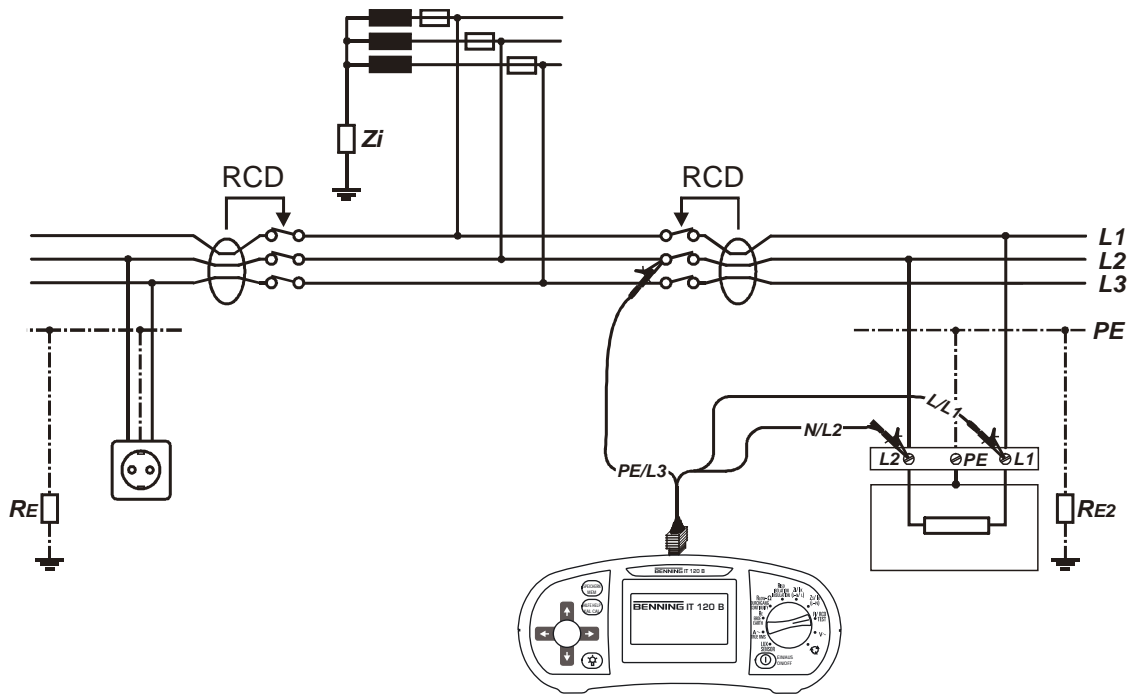


Figure 11.3: FI/RCD test in an IT system

11.3.4 First fault leakage current (ISFL)

The ISFL measurement is carried out in order to measure the maximum current which could flow from the tested line into the protective conductor. This current flows through the insulating resistance and the insulation reactive impedance (capacitive) between the protective conductor and the other conductors.

How to measure the fault current in case of a first fault:

Step 1 First select the ISOLATION/ INSULATION function by means of the function selector switch. Then, select the „ISFL (first fault current)“ by means of the ▲/▼ keys. The following menu is displayed:

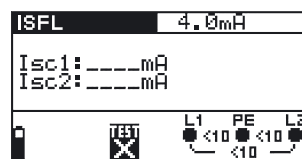


Figure 11.4: Measuring menu for fault current in case of a first fault

Connect the test cable to the BENNING IT 120 B.

Step 2 Set the following limiting value:
- upper current limit for the first fault

Step 3 Connect the test cable to the component to be tested. For carrying out the fault current measurement for the first fault, follow the connection plan shown in figure 11.5. Please use the help function, if necessary.

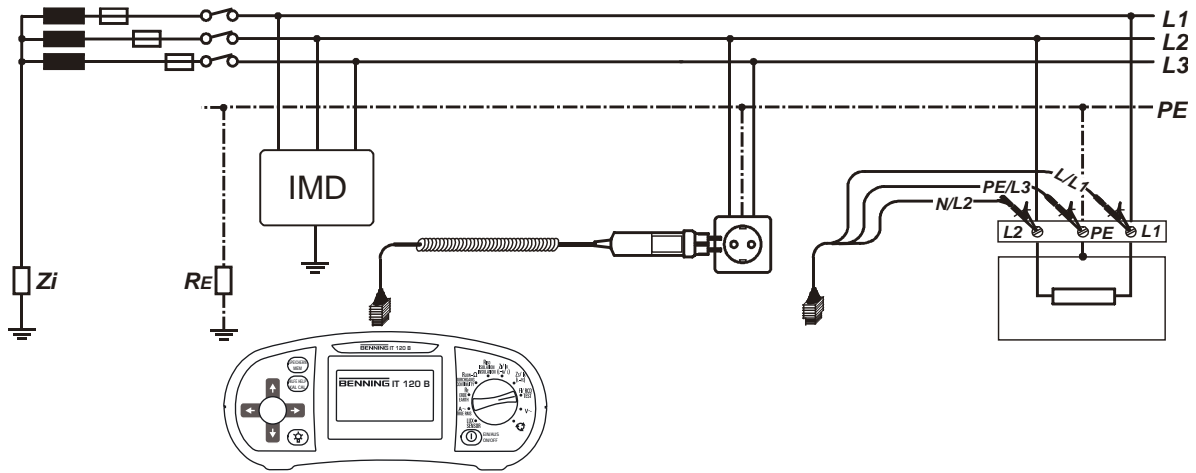


Figure 11.5: Connection of test commander and universal test cable

Step 4 Before measuring, please observe the warnings displayed and the online voltage/ terminal monitor. If you do not observe any problems, press the TEST key. After the measurement, the measuring results are displayed together with a PASS/ FAIL information (if applicable).



Figure 11.6: Example of a first fault current measuring result

Displayed results:

I_{SC1} first fault current between L1 and the PE conductor
 I_{SC2} first fault current between L2 and the PE conductor

If required, it is possible to save the displayed measuring results. Please refer to chapter 6.1 for further information. „Saving measuring results“.

11.4 Technical data

Here, only technical data are listed which differ from the data in chapter 9.

11.4.1 First fault leakage current (ISFL)

| Measuring range (mA) | Resolution (mA) | Accuracy |
|----------------------|-----------------|-------------------------------|
| 0.0 - 9.9 | 0.1 | ± (5 % of reading + 3 digits) |
| 10 - 19 | 1 | ± (5 % of reading) |

measuring resistance

approx. 1000 Ω

12 Appendix C Power Supply Network with Lower Voltage

12.1 Applicable standards

BS7671

12.2 Basic information

If an integrated protection against electrical accidents is required, but no safety extra-low voltage is used, it is necessary to use specific power supply networks. For this purpose, it is possible to use power supply networks with lower voltage and earthing.

For a nominal voltage of 110 V, two options are possible:

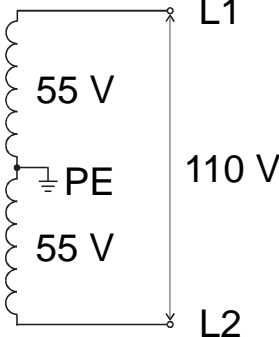
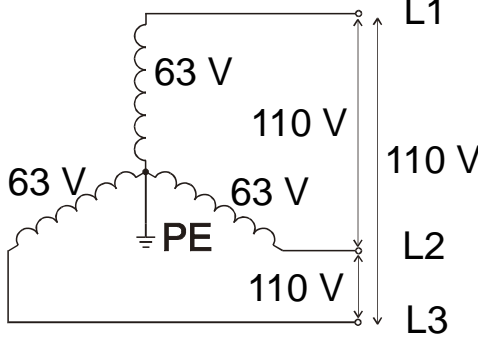
| | |
|---|--|
|  |  |
| <ul style="list-style-type: none"> - single-phase with center tap, connected to the protective conductor (i.e. 2 x 55 V) | <ul style="list-style-type: none"> - three-phase star connection with center tap, connected to the protective conductor (i.e. 3 x 63 V) |
| <ul style="list-style-type: none"> - no neutral conductor | <ul style="list-style-type: none"> - no neutral conductor |

Figure 12.1: General power supply networks with lower voltage

12.3 Measuring guidelines

Before testing, the user has to select the power supply network with lower voltage in the device. To know how to select the power supply network with lower voltage, refer to chapter 4.4.1 „Settings of the Power Supply Network“. After having selected the power supply network with lower voltage, the device can be used immediately. The selected power supply network remains stored in the device even if the device is switched off.

The table below lists the functions of the BENNING IT 120 B intended for testing and measuring of power supply networks. It also contains remarks on compatibility with regard to power supply networks with lower voltage.

| Functions for power supply networks with lower voltage | Remarks |
|--|--|
| Continuity test | |
| R low-Ω | independent of the selected power supply network |
| continuity test | |
| Insulation | independent of the selected power supply network |
| Line resistance | |
| line resistance | resistance RL1-L2. |
| prospective short-circuit current | I_{PSC} for $U_{L1-L2} = 110 \text{ V}$ |

| | |
|---|--|
| Fault loop resistance | |
| fault loop resistance | both fault loops, R1 (L1-PE) and R2 (L2-PE) |
| prospective fault current | I_{SC1} and I_{SC2} for both fault loops |
| Voltage, frequency | symbols adapted to a power supply network with lower voltage |
| Phase shift | automatic recognition of three-phase mains |
| FI/RCD functions | |
| contact voltage U_c | for both options, U1 (L1-PE) and U2 (L2-PE) |
| tripping time | maximum nominal differential current is limited to 1 A |
| tripping current | |
| automatic testing | |
| Resistance to earth | independent of the selected power supply network |
| PE conductor test key (TEST key) | deactivated |

12.3.1 Voltage

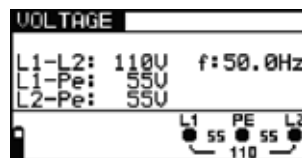


Figure 12.2: Example of voltage and frequency measurements

Displayed results for a single-phase system:

L1-L2 voltage between external conductors,

L1-PE voltage between external conductor 1 and protective conductor,

L2-PE voltage between external conductor 2 and protective conductor.

12.3.2 FI/RCD testing

The normal maximum FI/RCD testing current is 1 A RMS (peak current 1.4 A) and can only be reached, if the fault loop resistance is below 1 Ω .

Tests are carried out automatically for both combinations (L1-PE and L2-PE).

For each individual test result, the corresponding indication is shown.

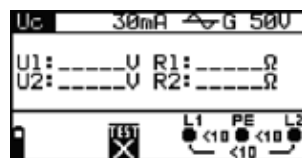


Figure 12.3: FI/RCD contact voltage test

12.3.3 Line resistance and prospective short-circuit current

The measured resistance represents the phase-to-phase resistance (R_{L1-L2}). The nominal voltage for calculating I_{PSC} is set to 110 V.

The nominal voltage range for measuring the line resistance is 90 V to 121 V. If the input voltage is outside this range, this is displayed on the online voltage/ terminal monitor together with the \times symbol.

12.3.4 Loop resistance and prospective fault current

The definition of the nominal voltage for calculating I_{PFC} is modified as follows:

- 55 V for selection of a single-phase center-tapped network,
- 63 V for selection of a three-phase network.

The test can be carried out for both combinations (L1-PE and L2-PE). For each individual test result, the corresponding indication is shown.

Nominal input voltages:

| Nominal input voltage U_N | Voltage range |
|-----------------------------|-----------------------------|
| single-phase network, 55 V | (44 V \leq U \leq 61 V) |
| three-phase network, 63 V | (56 V \leq U \leq 70 V) |

If the input voltage is outside this range, this is displayed on the online voltage / terminal monitor together with the \times symbol.

12.4 Technical data

Here, only technical data are listed which differ from the data in chapter 9.

12.4.1 FI/RCD Testing

General data

| | |
|---|---|
| Nominal fault current | 10 mA, 30 mA, 100 mA, 300 mA, 500 mA, 1000 mA |
| Accuracy of the nominal fault current | 0 / + 0.1 $\times I_{\Delta}$; $I_{\Delta} = I_{\Delta N}$, $2 \times I_{\Delta N}$, $5 \times I_{\Delta N}$ - 0.1 I_{Δ} / + 0; $I_{\Delta} = \frac{1}{2} \times I_{\Delta N}$ |
| Maximum nominal differential current for the specified accuracy | 1000 mA für $I_{\Delta N}$ 500 mA für $2 \times I_{\Delta N}$ 100 mA für $5 \times I_{\Delta N}$ |
| Maximum testing current | 1 A (for Z-LOOP < 1 Ω) |
| Wave form of the testing current | sine waves (AC), pulsating (A) |
| DC shift for pulsating testing current | 6 mA (typical) |
| Type of FI/RCD | standard (G, undelayed), selective (S, delayed) |
| Initial polarity of the testing current | 0° or 180 °C |
| Nominal input voltage | 55 V / 63 V (45 Hz \div 65 Hz) |

Contact voltage

In compliance with EN61557-6, the measuring range for the limiting contact voltage of 25 V goes from 3.0 V to 32.6 V.

In compliance with EN61557-6, the measuring range for the limiting contact voltage of 50 V goes from 3.0 V to 66.0 V.

| Measuring range (V) | Resolution (V) | Accuracy |
|---------------------|----------------|---------------------------------------|
| 0.0 - 9.9 | 0.1 | (- 0 %/ + 15 % of reading + 2 digits) |
| 10.0 - 99.9 | 0.1 | (- 0 %/ + 15 % of reading) |

Under standard conditions, the accuracy shall apply for one year. The temperature coefficient outside these limiting values is +1 digit.

| | |
|-----------------|--------------------------------|
| Testing current | max. $0.5 \times I_{\Delta N}$ |
|-----------------|--------------------------------|

Contact voltage limiting value 25 V or 50 V
 The contact voltage is calculated relating to $I_{\Delta N}$ (standard) or $2 \times I_{\Delta N}$ (selective).

For the contact voltage, the fault loop resistance is calculated as follows:

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

Tripping time

The entire measuring range complies with the requirements specified in EN61557-6. The specified accuracies apply to the entire operating range.

Standard FI/RCD (undelayed)

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

Selective FI/RCD (delayed)

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

Testing current $\frac{1}{2} \times I_{\Delta N}$, $I_{\Delta N}$, $2 \times I_{\Delta N}$, $5 \times I_{\Delta N}$
 $5 \times I_{\Delta N}$ does not apply to $I_{\Delta N} \geq 100$ mA (FI/RCD of types AC, A)
 $2 \times I_{\Delta N}$ does not apply to $I_{\Delta N} \geq 500$ mA (FI/RCD of type AC) or $I_{\Delta N} \geq 300$ mA (FI/RCD of type A)
 $1 \times I_{\Delta N}$ does not apply to $I_{\Delta N} \geq 1000$ mA (FI/RCD of type AC) or $I_{\Delta N} \geq 500$ mA (FI/RCD of type A)

Tripping current

Tripping current ($I_{\Delta N} = 10$ mA)

The measuring range complies with the requirements specified in EN61557-6. The specified accuracies apply to the entire operating range.

| Measuring range I_{Δ} | Resolution I_{Δ} | Accuracy |
|--|----------------------------|-------------------------------|
| $0.2 \times I_{\Delta N} \div 1.1 \times I_{\Delta N}$ (AC type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} \div 2.2 \times I_{\Delta N}$ (A type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |

Tripping current ($I_{\Delta N} \geq 30$ mA)

Der Messbereich entspricht den Anforderungen von EN61557-6. Die angegebenen Genauigkeiten gelten für den gesamten Betriebsbereich.

| Measuring range I_{Δ} | Resolution I_{Δ} | Accuracy |
|--|----------------------------|-------------------------------|
| $0.2 \times I_{\Delta N} \div 1.1 \times I_{\Delta N}$ (AC type) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |
| $0.2 \times I_{\Delta N} \div 1.5 \times I_{\Delta N}$ (A type, $I_{\Delta N} \geq 30$ mA) | $0.05 \times I_{\Delta N}$ | $\pm 0.1 \times I_{\Delta N}$ |

Tripping time

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

Contact voltage

| Measuring range (V) | Resolution (V) | Accuracy |
|---------------------|----------------|-------------------------------------|
| 0.0 ÷ 9.9 | 0.1 | (-0 %/ +15 % of reading + 2 digits) |
| 10.0 ÷ 99.9 | 0.1 | (-0 %/ +15 % of reading) |

12.4.2 Loop resistance and prospective fault current

Rs sub-function

In compliance with EN61557-3, the measuring range is between 0.32 Ω ÷ 1999 Ω.

| Measuring range (Ω) | Resolution (Ω) | Accuracy |
|---------------------|----------------|------------------------------|
| 0.00 ÷ 19.99 | 0.01 | ±(5 % of reading + 5 digits) |
| 20.0 ÷ 99.9 | 0.1 | |
| 100 ÷ 1999 | 1 | |

*) The accuracy shall apply provided that the mains voltage is stable during measurement.

Prospective fault current (calculated value)

| Measuring range (A) | Resolution (A) | Accuracy |
|---------------------|----------------|---|
| 0.00 ÷ 19.99 | 0.01 | Please observe the accuracy of the fault loop resistance measurement. |
| 20.0 ÷ 99.9 | 0.1 | |
| 100 ÷ 999 | 1 | |
| 1.00 k ÷ 9.99 k | 10 | |
| 10.0 ÷ 24.4 k | 100 | |

Calculation of I_{PFC}

$$I_{PFC} = U_N \times k_{SC} / Z_{L-PE}$$

$U_N = 55 \text{ V}$, (44 V ≤ U < 61 V) for the selected single-phase network (55 V)
 $U_N = 63 \text{ V}$, (56 V ≤ U < 70 V) for the selected three-phase network (63 V)

Testing current

1.9 A (10 ms)

Nominal input voltage

55 V / 63 V (45 Hz ÷ 65 Hz)

Test options

L1-PE and L2-PE

Trip protection sub-function **Rs(rcd)**

In compliance with EN61557, the measuring range is between 0.85 Ω ÷ 1999 Ω.

| Measuring range (Ω) | Resolution (Ω) | Accuracy |
|---------------------|----------------|--------------------------------|
| 0.00 ÷ 19.99 | 0.01 | ±(10 % of reading + 15 digits) |
| 20.0 ÷ 99.9 | 0.1 | ±(10 % of reading) |
| 100 ÷ 1999 | 1 | ±(10 % of reading) |

*) The accuracy can be affected by strong noise of the mains voltage.

Prospective fault current (calculated value)

| Measuring range (A) | Resolution (A) | Accuracy |
|---------------------|----------------|---|
| 0.00 ÷ 19.99 | 0.01 | Please observe the accuracy of the fault loop resistance measurement. |
| 20.0 ÷ 99.9 | 0.1 | |
| 100 ÷ 999 | 1 | |
| 1.00 k ÷ 9.99 k | 10 | |
| 10.0 ÷ 24.4 k | 100 | |

Calculation of I_{PFC}

$$I_{PFC} = U_N \times k_{SC} / Z_{L-PE}$$

$U_N = 55 \text{ V}$, (44 V ≤ U < 61 V) for the selected single-phase network (55 V)
 $U_N = 63 \text{ V}$, (56 V ≤ U < 70 V) for the selected three-phase network (63 V)

Nominal input voltage

55 V / 63 V (45 Hz ÷ 65 Hz)

Test options

L1-PE and L2-PE

No tripping of the FI/RCD

12.4.3 Line resistance and prospective short-circuit current

Line resistance

In compliance with EN61557-3, the measuring range is between 0.25 Ω ÷ 1999 Ω.

| Measuring range (Ω) | Resolution (Ω) | Accuracy |
|---------------------|----------------|------------------------------|
| 0.00 ÷ 19.99 | 0.01 | ±(5 % of reading + 5 digits) |
| 20.0 ÷ 99.9 | 0.1 | |
| 100 ÷ 1999 | 1 | |

*) The accuracy can be affected by strong noise of the mains voltage.

Prospective short-circuit current (calculated value)

| Measuring range (A) | Resolution (A) | Accuracy |
|---------------------|----------------|---|
| 0.00 ÷ 19.99 | 0.01 | Please observe the accuracy of the line resistance measurement. |
| 20.0 ÷ 99.9 | 0.1 | |
| 100 ÷ 999 | 1 | |
| 1.00k ÷ 9.99k | 10 | |
| 10.0 ÷ 24.4k | 100 | |

Calculation of I_{PFC}

$$I_{PFC} = U_N \times k_{SC} / Z_{L-N}$$

$U_N = 110 \text{ V}, (90 \text{ V} \leq U < 121 \text{ V})$

Testing current

3.1 A (10 ms)

Nominal input voltage

110 V (45 Hz ÷ 65 Hz)

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