MI 3340
Application notes

Ver 1.1.2. Code No. 20 753 446

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Introduction

The new standards EN 50678 and EN 50699 for electrical equipment testing cover additional device types compared to previous editions. This document shows appropriate testing procedures for them. Certain applications require associated optional accessories.

This application note shall not be considered a substitute for the standards **EN 50699** and **EN 50698**, which were used as normative references in the preparation of this document.
For any clarification or additional information concerning the content of this document, contact **Metrel d.o.o.**.
This document is intended to support users of Metrel instruments in the proper selection of test procedures, configuration of test parameters, and correct connection of the test equipment when performing the described measurements.

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1. Mode 2 EV cables testing using A 1632

A 1632 eMobility Analyser is a multi-functional, portable, battery or mains-powered test adapter intended for safety and functional testing of EVSE and charging cables for EVs.

Available functions and features of eMobility Analyser relevant to these applications:

- Simulation of an electrical vehicle's CP and PP circuits;
- Simulation of errors on the CP circuit and input mains;
- Accessible Inputs/Outputs for connection of safety testers;
- Diagnostic test for verification of proper operation of the CP circuit;
- Communication monitoring between the charging station and the EV;
- Bluetooth communication with Metrel safety testers.

I. Mode 2 EV Cable testing (3-phase)

Due to the steady growth of the number of electric vehicles on public roads, there has been a consequent growth of public and private charging stations. Charging stations and charging cables are subject to wear and ageing due to frequent use and environmental factors. The equipment shall be regularly inspected and tested using the following procedures to avoid any defects critical to user safety.

After the appropriate electrical examination has been carried out and any defects found have been eliminated, the required safety for the user is restored.

EV cables must be recurrently tested according to EN 50699. Additional requirements may be specified in other statutory ordinances or regulations

The rules of technology that were valid at the time of the first installation of the tested electrical equipment or system must be considered.

According to EN 50699, the electrical safety and conformity of further protective measures shall be evaluated, as well as the complete functionality of electrical equipment.

List of Applicable Tests, Limits and Results

Measurements according to the German guideline for E-Mobility		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Functional inspection		
Continuity of protective conductor	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance of the protective conductor to the neutral and phase conductor	Insulation resistance measurement	≥ 1.0 MΩ (secondary side)
Protective conductor current	Measurement with a residual current clamp	≤ 3,5 mA
Compliance with tripping current PRCD	Trip test PRCD	IΔNa < IΔN
Proximity Pilot resistor check (Optional)		

Table 1_Applicable measurements

Switch CP STATE	**Vehicle status**	**Result**
Status A	Vehicle not connected (idle state).	Yes / No
Status B	Vehicle connected but not ready to charge.	Yes / No
Status C	Vehicle connected and ready for charging, charging area ventilation not required.	Yes / No

Table 2_Applicable functional statuses

ERRORS	**Applied to:**	**Test condition**
L / L1op	INPUT	L/L1 conductor opened
L / L2op		L/L2 conductor opened
L / L3op		L/L3 conductor opened
Nop		N conductor opened
PEop		PE conductor opened
L ⇄ PE		L/L1 and PE conductors crossed*
U_{EXT} (PE)		External voltage on PE (on input side)*
PEop	OUTPUT	PE opened / EVSE output should de-energise within 100 ms.
CPsh		CP - PE shorted / EVSE output should de-energise within 3 s.
sh		CP diode shorted / EVSE output should de-energise within 3 s.

Table 3_Applicable errors

Visual inspection

Scope of test:

The visual inspection shall detect external defects and, if possible, determine suitability of the equipment for the environment.

Figure 1_Visual inspection

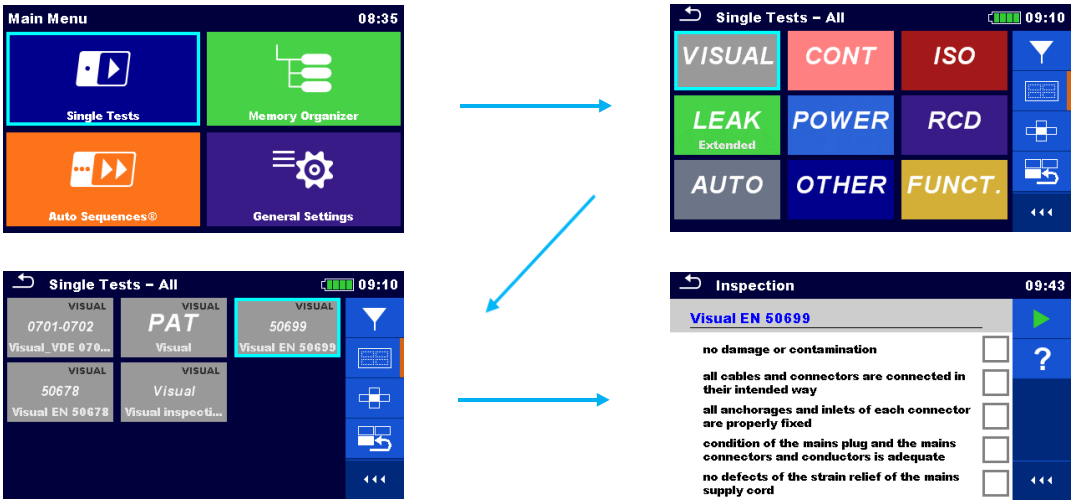

Figure 2_Visual inspection setup

Special attention shall be paid to the following:

- Check that there is no damage or contamination.
- Check that the connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the mains lead cord grip.
- Check for damage to the housing and protective cover that could expose live or dangerous parts.
- Check for signs of overload or overheating.

- Check for signs of corrosion that impact protective measures and improper ageing.
- Check functionality of the switches, control and setup equipment.
- Check for defects due to the bending of the cord.

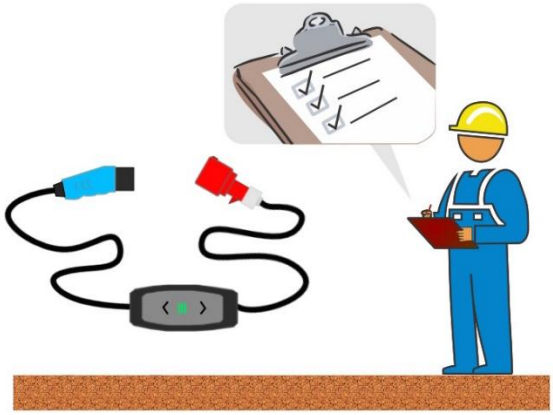

Figure 3_Visual inspection

Functional test

Scope of test:

Functional test of a Mode 2 EV cable ensures that the cable operates properly and safely when charging an electric vehicle and helps assess its overall condition and functionality.

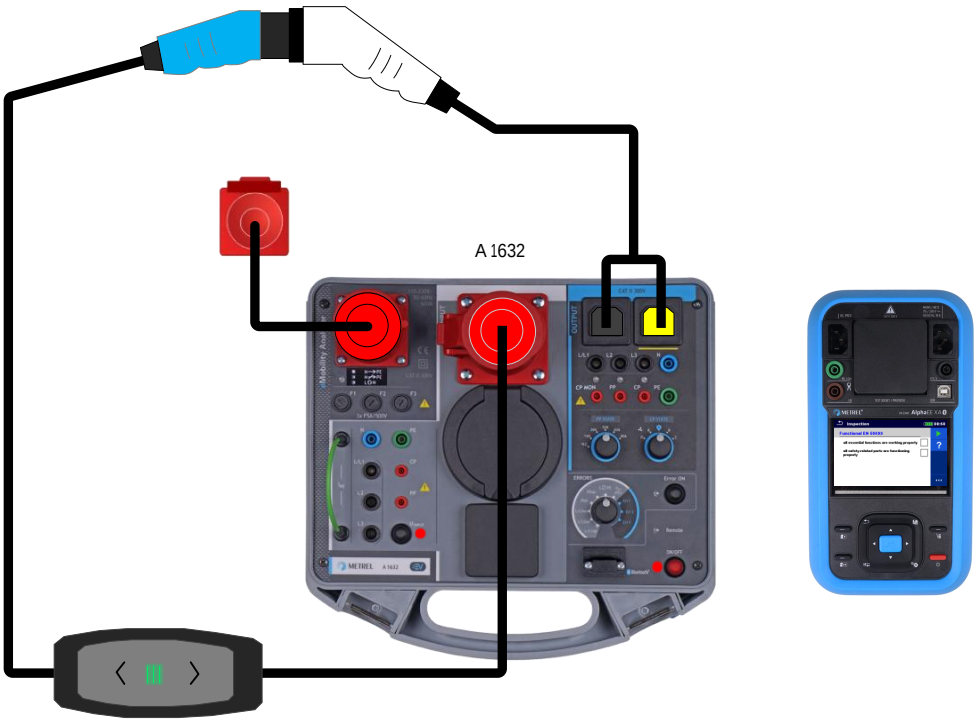

Figure 4_Mode 2 cable connection

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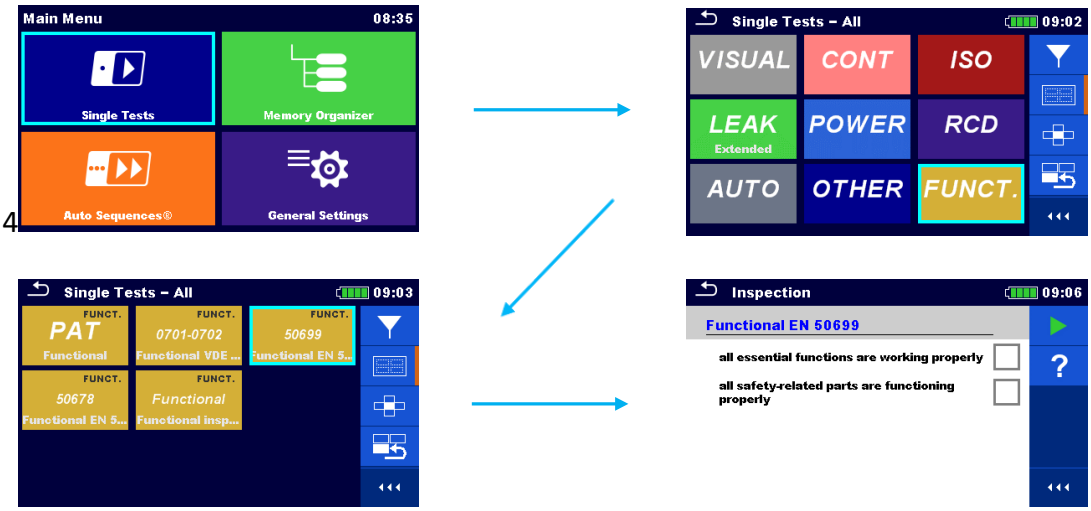


Figure 5_Functional inspection setup

Measurement procedure:

- EV stations with ventilation are mostly obsolete, and the relevant steps can be disregarded.
- Connect the charging cable to the eMobility Analyser (A 1632) (see Figure 4_Mode 2 cable connection).
- Follow the test procedure in the Table 4_Vehicle status.
- Check the response of the tested charging cable.

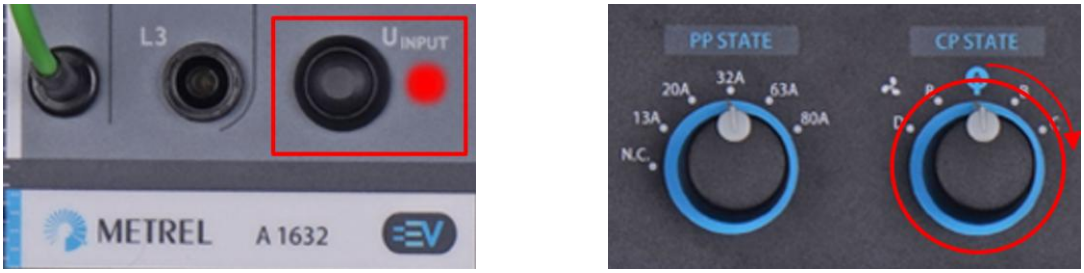


Figure 6_A 1632 keys and switches

*Switch between steps dynamically from A → C. The delay between switching depends on the design of the EVSE.					
Step	**Key UINPUT**	**Switch CP STATE ***	**Vehicle status**	**Mode 2 cable condition**	**Result**
1.	UINPUT = **On**	Not connected **Status A**	Vehicle not connected (idle state)	Observe the manufacturer's information for proper operation.	Yes / No
2.	UINPUT = **On**	Connected **Status B**	Vehicle connected but not ready to charge.	Observe the manufacturer's information for proper operation.	Yes / No
3.	UINPUT = **On**	Charging **Status C**	Vehicle connected and ready for charging, charging area ventilation not required.	Observe the manufacturer's information for proper operation.	Yes / No
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.					

Table 4_Vehicle status

Once confirmed that the Mode 2 cable can be set to status C and it is properly operating, proceed with electrical safety testing.

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340 & A 1632 to test the PE conductor between the input and the output terminal on the cable and any accessible earthed parts if present.

Some Mode 2 cables need to be set to the charging position to evaluate the PE conductor in the cable. Observe the manufacturer's information for proper operation.

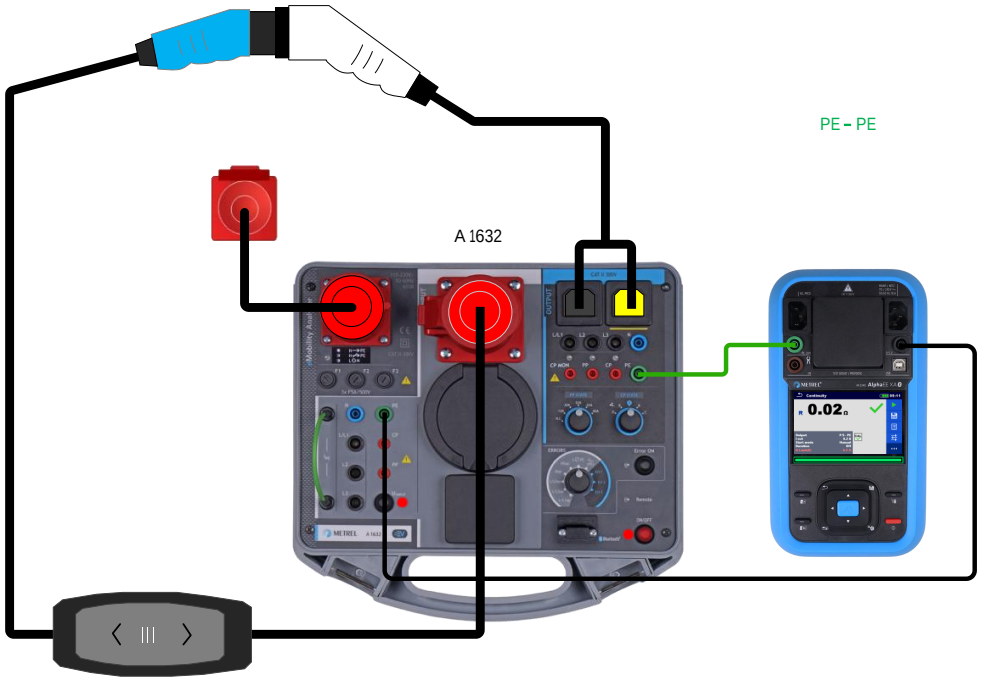


Figure 7_Continuity of protective earth

Test step	Test lead	A 1632	MI 3340
1	Black	PE Output	P/S
1	Green	PE Input	PE

Table 5_Test leads setup

Notes:

- The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

- Compensation of the test leads must be performed before testing to achieve an accurate result.

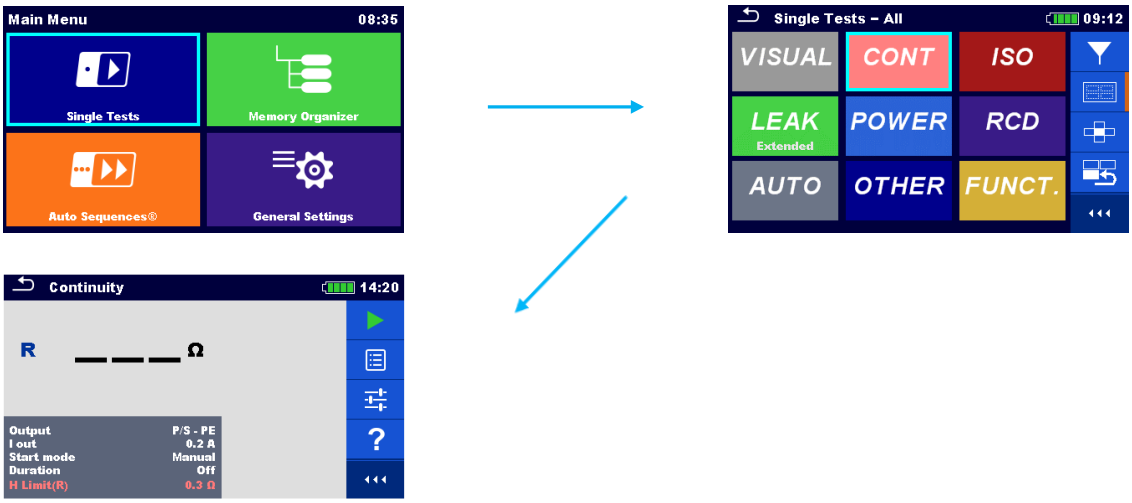


Figure 8_Earth continuity setup

Measuring function: Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the EV cable according to the connection diagram Figure 7_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Compensation of test leads

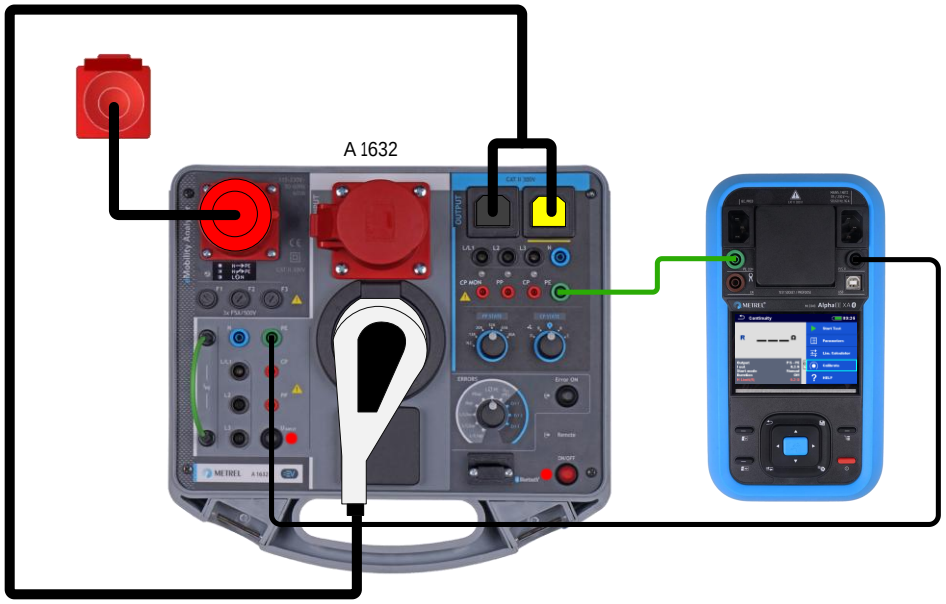


Figure 9_Test leads compensation

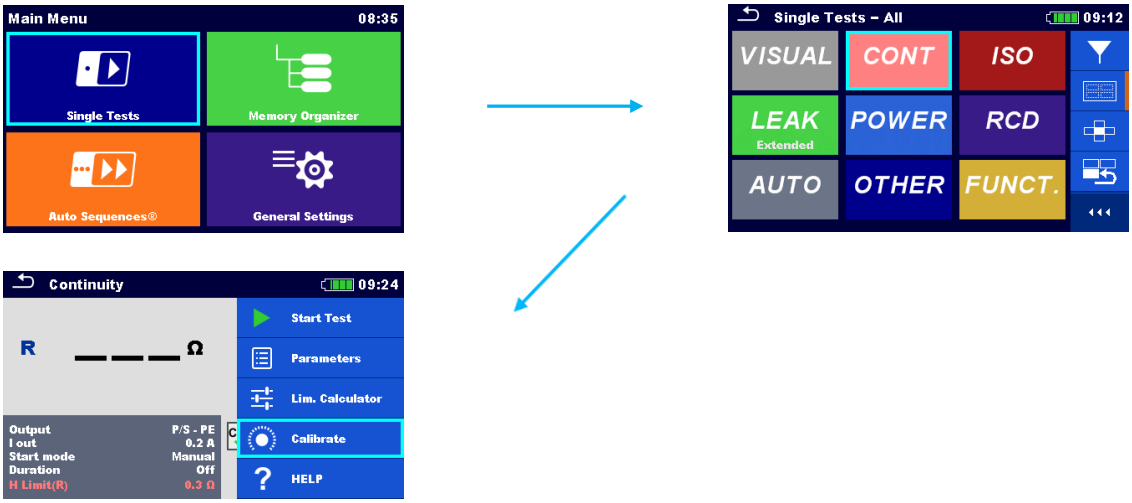


Figure 10_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 9_Test leads compensation,
- Select Continuity measurement,
- Select Calibrate from the menu on the right,
- Start the calibration.

Insulation resistance between the protective conductor and live conductors (L and N)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340 and A 1632. Connection is made between the PE conductor and the live parts on the secondary side of the Mode 2 cable, see Figure 11_Insulation resistance.

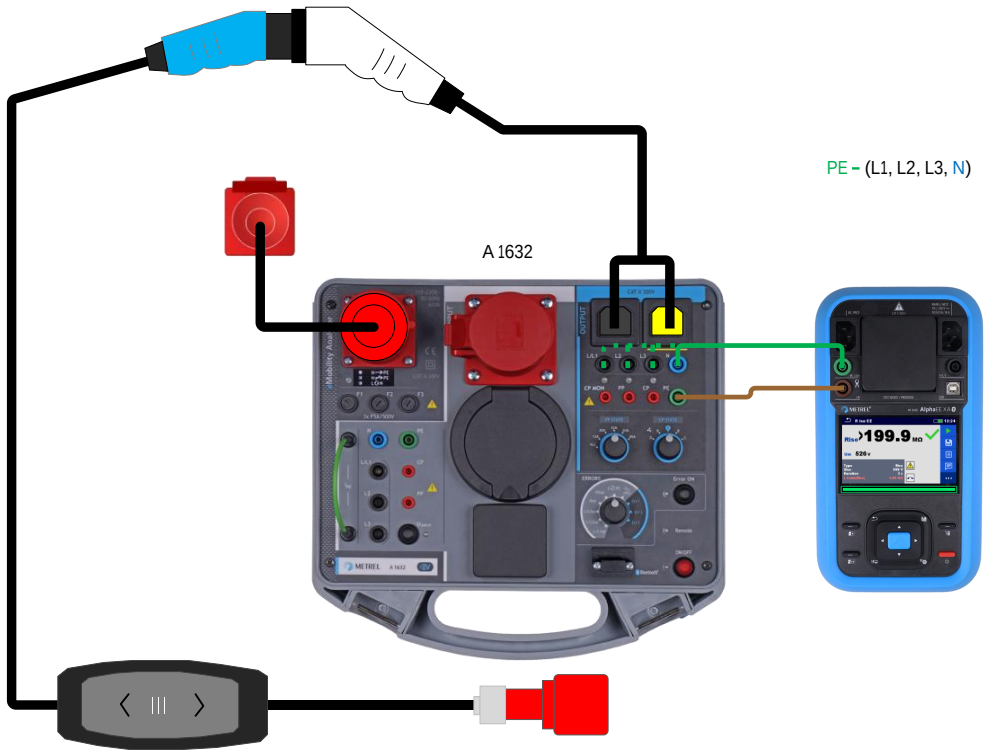


Figure 11_Insulation resistance

Test step	Test lead	A 1632	MI 3340
1 – 4	Brown lead	PE	LN
1	Green lead	N	PE
2	Green lead	L3	PE
3	Green lead	L2	PE
4	Green lead	L1	PE

Table 6_Test leads setup

Note!

The CEE cable shall be disconnected.

All live parts shall be subject to test. Reconnect the LN/probe on the A 1632 output side for evaluation of each live part separately.

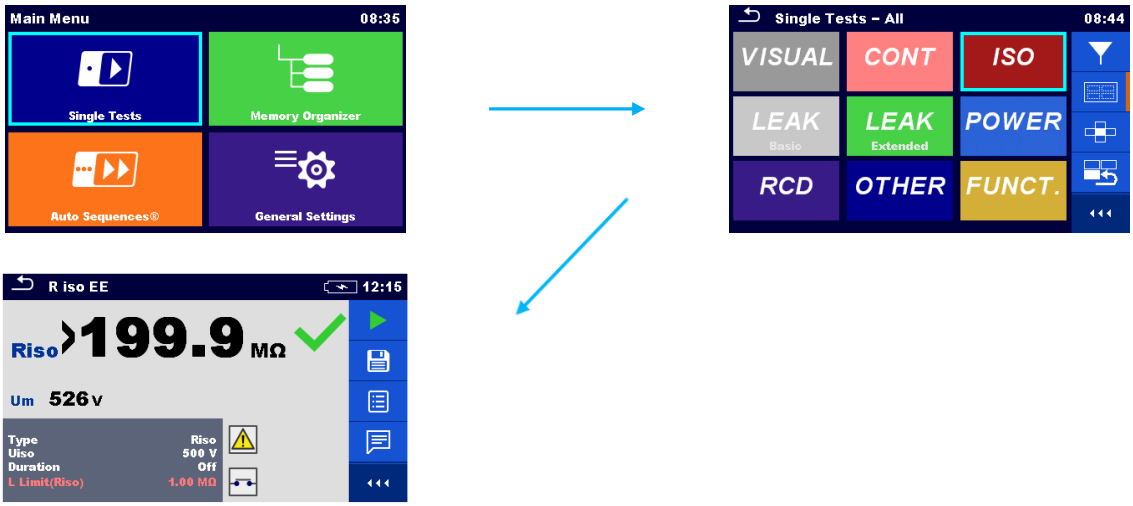


Figure 12_Insulation resistance setup

Measuring function: Riso EE
Output parameter: Riso
Uiso: 50 V, 100 V, 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ (secondary side)

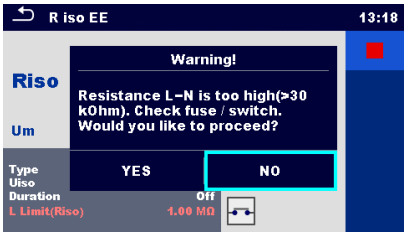


Figure 13_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user about the following possible issues:

- The device under test is not connected or switched on.
- The input fuse of the device under test is blown.

The warning message can be disregarded as the test is made on the secondary side of the cable only.
Select **YES** to proceed with or **NO** to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu! Load pretest (On/**Off**).

Protective conductor leakage current

Scope of test:

The PE leakage current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions.

The device must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the PE conductor.
Unearthed accessible conductive parts are not included in this test. They are considered Class II parts and are checked with the Touch Leakage test.

The measurement is performed using the MI 3340, the (optional) current clamp A 1472 and the A 1632. The measured leakage current reflects the insulation resistance and capacitance in AC conditions between the PE conductor and the live parts of the Mode 2 cable.

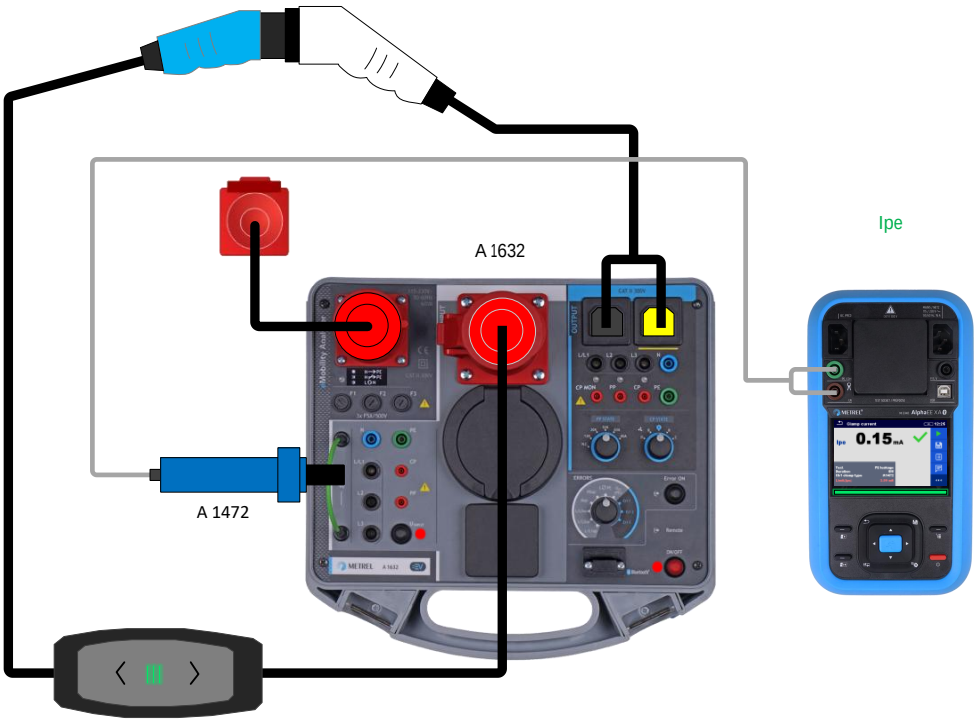


Figure 14_PE leakage current

Note!

Mode 2 cable shall be set to charging mode (Status C) using the CP STATE switch of the A 1632. UINPUT key is set to On.

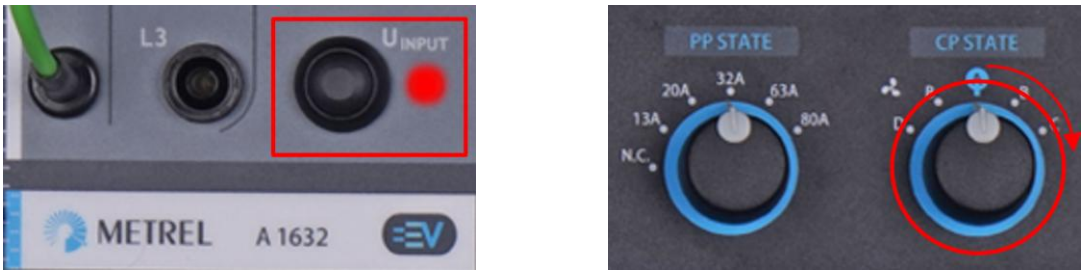


Figure 15_A 1632 keys and switches

*Switching between steps shall be performed dynamically from A → C. The delay between switching depends on the design of the EVSE.		
Step	**Key** **UINPUT**	**Switch** **CP STATE**
1.	UINPUT = **On**	Not connected **Status A**
2.	UINPUT = **On**	Connected **Status B**
3.	UINPUT = **On**	Charging **Status C**

Table 7_Mode 2 cable setup

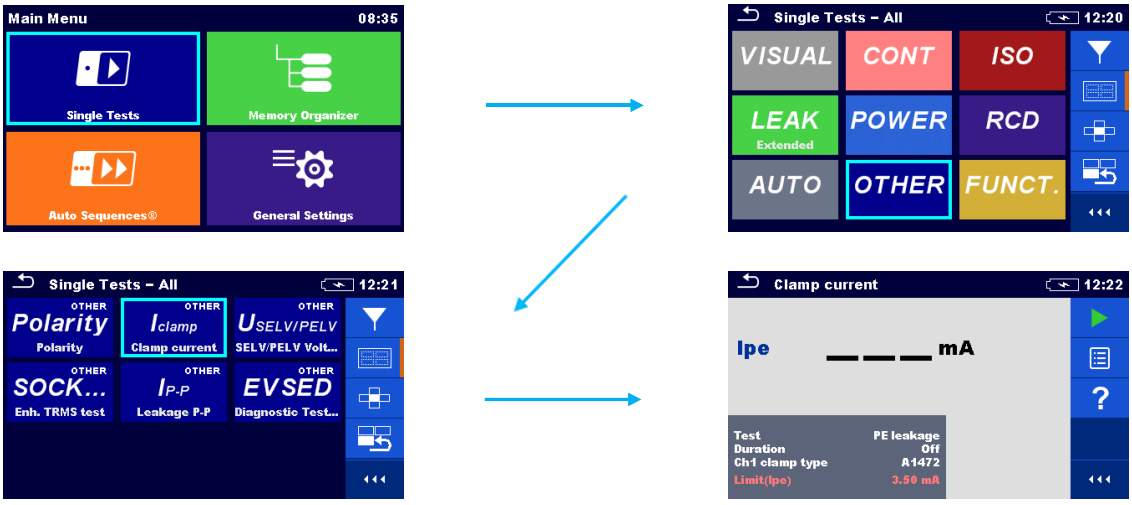


Figure 16_Current clamp setup

Measuring function: Iclamp / Clamp current
Clamp type: A 1472
Test: PE leakage
Limit: ≤ 3,5 mA

EV-RCD trip-out current

Scope of test:

According to EN 50699 and the German guideline for E-Mobility testing, the operation of further protective measures must be evaluated if the equipment under test includes such parts. The protective device in this case is the EV-RCD.

The EV-RCD in the Mode 2 cable provides an additional layer of electrical safety by monitoring the current flow and cutting the supply in the event of a fault (sensed as a sudden high leakage). Testing the EV-RCD ensures it functions correctly and can provide the necessary protection against electric shocks.

Always refer to the manufacturer's instructions or consult a qualified electrician to confirm the correct testing procedures for EV-RCDs in Mode 2 EV cables, as they may vary depending on the specific model and regulations in your location.

Generally, it is enough to test only the ability of the EV-RCD to trip in case of a fault. This can be evaluated on a single phase or all three phases separately.

*I. Test setup for EV RCD **3-Phase evaluation L1, L2, L3***

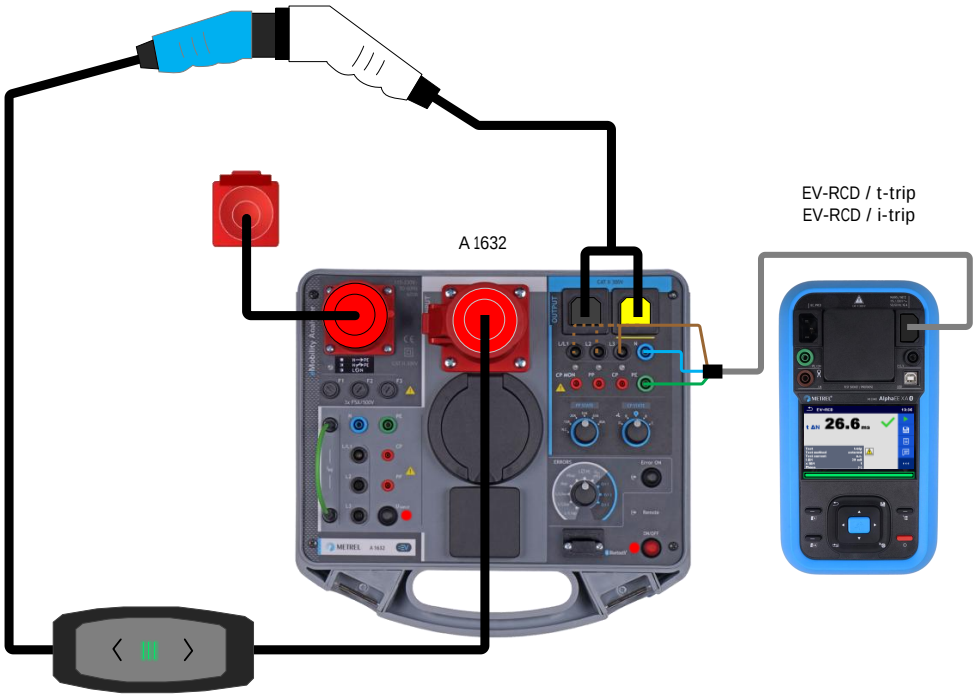


Figure 17_EV-RCD_Test method_external (all 3-phases evaluation)

Notes!

- Functionality of the EV-RCD shall be evaluated on all lines and each line separately. Connect L/probe on the A 1632 output side.
- Set the CP STATE switch to charging mode (Status C) on the A 1632.

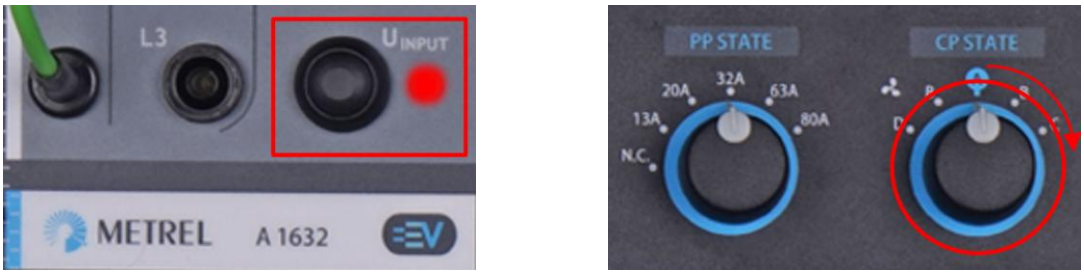


Figure 18_A 1632 keys and switches

The measurement is performed using the MI 3340 and the A 1632. The subject of evaluation is EV-RCD of the Mode 2 cable.

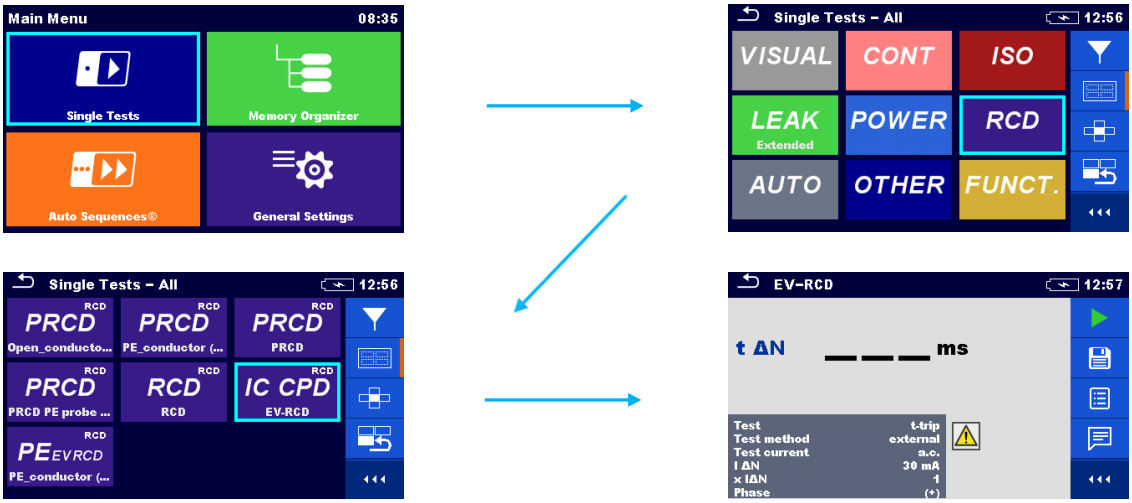


Figure 19_EV-RCD test setup

Measuring function: IC CPD / EV-RCD
Test method: external
Test: t-trip, i-trip
Limit: IΔNa < IΔN

Measurement procedure for EV RCD 3-phase evaluation (Test method external)

Key UINPUT	**Switch CP STATE**	**Action**	**Action**	**Status**	**Status**	**Action**
A 1632	A 1632	MI 3340	MI 3340	IC-CPD	MI 3340	MI 3340
UINPUT = **On**	Charging **Status C**	Accordingly, connected via A 1670 cable	Start test ▶	EV RCD trip out	TURN ON MAINS VOLTAGE!	Connect the instrument to the mains!
Set switch CP state to Status A. Proceed to the next step.						

Table 8_EV-RCD test procedure

Notes!

- Repeat test procedure for different EV-RCD settings if applicable.

Proximity Pilot resistor check (Optional)

Scope of test:

Charging speed is determined through the Proximity Pilot (PP). The PP is a resistor connected between the PP pin and the PE pin on the Type 2 connector or socket of a Mode 2 EV cable, a Mode 3 EVSE charging station or the EV. The coding of the resistor actually determines what cable is being used (the cross section) which further determines the maximum charging current and consequently charging speed.

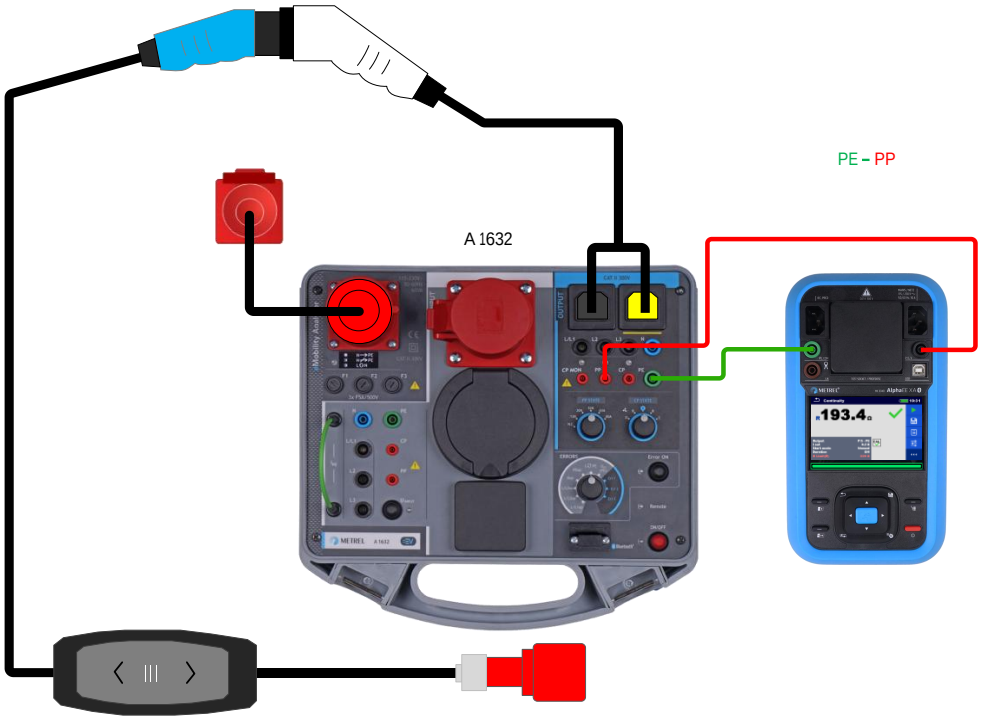


Figure 20_PP resistor_Test

Test lead	A 1632	MI 3340
Red	PP	P/S
Green	PE	PE

Table 9_Test leads setup

Note!

- Rotary switch on the A 1632 shall be set to (Status NC) using PP STATE switch. UINPUT is set to On.

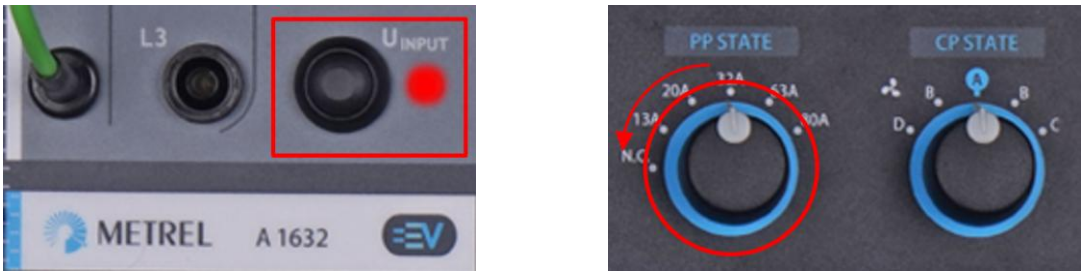


Figure 21_A 1632 keys and switches

The measurement is performed using the MI 3340 & A 1632. The subject of evaluation is the resistance of the PP resistor on the secondary side of the Mode 2 cable.

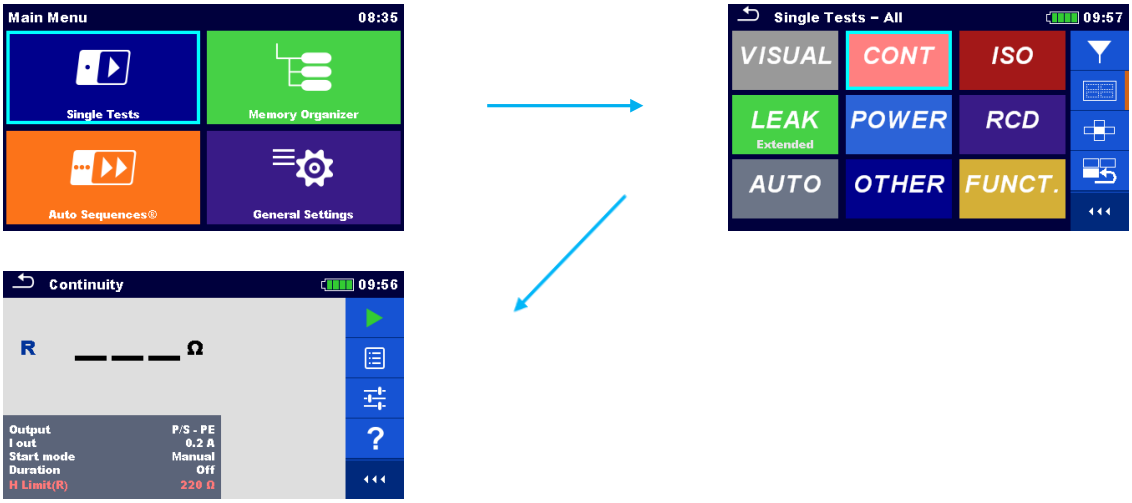


Figure 22_Resistance measurement setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
Iout: 0.2 A
Limits: The PP resistor can have the following values according to EN 61851-1:

- 1500 Ω → 13 A Charging cable
- 680 Ω → 20 A Charging cable
- 220 Ω → 32 A Charging cable
- 100 Ω → 63 A Charging cable

Error test

Scope of test:

Error test assesses the overall condition and functionality of the Mode 2 EV cable and the ability of its protective circuit to react to errors on the input and output side of the cable.

Simulating errors at the Mode 2 cable output ensures that the dangerous mains voltage is switched off at the cable output in the event of a malfunction on the EV vehicle.

A 1632 has two options for simulating input mains errors:

- Simulation of a faulty mains connection.
- Simulation of a fault during operation.

Testing the response and functionality of the cable during these faults ensures safe and reliable EV charging. Appropriate measures can be taken to repair or replace the cable, if any issue is discovered.

Figure 23_Functional inspection

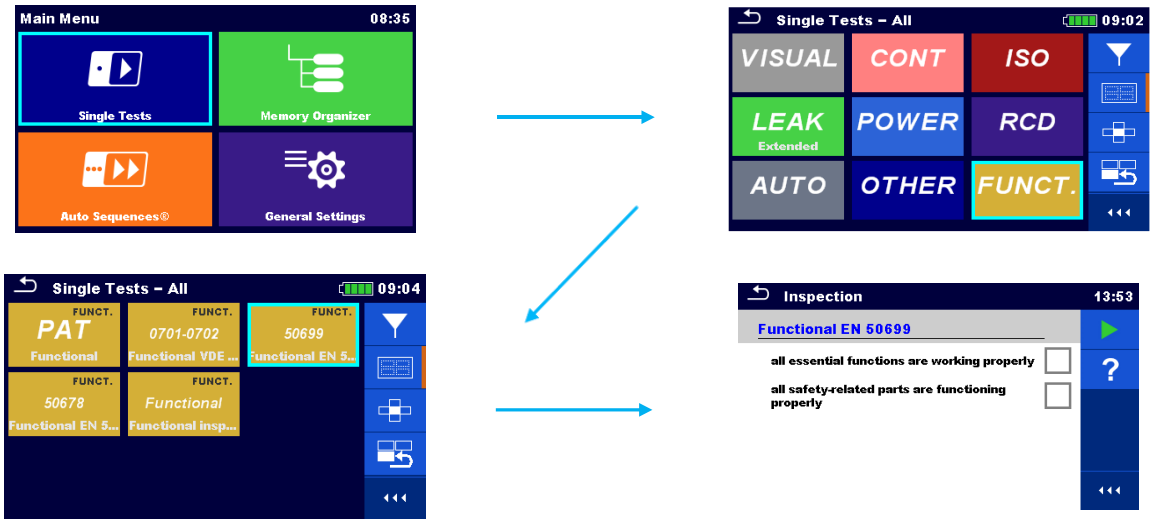


Figure 24_Functional inspection setup

Measurement procedure

Connect the charging cable to the A 1632 (see Figure 4_Mode 2 cable connection).

Rotate the Errors state rotary switch through all positions clockwise, starting from the first position (L/L1op), and set the rest of the switches according to the following table.

Check the response of the tested charging cable.

→					
Step	**Key** **UINPUT**	**Switch** **ERRORS**	**Switch** **CP STATE**	**Switch** **Error ON**	**Test condition**
1.	UINPUT = **On**	INPUT **L / L1op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L1 interrupted**. Observe output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
2.	UINPUT = **On**	INPUT **L / L2op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L2 interrupted**. Observe output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
3.	UINPUT = **On**	INPUT **L / L3op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L3 interrupted**. Observe output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
4.	UINPUT = **On**	INPUT **Nop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **N interrupted**. Observe output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
5.	UINPUT = **On**	INPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **PE interrupted**. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
6.	UINPUT = **Off**	INPUT **L ⟳ PE**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L_PE switched**. The device shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					

7.	U_{INPUT} = **Off**	INPUT **U_{EXT}** **(PE)**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **External voltage present on PE**. The device shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
8.	U_{INPUT} = **On**	OUTPUT **CPsh**	Charging **Status C**	Error ON/OFF = **On**	**CP - PE shorted**, EVSE output should de-energise within 3 s. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
9.	U_{INPUT} = **On**	OUTPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	**PE opened**, EVSE output should de-energise within 100 ms. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
*10.	U_{INPUT} = **On**	OUTPUT 	Charging **Status C**	Error ON/OFF = **On**	**CP diode shorted**, EVSE output should de-energise within 3 s. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Error test finished.					

Table 10_Applicable error test

*CP diode shorted test is optional.

II. Mode 2 EV Cable testing (1-phase)

List of Applicable test & Limits

Measurements according to the German guideline for E-Mobility		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Functional inspection		
Continuity of protective conductor	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance of the protective conductor to the neutral and phase conductor	Insulation resistance measurement	≥ 1.0 MΩ (secondary side)
Protective conductor current	Direct method	≤ 3,5 mA
Compliance with tripping current PRCD	Trip test PRCD	IΔNa < IΔN
Proximity Pilot resistor check (Optional)		

Table 11_Applicable measurements

Switch CP STATE	**Vehicle status**	**Result**
Status A	Vehicle not connected (idle state)	Yes / No
Status B	Vehicle connected but not ready to charge.	Yes / No
Status C	Vehicle connected and ready for charging, charging area ventilation not required.	Yes / No

Table 12_Applicable functional statuses

ERRORS	**Applied to:**	**Test condition**
L / L1op	INPUT	L/L1 conductor opened
Nop		N conductor opened
PEop		PE conductor opened
L ⇄ PE		L and PE conductors crossed*
U_{EXT} (PE)		External voltage on PE (on input side)*
PEop	OUTPUT	PE opened / EVSE output should de-energise within 100 ms.
CPsh		CP - PE shorted / EVSE output should de-energise within 3 s.
sh		CP diode shorted / EVSE output should de-energise within 3 s.

Table 13_Applicable errors

Visual inspection

Scope of test:

The visual inspection shall take place to detect external defects and, if possible, to determine the suitability of the equipment for the environment.

Figure 25_Visual inspection

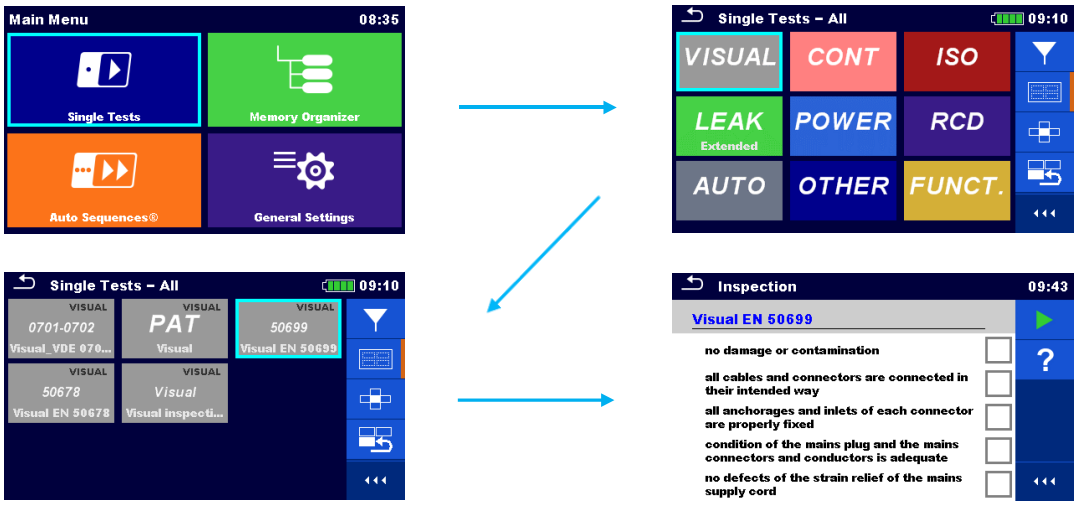


Figure 26_Visual inspection setup

Special attention shall be paid to the following:

- Check that there is no damage or contamination.
- Check that the connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the mains lead cord grip.
- Check for damage to the housing and protective cover that could expose live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check functionality of the switches, control and setup equipment.

- Check for defects due to the bending of the cord.

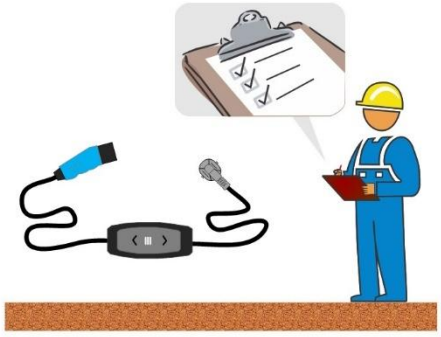


Figure 27_Visual inspection

Functional test

Scope of test:

Functional test of a Mode 2 EV cable ensures that the cable operates properly and safely when charging an electric vehicle and helps assess the overall condition and functionality of the Mode 2 EV cable.

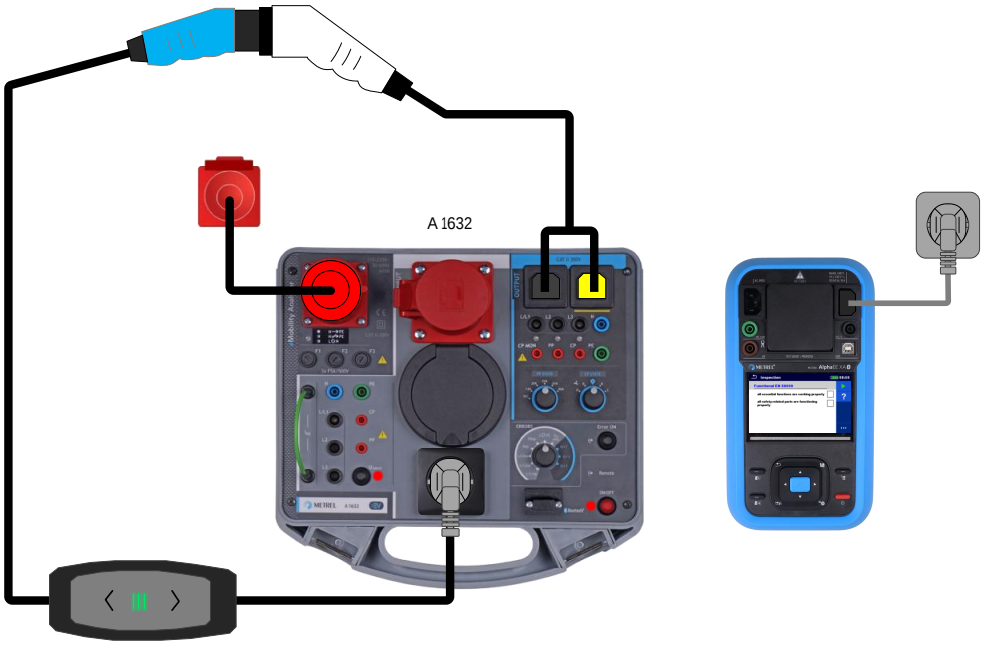


Figure 28_Mode 2 cable connection

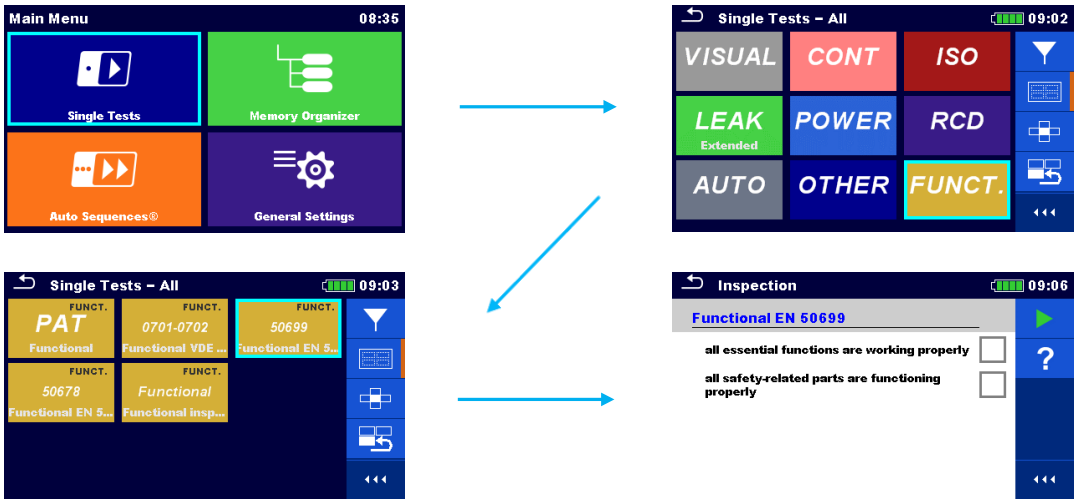


Figure 29_Functional inspection setup

Measurement procedure *(EV stations with ventilation are mostly obsolete)*:

- Connect the charging cable to the eMobility Analyser (A 1632) (see Figure 4_Mode 2 cable connection).
- Follow the test procedure from the table Table 4_Vehicle status.
- Check the response of the tested charging cable.

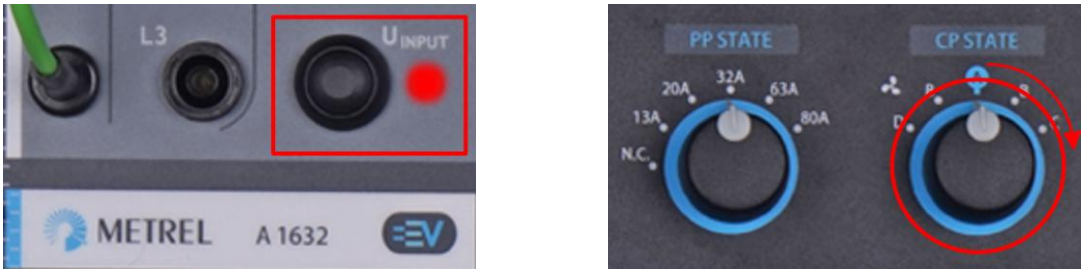


Figure 30_A 1632 keys and switches

*Switching between steps shall be performed dynamically from A → C. The delay between switching depends on the design of the EVSE.					
Step	**Key UINPUT**	**Switch CP STATE ***	**Vehicle status**	**Mode 2 cable condition**	**Result**
1.	UINPUT = **On**	Not connected **Status A**	Vehicle not connected (idle state)	Observe the manufacturer's information for proper operation.	Yes / No
2.	UINPUT = **On**	Connected **Status B**	Vehicle connected but not ready to charge.	Observe the manufacturer's information for proper operation.	Yes / No
3.	UINPUT = **On**	Charging **Status C**	Vehicle connected and ready for charging, charging area ventilation not required.	Observe the manufacturer's information for proper operation.	Yes / No
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.					

Table 14_Vehicle status

Once confirmed that the Mode 2 cable can be set to status C and is properly operating, proceed with electrical safety testing.

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340 & A 1632 to test the PE conductor between the input and the output terminal on the cable and any accessible earthed parts if present.

Some Mode 2 cables need to be set to the charging position to evaluate the PE conductor in the cable. Observe the manufacturer's information for proper operation.

Therefore, there are two different test setups applicable:

I. Test setup (A 1632 not set to charging status)

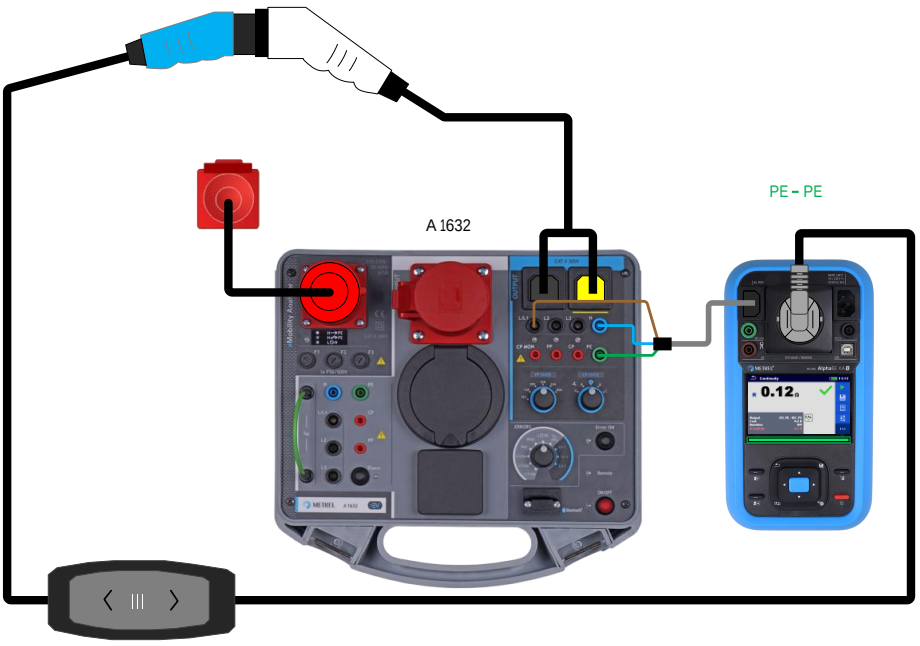


Figure 31_Continuity of protective earth

Test step	Test lead	A 1632	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 15_Test leads setup

Notes!

- The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.
- Compensation of the test leads must be performed before testing to achieve an accurate result.

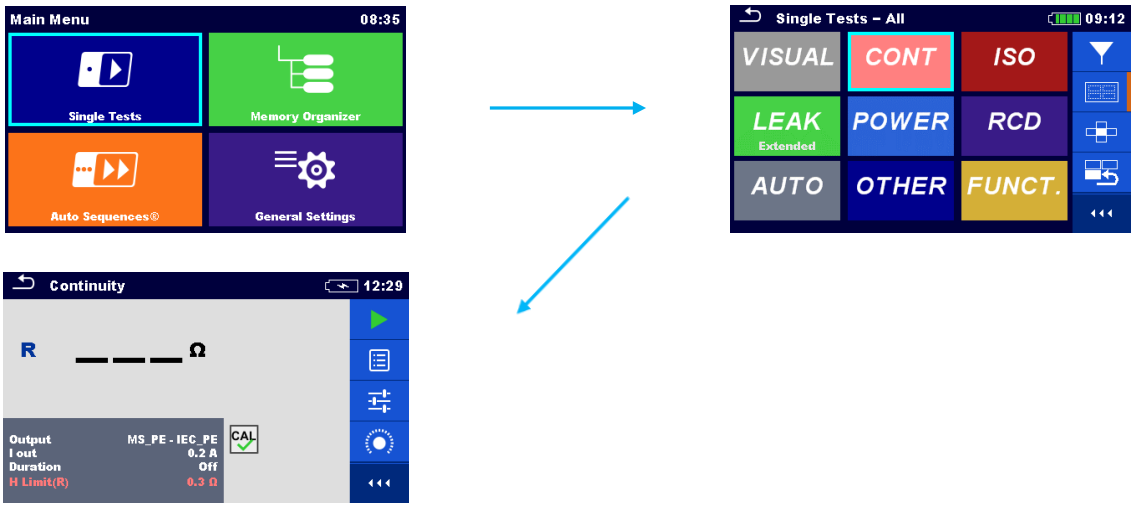


Figure 32_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: MS_PE – IEC_PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the EV cable according to the connection diagram Figure 31_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Compensation of test leads

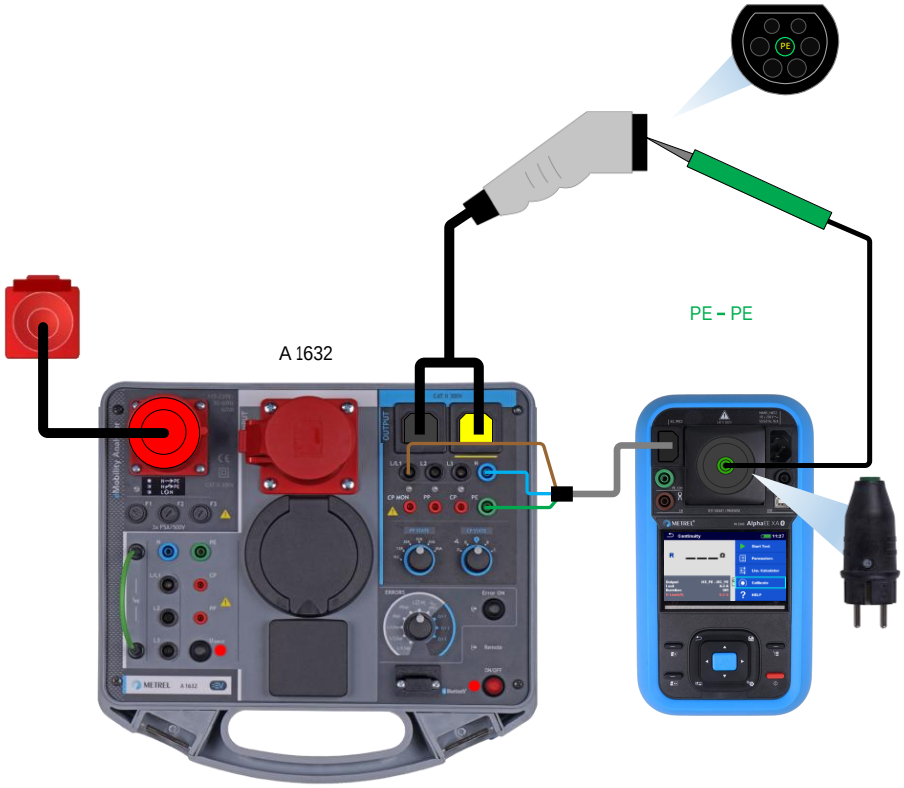


Figure 33_Test leads compensation

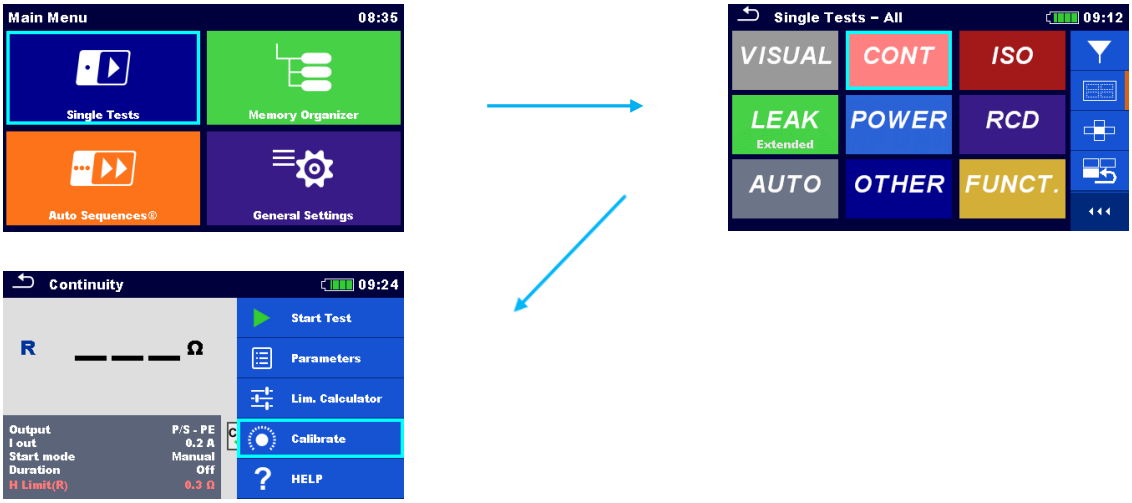


Figure 34_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 33_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

II. Test setup (A 1632 set to charging status)

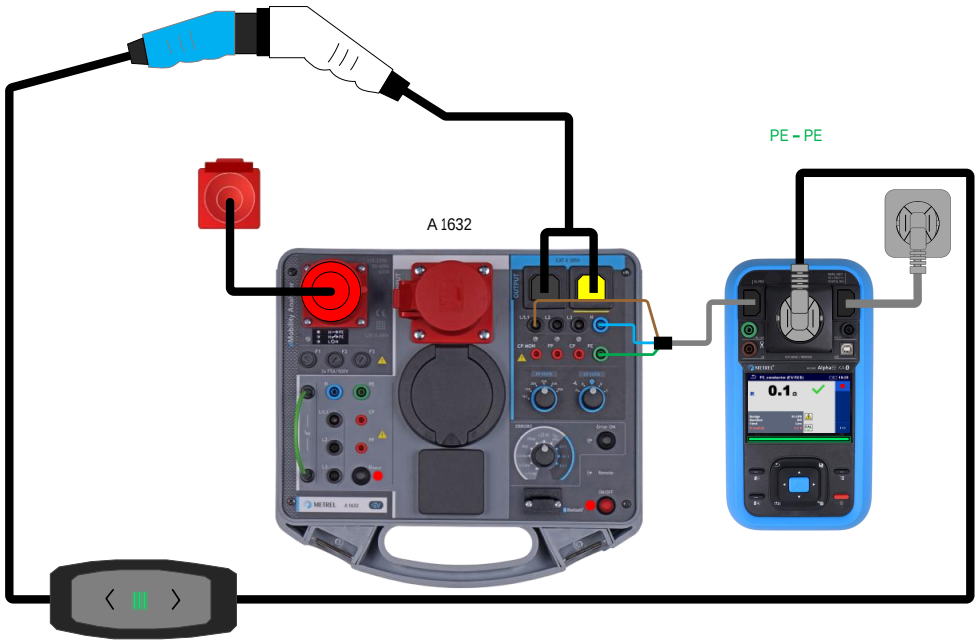


Figure 35_Continuity of protective earth

Test step	Test lead	A 1632	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 16_Test leads setup

Notes!

- The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.
- Compensation of the test leads must be performed before testing to achieve an accurate result.

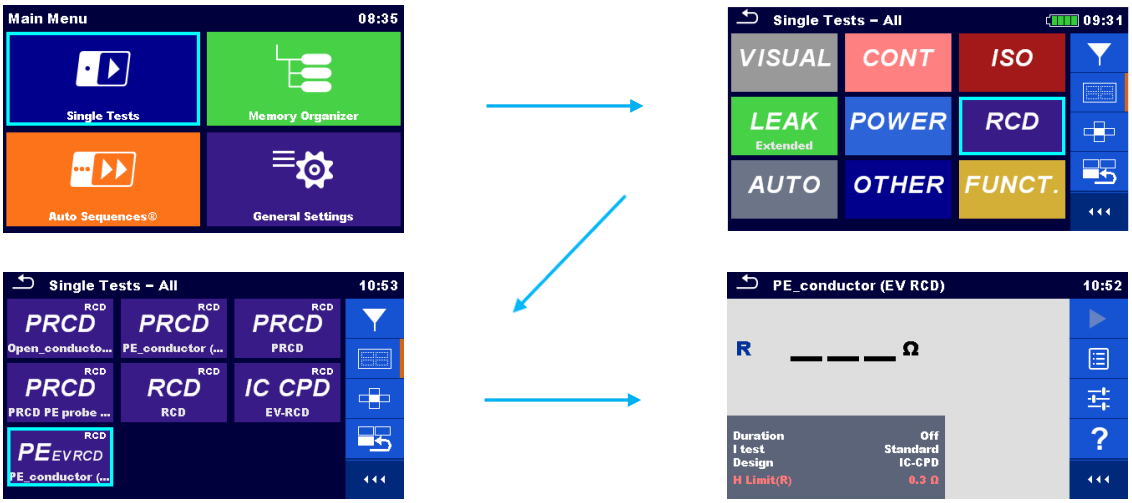


Figure 36_Earth continuity setup

Measuring function: PE$_{EVRCD}$ / PE_conductor (EV RCD)
Design: IC-CPD / (Observe manufacturer information for proper operation.)
I test: Standard
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

			15s		6s		15s	
Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**	**Step 9**
Switch CP STATE	**Key UINPUT**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**
A 1632	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340
Not connected **State A**	UINPUT = **On**	Start test	Set A 1632 state A to state C.	Charging **Status C**	Set A 1632 to state A. See Notes.	Not connected **Status A**	Set A 1632 state A to state C.	Charging **Status C**
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.								

Table 17_EV-RCD test procedure

Notes!

- Some IC CPDs can detect the PE leakage current. For such devices, set the parameter I test to Low.
- Some IC CPDs have an auto-restart function and allow skipping steps 6 and 7.

Compensation of test leads

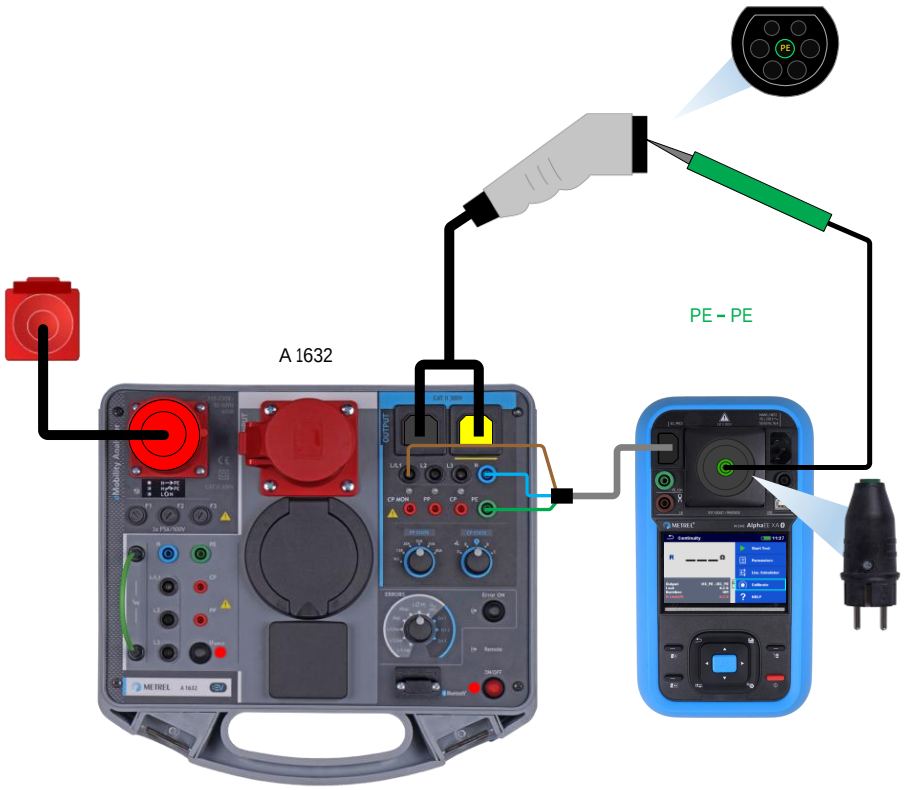


Figure 37_Test leads compensation

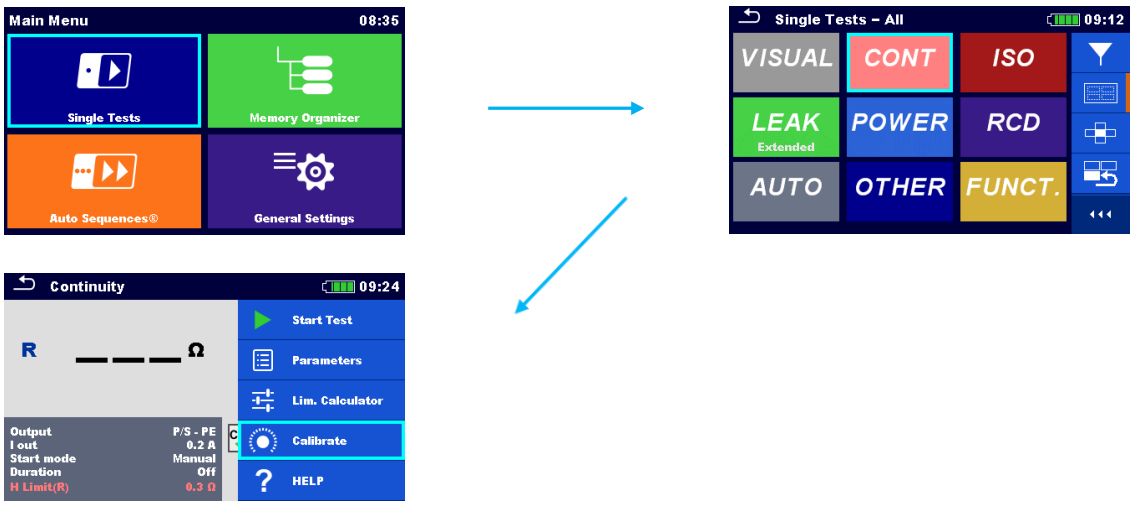


Figure 38_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 37_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340 and A 1632. Connection is made between the PE conductor and the live parts on the secondary side of the Mode 2 cable, see Figure 39_Insulation resistance.

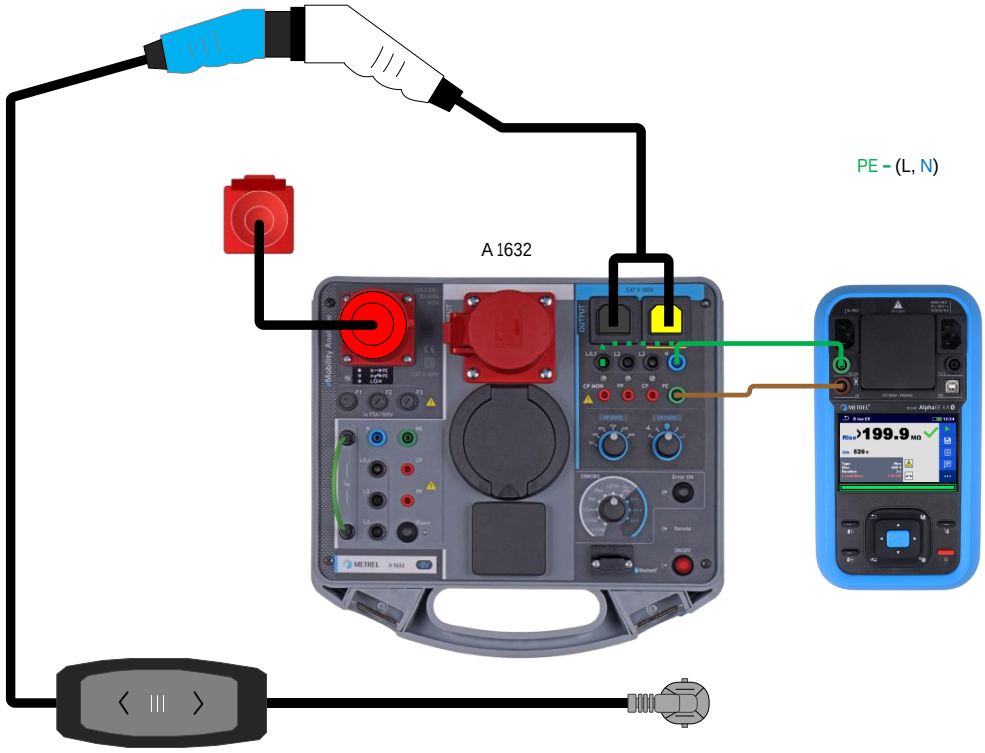


Figure 39_Insulation resistance

Test step	Test lead	A 1632	MI 3340
1 – 2	Brown lead	PE	LN
1	Green lead	N	PE
2	Green lead	L1	PE

Table 18_Test leads setup

Note!

All live parts shall be subject to test. Reconnect the LN/probe on A 1632 output side to evaluate each live part separately.

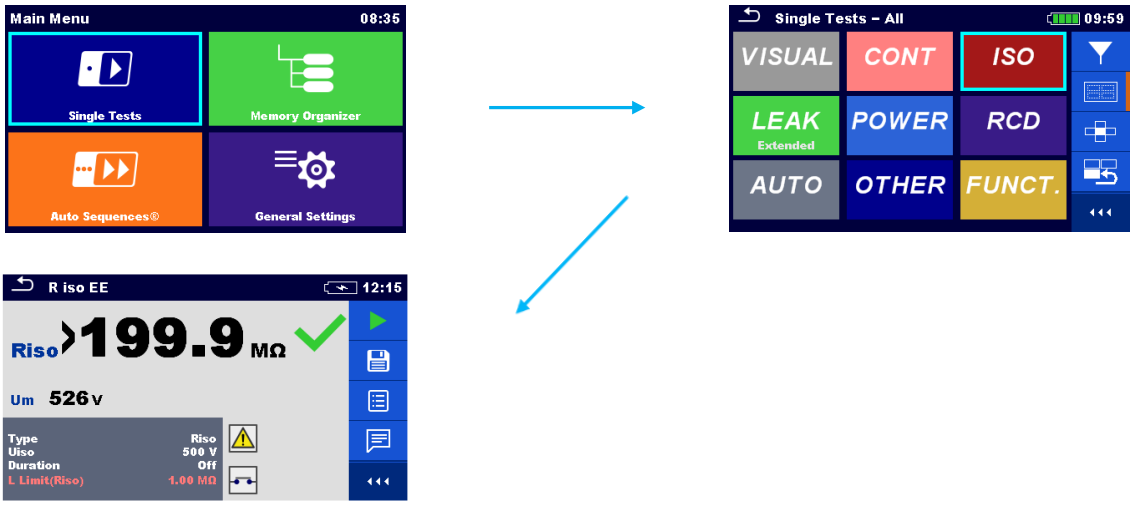


Figure 40_Insulation resistance setup

Measuring function: RPAT / Riso EE
Output parameter: Riso
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ (secondary side)

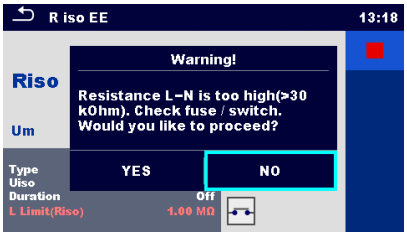


Figure 41_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user about the following possible issues:

- The device under test is not connected or switched on.
- The input fuse of the device under test is blown.

The warning message can be disregarded as the test is made on the secondary side of the cable only.
Select **YES** to proceed with or **NO** to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu! Load pretest (On/**Off**).

Protective conductor (leakage) current

Scope of test:

The PE current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions.

The device under test must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the PE conductor. Unearthed accessible conductive parts are not included in this test. They are considered Class II parts and are checked with the Touch Leakage test.

The measurement is performed using the MI 3340 and the A 1632. The measured leakage current reflects the insulation resistance and capacitance in AC conditions between the PE conductor and the live parts of the Mode 2 cable.

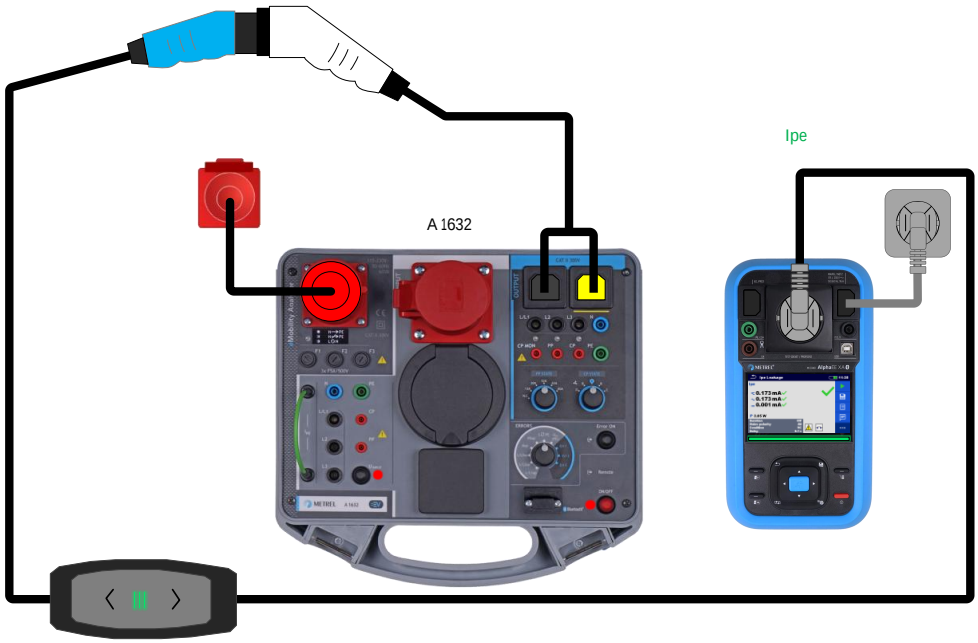


Figure 42_PE leakage current

Note!

Mode 2 cable shall be set to charging mode (Status C) using CP STATE switch of the A 1632, UINPUT key is set to On.

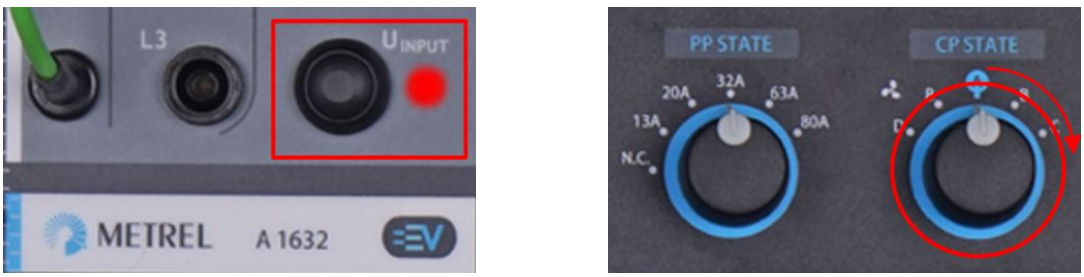


Figure 43_A 1632 keys and switches

*Switching between steps shall be performed dynamically from A → C. Switching delay depends on the design of the EVSE.		
Step	**Key** **UINPUT**	**Switch** **CP STATE**
1.	UINPUT = **On**	Not connected **Status A**
2.	UINPUT = **On**	Connected **Status B**
3.	UINPUT = **On**	Charging **Status C**

Table 19_Mode 2 cable setup

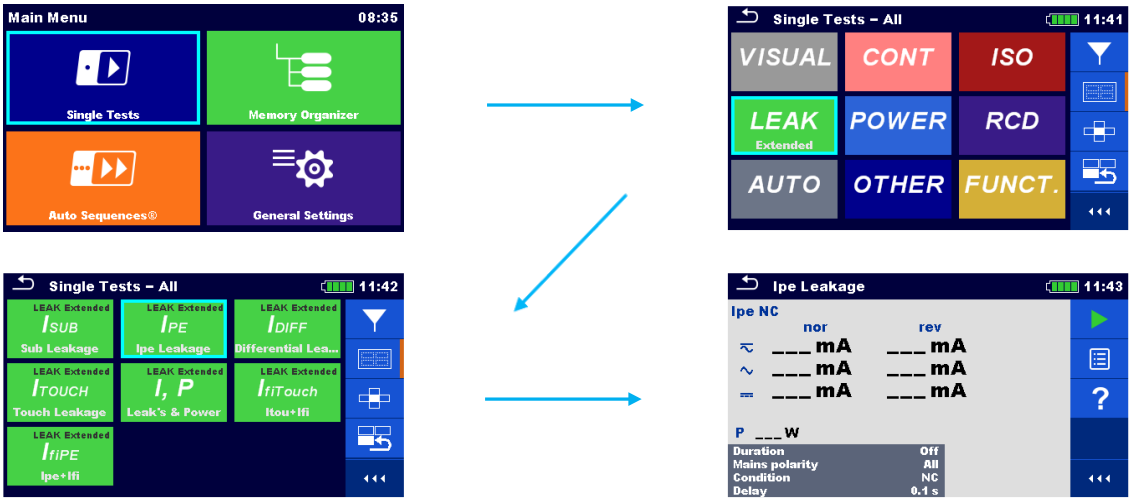


Figure 44_Current clamp setup

Measuring function: Ipe Leakage
Test: PE leakage
Limit: ≤ 3,5 mA

EV-RCD tripping current

Scope of test:

According to EN 50699 and the German guideline for E-Mobility testing, the operation of further protective measures must be evaluated if the equipment under test includes such parts. The protective device in this case is the EV-RCD.

The EV-RCD in the Mode 2 cable provides an additional layer of electrical safety by monitoring the current flow and cutting the supply in the event of a fault (sensed as a sudden high leakage). Testing the EV-RCD ensures it functions correctly and can provide the necessary protection against electric shocks.

Always refer to the manufacturer's instructions or consult a qualified electrician to confirm the correct testing procedures for EV-RCDs in Mode 2 EV cables, as they may vary depending on the specific model and regulations in your location.

Generally, it is enough to test only the ability of the EV-RCD to trip in case of fault. This can be evaluated on a single phase or all three phases separately.

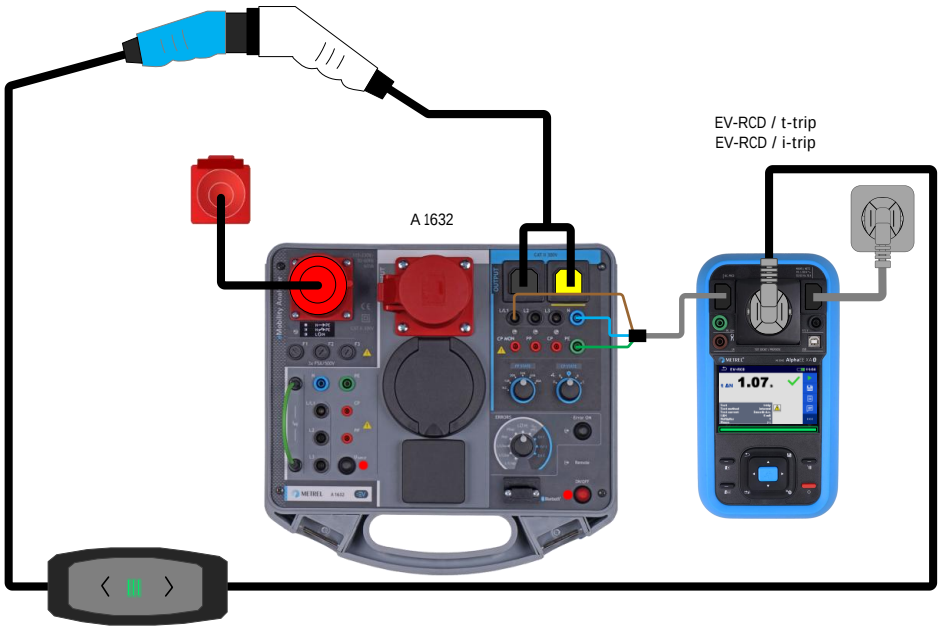


Figure 45_EV-RCD_Test method_internal

Test step	Test lead	A 1632	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 20_Test leads setup

Notes!

- Functionality of the EV-RCD is evaluated on phase L1.

- Mode 2 cable shall be set to charging mode (Status C) using the CP STATE switch on the A 1632.

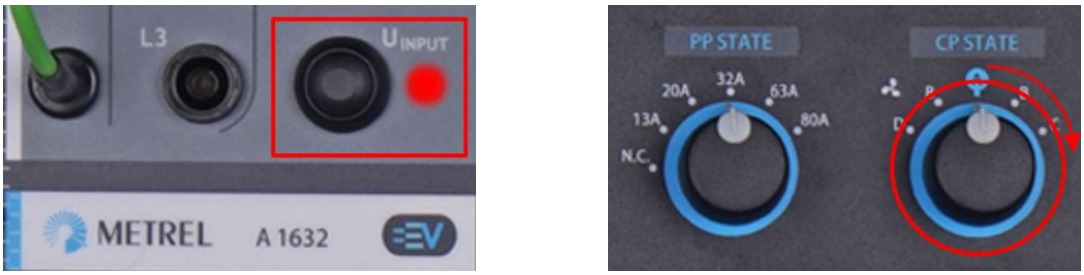


Figure 46_A 1632 keys and switches

The measurement is performed using the MI 3340 & A 1632. The subject of evaluation is EV-RCD of the Mode 2 cable.

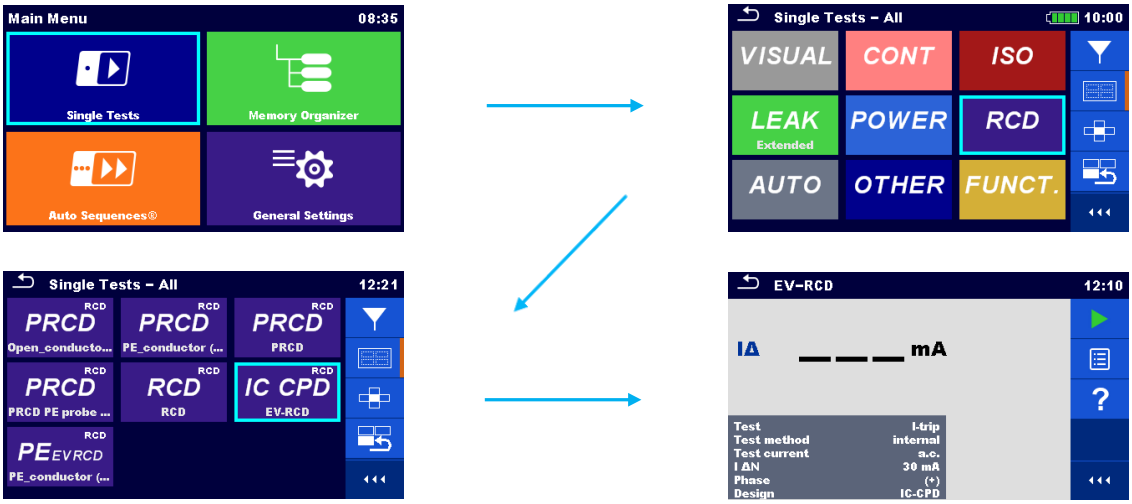


Figure 47_EV-RCD test setup

Measuring function: IC CPD / EV-RCD
Test method: internal/external
Test: t-trip / I-trip
Limit: IΔNa < IΔN

Measurement procedure >> *Internal* **<<**

			15s		6s		15s	
Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**	**Step 9**
Switch CP STATE	**Key UINPUT**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**
A 1632	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340
Not connected **State A**	UINPUT = **On**	Start test	Set A 1632 state A to state C.	Charging **Status C**	Set A 1632 to state A. See Notes.	Not connected **Status A**	Set A 1632 state A to state C.	Charging **Status C**
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.								

Table 21_EV-RCD test procedure

Notes!

- Some IC CPDs can detect the PE leakage current. For such devices, set the parameter I test to Low.
- Some IC CPDs have an auto-restart function and allow skipping steps 6 and 7.

Proximity Pilot resistor check (Optional)

Scope of test:

The highest possible charging speed is set using the Proximity Pilot (PP) switch. The PP is a set of resistors connected between the PP pin and the PE pin on the Type 2 connector or socket of a Mode 2 EV cable, a Mode 3 EVSE charging station or the EV. The coding of the chosen resistor informs about the cross-section of the cable used. The cross-section is the physical limit on the maximum charging current and, consequently, the charging speed.

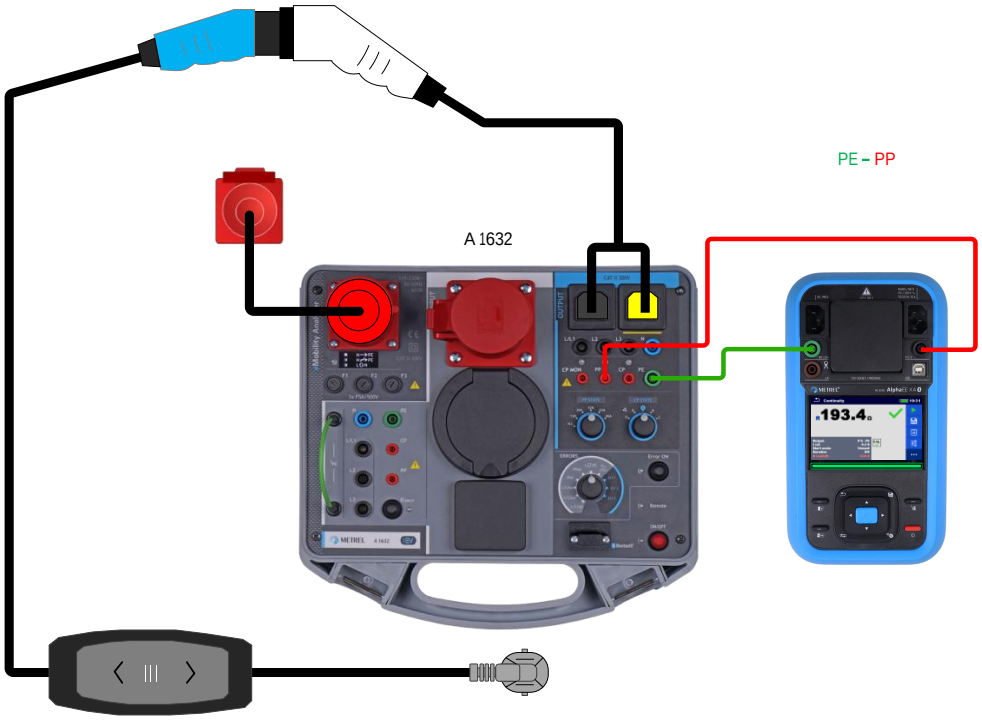


Figure 48_PP resistor_Test

Test lead	A 1632	MI 3340
Red	PP	P/S
Green	PE	PE

Table 22_Test leads setup

Note!

- Rotary PP STATE switch on the A 1632 shall be set to Status NC. UINPUT is set to On.

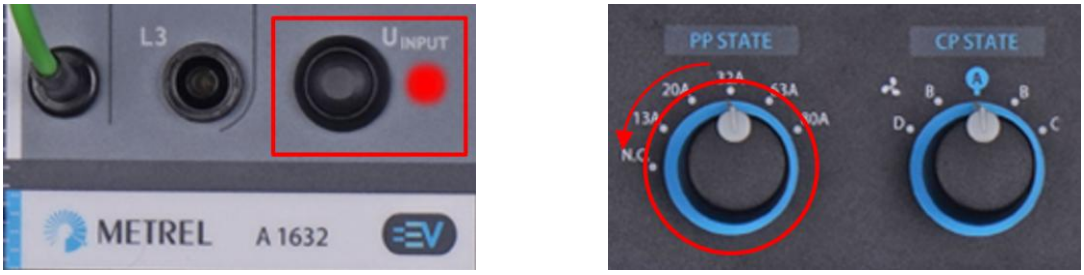


Figure 49_A 1632 keys and switches

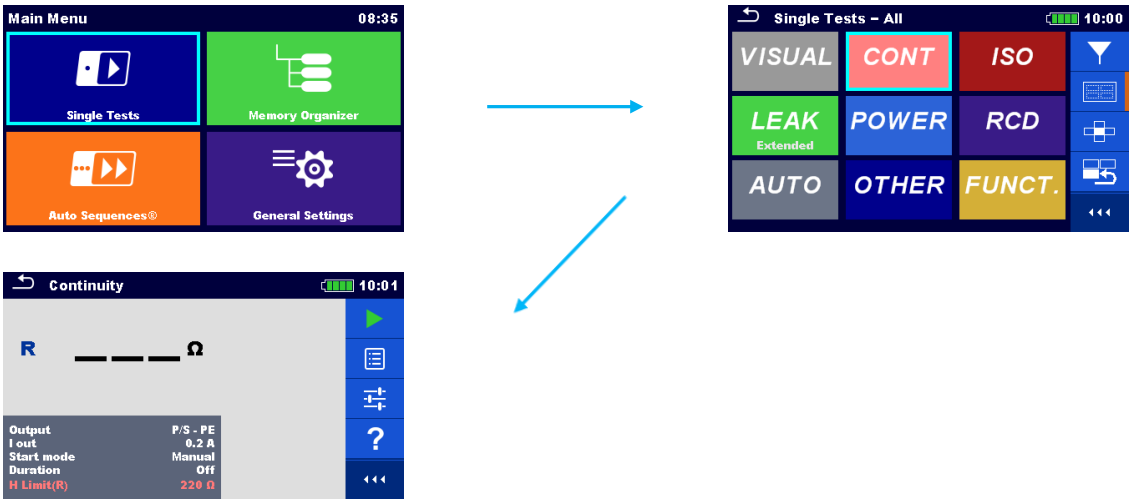


Figure 50_Resistance measurement setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
Iout: 0.2 A
Limits: The PP resistor can have the following values according to EN 61851-1:

- 1500 Ω → 13 A Charging cable
- 680 Ω → 20 A Charging cable
- 220 Ω → 32 A Charging cable
- 100 Ω → 63 A Charging cable

Error test

Scope of test:

The error test assesses the overall condition and functionality of the Mode 2 EV cable and the ability of its protective circuit to react to errors on the input and output side of the cable.

Simulating errors at the Mode 2 cable output ensures that the dangerous mains voltage is switched off at the cable output in the event of a malfunction on the EV vehicle.

A 1632 has two options for simulating input mains errors:

- Simulation of a faulty mains connection.
- Simulation of a fault during operation.

Testing the response and functionality of the cable during these faults ensures safe and reliable EV charging. Appropriate measures can be taken to repair or replace the cable.

Figure 51_Functional inspection

Figure 52_Functional inspection setup

Measurement procedure

Connect the charging cable to the A 1632 (see Figure 28_Mode 2 cable connection).

Set the Errors state rotary switch through all positions clockwise, starting from first position (L/L1op), follow the steps from bellow table.

Check the response of the tested charging cable.

→					
Step	**Key** **U_{INPUT}**	**Switch** **ERRORS**	**Switch** **CP STATE**	**Switch** **Error ON**	**Test condition**
1.	U_{INPUT} = **On**	INPUT **L / L1op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable, **L1 interrupted**. Observe the output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
2.	U_{INPUT} = **On**	INPUT **Nop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable, **N interrupted**. Observe the output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
3.	U_{INPUT} = **On**	INPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable, **PE interrupted**. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
4.	U_{INPUT} = **Off**	INPUT **L ⟲ PE**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable, **L_PE switched**. The device shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
5.	U_{INPUT} = **Off**	INPUT **U_{EXT}** **(PE)**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable, **External voltage on PE**. The device shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
6.	U_{INPUT} = **On**	OUTPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	**PE opened**,

					EVSE output should de-energise within 100 ms. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
7.	U_{INPUT} = **On**	OUTPUT CPsh	Charging **Status C**	Error ON/OFF = **On**	**CP - PE shorted**, EVSE output should de-energise within 3 s. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
*8.	U_{INPUT} = **On**	OUTPUT 	Charging **Status C**	Error ON/OFF = **On**	**CP diode shorted**, EVSE output should de-energise within 3 s. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Error test finished.					

Table 23_Applicable error test

*The CP diode shorted test can be performed optionally.

2. Mode 2 EV cables testing using A 1532

The A 1532 XA is an interface adapter between the Electric Vehicle Supply Equipment (EVSE) and the test instrument. It is intended for testing Mode 3 EV supply equipment with a Type 2 connector.

Mode 2 EV Cable testing (1-phase)

List of Applicable test & Limits

Measurements		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Functional inspection		
Continuity of protective conductor	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance of the protective conductor to the neutral and phase conductor	Insulation resistance measurement	≥ 1.0 MΩ (secondary side)
Protective conductor current	Direct method	≤ 3,5 mA
Compliance with tripping current PRCD	Trip test PRCD	IΔNa < IΔN
Proximity Pilot resistor check (Optional)		

Table 24_Applicable measurements

Switch CP STATE	**Vehicle status**	**Result**
Status A	Vehicle not connected (idle state)	Yes / No
Status B	Vehicle connected but not ready to charge.	Yes / No
Status C	Vehicle connected and ready for charging, charging area ventilation not required.	Yes / No

Table 25_Applicable functional statuses

ERRORS	**Applied to:**	**Test condition**
PEop	OUTPUT	PE opened / EVSE output should de-energise within 100 ms.
CPsh		CP - PE shorted / EVSE output should de-energise within 3 s.
		CP diode shorted / EVSE output should de-energise within 3 s.

Table 26_Applicable errors

Visual inspection

Scope of test:

The visual inspection shall take place to detect external defects and, if possible, to determine the suitability of the equipment for the environment.

Figure 53_Visual inspection

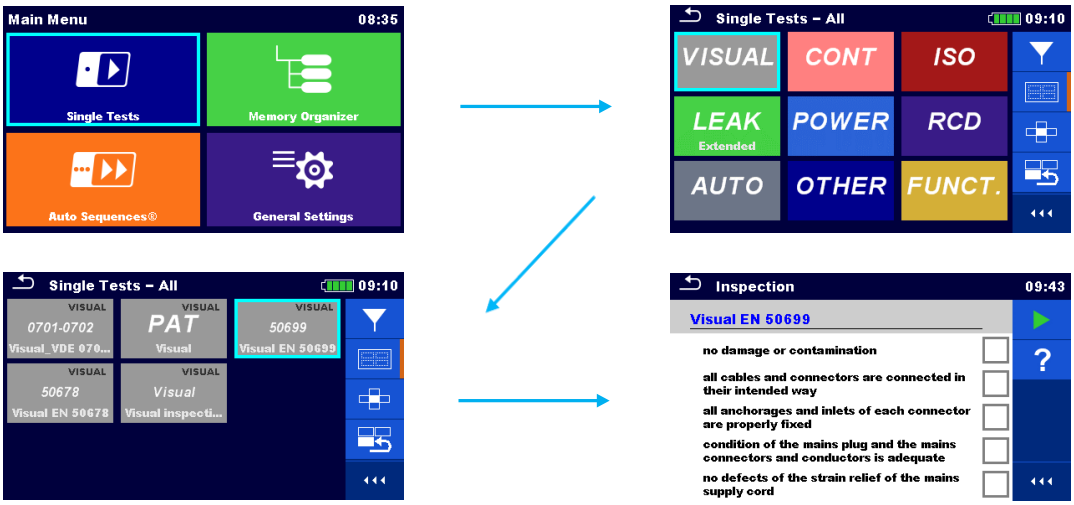


Figure 54_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cord.

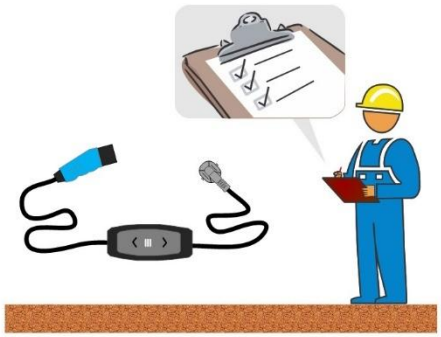


Figure 55_Visual inspection

Functional test

Scope of test:

Functional test of a Mode 2 EV cable ensures that the cable operates properly and safely when charging an electric vehicle and helps assess the overall condition and functionality of the Mode 2 EV cable.

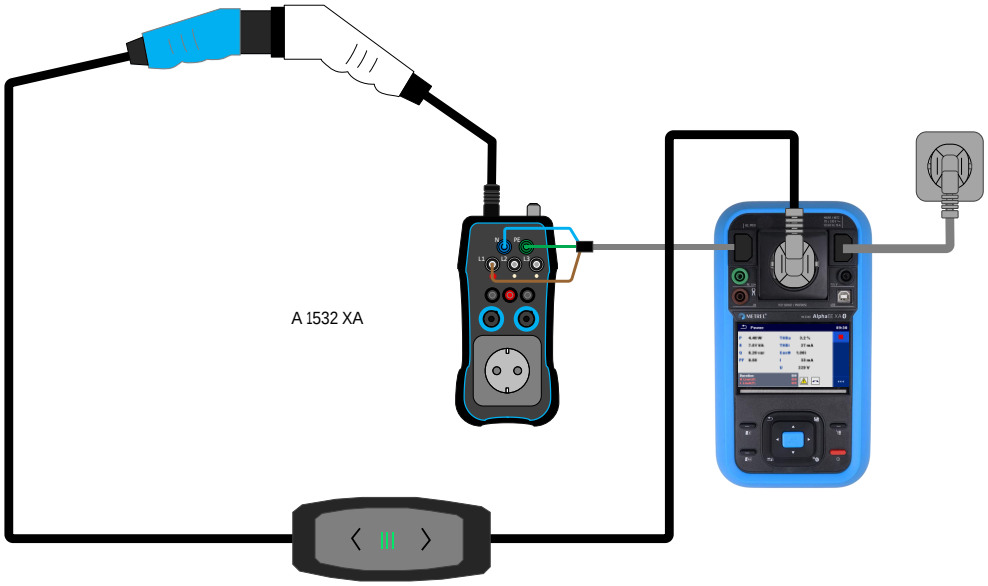


Figure 56_Mode 2 cable connection

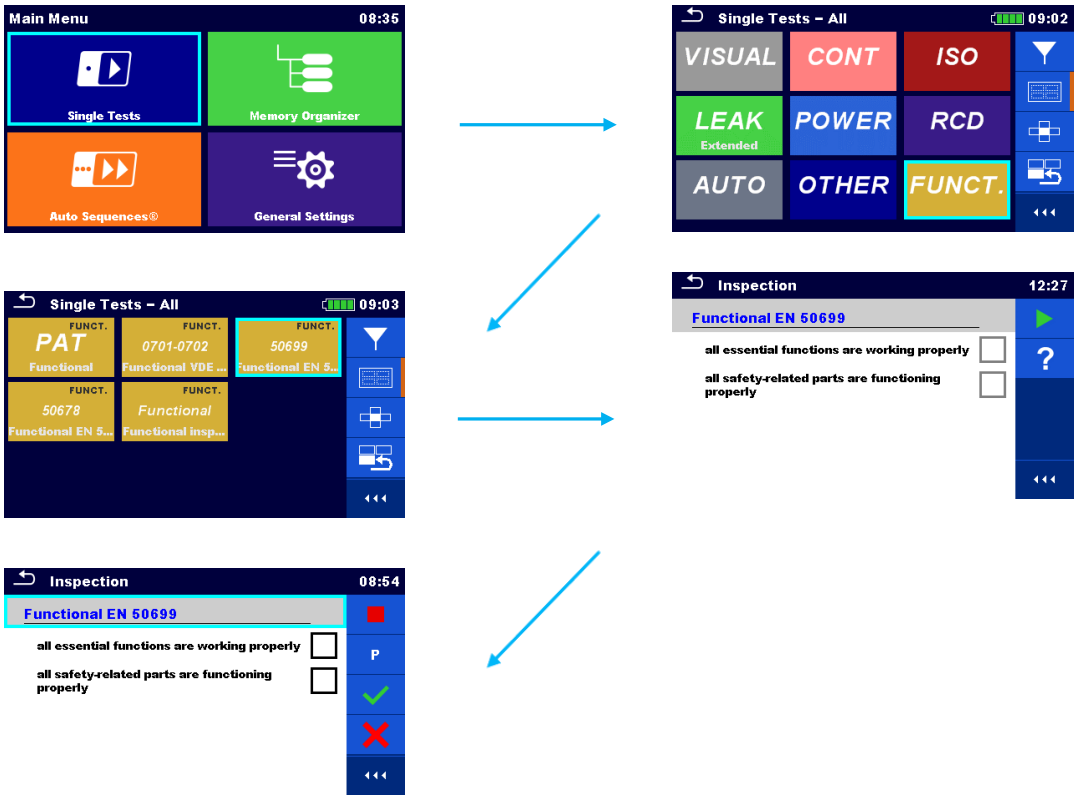


Figure 57_Functional inspection setup

Measurement procedure *(EV stations with ventilation are mostly obsolete)*:

- Connect the charging cable to the EVSE adapter (A 1532 XA) (see Figure 56_Mode 2 cable connection).
- Follow the test procedure from the table: Table 27_Vehicle statusTable 4_Vehicle status.
- Check the response of the tested charging cable.

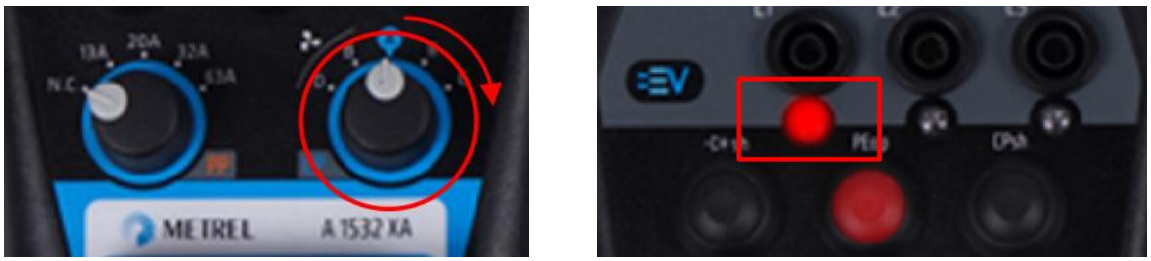


Figure 58_A 1532 keys and switches

*Switching between steps shall be performed dynamically from A → C. The delay between switching depends on the design of the EVSE.					
Step	**MI 3340**	**Switch CP STATE ***	**Vehicle status**	**Mode 2 cable condition**	**Result**

1.	Power test = **On**	Not connected **Status A**	Vehicle not connected (idle state)	Observe the manufacturer's information for proper operation.	Yes / No
2.	Power test = **On**	Connected **Status B**	Vehicle connected but not ready to charge.	Observe the manufacturer's information for proper operation.	Yes / No
3.	Power test = **On**	Charging **Status C**	Vehicle connected and ready for charging, charging area ventilation not required.	Observe the manufacturer's information for proper operation.	Yes / No
Turn off the Power test, set switch CP state to Status A. Proceed to the next step.					

Table 27_Vehicle status

Once confirmed that the Mode 2 cable can be set to status C and is properly operating, proceed with the electrical safety testing.

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340 & A 1632 to test the PE conductor between the input and the output terminal on the cable and any accessible earthed parts if present.

Some Mode 2 cables need to be set to the charging position to evaluate the PE conductor in the cable. Observe the manufacturer's information for proper operation.

Therefore, there are two different test setups applicable.

I. Test setup (EV not set to charging status)

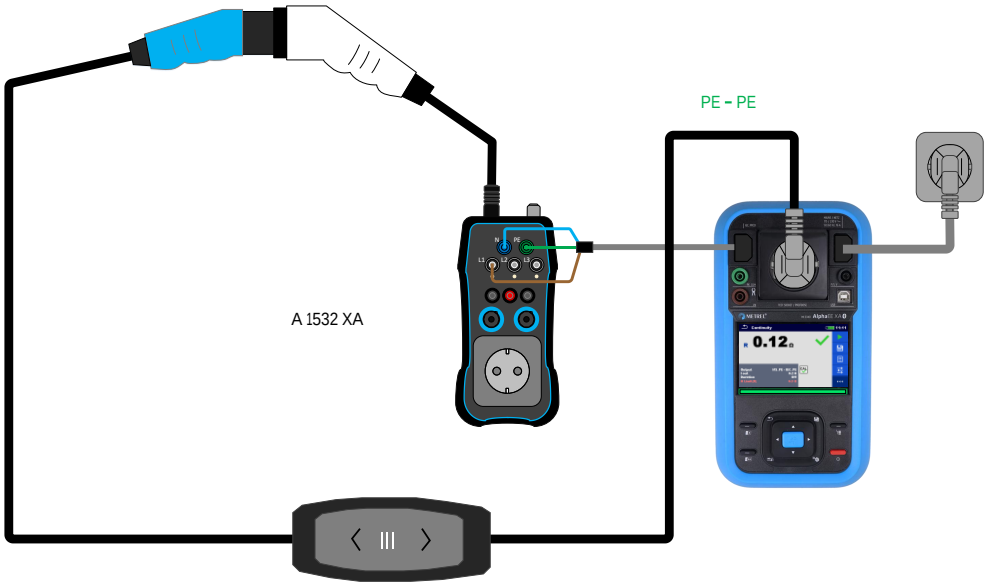


Figure 59_Continuity of protective earth

Test step	Test lead	A 1532	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 28_Test leads setup

Note!

- The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.
- Compensation of the test leads must be performed before testing to achieve an accurate result.

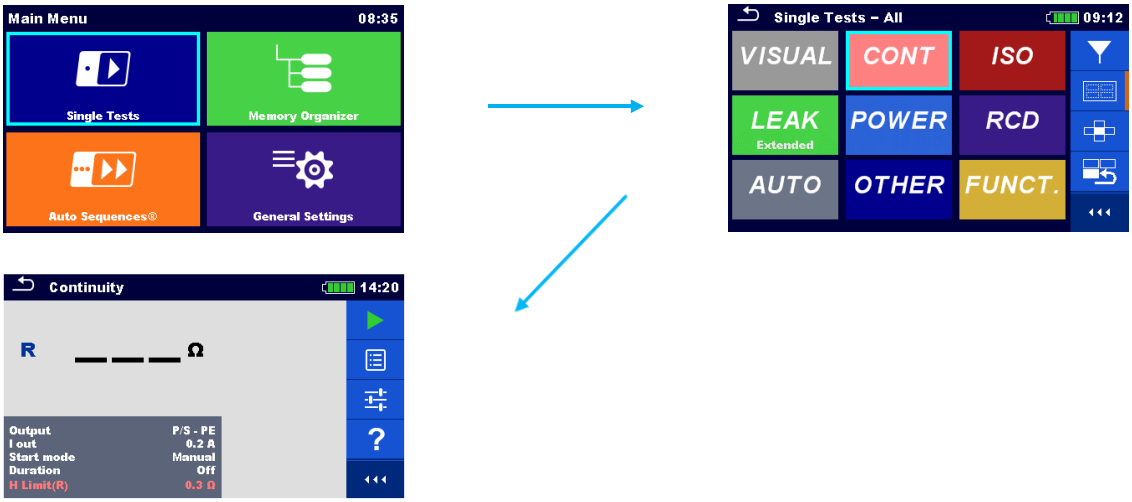


Figure 60_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: MS_PE – IEC_PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the EV cable according to the connection diagram Figure 59_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Compensation of test leads

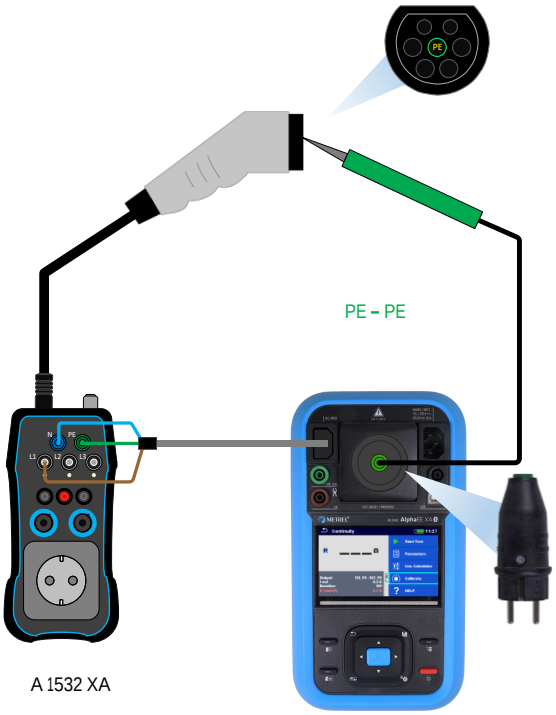


Figure 61_Test leads compensation

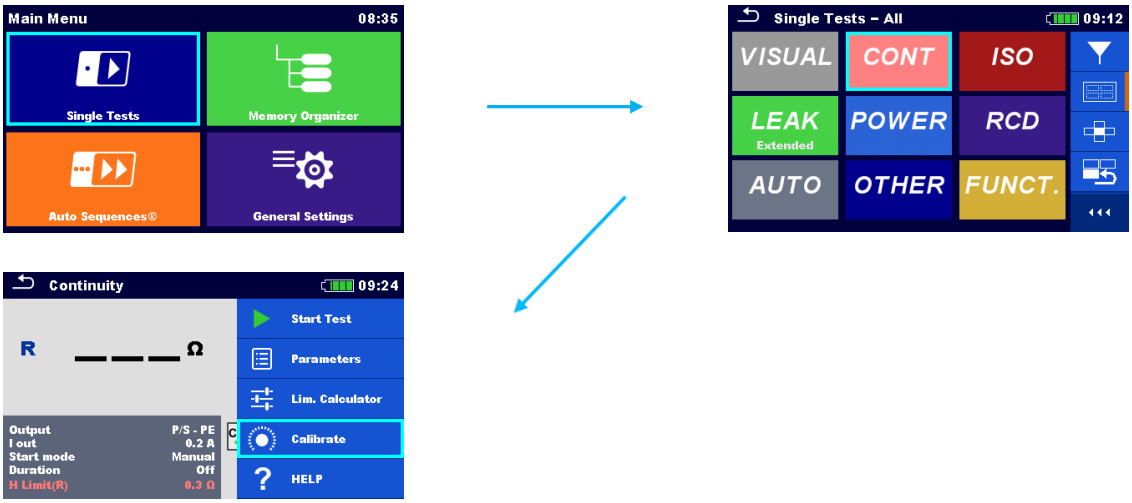


Figure 62_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 61_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

II. Test setup (EV set to charging status)

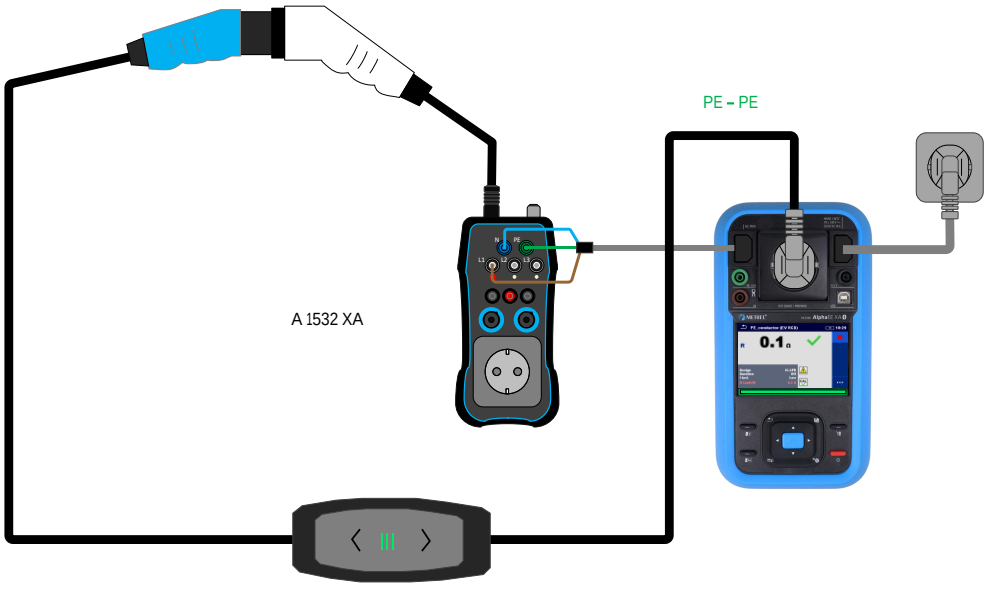


Figure 63_Continuity of protective earth

Test step	Test lead	A 1532	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 29_Test leads setup

Note!

- The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

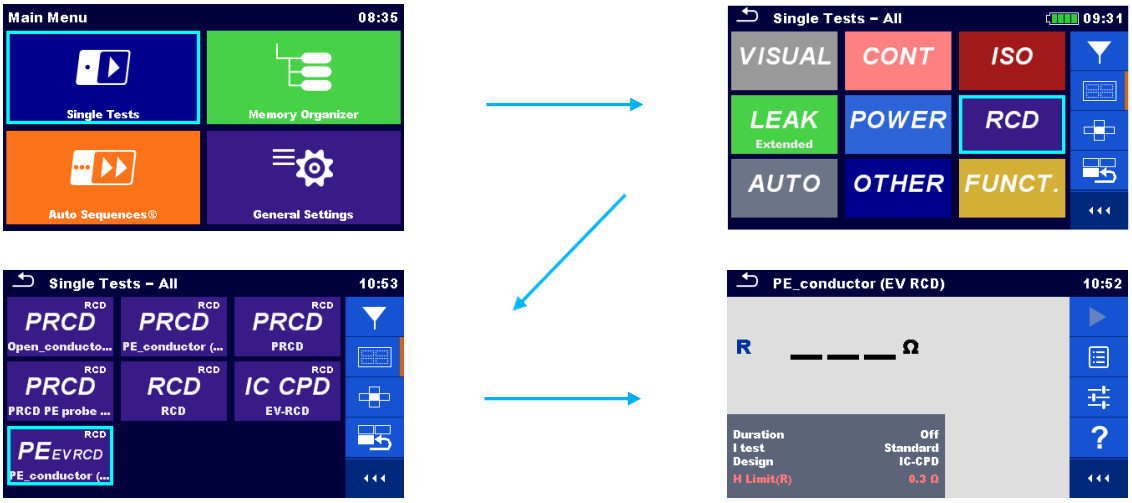


Figure 64_Earth continuity setup

Measuring function: PEEVRCD / PE_conductor (EV RCD)
Design: IC-CPD / (Observe manufacturer information for proper operation.)
I test: Standard
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

			15s		6s		15s	
Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**	**Step 8**	**Step 9**
Switch CP STATE	**Key UINPUT**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**	**Switch CP STATE**	**Status**
A 1632	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340
Not connected **State A**	UINPUT = **On**	Start test ▶	Set A 1632 state A to state C.	Charging **Status C**	Set A 1632 to state A. See Notes.	Not connected **Status A**	Set A 1632 state A to state C.	Charging **Status C**
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.								

Table 30_EV-RCD test procedure

Notes!

- Some IC CPDs can detect the PE leakage current. For such devices, set (I test) to Low.

- Some IC CPD's have an auto-restart function; for such devices, steps 6 & 7 can be skipped.
- To perform measurement accurately, the resistance of test leads should be compensated before execution of the Continuity test.

Compensation of test leads

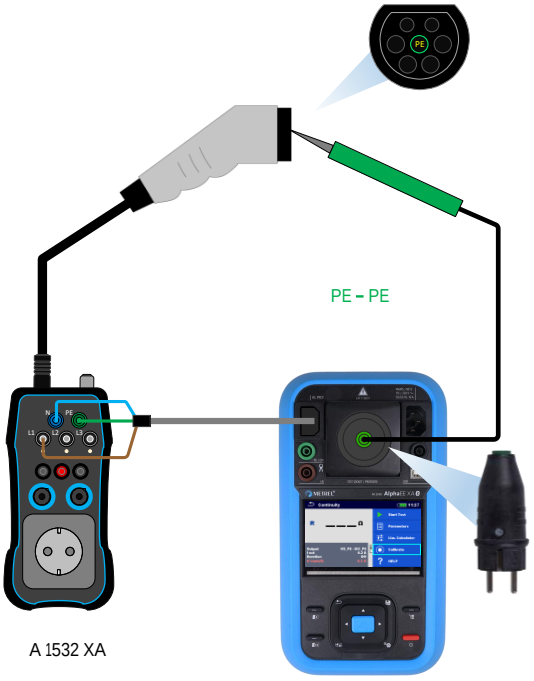


Figure 65_Test leads compensation

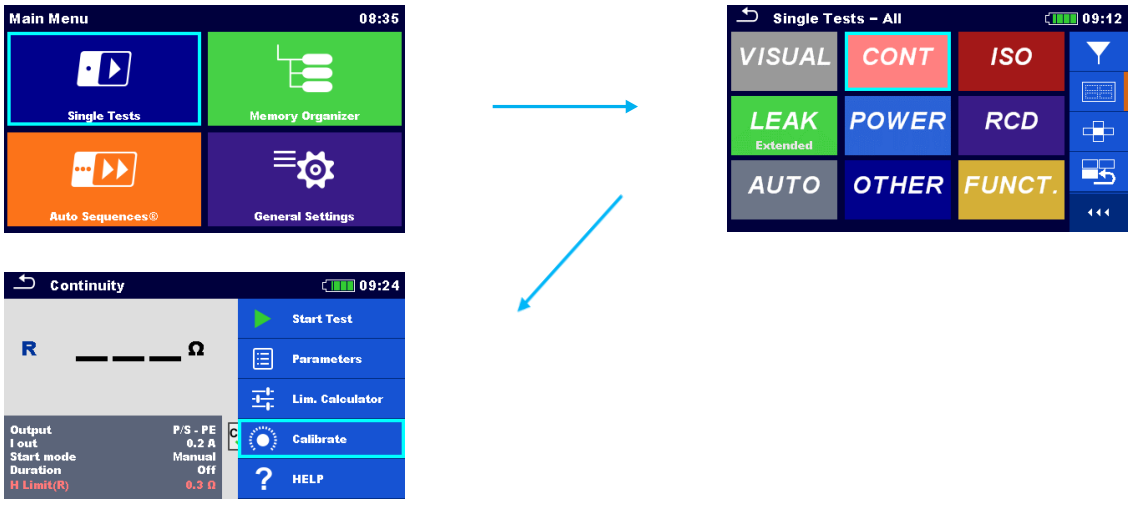


Figure 66_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 65_Test leads compensation,

- Select appropriate measurement,
- Start the calibration.

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340 and A 1632. Connection is made between the PE conductor and the live parts on the secondary side of the Mode 2 cable, see Figure 67_Insulation resistance.

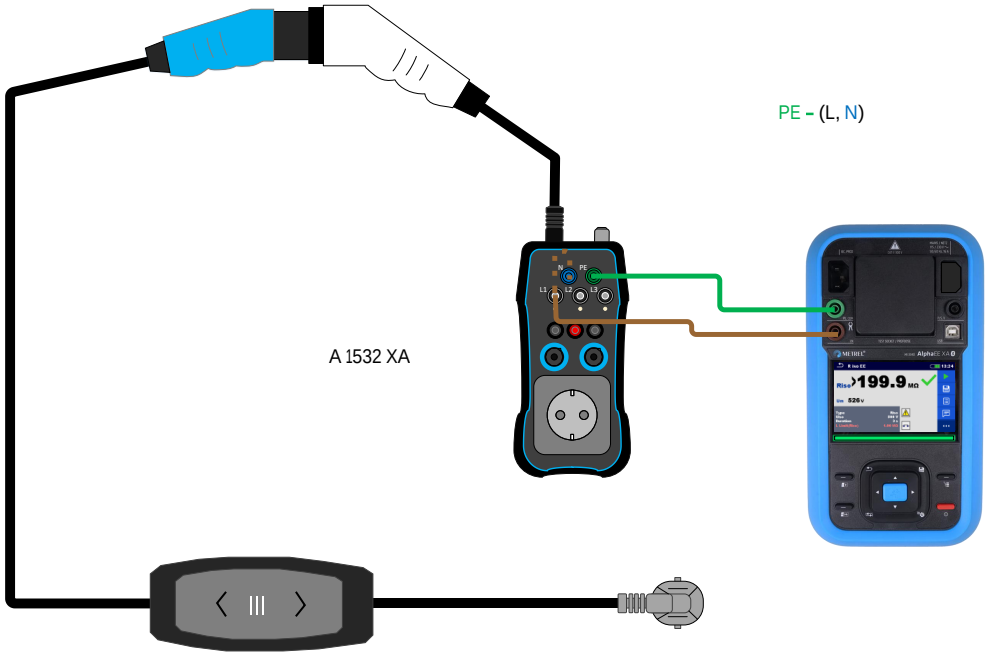


Figure 67_Insulation resistance

Test step	Test lead	A 1532	MI 3340
1 – 2	Green lead	PE	PE
1	Brown lead	N	LN
2	Brown lead	L1	LN

Table 31_Test leads setup

Note!

All live parts shall be subject to test. Reconnect the LN/probe on the A 1532 output side for evaluation of each live part separately.

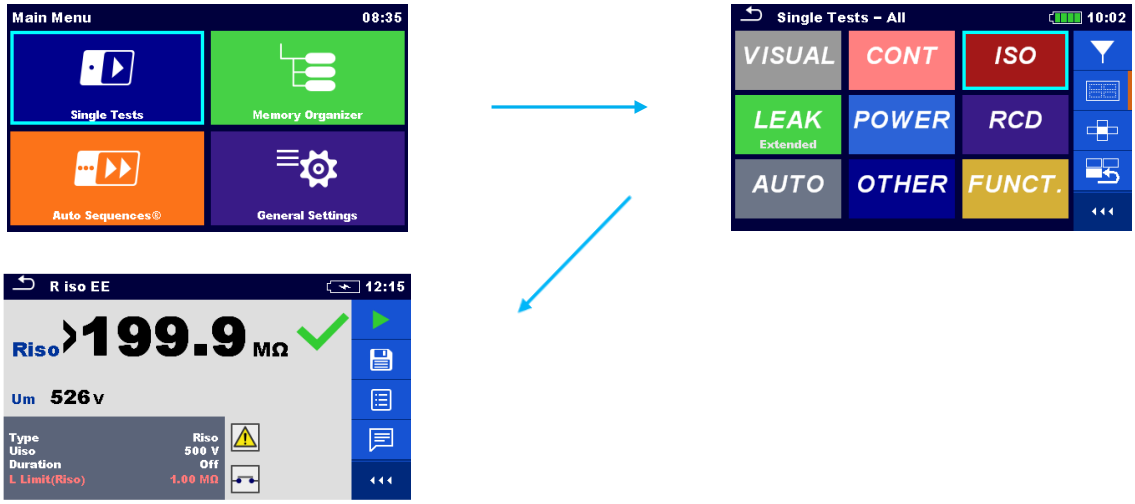


Figure 68_Insulation resistance setup

Measuring function: RPAT / Riso EE
Output parameter: Riso
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ (secondary side)

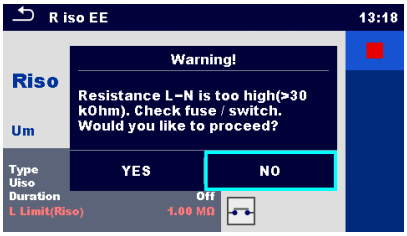


Figure 69_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user about the following possible issues:

- The device under test is not connected or switched on.
- The input fuse of the device under test is blown.

The warning message can be disregarded as the test is made on the secondary side of the cable only.
Select **YES** to proceed with or **NO** to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu! Load pretest (On/**Off**).

Protective conductor (leakage) current

Scope of test:

The PE leakage current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions.

The device must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the PE conductor.

Unearthed accessible conductive parts are not included in this test. They are considered Class II parts and are checked with the Touch Leakage test.

The measurement is performed using the MI 3340 and the A 1632. The measured leakage current reflects the insulation resistance and capacitance in AC conditions between the PE conductor and the live parts of the Mode 2 cable.

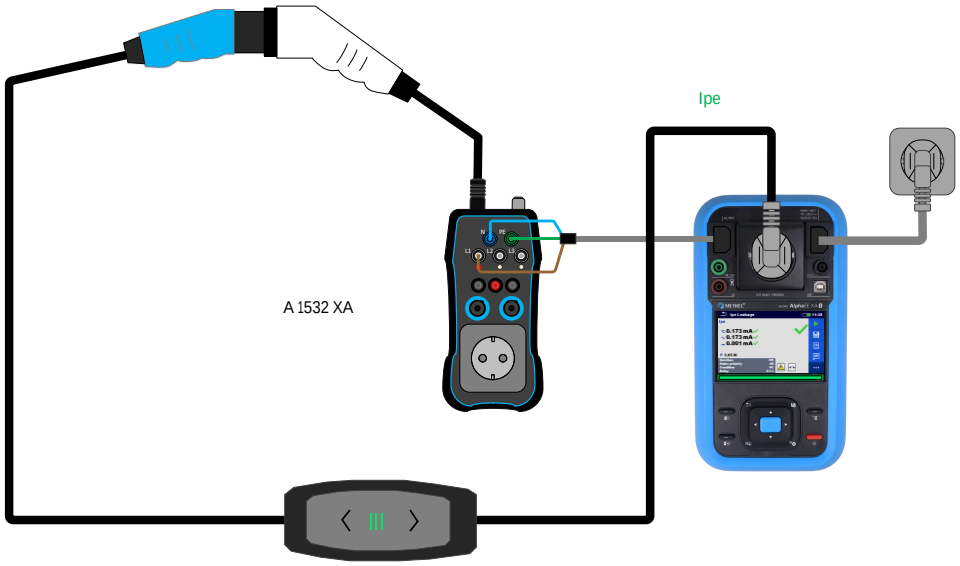


Figure 70_PE leakage current

Note!

Mode 2 cable shall be set to charging mode (Status C) using the CP STATE switch of the A 1532, UINPUT key is set to On.

Figure 71_A 1532 keys and switches

*Switching between steps shall be performed dynamically from A → C. The delay between switching depends on the design of the EVSE.		
Step	**Key** **UINPUT**	**Switch** **CP STATE**
1.	PE Leakage test = **On**	Not connected **Status A**
2.	PE Leakage test = **On**	Connected **Status B**
3.	PE Leakage test = **On**	Charging **Status C**

Table 32_Mode 2 cable setup

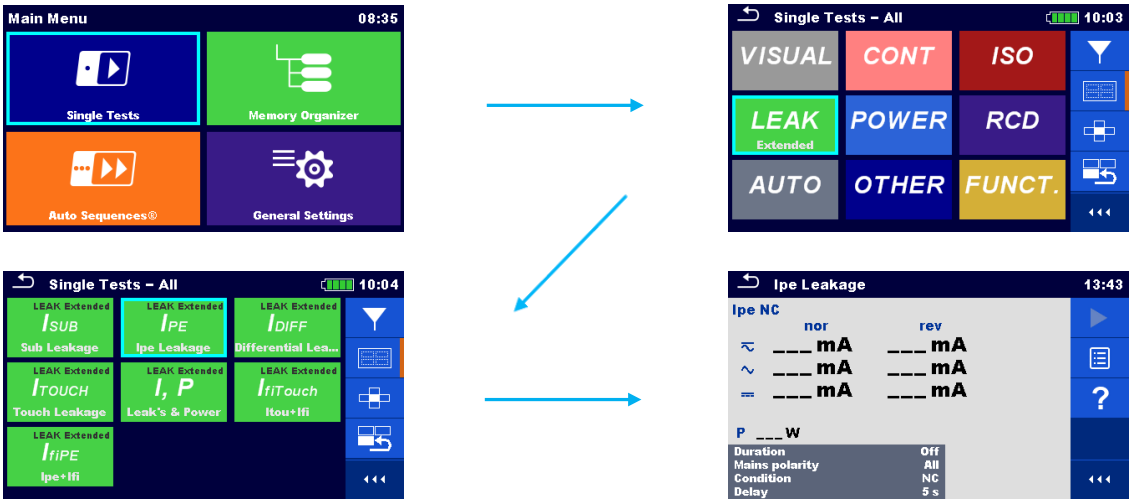


Figure 72_Current clamp setup

Measuring function: Ipe Leakage
Test: PE leakage
Limit: ≤ 3,5 mA

EV-RCD trip-out current

Scope of test:

According to EN 50699 and the German guideline for E-Mobility testing, the operation of further protective measures must be evaluated if the equipment under test includes such parts. The protective device in this case is the EV-RCD.

The EV-RCD in the Mode 2 cable provides an additional layer of electrical safety by monitoring the current flow and cutting the supply in the event of a fault (sensed as a sudden high leakage). Testing the EV-RCD ensures it functions correctly and can provide the necessary protection against electric shocks.

Always refer to the manufacturer's instructions or consult a qualified electrician to confirm the correct testing procedures for EV-RCDs in Mode 2 EV cables, as they may vary depending on the specific model and regulations in your location.

Generally, it is enough to test only the ability of the EV-RCD to trip in case of a fault.

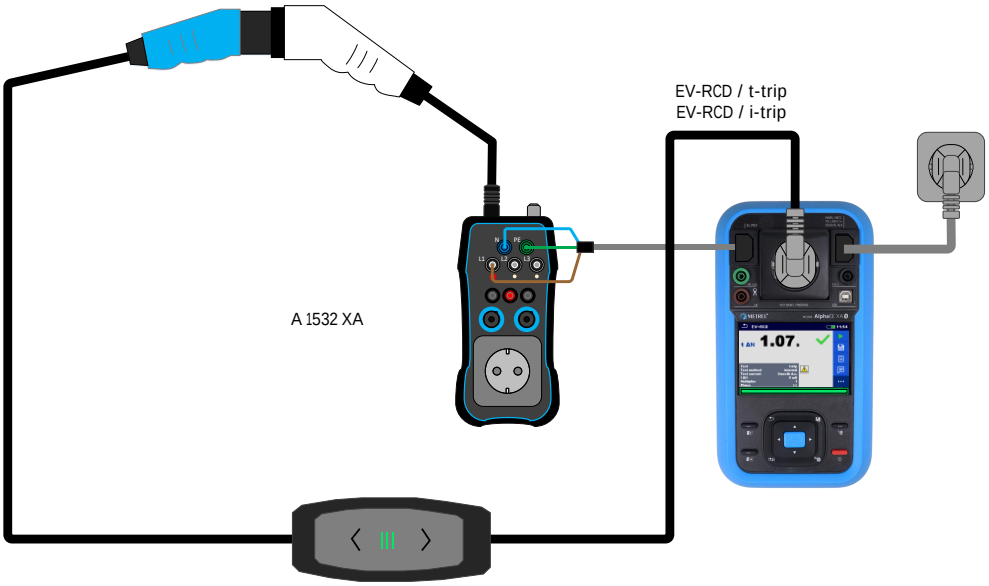


Figure 73_EV-RCD_Test method_internal

Test step	Test lead	A 1532	MI 3340
1	A 1670	PE	IEC/PRCD
1	A 1670	N	IEC/PRCD
1	A 1670	L1	IEC/PRCD

Table 33_Test leads setup

Notes!

- Functionality of the EV-RCD is evaluated on phase L1.
- Mode 2 cable shall be set to charging mode (Status C) using the CP STATE switch of the A 1532.

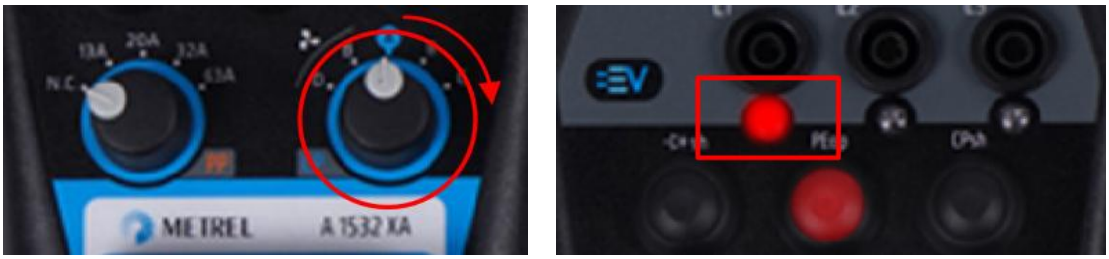


Figure 74_A 1532 keys and switches

The measurement is performed using the MI 3340 & A 1532. The subject of evaluation is EV-RCD of the Mode 2 cable.

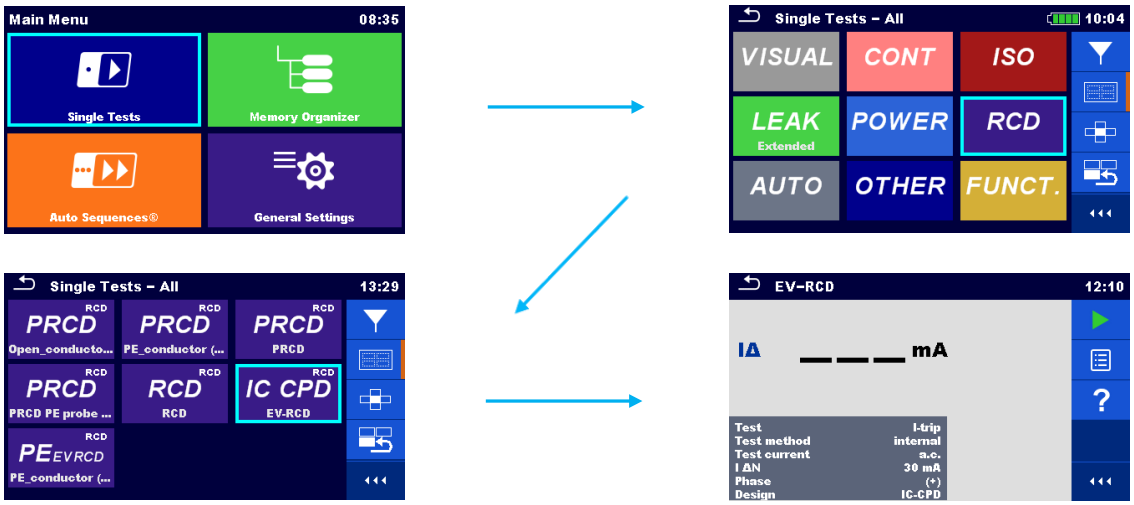


Figure 75_EV-RCD test setup

Measuring function: IC CPD / EV-RCD
Test method: internal/external
Test: t-trip / I-trip
Limit: IΔNa < IΔN

Measurement procedure >> *Internal* **<<**

			15s		6s		15s	
Step 1 **Switch CP STATE**	**Step 2** **Key UINPUT**	**Step 3** **Status**	**Step 4** **Switch CP STATE**	**Step 5** **Status**	**Step 6** **Switch CP STATE**	**Step 7** **Status**	**Step 8** **Switch CP STATE**	**Step 9** **Status**
A 1632	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340	A 1632	MI 3340
Not connected **State A**	UINPUT = **On**	Start test	Set A 1632 state A to state C.	Charging **Status C**	Set A 1632 to state A. See Notes.	Not connected **Status A**	Set A 1632 state A to state C.	Charging **Status C**
Turn off the UINPUT key, set the switch CP state to Status A. Proceed to the next step.								

Table 34_EV-RCD test procedure

Notes!

- Repeat the test procedure for different EV-RCD settings.
- Some IC CPD's have an auto-restart function; for such devices, steps 6 & 7 can be skipped.

Proximity Pilot resistor check (Optional)

Scope of test:

The highest possible charging speed is set using the Proximity Pilot (PP) switch. The PP is a set of resistors connected between the PP pin and the PE pin on the Type 2 connector or socket of a Mode 2 EV cable, a Mode 3 EVSE charging station or the EV. The coding of the chosen resistor informs about the cross-section of the cable used. The cross-section is the physical limit on the maximum charging current and, consequently, the charging speed.

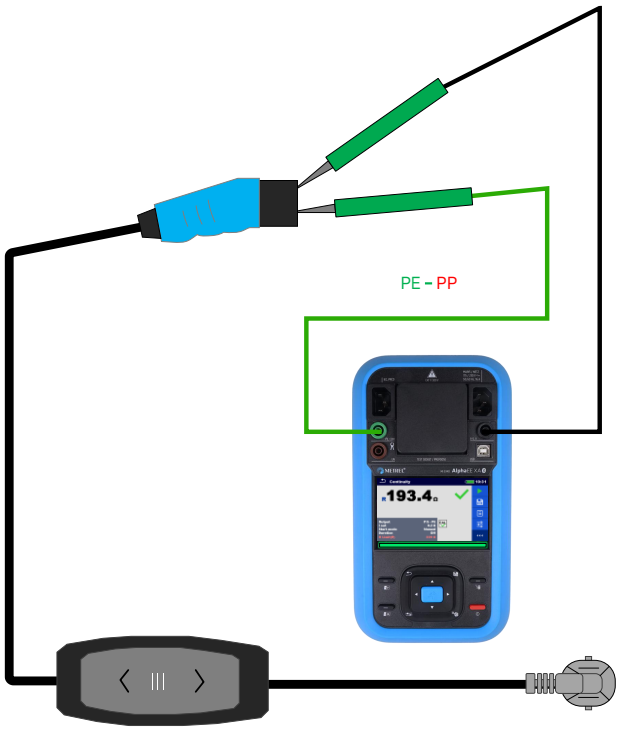


Figure 76_PP resistor_Test

Test lead	EV Cable	MI 3340
Black	PP-pin	P/S
Green	PE-pin	PE

Table 35_Test leads setup

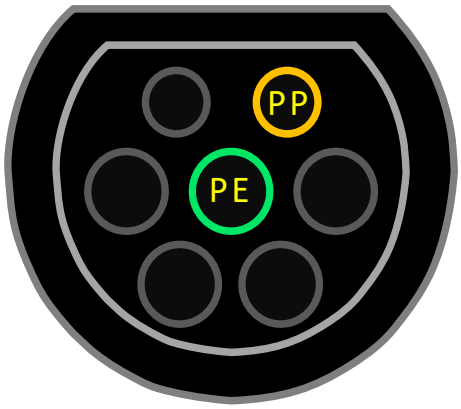


Figure 77_Position of the PE & PP pins on the mode 2 EV cable

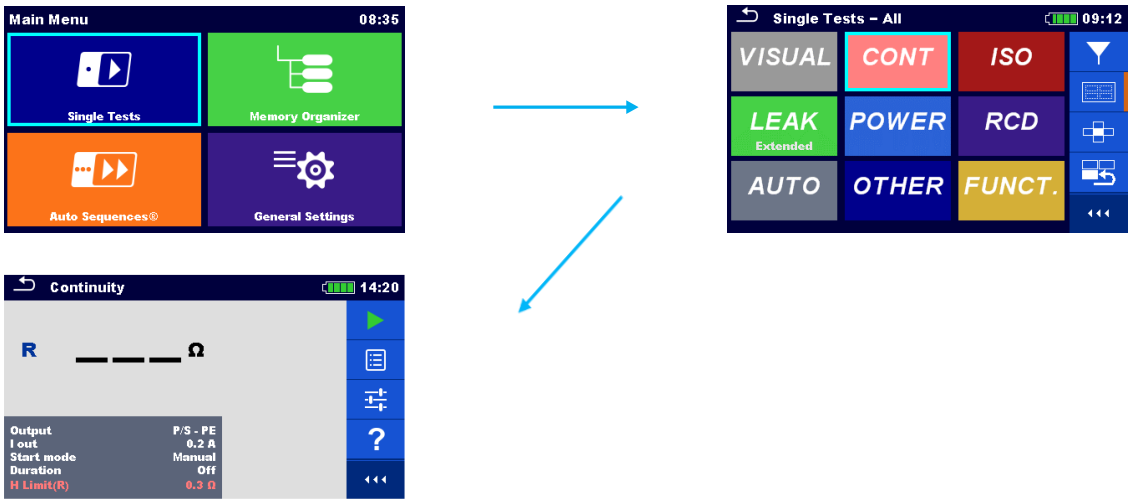


Figure 78_Resistance measurement setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
Iout: 0.2 A
Limits: The PP resistor can have the following values according to EN 61851-1:

- 1500 Ω → 13 A Charging cable
- 680 Ω → 20 A Charging cable
- 220 Ω → 32 A Charging cable
- 100 Ω → 63 A Charging cable

Error test

Scope of test:

The error test assesses the overall condition and functionality of the Mode 2 EV cable and the ability of its protective circuit to react to errors on the input and output side of the cable.

Simulating errors at the Mode 2 cable output ensures that the dangerous mains voltage is switched off at the cable output in the event of a malfunction on the EV vehicle.

Testing the response and functionality of the cable during these faults ensures safe and reliable EV charging. Appropriate measures can be taken to repair or replace the cable.

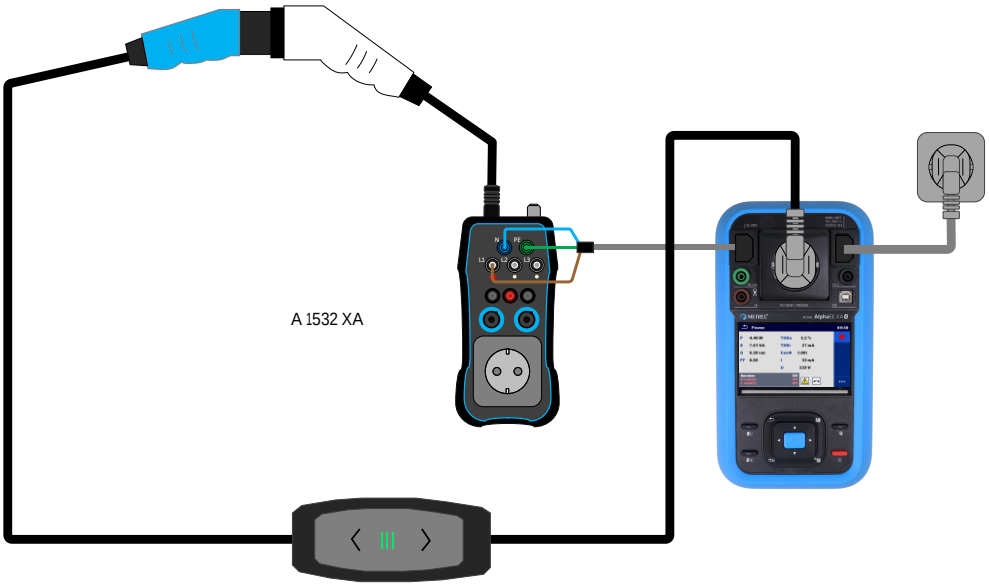


Figure 79_Error test

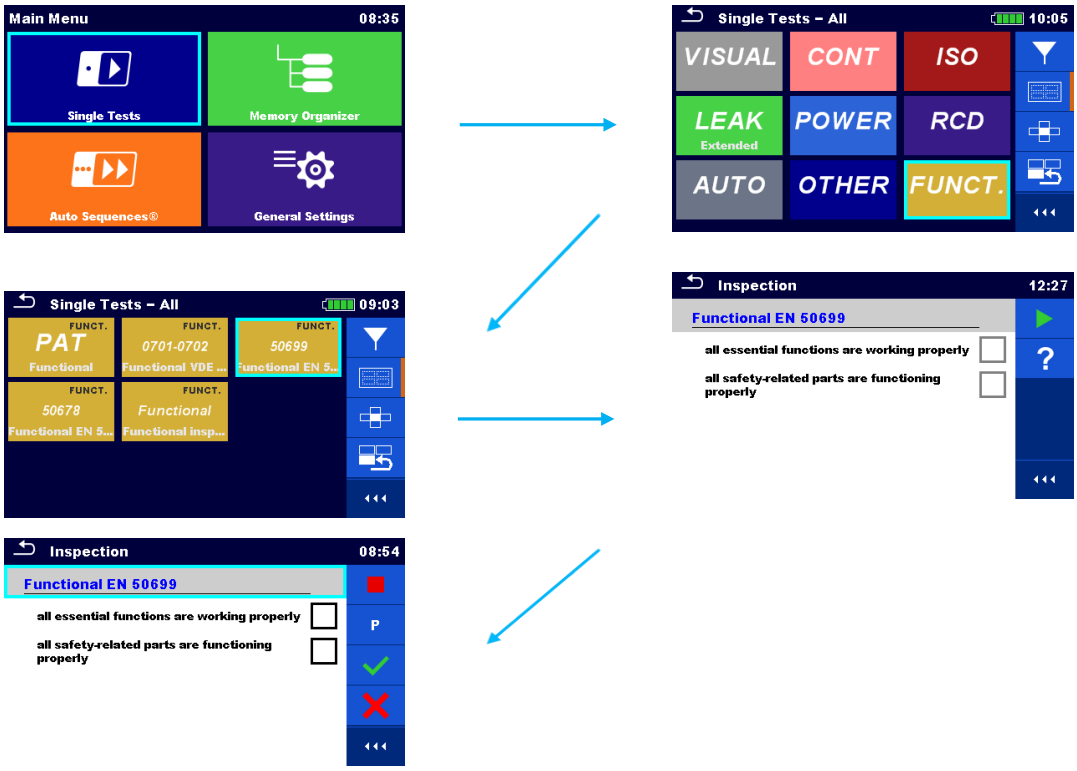


Figure 80_Functional inspection setup

Measurement procedure

Connect the charging cable between the MI 3340 and the A 1532 (see Figure 79_Error test).

While the EVSE is in state C or D press and hold any of the fault simulation push buttons for at least 3 s and check the response of the EVSE, follow the steps from bellow table.

Check the response of the tested charging cable.

→					
Step	**Key** **UINPUT**	**Switch** **ERRORS**	**Switch** **CP STATE**	**Switch** **Error ON**	**Test condition**
1.	UINPUT = **On**	INPUT **L / L1op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L1 interrupted**. Observe the output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
2.	UINPUT = **On**	INPUT **L / L2op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L2 interrupted**. Observe the output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
3.	UINPUT = **On**	INPUT **L / L3op**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L3 interrupted**. Observe the output LEDs for status.

Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
4.	U_{INPUT} = **On**	INPUT **Nop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **N interrupted**. Observe the output LEDs for status.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to next step.					
5.	U_{INPUT} = **On**	INPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **PE interrupted**. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
6.	U_{INPUT} = **Off**	INPUT **L ⟲ PE**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **L_PE switched**. The tested EVSE shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
7.	U_{INPUT} = **Off**	INPUT **U_{EXT}** **(PE)**	Charging **Status C**	Error ON/OFF = **On**	Mains voltage ERROR condition on the input of the charging cable: **External voltage present on PE**. The tested EVSE shall not enter operation mode when set to status C. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
8.	U_{INPUT} = **On**	OUTPUT **CPsh**	Charging **Status C**	Error ON/OFF = **On**	**CP - PE shorted**. EVSE output should de-energise within 3 s. Observe the manufacturer's information for proper operation
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
9.	U_{INPUT} = **On**	OUTPUT **PEop**	Charging **Status C**	Error ON/OFF = **On**	**PE opened**. EVSE output should de-energize within 100 ms. Observe the manufacturer's information for proper operation.
Turn off the Error ON/OFF key, set switch CP state to Status A. Proceed to the next step.					
*10.	U_{INPUT} = **On**	OUTPUT ⏚sh	Charging **Status C**	Error ON/OFF = **On**	**CP diode shorted**. EVSE output should de-energize within 3 s. Observe the manufacturer's information for proper operation
Turn off the Error ON/OFF key, set switch CP state to Status A. Error test finished.					

Table 36_Applicable error test

*CP diode shorted test can be performed optionally.

3. Mode 3 EV cables testing using A 1832

The A 1832 is intended for testing Mode 3 EV charging cables with type 2 connector. Different tests can be carried out in combination with Metrel or third-party safety testers.

List of Applicable test & Limits

Measurements according to the German guideline for E-Mobility		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Continuity of protective conductor	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance of the protective conductor to the neutral and phase conductor	Insulation resistance measurement	≥ 1.0 MΩ
Check the resistance coding for the vehicle coupling and connector according to IEC 61851-1	Resistance measurement	13 A Charging cable 1500 Ω 20 A Charging cable 680 Ω 32 A Charging cable 220 Ω 63 A Charging cable 100 Ω

Table 37_Applicable measurements

Note!

Based on field experience, it is important to check not only the continuity of the protective conductor but also the continuity of all other conductors, as this is the only way to ensure proper charging of electric vehicles.

Visual inspection

Scope of test:

The visual inspection shall detect external defects and, if possible, determine the equipment's suitability for the environment.

Figure 81_Visual inspection

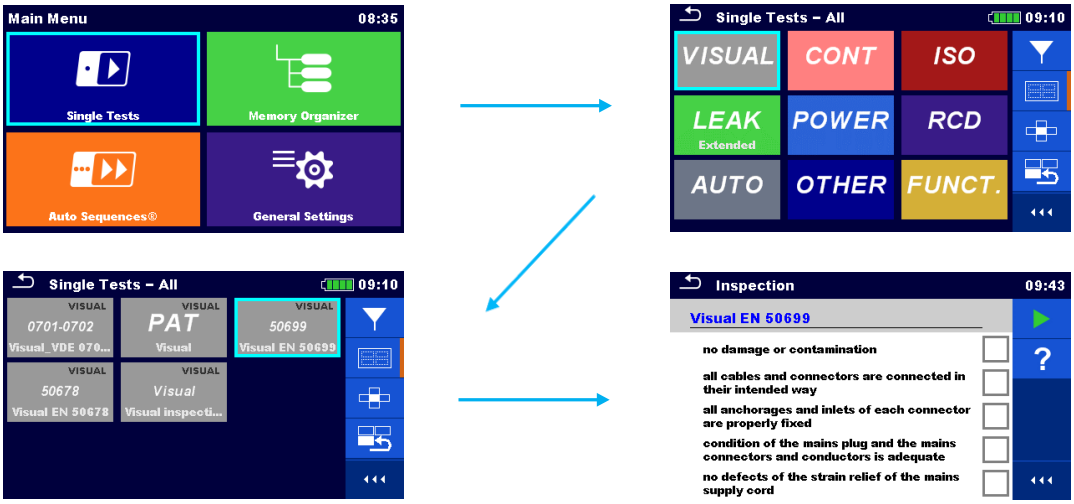


Figure 82_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cord.

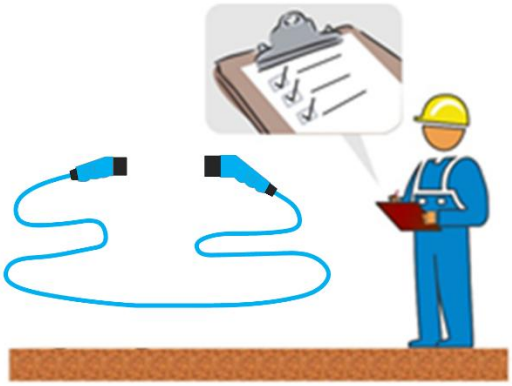


Figure 83_Visual inspection

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340 & A 1832. The subject of evaluation is the PE conductor, between the input and the output terminal of the cable.

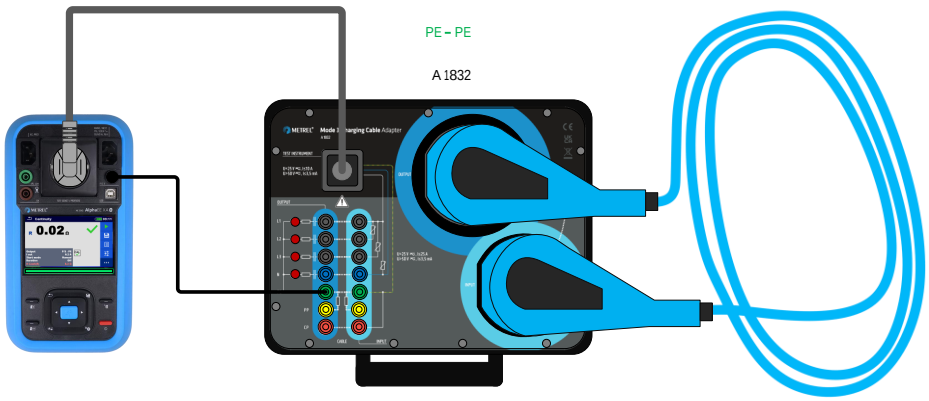


Figure 84_Continuity of protective earth

Note!

The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

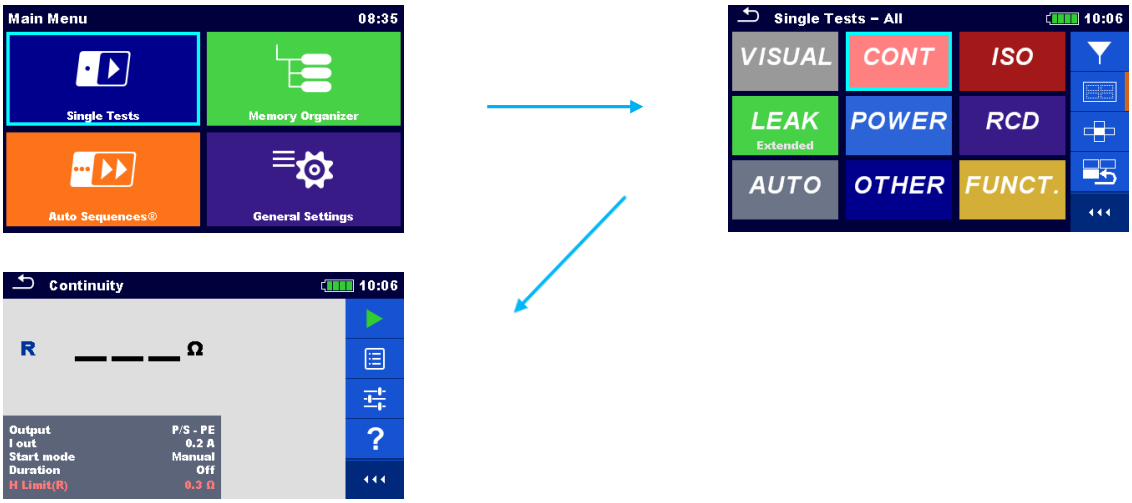


Figure 85_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Compensation of test leads

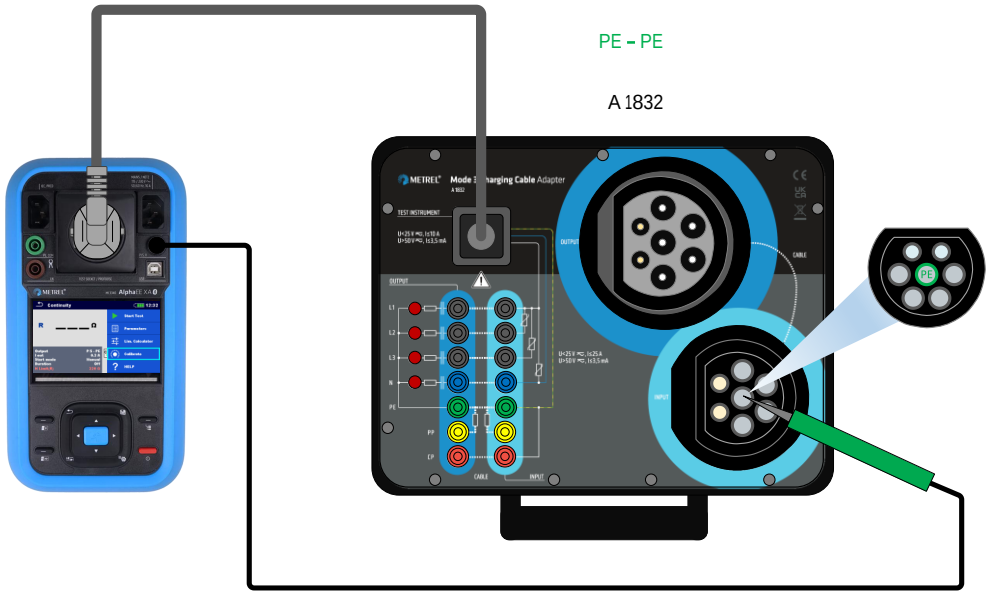


Figure 86_Test leads compensation

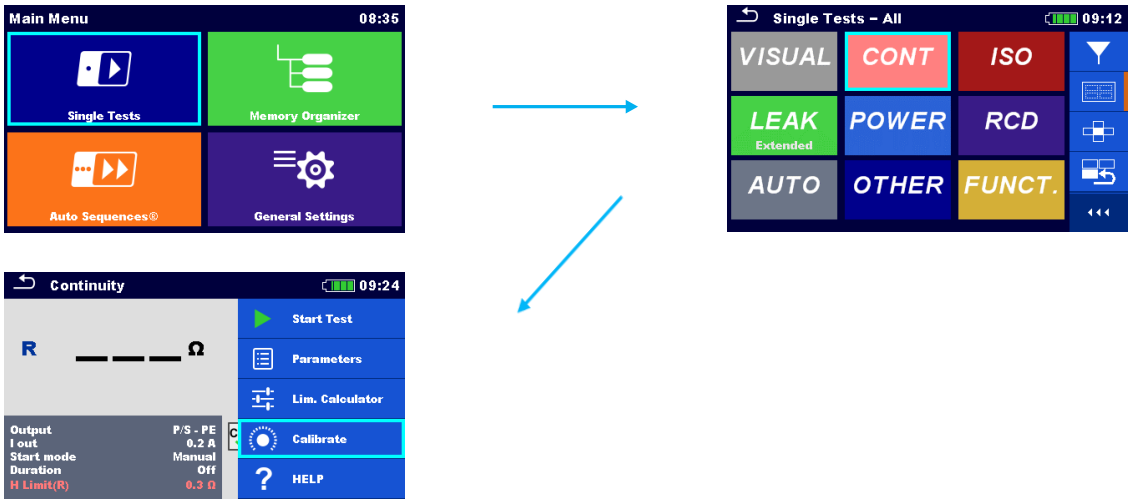


Figure 87_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 86_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

Proximity Pilot resistor check (Input and Output)

Scope of test:

Charging speed is determined by the **Proximity Pilot (PP)**, which is implemented as a **resistor connected between the PP pin and the PE (Protective Earth) pin** on the **Type 2 connector** of a **Mode 3 charging cable**.

This **resistor encodes the cable's current-carrying capacity** based on its **cross-sectional area**, thereby indicating the **maximum allowable charging current**—and, by extension, the **charging speed**. The PP resistor is **integrated at both ends of the cable**, allowing the vehicle and charging station to recognize the cable type and apply appropriate charging parameters.

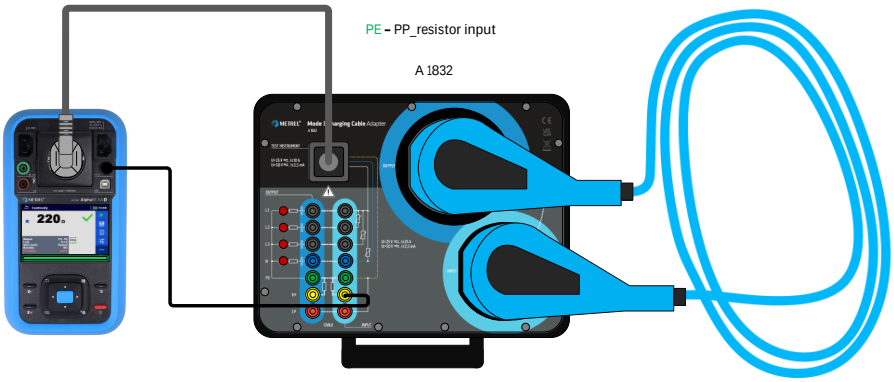


Figure 88_PP resistor Test Input

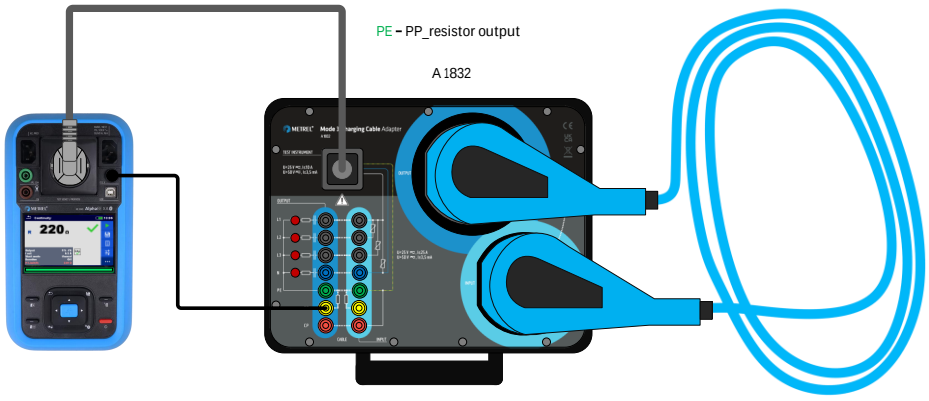


Figure 89_PP resistor Test Output

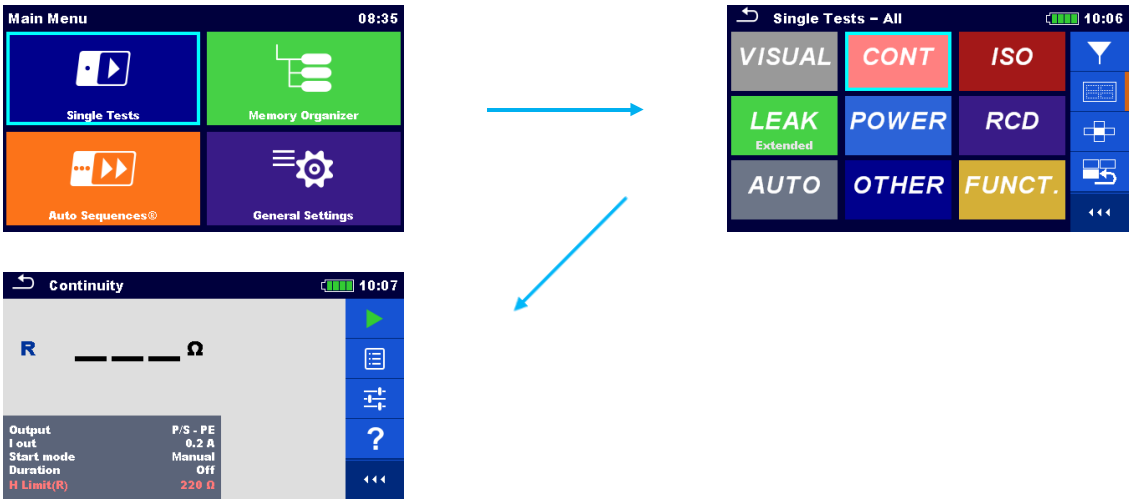


Figure 90_Resistance measurement setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
Iout: 0.2 A
Limits: The PP resistor can have the following values according to EN 61851-1:

- 1500 Ω → 13 A Charging cable
- 680 Ω → 20 A Charging cable
- 220 Ω → 32 A Charging cable
- 100 Ω → 63 A Charging cable

Continuity of the CP (Control pilot) wire

Scope of test:

Continuity of the Control Pilot wire is confirmed using the low resistance measurement.

The measurement is performed using the MI 3340 & A 1832. The subject is the CP wire between the input and the output terminals of the cable.

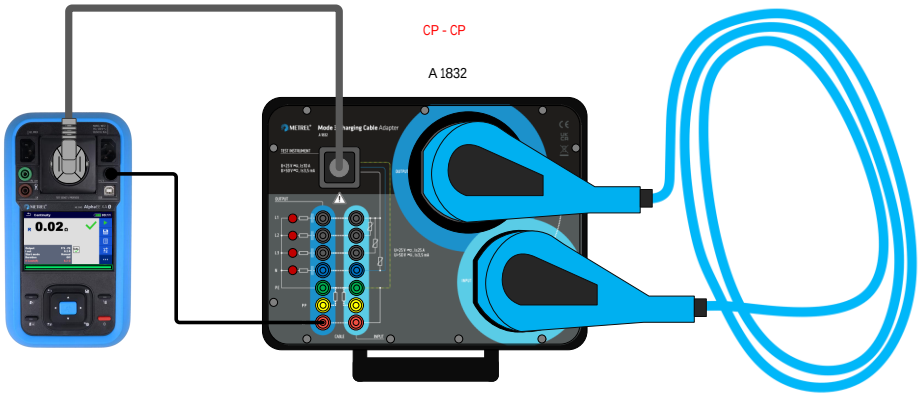


Figure 91_Continuity of Control pilot wire

Note!

The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

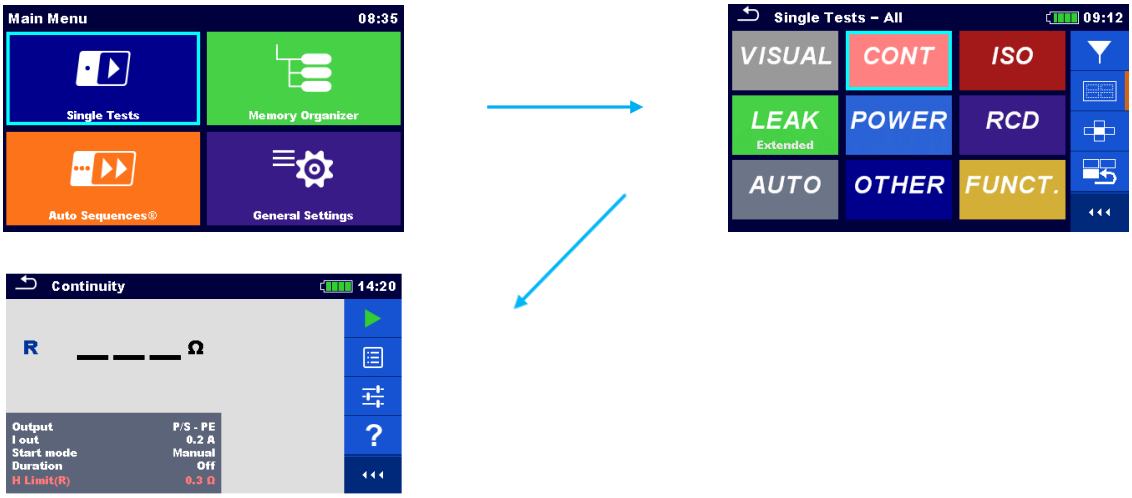


Figure 92_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Continuity of live wires

Scope of test

The connection effectiveness of the live wires is evaluated.

All live wires can be checked in a single test using the substitute leakage measurement and the internal circuit of A 1832.

The measurement is performed using the MI 3340 & A 1832. The subject of evaluation is the live conductors between the input and the output terminal.

All LED lamps on A 1832 light up on a positive test result.

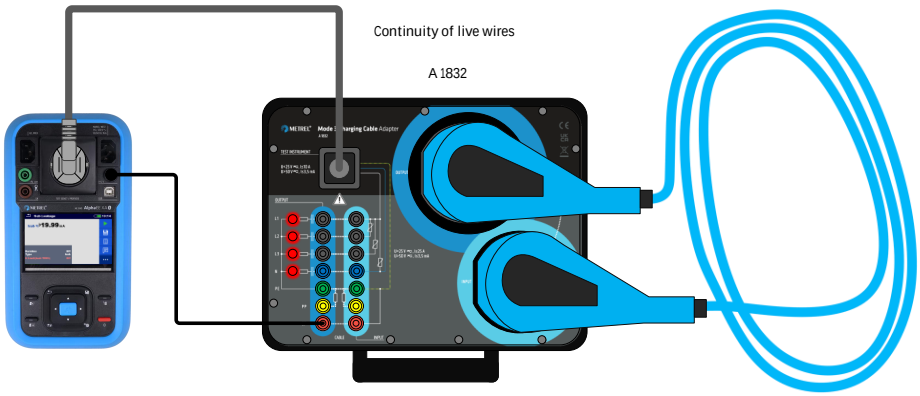


Figure 93_Continuity of live wires

Notes!

The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

The measurement result on MI 3340 is irrelevant to the test result and therefore shall not be recorded.

In case of failure (some LED lamps on A 1832 do not turn on), each wire can be evaluated separately using the Continuity function.

The polarity of the wires is not detected in this test.

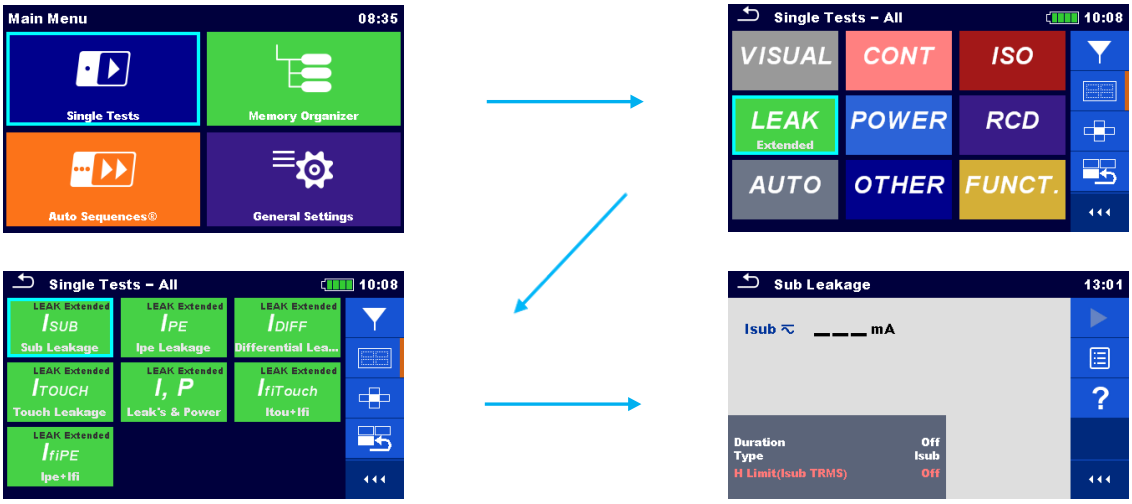


Figure 94_Earth continuity setup

Measuring function: Sub leakage
Type: Isub
Limit: All LED lamps on A 1832 shall light up

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340 and A 1832. The subject of evaluation is the insulation resistance and capacitance between the PE conductor and the live parts of the Mode 3 cable.

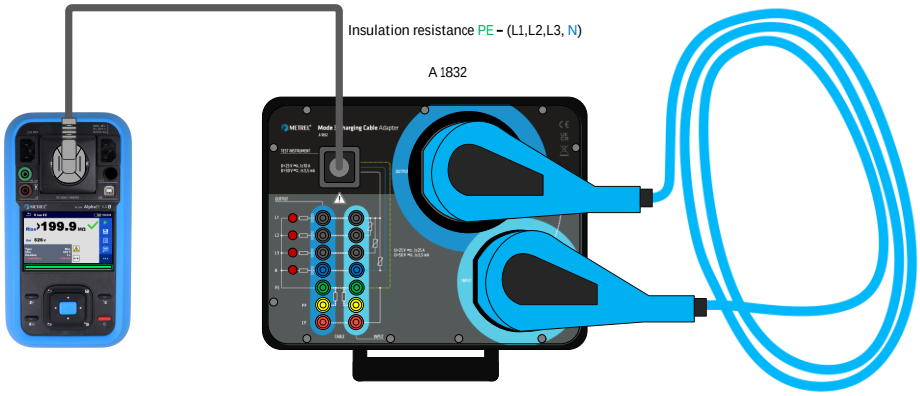


Figure 95_Insulation resistance

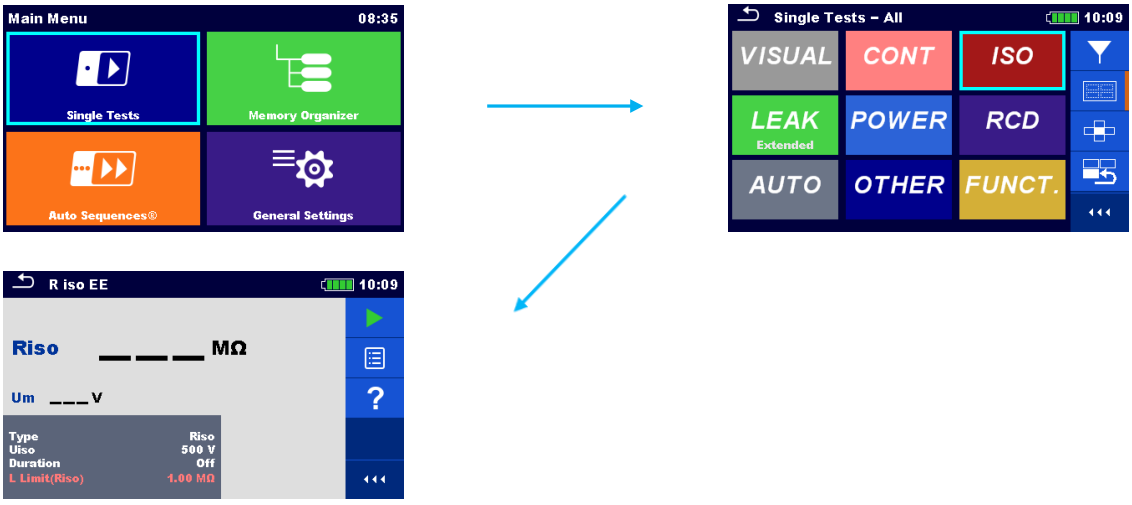


Figure 96_Insulation resistance setup

Measuring function: RPAT / Riso EE
Output parameter: Riso
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ

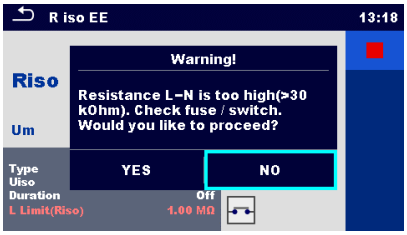


Figure 97_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user of the following possible causes:

- The device under test is not connected or switched on

In this application, the warning message is irrelevant as the test is made on the cable without internal resistance.
Select **YES** to proceed with or NO to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu.
Load pretest (On/**Off**).

4. Testing devices with floating inputs

Electrical equipment with isolated inputs includes oscilloscopes, power analysers, bench multimeters and others. They can be found in laboratories or educational institutions, amongst others.

The main measuring problem is applying the maximum permissible nominal input voltage to the insulated input of the DUT (device under test) to determine the leakage current. Most testers don't have a suitable voltage generator installed.

An accurate measurement result can be obtained using the alternative methods described below.

General information about devices with floating inputs

Standards EN 50678 and EN 50699 require touch current and the protective conductor current measurements on devices with floating inputs.

Additionally, the leakage current caused by the rated input voltage on the input terminals shall be measured.

The highest-rated input voltage must be marked on the DUT, usually right next to the input connector and measurement category (CAT) rating. **This voltage can be much higher than 230 V.**

Typical devices in this group are **power analysers** or **multimeters,** with a rated input voltage of 600-1000 V.

Figure 98_Typical devices with floating inputs

List of Applicable test & Limits

Measurements		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Continuity of protective conductor (Class I)	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance of the protective conductor to the neutral and phase conductor	Insulation resistance measurement	≥ 1.0 MΩ (secondary side)
Ipe + Ifi (Class I)	Direct, residual, or alternative method	≤ 3,5 mA
Itou + Ifi (Class I, Class II)	Direct, residual, or alternative method	≤ 0,5 mA
Functional inspection		

Table 38_Applicable measurements

Visual inspection

Scope of test:

The visual inspection shall detect external defects and, if possible, determine the equipment's suitability for the environment.

Figure 99_Visual inspection

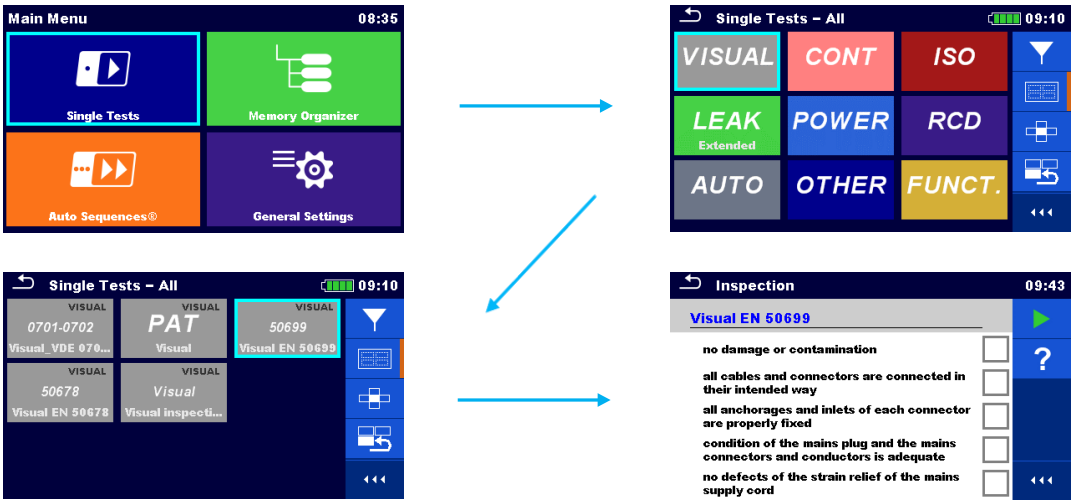


Figure 100_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the cables and connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cords, hoses or tubes.
- Check for damage on the mains plug, the mains connectors and conductors.
- Check for defects on the strain relief of the mains supply cord.
- Check the condition of the anchorage, cable clip, and accessible fuse insert.
- Check for signs of improper change.
  Check that the cooling openings aren't blocked and the filter condition.
  Check the condition and tightness of any water, air or other media container, and its pressure control valve.
- Check the functionality of switches, control and setup of equipment.
- Check all safety-relevant markings, labels or symbols, ratings, and the position indicators are legible and complete.
- Check that all accessible fuses comply with the manufacturer's requirements (rated current, characteristics).
- Check the condition of all the relevant accessories (e.g. detachable or fixed power supply cords, tubing).

Figure 101_Visual inspection

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340. The subject of evaluation is the PE conductor between the PE pin on the supply cable and any accessible earthed parts.

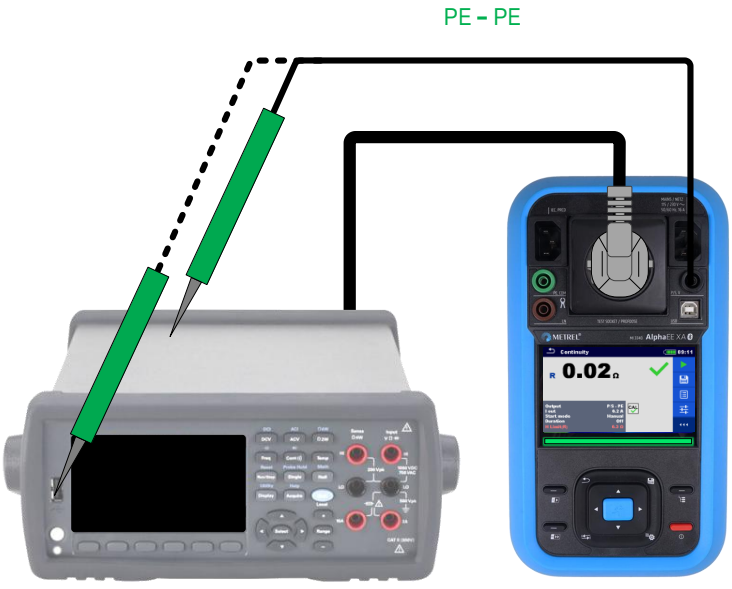


Figure 102_Continuity of protective earth

Note!

All earthed metal parts shall be evaluated. Check the manufacturer's information.

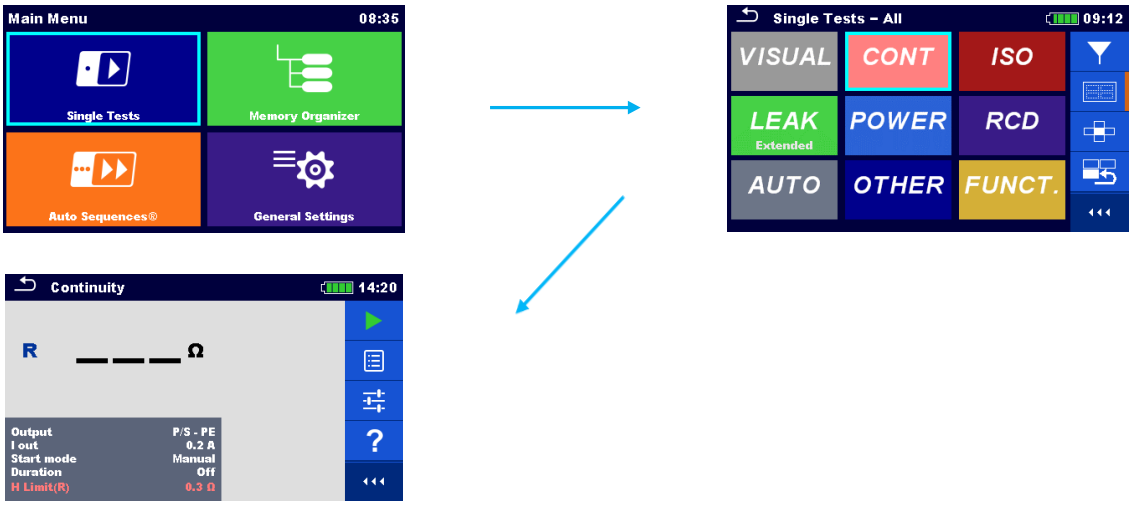


Figure 103_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the DUT according to the connection diagram Figure 102_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340. The subject of evaluation is the insulation resistance between the PE conductor and the live parts.

Figure 104_Insulation resistance Class I

Note!

If the device under test has isolated metal parts, they must be tested separately.

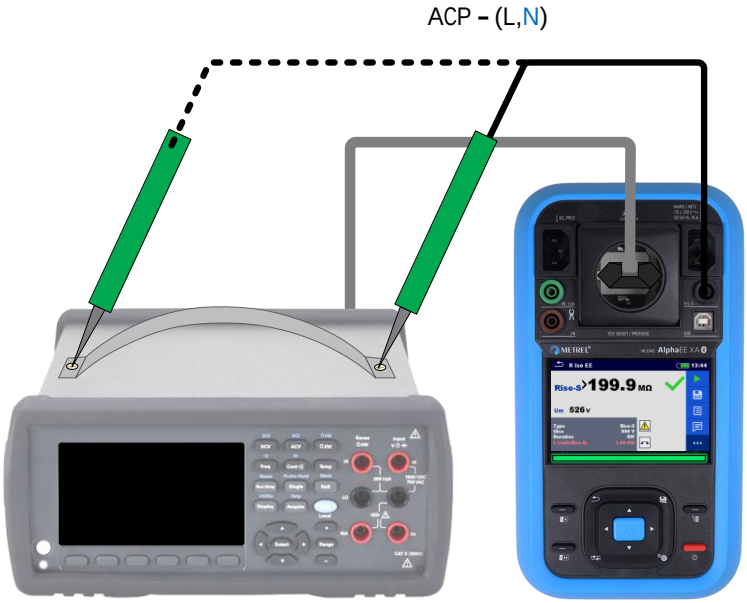


Figure 105_Insulation resistance Class II

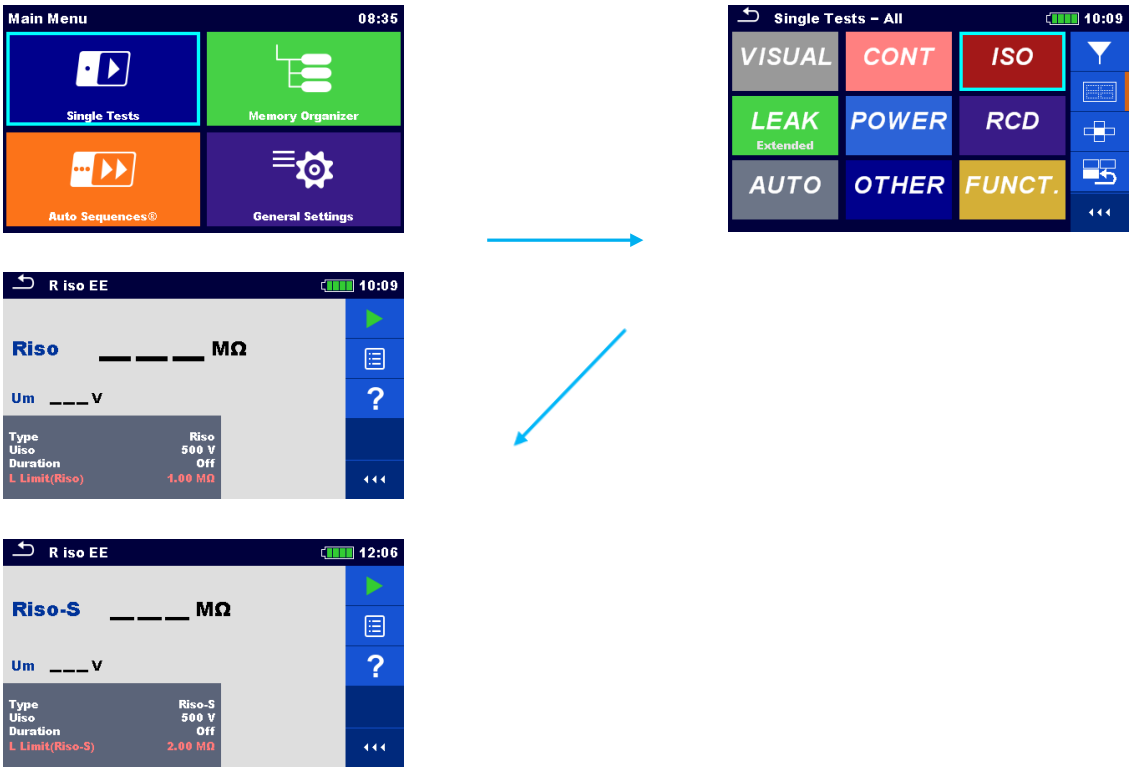


Figure 106_Insulation resistance setup

Measuring function: RPAT / Riso EE (CassI), Riso-S EE (CassII),
Output parameter: Riso / Riso-S
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ

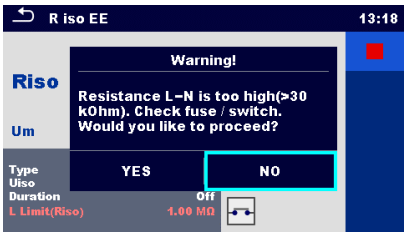


Figure 107_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user of the following possible causes:

- The device under test is not connected or switched on
- The input fuse of the device under test is blown.

Select **YES** to proceed with or NO to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu. Load pretest (On/**Off**).

Measurement procedure

- Connect the DUT according to the connection diagram Figure 104_Insulation resistance Class I or Figure 105_Insulation resistance Class II,
- Set appropriate measurement parameters,
- Start the test.

Leakage current test

How to perform a test on floating inputs

The standard allows two test methods:

1. Use a testing device with a powerful enough generator rated for floating inputs.
    - For example, use the MI 3394 **CE MultiTesterXA for the high voltage test**
2. If such a device is not available, the measurement can be performed in 3 steps using the alternative methods. The methods are different for Class I and Class II devices.

Class I

Step 1

The protective conductor current is evaluated with the inputs disconnected using either the direct (Ipe) or differential (Idiff) leakage current measurement.

The subject of evaluation is the insulation resistance and capacitance in AC conditions between the PE conductor and the live parts of the Electrical equipment.

Figure 108_PE leakage current

Step 2

Voltage as required by the alternative leakage current method is applied to the floating inputs, and the PE current is measured.

The resulting current is called the floating input current (Ifi.

If there are multiple floating inputs, each can be measured successively, and the results are added together.

Using the **Alternative leakage current** measurement, the subject of evaluation is the insulation resistance and capacitance between the live parts and floating inputs of the Electrical equipmentDUT.

The leakage current shall be scaled to the highest rated voltage specified for the floating inputs.

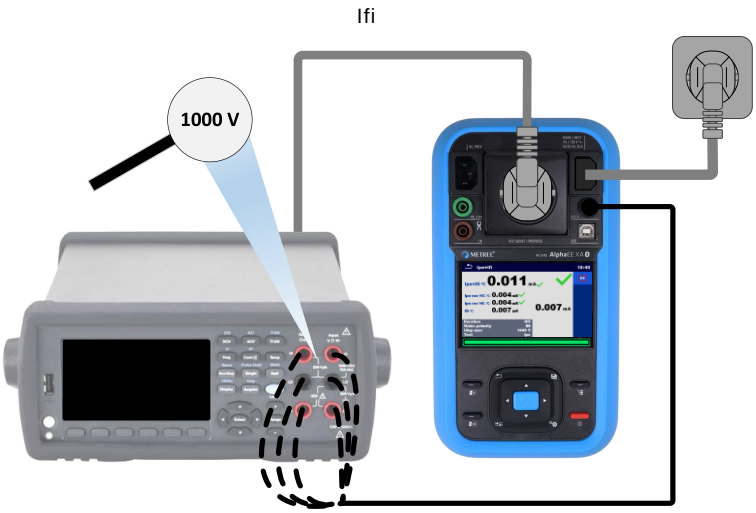


Figure 109_Ifi_Alternative method Class I

Step 3 (Class I)

The total protective conductor current / touch-current evaluated by addition of the leakage current in step 1) and step 2).

The end result Ipe + Ifi or Idiff + Ifi is calculated as sum of Ipe or Idiff current and Ifi (the overall value).

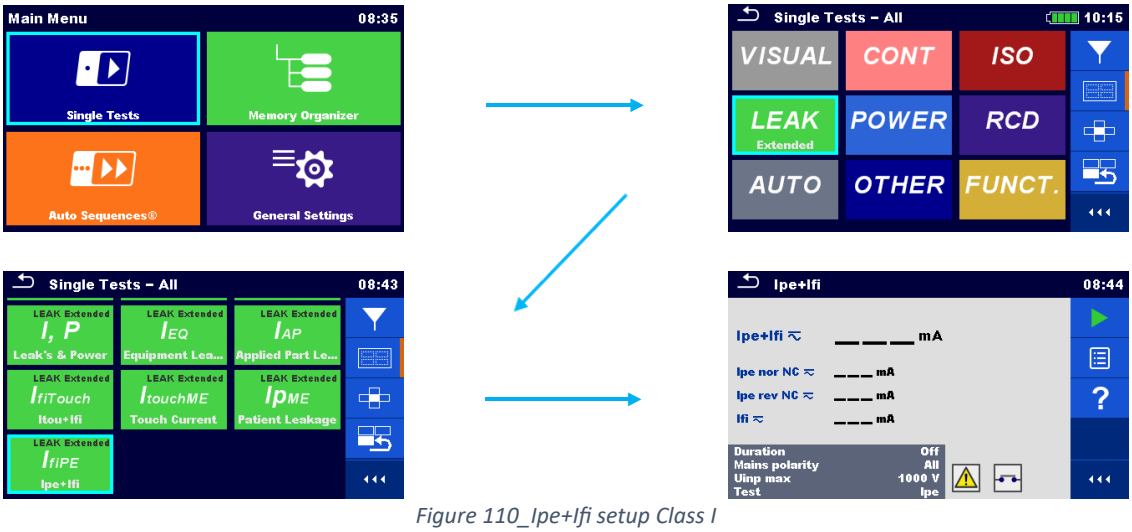


Figure 110_Ipe+Ifi setup Class I

Measuring function: Ifipe Leakage (PE leakage, direct/residual)
Test: PE leakage + Floating input leakage
Limit: ≤ 3,5 mA

asurement procedure Class I

- Connect the DUT to the test instrument test socket.
- Select the Ifipe measuring function, and check for the maximum rated input voltage specified next to floating inputs. Enter the rated voltage under parameter **Uinp max**.
- Proceed with step 1.

After Step 1 is finished, reconnect the device under test according to Step 2 and proceed with measuring the leakage current produced on floating inputs.

Note!
Uinp max is used for the calculation of Ifi.

Class II

Step 1

Touch current (Itou) is evaluated in this step while the inputs are disconnected. All test methods are allowed.

Itou (Class I, Class II)

Itou is measured.

With the **Touch leakage current** measurement, the subject of evaluation is the insulation resistance and capacitance between the Isolated conductive parts and the live parts of the Electrical Equipment.

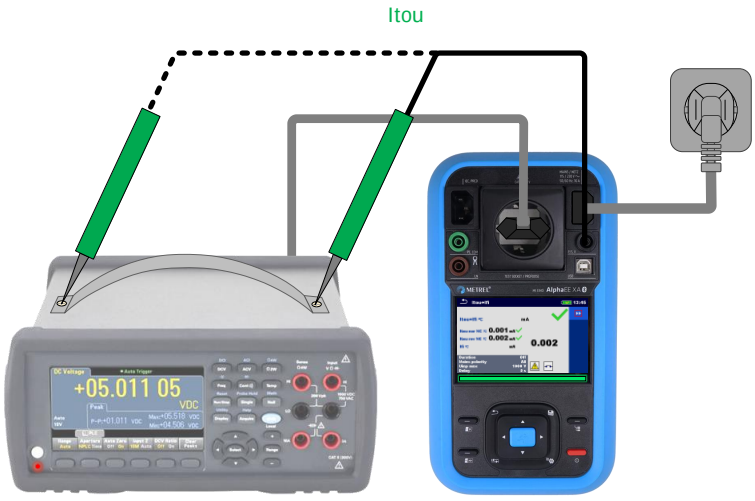


Figure 111_Touch leakage current (Class II)

Step 2

Voltage as required by the alternative leakage current measurement is applied to the floating inputs, and the touch current is measured.

Ifi (Class II)

The floating input current (Ifi) is measured. If there are multiple floating inputs, each can be measured successively, and the results are added together.

The subject of evaluation is the insulation resistance and capacitance between the accessible conductive parts and floating inputs of the DUT.

The leakage current shall be scaled to the highest rated voltage specified for the floating inputs.

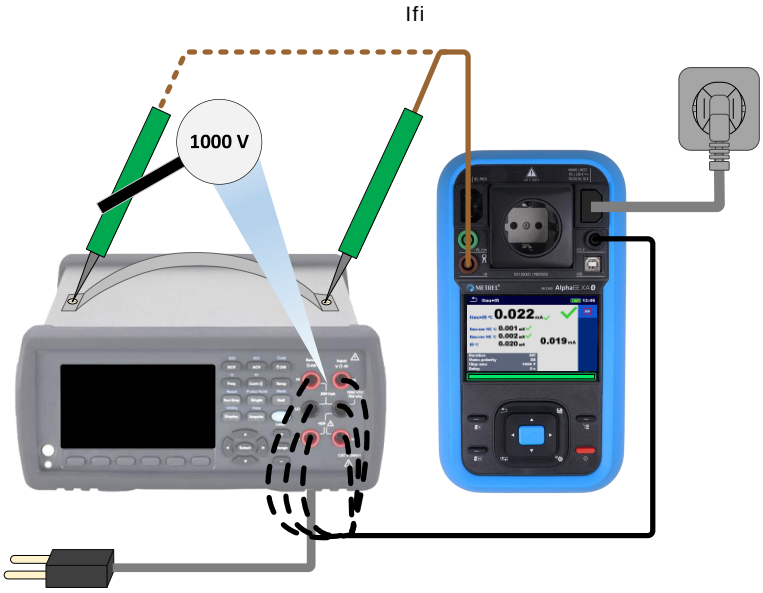
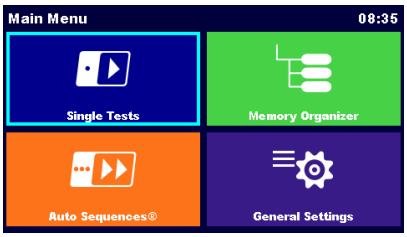


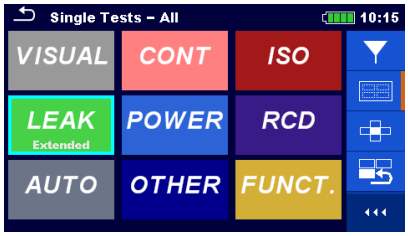
Figure 112_Ifi_Alternative method Class II

Step 3 (Class II)

The total protective conductor current / touch-current evaluated by addition of the leakage current in step 1) and step 2).

The end result Ipe + Ifi or Idiff + Ifi is calculated as sum of Ipe or Idiff current and Ifi (the overall value).





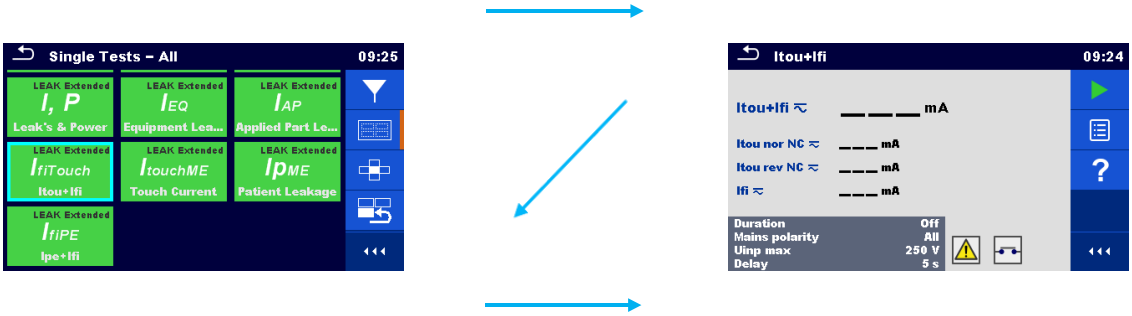


Figure 113_Itou+ Ifi setup ClassII

Measuring function: IfiTouch Leakage
Test: Touch Leakage + Floating input leakage
Limit: ≤ 0,5 mA

Measurement procedure Class II

- Connect the DUT to the test instrument's test socket, see Figure 111_Touch leakage current (Class II) and Figure 112_Ifi_Alternative method Class II
- Select the correct measuring function, and check for the maximum rated input voltage specified next to floating inputs. Enter the rated voltage under parameter **Uinp max**.
- Proceed with step 1.

Note!
Uinp max value is used for the calculation of Ifi.

After Step 1 is finished, reconnect the device under test according to Step 2 and proceed with measuring the touch leakage current produced on the floating inputs.

Functional inspection

A functional test shall be carried out to finish the safety test procedure. The manufacturer's recommendations shall be considered.

Figure 114_Functional inspection

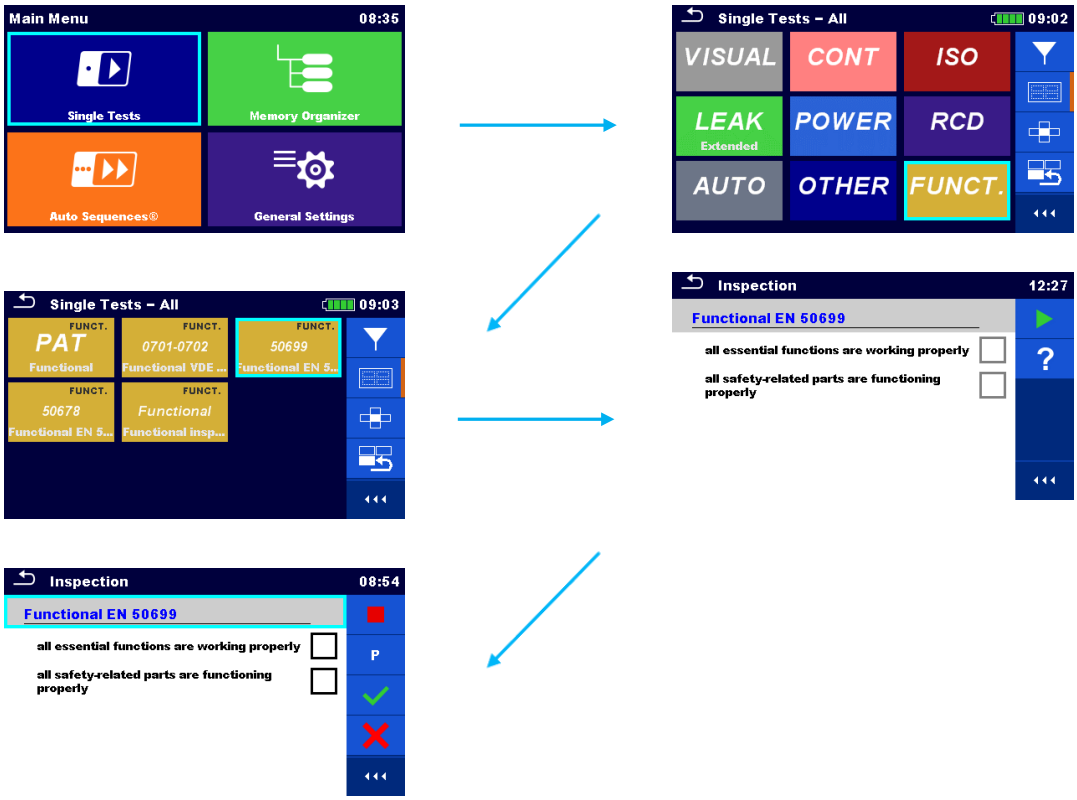


Figure 115_Functional inspection setup

Measurement procedure

- Connect the Electrical equipment instrument test socket, see Figure 114_Functional inspection.
- select the correct measuring function (Functional inspection),
- start the test and tick off the correct statuses. Power can be applied to the device under test to check correct operation and consumption.

5. Testing 3-Phase Electrical Equipment Using the Metrel A 1830 and MI 3340

Testing 3-phase electrical equipment is essential to ensuring safety, efficiency, and compliance with industry standards. The **A 1830 3-Phase Active Leakage Adapter** and MI 3340 AlphaEE XA Tester provide a reliable solution for testing various parameters of 3-phase electrical equipment. This application note outlines the procedure for using these instruments to conduct effective and accurate electrical tests.

List of Applicable test & Limits

Measurements		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Continuity of protective conductor (Class I)	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance test between mains and earthed parts	Insulation resistance measurement	General DUT ≥ 1,0 MΩ
		DUT with heating elements ≥ 0,3 MΩ
Protective conductor measurement	Direct method, Residual method, Alternative method.	General ≤ 3,5 mA The DUT manufacturer may allow a higher limit.
Touch-current measurement	Direct method, Residual method, Alternative method.	Accessible parts not connected to protective earth ≤ 0,5 mA.
Functional inspection		
If devices of class I with heating elements > 3,5 kW do not conform to the insulation resistance limits, the test is passed if the earth leakage current does not exceed 1 mA/kW up to 10 mA as a maximum limit.		

Table 39_Applicable measurements

Visual inspection

Scope of test:

The visual inspection shall detect external defects and, if possible, determine the equipment's suitability for the environment.

Figure 116_Visual inspection

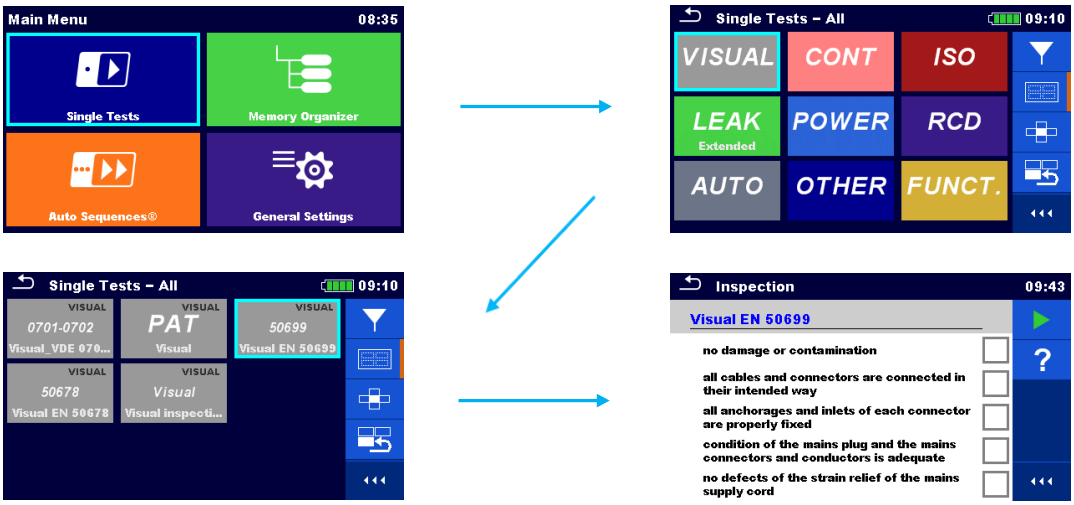


Figure 117_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the cables and connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cords, hoses or tubes.
- Check for damage on the mains plug, the mains connectors and conductors.

- Check for defects on the strain relief of the mains supply cord.
- Check the condition of the anchorage, cable clip, and accessible fuse insert.
- Check for signs of improper change.
  Check that the cooling openings aren't blocked and the filter condition.
  Check the condition and tightness of any water, air or other media container, and its pressure control valve.
- Check the functionality of switches, control and setup of equipment.
- Check all safety-relevant markings, labels or symbols, ratings, and the position indicators are legible and complete.
- Check that all accessible fuses comply with the manufacturer's requirements (rated current, characteristics).
  Check the condition of all the relevant accessories (e.g. detachable or fixed power supply cords, tubing).

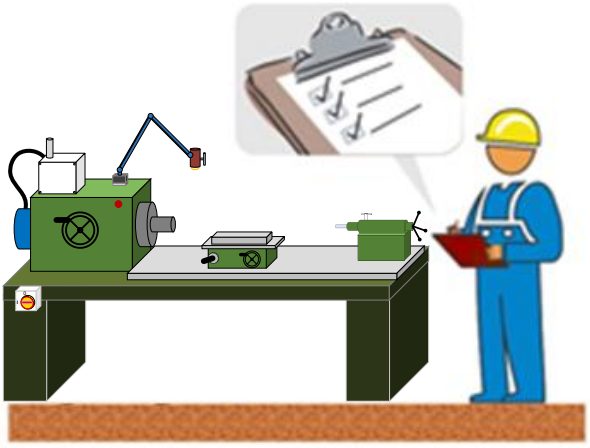


Figure 118_Visual inspection

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340 + A 1830. The subject of evaluation is the PE conductor between the input terminal (likely a pin in the socket) and any accessible earthed parts.

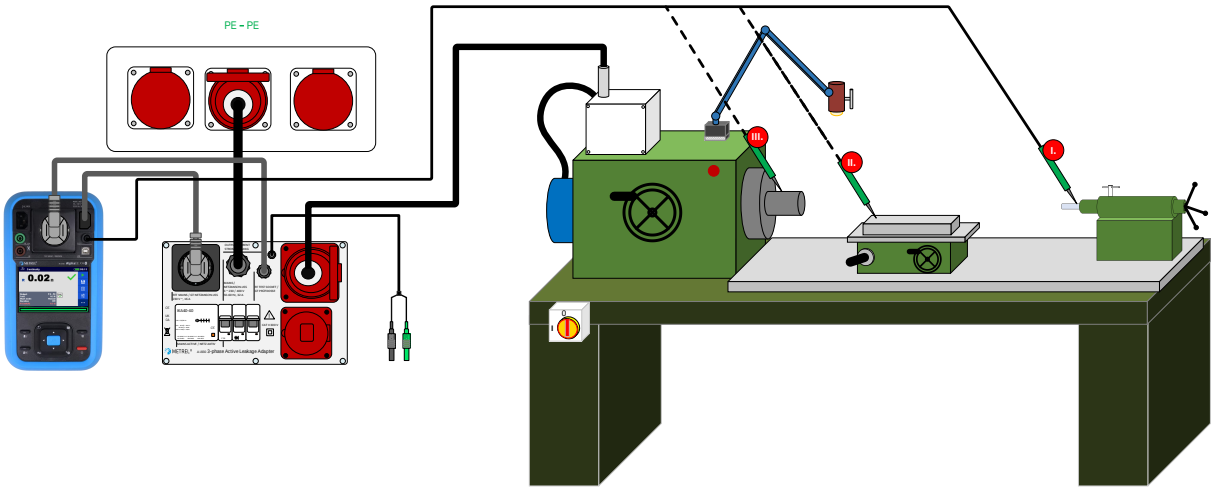


Figure 119_Continuity of protective earth

Note!

All relevant metal parts shall be evaluated. Check the manufacturer's information.

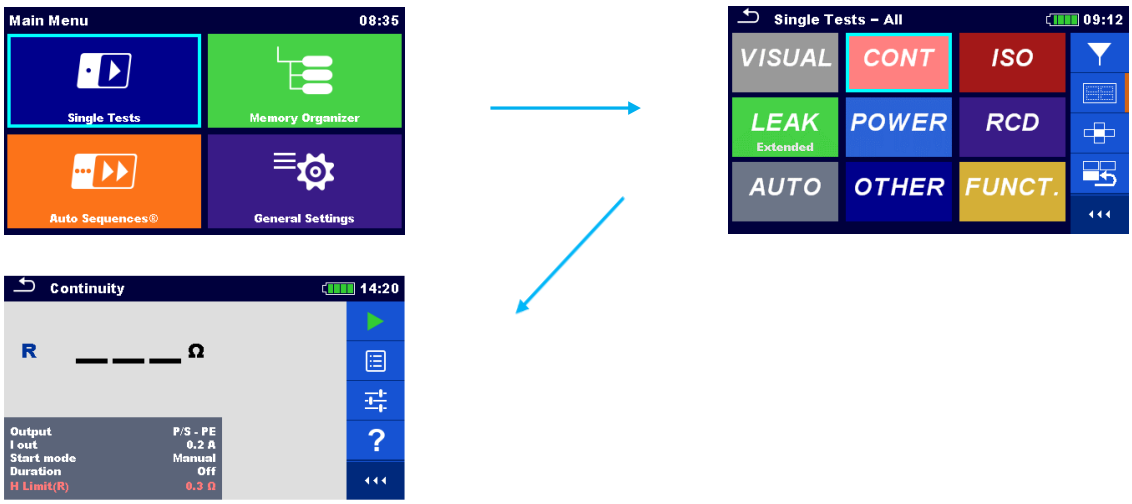


Figure 120_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the DUT according to the connection diagram Figure 119_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Compensation of test leads

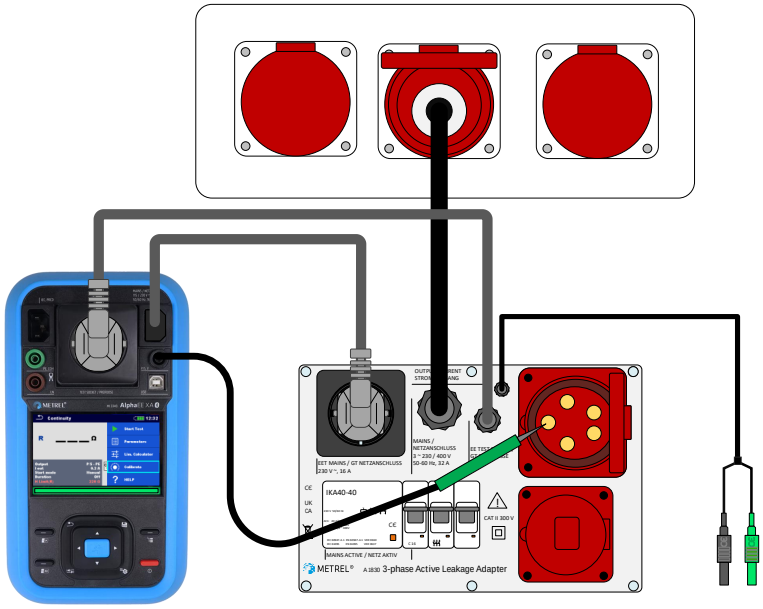


Figure 121_Test leads compensation

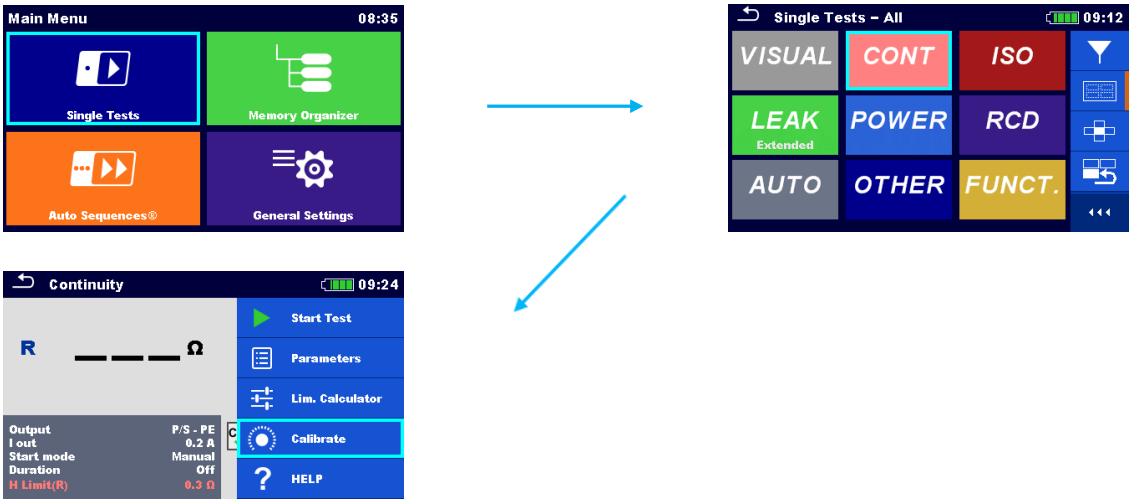


Figure 122_Calibration setup

Compensation procedure

- Connect the test lead according to the connection diagram Figure 121_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340 + A 1830. The subject of evaluation is the insulation resistance between the PE conductor and the live parts.

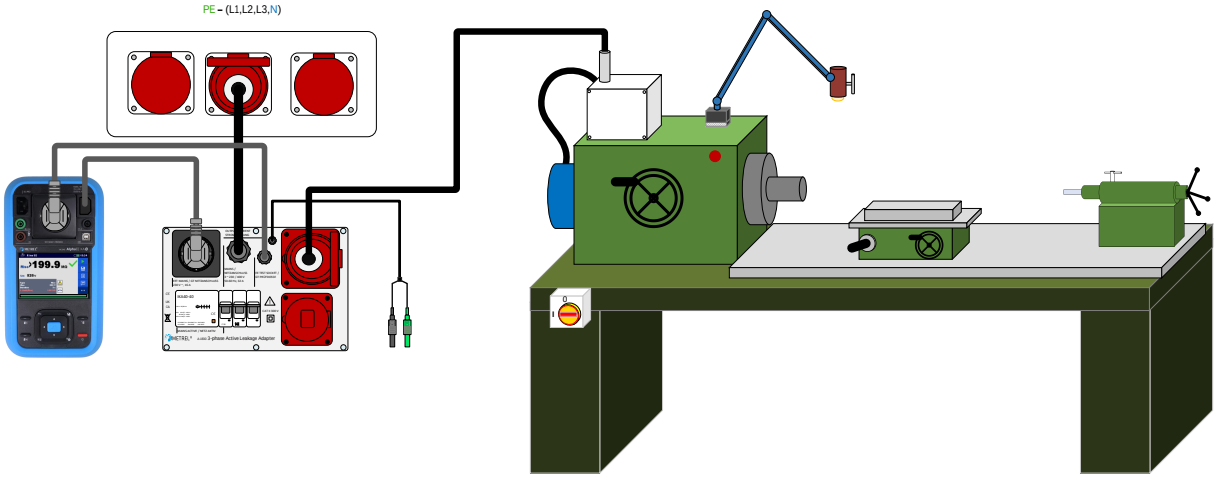


Figure 123_Insulation resistance test between PE and live parts

Note!

If the device under test has IACP (isolated accessible conductive parts), these should also be evaluated.

All supply conductors can be connected in parallel with the poly-phase electrical equipment.

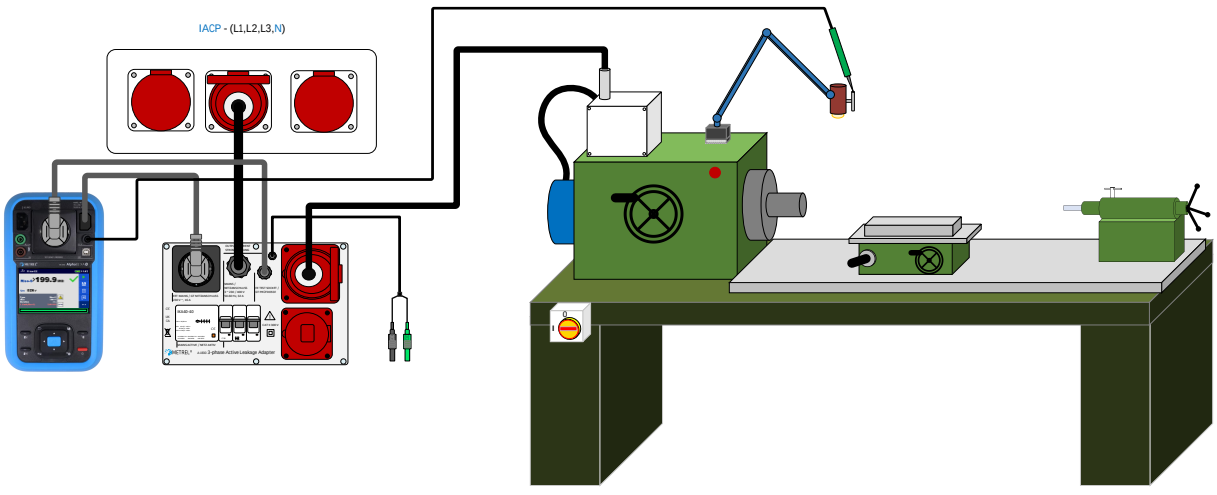


Figure 124_Insulation resistance between IACP and live parts

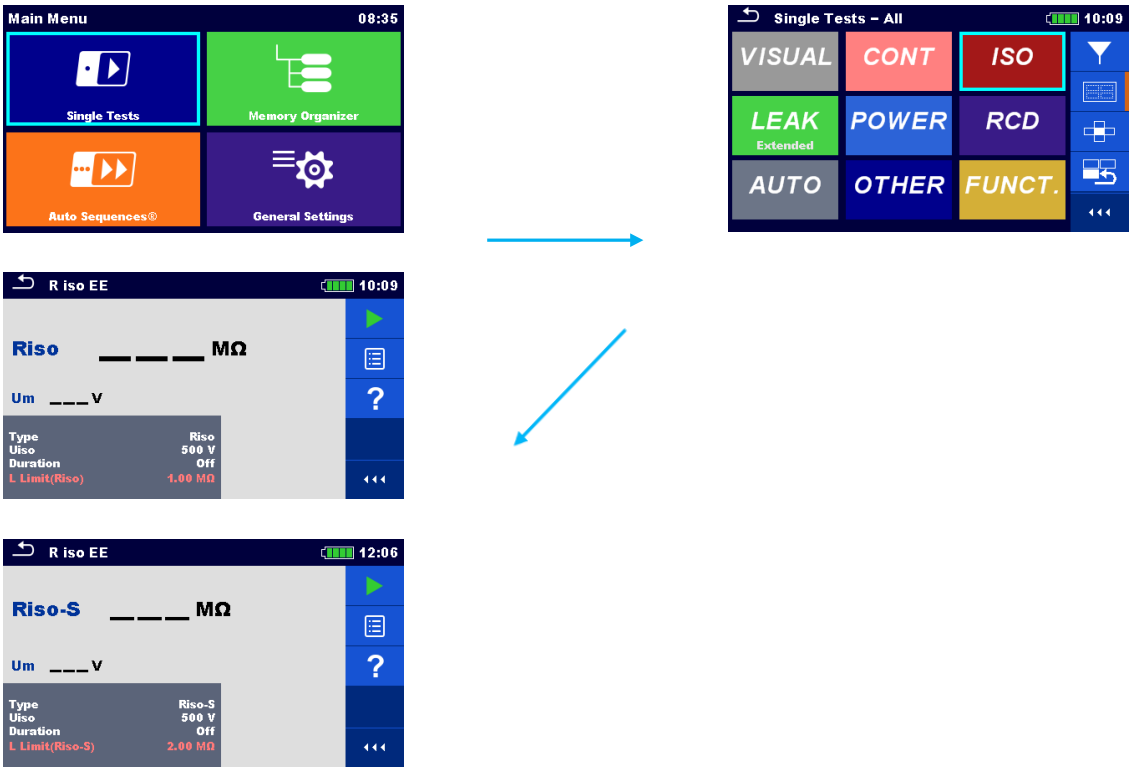


Figure 125_Insulation resistance setup

Measuring function: RPAT / Riso EE (Class I), Riso-S EE (Class II),
Output parameter: Riso / Riso-S
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ

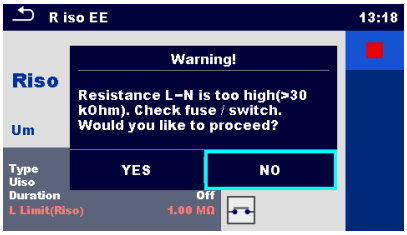


Figure 126_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user of the following possible issues:

- The device under test is not connected or switched on
- The input fuse of the device under test is blown.

Note!
The warning message can be disabled under the Settings, in the instrument's setup menu! Load pretest (On/**Off**).

Measurement procedure

- Connect the DUT according to the connection diagram Figure 124_Insulation resistance between IACP and live parts,
- Set appropriate measurement parameters,
- Start the test.

Protective conductor (leakage) current

Scope of test:

The PE current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions. The measurement is performed using the MI 3340 + A 1830.

Depending on the tested equipment, one of the following methods of measuring the protective conductor current may be used:

- direct method,
- residual current method,
- alternative method, if there are no voltage-dependent switches inside the equipment.

The subject of evaluation is the insulation resistance and capacitance between the PE conductor and the live parts of the 3-phase electrical equipment.

Direct method

Current is measured directly in the PE wire. The device under test must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the PE conductor.

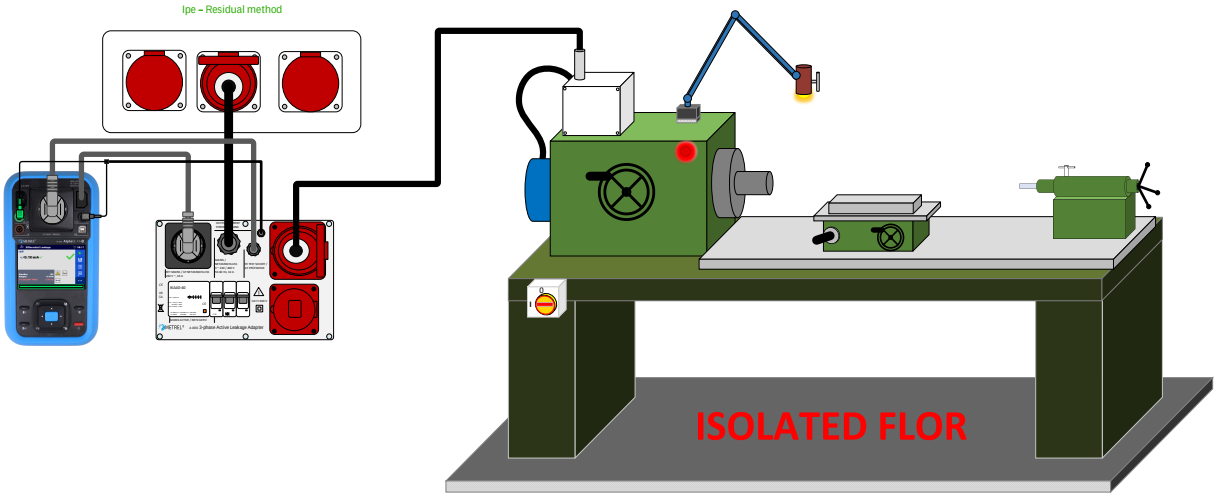


Figure 127_PE leakage current direct method

Residual method

The residual method measures the leakage current as the difference between currents through L and N supply conductors. The result does not depend on what type of floor the appliance is placed.

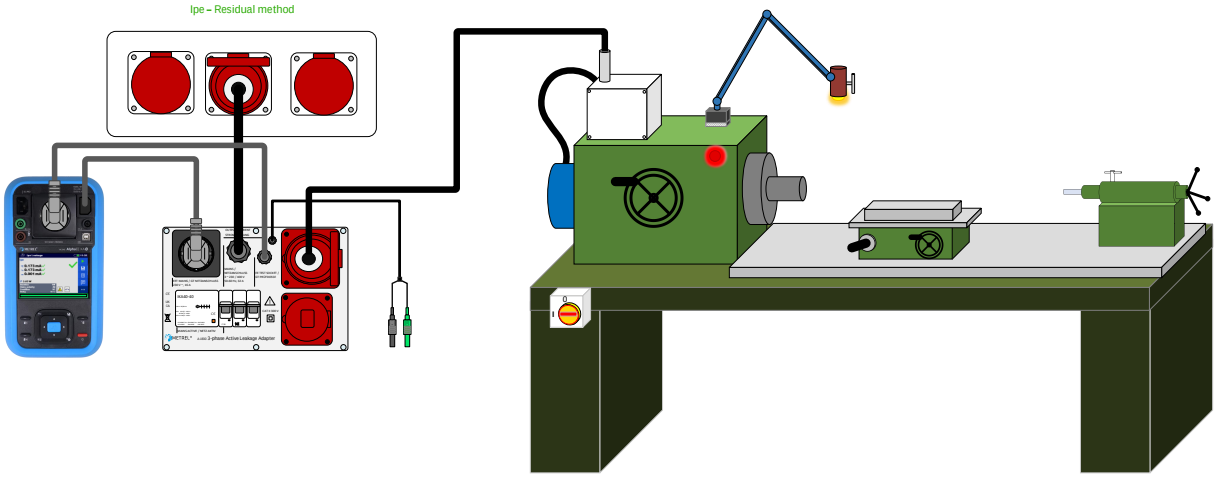


Figure 128_PE leakage current residual method

Alternative method

The alternative method is employed, the measured values might surpass the maximum allowable limits due to systematic errors in the measurement process, such as those caused by filters or cable impedances. In such cases, the direct or residual method should be used as the reference method.

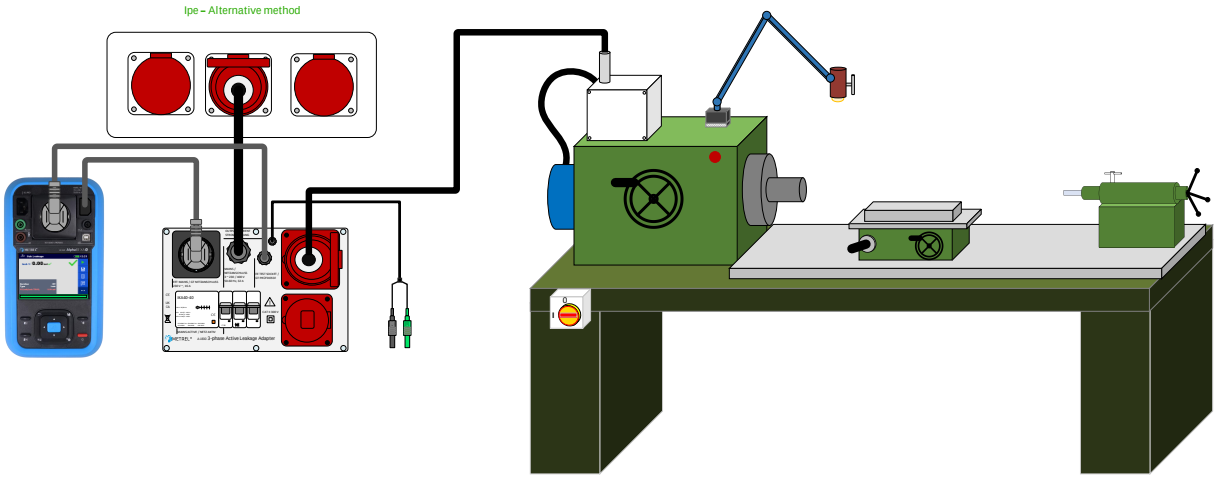


Figure 129_PE leakage current alternative method

Note!
All supply conductors can be connected in parallel with poly-phase equipment during the alternative method measurement.

Unearthed accessible conductive parts are not included in any of the protective conductor leakage test methods. They are considered Class II parts and are checked with the Touch Leakage test.

Measuring function: Ipe Leakage (direct method), Differential Leakage (residual method), Sub Leakage “Isub” (alternative method).

Test: PE leakage current
Limit: ≤ 3,5 mA

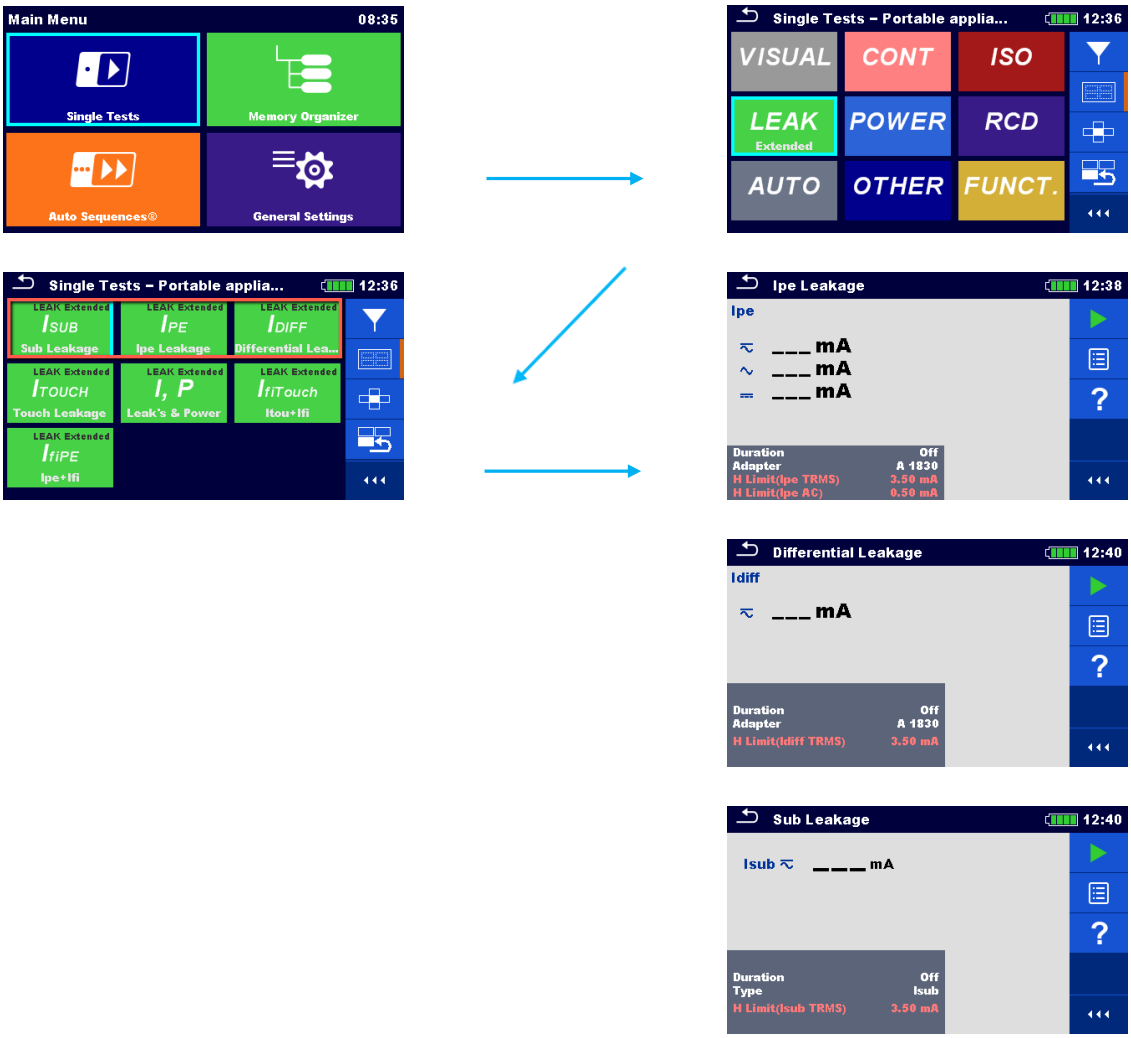


Figure 130_PE Leakage setup

Touch leakage test

The touch current shall be measured on every accessible conductive part of the equipment that is not connected to the protective earth conductor. Depending on the type of equipment, one of the following measurement methods may be used:

Direct method

Current is measured directly in the probe. The device under test must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the probe.

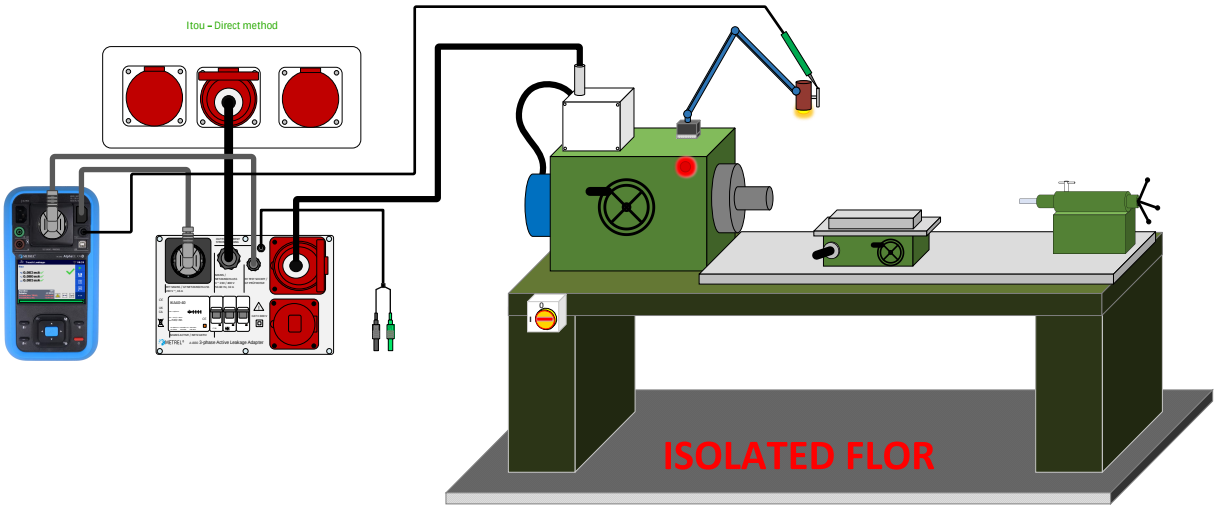


Figure 131_Touch leakage current direct method

Residual current method

Residual current method measures the leakage using difference between currents in L and N wires. It will account for both the touch and PE leakage currents. If the total current exceeds the touch current limit, the direct method can be used.

Alternative method

The alternative method can be applied when no voltage-dependent circuits are present, and the insulation resistance measurement has passed. All supply conductors can be connected in parallel with poly-phase equipment during the alternative method measurement.

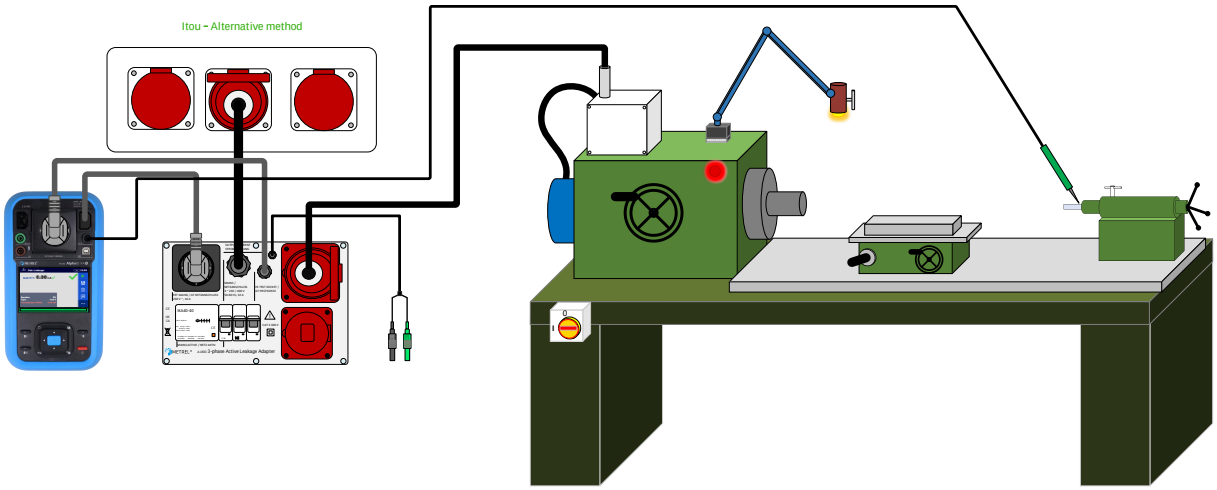


Figure 132_Touch leakage current alternative method

Note!

The alternative method shall not be used in the following cases:

- Presence of voltage-dependent switches.

- Use of switched power supplies.

In case of any doubt, use the direct method or the residual current method.

Direct method results can be distorted in case of any contact between the DUT with earthed equipment (such as water pipes or data lines).

Measuring function: Touch Leakage (direct method), Sub-S Leakage “Isub-S” (alternative method).

Test: Touch leakage current
Limit: ≤ 0,5 mA

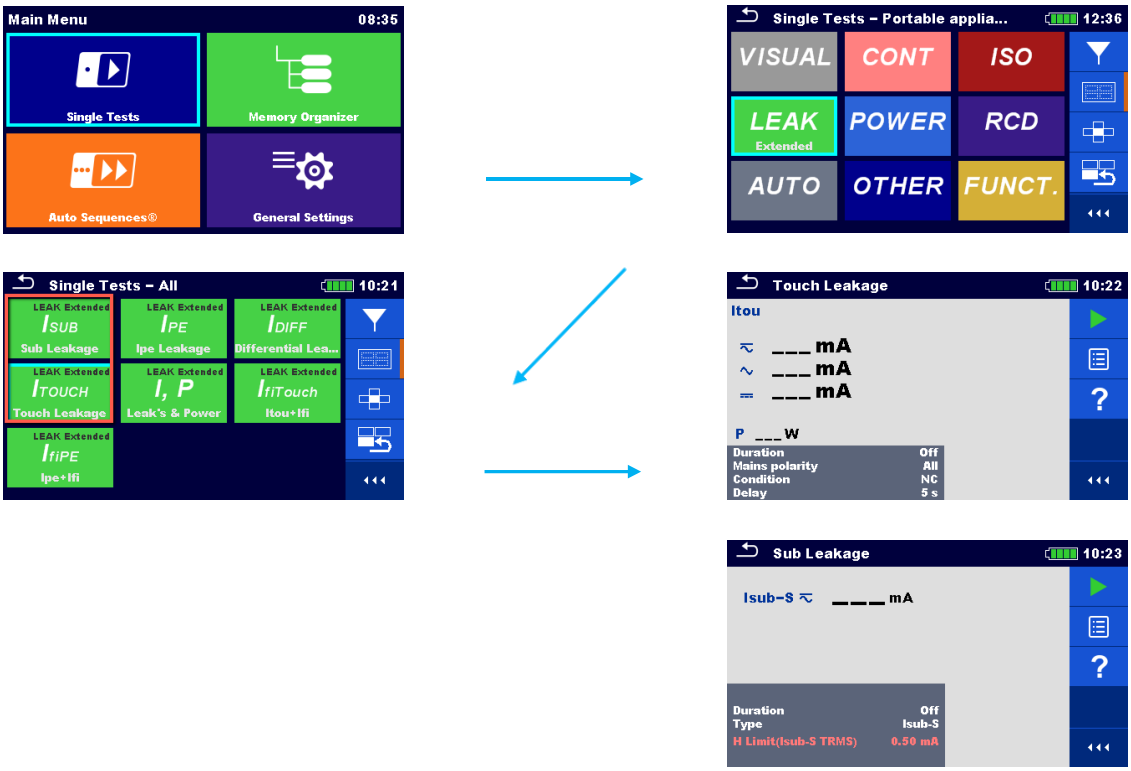


Figure 133_Touch Leakage setup

Functional inspection

To complete the safety test procedure, a functional test should be carried out. The manufacturer’s recommendations shall then be considered.

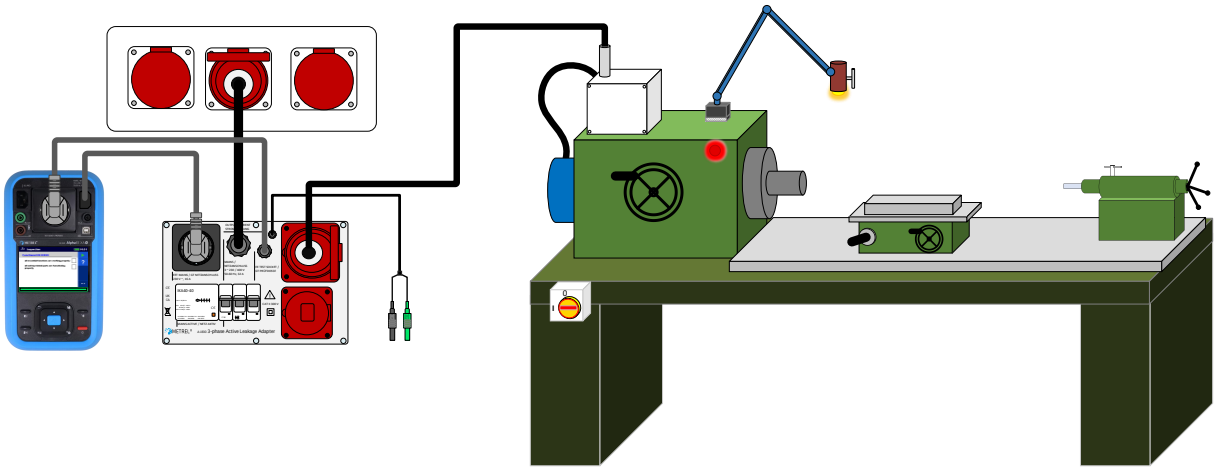


Figure 134_Functional inspection

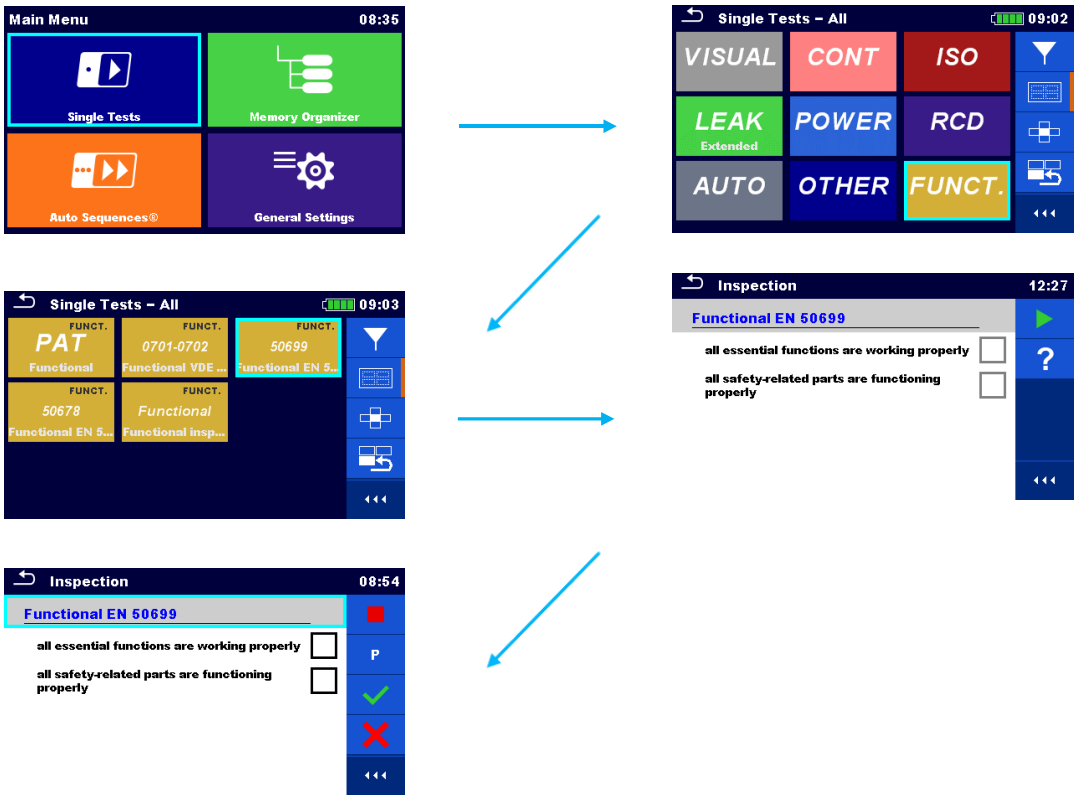


Figure 135_Functional inspection setup

Measurement procedure

Connect the Electrical equipment instrument test socket, select the correct measuring function (Functional inspection), start the test and tick the correct statuses. Power can be applied to the device under test to check correct operation and consumption.

6. P-RCD equipment testing

Verification of the additional protective measures should be performed to comply with EN 50699 & EN 50678.

If the equipment includes additional protective measures for electrical safety, and they are visible to the person conducting the test, an electrically skilled person must determine the testing procedure. The manufacturer's instructions, as well as the requirements and tests outlined in the product standard, should be considered.

Examples of additional protective measures include RCDs, PRCDs, and under-voltage protection devices.

According to DGUV Information 203-006, a mobile residual current protective device (as per DIN VDE 0661) must be used when connecting electrical equipment to external outlets. It must meet the following requirements:

- Rated differential current IΔn ≤ 30 mA
- Switches on all poles, including the protective conductor
- Includes undervoltage release
- Prevents automatic restart after power is restored

Additionally, the device must:

- Prevent activation if the protective conductor is interrupted or energised.
- Shut off if voltage is detected on the protective conductor or if the protective conductor is interrupted during operation.
- Ensure the protective conductor remains connected if external voltage is detected on it.

List of Applicable test & Limits

Measurements		
Measurement	**Measuring method**	**Limits**
Visual Inspection		
Continuity of protective conductor (live test)	Low resistance measurement	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Protective conductor current	Residual method	≤ 3,5 mA

Compliance with tripping current PRCD	Trip test PRCD	IΔNa < IΔN
Open conductor test (functional test)	Depending on the P-RCD design	2-Pole / Detection of open L, N, 3-Pole / Detection of open L, N, K-Type / Detection of open L, N, S-Type / Detection of open L, N, PE,
Polarity test		
Functional inspection		

Table 40_Applicable measurements

Visual inspection

Scope of test:

The visual inspection shall take place to detect external defects and, if possible, to determine the qualification of the suitability of the equipment for the environment.

Figure 136_Visual inspection

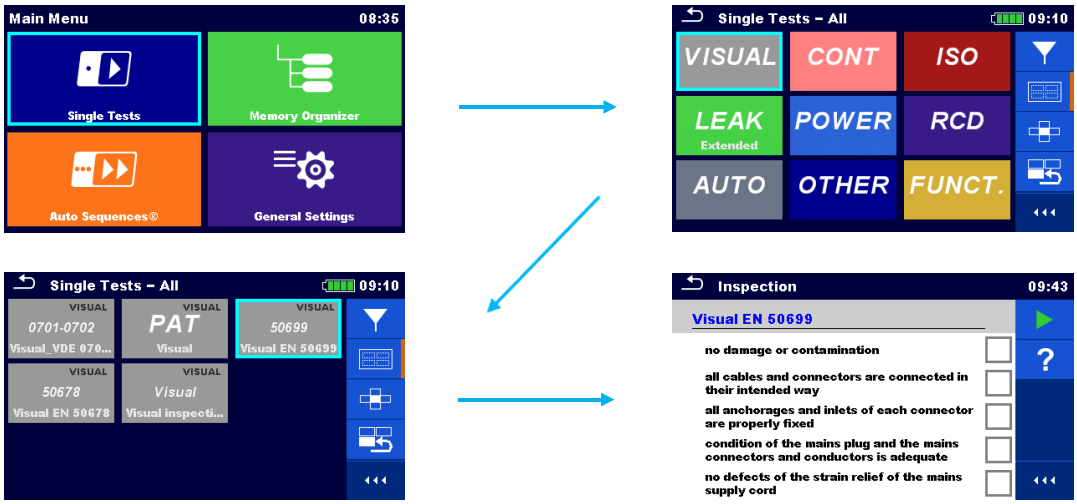


Figure 137_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cord.

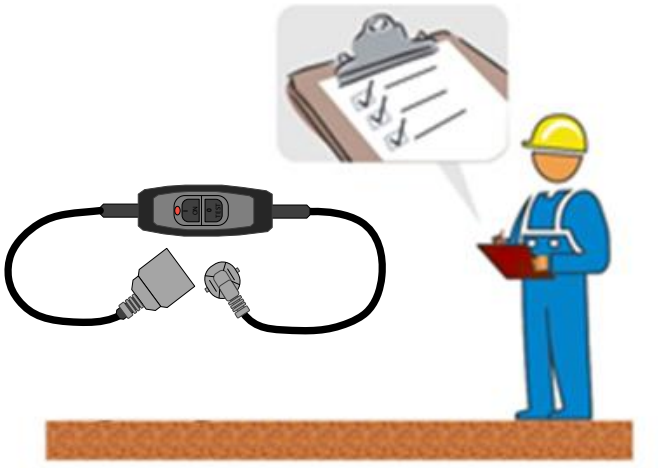


Figure 138_Visual inspection

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor. The measurement is performed using the MI 3340 and IEC test lead. The subject of evaluation is the PE conductor, between the input and the output terminal and any accessible earthed parts if applicable.

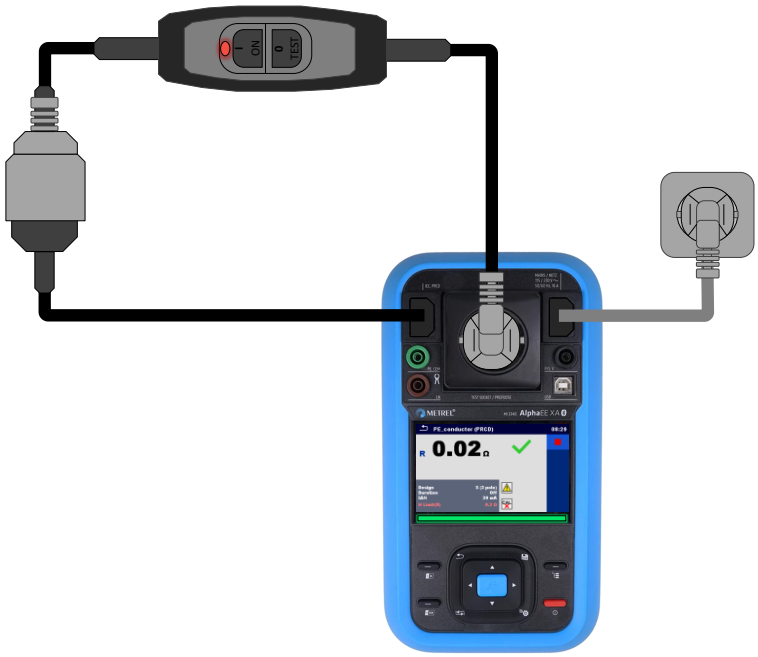


Figure 139_Continuity of protective earth

Note!

The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

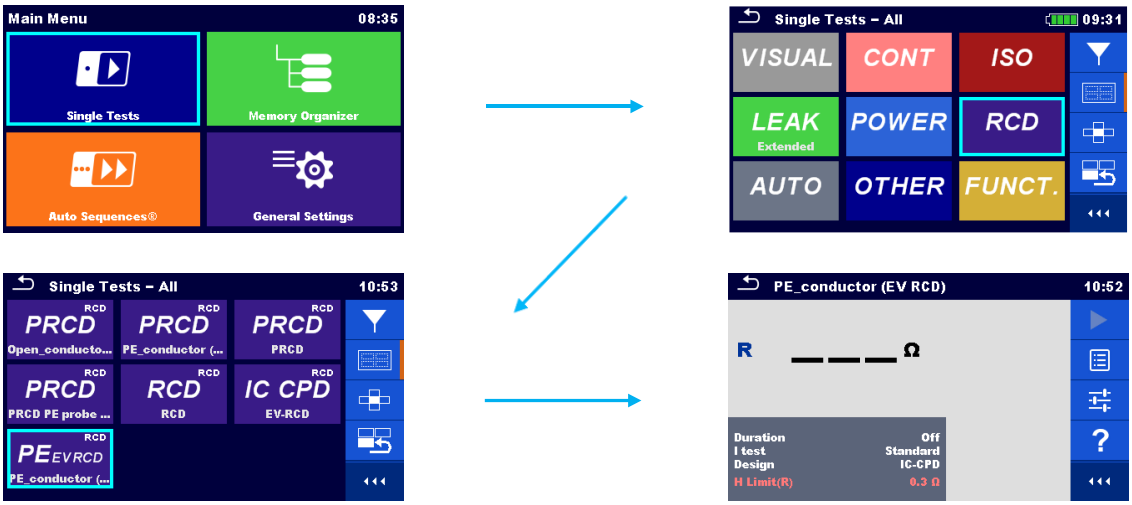


Figure 140_Earth continuity setup

Measuring function: PRCD / PE_conductor (PRCD)
Design:

- 2 pole,
- 3 pole,
- K/Di (varistor),
- S (3 pole),
- S+

Observe the manufacturer's information for proper operation.
IΔN: 10 mA, 15 mA, 30 mA – select depending on the rated residual current of the DUT
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the DUT according to the connection diagram Figure 139_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Note!

In order to perform measurement accurately the resistance of test leads should be compensated prior to execution of the Continuity test.

Compensation of test leads

Figure 141_Test leads compensation

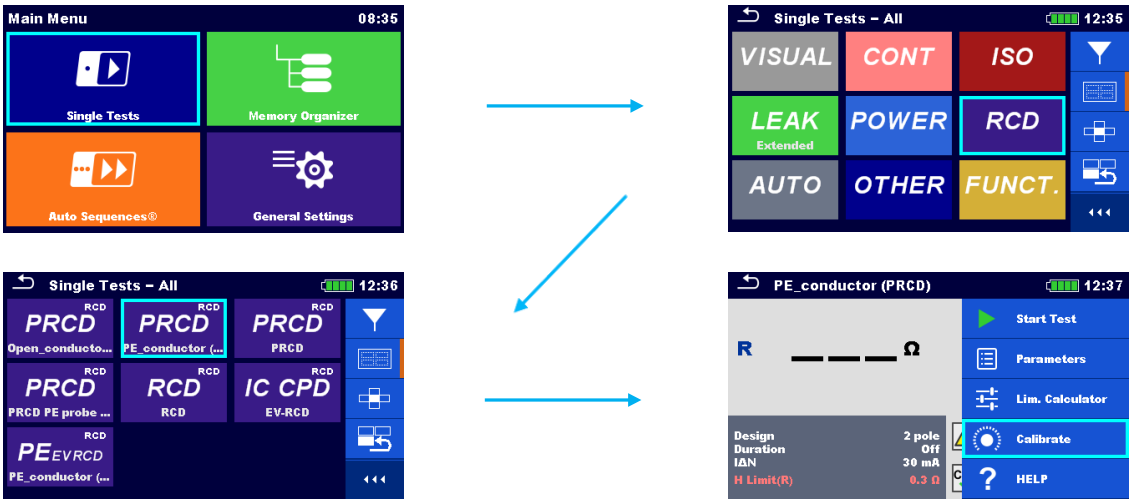


Figure 142_Calibration setup

Compensation procedure

- Connect the test lead according to the connection diagram Figure 141_Test leads compensation,
- Select appropriate measurement,
- Start the calibration.

Protective conductor (leakage) current

Scope of test:

The PE current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions.

Unearthed accessible conductive parts are not included in this test. They are considered Class II parts and are checked with the Touch Leakage test.

The measurement is performed using the MI 3340 & IEC test lead. The subject of evaluation is the insulation resistance and capacitance between the PE conductor, and the live parts of the P-RCD protected cable.

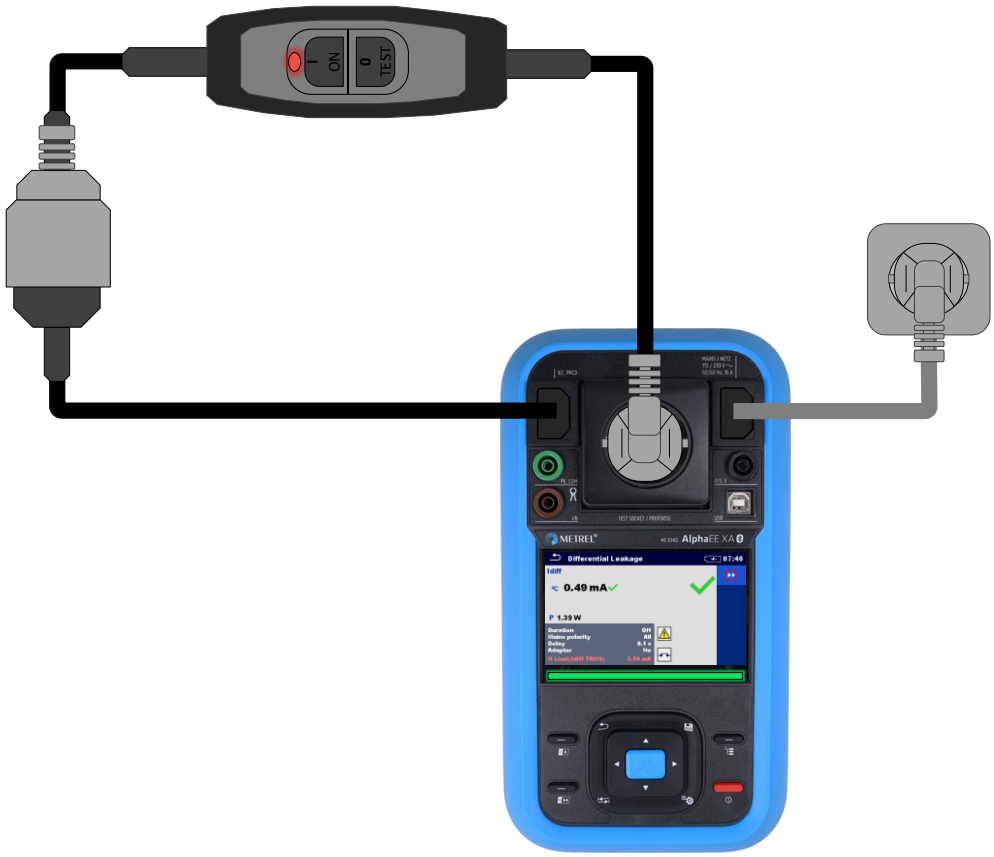


Figure 143_PE leakage current Class I

Note!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

The leakage current shall be evaluated at normal and reversed mains polarity.

If the device under test has IACP (isolated accessible conductive parts), they should be evaluated using the touch leakage method.

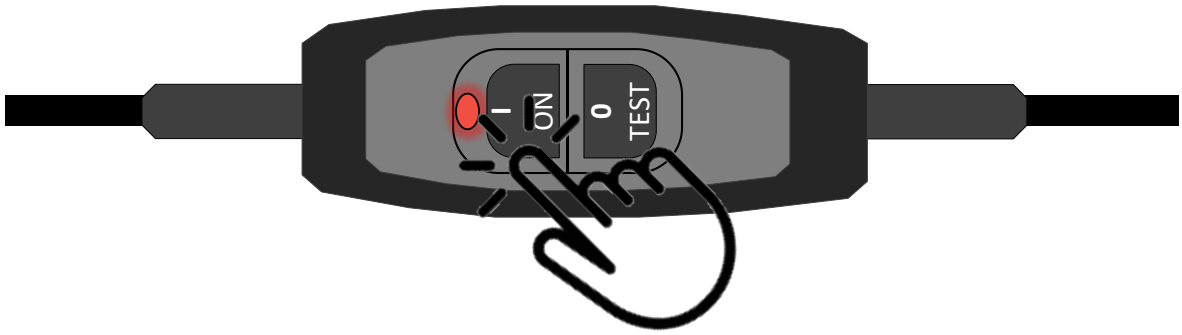


Figure 144_Arming P-RCD

Measuring function: Differential Leakage (residual method).
Test: PE leakage current
Limit: ≤ 3,5 mA

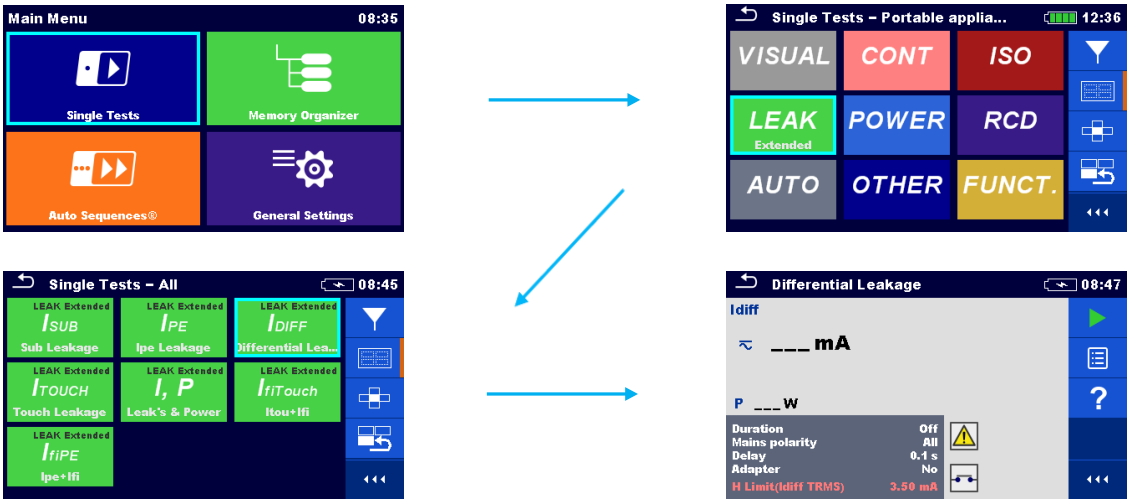


Figure 145_PE Leakage setup

Measurement procedure

- Connect the DUT according to the connection diagram Figure 143_PE leakage current Class I,
- Set appropriate measurement parameters,
- Start the test,
- Arm the P-RCD using the On/Off switch on the device.
- Stop the test,
- Repeat test procedure at reversed mains polarity.

Touch leakage test

The touch current shall be measured on every accessible conductive part of the equipment that is not connected to the protective earth conductor.

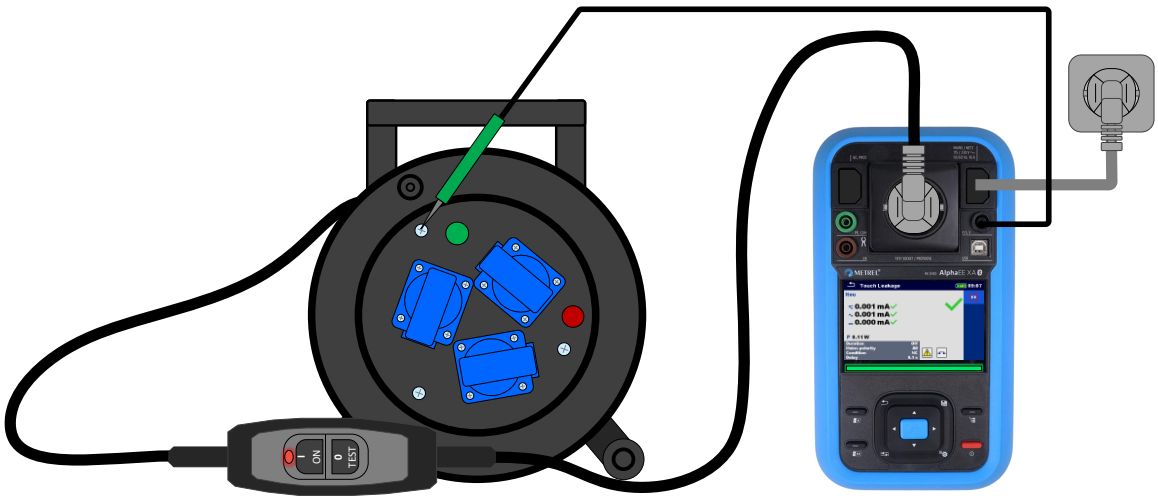


Figure 146_Touch leakage current on IACP

Notes!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

The leakage current shall be evaluated at normal and reversed mains polarity.

All IACP (isolated accessible conductive parts) should be evaluated.

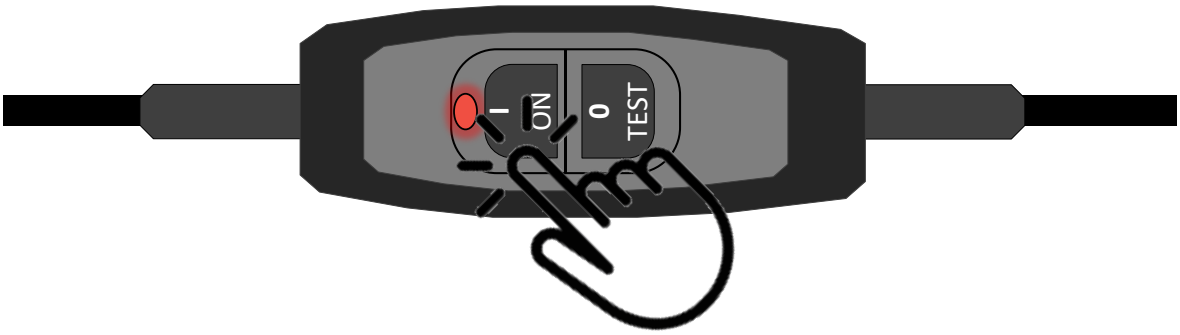


Figure 147_Arming P-RCD

Measuring function: Touch Leakage (direct method),
Test: Touch leakage
Limit: ≤ 0,5 mA

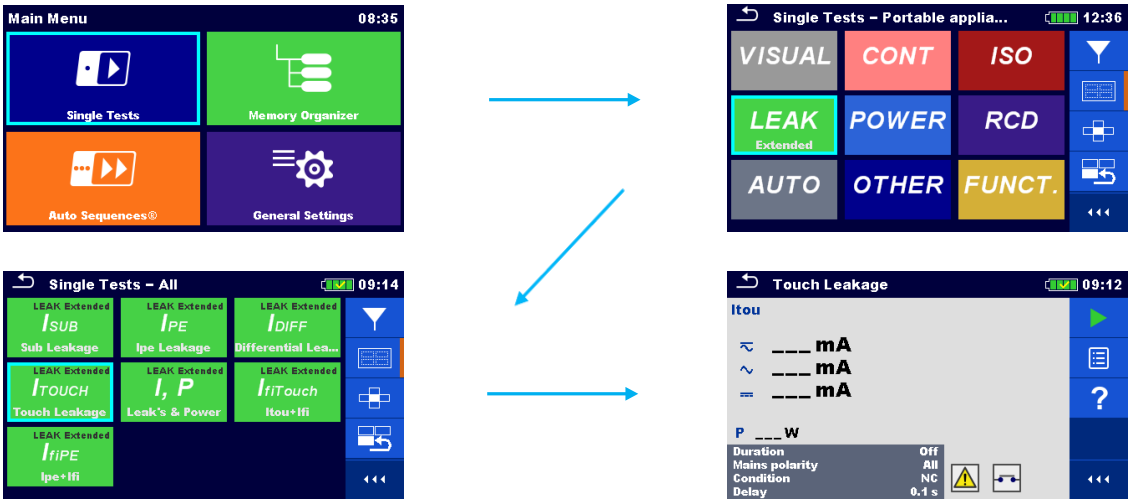


Figure 148_Touch Leakage setup

Measurement procedure

- Connect the device under test according to the connection diagram Figure 146_Touch leakage current on IACP,
- Set the appropriate measurement parameters,
- Start the test,
- Arm the P-RCD using the On/Off switch on the device.

- Stop the test,
- Repeat the test procedure at reversed mains polarity.

P-RCD trip-out current

Scope of test:

The effectiveness of the protective device is evaluated with the P-RCD test.

According to EN 50699 and the German guideline DGUV Information 203-006, the operation of further protective measures needs to be evaluated if the equipment under test includes such parts. This part is in our case P-RCD.

The P-RCD provides an additional layer of safety from electrical shock by monitoring the current flow and cutting off the power in the event of a fault or elevated leakage. Testing the P-RCD ensures its correct function and the necessary protection against electric shocks.

Remember to refer to the manufacturer's instructions or consult with a qualified electrician to ensure the correct testing procedures for different types of P-RCDs. There may be variations depending on the specific model and design.

Generally, it is enough to test only the ability of the P-RCD to trip in case of a fault.

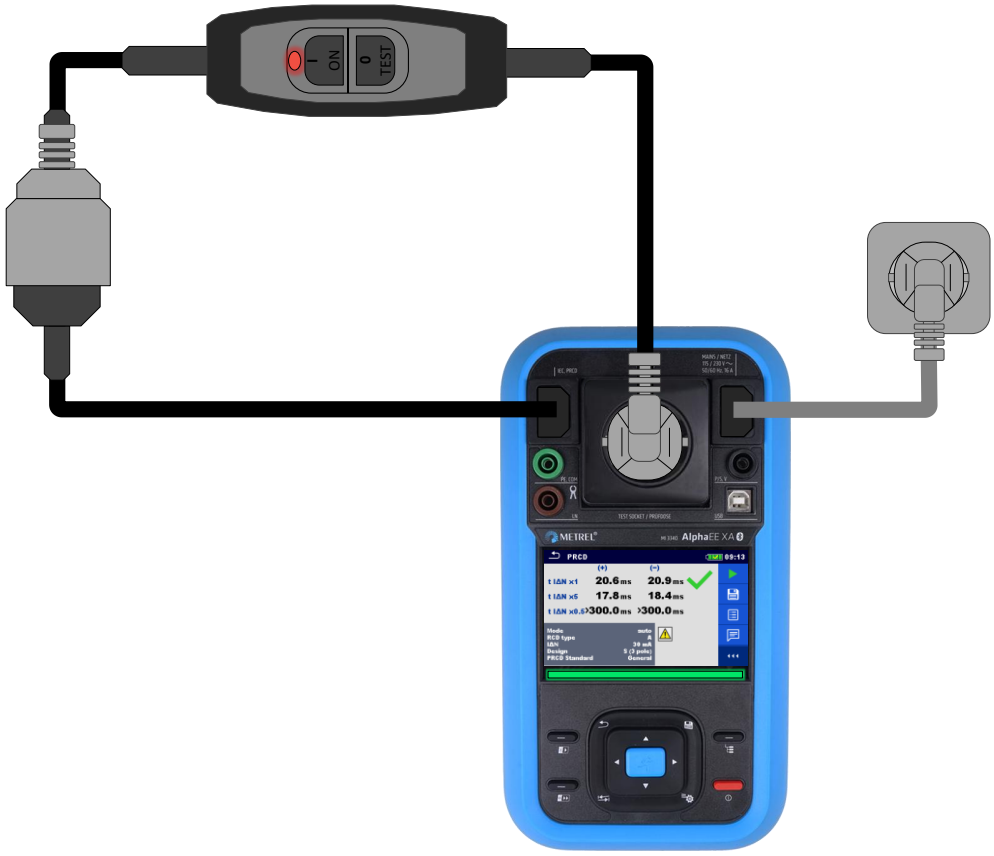


Figure 149_P-RCD_Test method

Note!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

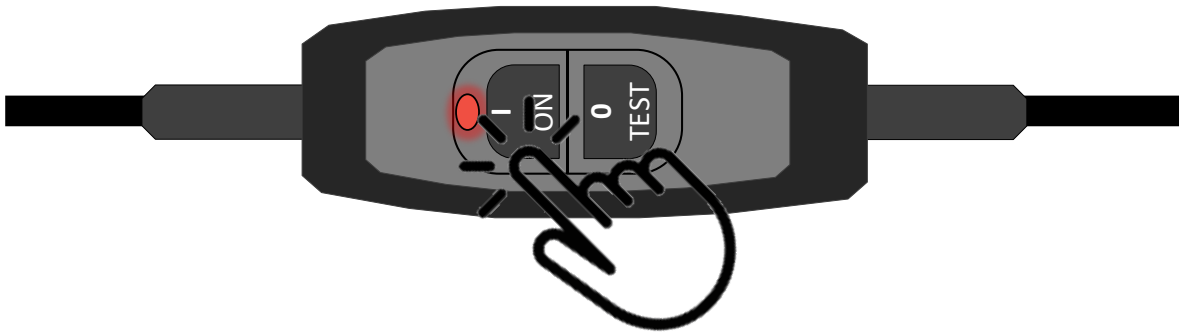


Figure 150_Arming P-RCD

The measurement is performed using the MI 3340 & IEC test lead. The subject of evaluation is the P-RCD's ability to trip in case of failure.

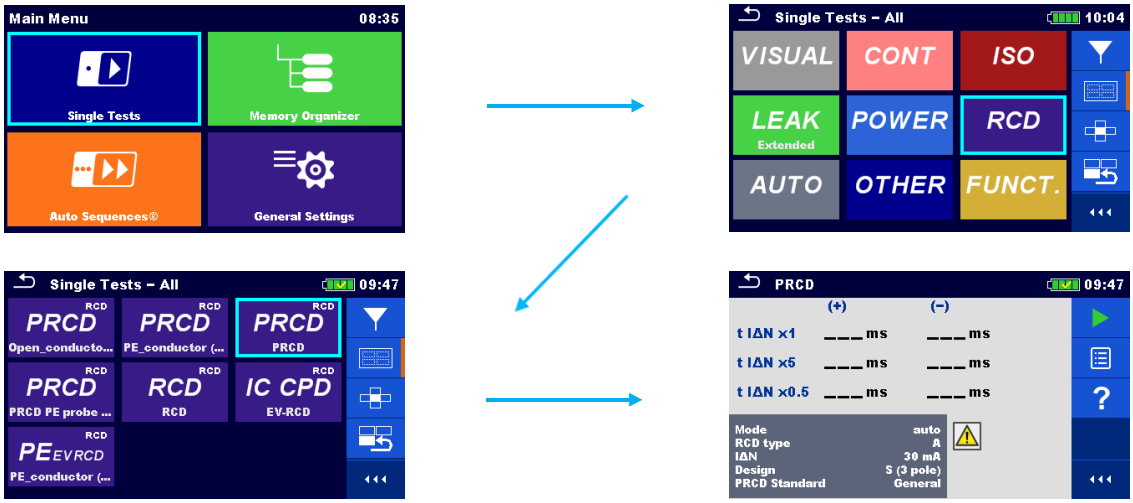


Figure 151_P-RCD test setup

Measuring function: PRCD
Test mode: single / auto
RCD type: AC / A / B / B+ / F
IΔN: 10 mA / 15 mA / 30 mA
Design:

- 2 pole,
- 3 pole,
- K/Di (varistor),
- S (3 pole),
- S+

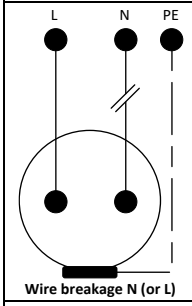
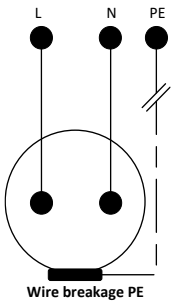
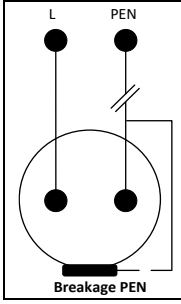
Observe the manufacturer's information for proper operation.
Test: t-trip / I-trip
Limit: IΔNa < IΔN

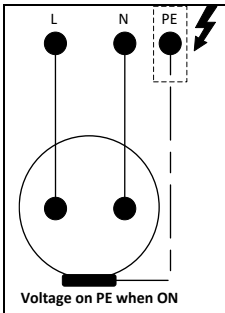
Measurement procedure

- Connect the device under test according to the connection diagram Figure 149_P-RCD_Test method.
- Set the appropriate measurement parameters.
- Start the test.
- Arm the P-RCD using the On/Off switch on the device.
- Wait for trip-out to occur.
- Follow instructions on the test device.
- Record the data.

Functional testing (optional)

Some manufacturers of special types of P-RCDs recommend that their extended functionality should be tested in addition to the standard verification of the ability to disconnect. The functionalities of the special P-RCDs are specified in the manufacturer's instructions. Most commonly they involve detection of different faults in the network the P-RCD is connected to. Different types of P-RCDs can detect various network faults, as shown in the table below.

Design	PRCD-S pro	PRCD-S	PRCD-K	3-pole	2-pole	RCD classic
	✓ Cannot be switched on. Interruption of L & N. PE remains closed.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L & N.	! Can be switched on. Secondary accidents are possible.
	✓ Cannot be switched on when PE is > 1 kΩ. Interruption of L&N during operation if PE is > 1 kΩ	✓ Cannot be switched on. Interruption of L, N & PE.	! Can be switched on. Secondary accidents are possible.	! Can be switched on. Secondary accidents are possible.	! Can be switched on. Secondary accidents are possible.	! Can be switched on. Secondary accidents are possible.
	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L, N & PE.	✓ Cannot be switched on. Interruption of L & N.	 Cannot be switched on. Mortal danger!

	✓ Cannot be switched on. Fault-free operation of the device when wearing gloves.	✓ Cannot be switched on. Caution: protective function not guaranteed when wearing gloves.	✓ Can be switched on. Secondary accidents are possible.	✓ Can be switched on. Secondary accidents are possible.	⚡ Cannot be switched on. Mortal danger!	⚡ Cannot be switched on. Mortal danger!

Using the special test function Open_conductor (PRCD), it is possible to simulate network faults and thus test the PRCD's functionality. Similarly, the test function PRCD PE probe test simulates the presence of dangerous voltage on the PE.

Open conductor test

The test goal is to check P-RCD operation in under-voltage or during a network fault. The mains voltage is applied to the PRCD using the Open_conductor test function. Different conductors are interrupted depending on the PRCD type to check its functionality.

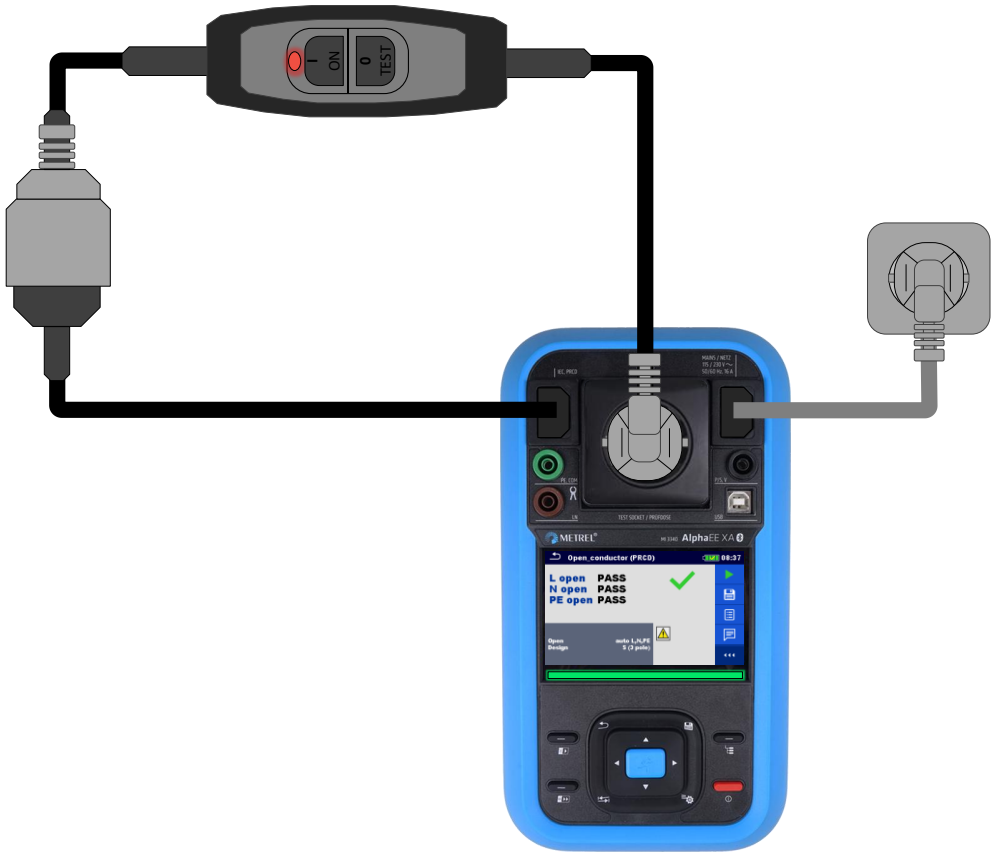


Figure 152_Open conductor test

Note!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

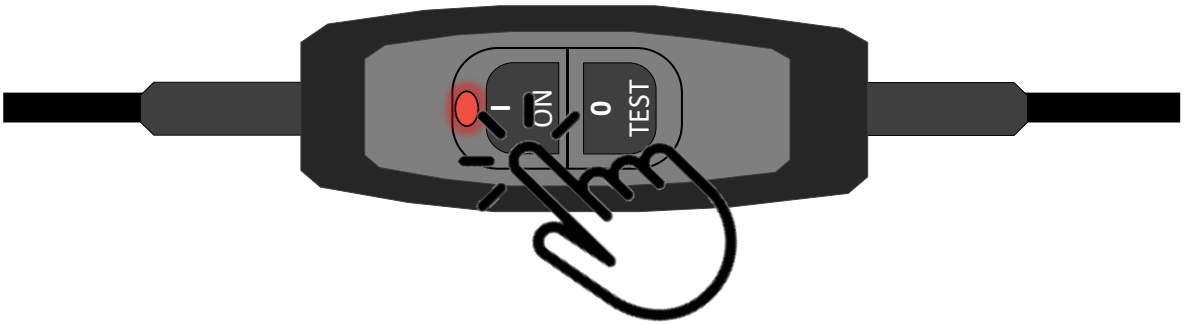


Figure 153_Arming P-RCD

The measurement is performed using the MI 3340 & IEC test lead. The subject of evaluation is the ability to detect network wiring failure.

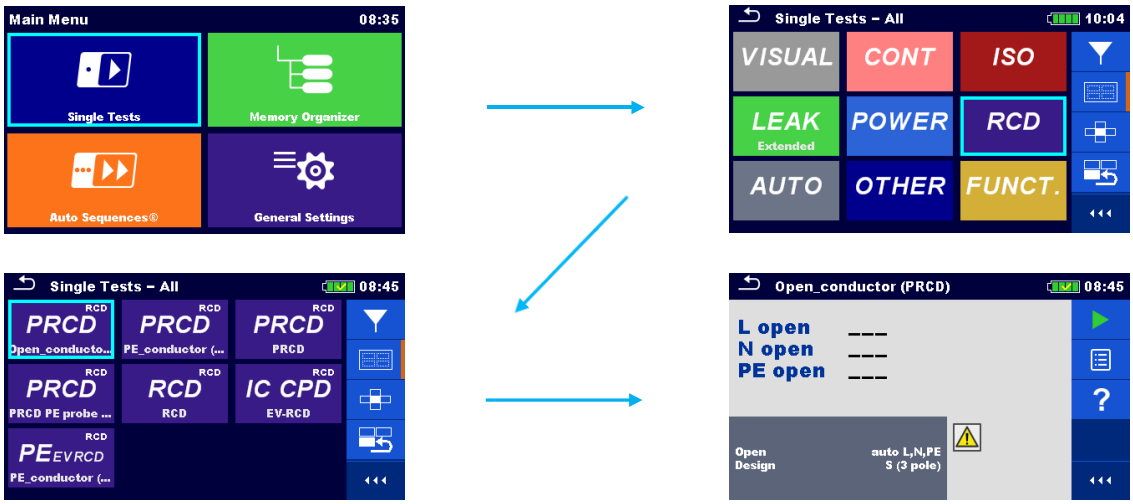


Figure 154_Open conductor test setup

Measuring function: Open conductor (PRCD)
Test mode (Open): L / N / PE, auto L,N, auto L,N,PE
Design:

- 2-pole,
- 3-pole,
- K/Di (varistor),
- S (3-pole),
- S+

Observe the manufacturer's information for proper operation.
Test: PRCD-trip on wiring error

Measurement procedure

- Connect the DUT according to the connection diagram Figure 152_Open conductor test,
- Set the appropriate measurement parameters,
- Start the test,
- Arm the P-RCD using the On/Off switch on the device,
- Wait for the trip-out to occur,
- Follow instructions on the test device,
- Record the data.

PRCD PE probe test

This is an extended functionality test applicable only to some types of PRCDs. In the event of a "Phase on PE" fault (e.g., PE and N/L reversed), the PRCD-S / PRCD-S PRO must trip or must not allow being switched on.

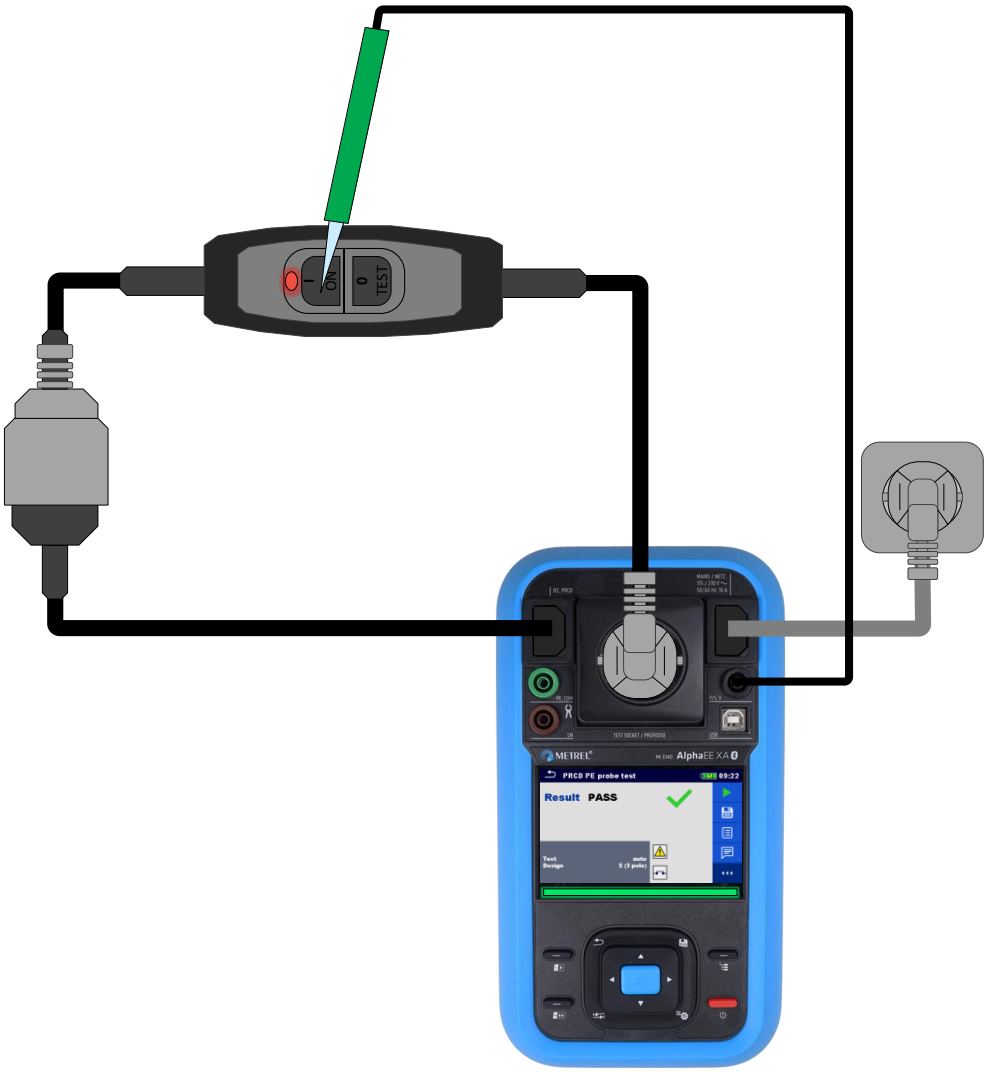


Figure 155_PRCD PE probe test_Auto mode

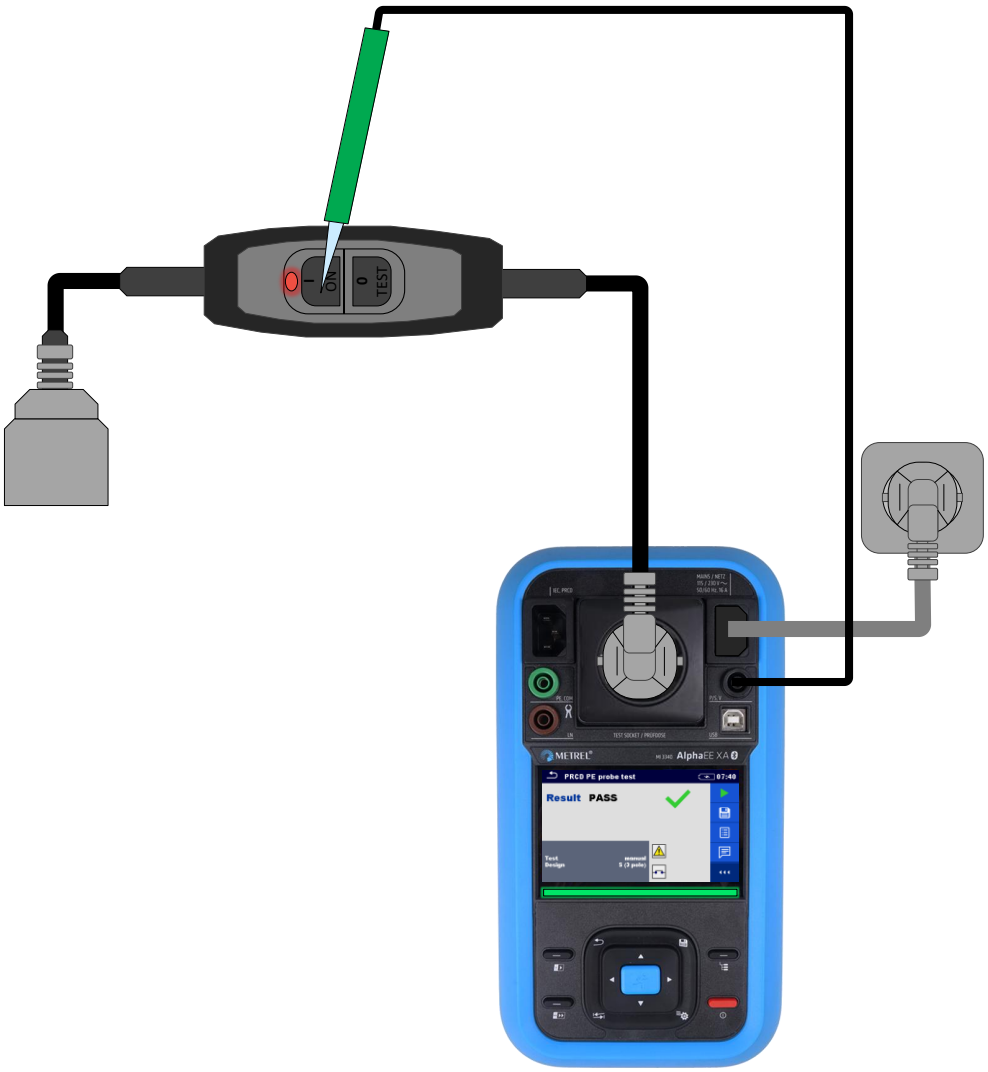


Figure 156_PRCD PE probe test_Manual mode

Note!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

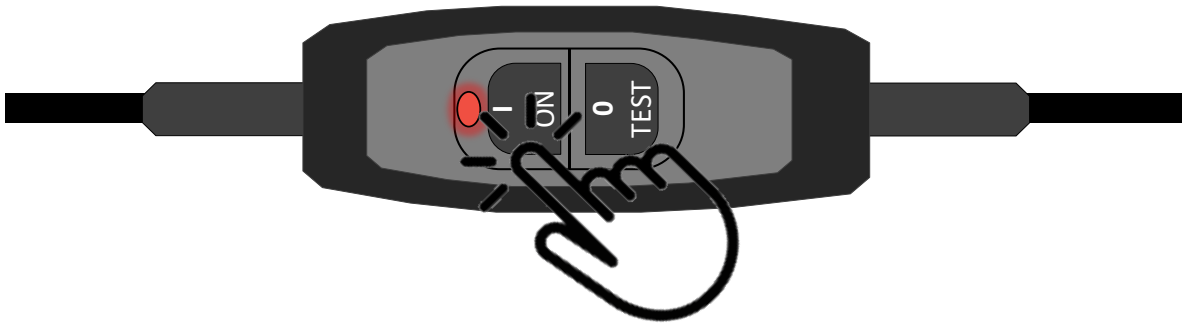


Figure 157_Arming P-RCD

The measurement is performed using the MI 3340, the IEC test lead, and the P/S probe. The subject of evaluation is the ability to detect dangerous voltage on PE.

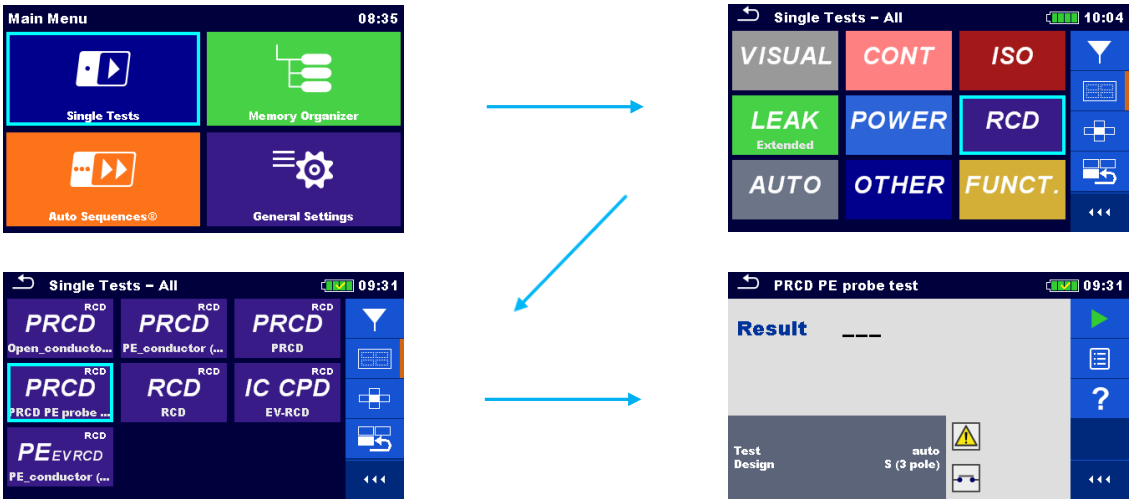


Figure 158_PRD PE probe test setup

Measuring function: PRCD PE probe test
Test mode: auto/manual
Design:

- 2 pole,
- 3 pole,
- K/Di (varistor),
- **S (3 pole),**
- **S+**

(Observe manufacturer information for proper operation.)
Test: PRCD-trip when the presence of dangerous voltage on PE

Measurement procedure

- Connect the DUT according to the connection diagram Figure 155_PRCD PE probe test,
- Set the appropriate measurement parameters,
- Start the test,
- Arm the P-RCD using the On/Off switch on the device,
- Connect a probe to the ON-Cap,
- Wait for the trip-out to occur,
- Record the data.

Polarity test

Correct polarity of IEC leads, prolongation cords, etc. is checked. This test is obligatory in countries (e.g. UK, Australia) where the position of line and neutral conductors is predefined. With the polarity test shorts, crossed and opened wires in cords can be found.

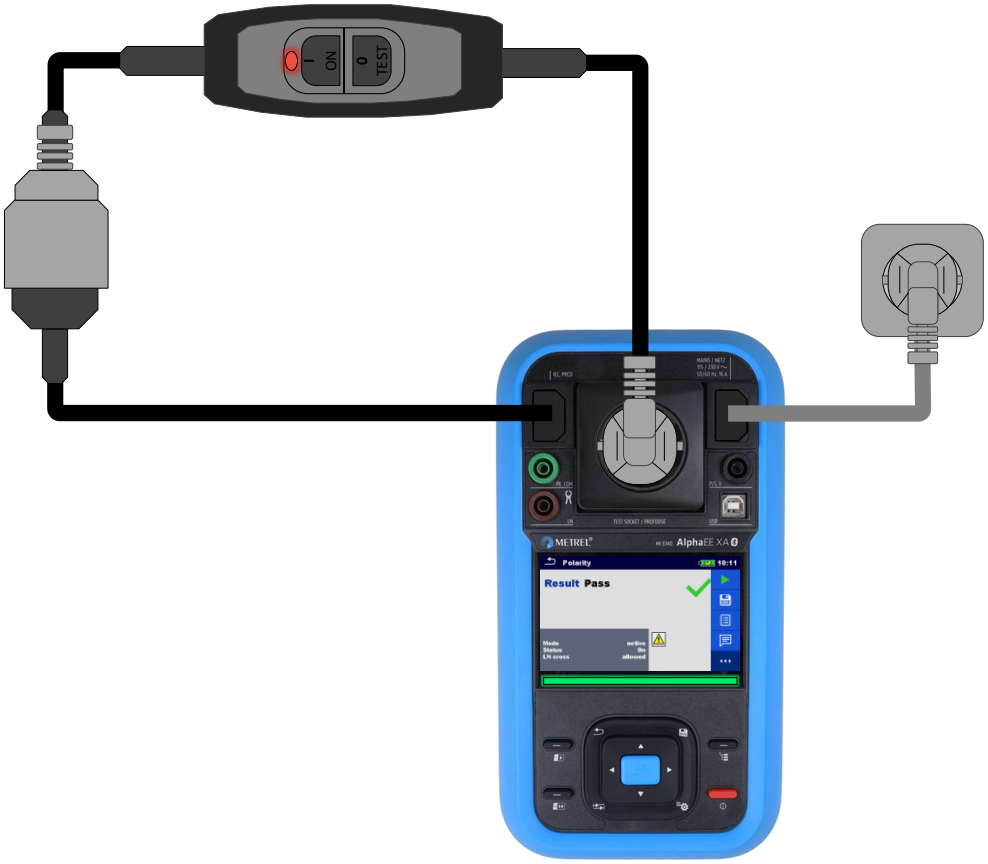


Figure 159_Polarity test

Note!

P-RCD shall be set to operating mode using the ON/OFF switch on the device.

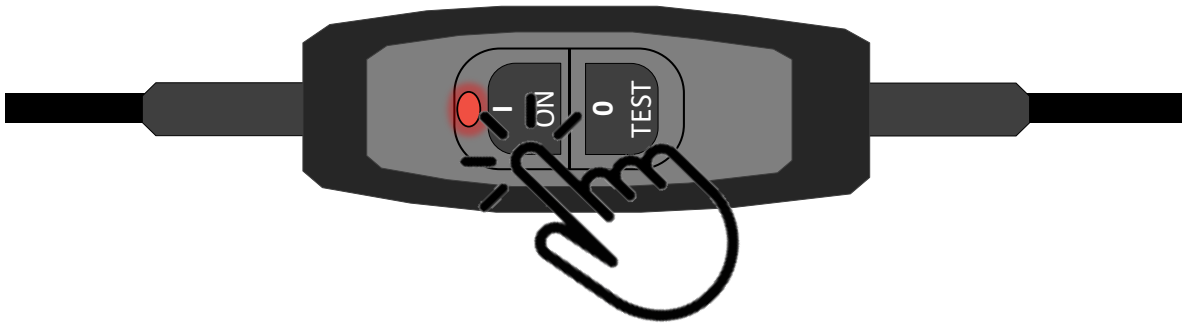


Figure 160_Arming P-RCD

The measurement is performed using the MI 3340 & IEC test lead. The subject of evaluation is correct wiring of the cable.

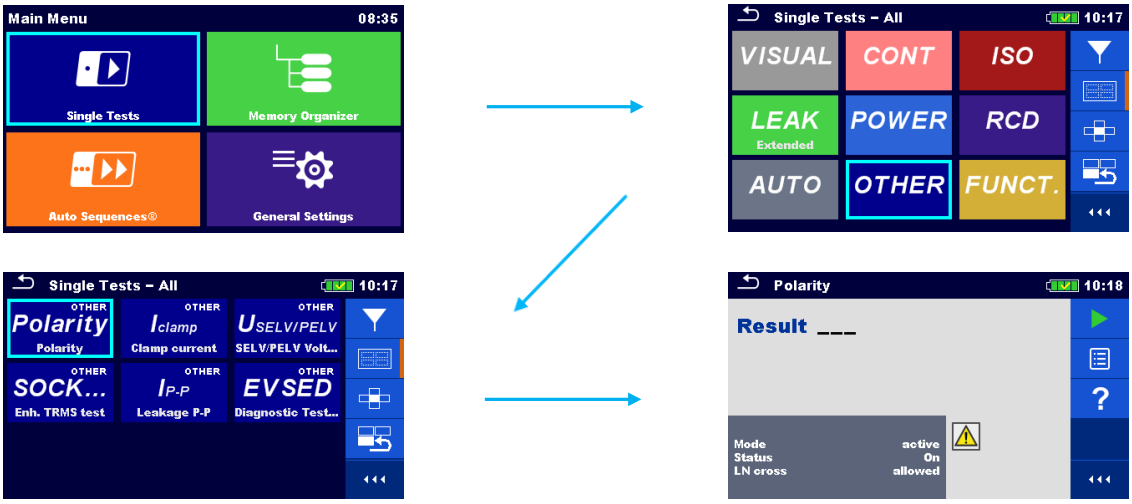


Figure 161_Polarity test setup

Measuring function: Polarity test
Test mode: active/normal
LN cross: allowed / not allowed

Position of line and neutral conductors is predefined in some countries (e.g. UK, Australia), and there LN cross shall be set to **not allowed**.

Test: Correct wiring will PASS the test.

Measurement procedure

- Connect the DUT according to the connection diagram Figure 159_Polarity test,
- Set the appropriate measurement parameters,
- Start the test,
- Arm the P-RCD using the On/Off switch on the device,
- Wait for the trip-out to occur,
- Record the data.

Functional inspection

A functional test should be carried out to complete the safety test procedure. The manufacturer's recommendations shall be considered.

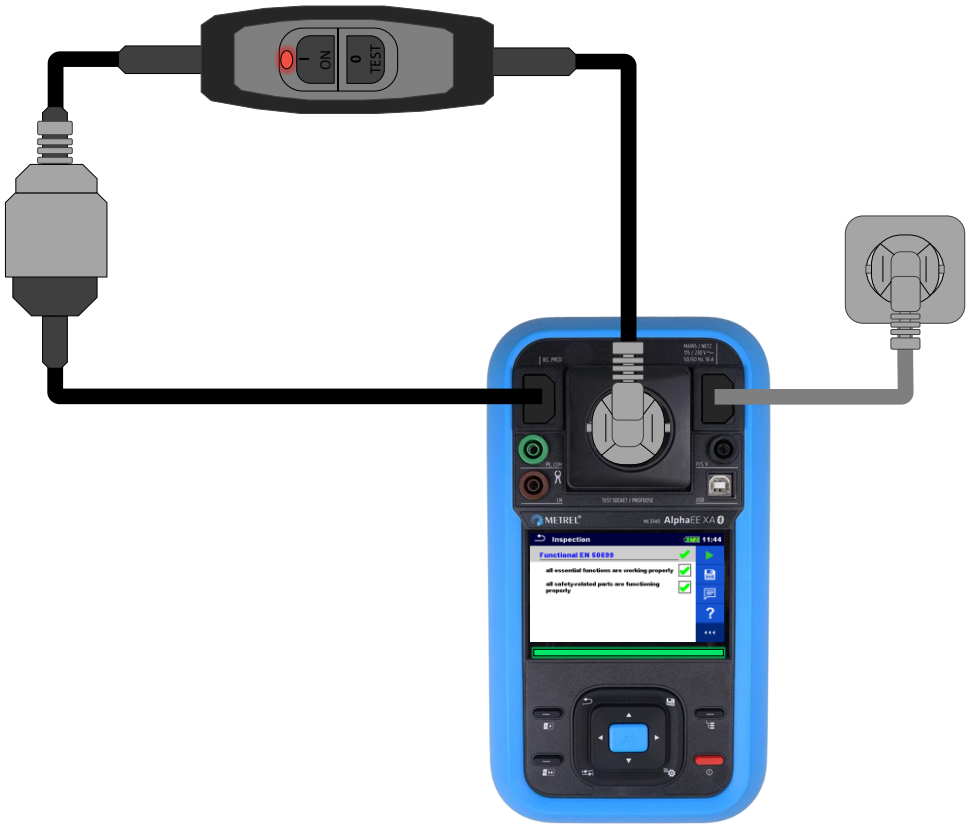


Figure 162_Functional inspection

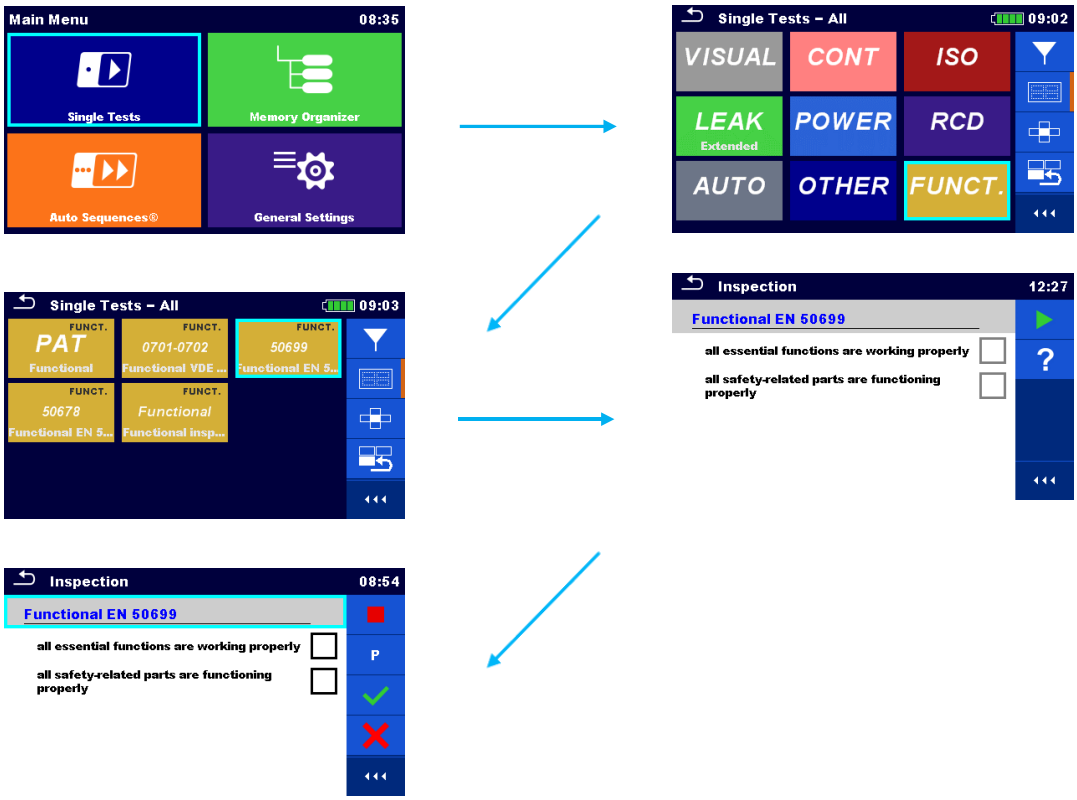


Figure 163_Functional inspection setup

Measurement procedure

Connect the PRCD equipment to the test socket, and the IEC test lead to the return connection – see Figure 162_Functional inspection. Select the correct measuring function (Functional inspection), start the test and tick off the correct statuses. Power can be applied to the device under test to check correct operation and consumption.

7. Fixed installed electrical equipment testing

Standards for electrical equipment testing do not differentiate between portable, movable, or fixed-installed devices—whether they have a plug or not.

According to EN 50699 and EN 50678, all current-using equipment or appliances:

- with a rated voltage between 25 V AC and 1,000 V AC, or 60 V DC and 1,500 V DC,
- currents up to 63 A,
- connected to the final circuits,

must be tested. This applies to both pluggable equipment of type A and permanently connected (fixed-installed) devices.

The inspections and tests conducted on fixed-installed equipment are identical to those performed on devices with a plug. The primary challenge lies in isolating the equipment from the mains supply and establishing proper connections for testing.

The individual performing tests on fixed-installed equipment must be an electrically skilled person with the appropriate competencies.

it is crucial to perform a thorough risk assessment before any testing on fixed-installed equipment. The risks associated with conducting the test may outweigh those of not conducting it.

Typical examples of fixed installed appliances are hand dryers, air conditioning units, towel radiators, hot water boilers, cookers, etc.

Isolating electrical equipment from the mains supply

Identify the electrical circuit the DUT is connected to and disconnect the corresponding circuit breaker.

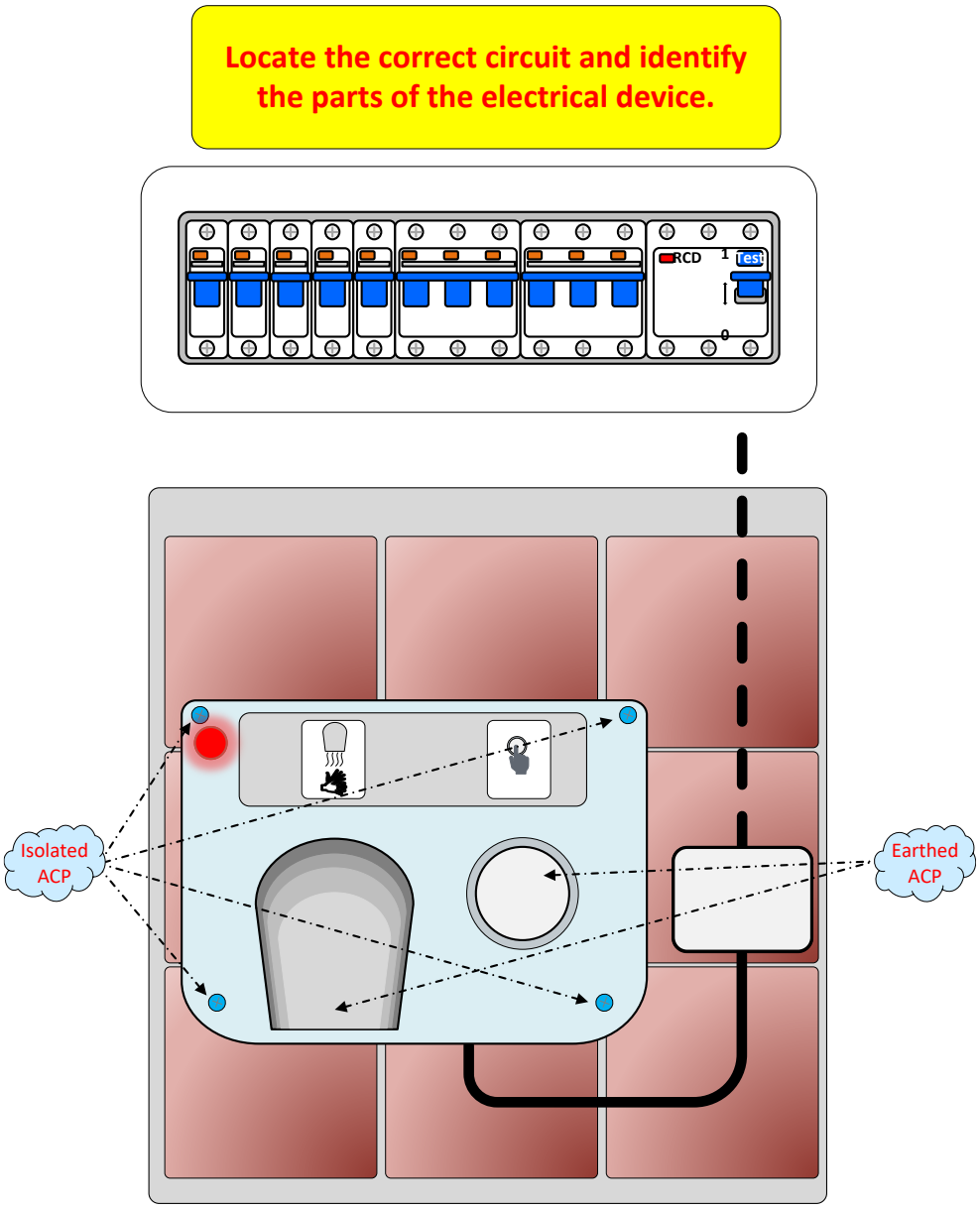


Figure 164_Isolating electrical equipment from mains

Visual inspection

Scope of test:

The visual inspection shall take place to detect external defects and, if possible, to determine the qualification of the suitability of the equipment for the environment.

Figure 165_Visual inspection

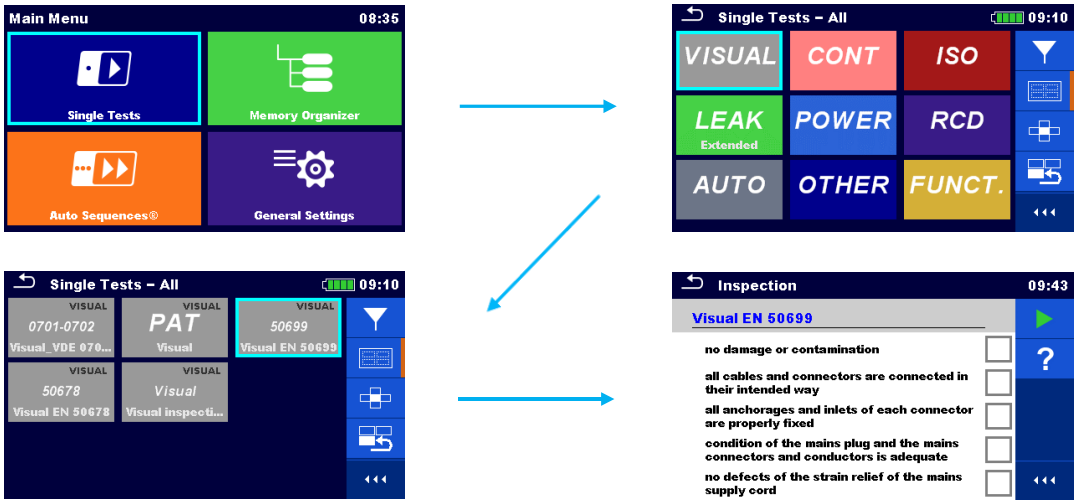


Figure 166_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the cables and connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.
- Check for any defects due to the bending of the cords, hoses or tubes.
- Check for damage on the mains plug, the mains connectors and conductors.
- Check for defects on the strain relief of the mains supply cord.
- Check the condition of the anchorage, cable clip, and accessible fuse insert.
- Check for signs of improper change.
  Check that the cooling openings aren't blocked and the filter condition.

Check the condition and tightness of any water, air or other media container, and its pressure control valve.

- Check the functionality of switches, control and setup of equipment.
- Check all safety-relevant markings, labels or symbols, ratings, and the position indicators are legible and complete.
- Check that all accessible fuses comply with the manufacturer's requirements (rated current, characteristics).
- Check the condition of all the relevant accessories (e.g. detachable or fixed power supply cords, tubing).

Figure 167_Visual inspection

Voltage test

See the SELV/PELV voltage test function to check the mains voltage level, which should be 0V or slightly above. If the disconnected wires run parallel to live conductors, they may pick up a small, induced voltage.

Once you ensure that a dangerous voltage is no longer present, disconnect the device from the network by disconnecting the L, N and PE conductors.

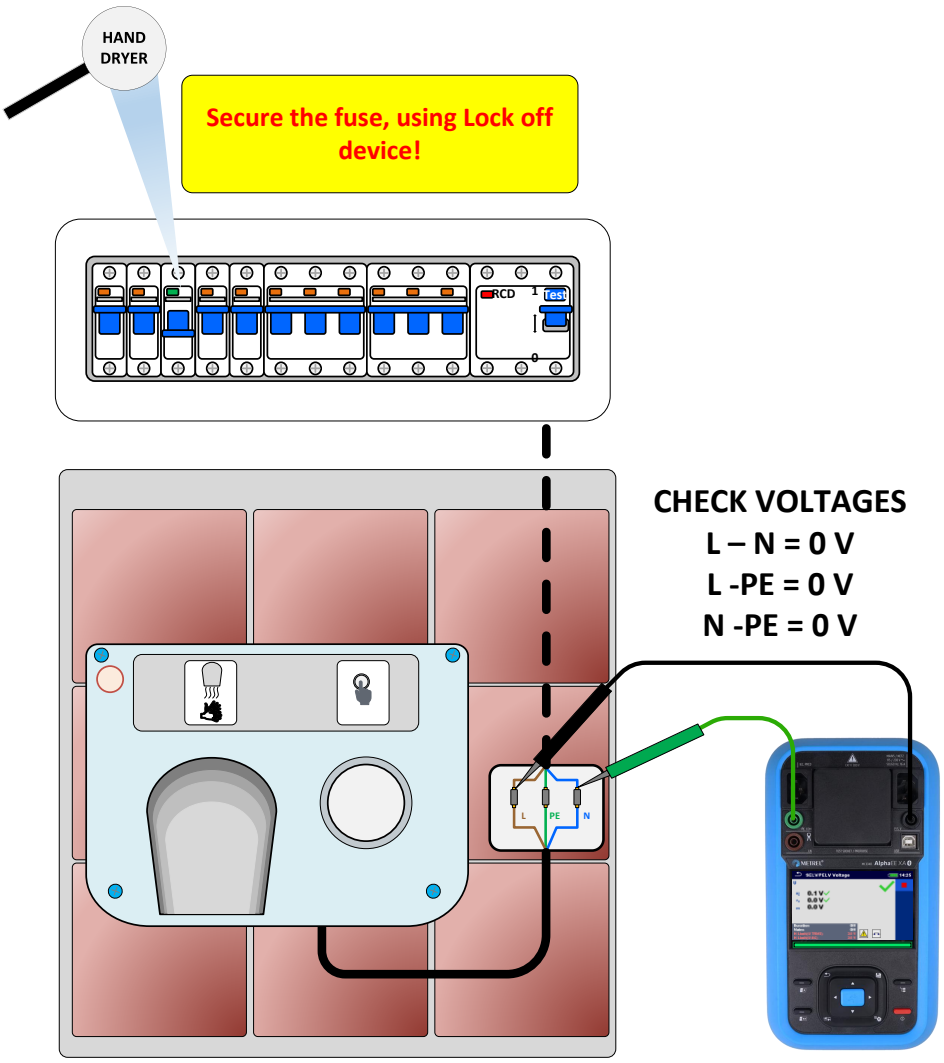


Figure 168_Voltage test

Continuity of protective conductor

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340. The subject of evaluation is the PE conductor between the input terminal and any accessible earthed parts, if present.

The measurement is performed using the point-to-point test method with two probes.

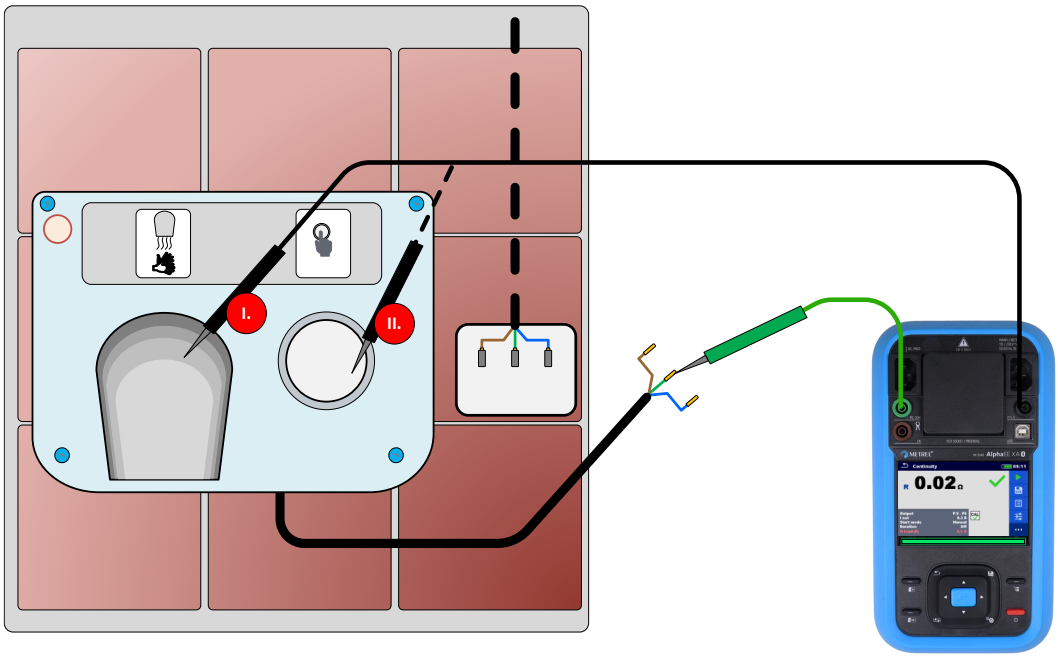


Figure 169_Continuity of protective earth

Note!

The cord must be continuously folded during the test! If the result changes during the measurement, the test fails.

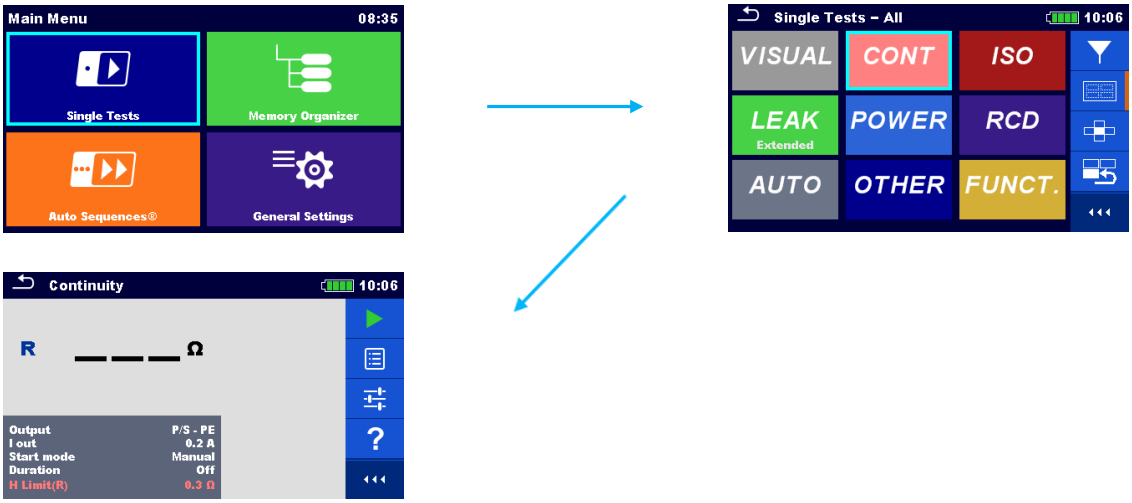


Figure 170_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Compensate the test leads – see Compensation of test leads below.

- Connect the DUT according to the connection diagram Figure 169_Continuity of protective earth.
- Set the appropriate measurement parameters.
- Start the test.

Compensation of test leads

Figure 171_Test leads compensation

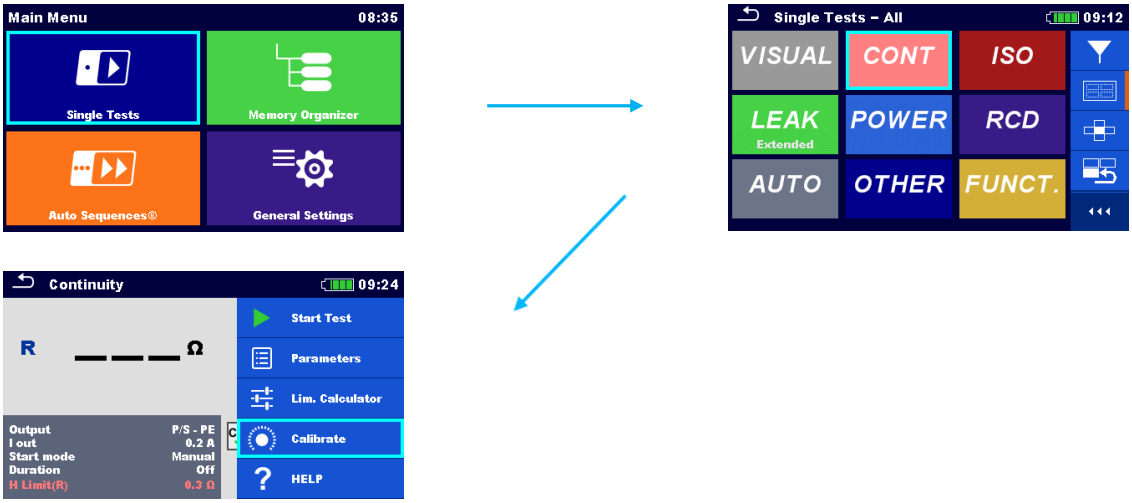


Figure 172_Calibration setup

Compensation procedure

- Connect test leads according to the connection diagram Figure 171_Test leads compensation,
- Select the appropriate measurement,
- Start the calibration.

Insulation resistance between the protective conductor and live conductors (N and L)

Scope of test:

Insulation resistance measurement confirms the effectiveness of the insulation between live parts and accessible conductive parts connected to the protective earth. It discloses faults caused by pollution, moisture, deterioration of insulation material, etc.

The measurement is performed using the MI 3340. The subject of evaluation is the insulation resistance between the PE conductor and the live parts.

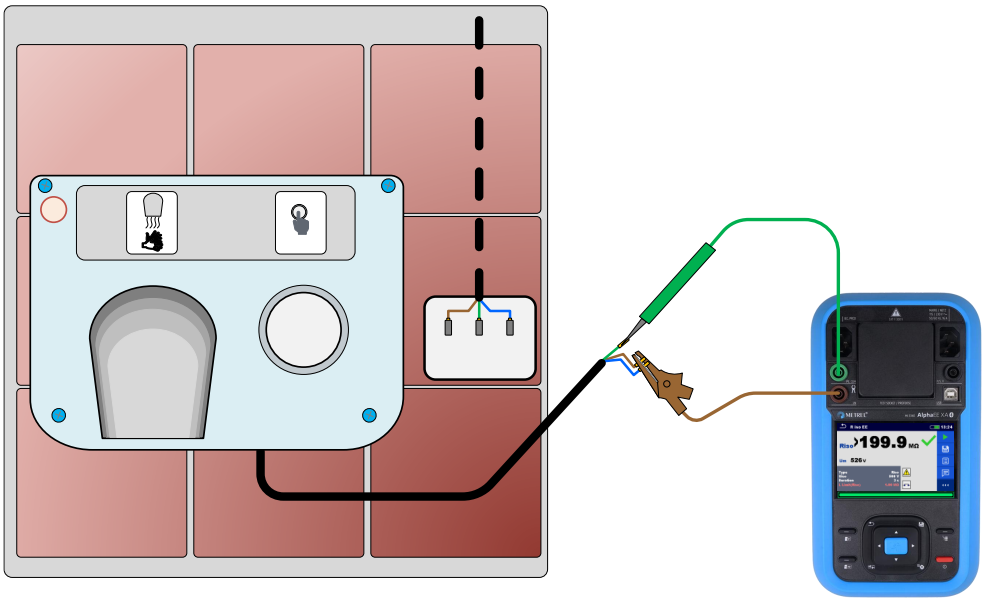


Figure 173_Insulation resistance on fixed installed equipment

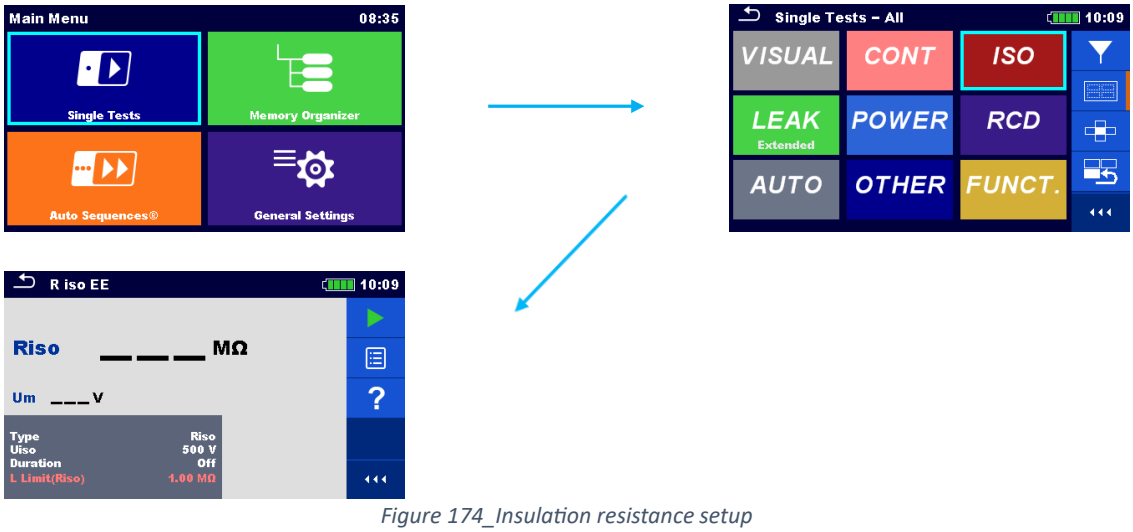


Figure 174_Insulation resistance setup

Measuring function: RPAT / Riso EE
Output parameter: Riso
Uiso: 250 V, 500 V (observe manufacturer's information for an appropriate test voltage)
Limit: ≥ 1,0 MΩ

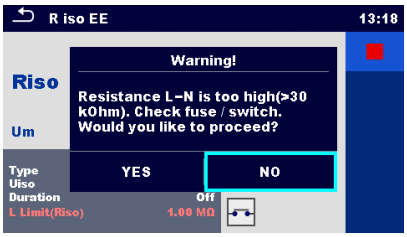


Figure 175_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user of the following possible issues:

- The device under test is not connected or switched on
- The input fuse of the device under test is blown.

Note!
The warning message can be disabled under the settings, in the instrument's setup menu! Load pretest (On/**Off**).

Measurement procedure

- Connect the DUT according to the connection diagram Figure 173_Insulation resistance on fixed installed equipment,
- Set the appropriate measurement parameters,
- Start the test.

Protective conductor (leakage) current

Scope of test:

The PE current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions.

Unearthed accessible conductive parts are not included in this test. They are considered Class II parts and are checked with the Touch Leakage test.

The measurement is performed using the MI 3340.

For safety reasons, it is advisable to disconnect the DUT from the network and use the alternative method for measuring the leakage current.

If the person performing the measurements is professionally trained (a skilled person), they may carry out a leakage current measurement on a permanently connected device while in operation. This is possible with the MI 3340's point-to-point leakage current measurement function.

The point-to-point leakage current measurement also enables the measurement of leakage current on isolated conductive metal parts. For protection class I devices, it is necessary to first perform a protective conductor continuity test.

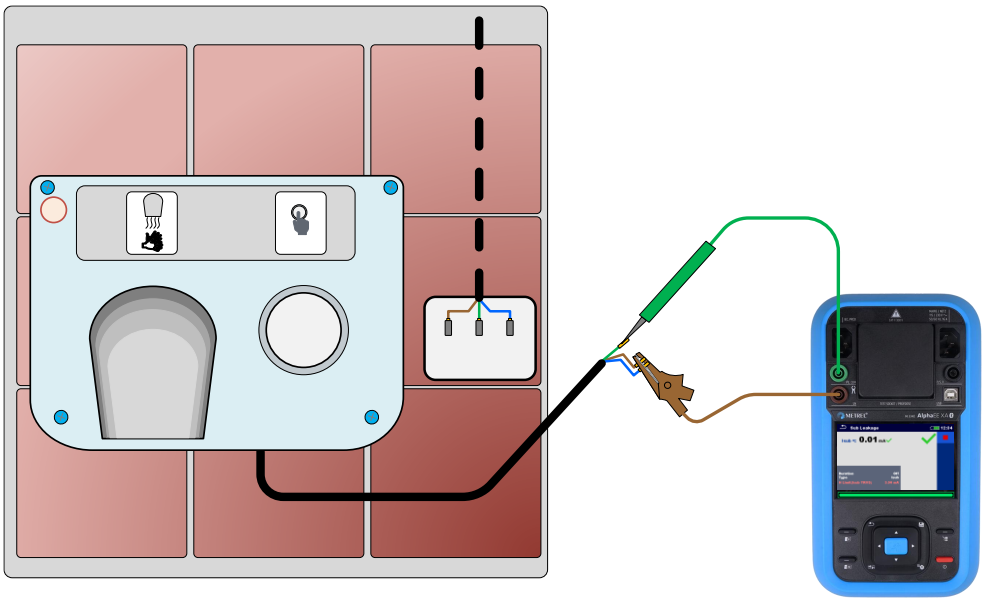


Figure 176_Substitute leakage on fixed installed equipment

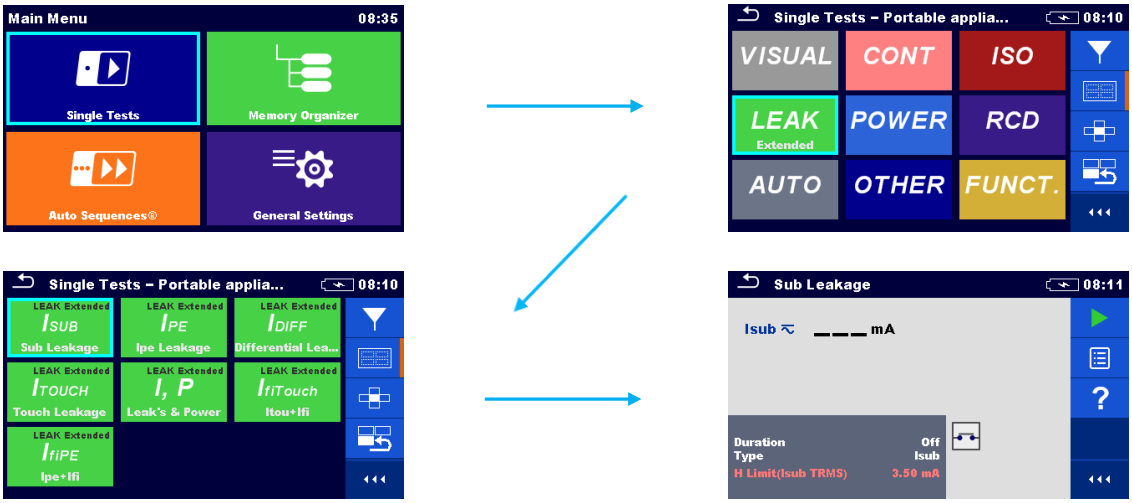


Figure 177_Substitute leakage setup

Measuring function: Sub Leakage “Isub” (alternative method).
Test: PE leakage current
Limit: ≤ 3,5 mA

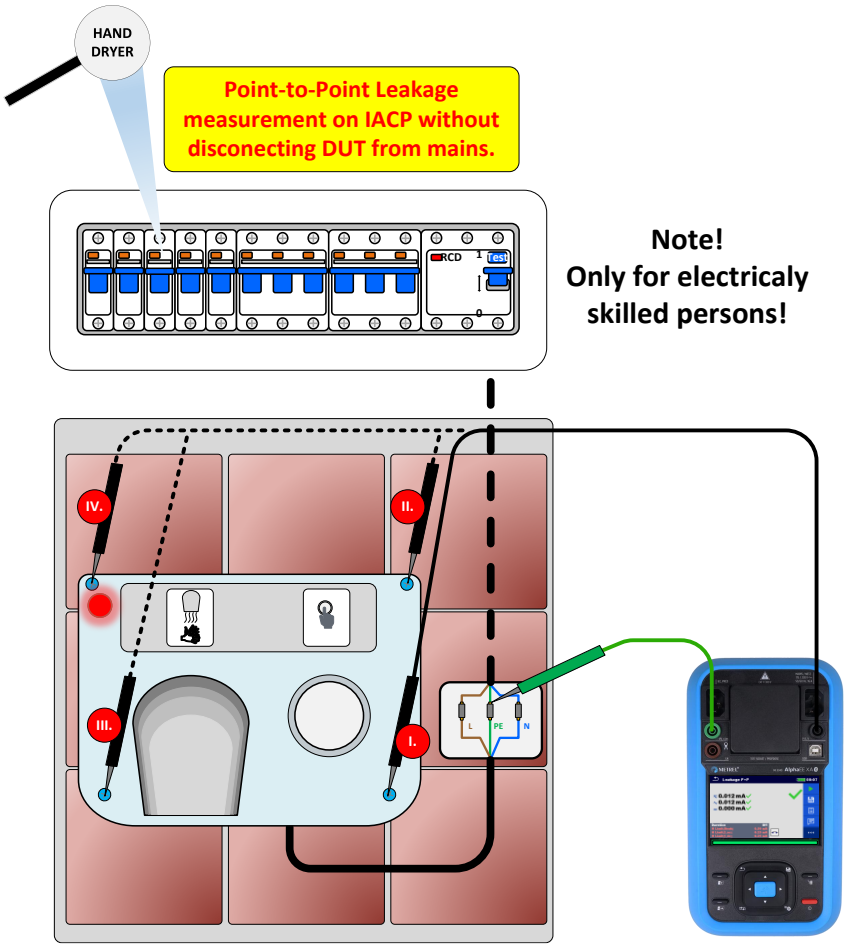


Figure 178_Point-to-Point leakage on fixed installed equipment

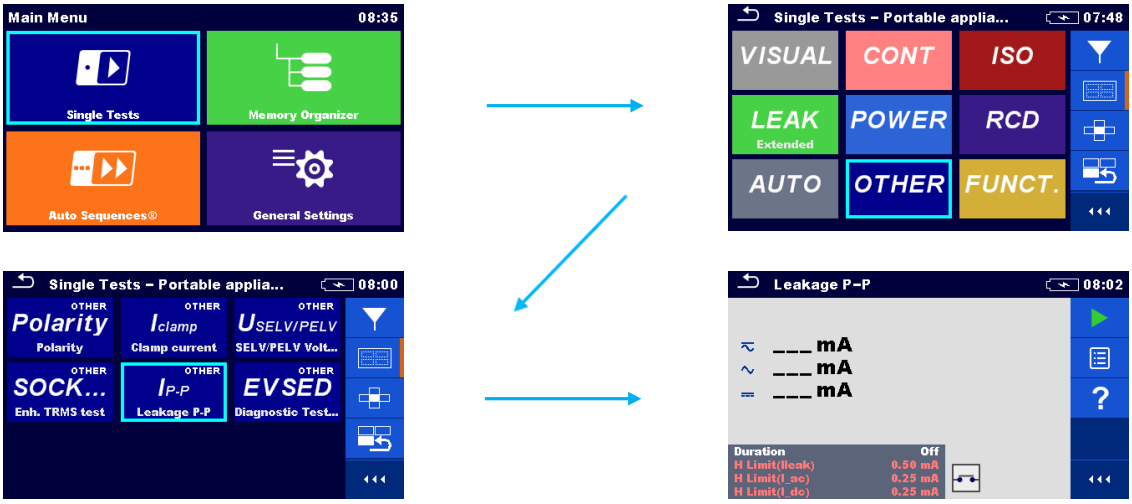


Figure 179_P-P leakage setup

Measuring function: Leakage P-P (direct method).
Test: PE leakage current
Limit: ≤ 0,5 mA

8. SELV / PELV electrical equipment testing

SELV (Safety Extra-Low Voltage) and **PELV (Protective Extra-Low Voltage)** systems are used where electric shock protection is critical. According to EN 50699 & EN 50678, these equipment needs to be tested under normal conditions and under single fault conditions including earth faults in other electric circuits (not applicable for PELV).

SELV:

Used in situations where complete isolation from earth is necessary for safety, such as in wet environments or where accidental contact with higher voltages is a concern.

SELV:

- Fully isolated from mains voltage
- No connection to protective earth
- Operates ≤50 VAC or ≤120 VDC (commonly ≤24 V)
- Protection class: **Class III**

Performing an **insulation resistance test for a SELV (Safety Extra-Low Voltage) source** requires special attention because SELV systems are **completely isolated** from higher voltage circuits and from protective earth (PE). This isolation is the primary safety feature, and the insulation test is used to verify that the **separation between SELV and other circuits or ground is intact**.

PELV:

Used in general applications where a lower voltage is desirable for safety, but earthing is necessary for the specific equipment or application.

PELV:

- Similar voltage level as SELV
- May be grounded
- Common in industrial environments
- Protection class: **Class I or II**

To correctly perform an **insulation resistance test** on a **PELV voltage source**, it's important to understand that while **PELV systems** operate at **extra-low voltage levels** (≤ 50 VAC / ≤ 120 VDC), they **can be grounded**—unlike SELV systems.
The purpose of the insulation resistance test in this context is to **verify safe separation from higher-voltage circuits** and to **ensure that the system's insulation remains intact and effective**.

Protective Extra-Low Voltage

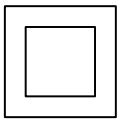
For devices which generate a SELV or PELV voltage through a safety transformer or a switched-mode power supply, their effectiveness or protective effect must be checked by the following test steps:

- Verification of the conformity of the rated voltage with the specifications for the SELV or PELV voltage;

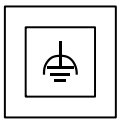
U < 50 V a.c. / U < 120 V d.c.	EN 60364-4-41 : 2001
U < 33 V a.c. / U < 70 V d.c.	EN 61010-1 : 2001

- Measurement of the insulation resistance between primary and secondary side of the voltage source;
- Measurement of the insulation resistance between active parts of the SELV / PELV output circuit and accessible conductive parts.

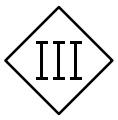
Markings:



Class II equipment can be identified by the **Class II symbol** (a square within a square), which is typically displayed in a prominent location on the device. This type of equipment **does not have an earth (ground) conductor** in its supply cable, as it relies on **double or reinforced insulation** for user protection.

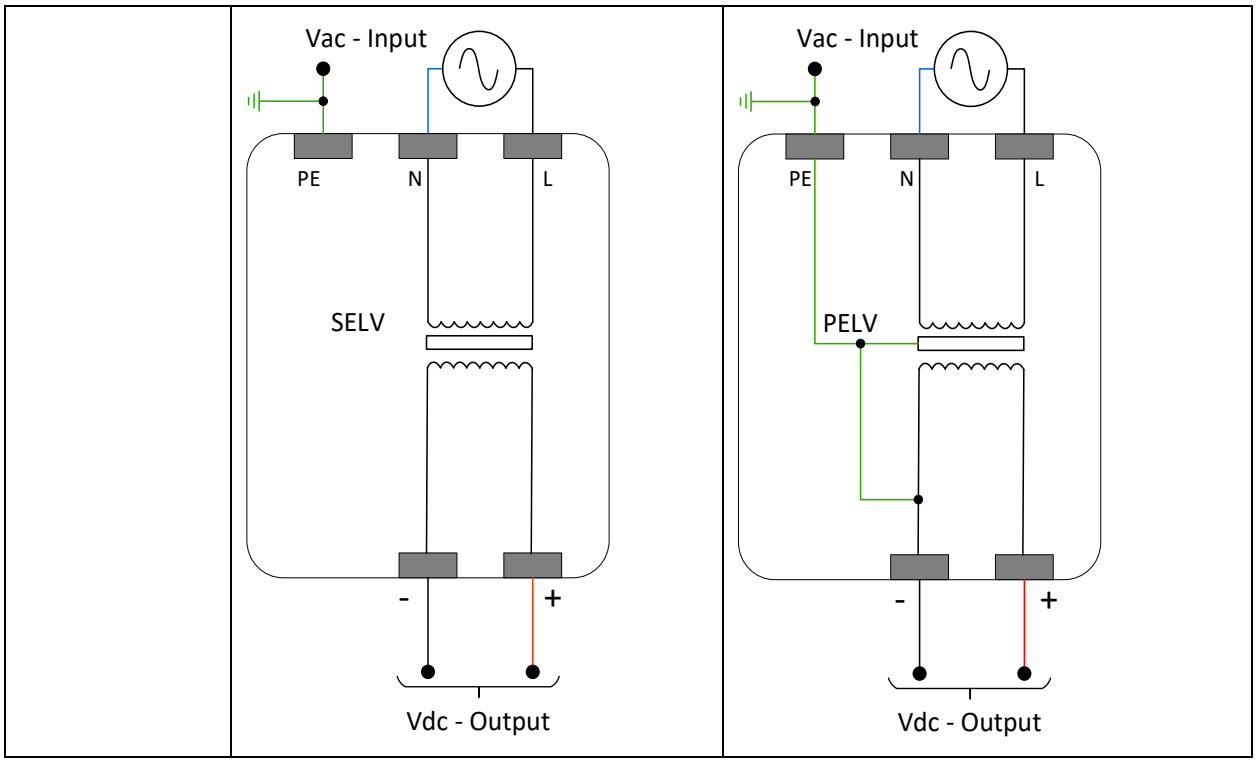


In some cases, class II devices may have a functional ground. Though class II devices do not require a protective earth ground, they do sometimes require a **functional ground for electromagnetic compatibility** (EMC). As with protective earth grounds, a transformer blocks the power current from flowing to earth but allows any transient current or leakage to flow to the ground



Class III equipment can be identified by the **Class III symbol**, which indicates that the device is designed to operate at **SELV (Safety Extra-Low Voltage)** and does **not rely on mains power** for protection.

Type	**SELV**	**PELV**
Definition	Safety Extra Low Voltage	Protection Extra Low Voltage
Voltage Range	U < 50 V a.c. / U < 120 V d.c. U < 33 V a.c. / U < 70 V d.c.	U < 50 V a.c. / U < 120 V d.c. U < 33 V a.c. / U < 70 V d.c.
Grounded	No	Yes
Accessible	Yes	Yes
Example	Hone charger module with USB output. 5V output of phone charger is not connected to supply ground in a SELV system	Some computer power supplies where one leg of DC is connected to ground



List of Applicable test & Limits

Testing according to EN 50678 (after repair) and EN 50699 (periodic testing):

Measurement	**SELV**	**PELV**	**Limits**
Visual inspection	✓	✓	No Faults
Continuity of protective conductor	×	✓	≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω per additional 7.5 m up to max. 1.0 Ω
Insulation resistance test	×	Between L+N to PE.	> 1.0 MΩ
	Between L+N to each AICP, (ClassI or ClassII).		> 2.0 MΩ
	Between L+N to SELV/PELV live parts.		> 0.25 MΩ
Touch Leakage current	✓	✓	≤0.5 mA
PE Leakage current	✓	×	≤ 3.5 mA
Functional test (output voltage)	✓	✓	U < 50 V a.c. / U < 120 V d.c. U < 33 V a.c. / U < 70 V d.c.
Functional inspection	✓	✓	

For testing live parts with the protective means SELV/PELV against accessible conductive parts, the test voltage may be reduced to 250 V DC.

- ACP = Accessible Conductive Part
- AICP = Accessible Isolated Conductive Part
- PE = Protective Earth

Visual inspection

Scope of test:

The visual inspection shall take place to detect external defects and, if possible, to determine the qualification of the suitability of the equipment for the environment.

Figure 180_Visual inspection

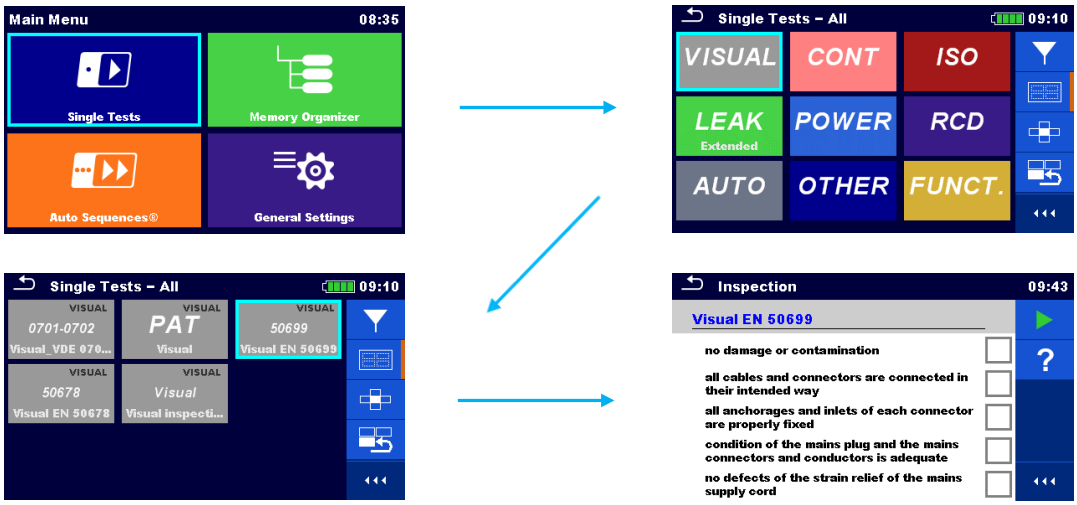


Figure 181_Visual inspection setup

Special attention shall be paid to the following:

- Check for damage or contamination.
- Check that the cables and connectors are connected in their intended way.
- Check by hand that the anchorages and the inlets of each connector are properly fixed.
- Check for defects in the lead cord grip.
- Check for damage to the housing that could give access to live or dangerous parts.
- Check for signs of overload or overheating.
- Check for signs of corrosion that impact protective measures and improper ageing.

- Check for any defects due to the bending of the cords, hoses or tubes.
- Check for damage on the mains plug, the mains connectors and conductors.
- Check for defects on the strain relief of the mains supply cord.
- Check the condition of the anchorage, cable clip, and accessible fuse insert.
- Check for signs of improper change.
  Check that the cooling openings aren't blocked and the filter condition.
  Check the condition and tightness of any water, air or other media container, and its pressure control valve.
- Check the functionality of switches, control and setup of equipment.
- Check all safety-relevant markings, labels or symbols, ratings, and the position indicators are legible and complete.
- Check that all accessible fuses comply with the manufacturer's requirements (rated current, characteristics).
- Check the condition of all the relevant accessories (e.g. detachable or fixed power supply cords, tubing).

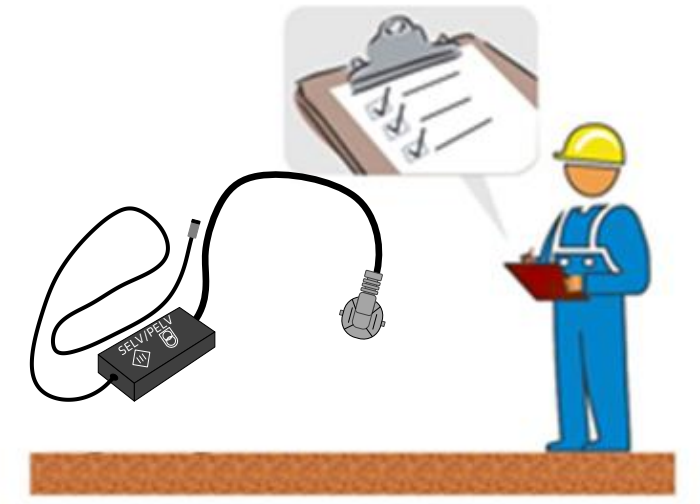


Figure 182_Visual inspection

Continuity of protective conductor (PELV- ClassI)

Scope of test:

The effectiveness of protective bonding is tested with the low resistance measurement. The test is done on all accessible conductive parts and any other parts connected to the PE conductor.

The measurement is performed using the MI 3340. The subject of evaluation is the PE conductor between the PE pin on the supply cable and any accessible earthed parts.

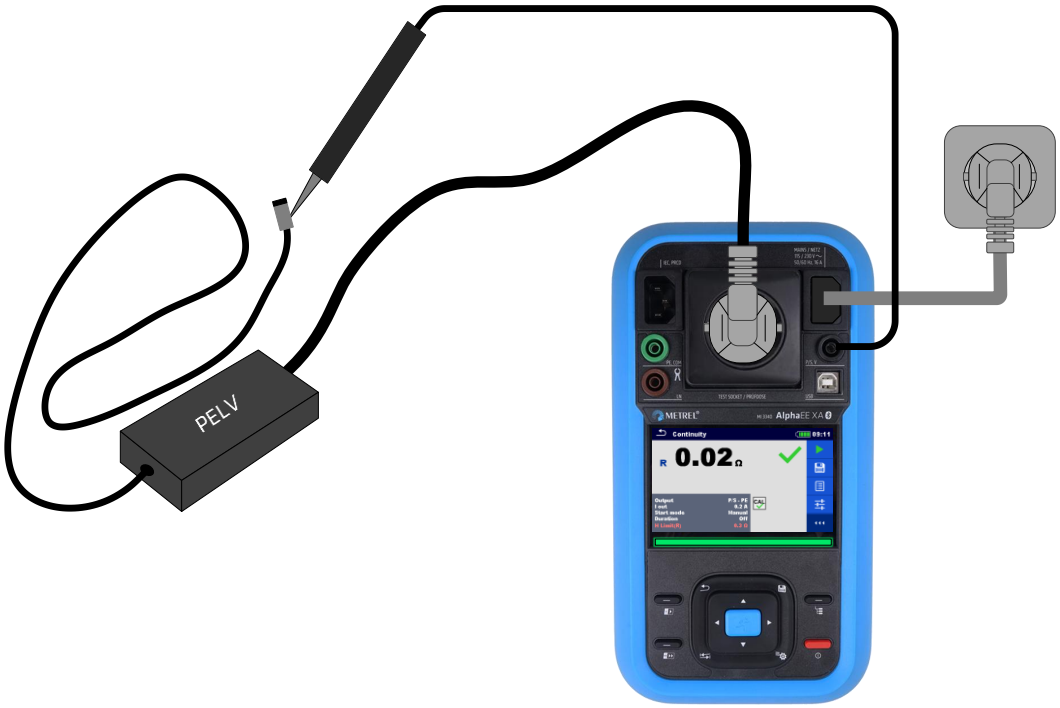


Figure 183_Continuity of protective earth

Note!

All earthed metal parts shall be evaluated. Check the manufacturer's information.

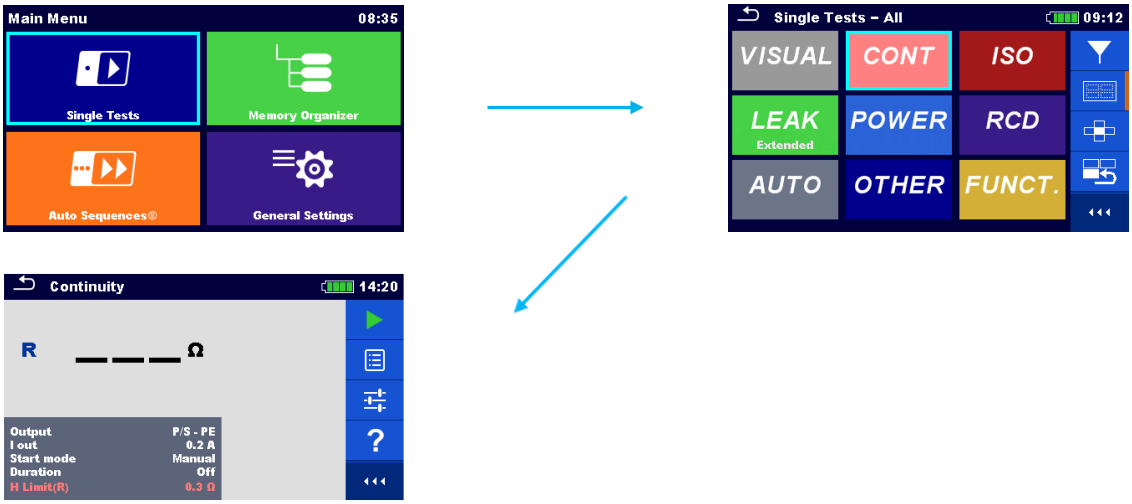


Figure 184_Earth continuity setup

Measuring function: R Continuity / Continuity
Output parameter: P/S – PE
I out: 0.2 A
Limit: ≤ 0.3 Ω (with connecting cables up to 5 m in length) | plus 0.1 Ω for each additional 7.5 m up to max. 1.0 Ω

Measurement procedure

- Connect the DUT according to the connection diagram Figure 183_Continuity of protective earth,
- Set appropriate measurement parameters,
- Start the test.

Insulation resistance test

Scope of test:

To confirm the effectiveness of the insulation in SELV/PELV electrical equipment, an **insulation resistance measurement** should be performed between the following points:

1. **Live parts** and **accessible conductive parts** connected to **protective earth (PE)** – typically applied to **Class I equipment**.
2. **Live parts** and **accessible conductive parts** protected by **double or reinforced insulation** and **not connected to PE** – primarily for **Class II equipment**, but also applicable to certain **Class I equipment**.
3. **Live parts** and **accessible conductive parts** protected by **SELV/PELV** systems.
4. **Insulated inputs/outputs** and **PE** – to ensure isolation from protective earth.

The objective of these measurements is to **verify safe separation** from hazardous live circuits and to ensure that **insulation remains intact and compliant** with relevant safety standards.

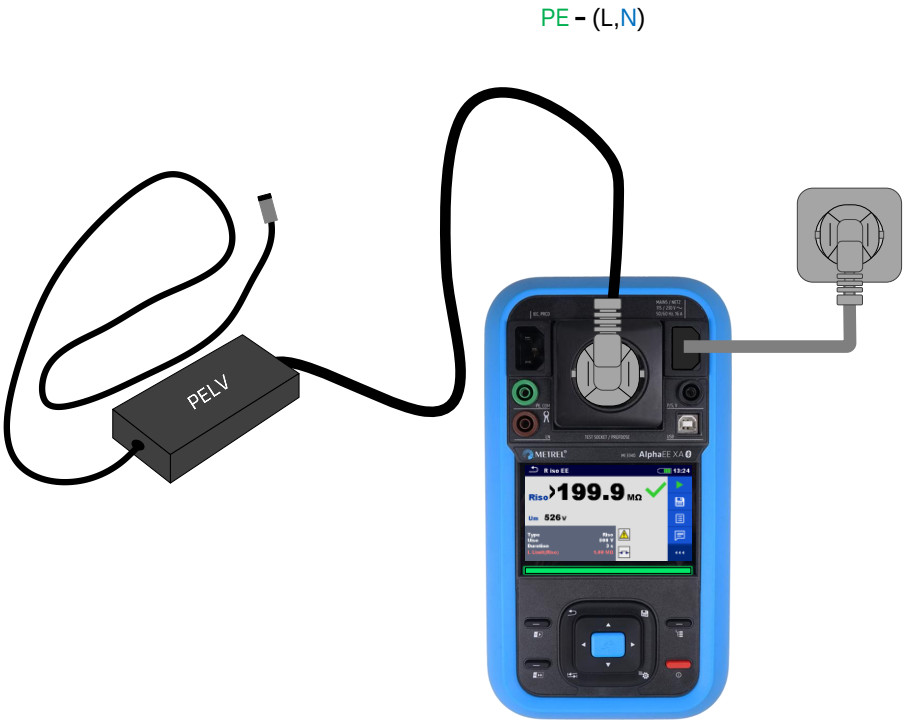


Figure 185_Insulation resistance Class I

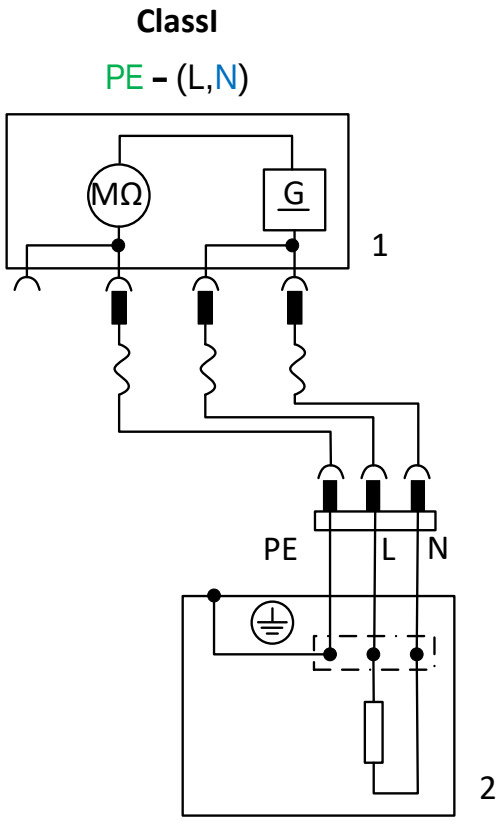


Figure 186_Insulation resistance Class I

Note!

If the device under test has isolated metal parts, they must be tested separately.

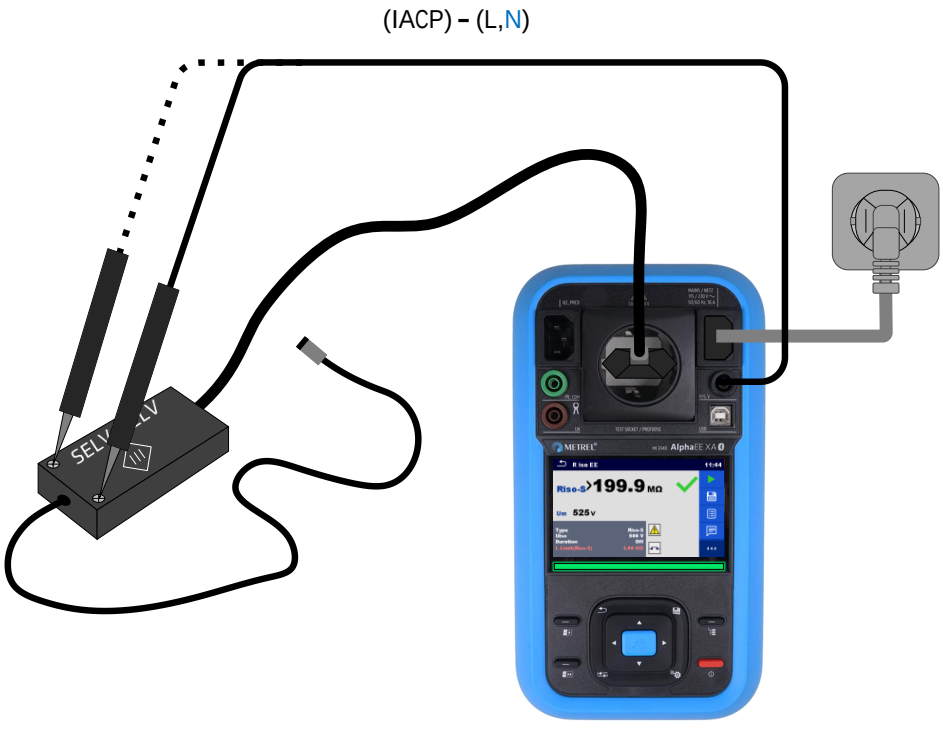


Figure 187_Insulation resistance Class II, ClassIII

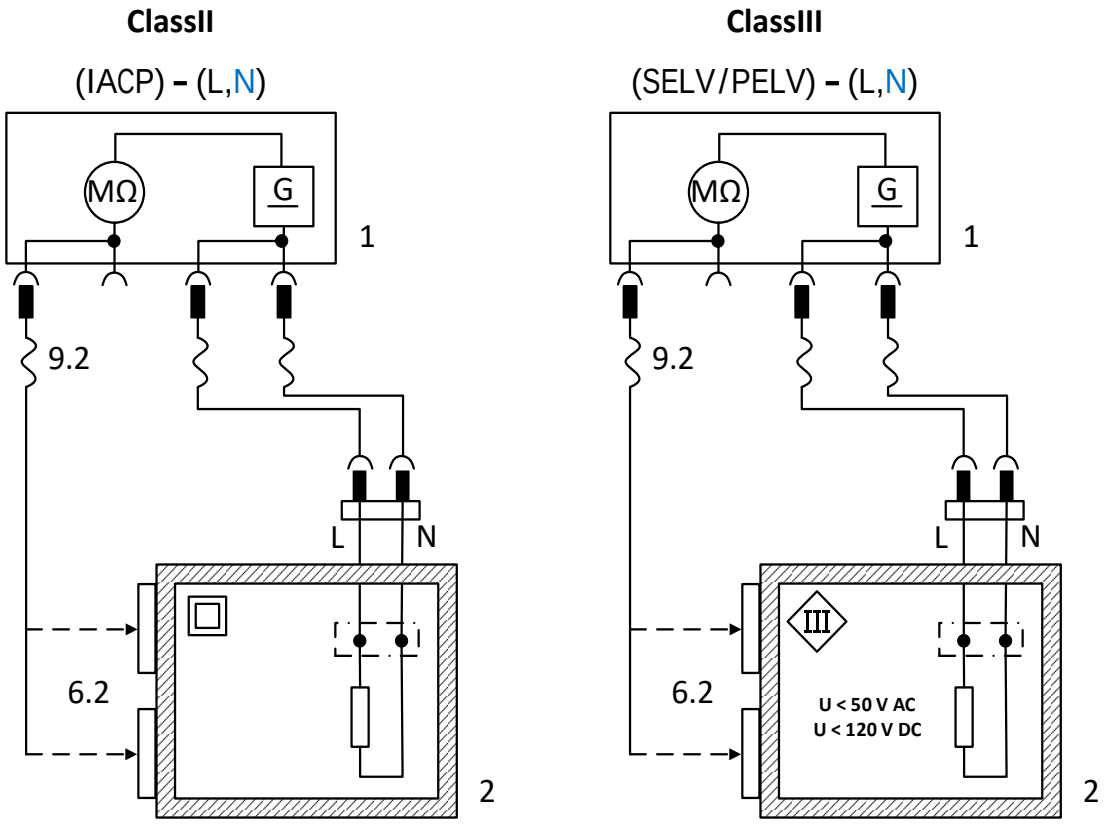


Figure 188_Insulation resistance Class II, ClassIII

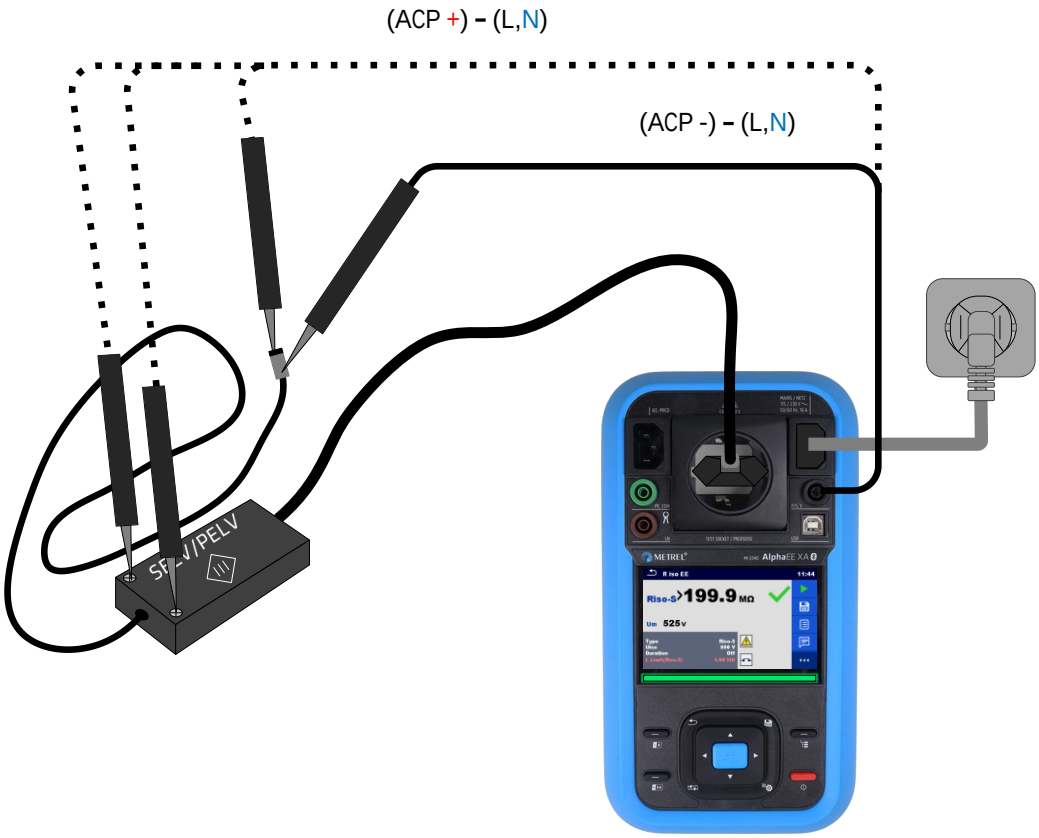


Figure 189_Insulation resistance Class I, Class II

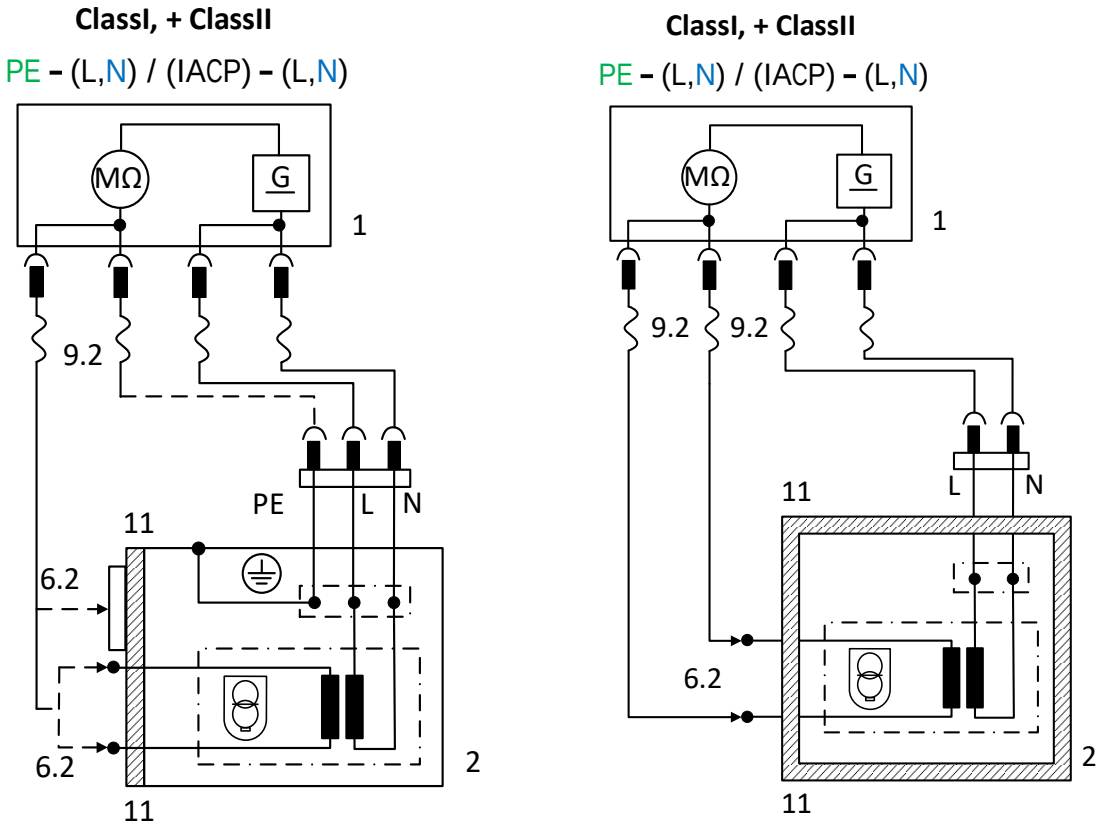


Figure 190_Insulation resistance Class I, Class II

Key

G generating measuring supply
1 test equipment
2 equipment under test
3 fuse or circuit breaker
4 socket
5 N (neutral) or live interrupted
6.1 test point(s), accessible conductive parts, connected to PE
6.2 test point(s), accessible conductive parts, not connected to PE
7 earth potential
8 equipment is isolated from earth
9.1 test probe to protective earth and to accessible protective parts, connected to PE
9.2 test probe to protective earth and to accessible protective parts, not connected to PE
9.3 test probe to live parts
10 possible earth connections
11 double or reinforced insulation

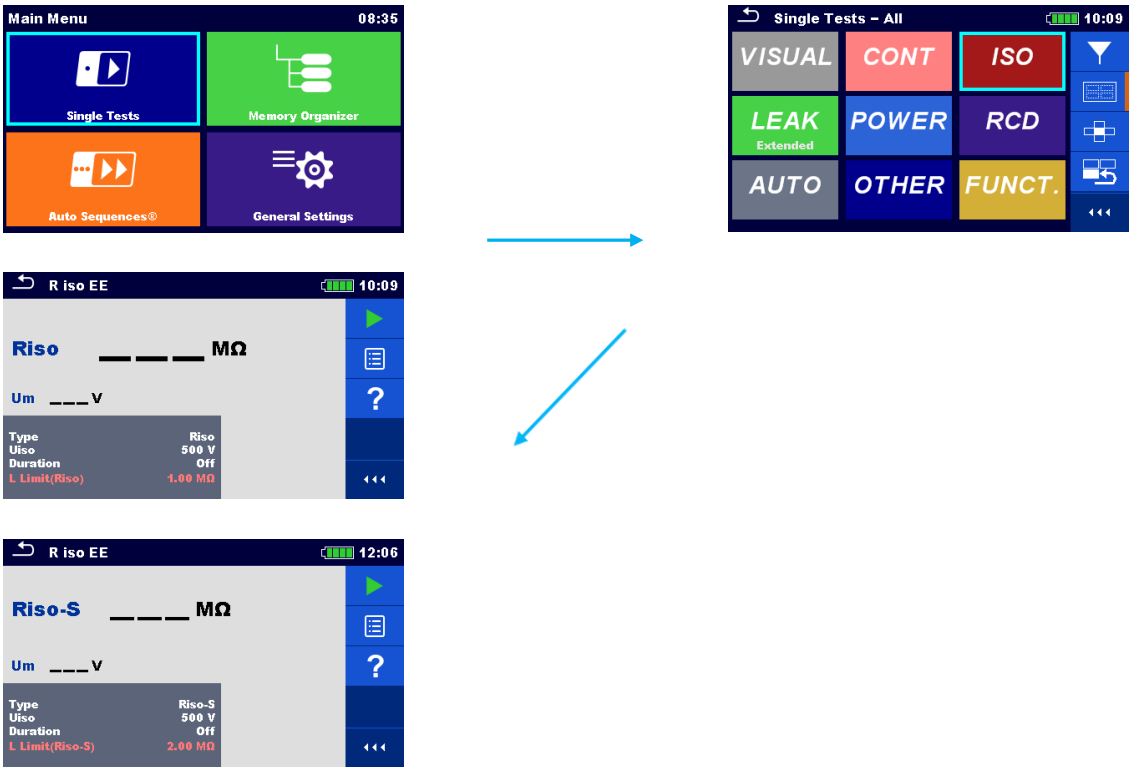


Figure 191_Insulation resistance setup

Measuring function: RPAT / Riso EE (CassI), Riso-S EE (CassII),
Output parameter: Riso / Riso-S
Uiso: 250 V, 500 V (Observe manufacturer's information for appropriate test voltage)
Limit: ≥ 1,0 MΩ

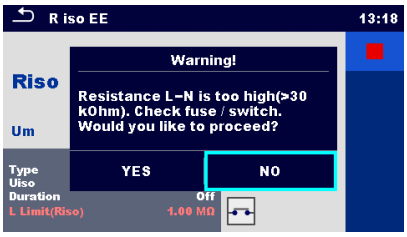


Figure 192_Insulation resistance warning

Insulation resistance pre-test is intended to warn the user of the following possible causes:

- The device under test is not connected or switched on
- The input fuse of the device under test is blown.

Select **YES** to proceed with or NO to cancel the measurement.

Note!
The warning message can be disabled in the Settings in the instrument's setup menu. Load pretest (On/**Off**).

Measurement procedure

- Connect the DUT according to the connection diagram Figure 185_Insulation resistance Class I, Figure 187_Insulation resistance Class II, ClassIII , or Figure 189_Insulation resistance Class I, Class II
- Set appropriate measurement parameters,
- Start the test.

Protective conductor (leakage) current

Scope of test:

The PE current measurement evaluates compliance with the leakage current limits. The method measures the leakage current that occurs under normal operating conditions. The measurement is performed using the MI 3340.

Depending on the tested equipment, one of the following methods of measuring the protective conductor current may be used:

- direct method,
- residual current method,
- alternative method, if there are no voltage-dependent switches inside the equipment.

The subject of evaluation is the insulation resistance and capacitance between the PE conductor and the live parts PELV electrical equipment.

Direct method

Current is measured directly in the PE wire. The device under test must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the PE conductor.

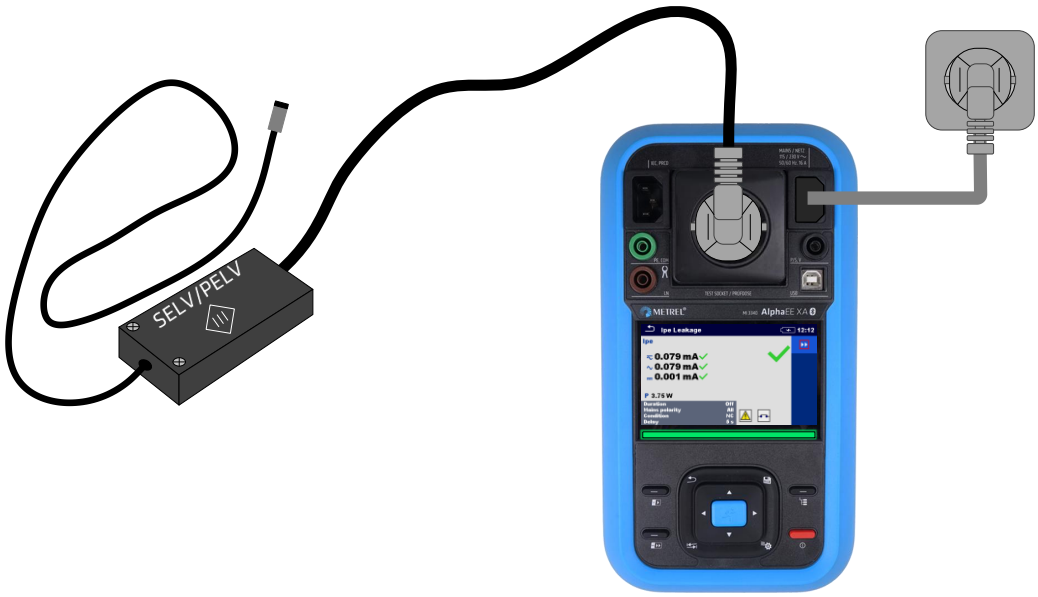


Figure 193_PE leakage current direct method

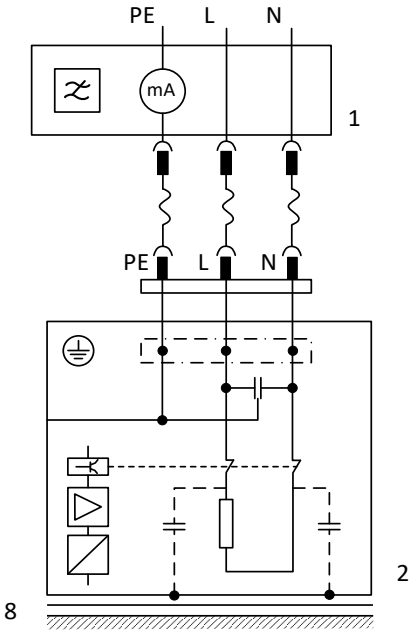


Figure 194_PE leakage current direct method

Residual method

The residual method measures the leakage current as the difference between currents through L and N supply conductors. The result does not depend on what type of floor the appliance is placed.

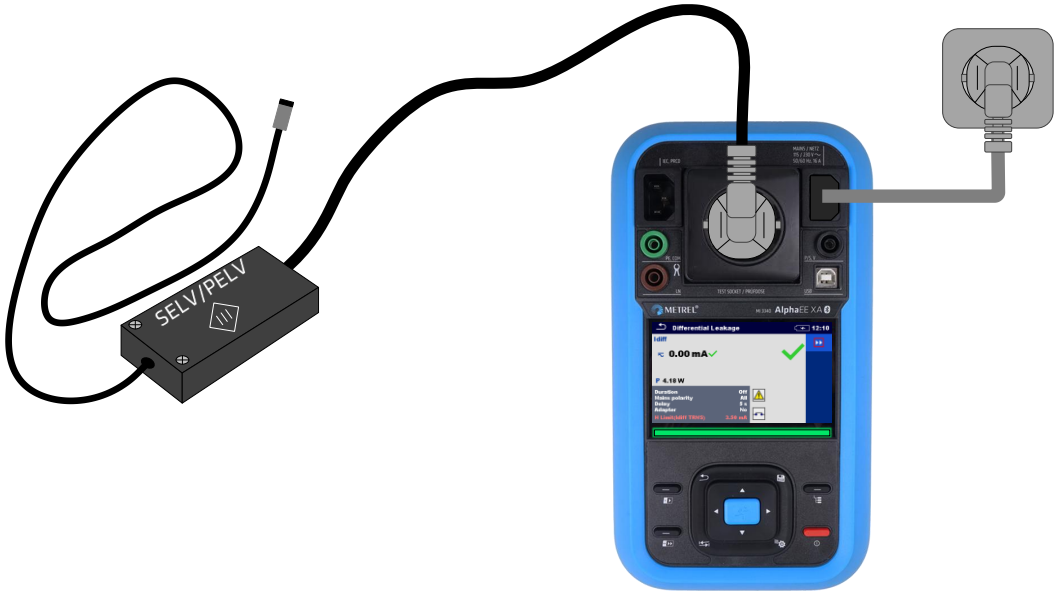


Figure 195_PE leakage current residual method

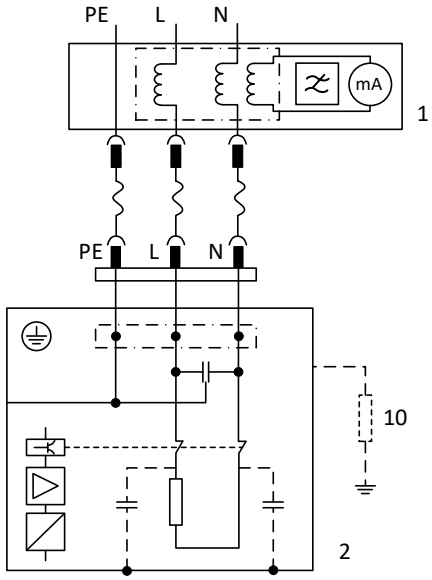


Figure 196_PE leakage current residual method

Alternative method

The alternative method is employed, the measured values might surpass the maximum allowable limits due to systematic errors in the measurement process, such as those caused by filters or cable impedances. In such cases, the direct or residual method should be used as the reference method.

Figure 197_PE leakage current alternative method

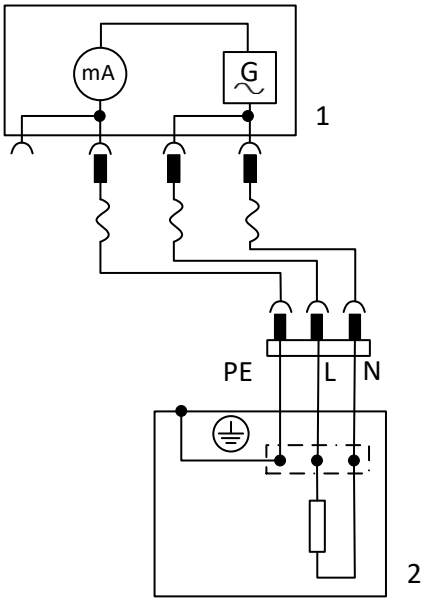


Figure 198_PE leakage current alternative method

Note!
All supply conductors can be connected in parallel with poly-phase equipment during the alternative method measurement.

Unearthed accessible conductive parts are not included in any of the protective conductor leakage test methods. They are considered Class II parts and are checked with the Touch Leakage test.

Measuring function: Ipe Leakage (direct method), Differential Leakage (residual method), Sub Leakage “Isub” (alternative method).

Test: PE leakage current
Limit: ≤ 3,5 mA

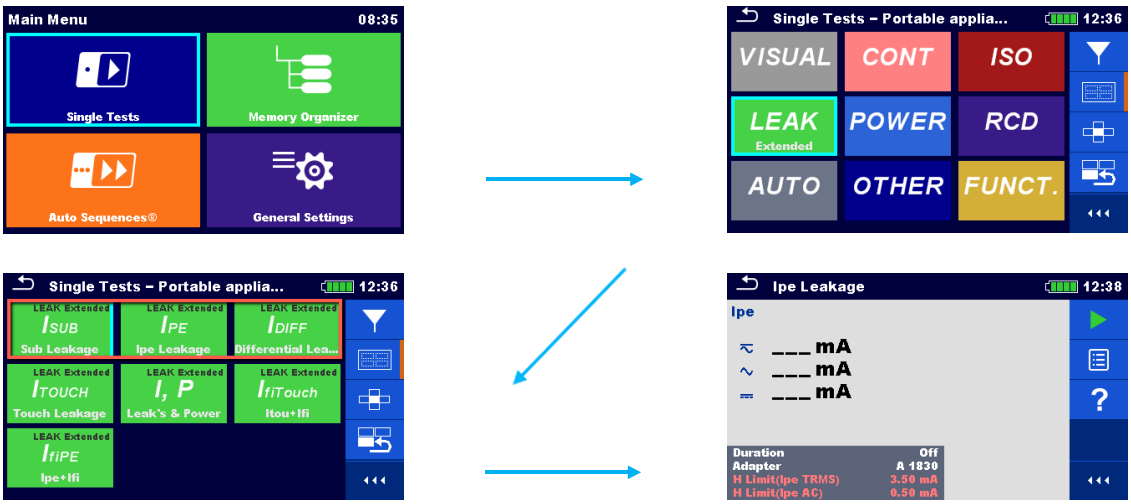


Figure 199_PE Leakage setup

Touch leakage test

The touch current shall be measured on every accessible conductive part of the equipment that is not connected to the protective earth conductor. Depending on the type of equipment, one of the following measurement methods may be used:

Direct method

Current is measured directly in the probe. The device under test must be placed on an isolative floor to prevent part of the leakage current from flowing directly into the ground instead of the probe.

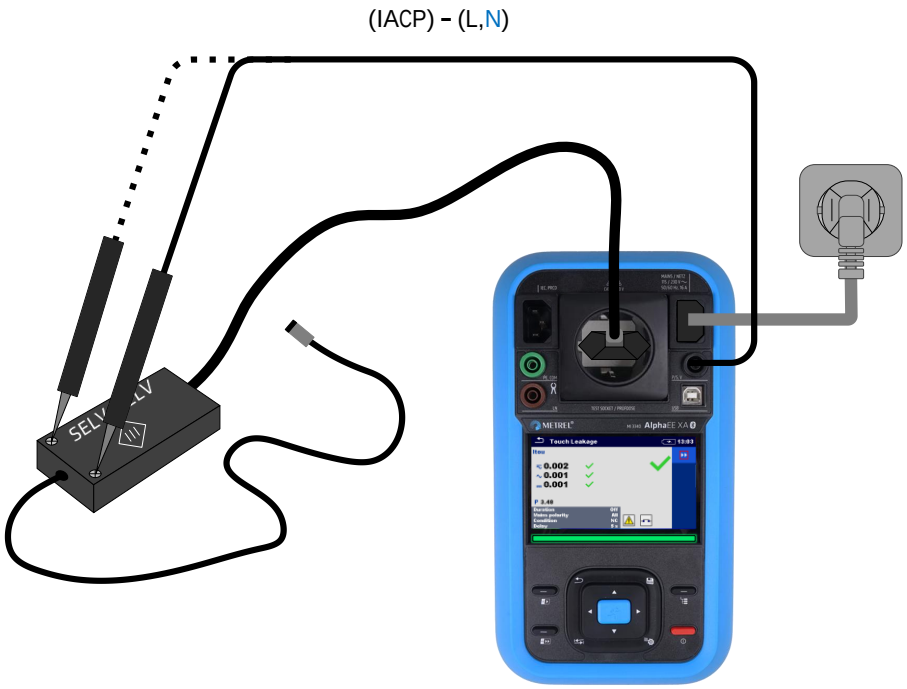


Figure 200_Touch leakage current direct method

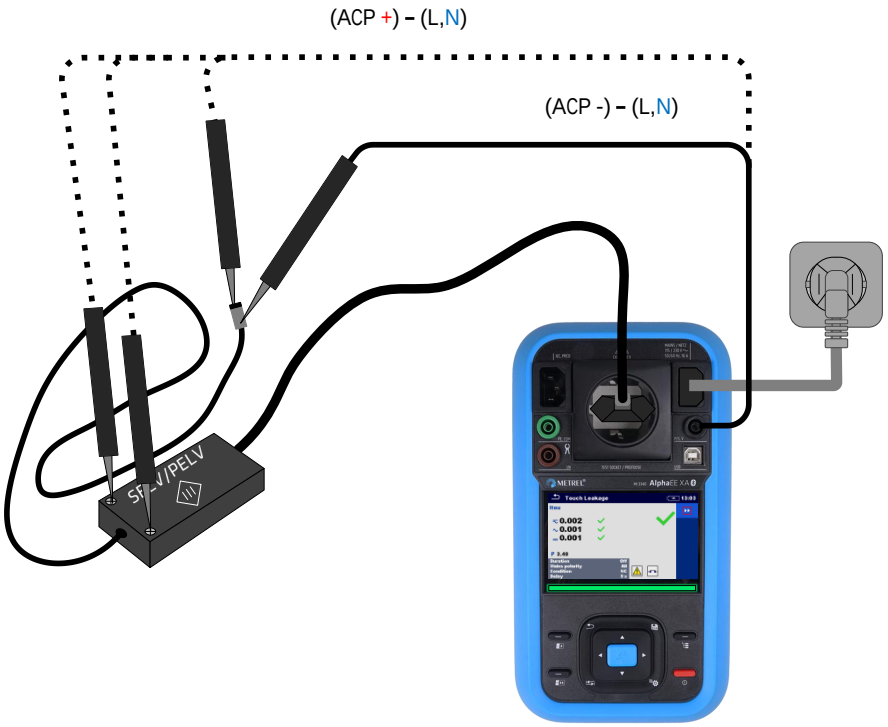


Figure 201_Touch leakage current direct method on SELV/PELV connectors ClassII

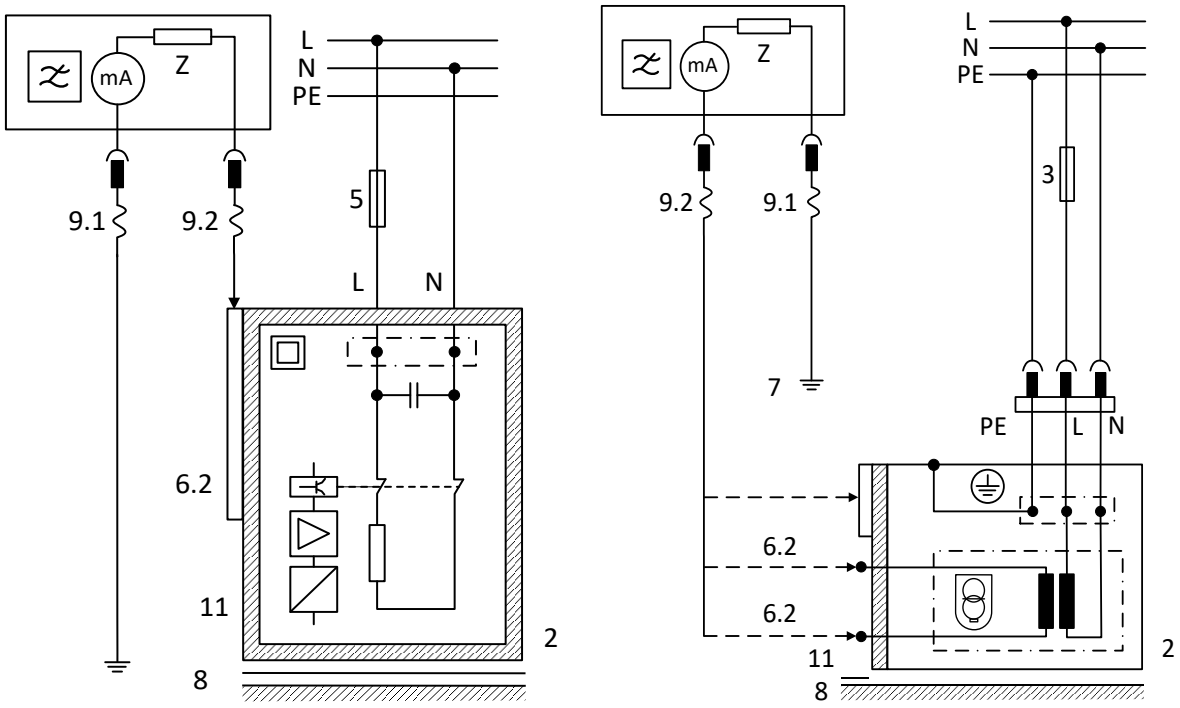


Figure 202_Touch leakage current direct method ClassII / SELV/PELV connectors ClassII Touch leakage

Alternative method

The alternative method can be applied when no voltage-dependent circuits are present, and the insulation resistance measurement has passed. All supply conductors can be connected in parallel with poly-phase equipment during the alternative method measurement.

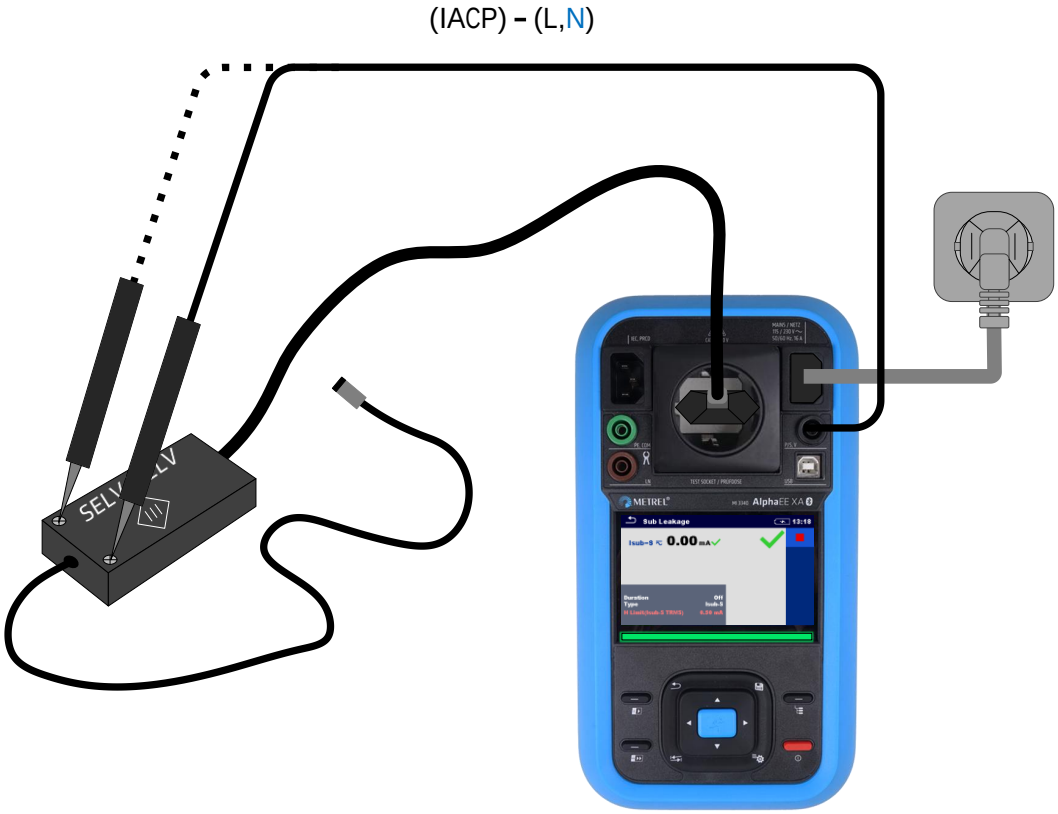


Figure 203_Touch leakage current alternative method

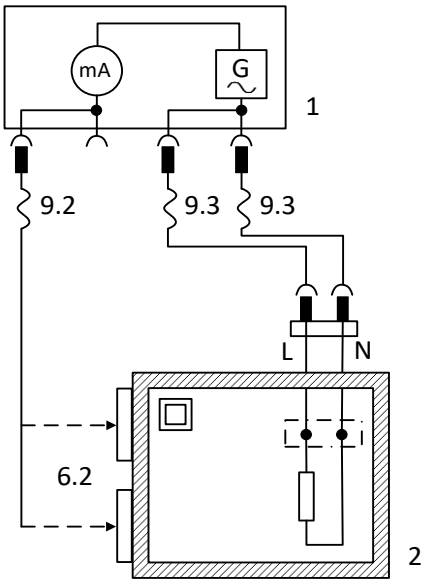


Figure 204_Touch leakage current alternative method

Note!

The alternative method shall not be used in the following cases:

- Presence of voltage-dependent switches.
- Use of switched power supplies.

In case of any doubt, use the direct method or the residual current method.

Direct method results can be distorted in case of any contact between the DUT with earthed equipment (such as water pipes or data lines).

Measuring function: Touch Leakage (direct method), Sub-S Leakage “Isub-S” (alternative method).

Test: Touch leakage current
Limit: ≤ 0,5 mA

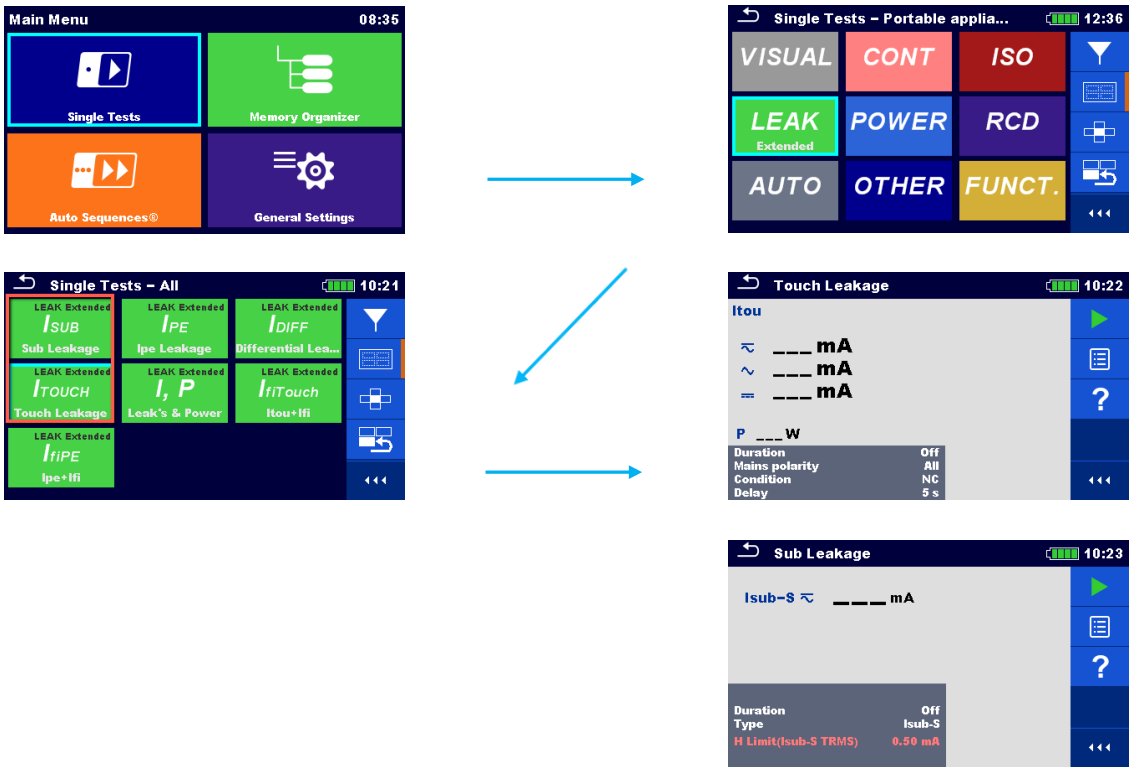


Figure 205_Touch Leakage setup

SELV/PELV Voltage test

Compliance with the requirements for the SELV/PELV protective measure shall be confirmed by measuring the output voltage, if the output is accessible as specified in section List of Applicable test & Limits.

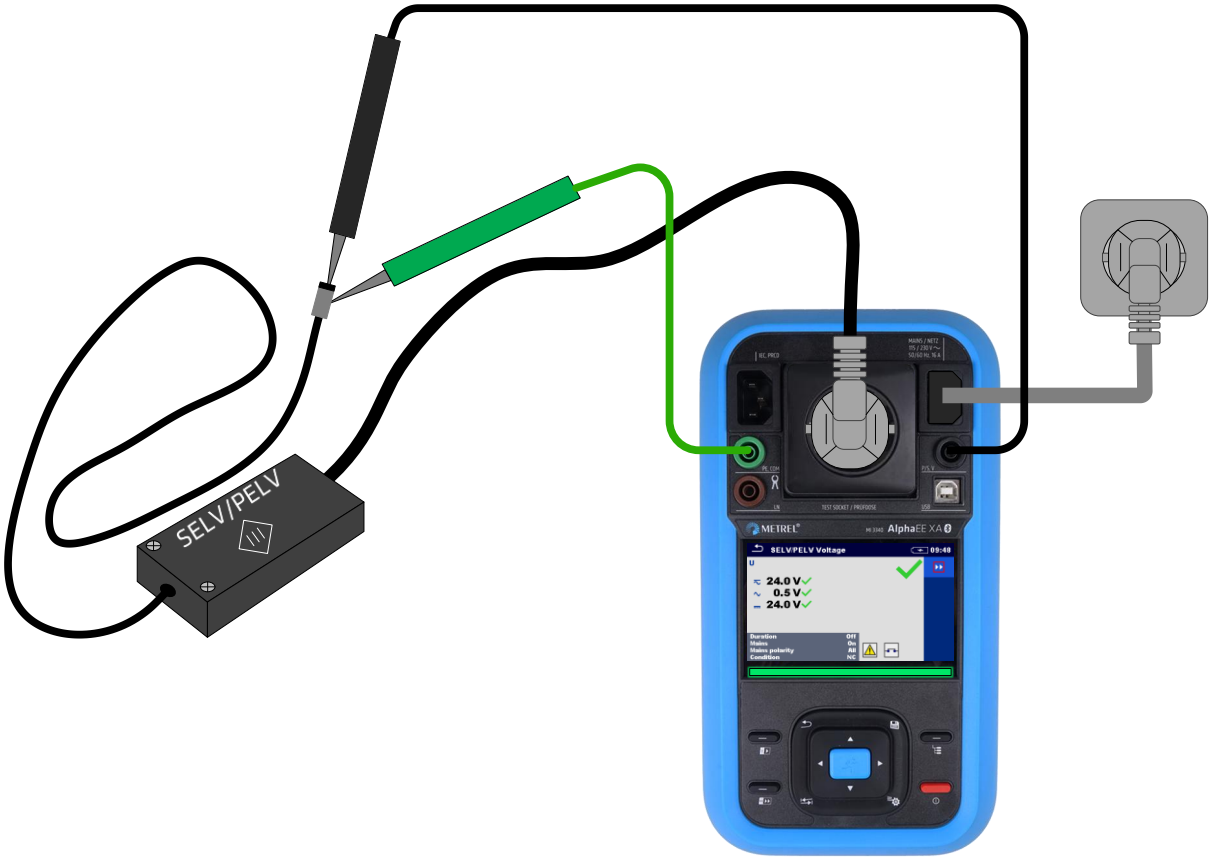


Figure 206_Functional inspection (SELV/PELV) voltage test

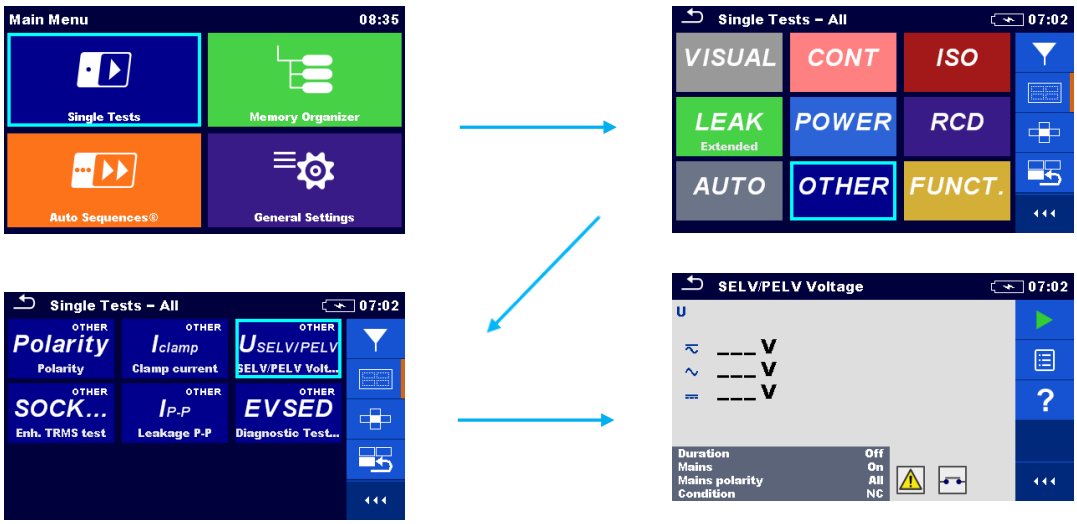


Figure 207_SELV/PELV Voltage test setup

Functional inspection

To complete the safety test procedure, a functional test should be carried out. The manufacturer's recommendations shall then be considered.

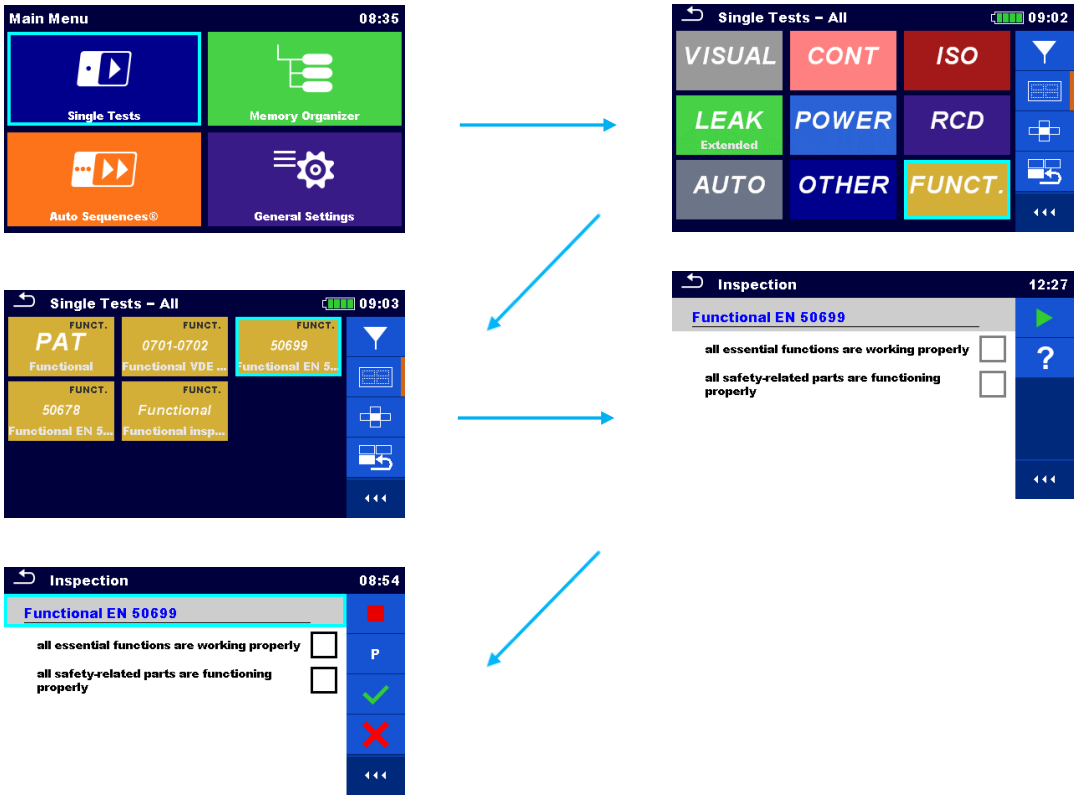


Figure 208_Functional inspection setup

Measurement procedure

Connect the Electrical equipment instrument test socket, select the correct measuring function (Functional inspection), start the test and tick the correct statuses. Power can be applied to the device under test to check correct operation and consumption.