MARTINDALE

ET4000, ET4500

Multifunction Installation Testers

Instruction manual

MARTINDALE ELECTRIC

ALWAYS READ THESE INSTRUCTIONS BEFORE PROCEEDING

Thank you for buying one of our products. For safety and a full understanding of its benefits please read this manual before use. Technical support is available from 01923 441717 and support@martindale-electric.co.uk.

Table of contents

1 Safety information

REMEMBER: SAFETY IS NO ACCIDENT

These instructions contain both information and warnings that are necessary for the safe operation and maintenance of this product. It is recommended that you read the instructions carefully and ensure that the contents are fully understood. Failure to understand and to comply with the warnings and instructions can result in serious injury, damage or even death.

Particular attention should be paid to the Warnings, Precautions and Technical Specifications.

Please keep these instructions for future reference. Updated instructions and product information are available at: www.martindale-electric.co.uk

1.1 Meaning of symbols and markings

Caution - risk of danger and refer to instructions

Caution - risk of electric shock

Equipment protected by double or reinforced insulation (Class II)

Do not use in distribution systems with voltages higher than 550V.

CAT II **(Measurement Category II)** is applicable to test and measuring equipment connected directly to utilization points (socket outlets and similar points) of the low-voltage MAINS installation.

CAT III **(Measurement Category III)** is applicable to test and measuring equipment connected to the distribution part of the building's low-voltage MAINS installation.

CAT IV **(Measurement Category IV)** is applicable to test and measuring equipment connected at the source of the building's low-voltage MAINS installation.

For further information on measurement categories refer to appendix B or visit www.martindale-electric.co.uk/measurement_categories.php

Equipment complies with relevant EU Directives

End of life disposal of this equipment should be in accordance with relevant EU Directives.

1.2 Precautions

This product has been designed with your safety in mind, but please pay attention to the following warnings and cautions before use.

Warnings

- **In order to avoid the danger of electrical shock, it is important that proper safety measures are taken when working with voltages exceeding 30V AC rms, 42V AC peak or 60V DC.**
- **Where applicable other safety measures such as the use of protective gloves, goggles etc. should be employed.**
- **The instrument must only be used by a skilled and competent person who is familiar with the relevant regulations, the safety risks involved and the consequent normal safe working practices.**
- **If the test equipment is used in a manner not specified in this user manual, the protection provided by the equipment could be impaired.**
- **Before each use the instrument and any associated test leads and accessories should be examined for damage, cracks, cuts or scratches. DO NOT USE if damaged in any way.**
- **Make sure the instrument and any associated test leads are dry, clean and free from dust, grease and moisture while in use to avoid the danger from electric shock due to surface leakage.**
- **Do not use the instrument in AC supply systems with voltages higher than 550 Va.c.**
- **If the removable probe tip caps are not fitted to the probes of the test leads or the TL180 test probe, their measurement category becomes CAT II 1000V, and they must not be used on CAT III or CAT IV installations to avoid the risk of shorting high energy circuits and arc flash.**
- **When this unit is used in combination with test leads, the measurement category of the combination is the lower measurement category of either this unit or the test leads used. Likewise if test lead accessories such as crocodile clips are also used, the measurement category will be the lowest measurement category in that combination.**
- **The test probe TEST button does not connect/disconnect the probe tip to/from the 3 pin plug of the test probe.**
- **Do not use if the battery compartment cover is not fitted.**
- **When using test leads / crocodile clips, always keep your fingers behind the finger guard on the test lead probe or crocodile clip.**
- **Test leads and any test lead accessories must be properly seated and firmly connected before use.**

Cautions

- **Avoid severe mechanical shock or vibration and extreme temperature.**
- **When using test leads avoid excessive stresses to the cable entry points at the probe and 4mm plug connector.**
- **To avoid possible corrosion from leaking batteries, remove the batteries if discharged, or when the unit is not in use for an extended period.**
- **The ET4000 and ET4500 come supplied with rechargeable NiMH batteries. The batteries should only be replaced with the same type as defined on the battery compartment label or as described in this manual.**
- **If the ET4000 or ET4500 is to be fitted with alkaline batteries, only fit the same type as defined on the battery compartment label or as described in this manual.**
- **Do not connect the charging adapter to the instrument if alkaline batteries are fitted, as they may explode.**

2 Introduction

2.1 Inspection

Examine the shipping carton for any sign of damage. Inspect the unit and any accessories for damage. If there is any damage then consult your distributor immediately.

2.2 Description

The Martindale ET4000 and ET4500 are professional multifunction hand-held test instruments designed to perform the measurements required for testing of low voltage a.c. electrical installations.

The following measurements and tests can be performed:

- Voltage and frequency
- Phase sequence
- Continuity tests
- Insulation resistance tests
- RCD testing
- Fault loop / RCD non trip impedance measurements
- Line impedance and voltage drop
- Earth resistance tests (ET4500 only)

The graphic display with backlight provides a clear view of results, indications, measurement parameters and messages. Two LED PASS/FAIL indicators are placed at the sides of the LCD.

2.3 Accessories

2.3.1 Supplied with the ET4000

- Soft carrying bag
- Soft carrying neck belt
- Set of carrying straps
- TL180 - test probe
- TL207 - 13A plug to 3x4mm connector mains
- TL36 - test lead set
- RS232 - PS/2 cable (only used for firmware upgrade)
- 6 x 1.2V AA rechargeable Ni-MH batteries and PSUPD230 mains charger
- CD containing full instruction manual and ET-link PC software (*ET-link PC software is only useable with the ET4500*)
- Short instruction manual
- Verification certificate

2.3.2 Supplied with the ET4500

- Soft carrying bag
- Soft carrying neck belt
- Set of carrying straps
- TL180 - test probe
- TL207 - 13A plug to 3x4mm connector mains
- TL36 - test lead set
- RS232 - PS/2 cable
- USB cable
- 6 x 1.2V AA rechargeable Ni-MH batteries
- PSUPD230 - Battery charging adaptor
- CD containing full instruction manual and ET-link PC software
- Short instruction manual
- Verification certificate

2.3.3 Optional accessories

- ER2KIT/S - Earth test lead set with two earth spikes
- TL78 - 50m earth wire test lead
- TL54 - Fused test lead set
- CB12 - Calibration checkbox
- SB13 - Safebreak socket test adaptor
- ETLink PRO - PC software with Amendment 3 Certification
- T10 - T80 Amendment 3 Certification Pads

3 Instrument description

3.1 Front panel

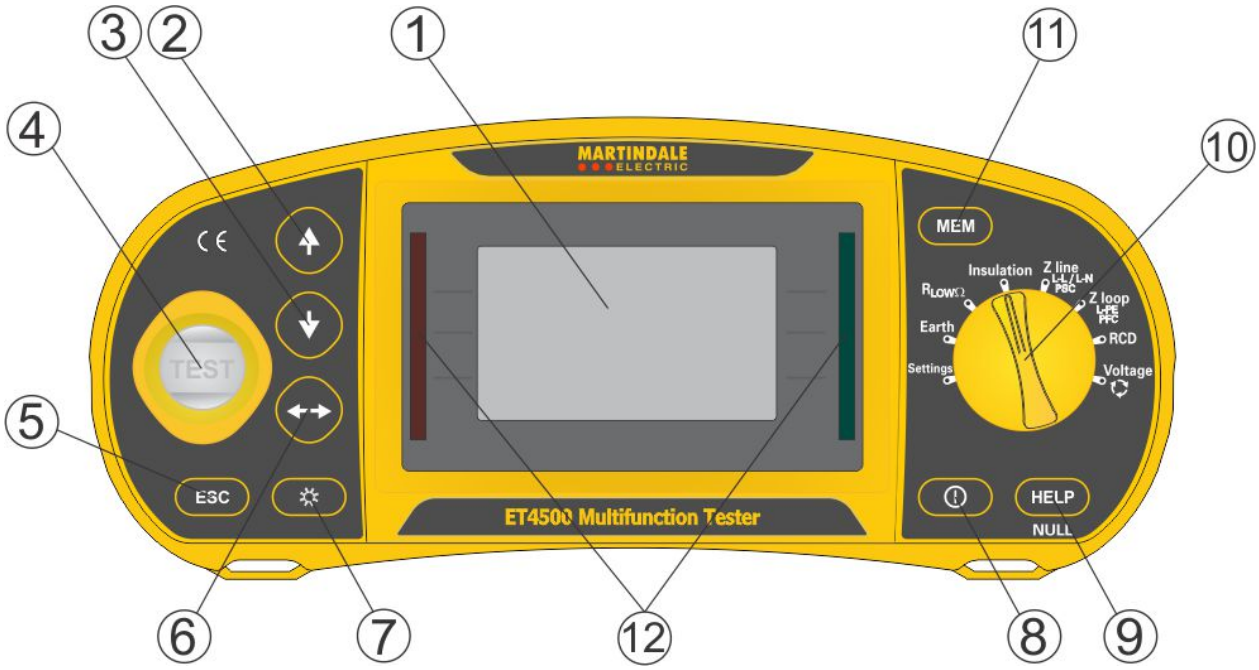


Figure 3.1: Front panel

Legend:

1	**LCD**	128 x 64 dot matrix display with backlight.	
2	**UP**	Modifies selected parameter.	
3	**DOWN**		
4	**TEST**	TEST	Starts measurements. Also acts as the PE touching electrode.
5	**ESC**	Goes one level back.	
6	**TAB**	Selects the parameters in selected function.	
7	**Backlight, Contrast**	Changes backlight level and contrast.	
8	**ON / OFF**	Switches the instrument power on or off. The instrument automatically turns off 15 minutes after the last key press.	
9	**HELP / NULL**	Accesses help menus. Nulls test leads in Continuity functions.	
		Starts Z_{REF} measurement in Voltage drop sub-function.	
10	**Function selector switch**	Selects test / measurement function and settings.	
11	**MEM**	Stores to / recalls from instrument memory (ET4500 only). No function (ET4000).	
12	**Green LED's** **Red LED's**	Indicates test PASSES. Indicates test FAILS. The PASS / FAIL indication is only enabled when a limit is set.	

3.2 Connector panel

Figure 3.2: Connector panel

1	**Test terminals**	L / L1 (H) terminal
2		N / L2 (E) terminal
3		PE / L3 (S) terminal
4	**TL180 probe inputs**	Test inputs from TL180 test probe
5	**Charger socket**	
6	**PS/2 connector**	Communication with PC serial port (For firmware upgrade only on ET4000).
7	**USB connector**	Communication with PC USB (1.1) port (ET4500 only).
8	**Protective cover**	Restricts access to the charger and comms ports when testing

Warnings!

- Maximum allowed voltage between any test terminal and ground is 600 V.
- Maximum allowed voltage between test terminals on test connector is 550 V.
- Maximum short-term voltage of external charging adapter is 14 V.

3.3 Instrument rear

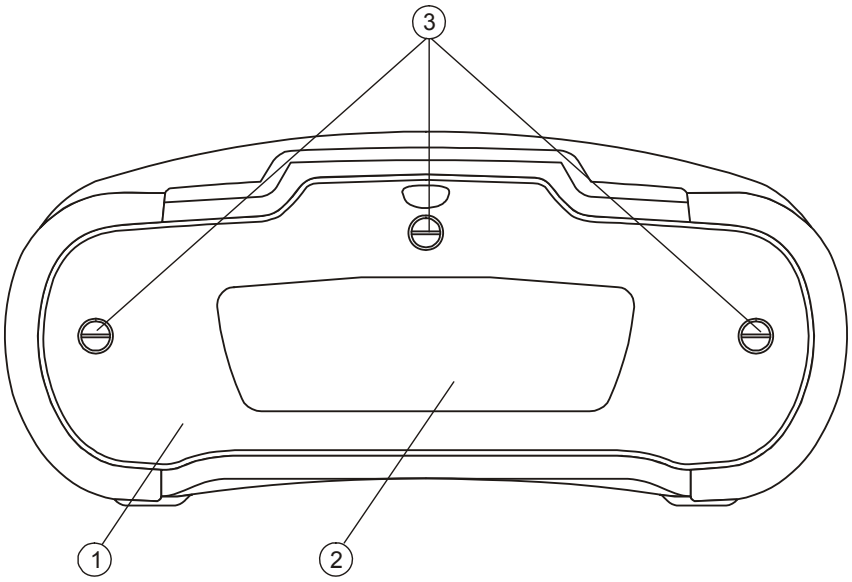


Figure 3.3: Back panel

Legend:

1	**Battery / fuse compartment cover**
2	**Back panel information label**
3	**Fixing screws for battery / fuse compartment cover**

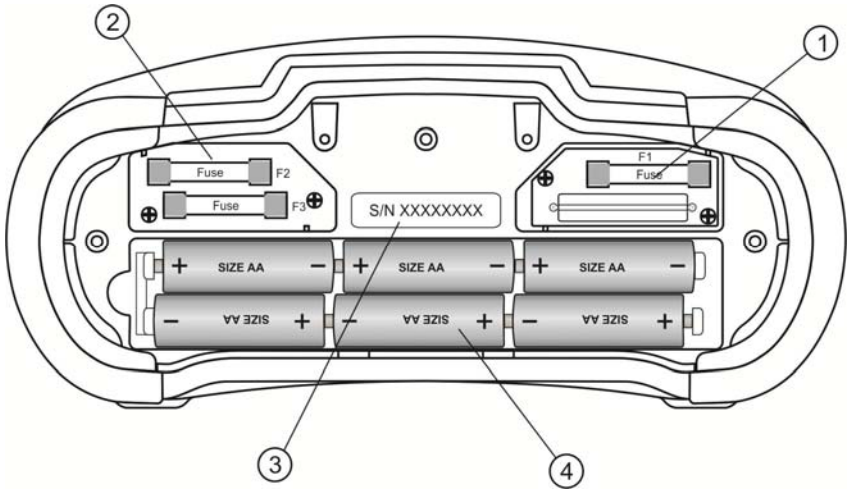


Figure 3.4: Battery and fuse compartment

Legend:

1	**Fuse F1**	M 315 mA / 250 V
2	**Fuses F2 and F3**	F 4 A / 500 V (breaking capacity 50 kA)
3	**Serial number label**	
4	**Batteries**	Size AA, alkaline / rechargeable NiMH

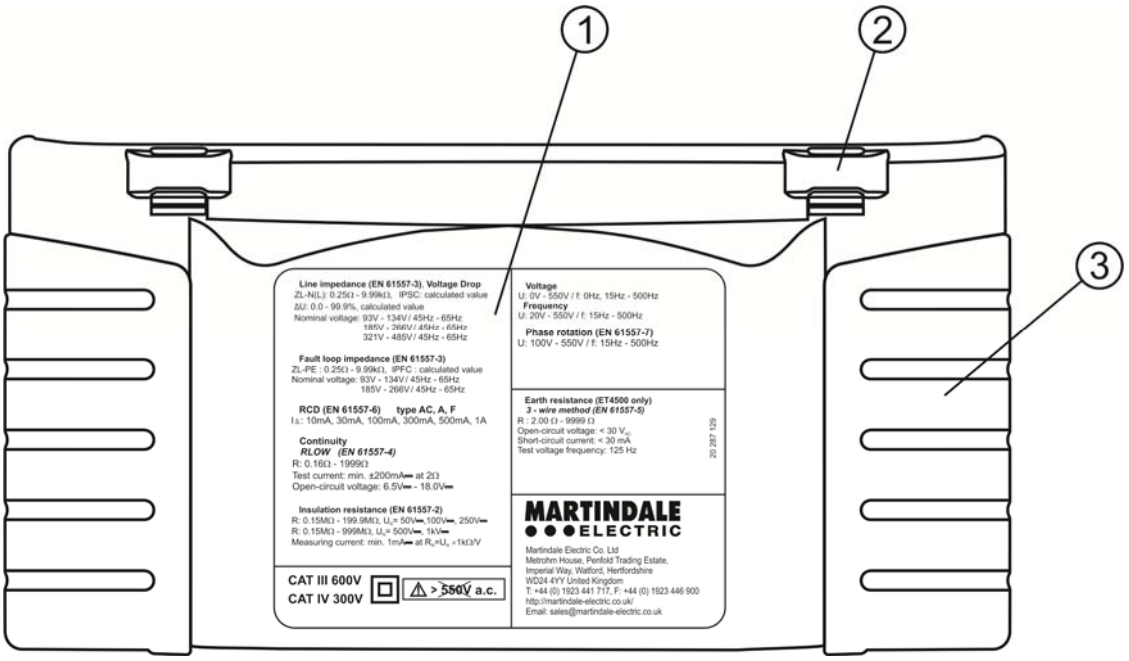


Figure 3.5: Bottom

Legend:

1	**Bottom information label**
2	**Carrying strap loops**
3	**Side handles**

3.4 Carrying the instrument

With the carrying strap supplied, various possibilities for carrying the instrument are available. Operators can choose the appropriate one. See the following examples:

		The instrument hangs around the operators neck – quick placing and removal.

	The instrument can be used even when inside the soft carrying bag – test cables are connected to the instrument through the front opening.

3.4.1 Attaching the carrying strap

You can choose between two methods:

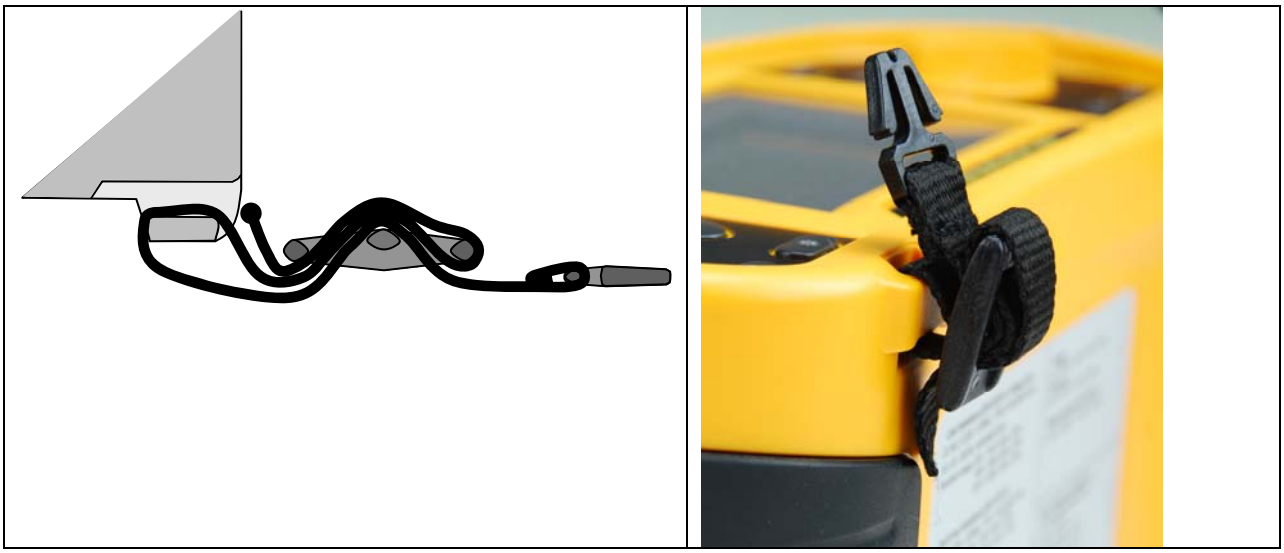


Figure 3.6: First method

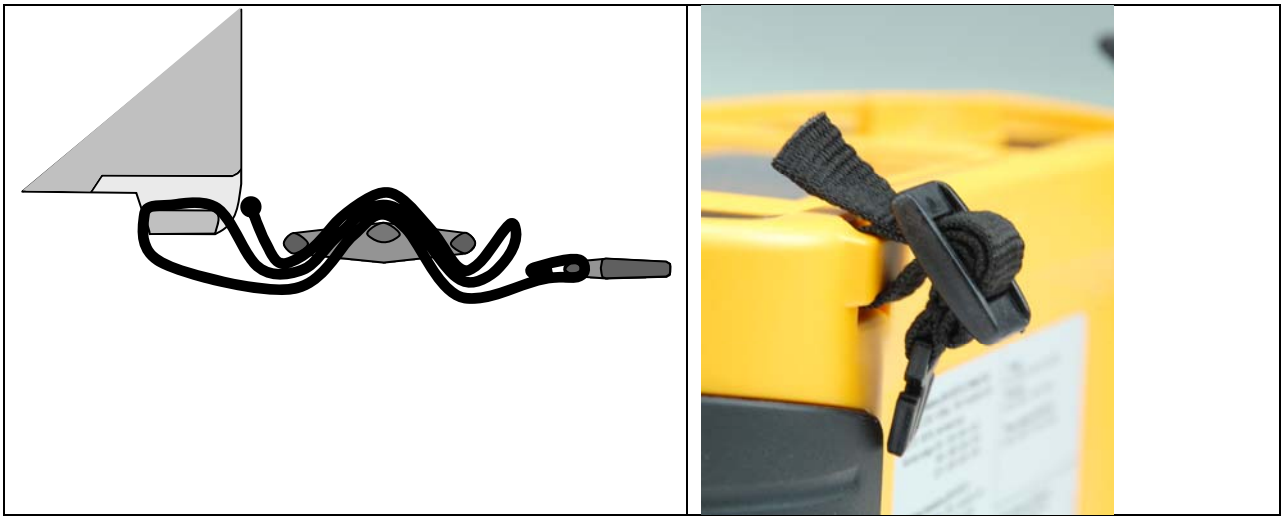


Figure 3.7: Alternative method

Please perform a periodical check of the attachment.

4 Instrument operation

4.1 Batteries and charging

The instrument uses six AA size alkaline or rechargeable Ni-MH batteries. The nominal operating time specified is for batteries with a nominal capacity of 2100 mAh. The battery condition is always displayed in the lower right corner of the display. If the batteries are too weak the instrument indicates this as shown in *Figure 4.1*. This indication appears for a few seconds and then the instrument turns itself off.

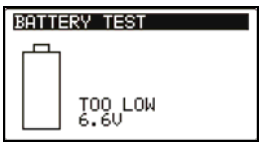


Figure 4.4.1: Discharged battery indication

The batteries are charged whenever the battery charging adapter is connected to the instrument. The charging adapter socket polarity is shown in *Figure 4.2*. Internal circuitry controls the charging and assures maximum battery lifetime.

Figure 4.4.2: Power supply socket polarity

Symbols:

	Indication of battery charging

Figure 4.4.3: Charging indication

Warnings related to safety:

- When connected to an installation, the instrument's battery compartment can contain hazardous voltages! When replacing batteries or before opening the battery compartment cover, always disconnect any test leads or measuring accessories and turn off the instrument.
- Ensure that the batteries are inserted correctly, otherwise the instrument will not operate and the batteries could become discharged.
- Do not recharge alkaline battery cells.
- Use only the PSUPD230 battery charging adapter supplied with the instrument.

Notes:

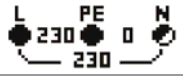
- The charger in the instrument is a pack cell charger. This means that the battery cells are connected in series during charging. The batteries have to be similar (same charge condition, same type and age).
- If the instrument is not to be used for a long period of time, remove all batteries from the battery compartment.

- Alkaline or rechargeable Ni-MH batteries (size AA) can be used in the ET4000 and ET4500. Martindale recommends only using rechargeable batteries with a capacity of 2100mAh or above.
- Unpredictable chemical processes can occur during the charging of batteries that have been left unused for a long period (more than 6 months). In this case it is recommended to repeat the charge / discharge cycle at least 2-4 times.
- If no improvement is achieved after several charge / discharge cycles, then each battery should be checked by comparing battery voltages. It is very likely that not all of the batteries have deteriorated. One bad battery can cause poor performance of the entire battery pack.
- The effects described above should not be confused with the normal decrease of battery capacity over time. Batteries also loses some capacity when repeatedly charged / discharged.

4.2 Display and audible indication

4.2.1 Terminal voltage monitor

The terminal voltage monitor constantly displays the voltages between the test terminals and shows which test terminals are active for the measurement function selected (see examples below).

	Online voltages are displayed together with test terminal indication. All three test terminals are used for the selected measurement.
	Online voltages are displayed together with test terminal indication. L and N test terminals are used for the selected measurement.
	L and PE are active test terminals; N terminal should also be connected for correct input voltage condition.
	Polarity of test voltage applied to the output terminals, L and N.

4.2.2 Battery indication

The battery indication indicates the charge condition of the batteries and the connection of an external charger.

	Battery capacity indication.
	Low batteries. Batteries are too weak to guarantee correct results. Replace or recharge the batteries.
	Charging in progress (if charging adapter is connected).

4.2.3 Messages

In the message field warnings and messages are displayed.

	Measurement is in progress, refer to any displayed warnings.
	Conditions on the input terminals allow starting the measurement; consider other displayed warnings and messages.
	Test button is inhibited. Conditions on the input terminals are not correct. Refer to displayed warnings and messages.
	RCD tripped-out during the measurement (in RCD functions).
	Instrument has overheated. The measurement is unavailable until the temperature decreases below the allowed limit.
	Result(s) can be stored. (ET4500 only)
	High electrical noise was detected during measurement. Results may be impaired.
	L and N are reversed.
	**Warning!** High voltage is applied to the test terminals.
	**Warning!** Dangerous voltage on the PE test terminal! Stop the activity immediately and eliminate the fault / connection problem before proceeding with any further activity. Such maintenance should only be carried out by a competent electrician who is familiar with the relevant regulations, the safety risks involved and the consequent normal safe working practices.
	Test lead resistance for Continuity measurements has not been nulled.
	Test lead resistance is compensated for in Continuity measurements.
	High resistance to earth of test probes. Results may be impaired.
	Measured signal is out of range (clipped). Results are impaired.
	Fuse F1 is broken.

4.2.4 Results

	Measurement result is inside pre-set limits (PASS).
	Measurement result is outside pre-set limits (FAIL).
	Measurement is aborted. Refer to displayed warnings and messages.

4.2.5 Audible warnings

Continuous sound	**Warning!** Dangerous voltage on the PE terminal is detected.

4.2.6 Help screens

HELP	Opens help screen.

Help menus are available in all functions. The Help menu contains schematic diagrams illustrating how to correctly connect the instrument to an electrical installation. After selecting the measurement you want to perform, press the HELP key in order to view the associated Help menu.

Keys in help menu:

UP / DOWN	Selects next / previous help screen.
ESC / HELP / Function selector switch	Exits help menu.

Figure 4.4: Examples of help screens

4.2.7 Backlight and contrast adjustments

The BACKLIGHT key is used to adjust the backlight and contrast.

Click	Toggles backlight intensity level.
Keep pressed for **1 s**	Locks high intensity backlight level until power is turned off or the key is pressed again.
Keep pressed for **2 s**	Bargraph for LCD contrast adjustment is displayed.

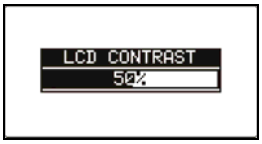


Figure 4.5: Contrast adjustment menu

Keys for contrast adjustment:

DOWN	Reduces contrast.
UP	Increases contrast.
TEST	Saves contrast setting.
ESC	Exits without changes.

4.3 Function selection

For selecting test/measurement function and entering the settings menu use the **FUNCTION SELECTOR SWITCH**.

Function selector switch and keys:

Function selector switch	Selects test / measurement function, enters settings menu and selects auto-test mode.
UP / DOWN	Selects sub-function in selected measurement function.
TAB	Selects the test parameter to be set or modified.
TEST	Runs selected test / measurement function.
MEM	Stores measured results / recalls stored results. (ET4500 only)
ESC	Exits back to main menu.

Keys in **test parameter** field:

UP / DOWN	Changes the selected parameter.
TAB	Selects the next measuring parameter.
Function selector switch	Toggles between the main functions.
MEM	Stores measured results / recalls stored results. (ET4500 only)

General rule regarding enabling **parameters** for evaluation of measurement / test result:

Parameter	**OFF**	No limit values, indication: _ _ _.
	ON	**Value(s)** – results will be marked as PASS or FAIL in accordance with selected limit.

Measurements for more information about the operation of the instrument test functions, see chapter ***5***.

4.4 Settings

Different instrument options can be set in the SETTINGS menu.

Options are:

- recalling and clearing stored results (ET4500 only),
- setting the date and time,
- selecting reference standard for RCD tests,
- entering Z factor,
- setting the instrument to factory default.

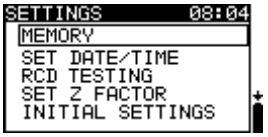


Figure 4.6: Options in Settings menu

Keys:

UP / DOWN	Selects appropriate option.
TEST	Enters selected option.
Function selector switch	Exits back to selected test / measurement function without changes.

4.4.1 Memory (ET 4500 only)

In this menu the stored data can be recalled or deleted. See chapter 6 **Data handling** for more information.

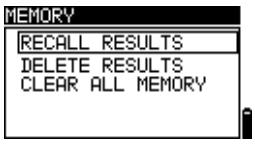


Figure 4.7: Memory options

Keys:

UP / DOWN	Selects option.
TEST	Enters selected option.
ESC	Exits back to settings menu.
Function selector switch	Exits back to selected test / measurement function without changes.

4.4.2 Date and time

In this menu the date and time can be set.

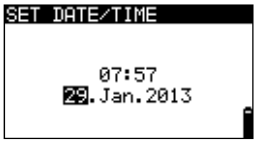


Figure 4.8: Setting date and time

Keys:

TAB	Selects the field to be changed.
UP / DOWN	Modifies selected field.
TEST	Confirms new date / time and exits.
ESC	Exits back to settings menu.
Function selector switch	Exits back to selected test / measurement function without changes.

Note:

- If the batteries are removed for more than 1 minute the set date and time will be lost. Saved test results are not lost.

4.4.3 RCD testing

In this menu the standard used for RCD tests can be set.

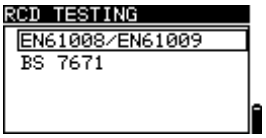


Figure 4.9: Selection of RCD test standard

Keys:

UP / DOWN	Selects standard.
TEST	Confirms selected standard.
ESC	Exits back to settings menu.
Function selector switch	Exits back to selected test / measurement function without changes.

Maximum RCD disconnection times differ in various standards.
The trip-out times defined in individual standards are listed below.

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

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

Trip-out times according to BS 7671:

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

Maximum test times related to selected test current for general (non-delayed) RCD

Standard	½×$I_{\Delta N}$	$I_{\Delta N}$	2×$I_{\Delta N}$	5×$I_{\Delta N}$
EN 61008 / EN 61009	300 ms	300 ms	150 ms	40 ms
BS 7671	2000 ms	300 ms	150 ms	40 ms

Maximum test times related to selected test current for selective (time-delayed) RCD

Standard	½×$I_{\Delta N}$	$I_{\Delta N}$	2×$I_{\Delta N}$	5×$I_{\Delta N}$
EN 61008 / EN 61009	500 ms	500 ms	200 ms	150 ms
BS 7671	2000 ms	500 ms	200 ms	150 ms

Note:

- Trip-out limit times for PRCD, PRCD-K and PRCD-S are equal to General (non-delayed) RCDs.

4.4.4 Z factor

In this menu the Z factor can be set to 0.80 or 1.00.

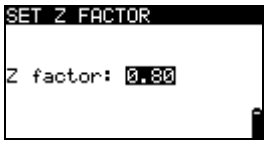


Figure 4.10: Selection of Z factor

Keys:

UP / DOWN	Sets Z value.
TEST	Confirms Z value.
ESC	Exits back to settings menu.
Function selector switch	Exits back to selected test / measurement function without changes.

The impedance limit values for different overcurrent protective devices can be scaled down by a factor 0,8 (Z factor). This means that the fault current will still be high enough at increased conductor temperatures and low supply voltages. This assures safe operation of the overcurrent protection device in all conditions.

See Appendix A ***Impedance tables*** for lists of the impedance limit values for the various overcurrent protection devices.

4.4.5 Initial settings

In this menu the instrument settings, measurement parameters and limits can be set to initial (factory) values.

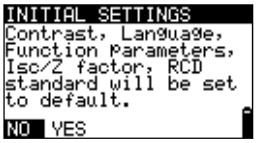


Figure 4.11: Initial settings dialogue

Keys:

UP / DOWN	Selects option [YES, NO].
TEST	Restores default settings (if YES is selected).
ESC	Exits back to settings menu.
Function selector switch	Exits back to selected test / measurement function without changes.

Warnings:

- Customized settings will be lost when this option is used.
- If the batteries are removed for more than 1 minute the custom made settings will be lost.

The default setup is listed below:

Instrument setting	**Default value**
Contrast	As defined and stored by adjustment procedure
Z factor	0.80
RCD standards	BS 7671

Function Sub-function	**Parameters / limit value**
EARTH RE (ET4500 only)	No limit
R ISO	L / E No limit Utest = 500 V
Low Ohm Resistance R LOWΩ, r_1, r_n, r_2, R1+R2, R2, R1+RN, CONTINUITY	 No limit No limit, sound OFF
Z - LINE VOLTAGE DROP	Fuse type: none selected ΔU: 4.0 % Z_{REF}: _.__ Ω (not set)
Z - LOOP	Fuse type: none selected
Zs rcd	Fuse type: none selected
RCD	RCD t

	Nominal differential current: $I_{\Delta N}$=30 mA RCD type: AC, non-delayed Test current starting polarity:  (0°) Limit contact voltage: 50 V Current multiplier: ×1

Note:

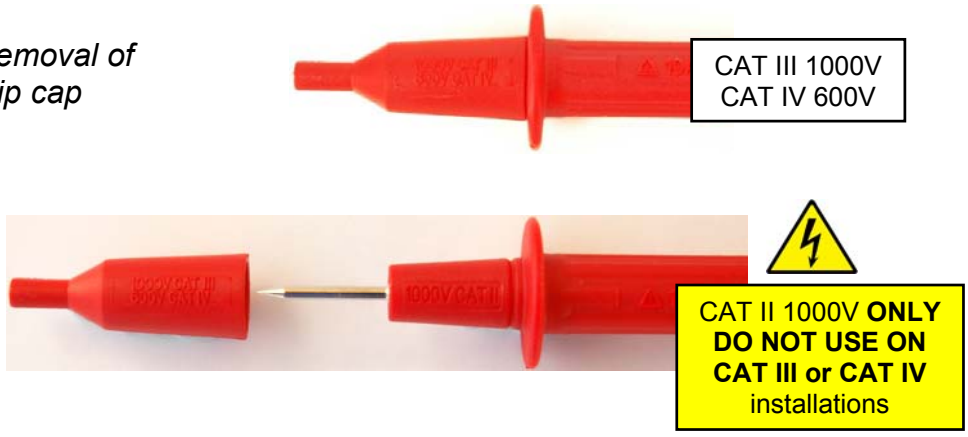
- Initial settings (reset of the instrument) can also be recalled by pressing the TAB key while the instrument is switched on.

4.5 Use of test leads and probes

4.5.1 TL36 test leads

Where access to test points may require extended probe tips, the probe tip caps may be removed by gently pulling them forward until they unclip from the probe body.

Figure 4.12: Removal of the probe tip cap



If crocodile clips are to be used, remove the test probe, if fitted, from the 4mm plug by pulling it forward, then push the crocodile clip onto the 4mm plug.

Figure 4.13: Fitting crocodile clips

4.5.2 TL207 test lead

In order to avoid the danger of electrical shock, **DO NOT** connect the 4mm plugs of this test lead to test probes, crocodile clips or any other object where live mains may become accessible.

The 4mm plugs of this test lead **MUST ONLY** be connected to the test equipment they are intended to be used with.

4.5.3 TL180 test probe

The TL180 test probe allows the operator to start a test / measurement by pressing the TEST button on the test probe rather than the TEST key on the instrument front panel.

Note:- The TL180 test button does not have the PE test touch terminal functionality of the front panel TEST key (see chapter *5.8 PE test touch terminal*).

Where access to test points may require extended probe tips, the probe tip caps may be removed by gently pulling them forward until they unclip from the probe body.

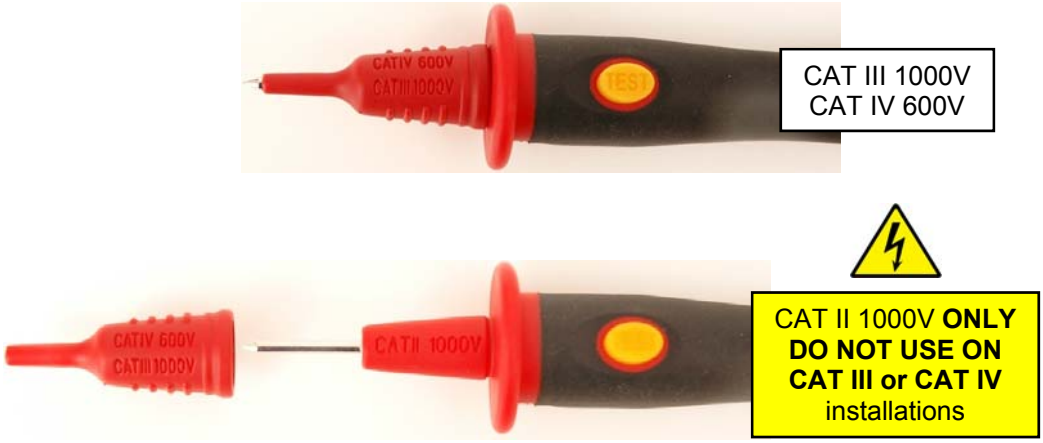


Figure 4.13: Removal of the TL180 probe tip cap

5 Measurements

5.1 Voltage, frequency and phase sequence

Voltage and frequency measurement is always active in the terminal voltage monitor. In the special ***VOLTAGE TRMS function*** the measured voltage, frequency and information about any detected three-phase connection can be stored. Three-phase measurements conform to BS EN 61557-7.

See chapter ***4.3 Function selection*** for instructions on key functionality.

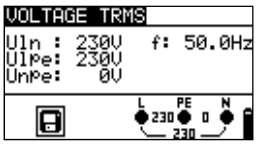


Figure 5.1: Voltage in a single phase system

Connections for voltage measurement

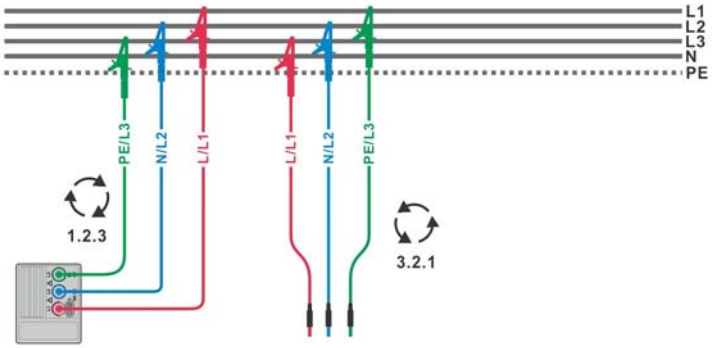


Figure 5.2: Connections of test leads in a three-phase system

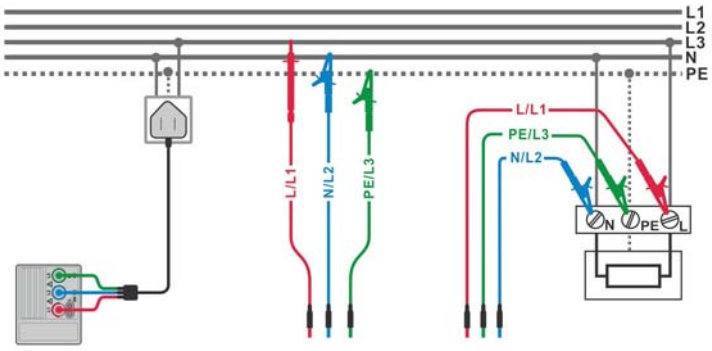


Figure 5.3: Connection of plug test cable and test leads in a single-phase system

Voltage measurement procedure

- Select the VOLTAGE TRMS function using the function selector switch.
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the wiring or socket to be tested (see *Figure 5.2* and *Figure 5.3*).
- **Store** voltage measurement results, if required, by pressing the **MEM** key (ET4500 only).

Measurement starts immediately after selection of the VOLTAGE TRMS function.

Figure 5.4: Examples of voltage measurement in a three-phase system

Displayed results for a single phase system:

UIn .....voltage between phase and neutral conductors
UIpe .....voltage between phase and protective conductors
Unpe .....voltage between neutral and protective conductors
f.....frequency

Displayed results for a three-phase system:

U12.....voltage between phases L1 and L2
U13.....voltage between phases L1 and L3
U23.....voltage between phases L2 and L3
1.2.3 .....correct connection – clockwise rotation sequence
3.2.1 .....incorrect connection – anticlockwise rotation sequence
f.....frequency

Testing considerations

- When only two of the three test terminals are connected to the electrical installation under test, only the voltage indication between those two terminals is correct.

5.2 Insulation resistance

Insulation resistance measurements are performed to ensure safety against electric shock through poor insulation. Typical applications are:

- insulation resistance between conductors of an installation,
- insulation resistance of non-conductive rooms (walls and floors),
- insulation resistance of ground cables and
- resistance of semi-conductive (antistatic) floors.

Four insulation resistance sub-functions are available:

- ISO L/E,
- ISO L/N,
- ISO L/L and
- ISO N/E.

The insulation resistance tests are carried out in the same way regardless which sub-function is selected. However it is important to select the appropriate sub-function in order to correctly classify the measurement when entering it into the required verification documents (Electrical Installation Certificate, Periodic Inspection Report etc.).

Please pay attention to the following warnings when performing insulation measurements:

- Insulation resistance measurements **must only** be performed on de-energized circuits and equipment.
- Do not touch the circuit or equipment under test during the measurement or before it has fully discharged.
- When an insulation resistance measurement has been performed on a capacitive circuit or equipment, automatic discharge may not be immediate. The warning message  and the actual voltage are displayed during discharge until the voltage drops below 30 V.
- Do not connect the test terminals to an external voltage higher than 550 V (AC or DC) or damage to the instrument may result.

See chapter ***4.3 Function selection*** for instructions on key functionality.

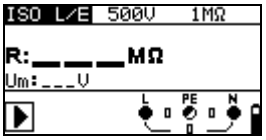


Figure 5.5: Insulation resistance

Test parameters for insulation resistance measurement

Test	**Sub-function** [ISO L/E, ISO L/N, ISO L/L, ISO N/E]
Uiso	**Nominal test voltage** [50 V, 100 V, 250 V, 500 V, 1000 V]
Limit	**Setting range** [OFF, 0.01 MΩ - 200 MΩ]

Test circuits for insulation resistance

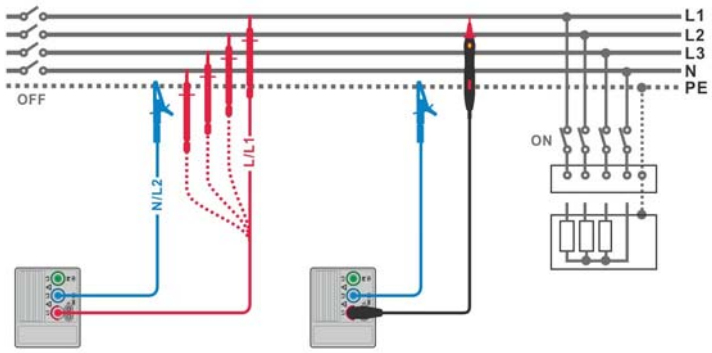


Figure 5.6: Connection of test leads and TL180 test probe

Insulation resistance measuring procedure

- Select the Insulation function using the function selector switch.
- Set sub-function to ISO L/E ISO L/N, ISO L/L, or ISO N/E using **UP / DOWN** keys.
- Set the required **test voltage**.
- Enable and set the **limit** value (optional).
- **Disconnect** the installation to be tested from the mains supply (and discharge the installation if required).
- **Connect** the test leads to the instrument and then to the installation wiring to be tested (see *Figure 5.6*).
- Press the **TEST** key to perform the measurement (double click for continuous measurement and later press once to stop the measurement).
- After the measurement has finished wait until the tested installation has fully discharged.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

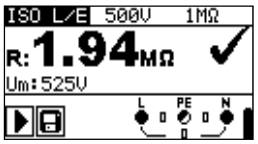


Figure 5.7: Example of insulation resistance measurement result

Displayed results:

R.....insulation resistance
Um .....test voltage (measured value)

Testing considerations

- If a voltage of higher than 30 V (AC or DC) is detected between the test terminals, the insulation resistance measurement will not be performed.
- The instrument automatically discharges the circuit or equipment under test after the measurement has finished.

5.3 Resistance of earth connection and equipotential bonding

The resistance measurement is performed to ensure the protective measures against electric shock through earth connections and bonding are effective. The following continuity sub-functions are available:

- r1
- rN
- r2
- R1+R2
- R2
- R1+RN
- R LOWΩ
- Continuity.

It is important to select the appropriate sub-function in order to correctly classify the measurement when entering it into the required verification documents (Electrical Installation Certificate, Periodic Inspection Report etc.). The r1, rN, r2, R1+R2 and R2 continuity tests are carried out between the L and PE terminals in the same way regardless of which sub-function is selected. The R1+RN, R LOWΩ and Continuity tests are carried out between the L and N terminals.

These measurements **must only** be performed on de-energized circuits and equipment!

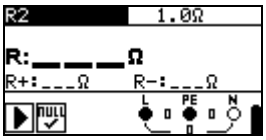


Figure 5.8: R2 continuity

See chapter ***4.3 Function selection*** for instructions on key functionality.

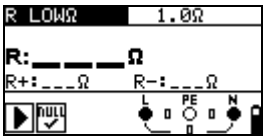


Figure 5.9: 200 mA RLOW Ω

Test parameters for resistance measurement

Test	**Resistance measurement sub-function** [r1, rN, r2, R1+R2, R2, R1+RN, R LOWΩ, CONTINUITY]
Limit	**Setting range** [OFF, 0.1 Ω - 20.0 Ω]

Additional test parameter for **Continuity sub-function**

	Buzzer On (sounds if resistance is lower than the set limit value)

Additional key:

HELP	*Click*	Nulls test leads in Continuity functions.
	Keep pressed for 1s	Enters Help screen

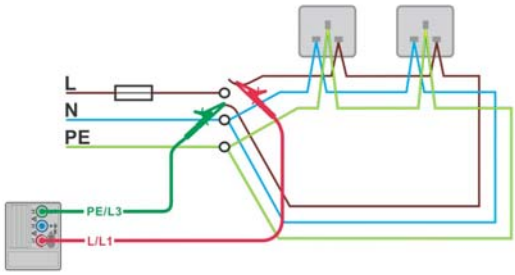
Testing considerations

- Parallel loops may influence the test results.
- If a voltage higher than 10 V (AC or DC) is detected between the test terminals, the continuity resistance test will be prevented.
- Null test lead resistance before performing a continuity measurement, where necessary.

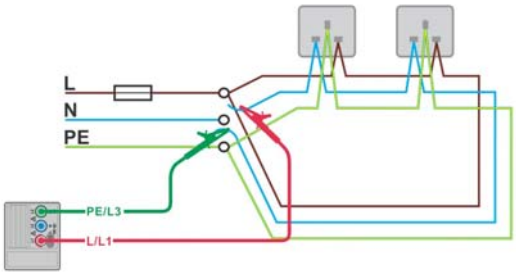
5.3.1 Continuous resistance measurement

The continuity measurements are performed with automatic polarity reversal of the test voltage in accordance with BS EN 61557-4.

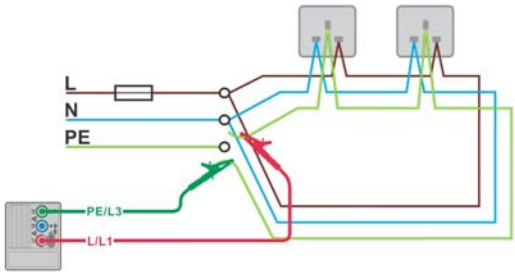
Test circuits for continuity measurements



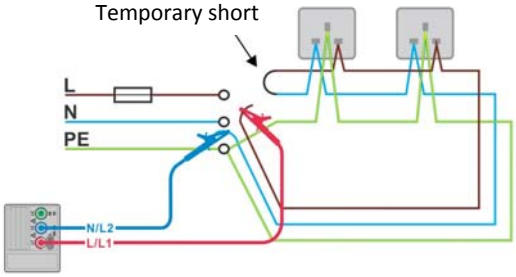
r1 – line continuity



rN – neutral continuity

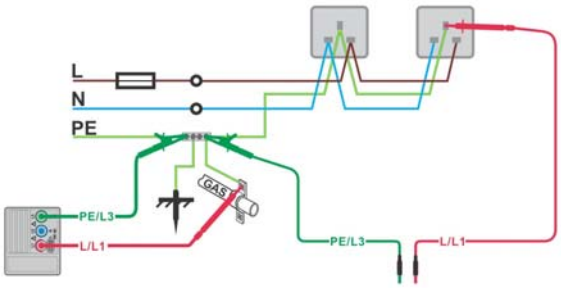


r2 – circuit protective conductor (cpc) continuity

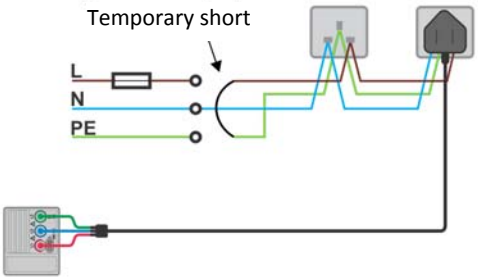


R1+RN – line and neutral continuity

Figure 5.10: Connections for testing the r1, rN, r2 and R1+RN sections of the wiring in ring circuits



R2 – circuit protective conductor (cpc) continuity



R1+R2 – line and cpc continuity

Figure 5.11: Connections for testing the R2 and R1+R2 sections of the wiring in final circuits

Continuity measurement procedure

- Select $R_{LOW\Omega}$ function using the function selector switch.
- Set sub-function to (r1, rN, r2, R1+R2, R2 or R1+RN) with **UP / DOWN** keys.
- Enable and set the limit (optional).
- **Connect** the test leads to the instrument.
- **Null** the test lead resistance if required (see section *5.3.4 Nulling of test lead resistance)*.
- **Disconnect** the installation to be tested from the mains supply.
- **Connect** the test leads to the installation wiring to be tested (see *Figure 5.10* and *Figure 5.11*: *)*.
- Press the **TEST** key to perform the measurement.
- After the measurement has finished **store** the result, if required, by pressing the **MEM** key (ET4500 only).

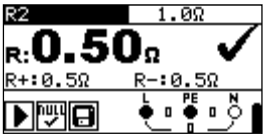


Figure 5.12: Example of continuity result

Displayed result:

R.....continuity resistance
R+ .....result for positive test polarity
R- .....result for negative test polarity

5.3.2 R LOWΩ, 200 mA resistance measurement

The resistance measurement is performed with automatic polarity reversal of the test voltage.

R LOWΩ measurement procedure

- Select $R_{LOW\Omega}$ function using the function selector switch.
- Set sub-function to R LOWΩ with **UP / DOWN** keys.
- Enable and set the **limit** (optional).
- **Connect** the test leads to the instrument.
- **Null** the test lead resistance if required (see section *5.3.4 Nulling of test lead resistance).*
- **Disconnect** from the mains supply and discharge the installation to be tested.
- **Connect** the test leads to the PE wiring to be tested.
- Press the **TEST** key to perform the measurement.
- After the measurement has finished **store** the result, if required, by pressing the **MEM** key (ET4500 only).

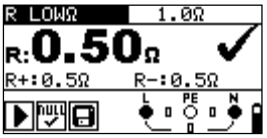


Figure 5.13: Example of RLOW result

Displayed result:

R.....R LOWΩ resistance
R+ .....result for positive test polarity
R- .....result for negative test polarity

5.3.3 Continuous low current resistance measurement

This function serves as a standard ohmmeter with a low test current. The measurement is performed continuously without polarity reversal. This function can also be used for testing the continuity of inductive components.

Test circuit for continuous resistance measurement

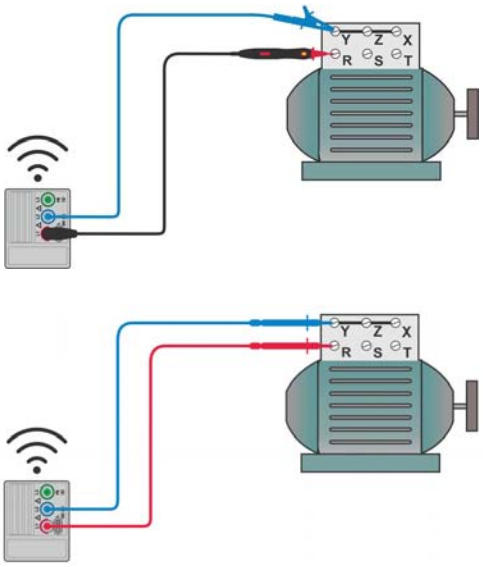


Figure 5.14: TL180 and test lead connections

Continuous resistance measurement procedure

- Select CONTINUITY function using the function selector switch.
- Set sub-function CONTINUITY with **UP / DOWN** keys.
- Enable and set the **limit** (optional).
- **Connect** the test leads to the instrument.
- **Null** the test lead resistance if required (see section *5.3.4 Nulling of test lead resistance*).
- **Disconnect** from the mains supply and discharge the item to be tested.
- **Connect** the test leads to the item under test (see *Figure 5.14*:).
- Press the **TEST** key to begin the continuous measurement.
- Press the **TEST** key to stop measurement.
- After the measurement has finished **store** the result, if required, by pressing the **MEM** key (ET4500 only).

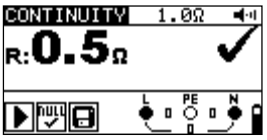


Figure 5.15: Example of continuous resistance measurement

Displayed result:

R.....resistance

5.3.4 Nulling of test lead resistance

This chapter describes how to null the test lead resistance for the continuity function. Compensation is required to remove the test lead resistance and the internal resistances of the instrument from the measured resistance. This lead compensation is therefore very important in order to obtain correct results. There are two separate calibration values:

- one for r1, rN, r2, R1+R2 and R2,
- one for R1+RN, R LOWΩ and CONTINUITY.

The 

symbol is displayed in the Continuity message fields if the nulling was successful.

Circuits for compensating the resistance of the test leads

Figure 5.16a

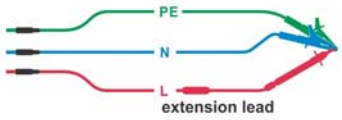


Figure 5.17b

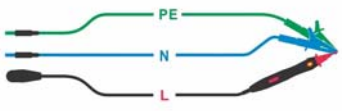


Figure 5.18c

Nulling of test lead resistance procedure

- Select the CONTINUITY function using the function selector switch.
- **Connect** the test leads to the instrument and short the test leads together using the Martindale shorting bar as shown (see Figures 5.16a, 5.16b and 5.16c).
- Press the **NULL** key to perform the test lead nulling.
- If the leads were successfully compensated the resistance with the old compensation data is displayed first and 0.00 Ω afterwards.

Figure 5.19: Results with old (left) and new (right) compensation values

Notes:

- The highest value for lead compensation is 5 Ω. If the resistance is higher the compensation value is set back to the default value.
- Symbol 

is displayed if no compensation value is stored.

5.4 Testing RCDs

Various tests and measurements are required for the verification of RCD's in RCD protected installations. The measurements conform to BS EN 61557-6.
The following measurements and tests (sub-functions) can be performed:

- contact voltage,
- trip-out time,
- trip-out current and
- RCD autotest.

See chapter ***4.3 Function selection*** for instructions on key functionality.

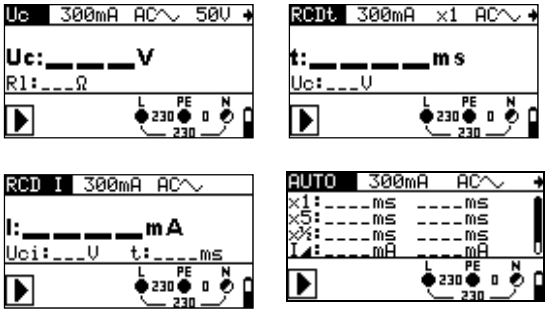


Figure 5.20: RCD tests

Test parameters for RCD test and measurement

TEST	**RCD sub-function test** [Uc, RCDt, RCD I, AUTO]
$I_{\square N}$	**Rated RCD residual current sensitivity $I_{\Delta N}$** [10 mA, 30 mA, 100 mA, 300 mA, 500 mA, 1000 mA].
type	**RCD type** [AC, A, F]. **starting polarity** [∿,∿,⌒,⌒]. **Characteristic and PRCD selection** [selective S, general non-delayed □].
MUL	**Multiplication factor for test current** [½, 1, 2, 5 $I_{\Delta N}$].
Ulim	**Conventional touch voltage limit** [25 V, 50 V].

Connections for testing RCD's

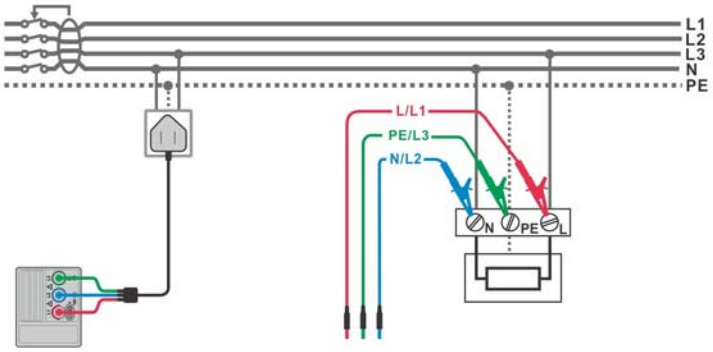


Figure 5.21: Connecting the plug test cable and test leads

5.4.1 Contact voltage (RCD Uc)

A current flowing into the PE terminal causes a voltage drop on the earth resistance, i.e. a voltage difference between the PE equipotential bonding circuit and earth. This voltage difference is called contact voltage and is present on all accessible conductive parts connected to the PE. It must always be lower than the conventional safety limit voltage.
The contact voltage is measured with a test current lower than ½ $I_{\Delta N}$ to avoid trip-out of the RCD and then normalized to the rated $I_{\Delta N}$.

Contact voltage measurement procedure

- Select the RCD function using the function selector switch.
- Set sub-function to Uc using **UP / DOWN** keys.
- Set test **parameters** (if required).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the wiring of the RCD to be tested (see *Figure 5.21*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

The contact voltage result relates to the rated nominal residual current of the RCD and is multiplied by an appropriate factor (depending on RCD type and type of test current). The 1.05 factor is applied to give a margin of error to take tolerances into consideration. See *Table 5.1* for detailed contact voltage calculation factors.

RCD type		Contact voltage Uc proportional to	Rated $I_{\Delta N}$
AC	⎍	$1.05\times I_{\Delta N}$	any
AC	S	$2\times1.05\times I_{\Delta N}$	
A, F	⎍	$1.4\times1.05\times I_{\Delta N}$	≥ 30 mA
A, F	S	$2\times1.4\times1.05\times I_{\Delta N}$	
A, F	⎍	$2\times1.05\times I_{\Delta N}$	< 30 mA
A, F	S	$2\times2\times1.05\times I_{\Delta N}$	

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

Loop resistance is indicative and calculated from the Uc result (without additional proportional factors) as follows: $R_L = \frac{U_C}{I_{\Delta N}}$.

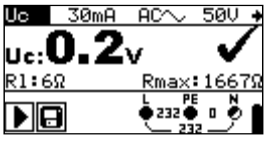


Figure 5.22: Example of contact voltage measurement results

Displayed results:

Uc..... contact voltage
Rl..... fault loop resistance
Rmax ..... Maximum earth fault loop resistance value according to BS 7671

5.4.2 Trip-out time (RCDt)

Trip-out time measurement verifies the sensitivity of the RCD at different residual currents.

Trip-out time measurement procedure

- Select the RCD function using the function selector switch.
- Set sub-function to RCDt using **UP / DOWN** keys.
- Set test **parameters** (if required).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the wiring of the RCD to be tested (see *Figure 5.21*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if requred, by pressing the **MEM** key (ET4500 only).

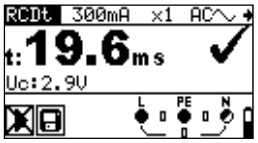


Figure 5.23: Example of trip-out time measurement results

Displayed results:

t.....trip-out time

Uc.....contact voltage for rated $I_{\Delta N}$

5.4.3 Trip-out current (RCD I)

A continuously rising residual current is used for testing the threshold sensitivity of RCD trip-out. The instrument increases the test current in small steps through the appropriate range as follows:

RCD type	Slope range		Waveform	Notes
	Start value	End value		
AC	$0.2\times I_{\Delta N}$	$1.1\times I_{\Delta N}$	Sine	All models
A, F ($I_{\Delta N} \geq 30$ mA)	$0.2\times I_{\Delta N}$	$1.5\times I_{\Delta N}$	Pulsed	
A, F ($I_{\Delta N} = 10$ mA)	$0.2\times I_{\Delta N}$	$2.2\times I_{\Delta N}$		

Maximum test current is I_{Δ} (trip-out current) or the end value when the RCD does not trip-out.

Trip-out current measurement procedure

- Select the RCD function using the function selector switch.
- Set sub-function to RCD I using **UP / DOWN** keys.
- Set test **parameters** (if necessary).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the wiring of the RCD to be tested (see *Figure 5.21*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

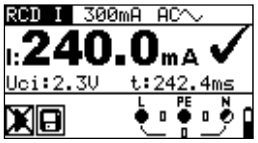


Figure 5.24: Trip-out current measurement result example

Displayed results:

I.....trip-out current
Uci.....contact voltage at trip-out current I or the end value when the RCD does not trip
t.....trip-out time

Testing considerations

- Parameters set in one function are also kept for other RCD functions.
- The measurement of contact voltage does not normally trip an RCD. However, the trip limit of the RCD may be exceeded as a result of leakage current flowing to the PE protective conductor or a capacitive connection between the L and PE conductors.
- RCD trip-out time and RCD trip-out current measurements will only be performed if the contact voltage in the pre-test at nominal differential current is lower than the set contact voltage limit.
- Ulim can be selected in the Uc sub-function only.
- Selective (time-delayed) RCDs have delayed response characteristics. As the contact voltage pre-test or other RCD tests influence time delayed RCD's it takes some time to return to normal state. Therefore a time delay of 30 s is inserted before performing a trip-out test by default.

5.4.4 RCD Autotest

The RCD autotest function is intended to perform a complete RCD test (trip-out time at different residual currents, trip-out current and contact voltage) in one set of automatic tests, controlled by the instrument.

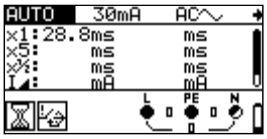
Additional key:

HELP	*Click*	Toggles between top and bottom part of results field.
	Keep pressed for 1s	Enters Help screen

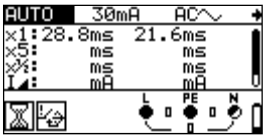
RCD autotest procedure

RCD Autotest steps	**Notes**
❑ Select the RCD function using the function selector Switch. ❑ Set sub-function to AUTO using **UP / DOWN** keys. ❑ Set test **parameters** (if necessary). ❑ **Connect** the test cable to the instrument. ❑ **Connect** the test leads to the wiring of the RCD to be tested (see *Figure 5.21*). ❑ Press the **TEST** key to perform the test.	Start of test
❑ Test with $I_{\Delta N}$, 0° (step 1).	RCD should trip-out
❑ **Re-activate RCD**. ❑ Test with $I_{\Delta N}$, 180° (step 2).	RCD should trip-out
❑ **Re-activate RCD**. ❑ Test with $5\times I_{\Delta N}$, 0° (step 3).	RCD should trip-out
❑ **Re-activate RCD**. ❑ Test with $5\times I_{\Delta N}$, 180° (step 4).	RCD should trip-out
❑ **Re-activate RCD**. ❑ Test with $½\times I_{\Delta N}$, 0° (step 5). ❑ Test with $½\times I_{\Delta N}$, 180° (step 6).	RCD should not trip-out RCD should not trip-out
❑ Trip-out current test, 0° (step 7).	RCD should trip-out
❑ **Re-activate RCD**. ❑ Trip-out current test, 180° (step 8).	RCD should trip-out
❑ **Re-activate RCD**. ❑ **Store** the result, if required, by pressing the **MEM** key (ET4500 only).	End of test

Result examples:



Step 1



Step 2

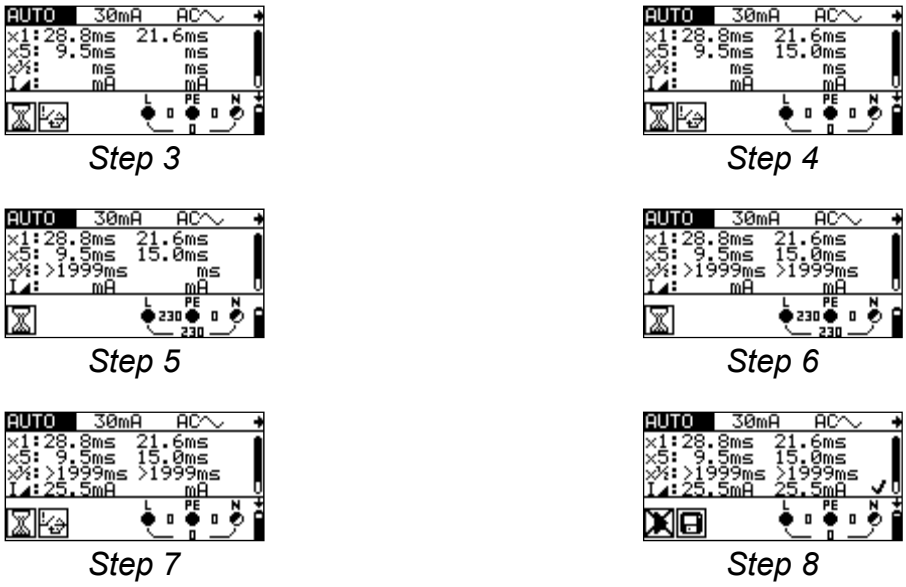


Figure 5.25: Individual steps in RCD autotest

Figure 5.26: Two parts of result field in RCD autotest

Displayed results:

x1 .....step 1 trip-out time (I_Δ=$I_{\Delta N}$, 0º)
x1 .....step 2 trip-out time (I_Δ=$I_{\Delta N}$, 180º)
x5 .....step 3 trip-out time (I_Δ=5×$I_{\Delta N}$, 0º)
x5 .....step 4 trip-out time (I_Δ=5×$I_{\Delta N}$, 180º)
x½ .....step 5 trip-out time (I_Δ=½×$I_{\Delta N}$, 0º)
x½ .....step 6 trip-out time (I_Δ=½×$I_{\Delta N}$, 180º)
I◢ .....step 7 trip-out current (0º)
I◢ .....step 8 trip-out current (180º)
Uc.....contact voltage for rated $I_{\Delta N}$

Notes:

- The autotest sequence is immediately stopped if any incorrect condition is detected, e.g. excessive Uc or trip-out time out of bounds.
- The auto test finishes without the x5 tests when testing RCD types A and F with rated residual currents of $I_{\square N}$ = 300 mA, 500 mA, and 1000 mA. In this case the auto test result passes if all other results pass, and the indications for x5 are omitted.
- Tests for sensitivity (I◢,, steps 7 and 8) are omitted for selective type RCD's.
- The autotest sequence (RCD AUTO function) stops when the trip-out time is outside the allowable time period.

5.5 Fault loop impedance and prospective fault current

Fault loop is a loop comprised of the mains source, line wiring and the PE path back to the mains source. The instrument measures the impedance of the loop and calculates the short circuit current. The measurements conform to BS EN 61557-3.

See chapter ***4.3 Function selection*** for instructions on key functionality.

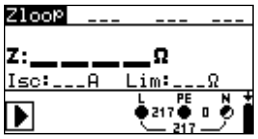


Figure 5.27: Fault loop impedance

Test parameters for fault loop impedance measurement

Test	Selection of **fault loop impedance sub-function** [Zloop, Zs rcd]
Fuse type	Selection of **fuse type** [---, BS88-2, BS3036, BS88-3, BS1362, B, C, D]
Fuse I	**Rated current** of selected fuse
Fuse T	**Maximum breaking time** of selected fuse
Lim	**Upper limit fault loop impedance value** for selected fuse

See Appendix A for reference fuse data.

Circuits for measurement of fault loop impedance

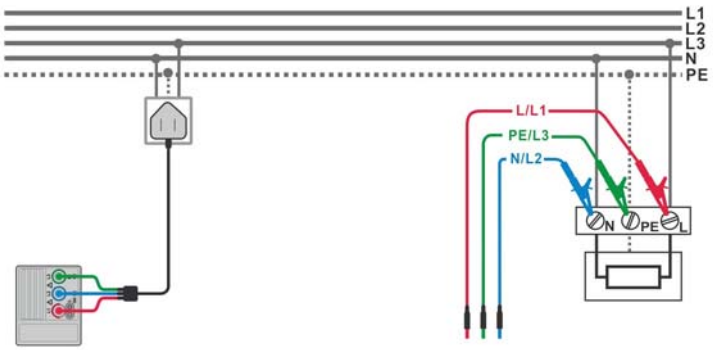


Figure 5.28: Connection for measurement of fault loop impedance

Fault loop impedance measurement procedure

- Select the Zloop function using the function selector switch.
- Set sub-function to Zloop or Zs rcd using **UP / DOWN** keys.
- Select test **parameters** (optional).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the installation wiring to be tested (see *Figure 5.21* and *Figure 5.28*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

Figure 5.29: Examples of loop impedance measurement result

Displayed results:

Z.....fault loop impedance
Isc.....prospective fault current
Lim.....upper limit fault loop impedance value

Prospective fault current I_{PFC} is calculated from the measured impedance as follows:

$$I_{PFC} = \frac{U_N}{Z_{L-PE} \cdot scaling\_factor}$$

where:
Un ..... Nominal $U_{L\text{-}PE}$ voltage (see table below),
Scaling factor.....Impedance correction factor (see chapter *4.4.4 Z factor*).

U_n	Input voltage range (L-PE)
110 V	(93 V ≤ $U_{L\text{-}PE}$ ≤ 134 V)
230 V	(185 V ≤ $U_{L\text{-}PE}$ ≤ 266 V)

Testing considerations

- Large fluctuations of mains voltage can influence the measurement results (the noise sign is displayed in the message field). In this case it is recommended that the measurements are repeated a few times to check if the readings are stable.
- The **Zloop** measurement will trip-out the RCD in RCD-protected electrical installations.
- Select the **Zs rcd** (non-trip) measurement to prevent trip-out of RCD's in RCD protected installations.
- The measurement of fault loop impedance using the **Zs rcd** (non-trip) function does not normally trip an RCD. However, the trip limit may be exceeded if a leakage current flows to the PE protective conductor or if there is a capacitive connection between the L and PE conductors.

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

5.6 Line impedance and prospective short-circuit current / Voltage drop

Line impedance is a loop comprising of the mains voltage source and line wiring. The measurements conform to BS EN 61557-3.
The voltage drop sub-function is intended to check that a voltage in the installation stays above acceptable levels if the highest current is flowing in the circuit. The highest current is defined as the nominal current of the circuit's fuse.

Sub-functions:

- Z LINE - Line impedance
- ΔU – Voltage drop measurement

See chapter ***4.3 Function selection*** for instructions on key functionality.

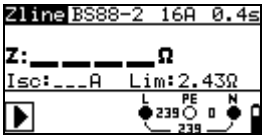


Figure 5.30: Line impedance

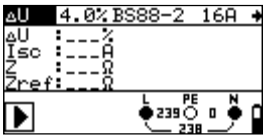


Figure 5.31: Voltage drop

Test parameters for line impedance measurement

Test	Selection of **line impedance** [Zline] or **voltage drop** [ΔU] **sub-function**
FUSE type	Selection of **fuse type** [---, BS88-2, BS3036, BS88-3, BS1362, B, C, D]
FUSE I	**Rated current** of selected fuse
FUSE T	**Maximum breaking time** of selected fuse
Lim	**Upper limit line impedance value** for selected fuse

See Appendix A for reference fuse data.

Additional test parameters for voltage drop measurement

ΔU_{MAX}	**Maximum voltage drop** [3.0 % - 9.0 %].

Additional key:

HELP / CAL	*Click*	Measures Zref value for ΔU function.
	Keep pressed for 1s	Enters Help screen.

5.6.1 Line impedance and prospective short circuit current

Circuits for measurement of line impedance

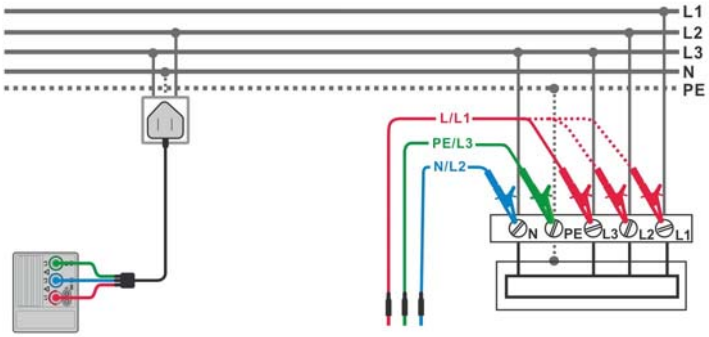


Figure 5.32: Phase-neutral or phase-phase line impedance measurement

Line impedance measurement procedure

- Select the Z LINE function using the function selector switch.
- Set sub-function to Zline using **UP / DOWN** keys.
- Select test **parameters** (optional).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the installation wiring to be tested (see *Figure 5.32*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

Figure 5.33: Examples of line impedance measurement result

Displayed results:

Z.....line impedance
Isc.....prospective short-circuit current
Lim.....upper limit line impedance value

Prospective fault current I_{PFC} is calculated from the measured impedance as follows:

$$I_{PFC} = \frac{U_N}{Z_{L-N(L)} \cdot scaling\_factor}$$

where:
Un ..... Nominal U_{L-N} or U_{L1-L2} voltage (see table below),
Scaling factor..... Impedance correction factor (see chapter *4.4.4 Z factor*).

U_n	Input voltage range (L-N or L1-L2)
110 V	(93 V ≤ U_{L-N} < 134 V)
230 V	(185 V ≤ U_{L-N} ≤ 266 V)
400 V	(321 V < U_{L-L} ≤ 485 V)

Testing considerations

- Large fluctuations of mains voltage can influence the measurement results (the noise sign is displayed in the message field). In this case it is recommended that the measurements are repeated a few times to check if the readings are stable.
- When measuring $Z_{Line-Line}$ with the instrument test leads PE and N connected together the instrument will display a warning of a dangerous PE voltage. The measurement will be performed anyway.
- The specified accuracy of the tested parameters is valid only if the mains voltage is stable during the measurement.

5.6.2 Voltage drop

The voltage drop is calculated and is based on the difference between the line impedance at the connection point (sockets) and the line impedance at the reference point (usually at the switchboard).

Circuits for measurement of voltage drop

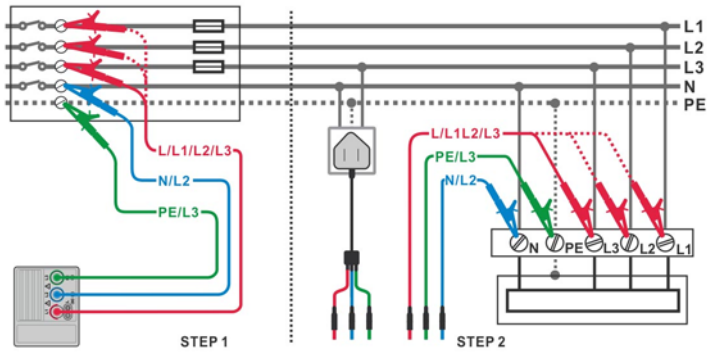


Figure 5.34: Phase-neutral or phase-phase voltage drop measurement

Voltage drop measurement procedure

Step 1: Measuring the impedance Zref at the origin

- Select the Z LINE function using the function selector switch.
- Set sub-function to ΔU using **UP / DOWN** keys.
- Select test **parameters** (optional).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the origin of the electrical installation (see Step 1 of *Figure 5.33*).
- Press the **NULL** key to perform the measurement.

Step 2: Measuring the voltage drop

- Set sub-function to **ΔU** using **UP / DOWN** keys.
- Select test **parameters** (Fuse type must be selected).
- **Connect** the test leads to the instrument.
- **Connect** the test leads to the point in the wiring or socket to be tested (see Step 2 of *Figure 5.33*).
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key (ET4500 only).

Step 1 - Zref *Step 2 - Voltage drop*

Figure 5.35: Examples of voltage drop measurement result

Displayed results:

ΔU .....voltage drop
Isc .....prospective short-circuit current
Z.....line impedance at measured point
Zref .....reference impedance

Voltage drop is calculated as follows:

$$\Delta U[\%] = \frac{(Z - Z_{REF}) \cdot I_N}{U_N} \cdot 100$$

where:
ΔU.....calculated voltage drop
Z .....impedance at test point
Z_{REF}.....impedance at reference point
I_N.....rated current of selected fuse
U_N .....nominal voltage (see table below)

U_n	Input voltage range (L-N or L1-L2)
110 V	(93 V ≤ U_{L-N} < 134 V)
230 V	(185 V ≤ U_{L-N} ≤ 266 V)
400 V	(321 V < U_{L-L} ≤ 485 V)

Testing considerations

- If the reference impedance is not set the value of Z_{REF} is considered as 0.00 Ω.
- The Z_{REF} is cleared (set to 0.00 Ω) by pressing the NULL key while the instrument is not connected to a voltage source.

- I_{SC} is calculated as described in chapter 5.6.1 Line impedance and prospective short circuit current.
- If the measured voltage is outside the ranges described in the table above the ΔU result will not be calculated.
- Large fluctuations of mains voltage can influence the measurement results (the noise sign  is displayed in the message field). In this case it is recommended that the measurements are repeated a few times to check if the readings are stable.
- The specified accuracy of the tested parameters is valid only if the mains voltage is stable during the measurement.

5.7 Earth resistance (ET4500 only)

Earth resistance is one of the most important parameters for protection against electric shock. Mains earthing arrangements, lightning systems, local earthing, etc can be verified with the earth resistance test. The measurements conforms to BS EN 61557-5.

The Earth resistance function uses a 3-wire earth resistance test method for standard earth resistance tests with two earthing rods.

Earth resistance measurements **must only** be performed on de-energized circuits.

See chapter ***4.3 Function selection*** for instructions on key functionality.

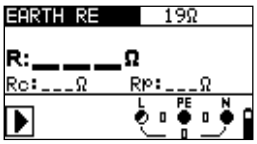


Figure 5.36: Earth resistance

Test parameters for earth resistance measurement

Test	**Test configuration** [EARTH RE]
Limit	**Setting range** [OFF, 1 Ω - 5 kΩ]

Earth resistance measurement procedure

- Select EARTH function using the function selector switch.
- Enable and set **limit** value (optional).
- **Connect** the test leads to the instrument.
- **Connect** the **E** test lead to the earth to be tested and the **H** and **S** test leads to the earth spikes (see *Figure 5.37 and Figure 5.38).*
- Press the **TEST** key to perform the measurement.
- **Store** the result, if required, by pressing the **MEM** key.

5.7.1 Standard earth resistance measurement

Connections for earth resistance measurement

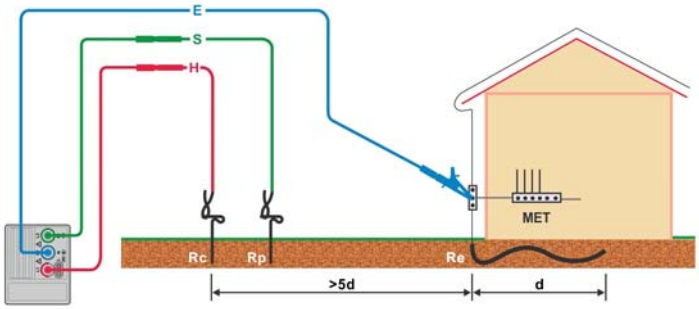


Figure 5.37: Resistance to earth, measurement of main installation earthing

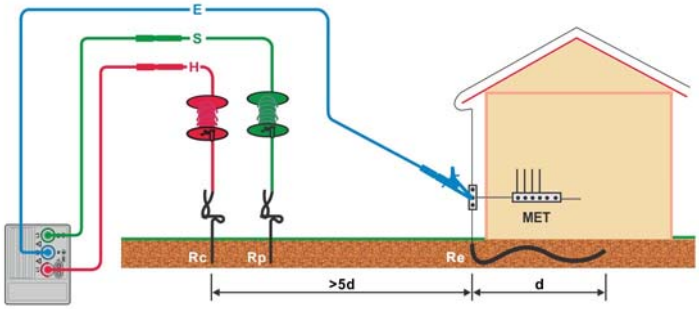


Figure 5.38: Resistance to earth, using extension leads

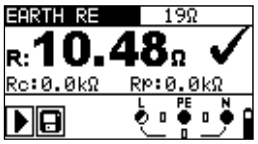


Figure 5.39: Example of earth resistance measurement result

Displayed results for earth resistance measurement:

R.....earth resistance
Rp .....resistance of S (potential) probe
Rc.....resistance of H (current) probe

Testing considerations

- High resistance of the S and H probes could influence the measurement results. In this case, “Rp” and “Rc” warnings are displayed. There is no PASS / FAIL indication in this case.
- Probes must be placed at sufficient distance from the measured object.
- If any voltage between the test terminals is higher than 30 V the resistance to earth measurement will be prevented.
- The instrument has been calibrated for the resistance of a TL36 test lead connected to the E terminal. If any other test lead type is connected to the E

terminal, such as the green test lead of the TL75 earth test lead set, it is advisable to determine the additional resistance introduced into the measurement by this test lead. This can be done by performing a measurement with all the test leads shorted together.

5.8 PE test touch terminal

The **TEST** key also acts as a PE test touch terminal and tests for voltage between the operator and the instrument's PE terminal when performing measurements where the mains supply is connected to the instrument terminals.
If for example the protective earth and phase of the wiring being tested were reversed the  symbol will be displayed and the test prevented. If the **TEST** key is touched the red and green LED's at the display sides will flash, an audible alarm will sound and the  symbol will be displayed.

There is however a wiring fault shown in *Figure 5.38* that can only be detected by the PE test touch terminal. For this reason, if the TL180 test probe is being used for testing, the instruments **TEST** key should always be touched once the test lead and test probe are in contact with the wiring being tested before proceeding with any measurements.

Example of the application of PE test terminal

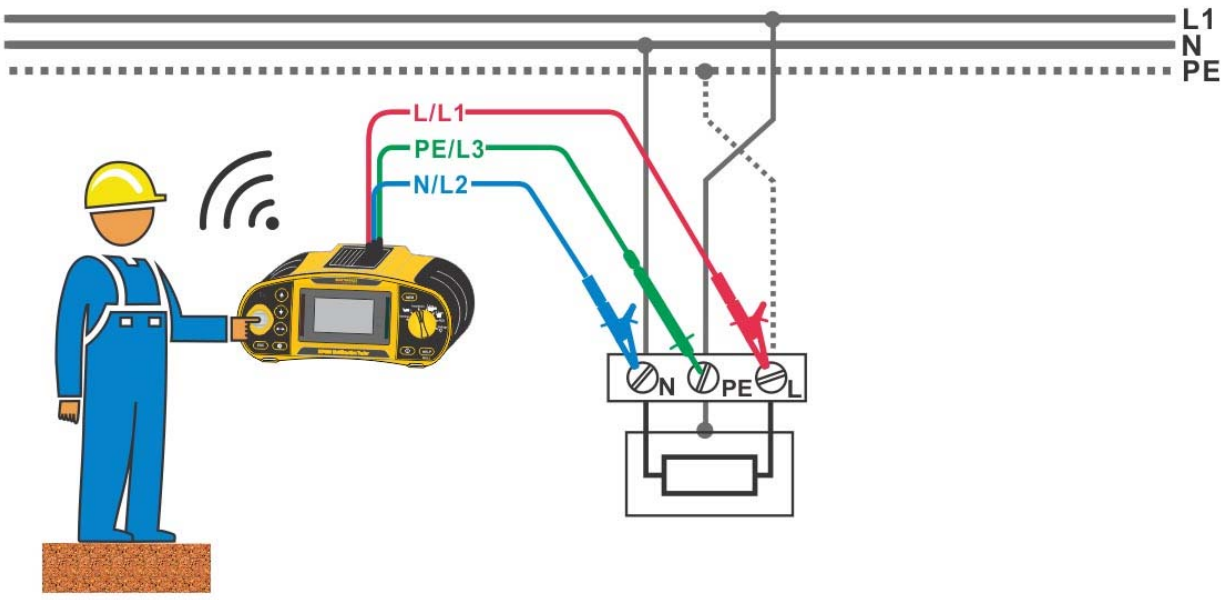


Figure 5.40: PE and Neutral at phase potential and Live earthed

PE terminal test procedure

- **Connect** the test leads to the instrument.
- **Connect** the test leads to the installation under test (see *Figure 5.40*)
- **Touch** the **TEST** key for at least one second.
- If the PE terminal is connected to phase voltage the warning message is displayed, the instrument buzzer is activated, and further measurements are disabled in Zloop, Zline and RCD functions.

Warning:
If a dangerous voltage is detected on the tested PE terminal, immediately stop all measurements, find and remove the fault. Maintenance should only be carried out by a competent electrician who is familiar with the relevant regulations, the safety risks involved and the consequent normal safe working practices.

Testing considerations

- The PE test terminal is NOT active in the Voltage, $R_{LOW\Omega}$, Earth and Insulation functions.
- The PE test terminal will not operate if the operator's body is completely insulated from the floor or walls.
- For correct testing, the TEST key has to be touched for a few seconds.
- Always stand on a non-isolated floor while carrying out the test, otherwise the test result may be incorrect.

6 Data handling (ET4500 only)

6.1 Memory organization

Measurement results together with all relevant parameters can be stored in the instrument's memory. After the measurement is completed, results can be saved to the flash memory of the instrument, together with the sub-results and function parameters.

6.2 Data structure

The instrument's memory place is divided into 4 levels each containing 199 locations. The number of measurements that can be stored into one location is not limited.

The data structure field describes the location of the measurement (which object, distribution board, circuit and connection) and where it can be accessed.
In the measurement field there is information about the type and number of measurements that belong to the selected structure element (object and distribution board and circuit and connection).
The main advantages of this system are:

- Test results can be organized and grouped in a structured manner that reflects the structure of typical electrical installations.
- Customized names of data structure elements can be uploaded from the ET-link PC program.
- Simple browsing through structure and results.
- Test reports can be created with few or no modifications after downloading results to a PC.

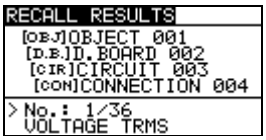


Figure 6.1: Data structure and measurement fields

Data structure field

RECALL RESULTS	Memory operation menu
[OBJ]OBJECT 001 [D.B.]D.BOARD 002 [CIR]CIRCUIT 003 [CON]CONNECTION 004	Data structure field
[OBJ]OBJECT 001	**1st level:** **OBJECT:** Default location name (object and its successive number). **001:** No. of selected element.
[D.B.]D.BOARD 002	**2nd level:** **DISTRIBUTION BOARD:** Default location name (distribution board and its successive number). **002:** No. of selected element.

[CIR]CIRCUIT 003	**3rd level:** **CIRCUIT:** Default location name (circuit and its successive number). **003:** No. of selected element.
[CON]CONNECTION 004	**4th level:** **CONNECTION:** Default location name (connection and its successive number). **004:** No. of selected element.
No.: 20 [132]	No. of measurements in selected location [No. of measurements in selected location and its sub-locations]

Measurement field

VOLTAGE TRMS	Type of stored measurement in the selected location.
No.: 1/36	No. of selected test result / No. of all stored test results in selected location.

6.3 Saving test results

After the completion of a test the results and parameters are ready for saving (icon is displayed in the information field). By pressing the **MEM** key, the user can save the results.

Figure 6.2: Save test menu

FREE:96.3%	Memory available for storing results.

Function of Keys in save test menu - data structure field

TAB	Selects the location element (Object / Distribution board / Circuit / Connection)
UP / DOWN	Selects number of selected location element (1 to 199)
MEM	Saves test results to the selected location and returns to the measuring function.
ESC / TEST	Exits back to measuring function without saving.
Function selector switch	Switches to other test / measuring function or settings menu without saving.

Notes:

- The instrument offers to save the result to the last selected location by default.
- If the measurement is to be stored to the same location as the previous one just press the MEM key twice.

6.4 Recalling test results

Press the **MEM key** in any measuring function when there is no result available for saving or select MEMORY in the SETTINGS menu.

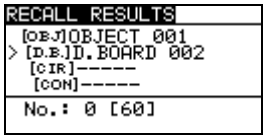


Figure 6.3: Recall menu - installation structure field selected

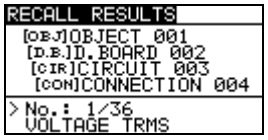


Figure 6.4: Recall menu - measurements field selected

Function of Keys in recall memory menu (installation structure field selected):

TAB	Selects the location element (Object / Distribution board / Circuit / Connection).
UP / DOWN	Selects number of selected location element (1 to 199).
ESC	Exits back to measuring function or memory menu.
Function selector switch	Switches to other test / measuring function or settings.
TEST / MEM	Enters measurements field.

Function of Keys in recall memory menu (measurements field selected):

UP / DOWN	Selects the saved measurement.
TAB / ESC	Returns to installation structure field.
Function selector switch	Switches to other test / measuring function or settings.
TEST / MEM	View selected measurement results.

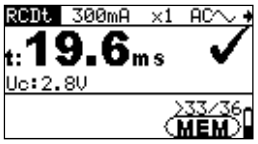


Figure 6.5: Example of recalled measurement result

Function of Keys in recall memory menu (measurement results are displayed)

UP / DOWN	Displays measurement results saved in selected location.
MEM / ESC	Returns to measurements field.
TEST	Returns to installation structure field.
Function selector switch	Switches to other test / measuring function or settings.

6.5 Clearing stored data

6.5.1 Completely clearing all memory content

Select **CLEAR ALL MEMORY** in **MEMORY menu**. A warning will be displayed.

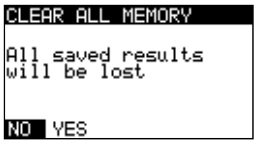


Figure 6.6: Clear all memory

Function of Keys in clear all memory menu

TEST	Confirms clearing of complete memory content (YES must be selected with **UP / DOWN** keys).
ESC	Exits back to memory menu without changes.
Function selector switch	Switches to test / measuring function without changes.

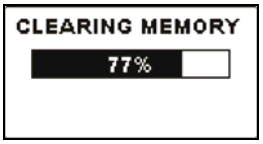


Figure 6.7: Clearing memory in progress

6.5.2 Clearing measurement(s) in selected locations

Select **DELETE RESULTS** in **MEMORY menu**.

Figure 6.8: Clear measurements menu (data structure field selected)

Function of Keys in delete results menu (installation structure field selected):

TAB	Selects the location element (Object / Distribution board / Circuit / Connection).
UP / DOWN	Selects number of selected location element (1 to 199)
Function selector switch	Switches to test / measuring function.
ESC	Exits back to memory menu.
TEST	Enters dialog box for deleting all measurements in selected location and its sub-locations.

Function of Keys in dialog for confirmation to clear results in selected location:

TEST	Deletes all results in selected location.
MEM / ESC	Exits back to delete results menu without changes.
Function selector switch	Switches to test / measuring function without changes.

6.5.3 Clearing individual measurements

Select **DELETE RESULTS** in **MEMORY menu**.

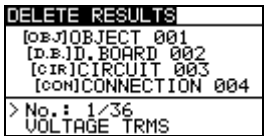


Figure 6.9: Menu for clearing individual measurement (installation structure field selected)

Function of Keys in delete results menu (installation structure field selected):

TAB	Selects the location element (Object / Distribution board / Circuit / Connection).
UP / DOWN	Selects number of selected location element (1 to 199)
Function selector switch	Switches to test / measuring function.
ESC	Exits back to memory menu.
MEM	Enters measurements field for deleting individual measurements.

Function of Keys in delete results menu (measurements field selected):

UP / DOWN	Selects measurement.
TEST	Opens dialog box for confirmation to clear selected measurement.
TAB / ESC	Returns to installation structure field.
Function selector switch	Switches to test / measuring function.

Function of Keys in dialog for confirmation to clear selected result(s):

TEST	Deletes selected measurement result.
MEM / TAB / ESC	Exits back to measurements field without changes.
Function selector switch	Switches to test / measuring function without changes.

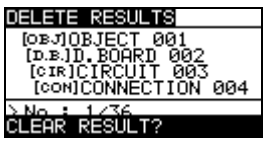


Figure 6.10: Dialog for confirmation

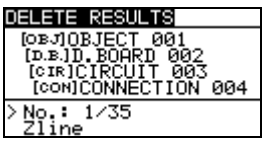


Figure 6.11: Display after measurement was cleared

6.5.4 Renaming installation structure elements (upload from PC)

Default installation structure elements are »Object«, »Distribution board«, »Circuit« and »Connection«.
In the software package ET-link default names can be changed with customized names that correspond to the installation under test. Refer to the ET-link HELP for information on how to upload customized installation names to the instrument.

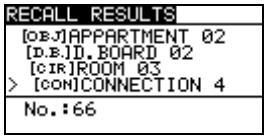


Figure 6.12: Example of menu with customized installation structure names

6.6 Communication

Saved results can be transferred to a PC (ET4500 only). A special communication program on the PC automatically identifies the instrument and enables data transfer between the instrument and the PC.
There are two communication interfaces available on the instrument: USB and RS 232.

6.6.1 USB and RS232 communication

The instrument automatically selects the communication mode according to the detected interface. The USB interface has priority.

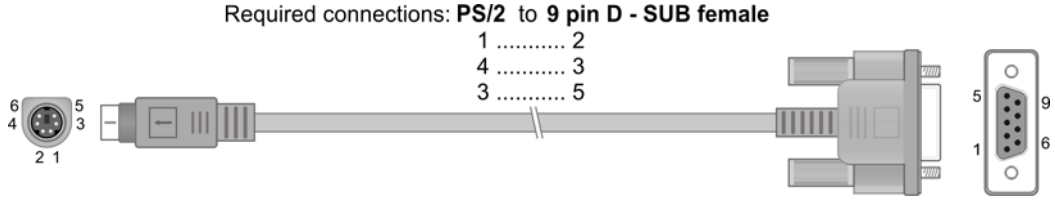


Figure 6.13: Interface connection for data transfer over PC COM port

How to establish a USB or RS-232 link:

- RS-232 communication: connect a PC COM port to the instrument PS/2 connector using the PS/2 - RS232 serial communication cable;
- USB communication: connect a PC USB port to the instrument USB connector using the USB interface cable.
- Switch on the PC and the instrument.
- Run the ET-link program.
- The PC and the instrument will automatically recognize each other.
- The instrument is now ready to communicate with the PC.

The PC program ET-link is compatible with Windows XP, Windows Vista, Windows 7, and Windows 8. Read the file README_ETlink.txt on the installation CD for instructions on installing and running the program.

Note:

- USB drivers should be installed on the PC before using the USB interface. Refer to the USB installation instructions available on the installation CD.

7 Upgrading the instrument firmware

The instrument firmware can be upgraded from a PC via the RS232 communication port. This enables the instrument to be kept up to date when standards or regulations change. The upgrade can be carried out using special upgrading software and the communication cable as shown in *Figure 6.13*. Please contact Martindale Electric for more information.

8 Maintenance

There are no user serviceable parts inside this instrument, except for the batteries and fuses under the battery compartment cover.

8.1 Battery replacement

Warning:

- Disconnect all test leads and accessories and switch off the instrument before opening the battery compartment cover. Hazardous voltage inside.

The battery compartment is at the rear of the instrument.

To gain access, undo the 3 screws securing the battery compartment cover, then lift off the cover.

The position of the batteries can be seen in *Figure 3.4: Battery and fuse compartment* in chapter ***3.3 Instrument rear***.

Fit 6 new 1.5V, AA alkaline batteries (IEC LR6, NEDA 15A) or 6 new rechargeable Ni-MH batteries observing correct polarity.

Refer to chapter *4.1 Batteries and charging* if rechargeable batteries are being replaced.

Replace the battery compartment cover and screws.

Note:- Do not mix old and new batteries.

8.2 Fuse replacement

Warnings:

- Disconnect all test leads and accessories and switch off the instrument before opening the battery compartment cover. Hazardous voltage inside.
- Replace the blown fuse with the original type only, otherwise the instrument or accessories may be damaged and/or the operator's safety impaired.

There are three fuses under the battery compartment cover.

- **F1**
  M 0.315 A / 250 V, 20×5 mm
  Martindale Part No. FUSEM315X3 (pack of 3)
  This fuse protects the internal circuitry of the continuity functions if the test terminals are inadvertently connected to the mains supply voltage during measurement.

- **F2, F3**
  F 4 A / 500 V, 32×6.3 mm (breaking capacity: 50 kA)
  Martindale Part No. FUSEF4AX3 (pack of 3)
  General input protection fuses for test terminals L/L1 and N/L2.

The position of the fuses can be seen in *Figure 3.4: Battery and fuse compartment* in chapter ***3.3 Instrument rear***.

8.3 Test lead replacement

If the test leads become damaged they should be replaced.

The replacement test leads must have the same (or better) overvoltage category rating as the TL36 and TL207 test leads supplied.

8.4 Cleaning

If contamination is found, clean with a damp soft cloth and if necessary a mild detergent or alcohol. Do not use abrasives, abrasive solvents, or detergents which can cause damage to the unit. If a mild detergent is used, the unit should subsequently be thoroughly cleaned with a water dampened soft cloth. After cleaning, dry and allow to remain in a dry environment for 2 hours before use.

8.5 Periodic calibration

To maintain the integrity of measurements made using your instrument, Martindale Electric recommends that it is returned at least once a year to an approved Calibration Laboratory for recalibration and certification.

Martindale Electric is pleased to offer you this service. Please contact our Service Department for details.
Email: service@martindale-electric.co.uk
Tel: 01923 650660

8.6 Service

There are no user serviceable parts in this unit other than those that may be described in section 8. Return to Martindale Electric if faulty. Our service department will quote promptly to repair any fault that occurs outside the guarantee period.

Before the unit is returned, please ensure that you have checked the unit, batteries, leads and poor connections.

8.7 Storage conditions

The instrument should be kept in warm dry conditions away from direct sources of heat or sunlight, and in such a manner as to preserve the working life of the unit. It is strongly advised that the unit is not kept in a tool box where other tools may damage it.

9 Technical specifications

The error in operating conditions should be no more than the error for reference conditions (specified in the manual for each function) +/-(1 % of measured value + 1 digit), unless otherwise specified in the manual for a particular function.

9.1 Insulation resistance

Insulation resistance (nominal voltages 50 V_{DC}, 100 V_{DC} and 250 V_{DC})
Measuring range to BS EN 61557-2 is 0.15 MΩ - 199.9 MΩ.

Measuring range (MΩ)	Resolution (MΩ)	Accuracy
0.00 - 19.99	0.01	±(5 % of reading + 3 digits)
20.0 - 99.9	0.1	±(10 % of reading)
100.0 - 199.9		±(20 % of reading)

Insulation resistance (nominal voltages 500 V_{DC} and 1000 V_{DC})
Measuring range to BS EN 61557-2 is 0.15 MΩ - 1 GΩ.

Measuring range (MΩ)	Resolution (MΩ)	Accuracy
0.00 - 19.99	0.01	±(5 % of reading + 3 digits)
20.0 - 199.9	0.1	±(5 % of reading)
200 - 999	1	±(10 % of reading)

Voltage

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

Nominal voltages .....50 V_{DC}, 100 V_{DC}, 250 V_{DC}, 500 V_{DC}, 1000 V_{DC}
Open circuit voltage .....-0 % / +20 % of nominal voltage
Measuring current.....min. 1 mA at $R_N=U_N\times 1$ kΩ/V
Short circuit current..... max. 3 mA
The number of possible tests..... > 1200, with a fully charged battery
Auto discharge after test.
Specified accuracy is valid up to 100 MΩ if relative humidity < 85 %.
If the instrument becomes damp, the results could be incorrect. In such a case, it is recommended to dry the instrument and accessories for at least 24 hours.
The error in operating conditions should be at most the error for reference conditions (specified in the manual for each function) ±5 % of measured value.

9.2 Continuity

9.2.1 Resistance R LOW, R2, R1+R2

Measuring range to BS EN 61557-4 is 0.16 Ω - 1999 Ω.

Measuring range R (Ω)	Resolution (Ω)	Accuracy
0.00 - 19.99	0.01	±(3 % of reading + 3 digits)
20.0 - 199.9	0.1	±(5 % of reading)
200 - 1999	1	

Measuring range R+, R- (Ω)	Resolution (Ω)	Accuracy
0.0 - 199.9	0.1	±(5 % of reading + 5 digits)
200 - 1999	1	

Open-circuit voltage.....6.5 VDC - 18 VDC
Measuring current.....min. 200 mA into load resistance of 2 Ω
Test lead compensation.....up to 5 Ω
Number of possible tests .....> 2000, with a fully charged battery
Automatic polarity reversal of the test voltage.

9.2.2 Resistance CONTINUITY

Measuring range (Ω)	Resolution (Ω)	Accuracy
0.0 - 19.9	0.1	±(5 % of reading + 3 digits)
20 - 1999	1	

Open-circuit voltage.....6.5 VDC - 18 VDC
Short-circuit current .....max. 8.5 mA
Test lead compensation.....up to 5 Ω

9.2.3 RING Continuity

Measuring range to BS EN 61557-4 is 0.16 Ω - 1999 Ω.

Measuring range R (Ω)	Resolution (Ω)	Accuracy
0.00 - 19.99	0.01	±(3 % of reading + 3 digits)
20.0 - 199.9	0.1	±(5 % of reading)
200 - 1999	1	

Open-circuit voltage.....6.5 VDC - 18 VDC
Measuring current.....min. 200 mA into load resistance of 2 Ω
Test lead compensation.....up to 5 Ω
Number of possible tests .....> 2000, with a fully charged battery

9.3 RCD testing

9.3.1 General data

Nominal residual current (A,AC) .....10 mA, 30 mA, 100 mA, 300 mA, 500 mA, 1000 mA
Nominal residual current accuracy.....-0 / +0.1·IΔ; IΔ = IΔN, 2×IΔN, 5×IΔN
-0.1·IΔ / +0; IΔ = 0.5×IΔN
Test current shape.....Sine-wave (AC), pulsed (A, F)
DC offset for pulsed test current .....6 mA (typical)
RCD type .....non-delayed, S (time-delayed)
Test current starting polarity ..... 0º or 180º
Voltage range .....93 V - 134 V (45 Hz - 65 Hz)
185 V - 266 V (45 Hz - 65 Hz)

	$I_{\Delta N}$ × 1/2		$I_{\Delta N}$ × 1		$I_{\Delta N}$ × 2		$I_{\Delta N}$ × 5		RCD I_{Δ}	
$I_{\Delta N}$ (mA)	**AC**	**A, F**	**AC**	**A, F**	**AC**	**A, F**	**AC**	**A, F**	**AC**	**A, F**
10	5	3.5	10	20	20	40	50	100	✓	✓
30	15	10.5	30	42	60	84	150	212	✓	✓
100	50	35	100	141	200	282	500	707	✓	✓
300	150	105	300	424	600	848	1500	n.a.	✓	✓
500	250	175	500	707	1000	1410	2500	n.a.	✓	✓
1000	500	350	1000	1410	2000	n.a.	n.a.	n.a.	✓	✓

n.a.....not applicable
AC type.....sine wave test current
A, F types…… .....pulsed current

9.3.2 Contact voltage RCD Uc

Measuring range to BS EN 61557-6 is 20.0 V - 31.0V for limit contact voltage 25V
Measuring range to BS EN 61557-6 is 20.0 V - 62.0V for limit contact voltage 50V

Measuring range (V)	Resolution (V)	Accuracy
0.0 - 19.9	0.1	(-0 % / +15 %) of reading ± 10 digits
20.0 - 99.9	0.1	(-0 % / +15 %) of reading

The accuracy is valid if the mains voltage is stable during the measurement and the PE terminal is free of interferance voltages.

Test current ..... max. 0.5×$I_{\Delta N}$
Limit contact voltage..... 25 V, 50 V
Specified accuracy is valid for the complete operating range.

9.3.3 Trip-out time

Complete measurement range conforms with BS EN 61557-6.
Maximum measuring times set according to selected reference for RCD testing.

Measuring range (ms)	Resolution (ms)	Accuracy
0.0 - 40.0	0.1	±1 ms
0.0 - max. time *	0.1	±3 ms

* For max. time see normative references in chapter *4.4.3 RCD testing* – this specification applies to max. time >40 ms.

Test current ..... ½×$I_{\Delta N}$, $I_{\Delta N}$, 2×$I_{\Delta N}$, 5×$I_{\Delta N}$
5×$I_{\Delta N}$ is not available for $I_{\Delta N}$=1000 mA (RCD type AC) or $I_{\Delta N} \geq$ 300 mA (RCD types A, F).
2×$I_{\Delta N}$ is not available for $I_{\Delta N}$=1000 mA (RCD types A, F).
Specified accuracy is valid for complete operating range.

9.3.4 Trip-out current

Trip-out current
Complete measurement range conforms to BS EN 61557-6.

Measuring range I_Δ	Resolution I_Δ	Accuracy
0.2×$I_{\Delta N}$ - 1.1×$I_{\Delta N}$ (AC type)	0.05×$I_{\Delta N}$	±0.1×$I_{\Delta N}$
0.2×$I_{\Delta N}$ - 1.5×$I_{\Delta N}$ (A type, $I_{\Delta N}$ ≥30 mA)	0.05×$I_{\Delta N}$	±0.1×$I_{\Delta N}$
0.2×$I_{\Delta N}$ - 2.2×$I_{\Delta N}$ (A type, $I_{\Delta N}$ <30 mA)	0.05×$I_{\Delta N}$	±0.1×$I_{\Delta N}$
0.2×$I_{\Delta N}$ - 2.2×$I_{\Delta N}$ (B type)	0.05×$I_{\Delta N}$	±0.1×$I_{\Delta N}$

Trip-out time

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

Contact voltage

Measuring range (V)	Resolution (V)	Accuracy
0.0 - 19.9	0.1	(-0 % / +15 %) of reading ± 10 digits
20.0 - 99.9	0.1	(-0 % / +15 %) of reading

The accuracy is valid if the mains voltage is stable during the measurement and the PE terminal is free from interferance voltages.
Specified accuracy is valid for the complete operating range.

9.4 Fault loop impedance and prospective fault current

9.4.1 No disconnecting device or FUSE selected

Fault loop impedance

Measuring range to BS EN 61557-3 is 0.25 Ω - 9.99kΩ.

Measuring range (Ω)	Resolution (Ω)	Accuracy
0.00 - 9.99	0.01	±(5 % of reading + 5 digits)
10.0 - 99.9	0.1	
100 - 999	1	± 10 % of reading
1.00 k - 9.99 k	10	

Prospective fault current (calculated value)

Measuring range (A)	Resolution (A)	Accuracy
0.00 - 9.99	0.01	Consider accuracy of fault loop resistance measurement
10.0 - 99.9	0.1	
100 - 999	1	
1.00 k - 9.99 k	10	
10.0 k - 23.0 k	100	

The accuracy is valid if the mains voltage is stable during the measurement.

Test current (at 230 V)..... 6.5 A (10 ms)
Nominal voltage range..... 93 V - 134 V (45 Hz - 65 Hz)
185 V - 266 V (45 Hz - 65 Hz)

9.4.2 RCD selected

Fault loop impedance

Measuring range to BS EN 61557-3 is 0.46 Ω - 9.99 kΩ.

Measuring range (Ω)	Resolution (Ω)	Accuracy
0.00 - 9.99	0.01	±(5 % of reading + 10 digits)
10.0 - 99.9	0.1	
100 - 999	1	± 10 % of reading
1.00 k - 9.99 k	10	

Accuracy may be impaired in case of heavy noise on the mains voltage.

Prospective fault current (calculated value)

Measuring range (A)	Resolution (A)	Accuracy
0.00 - 9.99	0.01	Consider accuracy of fault loop resistance measurement
10.0 - 99.9	0.1	
100 - 999	1	
1.00 k - 9.99 k	10	
10.0 k - 23.0 k	100	

Nominal voltage range..... 93 V - 134 V (45 Hz - 65 Hz)
185 V - 266 V (45 Hz - 65 Hz)

No trip out of RCD.

9.5 Line impedance and prospective short-circuit current / Voltage drop

Line impedance

Measuring range to BS EN 61557-3 is 0.25 Ω - 9.99kΩ.

Measuring range (Ω)	Resolution (Ω)	Accuracy
0.00 - 9.99	0.01	±(5 % of reading + 5 digits)
10.0 - 99.9	0.1	
100 - 999	1	± 10 % of reading
1.00 k - 9.99 k	10	

Prospective short-circuit current (calculated value)

Measuring range (A)	Resolution (A)	Accuracy
0.00 - 0.99	0.01	Consider accuracy of line resistance measurement
1.0 - 99.9	0.1	
100 - 999	1	
1.00 k - 99.99 k	10	
100 k - 199 k	1000	

Test current (at 230 V)..... 6.5 A (10 ms)
Nominal voltage range..... 93 V - 134 V (45 Hz - 65 Hz)
185 V - 266 V (45 Hz - 65 Hz)
321 V - 485 V (45 Hz - 65 Hz)

Voltage drop (calculated value)

Measuring range (%)	Resolution (%)	Accuracy
0.0 - 99.9	0.1	Consider accuracy of line impedance measurement(s)*

Z_{REF} measuring range..... 0.00 Ω - 20.0 Ω

*See chapter *5.6.2 Voltage drop* for more information on the calculation of the voltage drop result.

9.6 Resistance to earth (ET4500 only)

9.6.1 Standard earth resistance measurement – 3-wire measurement

Measuring range to BS EN 61557-5 is 2.00 Ω - 9999 Ω.

Measuring range (Ω)	Resolution (Ω)	Accuracy
0.00 - 19.99	0.01	±(5% of reading + 5 digits)
20.0 - 199.9	0.1	
200 - 9999	1	

Max. auxiliary earth electrode resistance R_C ... $100 \times R_E$ or 50 kΩ (whichever is lower)
Max. probe resistance R_P ..... $100 \times R_E$ or 50 kΩ (whichever is lower)

Additional probe resistance error at R_{Cmax} or $R_{Pmax.}$ ±(10 % of reading + 10 digits)

Additional error at 3 V voltage noise (50 Hz) ... ±(5 % of reading + 10 digits)
Open circuit voltage ..... < 30 VAC
Short circuit current..... < 30 mA
Test voltage frequency ..... 125 Hz
Test voltage shape ..... sine wave
Noise voltage indication threshold ..... 1 V (< 50 Ω, worst case)

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

9.7 Voltage, frequency, and phase rotation

9.7.1 Phase rotation

Nominal system voltage range ..... 100 V_{AC} - 550 V_{AC}
Nominal frequency range..... 15 Hz - 500 Hz
Result displayed ..... 1.2.3 or 3.2.1

9.7.2 Voltage

Measuring range (V)	Resolution (V)	Accuracy
0 - 550	1	±(2 % of reading + 2 digits)

Result type..... True r.m.s. (trms)
Nominal frequency range..... 0 Hz, 15 Hz - 500 Hz

9.7.3 Frequency

Measuring range (Hz)	Resolution (Hz)	Accuracy
5.00 - 9.99	0.01	±(0.2 % of reading + 1 digit)
10.0 - 499.9	0.1	

Nominal voltage range..... 20 V - 550 V

9.7.4 Online terminal voltage monitor

Measuring range (V)	Resolution (V)	Accuracy
10 - 550	1	±(2 % of reading + 2 digits)

9.8 General specifications

Display ..... 128x64 dots matrix display with backlight

Communication transfer speed
RS 232 ..... 57600 baud
USB ..... 256000 baud
Size of memory (ET4500 only) ..... ca 1800 measurements

Power supply ..... 6 x 1.5V, AA alkaline batteries (IEC LR6, NEDA 15A) or 6 x 1.2V, AA rechargeable Ni-MH batteries (2100 mAH).
Operation ..... typically 20 h
Charger socket input voltage ..... 12 V ± 10 %
Charger socket input current ..... 400 mA max.
Battery charging current ..... 250 mA (internally regulated)

Dimensions (w × h × d) ..... 23 cm × 10.3 cm × 11.5 cm
Weight ..... 1.3 kg, without battery cells

Environmental

Reference conditions
Reference temperature range ..... 10 °C - 30 °C
Reference humidity range ..... 40 %RH - 70 %RH

Operation conditions
Working temperature range ..... 0 °C - 40 °C
Maximum relative humidity ..... 95 %RH (0 °C - 40 °C), non-condensing

Storage conditions
Temperature range ..... -10 °C - +70 °C
Maximum relative humidity ..... 90 %RH (-10 °C - +40 °C)
80 %RH (40 °C - 60 °C)

Altitude ..... upto 2000m

Pollution degree 2

Safety

Complies with ..... BS EN61010-1 & BS EN61010-2-030
Measurment category ..... 600 V CAT III
300 V CAT IV

Functionality complies with BS EN61557 parts 1, 2, 3, 4, 5, 6, 7,10 & 12

Protection class ..... Class II, double insulation
Protection degree ..... IP 40

EMC

Complies with ..... BS EN 61326 – Class B (Hand-held equipment used in controlled EM environments)

Specification for TL36 test leads

Maximum voltage..... 1000V AC/DC
Maximum current..... 10A continuous
Connectors ..... 4mm banana plugs with fixed shrouds

Environmental

Temperature (Operating & Storage) . 0°C - 40°C
Altitude..... up to 2000m
Pollution degree..... 2

Safety

Complies with ..... BS EN61010-031
Measurment category ..... 600V CAT IV, 1000V CAT III, 10A (probe tip caps fitted)
1000V CAT II, 10A (probe tip caps removed)

600V CAT IV, 1000V CAT III, 10A (crocodile clip fitted)

Protection class ..... Class II, double insulation

Specification for TL207 test lead

Maximum voltage..... 300V AC/DC (1000V DC for insulation tests)
Maximum current..... 10A continuous
Connectors ..... 4mm banana plugs with fixed shrouds to mains plug

Environmental

Temperature (Operating & Storage) . 0°C - 40°C
Altitude..... up to 2000m
Pollution degree..... 2

Safety

Complies with ..... BS EN61010-031
Measurment category ..... 300V CAT II, 10A

Protection class ..... Class II, double insulation

Specification for TL180 test probe

Maximum voltage..... 1000V AC/DC
Maximum current..... 10A continuous

Environmental

Temperature (Operating & Storage) . 0°C - 40°C
Altitude..... up to 2000m
Pollution degree..... 2

Safety

Complies with ..... BS EN61010-031
Measurment category..... 600V CAT IV, 1000V CAT III, 10A (probe tip cap fitted)
1000V CAT II, 10A (probe tip cap removed)

Protection class ..... Class II, double insulation

10 Warranty and limitation of liability

This Martindale product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is 2 years and begins on the date of receipt by the end user. This warranty extends only to the original buyer or end-user customer, and does not apply to fuses, disposable batteries, test leads or to any product which, in Martindale's opinion, has been misused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation, handling or storage.

Martindale authorised resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Martindale.

Martindale's warranty obligation is limited, at Martindale's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to Martindale within the warranty period.

This warranty is the buyer's sole and exclusive remedy and is in lieu of all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose. Martindale shall not be liable for any special, indirect, incidental or consequential damages or losses, including loss of data, arising from any cause or theory.

Since some jurisdictions do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any part of any provision of this warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision or other part of that provision.

Nothing in this statement reduces your statutory rights.

Appendix A – Impedance tables

A.1 Impedance tables - for fuses, circuit-breakers and RCBO's

The maximum loop impedances in the following tables are used for the pass/fail limits for the measurement of loop impedance. The 1.0 Z factor setting maximum loop impedances are in accordance with BS 7671 Amendment No. 3: 2015.

Fuses to BS 88-2 – fuse systems E & G

Rated current (A)	Z factor setting			
	1.0		0.8	
	Disconnection time (s)			
	0.4	5	0.4	5
	Max. loop impedance (Ω)			
2	33.10	44.00	26.48	35.20
4	15.60	21.00	12.48	16.80
6	7.80	12.00	6.24	9.60
10	4.65	6.80	3.72	5.44
16	2.43	4.00	1.94	3.20
20	1.68	2.80	1.34	2.24
25	1.29	2.20	1.03	1.76
32	0.99	1.70	0.79	1.36
40		1.30		1.04
50		0.99		0.79
63		0.78		0.62
80		0.55		0.44
100		0.42		0.34
125		0.32		0.26
160		0.27		0.22
200		0.18		0.14

Fuses to BS 88-3 – fuse system C

Rated current (A)	Z factor setting			
	1.0		0.8	
	Disconnection time (s)			
	0.4	5	0.4	5
	Max. loop impedance (Ω)			
5	9.93	14.6	7.94	11.68
16	2.30	3.90	1.84	3.12
20	1.93	3.20	1.54	2.56
32	0.91	1.60	0.73	1.28
45		1.00		0.80
63		0.68		0.54
80		0.51		0.41
100		0.38		0.30

Fuses to BS 3036

Rated current (A)	Z factor setting			
	1.0		0.8	
	Disconnection time (s)			
	0.4	5	0.4	5
	Max. loop impedance (Ω)			
5	9.10	16.80	7.28	13.44
15	2.43	5.08	1.94	4.06
20	1.68	3.64	1.34	2.91
30	1.04	2.51	0.83	2.01
45		1.51		1.21
60		1.07		0.86
100		0.51		0.41

Fuses to BS 1362

Rated current (A)	Z factor setting			
	1.0		0.8	
	Disconnection time (s)			
	0.4	5	0.4	5
	Max. loop impedance (Ω)			
3	15.60	22.00	12.48	17.60
13	2.30	3.64	1.84	2.91

Type B circuit-breakers to BS EN 60898 and RCBO's to BS EN 61009-1

Disconnection time 0.4 & 5 s

Rated current (A)	Z factor setting	
	1.0	0.8
	Max. loop impedance (Ω)	
3	14.57	11.66
6	7.28	5.82
10	4.37	3.50
16	2.73	2.18
20	2.19	1.75
25	1.75	1.40
32	1.37	1.10
40	1.09	0.87
50	0.87	0.70
63	0.69	0.55
80	0.55	0.44
100	0.44	0.35
125	0.35	0.28

Type C circuit-breakers to BS EN 60898 and RCBO's to BS EN 61009-1

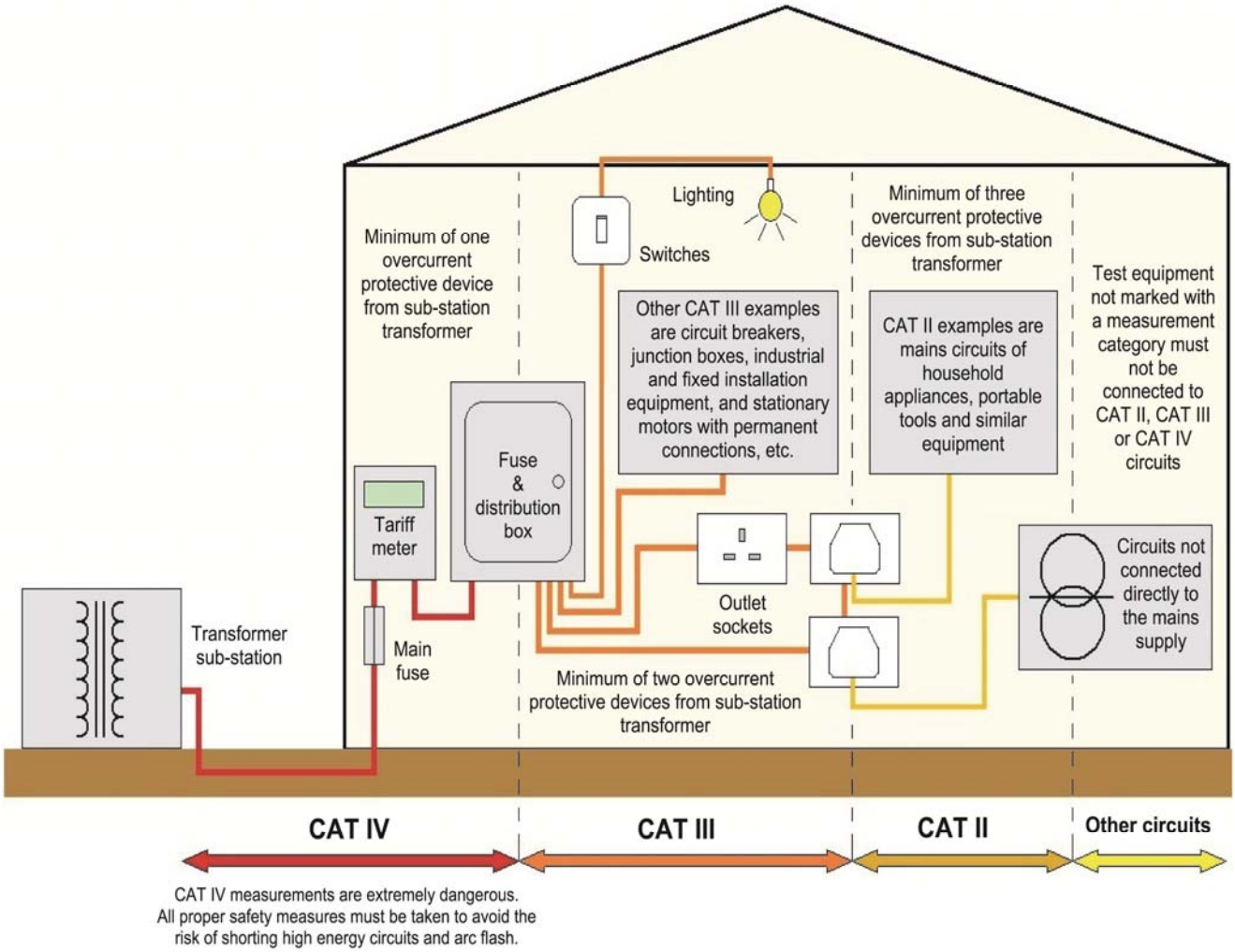
Disconnection time 0.4 & 5 s

Rated current (A)	Z factor setting	
	1.0	0.8
	Max. loop impedance (Ω)	
6	3.64	2.91
10	2.19	1.75
16	1.37	1.10
20	1.09	0.87
25	0.87	0.70
32	0.68	0.54
40	0.55	0.44
50	0.44	0.35
63	0.35	0.28
80	0.27	0.22
100	0.22	0.18
125	0.17	0.14

Type D circuit-breakers to BS EN 60898 and RCBO's to BS EN 61009-1

Rated current (A)	Z factor setting			
	1.0		0.8	
	Disconnection time (s)			
	0.4	5	0.4	5
	Max. loop impedance (Ω)			
6	1.82	3.64	1.46	2.91
10	1.09	2.19	0.87	1.75
16	0.68	1.37	0.54	1.10
20	0.55	1.09	0.44	0.87
25	0.44	0.87	0.35	0.70
32	0.34	0.68	0.27	0.54
40	0.27	0.55	0.22	0.44
50	0.22	0.44	0.18	0.35
63	0.17	0.35	0.14	0.28
80	0.14	0.27	0.11	0.22
100	0.11	0.22	0.09	0.18
125	0.09	0.17	0.07	0.14

Appendix B – Measurement categories



Measurement categories are determined by the potential for dangerous transient impulses on the mains supply system, the magnitude of which depends on the

amount of damping of the transient energy due to the location within the system and the system voltage. Short-circuit current levels are also a factor.

Test equipment used for measuring mains circuits will be marked with one or more of three measurement categories, **CAT II**, **CAT III** or **CAT IV**, to identify on which installations of a mains supply system it can safely be used.

Each category has a voltage rating marked to indicate the maximum safe phase to earth system voltage (conventionally 50V, 100V, 150V, 300V, 600V or 1000V).

Transient impulses are greatest for CAT IV 1000V installations.

'CAT IV 300V, CAT III 600V' is an example of measurement category marking.

The unit can be used safely on CAT IV installations where the phase to earth voltage is ≤300V and on CAT III installations where the phase to earth voltage is ≤600V.

Such a unit could safely be connected between phases on CAT IV installations of a 3-phase distribution system where the phase to phase voltage is 400V because the phase to earth voltage is 230V.

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